

**TEACHING SCHEME**

**M.TECH DEGREE IN**

**POWER & ENERGY SYSTEMS**

**(Department of Electrical Engineering)**

*EFFECTIVE FROM 2024-2025*



**NATIONAL INSTITUTE OF TECHNOLOGY**

**DELHI**

**(NIT DELHI)**

# **Department of Electrical Engineering**

## **National Institute of Technology Delhi**

### **1.1 About the Department**

Department of Electrical Engineering (EE), National Institute of Technology Delhi was established in 2010 under the aegis of Ministry of Human Resource and Development (MHRD), Govt. of India. Currently it is offering one Undergraduate (B. Tech) course and one Postgraduate (M. Tech) courses in Power Electronics & Drives. The Department also offers PhD programme in relevant areas. The department is equipped with state-of-the-art facilities to carry out research work at all levels. The research focus of the department is in the area of power system reliability, power electronics, renewable energy systems, power systems, control/time delay systems, pattern recognition, image processing etc. The department also actively involved in multi-disciplinary research activities. The UG program is embraced by rigor and span to prepare a practicing engineer for a lifetime of creative work and ongoing technical learning. The department provides healthy & competitive environment for all round development of students leading to several remarkable achievements in GATE, CAT, GRE, TOEFEL, PSUs etc. The department has laboratories, equipped with latest equipment and software platforms, to impart state-of-the-art technical knowledge. The department aims to setup new laboratories such as Green Energy Technologies, Digital Control & FPGA Design, Biometric etc. The Department has active collaborations with Institutes & research institutes in India and abroad.

The Department of EE has a blend of young as well as experienced dynamic faculty members and is committed to provide quality education and research in the field. Faculty members of the department have excellent academic & research credentials and published numerous peer reviewed journal articles/ papers, Books, Book Chapters etc. in diversified field and having adequate experience in advanced research. The department hopes to achieve the national goals and objectives of industrialization and self-reliance. As a result, it hopes to produce graduates with strong academic and practical background so that they can fit into the industry immediately upon graduation.

### **1.2 Vision**

- To excel in education, research and development services in electrical engineering in tune with societal aspirations.

### **1.3 Mission**

- Impart quality education to produce globally competent electrical engineers capable of extending technological services.
- To create entrepreneurial environment and industry interaction for mutual benefit.
- To be a global partner in training human resources in the field of power and energy systems.
- Nurture scientific temperament, professional ethics and industrial collaboration.

**M. Tech. (Power and Energy Systems) Semester wise Credit Structure**

Sl. No.	Courses	Credits				Total
		1 <sup>st</sup> Year		2 <sup>nd</sup> Year		
		1 <sup>st</sup> Sem	2 <sup>nd</sup> Sem	3 <sup>rd</sup> Sem	4 <sup>th</sup> Sem	
1	Program Core	09	09	0	0	18
2	Program Electives	09	09	0	0	18
3	Dissertation	0	0	16	16	32
4	Lab	02	02	0	0	04
5	MOOCs Course / Independent Study Course	0	0	3	3	06
6	Seminar	0	0	1	1	02
Total		20	20	20	20	80

<b>M. Tech (PES) 1 Year I Semester</b>				
<b>S.No</b>	<b>Course code</b>	<b>Course Title</b>	<b>L-T-P</b>	<b>C</b>
1	EELM 505	Power System Analysis and Operation (Mandatory)	3-0-0	3
2	EELM 5XX	Core-I	3-0-0	3
3	EELM 5XX	Core-II	3-0-0	3
4	EELM 5XX	Elective-I	3-0-0	3
5	EELM 5XX	Elective – II	3-0-0	3
6	EELM 5XX	Elective – III	3-0-0	3
7	EEPM 508	Power Systems Simulation and Hardware Lab	0-0-3	2
<b>Total</b>			<b>18-0-3</b>	<b>20</b>
<b>M. Tech (PES) 1 Year II Semester</b>				
<b>S.No</b>	<b>Course</b>	<b>Course Title</b>	<b>L-T-P</b>	<b>C</b>
1	EELM 555	Renewable and Distributed Energy Systems (Mandatory)	3-0-0	3
2	EELM 5XX	Core-III	3-0-0	3
3	EELM 5XX	Core-IV	3-0-0	3
4	EELM 5XX	Elective – IV	3-0-0	3
5	EELM 5XX	Elective – V	3-0-0	3
6	EELM 5XX	Elective – VI	3-0-0	3
7	EEPM 558	Energy Simulation and Hardware Lab	0-0-3	2
<b>Total</b>			<b>18-0-3</b>	<b>20</b>
<b>M. Tech (PES) II Year III Semester</b>				
<b>S.No</b>	<b>Course</b>	<b>Course Title</b>	<b>L-T-P</b>	<b>C</b>
1	EEPM 603	Dissertation-I	0-0-32	16
2		MOOCs Course – I/ Independent Study Course - I	3-0-0	3
3	EEPM 604	Seminar-I	0-0-2	1
<b>Total</b>				<b>20</b>
<b>M.Tech (PES) II Year IV Semester</b>				
<b>S.No</b>	<b>Course</b>	<b>Course Title</b>	<b>L-T-P</b>	<b>C</b>
1	EEPM 652	Dissertation-II	0-0-32	16
2		MOOCs Course – II/ Independent Study Course - II	3-0-0	3
3	EEPM 653	Seminar-II	0-0-2	1
<b>Total</b>				<b>20</b>
<b>Total Credits</b>				<b>80</b>

