Approved Syllabi of Courses offered by the Department of Electrical Engineering

[As per New Course Structure approved in the B. Tech. Ordinance (2017-18)]

for

B. Tech. 4th Year (Electrical Engineering and Non Electrical Engineering Branches)

Department of Electrical Engineering

School of Engineering

Harcourt Butler Technical University

Kanpur-208 002

B. Tech. IV Year (Electrical Engineering)

Course Structure, Evaluation Scheme and Detailed Syllabus (Effective from AS: 2020-21)

Semester VII

Sr. No.	Course Type	Subject Code	Course Title	Credits (LTP)	Sessional Marks				ESE	Total
					MSE	TA	Lab.	Total		
1.	PCC	EEE-401	Electric Drives	5 (3-1-2)	15	20	15	50	50	100
2.	PEC	PEC-I	PEC-I	3 (3-0-0)	30	20	-	50	50	100
3.	PEC	PEC-II	PEC-II	3 (3-0-0)	30	20	-	50	50	100
4.	OEC	OEC-I	OEC-I	3 (3-0-0)	30	20	-	50	50	100
5.	Industrial Training	EEE-461	Industrial Training	2 (0-0-4)	-	50	-	50	50	100
6.	Seminar	EEE-471	Seminar	2 (0-0-4)	-	50	-	50	50	100
7.	Project	EEE-497	Project	4 (0-0-8)	-	50	-	50	50	100
Total Credit				**22**						

Semester VIII

Sr. No.	Course Type	Subject Code	Course Title	Credits (LTP)	Sessional Marks				ESE	Total
					MSE	TA	Lab.	Total		
1.	PEC	PEC-III	PEC-III	4 (3-1-0)	30	20	-	50	50	100
2.	PEC	PEC-IV	PEC-IV	4 (3-1-0)	30	20	-	50	50	100
3.	OEC	OEC-II	OEC-II	4 (3-1-0)	30	20	-	50	50	100
4.	Project	EEE-498	Project	10 (0-0-20)	-	50	-	50	50	100
Total Credit				**22**						

Project (EEE-497) will have Internal Evaluation while Project (EEE-498) will have External Evaluation, towards ESE.

List of Programme Electives to be offered by the Department of Electrical Engineering in B. Tech. VII & VIII Semester, w. e. f. AS: 2020-21.

Programme Electives-I

Sl. No.	Course Code	Course Name	Credits
1.	EEE-411	Instrumentation and Process Control	3 (3-0-0)
2.	EEE-413	HVDC Transmission Systems	3 (3-0-0)
3.	EEE-415	Special Topics in Control Systems	3 (3-0-0)
4.	EEE-417	Electrical Energy Conservation and Auditing	3 (3-0-0)
5.	EEE-419	Power System Design	3 (3-0-0)
6.	EEE-421	Advanced Power Electronics	3 (3-0-0)

Programme Electives-II

Sl. No.	Course Code	Course Name	Credits
1.	EEE-423	Advanced Control System	3 (3-0-0)
2.	EEE-425	Special Electrical Machines	3 (3-0-0)
3.	EEE-427	Optimal Control System	3 (3-0-0)
4.	EEE-429	Power System Protection	3 (3-0-0)
5.	EEE-431	Electrical Machine Design	3 (3-0-0)
6.	EEE-433	Real Time Simulation Techniques of Power Electronic Converters	3 (3-0-0)

Programme Electives-III

Sl. No.	Course Code	Course Name	Credits
1.	EEE-440	Neural Network and Fuzzy System	4 (3-1-0)
2.	EEE-442	Power System Security and Analysis	4 (3-1-0)
3.	EEE-444	Applied System Theory	4 (3-1-0)
4.	EEE-446	Power Quality and FACTS	4 (3-1-0)
5.	EEE-448	Wind and Solar Energy Systems	4 (3-1-0)
6.	EEE-450	Modeling and Simulation of Electrical Machines	4 (3-1-0)

Programme Electives-IV

Sl. No.	Course Code	Course Name	Credits
1.	EEE-452	Robotics and Automation	4 (3-1-0)
2.	EEE-454	Power System Dynamics and Control	4 (3-1-0)
3.	EEE-456	Industrial Instrumentation	4 (3-1-0)
4.	EEE-458	Electrical and Electronics Engineering Materials	4 (3-1-0)
5.	EEE-460	Electrical and Hybrid Vehicles	4 (3-1-0)
6.	EEE-462	Advanced Electric Drives	4 (3-1-0)

List of Open Electives to be offered by the Department of Electrical Engineering in B. Tech. VII & VIII Semester, w. e. f. AS: 2020-21.

OEC-I

Sl. No.	Course Code	Course Name	Credits
1.	OEE 433	Non-Conventional Energy Sources	3(3-0-0)
2.	OEE 435	Power Plant Engineering	3(3-0-0)

OEC-II

Sl. No.	Course Code	Course Name	Credits
1.	OEE 444	Industrial Measurements	4(3-1-0)
2.	OEE 446	Industrial Control Systems	4(3-1-0)

EEE-401	Electrical Drives	3L:1T:2P	5 Credits	Course Type: PEC

Preamble:

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; EEE-304, Electrical Machines-I; EEE-202, Electrical Machines – II; EEE-301.

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

COs	Course Outcomes	Bloom's Level
CO1	Understand the Fundamentals of Electric Drive	Knowledge (1) Comprehension (2)
CO2	Understand the characteristics of dc motors and induction motors.	Knowledge (1) Comprehension (2) Analysis (4)
CO3	Understand the principles of speed-control of dc motors.	Knowledge (1) Application (3) Analysis (4)
CO4	Understand the principles of speed-control of induction motors.	Knowledge (1) Application (3) Analysis (4)
CO5	Design and Analyse power electronic converters used for speed control of DC and AC motors.	Application (3) Analysis (4) Synthesis (5) Evaluation (6)

Mapping with Programme Outcomes:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO1O	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
Avg.	2.6	2.4	2.2	1.8	1.4	0.6	0.2	-	-	-	-	0.6

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

Course Level Assessment Questions

Course Outcome 1:

1. Define Electric Drive.

2. What are the various types of loads?

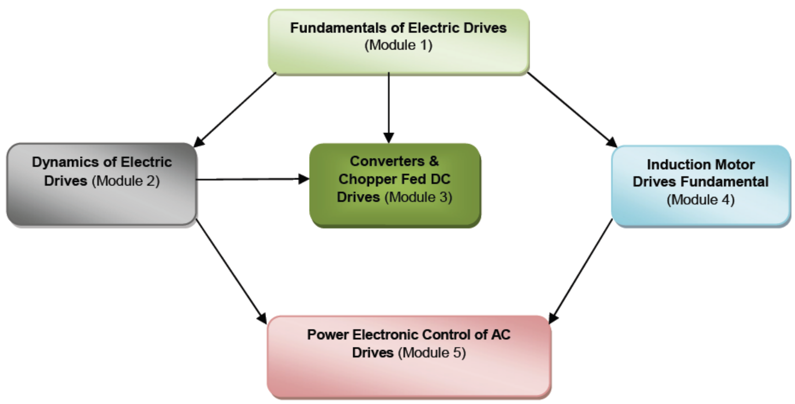
Course Outcome 2:
1. Explain the factors which have to be considered to decide a motor for particular application.
2. How thermal model of a motor helps to decide rating of motor?

Course Outcome 3:
1. Explain inner current control loop and outer speed control loop in closed loop speed control.
2. Deduce the expression $w_m = (\delta V / K) - (R_a / K^2)T$ for chopper fed separately excited D.C. motor drive.

Course Outcome 4:
1. Explain procedure for generation of three-phase PWM signals.
2. What do you understand by slip regulator?

Course Outcome 5:
1. Discuss Cyclo-converter based induction motor drive.
2. Discuss static voltage control scheme for induction motor drive.

Concept Map



Module 1: Fundamentals of Electric Drives: **(6 hours)**
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: **(7 hours)**
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: **(8 hours)**
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, duty ratio control, chopper fed dc motor for speed control, armature current waveform and ripple. 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: **(8 hours)**
Review of three-phase voltage source inverter, generation of three-phase PWM signals, sinusoidal modulation, 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: (11 hours)

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. Three Phase Synchronous motor: Self-controlled scheme.

Text / References:

1. G. K. Dubey, "Power Semiconductor Controlled Drives", Prentice Hall, 1989.
2. R. Krishnan, "Electric Motor Drives: Modeling, Analysis and Control", Prentice Hall, 2001.
3. S. K. Pillai, "A First Course on Electric Drives", New Age International.

Reference Books:

4. W. Leonhard, "Control of Electric Drives", Springer Science & Business Media, 2001.
5. M.Chilkin, "Electric Drives", Mir Publishers, Moscow.
6. Mohammed A. El-Sharkawi, "Fundamentals of Electric Drives", Thomson Asia, Pvt. Ltd. Singapore.
7. N.K. De and Prashant K.Sen, "Electric Drives", Prentice Hall of India Ltd.
8. V.Subrahmanyam, "Electric Drives: Concepts and Applications", Tata McGraw Hill.

Web Reference:

1. Video/Web contents on NPTEL

List of Experiments:

Note: - Minimum 10 experiments are to be performed.

Hardware/Real Time Simulation Based Experiments:

1. To study speed control of separately excited dc motor by varying armature voltage using single-phase fully controlled bridge converter.
2. To study speed control of separately excited dc motor by varying armature voltage using single phase half controlled bridge converter.
3. To study speed control of separately excited dc motor using MOSFET/IGBT chopper
4. To study closed loop control of separately excited dc motor
5. To study speed control of single phase induction motor using single phase ac voltage controller.
6. To study speed control of three phase induction motor using three phase ac voltage controller.
7. To study speed control of three phase induction motor using three phase voltage source inverter.
8. To study speed control of three phase slip ring induction motor using static rotor resistance control using rectifier.
9. To study speed control of three phase slip ring induction motor using static scherbius slip power recovery control scheme.

Software based experiments (MATLAB)

10. To study starting transient response of separately excited dc motor
11. To study speed control of separately excited dc motor using single phase fully / half controlled bridge converter in discontinuous and continuous current modes.
12. To study speed control of separately excited dc motor using chopper control in motoring and braking modes.
13. To study starting transient response of three phase induction motor
14. To study speed control of three phase induction motor using constant V/F control

15. To study speed control of three phase induction motor using Voltage and frequency control.

Course Contents and Lecture Schedule

Module No.	Topic (s)	No. of Lectures
1	Electric Drives and its parts, advantages of electric drives	2
	Classification of electric drives, Speed-torque conventions and multi-quadrant operations, Constant torque and constant power operation,	2
	Types of load, Load torque: components, nature and classification.	2
2	Dynamics of motor-load combination;	1
	Steady state stability of Electric Drive; Transient stability of electric Drive,	2
	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	3
	Load equalization	1
3	Single phase and three phase controlled converter fed separately excited dc motor drives,	2
	Chopper control of separately excited dc motor and dc series motor drive, duty ratio control, chopper fed dc motor for speed control, armature current waveform and ripple.	3
	Control structure of DC drive, Closed loop control of DC Motor drive, inner current loop and outer speed loop.	3
4	Review of three-phase voltage source inverter, generation of three-phase PWM signals, sinusoidal modulation	3
	Constant V/f control of induction motor, steady-state performance analysis based on equivalent circuit	2
	Speed drop with loading, slip regulation.	3
5	Three Phase induction Motor Drive, Static Voltage control scheme	3
	Static frequency control scheme (and cyclo-converter base), static rotor resistance and slip power recovery control schemes.	4
	Three Phase Synchronous motor: Self-controlled scheme.	4

List of Programme Electives-I

EEE-411	Instrumentation and Process Control	3L: 0T: 0P	3 Credits	Course Type: PEC

Preamble:

This course will provide a good understanding 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, Measurement Science and Techniques, Basic Instrumentation, Control Systems.

Course Outcomes:

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

COs	Course Outcomes	Bloom's Level
CO1	Able to know about Electrical Transducers	Remembering, Understanding
CO2	Able to understand and apply Telemetry and Data Acquisition system	Understanding, Applying
CO3	Able to understand and apply Display devices and Recorders	Understanding, Applying
CO4	Exhibit the knowledge of different Control modes and their application in controlling various processes	Understanding, Analysing, Applying
CO5	Develop the mathematical model of various Chemical processes.	Understanding, Analysing
CO6	Demonstrate fundamental understanding of Process Control	Analysing, Evaluating

Mapping with Programme Outcomes:

COs	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 Outcome 1:
1. Define and classify Transducers.
2. Briefly discuss the Strain gauges.
3. Explain the principle of working of Hall Effect Transducers.

Course Outcome 2:
1. Define Telemetry.
2. What are the different channels used in the Telemetry?
3. Discuss Data Acquisition Systems.

Course Outcome 3:
1. What are various display devices?
2. Differentiate between display devices and recorders.
3. Describe in brief the working of Magnetic tape recorders.

Course Outcome 4:
1. Derive time response expression of a standard second order control system with P controller.
2. Compare P, I and D controllers.
3. A P-I controller has a proportional band of 50% and integration time of 2 sec. Find the transfer function of the controller.

Course Outcome 5:
1. What do you understand by Analogous systems, explain?
2. What do you understand by Lumped and Distributed parameters?

3. Obtain electrical equivalent circuit of the given mechanical systems as shown in Fig. using *f*-*i* and *f*-*v* analogies.

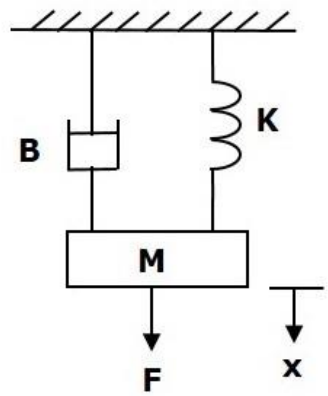
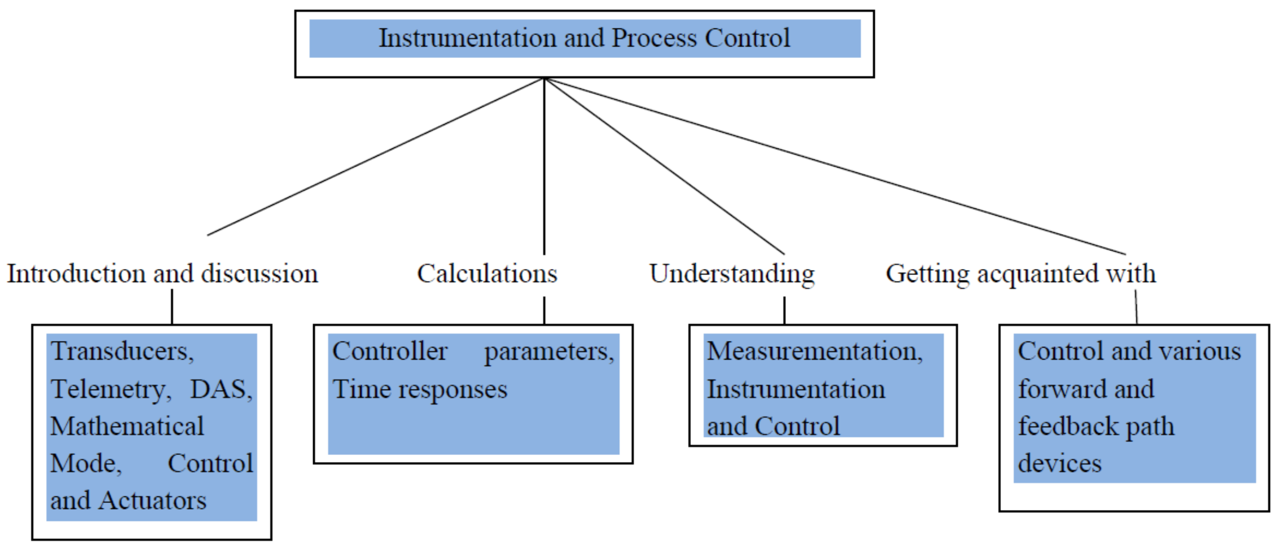


Fig. Mechanical System

Course Outcome 6:
1. Explain the principle of process control.
2. Describe the different Elements of the process control systems.
3. What do you understand by the Control Valves used in the process control?

Concept Map



Syllabus

Module 1: Electrical Transducers (10 Lectures)

Definition, Advantages, Classification, Characteristics, Factors affecting the choice of transducers, Strain Gauges, LVDT, Capacitive, Piezoelectric, Thermocouples, Hall Effect Transducers.

Module-II: Telemetry and Data Acquisition System (8 Lectures)

General Telemetry system, Land line & Radio Frequency Telemetering system, Transmission Channels and media, Analog Data Acquisition system, Digital Data Acquisition System.

Module-III: Display Devices and Recorders (8 Lectures)

Display Devices, X-Y Recorders, Magnetic Tape Recorders, Spectrum Analyzer, Recent Developments: Smart Sensors, Smart Transmitters.

Module IV: Control Modes (6 Lectures)

Characteristics and comparison of on-off, Proportional (P), Integral (I), Derivative (D), PI, PD, PID, Tuning of controllers: Ziegler-Nichols, Cohen-Coon methods.

Module V: Process Control (8 Lectures)

Principle, Elements of Process Control system, Definition of Process Variables, Mathematical Modeling, Lumped and Distributed Parameters, Analogies: Thermal, Electrical and Chemical systems, Modeling of Heat Exchanger, Introduction to Actuators and Control Valves.

Text Books / Reference Books:

1. A. K. Sawhney, "Advanced Measurements & Instrumentation", Dhanpat Rai & Sons.
2. Yaduvir Singh & S. Janardhanan, "Modern Control Engineering", Cengage Learning.
3. B. C. Nakra & K. Chaudhary, "Instrumentation, Measurement and Analysis", Tata Mc Graw Hill 2nd Edition.
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)
7. E.O. Decblin, "Measurement System – Application & design", Mc Graw Hill.
8. W.D. Cooper and A.P. Beltried, "Electronics Instrumentation and Measurement Techniques" Prentice Hall International
9. Liptak B.G., Instrument Engineers Handbook, Butterworth, Heinemann (2002)
10. Seborg D.E. and Edgar T., Process Dynamics and Control, John Wiley and Sons (1989)

Course Contents and Lecture Schedule

Module No.	Topic (s)	No. of Lectures
1	Definition, advantages, classification, characteristics, factors affecting the choice of transducers, Strain guages	4
1	LVDT, Capacitive, Piezoelectric, Thermocouples, Hall Effect Transducers.	6
2	General Telemetry System, Land line & Radio frequency telemetering system, Transmission Channels and Media.	5
2	Analog Data Acquisition system, Digital Data Acquisition system.	3
3	Display devices, X-Y Recorders, Magnetic tape recorders	5
3	Spectrum Analyzer, Recent Developments: Smart Sensors, Smart Transmitters.	3
4	Characteristics and comparison of on-off, Proportional (P), Integral (I), Derivative (D), PI, PD, PID.	3
4	Tuning of controllers: Ziegler-Nichols, Cohen-Coon methods	3
5	Principle, Elements of process control system, Definition of process variables, Mathematical Modeling, Lumped and distributed parameters, Analogies.	3
5	Thermal, Electrical and Chemical systems, Modeling of Heat Exchanger, Introduction to Actuators and Control Valves.	5

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EEE-413	HVDC Transmission Systems	3L: 0T: 0P	3 Credits	Course Type: PEC

Course Outcomes:

At the end of this course, students will have the ability to demonstrate and implement the:

1. Advantages of DC transmission over AC transmission.
2. Operation of Line Commutated Converters and Voltage Source Converters.
3. Control strategies used in HVDC transmission system.
4. Improvement of power system stability using an HVDC system.
5. Implementation of converters in HVDC Transmission.

Module 1: DC Transmission Technology (4 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 (10 hours)

Line Commutated Converters (LCCs): Six pulse converter, Analysis neglecting commutation overlap, harmonics, Twelve Pulse Converters. Inverter Operation. Effect of Commutation Overlap. Expressions for average dc voltage, AC current and reactive power absorbed by the converters. Effect of Commutation Failure, Misfire and Current Extinction in LCC links.

Voltage Source Converters (VSCs): Two and Three-level VSCs. PWM schemes: Selective Harmonic Elimination, Sinusoidal Pulse Width Modulation. Analysis of a six pulse converter. Equations in the rotating frame. Real and Reactive power control using a VSC.

Module 3: Control of HVDC Converters: (10 hours)

Principles of Link Control in a LCCHVdc system. Control Hierarchy, Firing Angle Controls – Phase-Locked Loop, Current and Extinction Angle Control, Starting and Stopping of a Link. Higher level Controllers Power control, Frequency Control, Stability Controllers. Reactive Power Control. Principles of Link Control in a VSC HVdc system: Power flow and dc Voltage Control. Reactive Power Control/AC voltage regulation.

Module 3:Components of HVDC Systems: (8 hours)

Smoothing Reactors, Reactive Power Sources and Filters in LCC HVdc systems DC line: Corona Effects. Insulators, Transient Over-voltages. dc line faults in LCC systems. dc line faults in VSC systems. dc breakers. Monopolar Operation. Ground Electrodes.

Module 4: Stability Enhancement using HVDC Control (4 hours)

Basic Concepts: Power System Angular, Voltage and Frequency Stability. Power
Modulation: basic principles – synchronous and asynchronous links. Voltage Stability Problem in AC/dc systems.

Module 5: MTDC Links (4 hours)

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.

