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

Course Structure & Syllabi

M. Tech. in Power Electronics & Control

(Effective from the Academic Session 2023-24 for new entrants)

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

M. Tech. in Power Electronics and Control

Course Structure and Evaluation Scheme

[Effective from the Academic Session: 2023-24 as per NEP]

I Year I Semester

Sl. No	Course Type	Course code	Course title	Credits	Sessional Marks				ESM	Total Marks
					MSE	TA	Lab	Total		
1.	PCC	NEE501	Advanced Control Systems	4(3-0-2)	15	20	15	50	50	100
2.	PCC	NEE503	Applied System Theory	4(3-1-0)	30	20	-	50	50	100
3.	PCC	NEE505	Advanced Power Electronics	4(3-1-0)	30	20	-	50	50	100
4.	PEC-I	NEE-	Please refer list of PEC-I	4(3-1-0)	30	20	-	50	50	100
Total Credits				**16**						

I Year II Semester

Sl. No	Cours e Type	Course code	Course title	Credits	Sessional Marks				ESM	Total Marks
					MSE	TA	Lab	Total		
1.	PCC	NEE-502	Digital Control System	4(3-1-0)	30	20	-	50	50	100
2.	PCC	NEE-504	Power Quality and FACTS	4(3-1-0)	30	20	-	50	50	100
3.	PCC	NEE-506	Instrumentation and Process Control	4(3-1-0)	30	20	-	50	50	100
4.	PEC-II	NEE	Please refer list of PEC-II	4(3-1-0)	30	20	-	50	50	100
Total Credits				**16**						

II Year III Semester

Sl. No	Course Type	Course code	Course title	Credits	Sessional Marks				ESM	Total Marks
					MSE	TA	Lab	Total		
1.	PCC	NEE	Seminar	2(0-0-4)	-	50	-	50	50	100
2.	PCC	NEE	Industrial Training	2(0-0-4)	-	50	-	50	50	100
3.	PCC	NEE	Dissertation-I	12(0-0-24)	-	50	-	50	50	100
Total Credits				**16**						

* Industrial training / Minor Project (during summer vacation after completion of First Year)

II Year IV Semester

Sl. No	Cours e Type	Course code	Course title	Credits	Sessional Marks				ESM	Total Marks
					MSE	TA	Lab	Total		
1.	PCC	NEE	Dissertation-II	16 (0-0-32)	-	50	-	50	50	100
Total Credits				**16**						
Total Credits of the M.Tech Programme: 64										

***The distribution of credits may be decided by the departments**

* For courses without lab component, there will be two class tests of 15 marks each (one based on theory and the other based on the laboratory)

A) Salient Features (Pertaining to NEP)

a) Students may register for 25% of the courses (2 numbers out of 8) in online mode.

b) The students shall have to undergo industrial training of 4-6 weeks after the completion of 2nd semester.

c) Provision of Multi entry and multi-exit

B) Multi-exit (grant of "PG Diploma" after completion of one year)

a) The M.Tech Students who complete the **coursework (32 credits)** and a **"minor project"** up to 2nd semester will be eligible for the grant of a "**PG Diploma".**

C) Multi-entry and exit (Grant of M.Tech degree after completion of 1 year)

Mode 1 (candidates with B.Tech (H) from HBTU Kanpur)

The undergraduate students of HBTU Kanpur, with a B.Tech (Hons) (who have completed 20 additional credits in the field of M.Tech specialization offered by their department). These 20 credits are to be earned over and above the 180 credits required for the award of a B.Tech degree.

If such candidates take admission in the M.Tech programme of the same specialization, they would be given a relaxation of 20 credits in the M.Tech course work. In such case, the students will have to earn only the remaining 44 credits i.e. 64-20 = 44. A possible option to earn these 44 credits could be as follows:

Dissertation: 32 credits

Seminar: 2 credits

Industrial Training: 2 credits (or 2/4 credit coursework in offline/online mode)

Courses: 8 credits (02 courses of 4 credits each) (These could be done in offline/online mode)

Candidates admitted through Mode 1, would be eligible for getting their M.Tech degree in 1 yr period. Depending upon the option of 2/4-credit coursework / 2-credit industrial training exercised by the student, he/she will be eligible for the grant of "**M.Tech Degree**" after 1 year or 1 yr and 6 weeks.