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EEE-415	Special Topics in Control Systems	3L: 0T: 0P	3 Credits	Course Type: PEC

Preamble:
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, Engineering Physics, Basic Electrical Engineering, Measurement Science and Technique, Control System

Course Objectives:
1. To study the importance of Reduced-order modelling, Some Frequency and Time-domain methods of MOR.
2.To understand the fundamentals of Neural Networks, Back propagation algorithm, learning methods.
3.To study the basics of Fuzzy logic, Fuzzification and Defuzzification methods.
4.To study the concept of Optimal and Adaptive Control, Classification of Adaptive control, Riccati equation and its solution.
5.To study the Nonlinear Phase plane and Describing function methods of analysis of Systems, Design of Nonlinear Control systems.

Course Outcomes:

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

COs	Course Outcomes	Bloom's Level
CO1	Able to know about types of control systems	Remembering, Understanding
CO2	Able to understand the concept of reduced order modeling	Understanding, Applying, Analysing
CO3	Evaluating various aspects of neural networks	Analysing, Evaluating
CO4	Understand various aspects of fuzzy logic	Understanding, Analysing
CO5	Able to do basic calculations of optimal control system	Understanding, Analysing, Applying
CO6	Able to understand working of non-linear system	Remembering, Understanding

Mapping with Programme Outcomes:

COs	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
CO6	2	1	3	2	1	2	1	3	1	3	1	2
Avg.	2.5	1.0	2.0	1.0	1.0	2.0	1.0	1.0	1.2	1.1	1.2	2.0

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

Course Outcome 1:

1. Differentiate between open loop and closed control systems with examples.

2. Fig. below shows a two-phase two-pole permanent magnet stepper motor. Explain its working and discuss its applications in control systems.

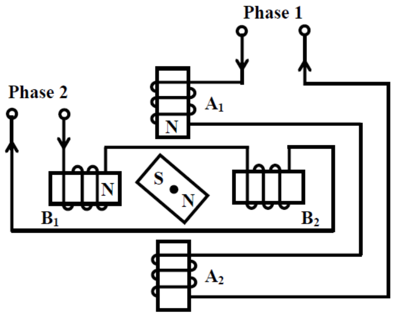


Fig.: A two-phase two-pole permanent magnet stepper motor

3. Convert the given block diagram as shown in the Fig. below, into signal flow graph and the find C1/R2 by using Mason's gain formula.

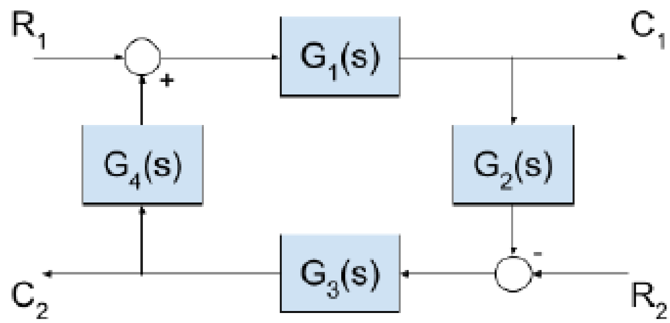


Fig.: Block Diagram

Course Outcome 2:

1. List importance of Reduced-order models.

2. Given the mechanical system shown in Fig. below, find J and D to yield 20% overshoot and a settling time of 2 second for a step input of torque T(t).

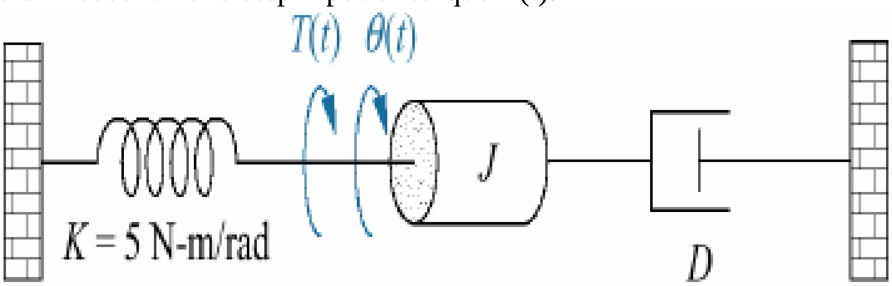


Fig.: A mechanical system

3. Find the time response of the following system, driven by unit step input signals, using Laplace transform.

$$\frac{d^2x}{dt^2} + 5\frac{dx}{dt} + 3x = 3u(t)$$

Course Outcome 3:

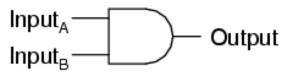
1. What are neural networks?

2. List applications of neural networks.

3. Design a perception neural network mimicking AND gate.

Table: Truth table of AND gate

2-input AND gate



A	B	Output
0	0	0
0	1	0
1	0	0
1	1	1

Course Outcome 4:

1. Explain fuzzy logic.
2. What are applications of fuzzy logic?
3. Explain Fig., as shown below.

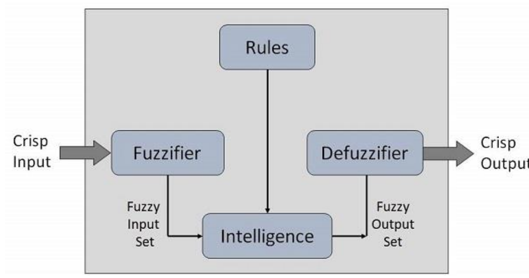


Fig.: Fuzzy Logic

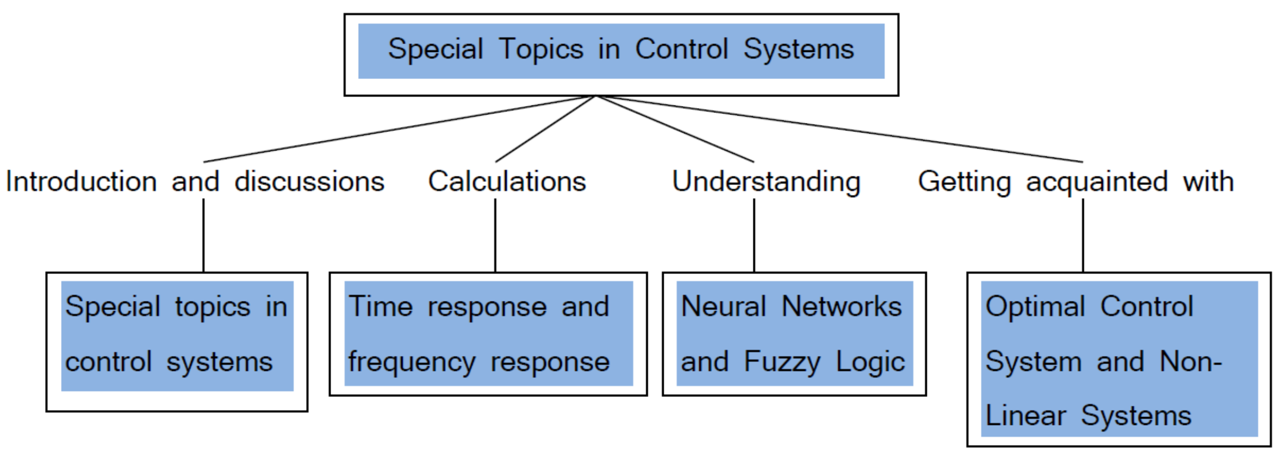
Course Outcome 5:

1. Explain Euler-Lagrange equation.
2. Explain Linear Quadratic Regulator.
3. What is Riccati Equation? Discuss its solution.

Course Outcome 6:

1. What are Phase-plane methods of analysis?
2. Discuss Describing function methods of analysis.
3. How non-linear control system design is done?

Concept Map



Syllabus:

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: 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 3: 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 4: 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.

Module 5: Analysis of Non-linear Systems (8 Lectures):
Introduction, Phase-plane and Describing function methods of analysis, Non-linear control system design.

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

Course Contents and Lecture Schedule

Module No.	Topic(s)	No. of Lectures
1	Model Order Reduction: Importance of Reduced-order models	4
1	Frequency domain Classical techniques, Introduction to Time domain techniques	4
2	Introduction, Neuron model, Activation functions, Perceptrons, Multilayer networks,	3
2	Back propagation algorithm, Recurrent Neural Networks, Supervised and Unsupervised Learning, Prediction using Neural Networks	5
3	Basics of Set Theory and Fuzzy Arithmetic, Crisp Sets versus Fuzzy Sets, Operation	3
3	Relation and composition of sets, Fuzzification and Defuzzification methods, Fuzzy Logic Controllers and its applications	5
4	Formulation of Optimal Control Problem, Performance Indices, Euler-Lagrange Equation, Linear Quadratic Regulator	4

4	Model Reference Adaptive Control and Self-Tuning Regulators, Riccati Equation and its Solution	4
5	Introduction, Phase-plane and Describing function methods of analysis	5
5	Non-linear control system design	3

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EEE-417	**Electrical Energy Conservation and Auditing**	**3L:0T:0P**	**3Credits**	**Course Type: PEC**

Preamble:
This course will provide a good understanding and hold to the students 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, Basic Electrical Engineering, Electrical Load management.

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

COs	**Course Outcomes**	**Bloom's Level**
CO1	Understand the energy scenario and importance of Electrical energy conservation.	Remembering, Understanding
CO2	Understand the concepts of energy management.	Applying, Analyzing
CO3	Analyze the Electricity tariff, load management related to Electrical systems.	Analyzing, Evaluating
CO4	Understand the methods of improving energy efficiency in different Electrical systems.	Understanding, Evaluating
CO5	Understand the concepts of different energy efficient devices.	Understanding, Analyzing, Creating

Mapping with Programme Outcomes:

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	-	-	-	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	-
Avg.	2.6	2.4	2.0	1.2	1.6	2.4	1.2	0.2	1.0	1.0	0.4	1.0

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

Course Level Assessment Questions

Course Outcome 1:

1. What are the reasons for motivating Energy Conservation?
2. Describe the methods for Energy Conservation used in the Industries.
3. Discuss the methods for Energy Conservation in Household and Commercial Sectors.

Course Outcome 2:
1. Explain the methods to calculate Electricity tariff.

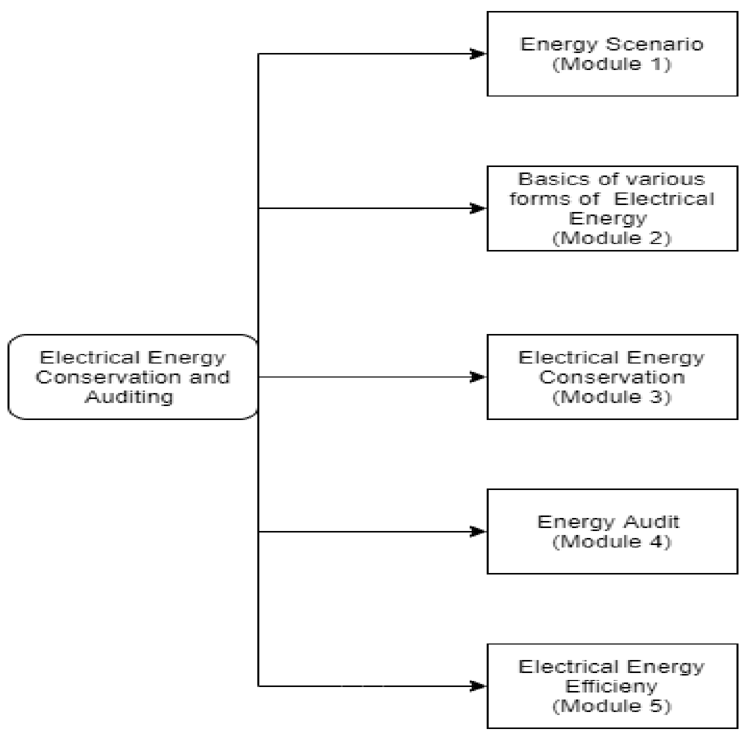
2. Why power factor improvement is required in the Electrical system. Write the benefits.
3. How maximum demand control is operated in Electrical System?

Course Outcome 3:
1. Describe the considerations with respect to energy use and energy saving opportunities for a motor system.
2. Explain the Energy Conservation in Boiler by Variable Speed Drives (VSD).
3. Briefly describe the lighting techniques.

Course Outcome 4:
1. Describe the Energy Flow Diagram.
2. What is the need of Energy Audit? Discuss the instruments for Electrical Energy Audit.
3. Explain the impact of renewable energy on energy audit recommendations.

Course Outcome 5:
1. Describe the energy saving opportunities with energy efficient motors.
2. In the dynamic operational and economic environment of a Thermal Plant, implementing the proper actions is necessary for the optimum utilities system management. Show this with one example.
3. Write the factors affecting Motor performance.

Concept Map



Syllabus:

Module -1: Energy Scenario (8 Hours):

Primary energy sources, energy needs of growing economy, energy sector reforms, restructuring of the energy supply sector, Introduction and Motivation for Energy Conservation, Principles of Energy Conservation, Energy Conservation in Industries, Energy Conservation in Electrical Generation, Transmission and Distribution, Energy Conservation in Household and Commercial Sectors, Transport, Agriculture etc., Energy conservation Acr-2001 and its features.

Module-2: Basics of Electrical Energy and its various forms (8 Hours):
Electricity tariff, load management and maximum demand control, power factor improvement and its benefits, selection & location of capacitors, 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 (7 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 Audit (9 Hours):
Aim of Energy Audit, Energy Flow Diagram, Strategy of Energy Audit, Comparison with Standards, Energy Management Team, Considerations in Implementing Energy with Conservation Programmes, impact of renewable energy on energy audit recommendations. Instruments for Energy Audit, Energy Audit of Electrical System.

Module-5: Energy efficiency in Electrical systems (8 Hours):
Electricity billing, energy saving opportunities with energy efficient motors, Distribution and transformer losses, Electric motors: types, losses in induction motors, Motor efficiency, Factors affecting motor performance, energy efficient motors, Case studies of implemented energy cost optimization projects in electrical utilities.

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.

Course Contents and Lecture Schedule

Module No.	Topic (s)	No of Lectures
1	Primary energy sources, energy sector needs and reforms, restructuring of the energy supply sector, Introduction and Motivation for Energy Conservation,	3
1	Energy Conservation in Industries, Energy Conservation in Electrical Generation, Transmission and Distribution,	2
1	Energy Conservation in Household and Commercial Sectors, Transport, Agriculture etc., Energy conservation Acr-2001 and its features.	3
2	Electricity tariff, load management and maximum demand control, power factor improvement and its benefits, selection & location of capacitors	4
2	Thermal Basics-fuels, thermal energy contents of fuel, temperature & pressure, heat capacity etc.	4

3	saving opportunities in electric motors, Energy conservation by VSD, Energy conservation in electric furnaces, ovens and boilers	4
3	lighting techniques – Natural , CFL, LED lighting sources and fittings.	3
4	Aim of Energy Audit, Energy Flow Diagram, Strategy of Energy Audit, Comparison with Standards.	3
4	Considerations in Implementing Energy with Conservation Programmes, impact of renewable energy on energy audit recommendations.	3
4	Case studies of implemented energy cost optimization projects in electrical utilities.	3
5	Electricity billing, energy saving opportunities with energy efficient motors, energy efficient motors.	3
5	Electric motors: types, losses in induction motors, Motor efficiency, Factors affecting motor performance.	2
5	Case studies of implemented energy cost optimization projects in electrical utilities.	3

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EEE-419	Power System Design	3L: 0T: 0P	3 Credits	Course Type: PEC

Preamble:

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: Basic Electrical Engineering, Electrical Power System, Engineering Physics.

Course Outcomes:

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

COs	Course Outcomes	Bloom's Level
CO1	Able to understand concept of power system	Remembering, Understanding
CO2	Able to design transmission Line	Understanding, Remembering, Analysing, Applying
CO3	Demonstrate fundamental understanding of design aspects of substation	Analysing, Evaluating
CO4	Exhibit the knowledge of conductors	Understanding, Remembering, Analysing, Applying
CO5	Exhibit the knowledge of insulator	Understanding, Remembering, Analysing, Applying
CO6	Exhibit the knowledge of poles	Understanding, Remembering, Analysing, Applying

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	1	1	1	1	2	1	-	1	2
CO2	2	2	3	2	1	2	1	2	2	-	1	3
CO3	2	1	3	1	1	2	1	1	1	1	1	2

CO4	2	1	3	1	1	2	1	1	1	1	1	2
CO5	2	1	3	1	1	2	1	1	1	1	1	2
CO6	2	1	3	1	1	2	1	1	1	1	1	2
Avg.	1.8	1.2	2.7	1.2	1.0	1.8	1.0	1.3	1.2	0.7	1.0	2.2

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

Course Outcome 1:
1. What is power system?
2. Explain typical AC electrical power system.
3. Discuss factors governing height of pole.

Course Outcome 2:
1. How the conductor size is determined?
2. What is cross arm?
3. What do you mean by pole, bracket and clamps?

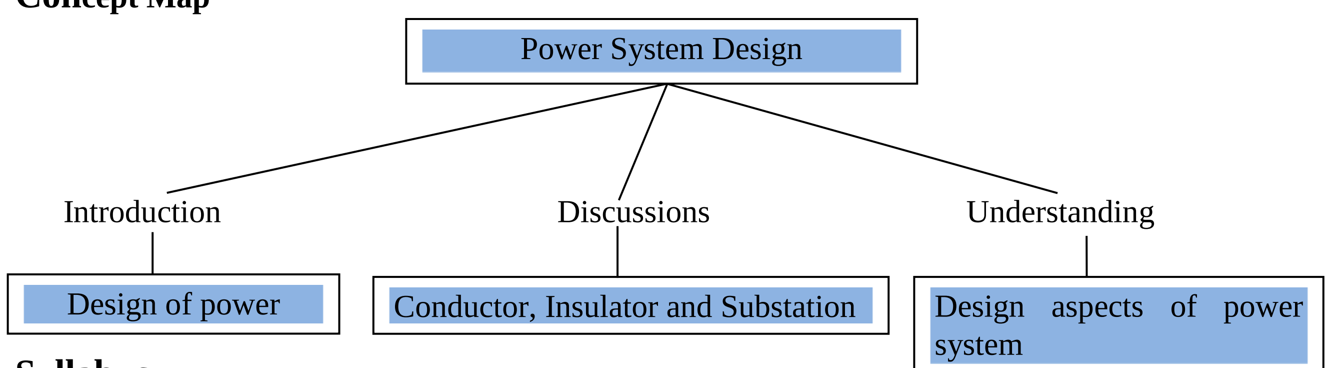
Course Outcome 3:
1. What is substation?
2. Differentiate between indoor and outdoor substations.
3. Briefly describe substation earthing.

Course Outcome 4:
1. How the conductor size is determined?
2. What do you mean by span length and how is decided?
3. Discuss various conductor configurations.

Course Outcome 5:
1. What is purpose of insulator?
2. Discuss various types of insulating materials.
3. What are the different types of insulators?

Course Outcome 6:
1. How the spacing between the conductors is decided?
2. Describe the fixing of cross arms.
3. Explain the erection of supports.

Concept Map



Syllabus

Module 1: Introduction (8 Lectures):
Introduction, Typical AC electrical power system, Main components of overhead lines, Line supports, Factors governing height of pole, Conductor materials.

Module 2: Conductor Selection (8 Lectures):
Determination of size of conductor for overhead transmission line, 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

Course Contents and Lecture Schedule

Module No.	Topic(s)	No. of Lectures
1	Introduction, Typical AC electrical power system, Main components of overhead lines, Line supports,	4
1	Factors governing height of pole, Conductor materials	4
2	Determination of size of conductor for overhead transmission line, Cross arms	4
2	Pole brackets and clamps, Conductors configuration spacing and clearances, Span lengths	4
3	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	4
3	Erection of supports, Fixing of insulators, Conductor erection, Positioning of conductors and attachment to insulators	4
4	Earthing of transmission lines, Guarding of overhead lines, Clearances of conductor from ground, Spacing between conductors, Testing and commissioning of overhead distribution line	4
4	Spacing between conductors, Testing and commissioning of overhead distribution line	4
5	Introduction, Classification, Selection and location, Main Electrical	3

	Connections	
5	Graphical symbols for various types of apparatus and circuit elements on substation main connection diagram, Key diagram of typical substations	5

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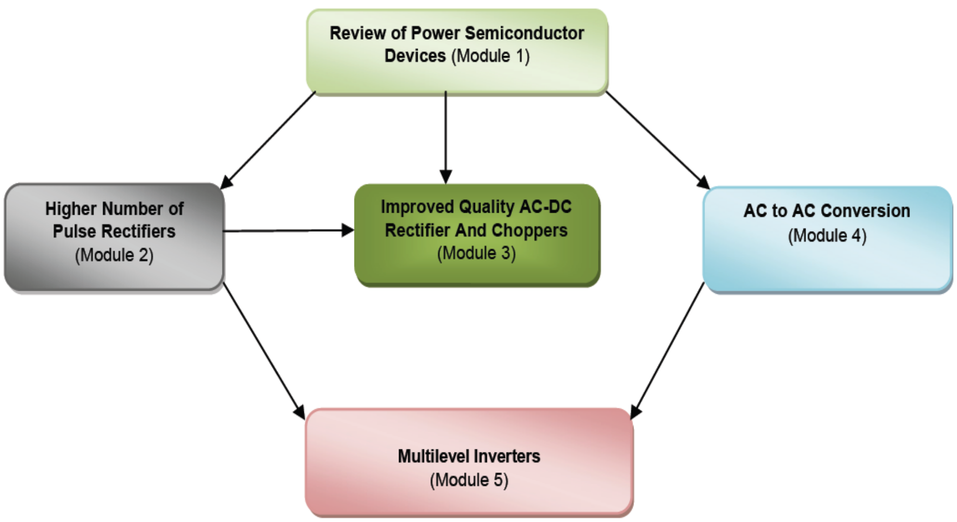
EEE-421	**Advanced Power Electronics**	**3L:0T:0P**	**3 Credits**

Preamble:

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; EEE-304.

Concept Map



Module 1: Review of Power Semiconductor Devices (08)

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 (09)

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 (10)

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 (07)

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

Module 5: AC-AC Conversion (06)

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

List of Programme Elective-II

EEE-423	Advanced Control System	3L: 0T: 0P	3 Credits	Course Type: PEC

Preamble:

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:

Basic Electrical Engineering, Engineering Mathematics, Measurement and Instrumentation, Control Systems

Course Outcomes:

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

COs	Course Outcomes	Bloom's Level
CO1	Able to know modelling of control systems	Remembering, Understanding
CO2	Able to found solutions and do stability analyses	Understanding, Applying,
CO3	Demonstrate fundamental understanding of non-linear control systems	Analysing, Evaluating
CO4	Develop the mathematical model of continuous and discrete system, non-linear control systems	Understanding, Analysing, Applying
CO5	Exhibit the knowledge of optimal control	Understanding, Remembering, Analysing, Applying
CO6	Exhibit the knowledge of the adaptive control	Remembering, Understanding

Mapping with Programme Outcomes

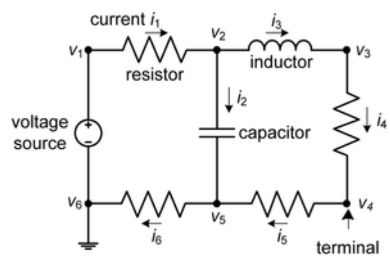
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	-	-	-	2	1	-	-	-	-	2
CO2	2	1	3	1	1	2	2	-	1	-	1	2

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
CO6	2	1	1	1	1	1	1	-	1	-	1	2
Avg.	2.0	1.3	1.3	0.8	0.8	2.0	1.3	0.2	1.2	0.2	1.0	2.0

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

Course Outcome 1:

1. Find state space model of following electric circuit. Output voltage is measured against the inductor.



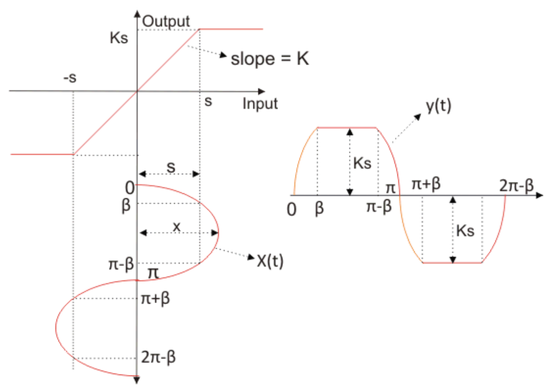
2. Describe conversion of state variable model to transfer function model and vice-versa.
3. Explain MRAC.

Course Outcome 2:

1. Find solution of a general state space model.
2. Define all Lyapunov's stability theorems.
3. Explain Jury stability criterion.

Course Outcome 3:

1. How system analysis is done by phase-plane method?
2. Find Describing Function for Saturation Non Linearity, as shown below.



3. Discuss various types of non-linearities in control systems.

Course Outcome 4:

1. Discuss state variable model and transfer function model of discrete system.
2. Model a first order sample-hold circuit.
3. List advantages of state space models.

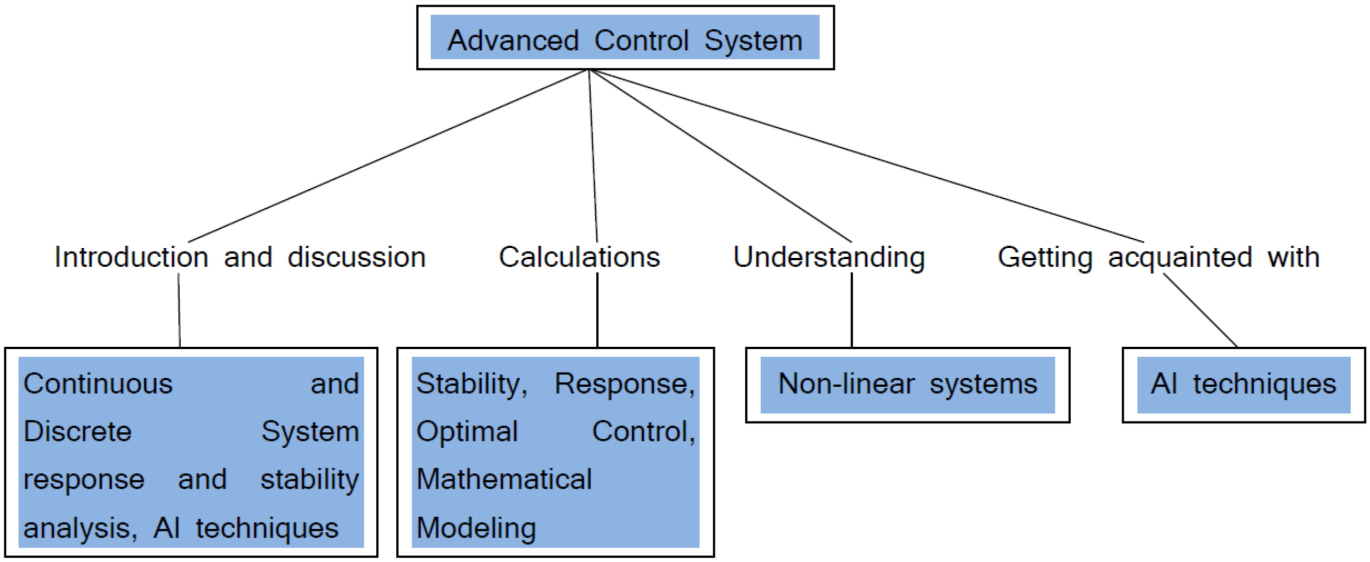
Course Outcome 5:

1. Explain Riccati equation and its solution.
2. Define Pontryagin's Minimum Maximum Principle.
3. Find weak form and a strong form of Euler-Lagrange equation $\delta P/\delta u = 0$.

Course Outcome 6:

1 Discuss Fuzzy Logic with examples.
2. Discuss Neural Netwroks with examples.
3. Explain Genetic Algorithms.

Concept Map



Syllabus

Module 1: State Space Analysis of Continuous System (7 Lectures):
Review of state variable representation of continuous system, State transition matrix, 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: Stability (10 Lectures):
Lyapunov’s stability theorems, Methods for generating Lyapunov functions, Popov’s criterion.
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 and G.B.Lamont, “Digital Control Systems: Theory, Hardware, Software”, Mc Graw Hill.

Course Contents and Lecture Schedule

Module No.	Topic (s)	No. of Lectures
1	Review of state variable representation of continuous system, State transition matrix, Concept of Controllability and Observability, Design of state observer and controller	7
2	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	4
2	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	4
3	Lyapunov’s stability theorems, Methods for generating Lyapunov functions, Popov’s criterion.	4
3	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	6
4	Introduction, formation of optimal control problem, Calculus of variations minimization of functions	3
4	Pontryagin’s Minimum Maximum Principle, Linear Quadratic Problem - Hamilton Jacobi equation, Riccati equation and its solution	5
5	Introduction, Modal reference adaptive control systems,	2
5	Self-tuning regulators	1
5	Introduction to neural network, fuzzy logic and genetic algorithms	4

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EEE-425	**Special Electrical Machines**	**3L:0T:0P**	**3 Credits**	**Course Type: PEC**

At the end of this course, students will have the ability to demonstrate and implement the:

1. Special AC Machines
2. Devices

3. Linear Machines
4. Linear Electric Motors
5. Advanced Motors and Drive

Module-I: Special AC Machines
Constructional aspects, design and analysis of reluctance, shaded pole, hysteresis, printed circuit, and claw motors, Servomotors and A.C. Tacho-generators.

Module-II: Devices
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.

Module-III: Linear Machines
Linear devices and actuators, Linear electric machines: Classification, application, constructional aspects, design and method of analysis of various types, Goodness factor.

Module-IV: Linear Electric Motors
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.

Module-V: Advanced Motors and Drive Systems
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.

Reference Books
1. B.K. Bose, Power Electronics and variable frequency drives, Prentice Hall, New Jersey.
2. T.J.E. Miller, Brushless permanent magnet and reluctance motor drives, Oxford University Press, UK.
3. S.A. Nasar, Linear induction motor, John Wiley, New York.
4. J. C. Andreas, Energy Efficient Motors, Marcel Dekker.
5. J.M.P. Murphy, Power Electronics control of AC Drives, Pergamon Press.

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EEE-427	Optimal Control System	3L: 0T: 0P	3 Credits	Course Type: PEC

Preamble:
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 Objectives:
1. To study formulation of Optimal Control problem and Static optimization.
2. To study Continuous-Time LQR, and Tracking problem.
3. To study optimal control of discrete-time systems, Discrete-Time LQR and Digital control of continuous-time systems.
4. To study Bellman’s principle of optimality, and Linear regulator problems.
5. To study robust output feedback design, Observers and Kalman filter LQG / LTR

Course Outcomes:

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

COs	Course Outcomes	Bloom's Level
CO1	Able to know about types of optimal control systems	Remembering, Understanding
CO2	Able to do design of optimal control of continuous time systems	Understanding, Applying, Analysing
CO3	Able to do design of optimal control of discrete time systems	Analysing, Evaluating
CO4	Understand various aspects of dynamic programming	Understanding, Analysing
CO5	Able to do basic calculations of time domain and frequency domain system	Understanding, Analysing, Applying
CO6	Able to robustness, multivariable frequency domain techniques and optimisation	Remembering, Understanding

Mapping with Programme Outcomes:

COs	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
CO6	2	1	3	2	1	2	1	3	1	3	1	3
Avg.	2.0	1.0	2.0	1.0	1.0	2.0	1.0	1.0	1.2	1.0	1.2	2.5

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

Course Outcome 1:
1. What is optimisation?
2. Discuss optimization with equality constraints.
3. Obtain state space model of mechanical system, as shown in the Fig., below.

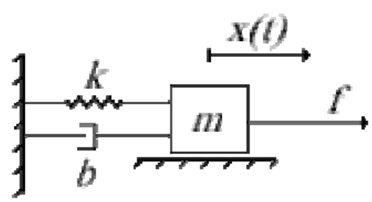


Fig.: A mechanical system

Course Outcome 2:
1. Explain continuous-time Linear Quadratic Regulator (LQR).
2. What is steady state closed-loop control?
3. Discuss tracking problem.

Course Outcome 3:
1. What is a discrete-time optimization problem? Give some examples.
2. Explain discrete-time LQR.
3. How digital control of continuous-time system is done?

Course Outcome 4:
1. Explain Bellman’s principle of optimality.
2. Discuss computational procedure for solving control problems.

3. Explain linear regulator problems

Course Outcome 5:

1. For the given the transfer function, find ξ and ω_n.

$$G(s) = \frac{36}{s^2 + 4.2s + 36}$$

2. For the state equation and initial state vector shown in the equations, where u(t) is a unit step, find the state transition matrix and then solve for x(t).

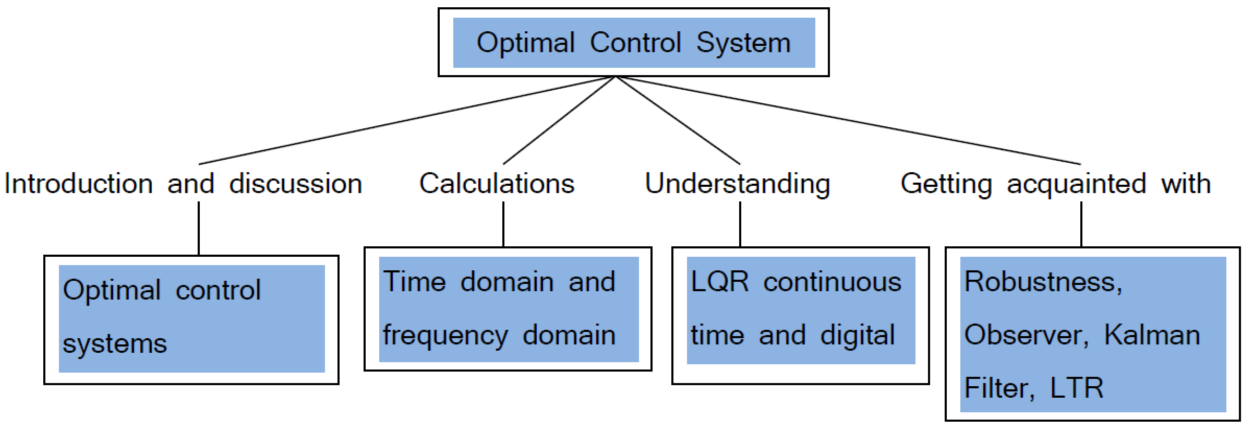
$$\dot{x} = \begin{bmatrix} 0 & 1 \\ -8 & -6 \end{bmatrix} x(t) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t) \quad , \qquad x(0) = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$$

3. What is frequency response?

Course Outcome 6:

1. Define robustness.
2. Explain observer design with the help of an example.
3. What is Kalman filter?

Concept Map



Syllabus:

Module 1: Introduction (7 Lectures):
Problem formulation, State variable representation, Static optimization, Optimization without constraints, Optimization with equality constraints.

Module 2: Optimal Control of Continuous-Time System (9 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 (8 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 (8 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 (8 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, 3rd Edition, 1986

Reference Book

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

Course Contents and Lecture Schedule

Module No.	Topic(s)	No. of Lectures
1	Problem formulation, State variable representation, Static optimization	3
1	Optimization without constraints, Optimization with equality constraints	4
2	The calculus of variations, functional of a single function, functional involving several functions, Continuous-time Linear Quadratic Regulator (LQR)	5
2	Steady state closed-loop control, and tracking problem	4
3	Solution of the general Discrete-time Optimization problem, Discrete-time LQR	4
3	Digital Control of Continuous-time systems, Frequency domain results	4
4	Bellman's principle of optimality, Computational procedure for solving control problems	4
4	Hamilton-Jacobi-Bellman equation, Linear regulator problems	4
5	Robust output-feedback design, Observers and Kalman filter	4
5	Linear Quadratic Gaussian (LQG),Loop-transfer recovery (LTR)	4

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EEE-429	**Power System Protection**	**3L:0T:0P**	**3 Credits**	**Course Type: PEC**

Preamble: This course will provide a good understanding and hold to the students in the area of Power System Protection. The course includes: different components of a protection system, fault current evaluation, basic Modeling and simulation of protection system.

Prerequisites: Engineering Mathematics, Engineering Physics, Basic Electrical Engineering, Power system components, Electrical Load Management.

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

COs	Course Outcomes	Bloom's Level
CO1	Understand the different components of a protection system.	Remembering, Understanding
CO2	Evaluate fault current due to different types of fault in a network.	Applying, Evaluating

CO3	Understand the protection schemes for different power system components.	Understanding, Analyzing,
CO4	Understand the basic principles of Modeling and simulation of protection system.	Understanding, Analyzing, Evaluating
CO5	Understand various system protection schemes, and the use of wide-area measurements.	Understanding, Analyzing, Creating

Mapping with Programme Outcomes

Cos	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
Avg.	2.8	2.0	1.4	1.2	1.8	2.0	1.0	-	1.6	0.4	0.8	1.0

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

Course Level Assessment Questions

Course Outcome 1:

1. Describe the Protection paradigms for system protection.
2. Elaborate various types of potential transformers with diagrams.
3. What do you mean by trip circuit of a circuit breaker?

Course Outcome 2:

1. Write classification of shunt faults in a three phase system.
2. Explain methods of Overcurrent Protection.
3. Describe with proper diagram the Overcurrent Relay.

Course Outcome 3:

1. Write general procedure for Transformer and Generator protection.
2. What do you mean by Bus Bar arrangement schemes? Explain in detail with proper diagram.
3. Write the steps for differential protection.

Course Outcome 4:

1. Explain the Pilot Relaying scheme.
2. Elaborate CT/PT Modeling and standards.
3. Explain the carrier current protection.

Course Outcome 5:

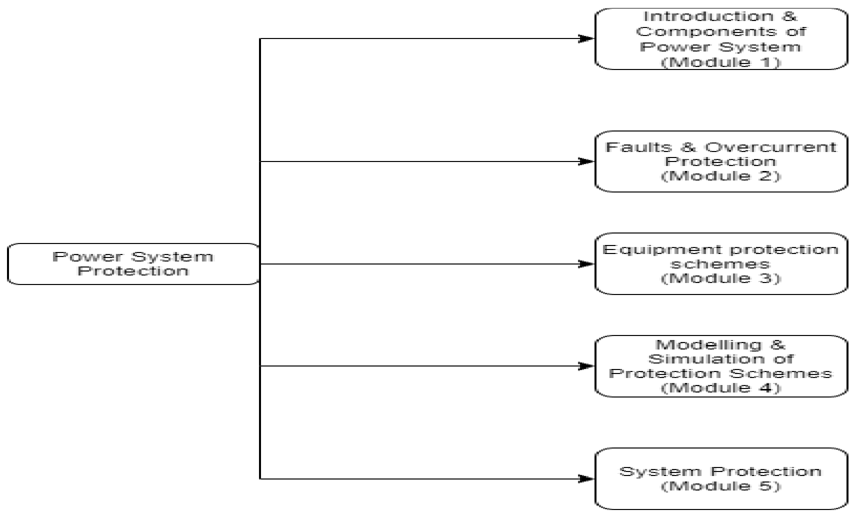
1. Discuss the Effect of Power Swings on Distance Relaying.
2. Discuss the Modern Trends in Power System Protection.
3. Explain the application of WAMS for improving Protection Systems.

Syllabus:

Module-1: Introduction and components of a Protection system (9 Hours):
Introduction to desirable attributes of protection, Protection paradigms for system protection, trip circuit of a circuit breaker, CTs &PTs: Current transformer construction, measurement and

protective CTs. Type of potential transformers, Functional characteristics of a relay, zone of protection, primary and backup protection, and circuit brakers.

Concept Map



Module 2: Faults and Over-Current Protection (7 hours):
Review of Fault Analysis, Sequence Networks. Introduction to Overcurrent Protection and Overcurrent Relay co-ordination.

Module 3: **Equipment Protection Schemes (7 hours):**
Directional, Distance, Differential protection. Transformer and Generator protection. Bus bar Protection, Bus Bar arrangement schemes.

Module 4: **Modeling and Simulation of Protection Schemes (8 hours):**
Computer aided protection, CT/PT modeling and standards, Relay Testing, Pilot Relaying Schemes: Introduction, Wire Pilot Protection, and Carrier Current Protection.

Module 5: **System Protection (9 hours):**
Effect of Power Swings on Distance Relaying. System Protection Schemes, Phasor Measurement Units and Wide-Area Measurement Systems (WAMS). Application of WAMS for improving protection systems, Modern Trends in Power System Protection: Introduction, gas insulated substation/switchgear (GIS).

Text Books / Reference Books:

1. B. Ram and D. N. Vishwakarma, Power System Protection and Switchgear, Mc. Graw Hill
2. Y. G.Paithankar and S. R. Bhide, “Fundamentals of power system protection”, Prentice Hall, India, 2010.
3. A. G. Phadke and J. S. Thorp, “Synchronized Phasor Measurements and their Applications”, Springer, 2008.
4. D. Reimert, “Protective Relaying for Power Generation Systems”, Taylor and Francis, 2006.
5. B. Ravindranath and M. Chander, Power system Protection and Switchgear, Wiley Eastern Ltd.
6. Sunil S. Rao.: Power System Protection and Switch Gear, Khanna Publishers

Course Contents and Lecture Schedule

Module No.	Topic (s)	No of Lectures
1	Protection paradigms for system protection, trip circuit of a circuit breaker, CTs &PTs: Current transformer construction, measurement and protective	3

	CTs.	
1	CTs &PTs: Current transformer construction, measurement and protective CTs. Type of potential transformers	3
1	Functional characteristics of a relay, zone of protection, primary and backup protection, circuit brakers.	3
2	Fault Analysis, Sequence Networks	3
2	Overcurrent Protection and overcurrent relay co-ordination.	4
3	Directional, Distance, Differential protection. Transformer and Generator protection	5
3	Bus bar Protection, Bus Bar arrangement schemes.	2
4	Computer aide protection, CT/PT modeling and standards, Relay Testing	4
4	Pilot Relaying Schemes, Wire Pilot Protection, Carrier Current Protection.	4
5	Effect of Power Swings on Distance Relaying. System Protection Schemes, Phasor Measurement Units and Wide-Area Measurement Systems (WAMS)	5
5	Modern Trends in Power System Protection	2
5	Gas insulated substation/switchgear (GIS)	2

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EEE-431	Electrical Machine Design	3L: 0T: 0P	3 Credits	Course Type: PEC

Preamble:

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

Prerequisites: Basic Electrical Engineering, Electrical Machine, Engineering Physics

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

COs	Course Outcomes	Bloom's Level
CO1	Able to understand concept of design	Remembering, Understanding
CO2	Able to design using CAD	Understanding, Remembering, Analysing, Applying
CO3	Demonstrate fundamental understanding of application aspects of electrical engineering	Analysing, Evaluating
CO4	Exhibit the knowledge of design of transformer	Understanding, Remembering, Analysing, Applying
CO5	Exhibit the knowledge of design of three phase induction motor	Understanding, Remembering, Analysing, Applying
CO6	Exhibit the knowledge of three phase synchronous machine	Understanding, remembering, Analysing, Applying

Mapping with Programme Outcomes

COs	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	1	2	1	2	1	1	-	1	1	1	2
CO4	2	2	3	2	2	2	1	1	2	-	1	3
CO5	2	2	3	2	2	2	1	1	2	-	1	3
CO6	2	2	3	2	2	2	1	1	2	-	1	3
Avg.	2.2	1.8	2.8	1.6	2.1	1.8	1.0	0.5	1.6	0.2	1.0	2.6

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

Course Outcome 1:

1. What do you understand by design?
2. What is need of design?
3. Discuss limitation in design.

Course Outcome 2:

1. Discuss the philosophy of computer aided design.
2. Write advantages and limitations of CAD.
3. Draw the flow chart for design of transformer.