Mode 2 (candidates with B.Tech "Major" in one branch and a "Minor" in another from HBTU Kanpur)

a) The undergraduate students of HBTU Kanpur, with a major in one branch and a minor in another (thereby implying that they have already earned 20 credits for getting that minor)- Such candidates, if admitted to the M.Tech programme in specialization related to the field of "minor" would be eligible for a relaxation of 20 credits in the coursework. In such case, the students will have to earn only the remaining 44 credits i.e. 64-20 = 44. A possible option to earn these 44 credits could be as follows:

Dissertation: 32 credits

Seminar: 2 credits

Industrial Training: 2 credits (or 2/4-credit coursework in offline/online mode)

Courses: 8 credits (02 courses of 4 credits each) (These could be done in offline/online mode)

Candidates admitted through Mode 2, would be eligible for getting their M.Tech degree in 1 yr period. Depending upon the option of 2/4 credit coursework / 2-credit industrial training exercised by the student, he/she will be eligible for the grant of "M.Tech Degree" after 1 year or 1 yr and 6 weeks.

LIST OF PROGRAMME ELECTIVE COURSES-I (PEC-I)

Sl. No.	Course Code	Course Title
1.	NEE-507	Modeling and Simulation in Electrical Engineering
2.	NEE-509	Non-conventional Energy Sources
3.	NEE-511	Electrical and Hybrid Vehicles
4.	NEE-513	Special Electrical Machines

LIST OF PROGRAMME ELECTIVE COURSES-II (PEC-II)

Sl. No.	Course Code	Course Title
1.	NEE-508	Neural Network and Fuzzy Systems
2.	NEE-510	Data Science and Machine Learning
3.	NEE-512	Advanced Electric Drives
4.	NEE-514	High Power Converters

I Semester

NEE-501	Advanced Control Systems	3L: 0T: 2P	4 Credits	Course Type: PCC

Objective:

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

Prerequisites: Engineering Mathematics, EMMI, Control Systems.

Course Outcomes:

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

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

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

Course Articulation Matrix (CO-PO Matrix):

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

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

Course Content:

Module 1

State Space Analysis of Continuous System: (6 Lectures)
Review of state variable representation of continuous system, State transition matrix, Solution of state equation, Concept of Controllability and Observability, Design of state observer and controllers.

Module 2

Analysis of Discrete System: (6 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 and hold circuit, solution of state difference equations, stability on the z-plane and Jury stability criterion, bilinear transformation.

Module 3

Analysis of Non-linear Systems: (6 Lectures)
Lyapunov's stability theorems, Methods for generating Lyapunov functions. Phenomena related to non-linear systems. Analysis of non-linear systems-Linearization method. second order non-linear system on the phase plane. singular points. system analysis by phase-plane method.

Module 4

Optimal Control: (6 Lectures)
Introduction, formation of optimal control problem, Calculus of variations, minimization of functions, Linear Quadratic Problem-Hamilton Jacobi equation, Riccati equation and its solution.

Module 5

Adaptive Control: (6 Lectures)
Introduction, Modal reference adaptive control systems, Self tuning regulators, Controller design Using MATLAB tool box.

List of Experiments:

Perform minimum eight of the given experiments:

1. Write a MATLAB program for finding State Transition matrix for a given state space model
2. Write a MATLAB program for finding controllability and observability for a given state space model
3. Write a MATLAB program for conversion of state variable to transfer function model and vice-versa, for a given system
4. Design a linear quadratic regulator (LQR) using MATLAB for a given system
5. Design a MRAC based Adaptive controller using MATLAB for a given system
6. Design a self tuning regulator using MATLAB for a given system
7. Design a pole placement controller using MATLAB for a given system
8. Design an Observer based controller using MATLAB for a given system
9. Design neural network based controller using NN Toolbox of MATLAB
10. Discretize a given continuous-time system using bilinear transformation using MATLAB.

Text Books 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" NewAge International.
3. Yaduvir Singh & S. Janardhanan, "Modern Control Engineering", Cengage Learning
4. S.Rajasekaran & G.A.Vjayalakshmi Pai, "Neural Networks, Fuzzy Logic and GeneticAlogorithms: Synthesis and Applications" Prentice Hall of India.

Reference Books:

1. Donald E. Kiv, "Optimal Control Theory: An Introduction" Prentice Hall
2. B.C. Kuo, "Digital Control Systems" Sounders College Publishing
3. C.H.Houpis and G.B.Lamont, "Digital Control Systems: Theory, Hardware, Software". McGraw Hill.

NEE-503	Applied System Theory	3L:1T:0P	Credits: 4	Course Type: PCC

Course Objectives:

1.To understand the basics of Eigen values and Eigenvectors, Vector and matrix norms, Singular value decomposition.
2.To study the various optimization techniques.
3.To study few model order reduction methods to get simplified dynamic systems.
4.To study the design of PID/IMC by tuning and optimization methods.
5.To study about fuzzy set theory, fuzzy controller and case studies using MATLAB.

Course Outcomes:

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

CO1	Understand Eigen values, Eigen vectors, diagonalization of a matrix, SVD and definiteness	K1, K2, K4
CO2	Apply engineering optimization methods to solve engg. problems	K3, K2
CO3	Understand and apply MOR methods for large scale systems	K2, K3
CO4	Understand industrial PID controller issues and remedies & IMC	K2, K5, K6
CO5	know fuzzy set theory, Fuzzy controller & Matlab tools	K1, K3, K5

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

Course Articulation Matrix (CO-PO Matrix):

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

1: Slight (low), 2: Moderate (Medium), 3: Substantial (High), For no correlation put '-'

Module 1

Introduction: (7 Lectures)

Eigen values and Eigen vectors, properties of Eigen values, Modal matrix, Diagonalization of a matrix, Definiteness of a matrix: positive, negative and semi-definite matrix. Singular value decomposition (SVD).

Module 2

Engineering Optimization Methods: (10 Lectures)
Introduction to Optimization: Engineering applications of Optimization – Statement of an Optimization problem. Nonlinear Programming Unconstrained Optimization: Introduction, Univariate Method-Pattern Directions-Hooke and Jeeves's Method, Indirect Search Methods-Gradient of a function-Steepest Descent Method-Conjugate Gradient Method-Newton's Method. Nonlinear Programming Constrained Optimization: Evolutionary Optimization Techniques: Genetic Algorithm (GA).

Module 3

Model Order Reduction Methods: (8 Lectures)

Reduced Order Models, Reduced Order Modelling Problem in time domain and frequency domain, necessity for model reduction, application of reduced order models algebraic reduction methods, different reduction methods in frequency domain & Time domain, stable reduction methods. Analytical and graphical methods for comparison

Module 4

Industrial PID and IMC Controllers: (8 Lectures)

Industrial series and parallel PID controllers, Process loop issues, PID Controller implementation issues: proportional kick, derivative kick, bandwidth limited derivative control, Integral windup, Reverse acting controller, Internal model control (IMC).

Mdule 5

Fuzzy Controller and Case studies: (7 Lectures)

Introduction to fuzzy set theory, Fuzzy controllers, Case Studies: Application of MATLAB to design PID/IMC controller, Design of fuzzy controller and use of GA tool of MATLAB.

Text/ Reference Books:

1. Dilip K. Pratihar: Soft Computing. Narosa Publishing House, 2015.
2. K. Ogata: Modern Control Engineering. Prentice-Hall.
3. B. C. Kuo: Automatic Control System, McGrawHill.
4. S.S. Rao: Engineering Optimization, New Age International, 2012.

NEE-505	**Advanced Power Electronics**	**3L:1T:0P**	**Credit: 4**	**Course type: PCC**

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

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

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

Course Articulation Matrix (CO-PO Matrix):

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

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

Course content:

Module 1

Review of Power Semiconductor Devices and Converters: (8 Lectures)

Review of Power diodes and SCR; Modern semiconductor devices: MOSFET, GTO, IGBT, GTO operating characteristics; driving circuits and protection, Review of Power Converters.

Module 2

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

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

Module 3

DC-AC Inverters (8 Lectures)

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

Module 4

AC-DC Rectifiers (8 Lectures)

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

Module 5

AC-AC Conversion (8 Lectures)

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

Text / References Books:

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

N. Mohan and T. M. Undeland, "Power Electronics: Converters, Applications and Design",JohnWiley & Sons, 2007.R. W. Erickson and D.Maksimovic,"Fundamentals of Power Electronics", SpringerScience & Business Media, 2007.

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

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

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

IEEE Journal Papers

LIST OF PROGRAMME ELECTIVE COURSE-I (PEC-I)

Sl. No.	Course Code	Course Title
1	NEE-507	Modeling and Simulation in Electrical Engineering
2	NEE-509	Non-conventional Energy Sources
3	NEE-511	Electrical and Hybrid Vehicles
4	NEE-513	Special Electrical Machines

NEE-507	Modeling and Simulation in Electrical Engineering	3L:1T:0P	4 Credits	Course Type: PEC

Objective:
This course will provide a good understanding and hold to the students in the area of modeling and simulation. The course includes the process of modeling and simulation of various engineering systems.
Prerequisites: Engineering Mathematics, Engineering Physics, Basic Electrical Engineering and Electrical Circuit Analysis.