Course Outcome 3:

1. Differentiate between core and yoke of transformer.
2. List applications of three phase induction motors.
3. Differentiate the two types of rotor construction of synchronous machines.

Course Outcome 4:

1. What do you mean by output equation of transformer?
2. What are different types of transformer windings?
3. Discuss the design aspects of yoke of transformer.

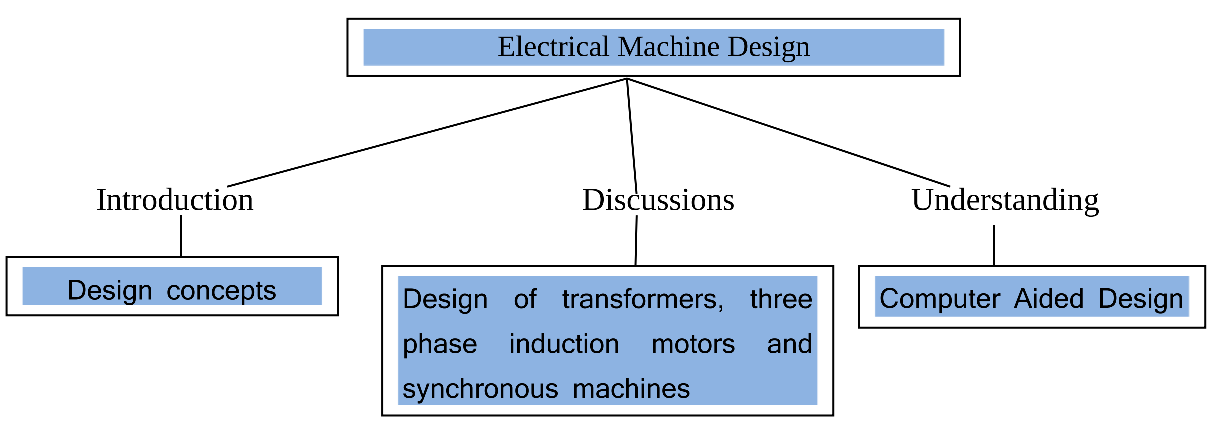
Course Outcome 5:

1. What is the difference between the design philosophies of rotating machines and transformers?
2. Define specific electric loading.
3. Explain design of core of three phase AC machine.

Course Outcome 6:

1. Why field system in put on rotor in synchronous machine?
2. How feel system is designed to reduce the rotor losses?
3. Explain the design of cylindrical rotor filed system of synchronous machine.

Concept Map



Syllabus

Module 1: Basic Considerations (6 Lectures):
Basic concept of design, Classification of insulating material, Calculations of total mmf and magnetising current.

Module 2: Transformer Design (8 Lectures):
Output equation, Design of core, yoke and windings, overall dimensions.

Module 3: Design of Rotating Machine - I (10 Lectures):
Output equations of rotating machines, specific electric and magnetic loadings, factors affecting size of rotating machines, Core and armature design of three phase AC machines.

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.

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.E. Clayton and N.N. Hancock, "The Performance and Design of D. C. Machines" Pitman & Sons
5. S.K. Sen, "Principle of Electrical Machine Design with Computer Programming" Oxford and IBM Publications

Course Contents and Lecture Schedule

Module No.	Topic(s)	No. of Lectures
1	Basic concept of design	2
1	Classification of insulating material, Calculations of total mmf and magnetising current	4
2	Output equation, Design of core, yoke and windings	6
2	Overall dimensions	2
3	Output equations of rotating machines, specific electric and magnetic loadings, factors affecting size of rotating machines	5
3	Core and armature design of three phase AC machines	5
4	Rotor design of three phase induction motors	4
4	Design of feel system of synchronous machines	4
5	Philosophy of computer aided design, advantages and limitations	4
5	Flow charts and computer programs for the design of transformer	4

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EEE-433	Real Time Simulation Techniques of Power Electronic Converters	3L: 0T: 0P	3 Credits	Course Type: PEC

Preamble:
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; EEE-304, Advanced Power Electronics; EEE-421, MATLAB Software.

Course Outcomes:

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

COs	Course Outcomes	Bloom's Level
CO1	Understand the basic concepts of real time simulation	Knowledge (1) Comprehension (2) Analysis (4)
CO2	Understand and perform real time simulation of Rectifier	Knowledge (1) Application (3) Analysis (4) Synthesis (5)
CO3	Understand and perform real time simulation of Chopper	Knowledge (1) Application (3) Analysis (4) Synthesis (5)
CO4	Understand and perform real time simulation of Inverter	Knowledge (1) Application (3) Analysis (4) Synthesis (5)
CO5	Understand and perform real time simulation of Multilevel Inverter	Knowledge (1) Application (3) Analysis (4) Synthesis (5)

Mapping with Programme Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO1O	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
Avg.	3.0	2.8	2.8	1.8	3.0	0.8	-	-	-	-	-	1.0

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

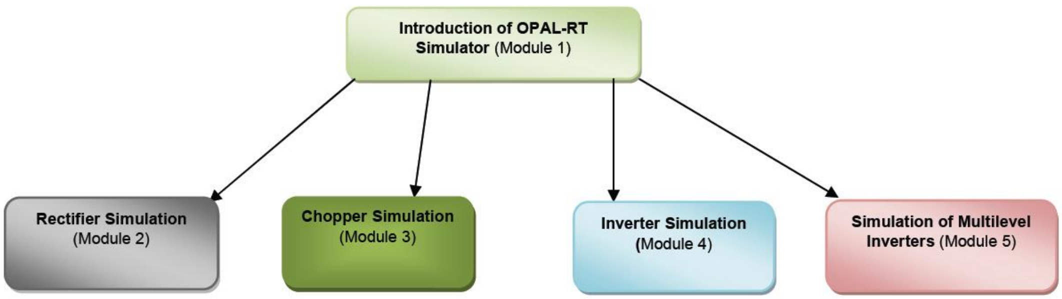
Course Level Assessment Questions

Course Outcome 1:

1. What do you mean by real time simulation?
2. What are the advantages of doing real time simulation?
Course Outcome 2:
1. Draw and discuss the Simulink model of 3-phase rectifier real time environment.
2. Discuss Simulink model of 1-phase bridge converter.
Course Outcome 3:
1. Discuss simulation of buck-boost chopper in real time environment.
2. Discuss simulation of buck chopper in real time environment.
Course Outcome 4:
1. Discuss simulation of 3-phase VSI in real time environment.
2. Discuss simulation of 1-Phase CSI in real time environment.

Course Outcome 5:
1. Discuss simulation of NPC 3-Level inverter in real time environment.
2. Discuss simulation of 5-level CHB inverter in real time environment.

Concept Map



Module 1: Introduction of OPAL-RT Simulator (8 Hours)
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 (8 Hours)
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 Hours)
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 (8 Hours)
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 (10 Hours)**

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 / References:

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.

Web Reference: Video/Web contents on NPTEL:

Course Contents and Lecture Schedule

Module No.	Topic (s)	No. of Lectures
1	Basic concept of Real-Time Simulations, Introduction, Simulation: Variable Vs Fixed step,	2
	How to choose a Time step for an Application, difference between Offline simulation and Real time simulation,	2
	RT Lab/Real Time Simulator, Opal-RT Internal architecture	4
2	Simulation of single phase uncontrolled rectifiers in real time environment,	2
	Simulation of single phase controlled rectifiers in real time environment,	2
	Simulation of three phase uncontrolled rectifiers in real time environment,	2
	Simulation of three phase controlled rectifiers in real time environment.	2
3	Simulation of buck chopper in real time environment,	2
	Simulation of boost chopper in real time environment,	2
	Simulation of buck-boost chopper in real time environment.	2
4	Simulation of single-phase voltage source inverter with R and R-L loads in real time environment,	2
	Simulation of three phase VSI Inverter in real time environment,	3
	Implementation of three-phase sinusoidal modulation in real time environment.	3
5	Simulation of NPC Multilevel Inverters in real time environment,	3
	Simulation of FC Multilevel Inverters in real time environment,	3
	Simulation of CHB Multilevel Inverters in real time environment.	2

****

List of Programme Electives-III

EEE-440	**Neural Network and Fuzzy System**	**3L: 1T: 0P**	**4 Credits**	**Course Type: PEC**

Preamble: 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, Computer Programming.

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

COs	Course Outcomes	Bloom's Level
CO1	Able to know about artificial intelligence	Remembering, Understanding
CO2	Able to understand and apply knowledge representation	Understanding, Applying,
CO3	Demonstrate fundamental understanding of smart control	Analysing, Evaluating
CO4	Develop the mathematical model of artificial intelligent techniques	Understanding, Analysing,
CO5	Exhibit the knowledge of machine intelligence and real time control	Understanding, Analysing, Applying
CO6	Exhibit the knowledge of the working on state-of-art controllers	Remembering, Understanding

Mapping with Programme Outcomes:

COs	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
Avg.	1.8	1.3	1.2	0.7	0.8	2.0	1.0	0.3	1.2	0.2	1.0	2.0

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

Course Outcome 1:

1. What do you understand by intelligence? How it is implemented?
2. Briefly describe knowledge representation.
3. Explain artificial intelligence.

Course Outcome 2:

1. Explain approaches to knowledge representation with example.
2. What is the relation between Knowledge & Intelligence?
3. Discuss various representation requirements.

Course Outcome 3:

1. Write a technical note on Symbolic vs. Connectionist approaches.
2. Explain "The Turing Test".
3. Explain an Expert System with an example.

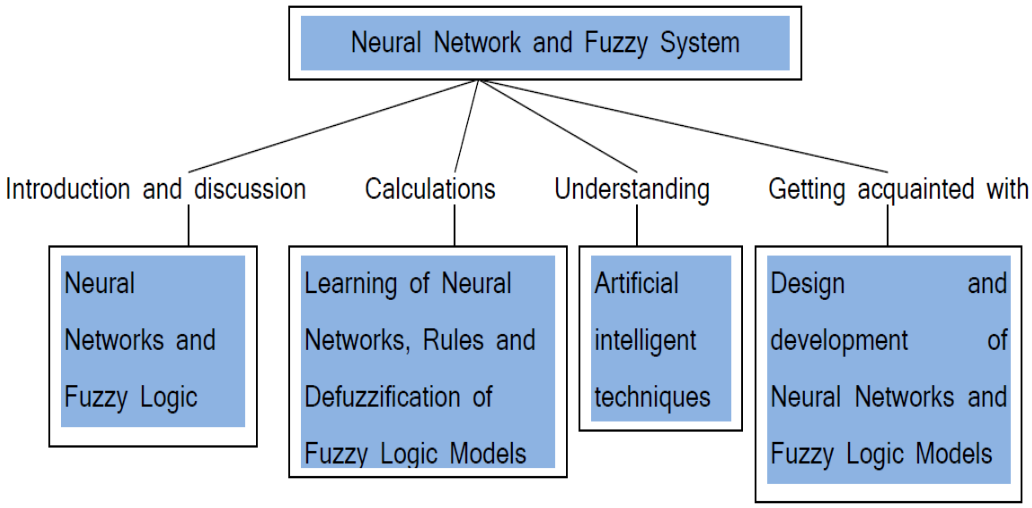
Course Outcome 4:

1. Design an Auto-correlator for following patterns and validate it i.e. correct recall for all input cases. A1=(-1, 1, -1,1), and A2=(-1, -1, -1, 1)
2. Explain e-BAM algorithm with the help of an example.
3. What are various Defuzzification Methods?

Course Outcome 5:
1. Explain step-by-step implementation of Fixed Increment Perceptron Learning Algorithm with the help of an example
2. Give a complete taxonomy of Neural Network Architectures.
3. Explain in detail, Method of Steepest Descent and Effect of Learning Rate.

Course Outcome 6:
1. Implement a Fuzzy PID controller for an application of your choice.
2. Implement a Neural PID controller for an application of your choice.
3. Explain Fuzzy-Neural hybrid algorithm.

Concept Map



Syllabus

Module 1: Introduction & Architecture 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; perception and convergence rule, Auto-associative and hetero-associative memory.

Module 2: Back Propagation Algorithm (8 Lectures):
Architecture: perceptron model, solution, single layer artificial neural network, multilayer perception model; back propagation learning methods, effect of learning rule co-efficient ;back propagation algorithm, factors affecting back propagation training, applications.

Module 3: Introduction to Fuzzy Logic (8 Lectures):
Basic concepts of fuzzy logic, Fuzzy sets and Crisp sets, Fuzzy set theory and operations, Properties of fuzzy sets, Fuzzy and Crisp relations, Fuzzy to Crisp conversion.

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, Industrial 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, applications.

Text Books:

1. Kumar Satish, "Neural Networks" Tata Mc Graw Hill

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. Siman Haykin,"Neural Netowrks"Prentice Hall of India

2. Timothy J. Ross, "Fuzzy Logic with Engineering Applications" Wiley India

Course Contents and Lecture Schedule

Module No.	Topic(s)	No. of Lectures
1	Neuron, Nerve structure and synapse, Artificial Neuron and its model, activation functions	2
1	Neural network architecture: single layer and multilayer feed forward networks, recurrent networks, Various learning techniques; perception and convergence rule	3
1	Auto-associative and Hetero-associative memory	3
2	Architecture: perceptron model, solution, single layer artificial neural network, multilayer perception model	3
2	back propagation learning methods, effect of learning rule co-efficient ;back propagation algorithm, factors affecting back propagation training, applications	5
3	Basic concepts of fuzzy logic, Fuzzy sets and Crisp sets, Fuzzy set theory and operations	4
3	Properties of fuzzy sets, Fuzzy and Crisp relations, Fuzzy to Crisp conversion	4
4	Membership functions, interference in fuzzy logic, fuzzy if-then rules	3
4	Fuzzy implications and Fuzzy algorithms, Fuzzyfications and Defuzzifications, Fuzzy Controller, Industrial applications	5
5	Type of fuzzy numbers, fuzzy neutron	2
5	Fuzzy back propagation (BP), architecture	3
5	Learning in fuzzy BP, inference by fuzzy BP, applications	3

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EEE-442	Power System Security and Analysis	3L: 1T: 0P	4 Credits	Course Type: PEC

At the end of this course, students will have the ability to demonstrate and implement the:

1. Power transmission in uncompensated AC transmission lines
2. Reactive power flow and voltage control problems
3. Voltage stability
4. Power system security
5. Voltage control and improvement of voltage stability in power transmission system

Module-I: Power Transmission in Uncompensated AC Transmission Lines:
Electrical parameters of transmission lines and representation by line equation, concept of power in AC transmission systems, Power flow in a two terminal power transmission network, Power circle diagram, Surge impedance loading, Operation of transmission lines under no-load conditions, heavy loading conditions, voltage regulation and its relation with reactive power, Maximum power transfer in an uncompensated line loadability.

Module-II: Reactive Power Flow and Voltage Control Problems:
Reactive power voltage, Coupling concept, Governing effects on reactive power flow, Real and reactive power, Static and transient stability, concept of dynamic stability, Relation between V-Q at a node, Reactive power requirement, Operation aspects, Basic principle system voltage control, reactive power flow constants, Effect of transformer tap changing and generator excitation adjustment in the post disturbance period, The practical aspects of reactive power flow problems leading to voltage collapse in EHV lines

Module-III: Voltage Stability:
Reactive power and voltage collapse and changes in the power system contributing to voltage collapse, Concept of stability of transmission system, Relation between voltage stability and rotor angle stability. Stability margin, Definition and classification of voltage stability, Mechanism of voltage collapse, Analysis of power system voltage stability, Voltage collapse and its Modeling, Voltage security and transient voltage analysis, Power transfer and voltage limits, Voltage stability indicators.

Module-IV: Power System Security:
Introduction, Power system security analysis, planning, operation & control and its assessment, Computation of voltage stability limits, Transfer capacity, Stability margin, Computation of voltage collapse time, Minimum singular value, Various methods of collapse point, Contingency analysis

Module-V: Voltage Control and Improvement of Voltage Stability in Power Transmission System:
Introduction, Role of transformer in voltage control of a power system its modeling under various cases, Quantitative methods to determine the tap setting for voltage control using OLTC at a load bus and its effect on voltage stability, Practical aspects of voltage instability due to OLTC operation, Voltage stability improvement methods, Series, shunt and series-shunt compensation, Use of various FACTS devices for these compensation

Reference Books:

1. Power System Analysis Operation and Control by Abhijit Chakrabarti and Sunita Halder, PHI Learning
2. Reactive Power Control and Voltage Stability in Power Transmission Systems by Abhijit Chakrabarti, D. P. Kothari, A.K. Mukhopadhyay and Abhinandan De, PHI Learning
3. Power System Stability and Control by Prabha Kundur, Tata McGraw Hill
4. Power System Stability by E W Kimbark, Wiley

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EEE-444	Applied System Theory	3L: 1T: 0P	4 Credits	Course Type: PEC

Preamble:
This course will provide a good understanding and hold to the students in the area of digital control systems, observer and non-linear systems. The course includes calculations of Eigen values, state space models and Lyapunov stability. This course also gives an insight into advanced control system.

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

Course Objectives:

1. To understand the basics of Eigenvalues and Eigenvectors, Vector and matrix norms, Singular value decomposition.
2. To study the various Discrete-time signals, Solution of difference equations, Jury stability criterion, Discretization methods, Dead-beat controllers.
3. To study the State space representation of Discrete-time systems, Conversion of State variable model to Transfer function model and vice-versa, Concepts of Controllability and Observability.
4. To study the design of Pole placement and Observer based Controllers.
5. To study the common physical nonlinearities, Phenomenon related to nonlinear systems, Analysis methods for nonlinear systems, Lyapunov stability for Continuous and Discrete-time systems.

Course Outcomes:

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

COs	Course Outcomes	Bloom's Level
CO1	Able to know about various components of digital control systems and controllers	Remembering, Understanding
CO2	Able to calculate Eigen values, Eigen vectors, and controller parameters	Understanding, Applying, Analysing
CO3	Evaluating various aspects of stability, controllability, observability	Analysing, Evaluating
CO4	Understand various aspects of digital control systems and observers	Understanding, Analysing,
CO5	Able to do basic calculations of describing functions, Lyapunov functions	Understanding, Analysing, Applying
CO6	Able to identify various aspects of non-linear control systems	Remembering, Understanding

Mapping with Programme Outcomes:

COs	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	1	-	2	2
CO4	3	2	1	1	1	2	1	-	2	-	1	3
CO5	3	2	2	1	1	2	1	1	2	-	2	3
CO6	3	1	1	1	1	1	1	1	1	-	1	2
Avg.	3.0	1.3	1.2	0.7	0.8	1.8	1.0	0.5	1.2	0.0	1.2	2.5

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

Course Outcome 1:
1. What are digital control systems?
2. How controller design is done?
3. Explain discretization methods.

Course Outcome 2:
1. Find Eigen values and Eigen vector of A matrix of a control system described as below

$$[A]=\begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} \quad [B]=\begin{bmatrix} 1 \\ 0 \end{bmatrix} \text{ and } [C]=[1 \quad 0]$$

2. Consider the two-tank liquid level system shown in Fig. below. Develop state space model for it. All symbols are standard and carry their usual meanings.

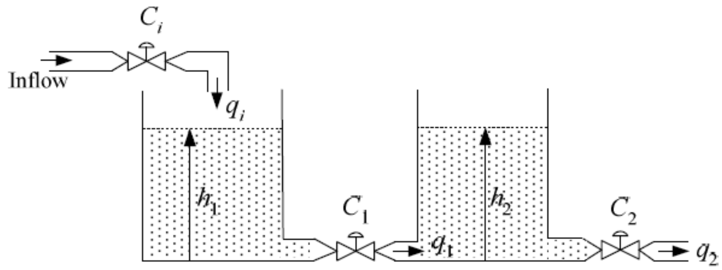


Fig.: Two-tank liquid level system

3. How Eigen values and Eigen vectors help in assessing stability of a digital control system?

Course Outcome 3:

1. Define and explain controllability.
2. Define and explain observability.
3. Find conditions of stability, observability and controllability of an automobile suspension system shown in the Fig. below.

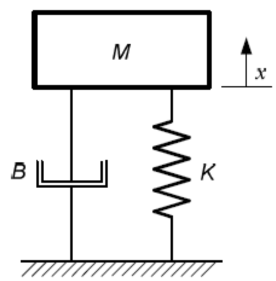


Fig. An automobile suspension system

Course Outcome 4:

1. What are similarity transformations? Explain.
2. Explain canonical forms and state-space realization of transfer matrices.
3. What are Observer-based Controllers?

Course Outcome 5:

1. Find describing Function of a Single-Relay.
2. How stability analysis is done with the help of Lyapunov function?
3. What is the basic scheme for describing function analysis?

Course Outcome 6:

1. Explain various common physical non-linearities.
2. What is phase plane analysis?
3. Explain sinusoidal-input describing function.