Course Outcomes:

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

CO1	Know the definition of system, model, and variables of the model	K1, K2
CO2	Perform modeling and simulation of distillation column, Stirred tank reactor, Heat exchanger.	K2, K3, K4
CO3	Perform modeling of DC machine, Single and Three-phase transformer.	K2, K3, K4
CO4	Perform modeling and simulation of power electronics converters and Inverters	K2, K3, K4
CO5	Introduction to ANN	K2, K3
CO6	Development of ANN models using MATLAB	K2, K3, K4

Course Articulation Matrix (CO-PO Matrix):

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

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

Course Content:

Module I: (8 Lectures)
Introduction: Physical system, model, input and output variables, State variables; Static and Dynamic systems/models; Hierarchy of knowledge about a system and Modeling Strategy. Transfer functions and State models.

Module II: (8 Lectures)
Introduction to 1^{st} and 2^{nd} order transfer function, Modeling and simulation of Different processes and study of dynamics: Continuous Stirred Tank Reactor, Mixing Process, Mass-spring-damper system, One and Two-tank System.

Module III: (8 Lectures)
Modeling of electric machines: DC shunts motors and generators, Simplex Lap and Wave Windings, 1-phase transformer, 3-phase transformer.

Module IV: (8 Lectures)
Modeling and simulation of power electronics converters: AC/DC rectifier, choppers, Inverters, Cycloconverters.

Module V: (8 Lectures):
Introduction to Artificial Neural Network, Development of ANN models of logic gates, Case study using Matlab/ANN tool box.

Text Books:

1. Gordan G., "System Simulation," Prentice Hall of India.
2. Chaturvedi, D. K, "Modelling and Simulation of Systems Using Matlab and Simulink", CRC Press, 2015

Reference Books:

3. Kobayashi H., mark B. L., "System Modeling and Analysis," Pearson Education, Inc, New Delhi.
4. R.P. Das, "Neural Networks & Fuzzy Logics", S.K. Kataria & Sons; 2012th edition

NEE-509	Non-Conventional Energy Sources	3L: 1T: 0P	4 Credits	Course Type: PEC

Objective:

This course on Non-Conventional Energy Sources will provide a good understanding and hold to the students in the area of renewable energy. The course includes understanding of energy generation, conventional and non-conventional resources comparisons, mathematical modeling, performance analyses and its applications.

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

Course Outcomes:

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

CO1	Able to understand energy, demand and supply issues	K1, K2
CO2	Able to find energy control solutions	K2, K3
CO3	Demonstrate fundamental understanding of non-conventional resources, principles of operations, hardware and related software requirements	K2, K3, K4
CO4	Develop deterministic and stochastic mathematical models of energy systems	K2, K3, K4, K5
CO5	Exhibit knowledge of MHD, Solar and Wind, and their applications, Issues and future research	K1, K2, K3, K4
CO6	Exhibit the knowledge of Geothermal and OTEC, and their applications, Issues and future research	K1, K2

Course Articulation Matrix (CO-PO Matrix):

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

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

Course Content:

Module 1

Power Situation: (6 Lectures)

Power crisis, Future energy demand, Role of government and private sectors in energy management. Indian Electricity Act, Energy Planning. Concept of Carbon neutrality.

Module 2

MHD Generation: (8 Lectures)

Working principle, Open and closed cycles MHD systems, Advantages, Parameters governing power output, Case study, Research trends

Module 3

Solar Power and Wind Energy: (12 Lectures)

Solar Power Plant: Conversion of solar heat to electricity, Solar energy collectors, Photovoltaic cell, Maximum Power Point Tracking (MPPT), Case study, Research trends

Wind Energy: Windmills, Power output, Maximum Power Point Tracking (MPPT), Case study, Research trends

Module 4

Geothermal Energy, Tidal Energy, and Wave Energy: (8 Lectures)

Earth energy, Heat extraction, Difficulties, Advantages and Disadvantages, Case study, Research trends

Tidal energy: Tidal phenomenon, Tidal power Schemes, Case study, Research trends

Wave Energy:

Ocean thermal energy conversion, Difficulties, Advantages and Disadvantages, Case study, Research trends

Module 5: (6 Lectures)

Introduction to Energy Storage System

Text Books

1. Sawhney G. S., "Non-Conventional Energy Resources", 2nd Edition, Prentice Hall of India, 2019

2. Khan B. H., "Non-Conventional Energy Resources", 2nd Edition, Mc Graw Hill Education,2017

3. Singhal R. K., "Non-Conventional Energy Resources, 2nd Edition, S. K. Kataria & Sons, 2009

4. D S Chauhan and S K Srivastava, "Non-Conventional Energy Resources", 3rd Edition, New Age International (P) Ltd Publishers, 2012