Syllabus

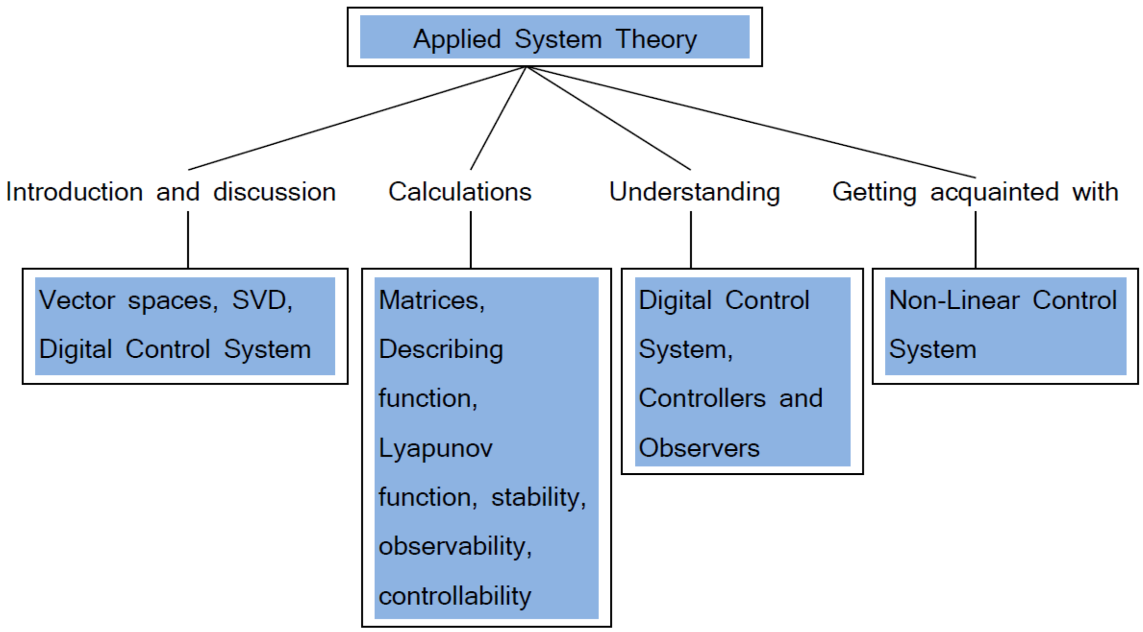
Module 1: Introduction (7 Lectures)

Vector spaces, Linear subspaces, Eigenvalues and eigenvectors, Matrix inversion formula, Invariant subspaces, Vector norms and Matrix norms, Singular value decomposition (SVD), Semi-definite matrices.

Module 2: Models of Digital Control Systems and Controllers (10 Lectures)

Introduction, Advantages of Digital control over Analog control and implementation problems, Discrete-time signals, Solution of Difference-Equations, Stability in the z-plane and Jury stability criterion, Discretization methods: Forward and backward difference method, bilinear transformation, System with dead time and dead-beat controllers.

Concept Map



Module 3: Digital Control System Analysis using State Variable Methods (6 Lectures)
State-space representation of Discrete-time systems, State-variable and Transfer-function models, Conversions of State-variable model to Transfer-function model and vice-versa, Diagonalization, Concepts of Controllability and Observability.

Module 4: Design of Controllers and Observers (7 Lectures):
Linear systems, Similarity transformations, Canonical forms, State-space realization of transfer matrices, Design of Pole placement and Observer-based Controllers.

Module 5: Non-linear Systems (10 Lectures):
Introduction, Common physical non-linearities, Phenomenon related to non-linear systems, Phase-plane and describing function methods of analysis, Lyapunov stability for Continuous and Discrete-time systems, Methods for constructing Lyapunov functions.

Text Books / Reference Books:

1. Ben Noble, Applied linear algebra, Pearson, J edition, 1987.
2. Chin-Tsong Chen; Linear system theory and design, Oxford Univ. PI' (Sd), 4 edition, 2012.
3. M. Gopal, State space and Digital Control System", Wiley Eastern Ltd.
4. K. Ogata, Discrete-Time Control Systems. Prentice-Hall, 1987.
5. B. C. Kuo, Digital Control System. Oxford University Press, second edition, 1992.
6. H. K. Khalil: Nonlinear control Systems, Prentice Hall, NJ, 1996.
7. J. J. E. Slotine, Applied Nonlinear Control.

Course Contents and Lecture Schedule

Module No.	Topic(s)	No. of Lectures
1	Vector spaces, Linear subspaces, Eigenvalues and eigenvectors, Matrix	3

	inversion formula	
1	Invariant subspaces, Vector norms and Matrix norms, Singular value decomposition (SVD), Semi-definite matrices	4
2	Introduction, Advantages of Digital control over Analog control and implementation problems, Discrete-time signals, Solution of Difference-Equations,	4
2	Stability in the z-plane and Jury stability criterion, Discretization methods: Forward and backward difference method	3
2	Bilinear transformation, System with dead time and dead-beat controllers	3
3	State-space representation of Discrete-time systems, State-variable and Transfer-function models	3
3	Conversions of State-variable model to Transfer-function model and vice-versa, Diagonalization, Concepts of Controllability and Observability	3
4	Linear systems, Similarity transformations, Canonical forms, State-space realization of transfer matrices,	4
4	Design of Pole placement and Observer-based Controllers	3
5	Introduction, Common physical non-linearities, Phenomenon related to non-linear systems,	4
5	Phase-plane and describing function methods of analysis,	3
5	Lyapunov stability for Continuous and Discrete-time systems, Methods for constructing Lyapunov functions	3

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EEE-446	Power Quality and FACTS	3L:1T:0P	4 Credits	Course Type: PEC

Preamble:
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, Engineering Physics, Basic Electrical Engineering, Power Quality parameters.

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

COs	Course Outcomes	Bloom's Level
CO1	Understand the basic concepts of power quality.	Remembering, Understanding
CO2	Understand the working principles of devices to improve power quality.	Understanding, Analyzing
CO3	Understand the characteristics of ac transmission and the effect of shunt and series reactive compensation.	Understanding, Analyzing, Evaluating
CO4	Understand the working principles of FACTS devices and their operating characteristics.	Understanding, Analysing, Evaluating
CO5	Understand the various applications of FACTS.	Understanding, Analyzing, Creating

Mapping with Programme Outcomes:

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

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

Course Level Assessment Questions

Course Outcome 1:
1. What are the Power Quality issues? Elaborate Electric Power Quality Standards.
2. Describe the common Power Frequency Disturbances.
3. Describe the application of Isolation Transformers.

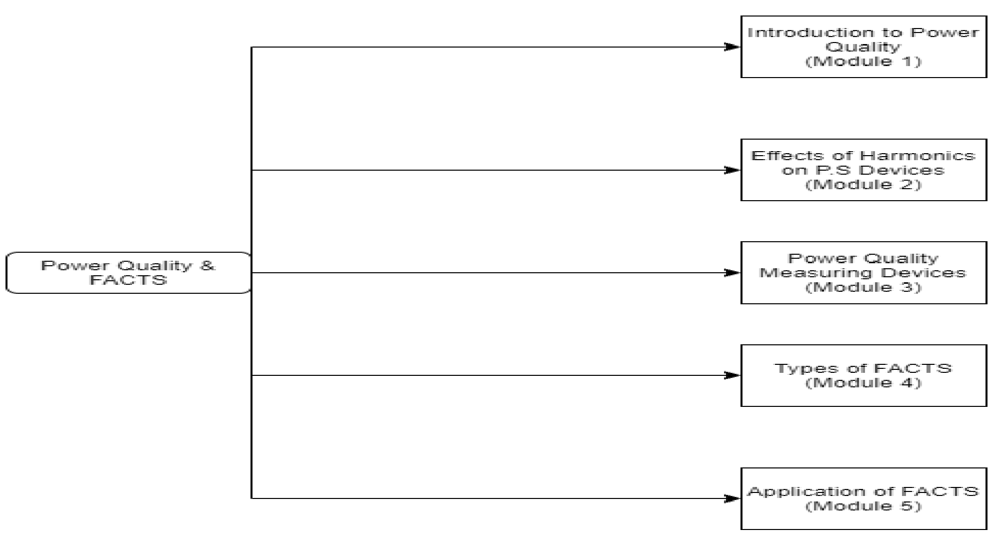
Course Outcome 2:
1. Distinguish between Individual and Total Harmonic Distortion.
2. What are the causes of Voltage and Current harmonics?
3. Explain Harmonic Current Mitigation.

Course Outcome 3:
1. Describe with proper details various Power Quality Measurement Devices.
2. Discuss working of Harmonic Analyzers.
3. Describe true RMS meter with proper diagram.

Course Outcome 4:
1. Describe basic types of FACTS Controllers.
2. Elaborate application of Thyristor Controlled Series Capacitor (TCSC) for different problems of power system.
3. Describe the principle of operation of Static Synchronous Series Compensator (SSSC).

Course Outcome 5:
1. Write application of FACTS devices for power-flow control and stability improvement.
2. Describe basic operating principles and characteristics of Unified Power Flow Controllers (UPFC).
3. Show the UPFC model for Power flow studies.

Concept Map



Syllabus

Module-1: Introduction to Power Quality (7 Hours):
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, Isolation Transformers, Voltage Regulators, Static Uninterruptible Power Source Systems.

Module-2: Effects of harmonics on Power System devices (7 Hours):
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 (8 Hours):
Power Quality Measurement Devices, Harmonic Analyzers, Transient-Disturbance Analyzers, Oscilloscopes, Data Loggers and Chart Recorders, True RMS Meters, Power Quality Measurements.

Module-4: Types of FACTS (9 Hours):
The emergence of Flexible Alternating Current Transmission Systems (FACTS), Types of FACTS controller ,Principle, configuration of Shunt compensation ,control and applications of Shunt Static VAR Compensator (SVC) and Static Synchronous compensator (STATCOM).Fundamental of series compensation, principle of operation, Application of Thyristor Controlled Series Capacitor (TCSC) for different problems of power system, TCSC layout, Static Synchronous Series Compensator (SSSC): principle of operation.

Module-5: Application of FACTS (9 Hours):
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).
5. Kennedy, B., Power Quality Primer, McGraw Hill (2000).
6. IEEE Standard 519-1992, IEEE recommended practices and requirements for harmonic control in electrical power systems, 1992.
7. G. J. Walkileh, “Power Systems Harmonics”, Springer Verlag, New York, 2001.

Course Contents and Lecture Schedule

Module No.	Topic (s)	No of Lectures
1	Power Quality Issues, Voltage Sags, Swells, Interruptions, Power Quality v/s Equipment Immunity, Electric Power Quality Standards.	3
1	Common Power Frequency Disturbances, Isolation Transformers	2
1	Voltage Regulators, Static Uninterruptible Power Source Systems	2
2	Causes of Voltage and Current Harmonics, Individual and Total Harmonic	2

	Distortion	
2	Effect of Harmonics on Power System Devices, Guidelines for Harmonic Voltage and Current Limitation	3
2	Harmonic Current Mitigation.	2
3	Power Quality Measurement Devices, Harmonic Analyzers, Transient-Disturbance Analyzers	4
3	Oscilloscopes, Data Loggers and Chart Recorders, True RMS Meters	2
3	Power Quality Measurements	2
4	FACTS, Types of FACTS controller ,Principle, configuration of Shunt compensation ,control and applications of Shunt Static Var Compensator (SVC) and Static Synchronous compensator (STATCOM)	4
4	Fundamental of series compensation, principle of operation, Application of Thyristor Controlled Series Capacitor (TCSC) for different problems of power system, TCSC layout	3
4	Static Synchronous Series Compensator (SSSC): principle of operation	2
5	Application of FACTS devices for power-flow control and stability improvement	4
5	Unified Power Flow Controllers (UPFC): Basic operating principles and characteristics	3
5	UPFC installation applications, UPFC model for power flow studies	2

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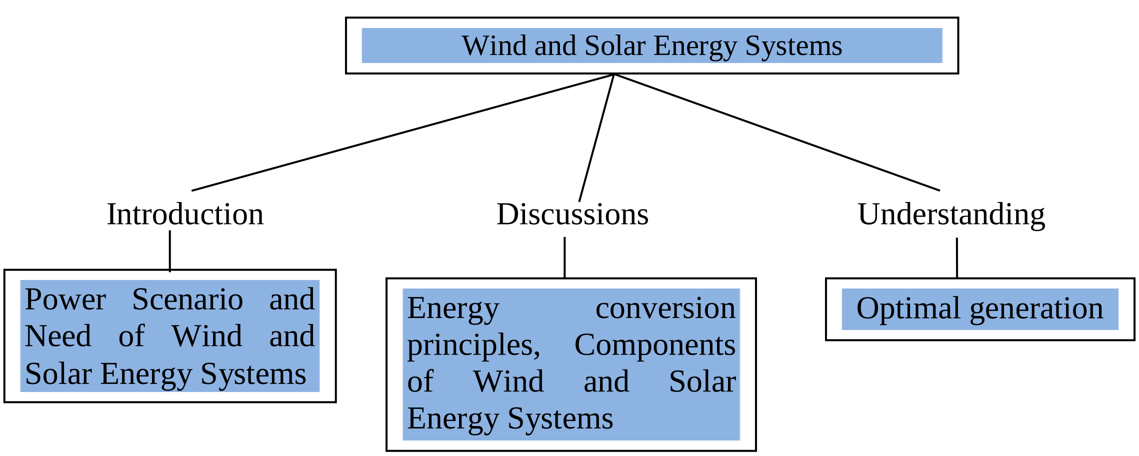
EEE-448	**Wind and Solar Energy Systems**	**3L: 1T: 0P**	**4 Credits**	**Course Type: PEC**

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

Concept Map



Syllabus

Module-1: Power Scenario (06)

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 (08)

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 (10)

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 (08)

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 (08)

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).

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EEE-450	**Modelling and Simulation of Electrical Machines**	**3L:1T:0P**	**4 Credits**

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

Prerequisites: Advanced Electric Drives; EEE-462, Electrical Machines-I; EEE-202, Electrical Machines-II; EEE-301.

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

COs	Course Outcomes	Bloom's Level
CO1	Understand the basic concepts of modelling of DC machine.	Knowledge (1) Comprehension (2) Analysis (4)
CO2	Understand the dynamic simulation of the speed-controlled DC Motor Drive.	Knowledge (1) Analysis (4) Synthesis (5)
CO3	Understand and modelling of AC motor model in different reference frame.	Knowledge (1) Analysis (4) Synthesis (5)
CO4	Understand modelling and simulation of 1-phase and 3-phase induction motor.	Knowledge (1) Application (3) Analysis (4) Synthesis (5)
CO5	Understand modelling and simulation of synchronous machine.	Knowledge (1) Analysis (4) Synthesis (5)

Mapping with Programme Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO1O	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
Avg.	3.0	2.8	2.0	1.8	3.0	0.6	-	-	-	-	-	1.0

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

Course Level Assessment Questions

Course Outcome 1:
1. What do you understand by modelling?
2. Explain Linearization Techniques for small perturbations.

Course Outcome 2:
1. Discuss Modeling of 3-phase Converter.
2. Discuss dynamic simulation model of DC motor.

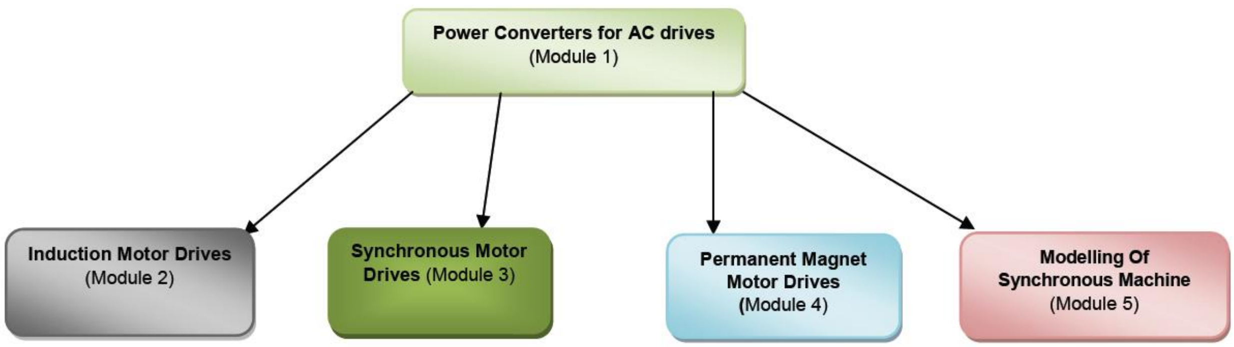
Course Outcome 3:

1. Discuss d-q transformation.
2. Explain stator reference frame model of induction motor.

Course Outcome 4:
1. Derive small signal equations of Induction machine model.
2. Discuss cross field theory of single - phase induction machine.

Course Outcome 5:
1. Derive voltage equations of synchronous motor in the rotor's dq0 reference frame.
2. Discuss modeling of PM Synchronous motor.

Concept Map



Module 1: Basic Concepts of Modelling (8 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: Modelling of DC Machines (8 Hours)

Principles of DC Motor Speed Control, Fundamental Relationship, Field Control, Armature Control, Armature and Field Controls, Four-Quadrant Operation, Phase-Controlled Converters, Single-Phase-Controlled Converter, Three-Phase-Controlled Converter, Control Circuit, Control Modelling 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 (8 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 - Electromagnetic torque - Derivation of commonly used Induction machine models - Stator reference frame model - Rotor reference frame model Synchronously rotating reference frame model -Equations in flux linkages - per unit model.

Module 4: Small Signal Modeling (8 Hours)

Small Signal Modeling of Three Phase Induction Machine Small signal equations of Induction machine, derivation 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 (8 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:

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

Web Reference:

Video/Web contents on NPTEL

Course contents and Lecture Schedule

Module No.	Topic (s)	No. of Lectures
1	DC Machine modelling: Mathematical model of separately excited D.C motor,	2
	Steady State analysis - Transient State analysis - Sudden application of Inertia Load - Transfer function of Separately excited D.C Motor,	3
	Mathematical model of D.C Series motor, Shunt motor- Linearization Techniques for small perturbations.	3
2	Principles of DC Motor Speed Control, Fundamental Relationship, Field Control, Armature Control, Armature and Field Controls, Four-Quadrant Operation, Phase-Controlled Converters,	2
	Single-Phase-Controlled Converter, Three-Phase-Controlled Converter, Control Circuit, Control Modelling of-the Three-Phase Converter,	2
	Steady-State Analysis of the Three-Phase Converter-Controlled Motor Drive,	2
	Dynamic Simulation of the Speed-Controlled DC Motor Drive, Motor Equations, Speed Feedback, Speed Controller.	2
3	Reference frame theory Real time model of a two phase induction machine-Transformation to obtain constant matrices - three phase to two phase transformation	2
	Power equivalence. Dynamic modelling of three phase Induction Machine Generalized model in arbitrary reference frame - Electromagnetic torque - Derivation of commonly used Induction machine models - Stator reference frame model,	3
	Rotor reference frame model Synchronously rotating reference frame model - Equations in flux linkages - per unit model	3
4	Small Signal Modelling of Three Phase Induction Machine Small signal equations of Induction machine,	3

	Derivation d-q flux linkage model derivation - control principle of Induction machine. Single phase induction motor;	3
	Cross field theory of single - phase induction machine.	2
5	Synchronous machine inductances – voltage equations in the rotor's dq0 reference frame,	3
	Electromagnetic torque - current in terms of flux linkages - simulation of three phase synchronous machine,	3
	Modelling of PM Synchronous motor.	2

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List of Programme Electives-IV

EEE-452	**Robotics and Automation**	**3L: 1T: 0P**	**4 Credits**	**Course Type: PEC**

Preamble:

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 this course, students will be able to:

COs	Course Outcomes	Bloom's Level
CO1	Able to know about robotic system	Remembering, Understanding
CO2	Able to understand and apply dynamics and control	Understanding, Applying,
CO3	Demonstrate fundamental understanding of system stability	Analysing, Evaluating
CO4	Develop the mathematical model of robots	Understanding, Analysing,
CO5	Exhibit the knowledge of nonlinear control, observer based control robust control	Understanding, Analysing, Applying
CO6	Exhibit the knowledge of the robotic system design	Remembering, Understanding

Mapping with Programme Outcomes:

COs	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
Avg.	1.8	1.3	1.2	0.7	0.8	2.0	1.0	0.3	1.2	0.2	1.0	2.0

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

Course Outcome 1:

1. What do you understand by robotic system?

2. Briefly describe automation.
3. Explain position control scheme.

Course Outcome 2:

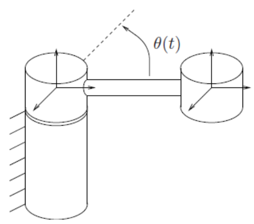
1. Explain forward dynamics with example.
2. Explain inverse dynamics with example.
3. The humanoid robot Apollo with 7 DoFs in each arm, executes a pick and place task. Write its inverse dynamics in feed-forward control.

Course Outcome 3:

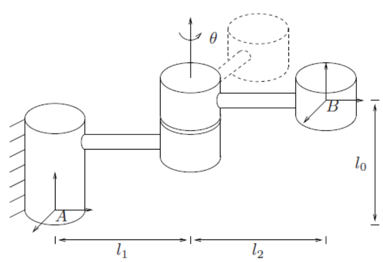
1. Consider the system $x' = -x + 2x^2 + y^2$, $y' = -y + y^2$. Examine the positive definite function $V(x, y) = x^2 + y^2$.
2. Consider a system $x' = -2x - 3y + x^2$, $y' = x + y$. Prove using Lyapunov functions that the origin is asymptotically stable and to estimate its basin of attraction.
3. Define Lyapunov stability theorems.