Reference Books

1. Deb Tanmoy, "Electrical Power Generation Conventional and Renewable", 1st Edition Khanna Publisher, 2018
2. Saeed S. H. and Sharma D. K., "Non-Conventional Energy Resources", 2nd Edition, S. K. Kataria & Sons, 2009
3. Anand Tembulkar and S.P. Meher, "Non-Conventional Energy Sources", 2nd Edition, Kataria, 2013
4. Rajput R. K. , "Non-Conventional Energy Sources and Utilisation", 2nd Edition, S Chand, 2016

NEE-511	Electrical and Hybrid Vehicles	3L: 1T: 0P	4 Credits	Course Type: PEC

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

Prerequisites:
Introduction to Electrical Engineering, Electrical Machines, Power Electronics and Electrical Drives.

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

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

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

Course Articulation Matrix (CO-PO Matrix):

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

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

Course Content:

Module 1

Introduction: (8 Lectures)

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

Module 2

Electric Drive Trains: (8 Lectures)

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

Module 3

Hybrid Electric Drive Trains: (8 Lectures)

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

Module 4:

Electric Propulsion Unit: (8 Lectures)

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

Module 5:

Energy Storage: (8 Lectures)

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

Text Books

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

Reference Book

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

NEE-513	Special Electrical Machines	L T P: 3 1 0	Credits: 4	Type: PEC

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

Prerequisites:
Engineering Mathematics, Electrical Machine - I, Electrical Machine – II
Course Outcomes:
On the successful completion of the course, the students will be able to

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

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

Course Articulation Matrix (CO-PO Matrix):

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

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

Course Content:

Module I

Special AC Machines: (8 Lectures)
Constructional aspects, design and analysis of reluctance, shaded pole, hysteresis, printed circuit, and claw motors, Servomotors and A.C. Tacho - generators, Research Paper(s) Study, Industrial Applications, Local, National and Global needs.

Module II

Devices: (8 Lectures)
Introduction of permanent magnet materials, angled field and axial field devices, cross-field machines, special forms of rotating amplifiers, electromagnetic clutches, coupling and brakes, eddy current devices, Environmental Considerations, Industrial Applications, Local, National and Global needs..

Module 3

Linear Machines: (8 Lectures)
Linear devices and actuators, Linear electric machines: Classification, application, constructional aspects, design and method of analysis of various types, Goodness factor, Industrial Applications.

Module 4

Linear Electric Motors (8 Lectures)
Transverse-edge, entry-end, exit end, short primary, short secondary effects in linear electric motors, Force, energy and power LEMs for low speed medium speed and high speed applications. Electromagnetic levitation and guidance schemes-attraction, repulsion, Industrial Applications.

Module 5

Advanced Motors and Drive Systems: (8 Lectures)
Principle, construction, operation and drive application of Square wave Permanent Magnet (PM) brushless motor drives, sine wave PM brushless motor drives, PM and synchronous reluctance based motors, switched reluctance motors, Energy efficient motors, Research Paper(s) Study, Industrial Applications, Local, National and Global needs.

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

2. T.J.E. Miller, Brushless permanent magnet and reluctance motor drives, Oxford University Press, UK, 2001.
3. S.A. Nasar, Linear induction motor, John Wiley, New York, 2000.

Text Books

1. J. C. Andreas, Energy Efficient Motors, Marcel Dekker, 1994.
2. J.M.P. Murphy, Power Electronics control of AC Drives, Pergamon Press, 1998.

NPTEL web links for Study Material / Course:
https://www.digimat.in/nptel/courses/video/108102156/L01.html

II SEMESTER

NEE-502	Digital Control System	3L:1T:0P	Credit: 04	Course Type: PCC

Course Objectives: The objective of this course is to provide the knowledge about digital signals, z-transform, stability analysis, state space analysis, design and optimization of discrete systems.

Course Outcomes:

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

CO1	Understand the discrete-time signals and z-transform.	K1, K2
CO2	Understand and apply the concepts to design digital control systems.	K1, K2, K3
CO3	Understand and analyze the state space models and create digital control systems.	K1, K2, K4, K6
CO4	Evaluate the stability of discrete time systems.	K1, K3, K5
CO5	Understand and evaluate the optimality of the digital systems.	K1, K2, K5

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

Course Articulation Matrix (CO-PO Matrix):

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

1: Slight; 2: Moderate (medium); 3: Substantial (High); for no correlation '-' put

Course Content:

Module 1
Signal Processing in Digital Control: (8 Lectures)
Basic digital control system, advantages of digital control and implementation problems, basic discrete-time signals, z-Transform and inverse z-Transform, modeling of sample-hold circuit, pulse transfer function, solution of difference equations by z-Transform method.

Module 2
Design of Digital Control Algorithms: (8 Lectures)
Steady-state accuracy, transient response and frequency response specifications, Digital compensator design using frequency response plots and root locus plots.

Module 3
State Space Analysis and Design: (8 Lectures)
State space representation of digital control systems, conversion of state variable models into transfer functions and vice-versa, solution of state difference equations, controllability and observability, Design of digital control system with state feedback.

Module 4
Stability of Discrete Systems: (8 Lectures)
Stability on the z-plane, Jury stability criterion, bilinear transformation, Routh stability criterion on rth plane, Lyapunov's stability in the sense of Lyapunov, Stability theorems for continuous and discrete systems, Stability analysis using Lyapunov's method.

Module 5
Optimal Digital Control: (8 Lectures)
Discrete Euler Lagrange equation, max. min. principle, Optimality and dynamic programming, Different type of problems and their solutions.

Text Books:

1. B.C. Kuo, Digital Control Systems, Oxford University Press, 2nd edition 2012.
2. Madan Gopal, Digital control and State variable Methods, McGraw Hill Education, 4th edition 2017.
3. K. Ogata, Discrete-time Control Systems, Pearson Education India, 2nd edition 2015.
4. Ghosh Arun K., Introduction to Linear and Digital Control Systems, PHI Learning private ltd., 2017.

Reference Books:

1. Robert N. Clark, Control System Dynamics, Cambridge University Press, 1996.
2. V.I. George, Digital Control Systems, Cengage press, 1st edition 2012.
3. Gene F. Franklin, Digital Control Dynamic Systems, Addison-Wesley, 2nd edition 1980.
4. Hugh F. Vanlandingham, Introduction to Digital Control System, Macmillan USA, 1985.

NEE-504	**Power Quality and FACTS**	**3L:1T:0P (Credit- 4)**	**Course Type: PCC**

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

Course Outcomes:

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

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

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

Course Articulation Matrix (CO-PO Matrix):

CO/PO	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	-

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

Course Content:

Module 1

Introduction to Power Quality: (8 Lectures)
Introduction of Power Quality problem, Terms used in Power Quality, loads causing power quality problems (Non-linear loads, Converters and VFD drives), Power Quality Standards (IEEE, IEC and ANSI standards).

Module 2

Reliability of Power Supply: (8 Lectures)
Difference between failures, outages and interruptions – causes of long and short duration Interruptions, Overview of Reliability evaluation, Customer oriented reliability indices (SAIFI, SAIDI, CAIFI, CAIDI, ENS, ASAI etc). and their calculation, Impact of fuse-saving scheme for increasing reliability of feeders, Sources of voltage sag, methods of sag mitigation.

Module 3

Harmonics in Power Supply and its Mitigation: (8 Lectures)
IEEE standards for harmonics in current and voltages, Effect of harmonics on Equipment Performance, Analysis and Design of Single-Phase Passive Shunt and series filters, Introduction to active shunt filters using a Voltage source Converter.

Module 4

Types of FACTS and Compensators: (8 Lectures)
The emergence of 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).

Module 5

Application of FACTS: (8 Lectures)
Application of FACTS devices for power-flow control and stability improvement, Unified Power Flow Controller (UPFC), Control of UPFC, Basic principle of P and Q control, Independent real and reactive power flow control, power quality issues, harmonics and their propagation, active and passive filters.

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.

NEE-506	Instrumentation and Process Control	3L: 1T: 0P	4 Credits	Course Type: PCC

Course Objective:

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.

Course Outcomes:

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

CO1	Able to know about Electrical Transducers	K1, K2
CO2	Able to understand and apply Telemetry and Data Acquisition system	K1, K2
CO3	Able to understand and apply Display devices and Recorders	K1, K2
CO4	Exhibit the knowledge of different Control modes and their application in controlling various processes	K2, K3, K4
CO5	Develop the mathematical model of various Chemical processes.	K2, K3
CO6	Demonstrate fundamental understanding of Process Control	K4, K5

Course Articulation Matrix (CO-PO Matrix):

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

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

Course Content:

Module 1

Electrical Transducers: (8 Lectures)

Definition, Advantages, Classification, Characteristics, Factors affecting the choice of transducers, ADC and DAC, Strain Gauges, LVDT, Capacitive, Piezoelectric, Thermocouples, Hall Effect Transducers, Introduction to wireless sensor networks.

Module 2

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, Power Line Carrier Communication (PLCC), Introduction to Internet of things.