Course Outcome 4:

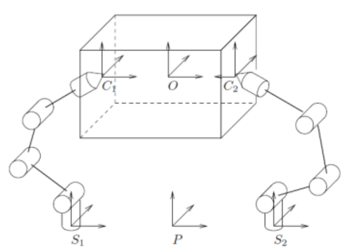
1. Develop mathematical model of robot as shown in figure below.



2. Develop mathematical model of robot as shown in figure below.



3. Develop mathematical model for a simple grasping application as shown below.



Course Outcome 5:

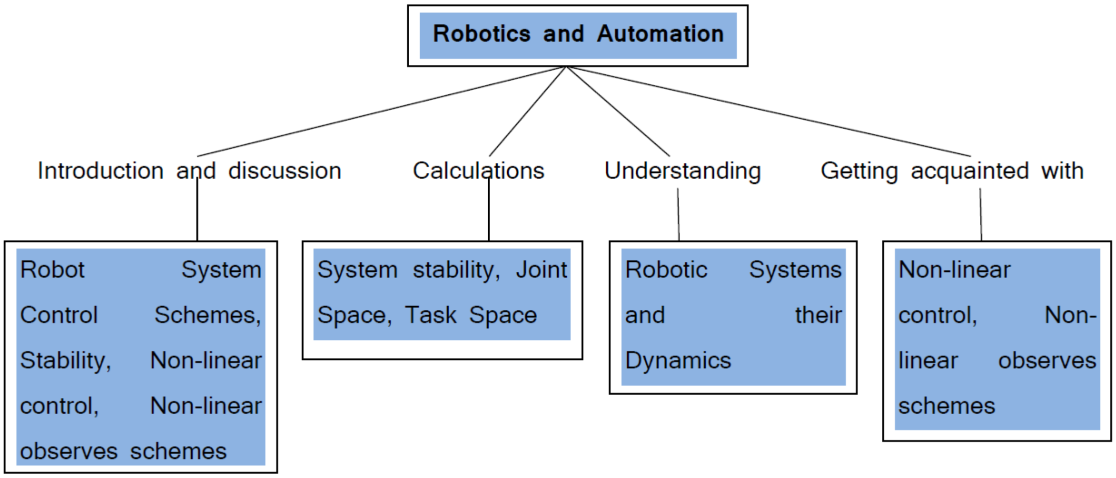
1. Explain sliding mode control.
2. Give a complete detail of adaptive control.
3. Explain observer based control.

Course Outcome 6:

1. Develop a complete mathematical model of SCARA robot including servo actuator dynamics.
2. Discuss observer design based on acceleration feedback.

3. How gravity compensation is done?

Concept Map



Syllabus

Module 1: Introduction and Overview of Robotic Systems and their Dynamics (8 Lectures):
Forward and inverse dynamics, Properties of the dynamic model and case studies, Introduction to nonlinear systems and control schemes.

Module 2: System Stability and Types of Stability (8 Lectures):
Lyapunov stability analysis, both direct and indirect methods. Lemmas and theorems related to stability analysis.

Module 3: Joint Space and Task Space Control Schemes (8 Lectures):
Position control, velocity control, trajectory control and force control.

Module 4: Nonlinear Control Schemes (8 Lectures):
Proportional and derivative control with gravity compensation, computed torque control, sliding mode control, adaptive control, and observer based control, robust control and optimal control.

Module 5: Nonlinear Observer Schemes (8 Lectures):
Design based on acceleration, velocity and position feedback, Numerical simulations using software packages namely MATLAB.

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 & S. Janardhanan, "Modern Control Engineering", Cengage Learning.

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 Control‖, 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.

Course Contents and Lecture Schedule

Module No.	Topic(s)	No. of Lectures
1	Forward and inverse dynamics	2
1	Properties of the dynamic model and case studies	3
1	Introduction to nonlinear systems and control schemes	3
2	Lyapunov stability analysis, direct and indirect methods	3
2	Lemmas and theorems related to stability analysis	5
3	Position control, velocity control	4
3	Trajectory control and force control	4
4	Proportional and derivative control with gravity compensation, computed torque control	3
4	Sliding mode control, adaptive control, observer based control, robust control and optimal control	5
5	Design based on acceleration, velocity and position feedback	4
5	Numerical simulations using software packages namely MATLAB	4

****

EEE-454	Power System Dynamics and Control	3L: 1T: 0P	4 Credits	Course Type: PEC

Course Outcomes:
At the end of this course, students will have the ability to demonstrate and implement the appropriate solution/solutions to:

1. The problem of power system stability and its impact on the system.
2. Analyze linear dynamical systems and use of numerical integration methods.
3. Model different power system components for the study of stability.
4. Analyze the stability problems.
5. Improve stability.

Module 1: Introduction to Power System Operations (3 hours)

Introduction to power system stability. Power System Operations and Control. Stability problems in Power System. Impact on Power System Operations and control.

Module 2 : Analysis of Linear Dynamical System and Numerical Methods (5 hours)
Analysis of dynamical System, Concept of Equilibrium, Small and Large Disturbance Stability. Modal Analysis of Linear System. Analysisusing Numerical Integration Techniques. Issues in Modeling: Slow and Fast Transients, Stiff System.

Module 3: Modeling of Synchronous Machines and Associated Controllers (12 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. Synchronization of Synchronous Machine to an Infinite Bus. Modeling of Excitation and Prime Mover Systems. Physical Characteristics and Models. Excitation System Control. Automatic Voltage Regulator. Prime Mover Control Systems. Speed Governors.

Module 4: Modeling of Other Power System Components (10 hours)

Modeling of Transmission Lines and Loads. Transmission Line Physical Characteristics. Transmission Line Modeling. Load Models - induction machine model. Frequency and Voltage Dependence of Loads. Other Subsystems – HVDC and FACTS controllers, Wind Energy Systems.

Module 5: Stability Analysis (11 hours)

Angular stability analysis in Single Machine Infinite Bus System. Angular Stability in multi-machine systems – Intra-plant, Local and Inter-area modes. Frequency Stability: Centre of Inertia Motion. Load Sharing: Governordroop. Single Machine Load Bus System: Voltage Stability. Introduction to Torsional Oscillations and the SSR phenomenon. Stability Analysis Tools:Transient Stability Programs, Small Signal Analysis Programs.

Module 6: Enhancing System Stability (4 hours)

Planning Measures. Stabilizing Controllers (Power System Stabilizers). Operational Measures-Preventive Control. Emergency Control.

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

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EEE-456	Industrial Instrumentation	3L: 1T: 0P	4 Credits	Course Type: PEC

Preamble:

This course will provide a good understanding and hold to the students in the area of industrial instrumentation. The course includes study of sensors, transducers, signal conditioning systems and telemetry and data acquisition systems. This course also gives an insight into industrial aspects of instrumentation.

Prerequisites:
Engineering Mathematics, Engineering Physics, Basic Electrical Engineering, Measurement Science and Technique

Course Objectives:

1. To understand the purpose of instrumentation in industrial processes.
2. To learn the working of different types of Passive and Active Transducers utilized for the instrumentation of physical quantities.
3. To study the Signal conditioning devices, Instrumentation amplifiers, Rectifiers and Active filters used for industrial instrumentation.
4. To study the various types of Analog to Digital and Digital to Analog Converters.
5. To study and understand the concepts and working of Telemetery and Data acquisition systems used in the instrumentation systems.

Course Outcomes:

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

COs	Course Outcomes	Bloom's Level
CO1	Able to know about various sensors and transducers,	Remembering, Understanding

	analog and digital systems	
CO2	Able to measure industrial variables	Understanding, Applying, Analysing
CO3	Evaluating various aspects of instrumentation design like amplifier, signal conditioning circuits	Analysing, Evaluating
CO4	Understand various aspects of rectifiers, filters, bridges	Understanding, Analysing
CO5	Able to do basic calculations of measurements and instrumentation	Understanding, Analysing, Applying
CO6	Able to understand working of telemetry and DAS	Remembering, Understanding

Mapping with Programme Outcomes:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	-	-	-	2	1	-	-	-	-	3
CO2	1	1	2	1	1	2	1	-	1	-	1	2
CO3	3	1	1	-	1	2	1	1	1	-	2	2
CO4	2	2	1	1	1	2	1	-	2	1	1	3
CO5	1	2	2	2	1	2	1	2	2	1	2	3
CO6	2	1	1	2	1	1	1	3	1	1	1	2
Avg.	2.0	1.3	1.2	1.0	0.8	1.8	1.0	1.0	1.2	0.5	1.2	2.5

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

Course Outcome 1:

1. Differentiate between sensor and transducer.
2. What are advantages of analog systems? List their limitations.
3. Explain the working of a 3-bit R-2R Ladder DAC as shown in the figure below.

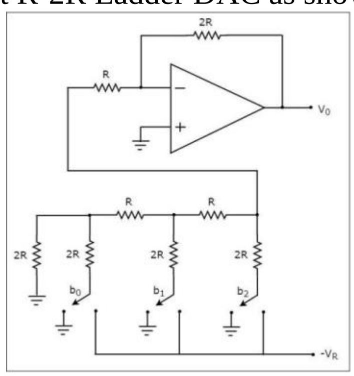


Fig.: DAC

Course Outcome 2:

1. List various industrial variables, which need measurements, with examples.
2. How to Select Flow meters? How their calibration is done?
3. A system travels in segments, as are described in the following table. Find average speed.

Segment	**Distance (miles)**	**Time (hours)**
1	30	1
2	45	2
3	50	1
4	65	2

Course Outcome 3:

1. What are industrial applications of amplifiers?

2. What is the gain of instrumentation amplifier as shown in the Fig., below.

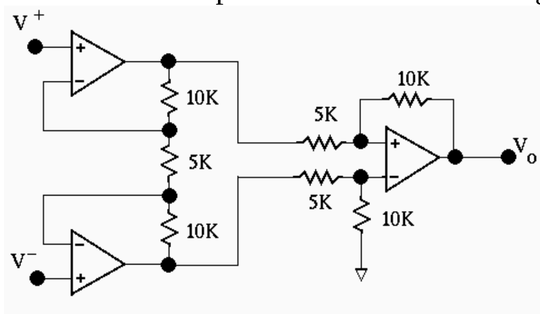


Fig.: Instrumentation Amplifier

3. Discuss the basic blocks of a generalised signal conditioning circuit.

Course Outcome 4:

1. The applied input a. c. power to a half-wave rectifier is 100 watts. The d. c. output power obtained is 40 watts.

(i) What is the rectification efficiency?

(ii) What happens to remaining 60 watts?

2. In the centre-tap circuit shown in Fig. below, the diodes are assumed to be ideal i.e. having zero internal resistance. Find :(i) d.c. output voltage(ii) peak inverse voltage (iii) rectification efficiency.

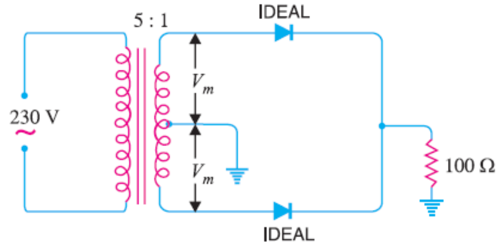


Fig.: Centre-tap Circuit

3. Explain working of Active Band Pass Filter Circuit as shown in the Fig., below.

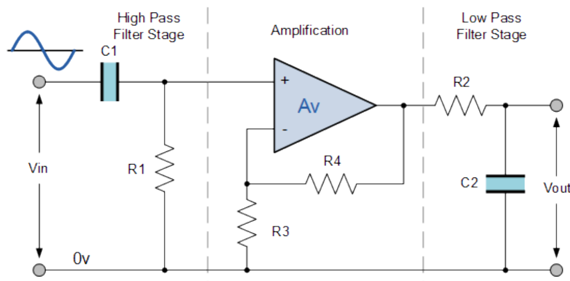


Fig.: Active Band Pass Filter Circuit

Course Outcome 5:

1. Explain working of Infinite Gain Multiple Feedback Active Filter as shown in the Fig., below.

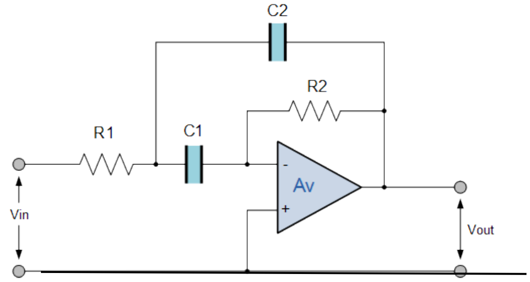


Fig.: Infinite Gain Multiple Feedback Active Filter

2. Explain inductive and capacitive transducers with examples.

3. What are industrial applications of Opto-electronic and Hall-effect type transducers?

Course Outcome 6:

1. What are various types of Telemetry Systems?
2. Discuss Frequency Telemetry.
3. Explain digital data acquisition system, as shown in Fig., below.

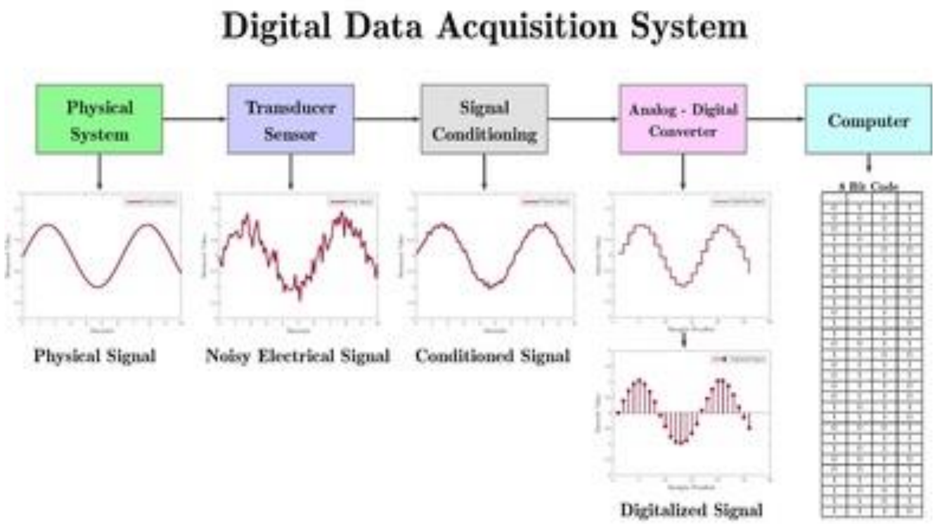
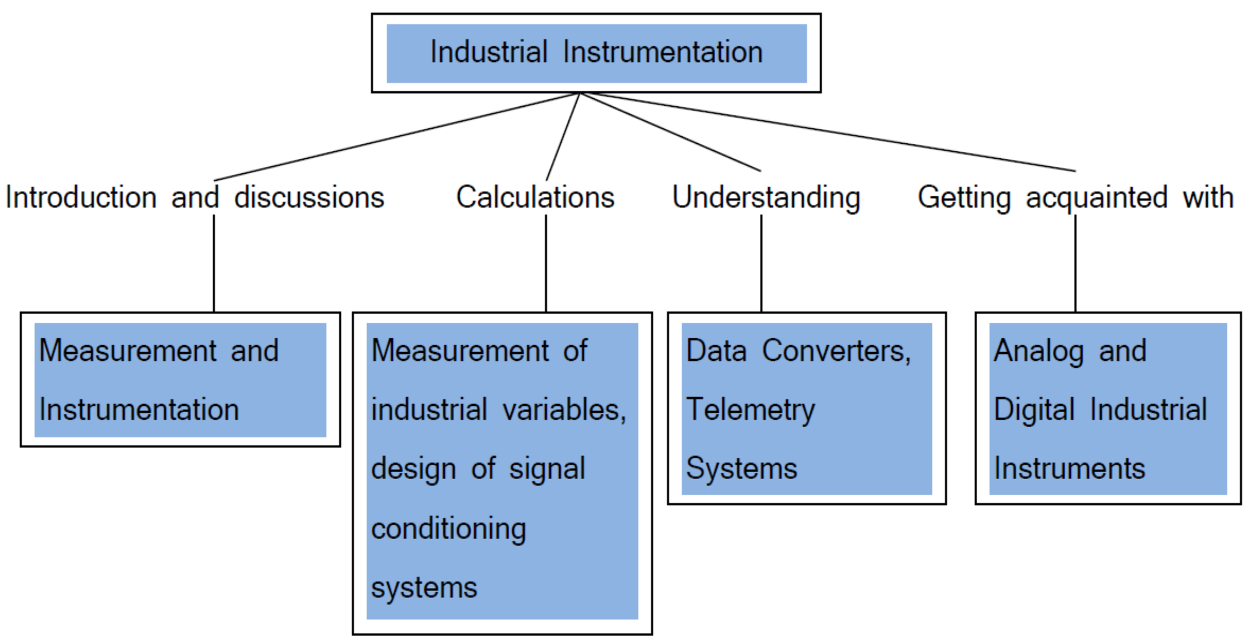


Fig.: Digital Data Acquisition System

Concept Map



Syllabus:

Module 1: Instrumentation Systems and Transducers (8 Lectures):
Role of instrumentation, Elements of instrumentation system, Sensors and transducers, Primary sensing elements, Electrical Transducers: classification, characteristics, desirable properties. Resistive, Inductive, Capacitive, Opto-electronic and Hall-effect type transducers: principle, Characteristics, Advantages and limitations, Industrial applications.

Module 2: Active and Digital Transducers (8 Lectures):
Thermo-electric, Piezo-electric, Photo-electric, Digital Transducers: types, principle, characteristics, Advantages and limitations. Applications of Transducers for instrumentation of common industrial variables: Temperature, Pressure, Flow, Liquid-level, Load / Force, Position, Speed and Acceleration.

Module 3: Electronic Instrumentation (8 Lectures):
Analog Signal Conditioning and Signal conversion, Transducer bridges for resistive and reactive transducers, Instrumentation amplifiers, Precision rectifiers and applications, Active filters: First-order low-pass, Second-order, Features and design.

Module 4: Data Converters and Digital Signal Conditioning (10 Lectures):
Sample and Hold operations, Digital to Analog Converters: R/2R, Binary weighted, BCD to analog types, Analog to Digital Converters: classifications, Capacitor charging type-VFC, PWM type, Dual-slope integrator types, Discrete voltage comparison type-Counter Ramp, Successive Approximation, Flash type, Properties and specifications.

Module 5: Telemetry and Data Acquisition Systems (6 Lectures):
Types of Telemetry Systems: Land line, Wireless, Analog and Digital, Current, Voltage, Position, Frequency Telemetry, Data Acquisition systems-configurations.

Text Books / Reference Books:

1. D. Patranabis –Principles of industrial instrumentation (TMH)
2. Rangan, Sharma, Mani – Instrumentation systems and Devices (TMH)
3. A. K. Sawhney – Instrumentation and Process Control, Dhanpat Rai & Sons

Course Contents and Lecture Schedule

Module No.	Topic(s)	No. of Lectures
1	Role of instrumentation, Elements of instrumentation system, Sensors and transducers, Primary sensing elements, Electrical Transducers: classification, characteristics, desirable properties	4
1	Resistive, Inductive, Capacitive, Opto-electronic and Hall-effect type transducers: principle, Characteristics, Advantages and limitations, Industrial applications	4
2	Thermo-electric, Piezo-electric, Photo-electric, Digital Transducers: types, principle, characteristics,	3
2	Advantages and limitations. Applications of Transducers for instrumentation of common industrial variables: Temperature, Pressure	3
2	Flow, Liquid-level, Load / Force, Position, Speed and Acceleration	2
3	Analog Signal Conditioning and Signal conversion, Transducer bridges for resistive and reactive transducers, Instrumentation amplifiers	4
3	Precision rectifiers and applications, Active filters: First-order low-pass, Second-order, Features and design	4
4	Sample and Hold operations, Digital to Analog Converters: R/2R, Binary weighted, BCD to analog types, Analog to Digital Converters: classifications, Capacitor charging type-VFC,	5
4	PWM type, Dual-slope integrator types, Discrete voltage comparison type-Counter Ramp, Successive Approximation, Flash type, Properties and specifications	5
5	Types of Telemetry Systems: Land line,	2

5	Wireless, Analog and Digital, Current, Voltage, Position, Frequency Telemetry,	2
5	Data Acquisition systems-configurations	2

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EEE-458	**Electrical and Electronics Engineering Materials**	**3L: 1T: 0P**	**4 Credits**	**Course Type: PEC**

Preamble: This course will provide a good understanding and hold to the students in the area of electrical energy conservation and auditing. The course includes: Basic crystal structure of materials, mechanism of conductivity in metals, semiconductor materials, applications of nano materials.

Prerequisites: Engineering Chemistry, Engineering Physics, Basic Electrical Engineering, Magnetic circuit Analysis.

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

COs	Course Outcomes	Bloom's Level
CO1	Understand the basic crystal structure of materials.	Remembering, Understanding
CO2	Understand the mechanism of conductivity of metals.	Understanding, Analyzing
CO3	Understand the merits and applications of semi-conductor materials and photonic devices.	Understanding, Analyzing, Evaluating, Creating
CO4	Understand the various magnetic properties of materials.	Understanding, Analyzing,
CO5	Understand the applications of Nano materials and modern techniques to study materials.	Remembering, Applying, Creating

Mapping with Programme Outcomes:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1	-	-	2	2	-	1	1	-	1
CO2	3	1	1	-	-	2	2	-	1	1	-	1
CO3	3	1	2	1	1	2	1	-	1	1	-	1
CO4	2	1	1	-	1	2	1	-	1	1	-	-
CO5	3	1	2	2	2	2	2	-	2	2	-	2
Avg.	2.8	1	1.4	.6	.8	2	1.6	-	1.2	1.2	-	1

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

Course Level Assessment Questions

Course Outcome 1:

1. Discuss the formation of energy bands in solids. Based on these bands classify Insulators, Conductors and Semi-conductors.
2. Explain Miller indices. Establish relation among Interplaner Spacing, Lattice Constant and Miller Indices.
3. Explain briefly the formation of allowed and forbidden energy bands in crystals.

Course Outcome 2:

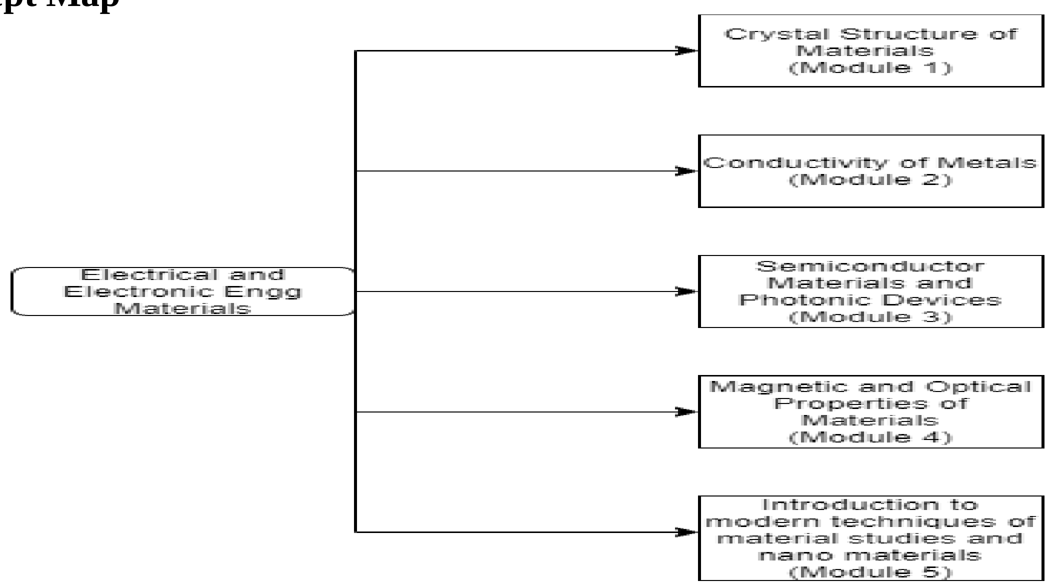
1. What is Superconductivity? Write properties and types of Superconductors.
2. Determine the mobility of electrons of Copper having resistivity=1.73 x 10^{-8} Ohm-m. Given average time of collision of electrons=2.42 x10^{-14} seconds.
3. Write the mechanical properties of metals.

Course Outcome 3:
1. Enumerate different types of semiconductors.
2. Classify the Photonic devices.
3. Write the basic steps in IC fabrication.

Course Outcome 4:
1. What are ferrites? Name few commonly used ferrites.
2. What are the advantages of using fibre-optic communication system?
3. Explain briefly the main optical properties of solids.

Course Outcome 5:
1. What do you mean by nanomaterials?
2. Describe two methods for synthesis of nanoparticles.
3. Describe two methods for fabrication of carbon nanotubes.

Concept Map



Syllabus:

Module –1: Crystal structure of materials (8 Hours):

Crystal Structure of Materials: Bonds in solids, crystal structure, co-ordination number, atomic packing factor, Miller Indices, Bragg's law and x-ray diffraction, structural Imperfections, crystal growth , Energy bands in solids, classification of materials using energy band.

Module-2: Conductivity of metals (8 Hours):

Conductivity of Metals: Electron theory of metals, factors affecting electrical resistance of materials, thermal conductivity of metals, heat developed in current carrying conductors, thermoelectric effect, superconductivity and super conducting materials, Properties and applications of electrical conducting and insulating materials, mechanical properties of metals

Module-3: Semiconductor materials and Photonic devices (8 Hours):

Types of semiconductors, properties of semi-conducting materials, measurement of semiconductor parameters, growth and refining of semiconductor materials, merits of semiconductor materials, preparation of Electronic grade silicon(EGS),Growth of semiconductor crystals from Melt-Czochralski method, Epitaxial growth –Vapour –Phase Epitaxy, refining of semiconductor materials, Microelectronic circuits and ICs, Basic steps in IC fabrication, Photonic devices, Photo-transistor, Photo diode, Light emitting diode.

Module-4: Magnetic and Optical properties of material (8 Hours):
Magnetic Properties of Material, Anti-ferromagnetism and Ferrimagnetic materials or Ferrites ,Application of hysteresis curve, soft and hard magnetic materials and their applications, permanent magnetic materials, basic features of electromagnetic radiation, response of the materials to Electromagnetic radiation ,introduction to optical fibre, merits and application of optical fibre, Light source materials for optical fibre communication.

Module-5: Introduction to modern techniques of material studies and Nano materials (8 Hours):

Brief history of Nano materials, Introduction to modern techniques of material studies and Nano materials: Brief introduction of Differential Scanning of Calorimeters, Transmission Electron Microscopy (TEM), Optical Absorption Spectroscopy, Scanning Electron Microscopy, production and application of Nano materials.

Text Books :

1. R. K. Shukla & A. Singh,"Electrical Engineering Materials" , Tata Mcgraw Hill,New Delhi.
2. R.K. Rajput," Electrical Engg. Materials," Laxmi Publications.

References :

3. Solymar, "Electrical Properties of Materials" Oxford University Press.
4. C.S. Indulkar & S.Triruvagdan "An Introduction to Electrical Engg. Materials, S.Chand & Co.
5. T. K. Basak, "Electrical Engineering Materials" New age International.

Course Contents and Lecture Schedule

Module No.	Topic (s)	No of Lectures
1	Crystal Structure of Materials: Bonds in solids, crystal structure, co-ordination number, atomic packing factor,	3
1	Miller Indices, Bragg's law and x-ray diffraction, structural Imperfections, crystal growth	3
1	Energy bands in solids, classification of materials using energy band	3
2	Conductivity of Metals: Electron theory of metals, factors affecting electrical resistance of materials, thermal conductivity of metals	2
2	heat developed in current carrying conductors, thermoelectric effect, superconductivity and super conducting materials	3
2	Properties and applications of electrical conducting and insulating materials, mechanical properties of metals	3
3	Types of semiconductors, properties of semi-conducting materials, measurement of semiconductor parameters, growth and refining of semiconductor materials, merits of semiconductor materials	3
3	preparation of Electronic grade silicon(EGS),Growth of semiconductor crystals from Melt-Czochralski method, Epitaxial growth–Vapour–Phase Epitaxy, refining of semiconductor materials,	3
3	Microelectronic circuits and ICs, Basic steps in IC fabrication, Photonic devices, Photo-transistor, Photo diode, Light emitting diode.	2
4	Magnetic Properties of Material, Antiferromagnetism and Ferrimagnetic materials or Ferrites ,Application of hysteresis curve, soft and hard magnetic materials and their applications, permanent magnetic materials	3
4	basic features of electromagnetic radiation, response of the materials to	2

	Electromagnetic radiation	
4	introduction to optical fibre, merits and application of optical fibre, Light source materials for optical fibre communication	3
5	Brief history of Nano materials	2
5	Introduction to modern techniques of material studies and Nano materials: Brief introduction of Differential Scanning of Calorimeters, Transmission Electron Microscopy(TEM),Optical Absorption Spectroscopy, Scanning Electron Microscopy	3
5	Production and application of Nano materials.	3

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EEE-460	Electrical and Hybrid Vehicles	3L: 1T: 0P	4 Credits	Course Type: PEC

Preamble:
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:
Basic Electrical Engineering, Engineering Mathematics, Engineering Physics, Electrical Machines, Power Electronics and Drives

Course Outcomes:

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

COs	Course Outcomes	Bloom's Level
CO1	Able to understand need of electric vehicle and hybrid vehicle	Remembering, Understanding
CO2	Able to choose a suitable drive scheme	Understanding, Applying,
CO3	Demonstrate basic schemes of electric vehicle and hybrid vehicle	Analysing, Evaluating
CO4	Develop control of DC and Induction Motor drives	Understanding, Analysing, Applying
CO5	Exhibit the knowledge of Electric Propulsion Unit	Understanding, Remembering, Analysing, Applying
CO6	Exhibit the knowledge of energy storage systems	Remembering, Understanding

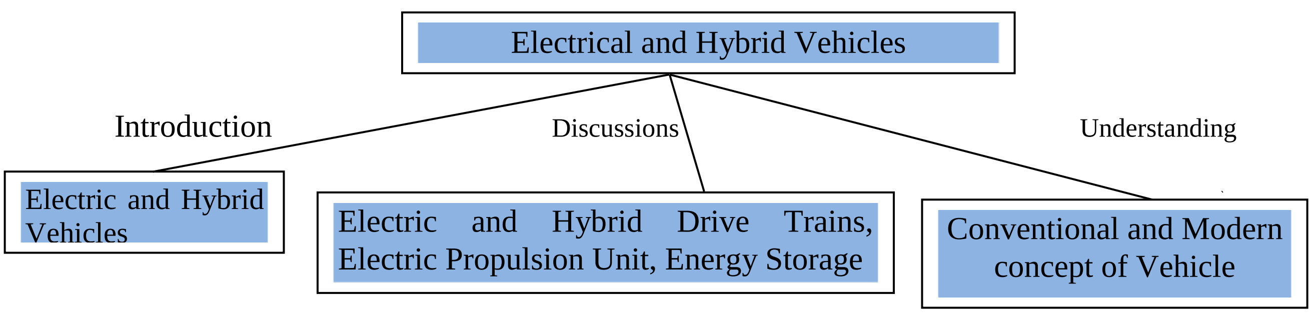
Mapping with Programme Outcomes:

COs	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
CO6	2	1	2	1	1	2	2	-	1	-	1	2
Avg.	2.0	1.6	2.3	1.3	2.0	2.0	2.3	0.7	1.3	0.2	1.2	2.3

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

Course Outcome 1:
1. What is need of electric vehicle?
2. What is need of hybrid vehicle?
3. What is social importance of electric vehicle?
Course Outcome 2:
1. What is the concept of traction?
2. Discuss any one hybrid drive-train topology.
3. Discuss any one electric drive-train topology.
Course Outcome 3:
1. What are different components used in electric vehicles?
2. Briefly explain the configuration of DC motor drive.
3. Discuss the configuration of induction motor drive.
Course Outcome 4:
1. Compare DC motor and induction motor drive.
2. Briefly explain the configuration of DC motor drive.
3. Discuss the control of induction motor drive.
Course Outcome 5:
1. What is Electric Propulsion Unit?
2. What are components used in electric vehicles?
3. What are components used in hybrid vehicles?
Course Outcome 6:
1. What are energy storage requirements in Hybrid and Electric Vehicles?
2. Explain fuel cells.
3. How hybridization of different energy storage devices is done?

Concept Map



Syllabus

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

Course Contents and Lecture Schedule

Module No.	Topic(s)	No. of Lectures
1	Introduction to electric vehicle and hybrid vehicle, Conventional Vehicles	3
1	Basics of vehicle performance, vehicle power source characterization, transmission characteristics	5
2	Basic concept, introduction to various electric drive-train topologies	4
2	Power flow control in electric drive-train topologies, fuel efficiency analysis	4
3	Basic concept of hybrid traction, introduction to various hybrid drive-train topologies	5
3	Power flow control in hybrid drive-train topologies, fuel efficiency analysis	3
4	Introduction to electric components used in hybrid and electric vehicles	4
4	Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives	4
5	Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis	3
5	Fuel Cell based energy storage and its analysis, Hybridization of different energy storage devices	5

****

EEE-462	Advanced Electric Drives	3L:1T:0P	4 Credits	Course Type: PEC

Preamble:
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; EEE-304, Electrical Machines-I; EEE-202, Electrical Machines – II; EEE-301, Electrical Drives; EEE-401.

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

COs	Course Outcomes	Bloom's Level
CO1	Understand the operation of power electronic converters for AC drives.	Knowledge (1) Comprehension (2) Analysis (4) Synthesis (5)
CO2	Understand the operation and control of induction motor drives.	Knowledge (1) Application (3) Analysis (4)
CO3	Understand the operation and control of synchronous motor drives.	Knowledge (1) Application (3) Analysis (4)
CO4	Understand the operation and control of permanent magnet motor drives.	Knowledge (1) Application (3) Analysis (4)
CO5	Understand the operation and control of switched reluctance motor drives.	Knowledge (1) Application (3) Analysis (4)

Mapping with Programme Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO1O	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
Avg.	2.6	2.6	2.2	1.8	1.4	0.6	0.2	-	-	-	-	0.6

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

Course Level Assessment Questions

Course Outcome 1:
1. Define Electric Drive.
2. Discuss various types on inverters used for AC drives.

Course Outcome 2:
1. Discuss d-q transformation.
2. Explain V/f control scheme used for induction motor?

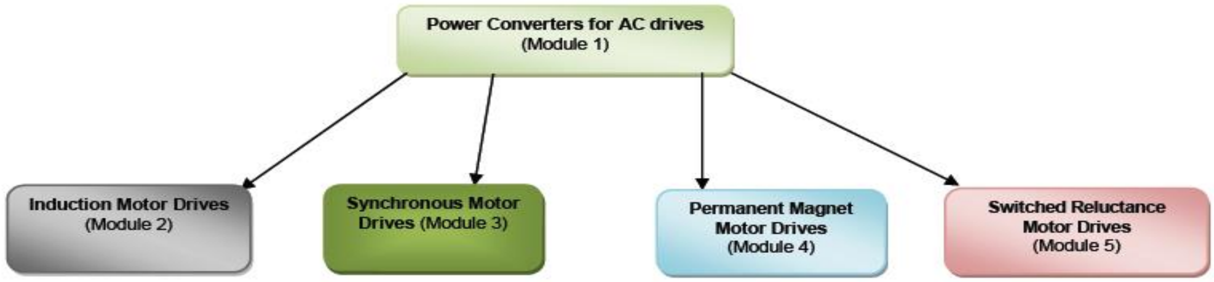
Course Outcome 3:
1. Discuss vector control in detail.
2. Discuss CSI fed synchronous motor drive.

Course Outcome 4:
1. Explain speed and torque control of BLDC machine.
2. Draw and discuss block diagram of PMSM drive.

Course Outcome 5:

1. Discuss closed loop scheme of SRM drive.
2. Discuss Switched reluctance motor drives.

Concept Map



Syllabus

Module 1: Power Converters for AC Drives (10 hours)
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 (10 hours)
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 hours)
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 (6 hours)
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 (6 hours)
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

Course Contents and Lecture Schedule

Module No.	Topic (s)	No. of Lectures
1	PWM control of inverter, selected harmonic elimination, space vector modulation	4

	Current control of VSI, three level inverter, Different topologies, SVM for 3 level inverter	3
	PWM converter as line side rectifier, current fed inverters with self-commutated devices. Control of CSI	3
2	Different transformations and reference frame theory,	4
	Modeling of induction machines,	2
	Voltage fed inverter control-v/f control, vector control,	2
	Direct torque and flux control (DTC)	2
3	Modeling of synchronous machines	2
	Open loop v/f control, vector control	3
	Direct torque control, CSI fed synchronous motor drives.	3
4	Introduction to various PM motors, BLDC and PMSM drive configuration,	2
	Comparison, block diagrams,	2
	Speed and torque control in BLDC and PMSM	2
5	Evolution of switched reluctance motors,	2
	Various topologies for SRM drives, comparison	2
	Closed loop speed and torque control of SRM.	2

****

List of OEC-I

OEE-433	Non-Conventional Energy Sources	3L: 0T: 0P	3 Credits	Course Type: OEC

Preamble: 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: Basic Electrical Engineering, Engineering Mathematics, Engineering Physics

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

COs	Course Outcomes	Bloom's Level
CO1	Able to understand energy, demand and supply issues	Remembering, Understanding
CO2	Able to found energy solutions	Understanding, Applying,
CO3	Demonstrate fundamental understanding of non-conventional resources	Analysing, Evaluating
CO4	Develop the mathematical model of energy systems	Understanding, Analysing, Applying
CO5	Exhibit the knowledge of MHD, Solar and Wind	Understanding, Remembering, Analysing, Applying
CO6	Exhibit the knowledge of Geothermal and OTEC	Remembering, Understanding

Mapping with Programme Outcomes:

COs	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
Avg.	2.0	1.5	1.5	0.8	0.8	2.5	1.3	0.2	1.2	0.2	1.0	2.5

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

Course Outcome 1:

1. Write a technical note on Power Crisis.
2. Describe role of Private sectors in energy management.
3. What is magnitude and nature of energy demand in our country?

Course Outcome 2:

1. What are various sources of energy?
2. What are various models for optimal utilization of energy?
3. What are various solutions for meeting deficiency in energy generation / supply?

Course Outcome 3:

1. Compare conventional and non-conventional energy resources.
2. List various types of non-conventional energy resources.
3. Discuss various causes of moving from conventional to non-conventional energy resources.

Course Outcome 4:

1. Discuss Law of Conservation of Energy.
2. What is Law of Conservation of Mass?
3. Mathematically show that mass transfer is related to energy flow in a system.

Course Outcome 5:

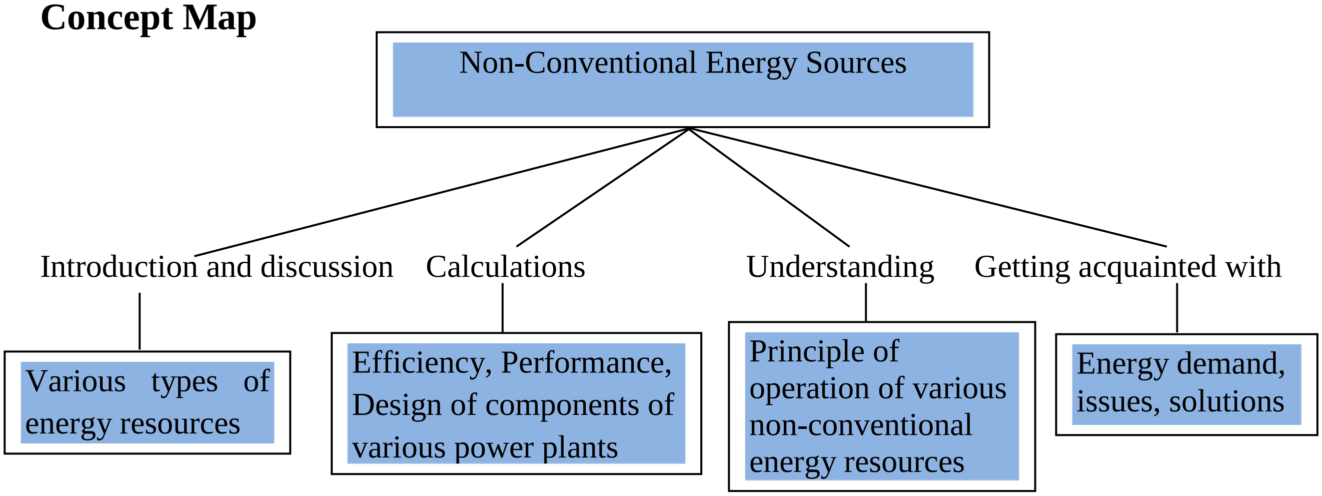
1. Explain working principle of MHD generation. Differentiate between open and closed cycles of MHD generation with the help of relevant schematics and diagrams.
2. How conversion of solar heat to electricity happens?
3. Explain various types of wind turbines. A wind turbine travels with the speed is 10 m/s and has a blade length of 20 m. Determine the wind power.

Course Outcome 6:

1. List advantages of Geothermal energy.
2. Discuss OTEC.

3. A Tidal Power Plant has a reservoir of area $100 \times 10^6\ m^2$. The tide has tidal range of 8 m. The turbine can be operational with a head of 2 m or more. The turbine generator has efficiency of 75%. Estimate the total power in one filling and employing cycle.

Concept Map



Syllabus

Module 1: Power Situation (7 Lectures):

Power Crisis, future energy demand, role of Private sectors in energy management.

Module 2: MHD generation (7 Lectures):

Working principle, open and closed cycles, MHD systems, advantages, parameters governing power output.

Module 3: Solar Power and Wind Energy (10 Lectures):

Solar power plant: Conversion of solar heat to electricity, Solar energy collectors, Photovoltaic cell, power generation, future prospects of solar energy use, Wind Energy: Windmills, power output with combined operation of wind turbine generation and isolated generating system, technical choices& economic size.

Module 4: Geothermal Energy (8 Lectures):
Earth energy, heat extraction, vapour turbine cycle, difficulties & disadvantages; Tidal energy: Tidal phenomenon, tidal barrage, tidal power Schemes.

Module 5: Ocean Thermal Energy and Case Studies based on Solar, Wind and Geothermal Power Plants (8 Lectures):

Introduction, energy conversion, case studies.

Text Books / Reference Books:

1. Sawhney G. S., “Non-Conventional Energy Resources”, Prentice Hall of India.
2. Khan B. H., Non-Conventional Energy Resources, Mc Graw Hill Education 3rd edition.
3. Singal R. K., Non-Conventional Energy Resources, S. K. Kataria & Sons, 2009.
4. Deb Tanmoy, "Electrical Power Generation Conventional and Renewable", Khanna Publisher.
5. Bansal N. K., Non-Conventional Energy Resources, Vikas Publishing House.
6. Saeed S. H. and Sharma D. K., Non-Conventional Energy Resources (2nd Edition), S. K. Kataria & Sons, 2009.