Module 3

Display Devices and Recorders: (8 Lectures)

Display Devices, X-Y Recorders, Vector network analyser, Spectrum Analyzer, Recent Developments: Smart Sensors, Smart Transmitters.

Module 4

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, Introduction to Actuators and Control Valves, Introduction to Mod Bus and RS-485.

Module 5

Advanced Process Control Techniques (8 Lectures)

Advanced Process Control Techniques: Concept of multiloop process controls, analysis and applications of cascade, ratio, Feed forward, override, split-range, selective and Auctioneering Control Systems with multiple loops.

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)

LIST OF PROGRAMME ELECTIVE COURSES-II (PEC-II)

Sl.No.	Course Code	Course Title
1	NEE-508	Neural Network and Fuzzy Systems
2	NEE-510	Data Science and Machine Learning
3	NEE-512	Advanced Electric Drives
4	NEE-514	High Power Converters

NEE-508	Neural Network and Fuzzy Systems	3L:1T:0P (Credit- 4)	Course Type: PEC

Course Objectives: The objective of this course is to provide the knowledge about the fuzzy set theory. fuzzy controller, basics of neural networks, training of various ANN models and Hybrid systems.

Course Outcomes (COs):

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

CO1	Understand the basics of ANN.	K1, K2
CO2	Understand and apply the methods of training for FFNN, FBNN etc.	K1, K3, K6
CO3	Know the theory of fuzzy logic, various operations and membership functions.	K2, K3, K5
CO4	Understand the FLC and apply methods to deisgn FLC and also understand the Fuzzy Clustering	K2, K3, K6
CO5	Apply the concepts to deisgn hybrid systems like GA-Fuzzy, Neuro-Fuzzy and Genetic-Neuro system.	K1, K2, K6

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

CO-PO Mapping Matrix

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

1: Slight; 2: Moderate (medium); 3: Substantial (High); for no correlation '-' put

Course Content:

Module 1
Neural Networks-I (Fundamentals of Neural Networks): (8 Lectures)
Biological Neuron, Artificial Neuron, Activation functions, A layer of Neurons, Multiple layers of neurons, Static vs. Dynamic Networks, training of Neural Networks: supervised learning, Un-supervised learning, Incremental training, Batch Mode of training.

Module 2
Neural Network-II (Neural Networks): (8 Lectures)
Types of neural networks: Feed forward Neural Networks (FFNNs), Recurrent Neural Networks (RNNs), Multi-Layer Feed-Forward Neural Network (MLFFNN), Training of network using back-Propagation algorithm, Perceptron model, solution, single layer artificial neural network, multi layer Perceptron models.

Module 3
Fuzzy Logic-I (Introduction to Fuzzy sets): (8 Lectures)
Introduction to crisp sets and Fuzzy sets, Representation of fuzzy set: discrete and continuous fuzzy sets; membership value/ functions, important terms of fuzzy sets, Operations in fuzzy sets and relations, properties of fuzzy sets, measure of fuzziness and inaccuracy of fuzzy sets.

Module 4
Fuzzy Logic-II (Fuzzy reasoning and Clustering): (8 Lectures)
Introduction to Fuzzy logic controller (FLC), Major forms of FLCs: Mamdani Approach and Takagi and Sugeno's Approach, Hierarchical Fuzzy logic controller, Sensitivity analysis, advantages and disadvantages of FLC, Fuzzy Clustering: fuzzy C-means clustering, entropy-

based fuzzy clustering

Module 5

Hybrid Networks: (8 Lectures)

Fuzzy-Genetic Algorithm, Genetic –Fuzzy System: working principle, Basics of Genetic-Neuro System, Working principle of G-N system, Combined Neural Networks with Fuzzy Logic, Neuro-Fuzzy System working based on Mamdani approach and Takagi & Sugeno's approach.

Text Books:

1. Dilip K. Pratihar, Soft Computing: Fundamentals and Applications, Narosa Publications, edition 2015.
2. S. Rajasekaran, G.A. Vijyalakshmi Pai, Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis and applications, PHI, 2011.
3. Simon Haykin, Neural networks and Learning Machines, Pearson, 3rd edition.

Reference Books:

4. Sudarshan K. Valluru, T.N. Rao, Introduction to Neural Networks, Fuzzy logic and Genetic Algorithms, Jaico Publishing House, first edition 2010.
5. S.N. Shivnandam and S.N. Deepa, Principles of soft computing, Wiley, 2018.

NEE-510	Data Science and Machine Learning	3L: 1T: 0P	4 Credits	Course Type: PEC

OBJECTIVE:

This course will provide a good insight to the students in the area of Data Science and Machine Learning (ML). The course includes understanding of Probability and Statistics, Business Intelligence, Programming languages Python and R, ML algorithms and Data Manipulation.