Course Contents and Lecture Schedule

Module No.	Topic (s)	No. of Lectures
1	Power Crisis, future energy demand,	3
1	Role of Private sectors in energy management	4

2	Working principle, open and closed cycles, MHD systems, advantages, parameters governing power output	4
2	MHD systems, advantages, parameters governing power output	3
3	Solar power plant: Conversion of solar heat to electricity, Solar energy collectors, Photovoltaic cell, power generation, future prospects of solar energy use	5
3	Wind Energy: Windmills, power output with combined operation of wind turbine generation and isolated generating system, technical choices& economic size	5
4	Earth energy, heat extraction, vapor turbine cycle, difficulties & disadvantages	4
4	Tidal energy: Tidal phenomenon, tidal barrage, tidal power Schemes	4
5	Introduction, energy conversion, case studies	8

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OEE-435	Power Plant Engineering	3L: 0T: 0P	3 Credits	Course Type: OEC

Preamble:

This course will provide a good understanding and hold to the students in the area of power plants. 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 this course, students will be able to:

COs	Course Outcomes	Bloom's Level
CO1	Able to know about various components of power plants	Remembering, Understanding
CO2	Able to calculate capital costs, operation costs, various factors, tariffs, power factor corrections, power output and power plant economics	Understanding, Applying, Analysing
CO3	Evaluating various aspects of power plants , sub-stations, power factor corrections and power plant economics	Analysing, Evaluating
CO4	Understand various aspects of power plant economics and their effects on power plant performance	Understanding, Analysing,
CO5	Able to do basic mechanical and electrical design calculations of some devices of power plants	Understanding, Analysing, Applying
CO6	Able to identify various aspects of non-conventional energy resources	Remembering, Understanding

Mapping with Programme Outcomes

COs	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
Avg.	3.0	1.3	1.2	0.7	0.8	1.8	1.0	0.0	1.2	0.0	1.2	2.5

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

Course Outcome 1:
1. What do you understand by energy? What are its different types?
2. Briefly describe sub-station in electrical power system.
3. Explain Principle of OTEC.

Course Outcome 2:
1. Find the power density at the blades and speed required to generate power by the Wind Turbine with 30% efficiency, if required Wind Turbine output is 120 Watts/m^2. Assume other standard values if any, as required in calculation.
2. An industrial load consists of (i) a synchronous motor of 100 metric h.p. (ii) induction motors aggregating 200 metric h.p. , 0.707 p.f. lagging and 82% efficiency and (iii) lighting load aggregating 30 kW.
The tariff is Rs.100 per annum per kVA maximum demand plus 6 paise per kWh. Find the annual saving in cost if the synchronous motor operates at 0.8 p.f. leading, 93% efficiency instead of 0.8 lagging at 93% efficiency.
3. Derive expression for sinking fund method of depreciation.
4. A transformer costing Rs 90,000/- has a useful life of 20 years. Determine the annual depreciation charge using straight line method. Assume the salvage value of the equipment to be Rs 10,000/-.

Course Outcome 3:
1. What are various methods of power factor correction?
2. Discuss general layout of a nuclear power plant.
3. A generating station has an installed capacity of 50,000 kW and delivers 220×10^6 units per annum. If the annual fixed charges are Rs 160/- per kW installed capacity and running charges are 4 paise per kWh, determine the cost per unit generated.

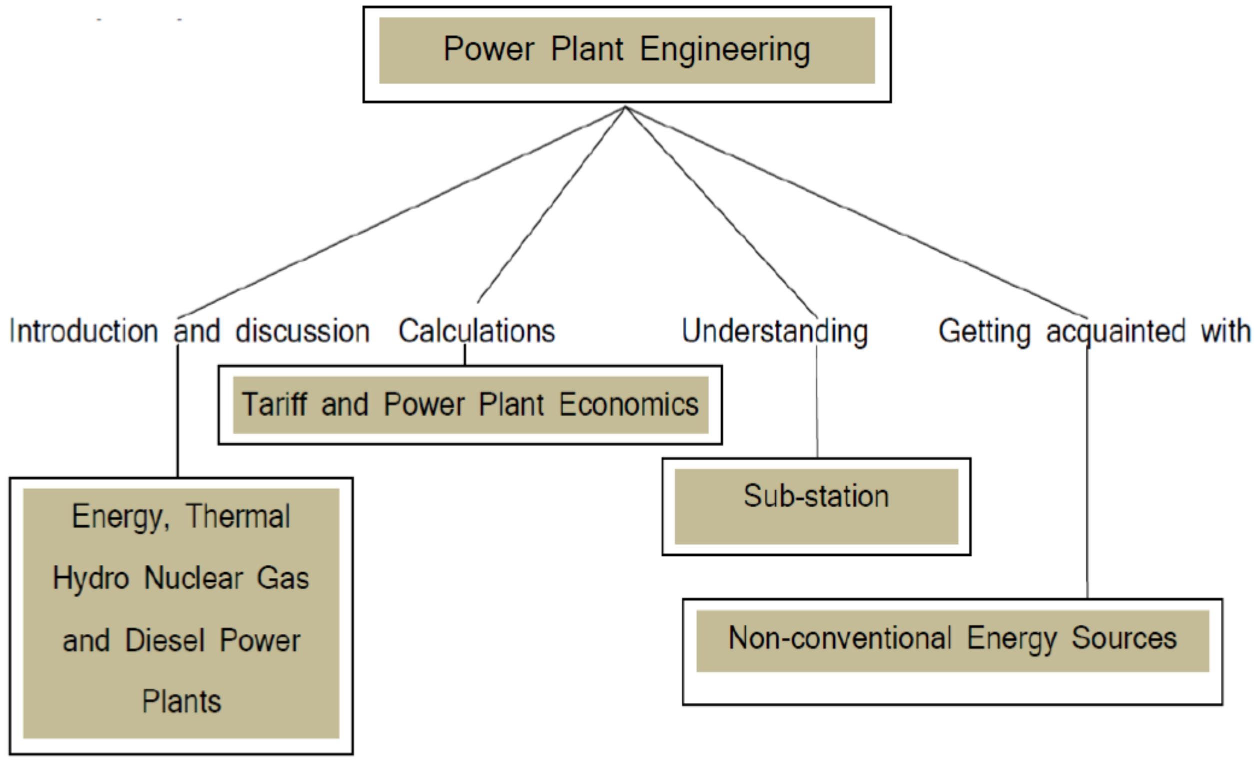
Course Outcome 4:
1. What is effect of low power factor on cost of energy generation in the case of conventional power plants?
2. The annual working cost of a power station is represented by the formula Rs (a + b kW + c kWh) where the various terms have their usual meaning. Determine the values of a, b and c for a 60 MW station operating at annual load factor of 50% from the following data :
(i) Capital cost of building and equipment is Rs 5×10^6
(ii) The annual cost of fuel, oil, taxation and wages of operating staff is Rs 9,00,000/-
(iii) The interest and depreciation on building and equipment are 10% per annum
(iv) Annual cost of organisation and interest on cost of site etc. is Rs 5,00,000/-.
3. What are different types of tariff systems?

Course Outcome 5:
1. Derive expressions for power output calculations in the case of a hydroelectric power plant.
2. Differentiate different types of turbines on the basis of their working principle, mechanical designs and construction.
3. What are roles of air pre-heater and economisers in the case of thermal power plants?

Course Outcome 6:

1. Find the power density at the blades and speed required to generate power by the Wind Turbine with 30% efficiency, if required Turbine output is 120 Watts/m2. Assume other standard values if any, as required in this calculation.
2. With the help of neat sketches, explain "Seeded Inert Gas MHD System.
3. Explain MPPT in the case of solar and wind energy power plants.

Concept Map



Syllabus:

Module 1: Introduction, Thermal Power Plant and Hydro Electric Plants (7 Lectures):
Introduction, Electric energy demand and growth in India, Electric energy sources; **Thermal Power Plant:** general layout and operation of plant; **Hydro Electric Plants:** general layout and operation of Plants.

Module 2: Nuclear Power Plant, Gas Turbine Plant and Diesel Power Plant (7 Lectures):
Nuclear Power Plant: general layout and operation of plant; Gas Turbine Plant: Operational principle & its efficiency; Diesel Plants: Diesel plant layout, components & their functions.

Module 3: Power Plant Economics and Tariffs (8 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; Causes and effects of low power factor, advantages of power factor improvement, and different methods for power factor improvements.

Module 4: Sub-stations Layout and Economic Operation of Power Systems (8 Lectures):
Types of substations, layout of substation; Economic Operation of Power Systems: Characteristics of steam and hydro-plants, Constraints in operation, Economic load scheduling of thermal plants, Penalty factor.

Module 5: Non-Conventional Energy Sources (10 Lectures):
Power Crisis, Role of Private sectors in energy management; **MHD generation:** Working principle, open and closed cycles, advantages; **Solar power plant:** Solar energy collectors, Photovoltaic cell operation; **Wind Energy:** Windmills, power output; **Geothermal Energy:** Earth energy extraction, difficulties & disadvantages; **Tidal Energy:** Tidal phenomenon, tidal power Schemes; **Ocean Thermal Energy:** Introduction, energy conversion.

Text Books
1. B.R. Gupta,"Generation of Electrical Energy", S. Chand Publication.
2. Soni, Gupta & Bhatnagar, "A text book on Power System Engg.", Dhanpat Rai & Co.
3. Sawhney G. S., "Non-Conventional Energy Resources", Prentice Hall of India.

Reference Books
1. W. D. Stevenson, "Elements of Power System Analysis", McGraw Hill.
2. S. L. Uppal, "Electrical Power", Khanna Publishers.
3. Khan B. H., "Non-Conventional Energy Resources", McGraw Hill Education 3rd edition.

Course Contents and Lecture Schedule

Module No.	Topic(s)	No. of Lectures
1	Introduction, Electric energy demand and growth in India, Electric energy sources	2
1	Thermal Power Plant: general layout and operation of plant	3
1	Hydro Electric Plants: general layout and operation of plants	2
2	Nuclear Power Plant: general layout and operation of plant	2
2	Gas Turbine Plant: Operational principle & its efficiency	2
2	Diesel Plants: Diesel plant layout, components & their functions	3
3	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	4
3	Objectives and forms of Tariff; Causes and effects of low power factor, advantages of power factor improvement, different methods for power factor improvements.	4
4	Types of substations, layout of substation, Economic Operation of Power Systems	4
4	Characteristics of steam and hydro-plants, Constraints in operation, Economic load scheduling of thermal plants, Penalty factor	4
5	Power Crisis, Role of Private sectors in energy management	1
5	MHD generation: Working principle, open and closed cycles, advantages,	2
5	Solar power plant: Solar energy collectors, Photovoltaic cell operation	2
5	Wind Energy: Windmills, power output	2
5	Geothermal Energy: Earth energy extraction, difficulties & disadvantages, Tidal energy: Tidal phenomenon, tidal power Schemes, Ocean Thermal Energy: Introduction, energy conversion	3

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List of OEC-II

OEE-444	Industrial Measurements	3L: 1T: 0P	4 Credits	Course Type: OEC

Preamble:
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:

COs	Course Outcomes	Bloom's Level
CO1	Able to know about industrial measurements	Remembering, Understanding
CO2	Able to understand and apply knowledge about electrical transducers	Understanding, Applying,
CO3	Demonstrate fundamental understanding of telemetry system	Analysing, Evaluating
CO4	Develop Data Acquisition System	Understanding, Analysing
CO5	Exhibit the knowledge of Display Devices and Recorders	Understanding, Analysing, Applying
CO6	Exhibit the knowledge of computer aided measurements	Remembering, Understanding

Mapping with Programme Outcomes:

COs	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
Avg.	2.0	1.3	1.2	0.7	1.0	2.0	1.0	0.3	1.5	0.2	1.0	2.0

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

Course Outcome 1:
1. What do you understand by measurement?
2. Briefly describe general components of a measurement device.
3. What is importance of calibration? How it is done?

Course Outcome 2:
1. Differentiate sensor and transducer.
2. List various electrical transducers used for industrial measurements.
3. What are static and dynamic characteristics of electric transducers?

Course Outcome 3:
1. Explain a General Telemetry System.
2. What are design differences of a receiver and a transmitter?
3. Explain land line and radio frequency telemetering system.

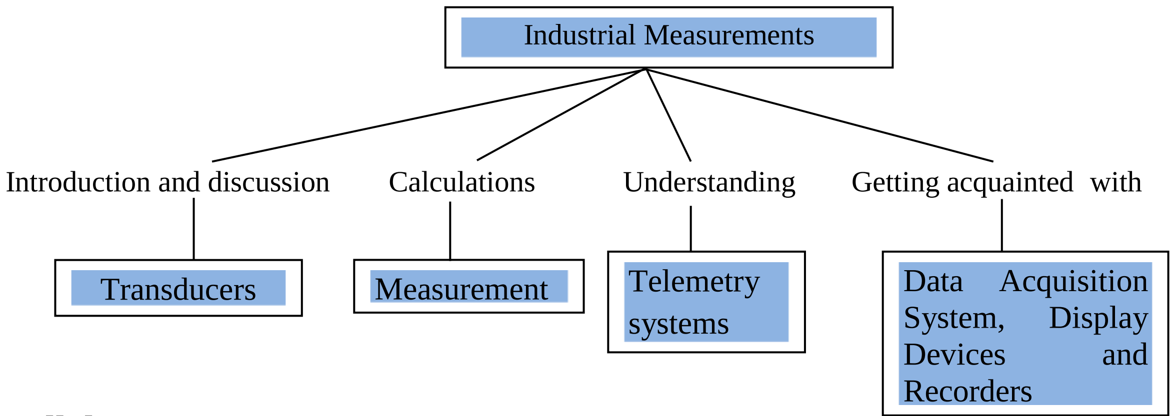
Course Outcome 4:
1. Differentiate between analog and digital data acquisition systems.

2. Differentiate between the Active and Passive Filters?
3. Describe in brief the working of Instrumentation Amplifier.

Course Outcome 5:
1. What is principle of operation of storage oscilloscope?
2. Give applications of spectrum analyzer.
3. Make a detailed comparison of magnetic tape and digital tape recorders.

Course Outcome 6:
1. How computer helps in measurement process?
2. Take a case study, and explain implementation of computer aided measurement process in it.
3. How, earlier measurements (prior to computer) were carried out?

Concept Map



Syllabus

Module 1: Measurement - I (9 Lectures):
Definition, advantages, classification, characteristics, factors affecting the choice of transducers, Potentiometers, Strain gauges, Resistance thermometer, Thermistors, Thermocouples, LVDT, RVDT.

Module 2: Measurement - II (10 Lectures):
Capacitive, Piezoelectric, Hall Effect and Opto-electronic transducers, Measurement of Motion, Force, Pressure, Temperature, Flow and Liquid level.

Module 3: Telemetry (5 Lectures):
General Telemetry System, Land line & Radio frequency Telemetering system, Transmission Channels and Media, Receiver & Transmitter.

Module 4: Signal Conditioning and Data Acquisition System (6 Lectures):
Signal conditioning, Active Filters, Instrumentation amplifiers, logarithmic amplifiers, Isolation Amplifiers, Analog Data Acquisition System and Digital Data Acquisition System.

Module 5: Display Devices and Recorders (10 Lectures):
Display devices, storage oscilloscope, spectrum analyzer, strip chart & X-Y recorders, Magnetic tape & Digital tape recorders. Recent Developments: Computer aided measurements, Fibre optic transducers, Microprocessors, 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.

Course Contents and Lecture Schedule

Module No.	Topic(s)	No. of Lectures
1	Definition, advantages of electrical transducers, classification, characteristics	2
1	Factors affecting the choice of transducers, Potentiometers, Strain guages	3
1	Resistance Thermometer, Thermistors, Thermocouples, LVDT, RVDT	4
2	Capacitive, Piezoelectric, Hall effect and Opto electronic transducers,	5
2	Measurement of Motion, Force, Pressure, Temperature, Flow and Liquid level	5
3	General telemetry system, Land line & Radio Frequency Telemetering system	3
3	Transmission Channels and media, Receiver & Transmitter	2
4	Signal conditioning, Active filters, Instrumentation amplifiers, Logarithmic amplifiers, Isolation amplifiers	4
4	Analog Data Acquisition System and Digital Data Acquisition System	2
5	Display Devices, Storage oscilloscope, Spectrum analyzer, Strip chart & X-Y recorders, Magnetic tape & Digital tape recorders	6
5	Recent Developments: Computer aided measurements, Fibre optic transducers, Microprocessors, Smart sensors, Smart transmitters	4

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OEE-446	Industrial Control Systems	3L: 1T: 0P	4 Credits	Course Type: OEC

Preamble:

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

COs	Course Outcomes	Bloom's Level
CO1	Able to understand industrial issues related to the control system	Remembering, Understanding
CO2	Able to control solutions	Understanding, Applying,
CO3	Demonstrate fundamental understanding of optimal control	Analysing, Evaluating
CO4	Exhibit the knowledge of Digital Computer Based Control Systems	Understanding, Remembering, Analysing, Applying
CO5	Exhibit the knowledge of Microprocessor and Microcontroller Based Control Systems	Understanding, Remembering, Analysing, Applying
CO6	Exhibit the knowledge of Artificial Intelligence Based	Understanding,

	Control Systems	Remembering, Analysing, Applying

Mapping with Programme Outcomes

COs	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	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
Avg.	2.0	1.5	1.5	0.8	0.8	2.5	1.7	0.2	1.2	0.2	1.0	2.5

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

Course Outcome 1:

1. Discuss layout of a control system.
2. How controller design is done?
3. How controller tuning design is done?

Course Outcome 2:

1. Discuss P, I and D controls.
2. How optimal controllers are designed?
3. Why control fails?

Course Outcome 3:

1. Discuss Pontryagin’s Minimum Maximum Principle.
2. What is Linear Quadratic Problem-Hamilton Jacobi equation? How it is formed?
3. Discuss Riccati equation and its solution.

Course Outcome 4:

1. Discuss General architecture and brief description of elements of digital computer.
2. Explain bus size and signals.
3. How digital computer based controller design is done?

Course Outcome 5:

1. Differentiate between a microprocessor and a microcontroller.
2. Discuss microprocessor and microcontroller architectures and operations.
3. How controller design is done using microprocessor?

Course Outcome 6:

1. Explain Fuzzy Logic.
2. Explain Neural Networks.
3. Explain Genetic Algorithms.

Syllabus

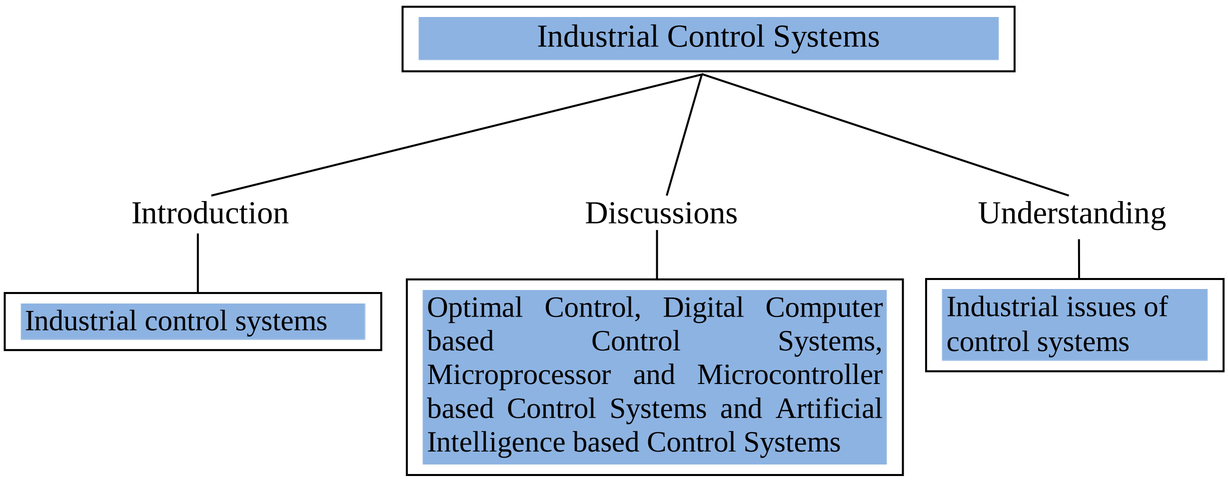
Module 1: Introduction (6 Lectures):

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 (9 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.

Concept Map



Module 3: Digital Computer Based Control Systems (10 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 (8 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 (7 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.

Course Contents and Lecture Schedule

Module No.	Topic(s)	No. of Lectures
1	Design specifications of second order systems: Derivative error, derivative output, integral error and PID compensations	4

1	Design considerations for higher order systems, performance indices	2
2	Introduction, formation of optimal control problem, calculus of variations minimization of functions, constrained optimization	4
2	Pontryagin's Minimum Maximum Principle, Linear Quadratic Problem-Hamilton Jacobi equation, Riccati equation and its solution	5
3	Digital Computers: General architecture and brief description of elements, instruction execution, instruction format, and instruction set, addressing modes, programming system, higher level languages.	6
3	Buses and CPU Timings: Bus size and signals, machine cycle timing diagram, instruction timing, processor timing, Controller design.	4
4	Evolution of Microprocessor and Microcontroller, Microprocessor and Microcontroller architecture and its operations.	4
4	Memory, inputs-outputs (I/Os), data transfer schemes interfacing devices, Controller Design.	4
5	Fuzzy Logic, Neural Networks, Genetic Algorithm, AI based Controller Design.	4
5	Genetic Algorithm, AI based Controller Design	3