Prerequisites:

Introduction to Electrical Engineering, Engineering Mathematics, Control Systems, Advanced Control System, Basic Course on Artificial Intelligence

Course Outcomes:

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

CO1	Able to understand statistics, probability, and linear algebra	K1, K2
CO2	Able to work on Decision Making, Various BI tools	K2, K3
CO3	Demonstrate fundamental understanding of data science and machine learning	K3, K4
CO4	Exhibit the knowledge of programming languages for data science Python and R	K1, K2, K3, K4
CO5	Exhibit the knowledge of various ML algorithms	K1, K2, K3, K4
CO6	Exhibit the knowledge of data sets, data manipulation and data visualization	K1, K2, K3, K4

Course Articulation Matrix (CO-PO Matrix):

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

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

Course Content:

Module 1
Probability and Statistics: (6 Lectures)
Mathematical fundamentals like statistics, probability, and linear algebra

Module 2
Business Intelligence (BI): (8 Lectures)
Decision Making, Various BI tools

Module 3
Programming Languages :(10 Lectures)
Programming languages for data science Python and R

Module 4

Machine Learning and AI: (10 Lectures)
Concept of supervised and unsupervised learning, Various ML algorithms, Regression approaches, Naive Bayes algorithm and Regression trees, Introduction to AI, Differences between ML and AI.

Module 5:
Data Manipulation: (6 Lectures)
Understanding data sets, data manipulation and data visualization, Application in Power Engineering.

Text Books

1. Reema Thareja, "Data Science and Machine Learning using Python", 1st Edition McGraw Hill, 2022.

2. Dirk P Kroese and Zdravko Botev and Thomas Taimre and Radislav Vaisman, Data Science And Machine Learning Mathematical And Statistical Methods, 1st Edition, Taylor & Francis, 2019.

3. Steven Cooper, "Data Science from Scratch" 1st Edition Data Science, 2022.

4. N. Meenakshi K. E. Rajakumari S. Hariharasitaraman , "Data Science and Machine Learning" 1st Edition Notion Press 2021

Reference Books

1. Rajiv Chopra "Data Science with Artificial Intelligence, Machine Learning and Deep Learning" Edition 1st Khanna Publishing 2022

2. Dirk P. Kroese , Thomas Taimre, Zdravko Botev, Radislav Vaisman, Dirk P Kroese "Data Science and Machine Learning", Taylor and Francis, CRC Press, Edition 1st, 2019

3. Rauf, "Physics of Data Science and Machine Learning", Edition 1st CRC Press, 2021

4. Peter Flach, "Machine Learning", Edition 1st Cambridge India, 2015

NEE-512	Advanced Electric Drives	3L:1T:0P	4 Credits	Course Type: PEC

OBJECTIVE:

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

Prerequisites: Advance Power Electronics, Electrical Machines, Electrical Drives.

Course Outcomes:

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

CO1	Understand the operation of power electronic converters for AC drives.	K1, K2, K4, K5
CO2	Understand the operation and control of induction motor drives.	K1, K3, K4
CO3	Understand the operation and control of synchronous motor drives.	K1, K3, K4
CO4	Understand the operation and control of permanent magnet motor drives.	K1, K3, K4
CO5	Understand the operation and control of switched reluctance motor drives.	K1, K3, K4

Course Articulation Matrix (CO-PO Matrix):

CO/ PO	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

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

Course Content:

Module 1

Power Converters for AC Drives: (8 Lectures)

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

Module 2

Induction Motor Drives: (8 Lectures)

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

Module 3

Synchronous Motor Drives: (8 Lectures)

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

Module 4

Permanent Magnet Motor Drives (8 Lectures)
Introduction to various PM motors. BLDC and PMSM drive configuration, comparison, block diagrams, Speed and torque control in BLDC and PMSM.

Module 5:

Switched Reluctance Motor Drives: (8 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

NEE-514	High Power Converters	L T P: 3 1 0	Credits: 4	Type: PEC

OBJECTIVE:

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

Prerequisites: Power Electronics, Electrical Machines, Electrical Drives.

Course Outcomes:

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

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

Course Articulation Matrix (CO-PO Matrix):

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

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

Course Content:

Module 1

Fundamentals of Harmonics: (8 Lectures)

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

Module 2

Causes of Harmonics: (8 Lectures)

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

Module 3

Effect and Elimination/Suppression of Harmonics (8 Lectures)

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

Module 4

Active Power Filters (8 Lectures)

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

Module 5

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

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

Text Books:

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