### **Special Note for Selection of Massive Open Online Courses (MOOCs)/ Independent Study Courses**

- Students are encouraged to take the above-mentioned MOOCs courses in their 3<sup>rd</sup> and 4<sup>th</sup> semesters preferably. The MOOCs courses can only be decided by the students in consultation with the Supervisor / Convener, DPGC (EE) and HoD (EE) and should be in allied/ relevant area related to the list of elective courses provided in the scheme.
- However, students willing to take those above MOOCs courses during their 1<sup>st</sup> and 2<sup>nd</sup> semester are also allowed but their evaluation and marks to be credited during their 3<sup>rd</sup> and 4<sup>th</sup> semesters respectively as indicated above.
- If a student completes a MOOC course and submits the evaluation result by the end of 3<sup>rd</sup> and 4<sup>th</sup> semester respectively, the they will be exempted from appearing for the Institute examination in the respective Independent Study Course – I (in the 3<sup>rd</sup> semester) and Independent Study Course – II (in the 4<sup>th</sup> semester).
- A student failing to complete the MOOC courses will have to choose an Independent Study course-I (in the 3<sup>rd</sup> semester) and Independent Study Course – II (in the 4<sup>th</sup> semester), *(from the list of elective courses and also which is not running in that semester/ previously not studied by the concern student)*, have to complete (as per the Institute's procedure) the self-study and examinations as per the Institute's rules and regulations.

**DEPARTMENTAL CORE**

S.No	Course code	Course Title	L-T-P
1	EELM 506	Power System Protection	3-0-0
2	EELM 509	Applied Power Electronics	3-0-0
3	EELM 556	Distribution System Operation and Planning	3-0-0
4	EELM 557	Energy Auditing and Management	3-0-0

**DEPARTMENTAL ELECTIVE FOR 1 YEAR I SEMESTER**

S. No	Course Code	Course Title	L-T-P
<b>Elective-I</b>			
1	EELM 519	Microgrid Dynamics and Control	3-0-0
2	EELM 520	Smart Grid Technologies	3-0-0
3	EELM 521	Grid Integration of Renewable Energy Systems	3-0-0
4	EELM 522	Energy Policies and Planning	3-0-0
5	EELM 523	Power System Dynamics and Control	3-0-0
6	EELM 524	Restructured and Deregulated Power Systems	3-0-0
7	EELM 531	Power System Planning and Operation	
<b>Elective-II</b>			
8	EELM 532	Computer Aided Power System Analysis	3-0-0
9	EELM 535	Power System Planning	3-0-0
10	EELM 526	Power System Transients	3-0-0
11	EELM 527	Economic Operation of Power Systems	3-0-0
12	EELM 528	Smart Grid Planning & Operation	3-0-0
13	EELM 511	Power Quality	3-0-0
14	EELM 512	Flexible AC Transmission Systems (FACTS)	3-0-0
<b>Elective-III</b>			
15	EELM 515	Soft Computing and Applications	3-0-0
16	EELM 517	AI Techniques and Applications	3-0-0
17	EELM 529	Pattern Recognition	3-0-0
18	EELM 530	Machine Learning and Deep Learning - Fundamentals and Applications	3-0-0
19	EELM 533	Operation and Control of Restructured Power System	3-0-0

**Departmental Elective for 1 Year II Semester**

<b>Elective-IV</b>			
20	EELM 507	Power System Reliability	3-0-0
21	EELM 567	Electric Vehicles	3-0-0
22	EELM 570	Forecasting Techniques for Power System	3-0-0
23	EELM 571	Smart Appliances and Internet of Things	3-0-0
24	EELM 572	Smart Grid Protection	3-0-0
<b>Elective-V</b>			
25	EELM 562	Special Electrical Machines	3-0-0
26	EELM 568	Energy Storage Devices	3-0-0
27	EELM 573	Smart Grid Communications and Protocols	3-0-0
28	EELM 574	Advanced Power Electronics	3-0-0
29	EELM 575	Statistical Signal Processing	3-0-0
30	EELM 593	Digital Control in Switched Mode Power Converters and FPGA-based Prototyping	3-0-0
31	EELM 595	Reliability Distributions	3-0-0
32	EELM 596	Design for Reliability & Maintainability	3-0-0
33	EELM 597	System Reliability Modeling	3-0-0
34	EELM 598	Reliability Testing & Physics of Failure	3-0-0
<b>Elective-VI</b>			
35	EELM 576	Smart Grid Resiliency and Cyber Security	3-0-0
36	EELM 577	Power Electronic Converters for Renewable Energy Systems	3-0-0
37	EELM 578	Power System Harmonics	3-0-0
38	EELM 579	High Voltage Technique	3-0-0

**\* MOOC Course/ Independent Study**

Sr. No.	Course code	Course Title	L-T-P
1	EELM 605	Smart Grid: Basics to Advanced Technologies	3-0-0
2	EELM 606	Power Electronics Application in Power Systems	3-0-0
3	EELM 607	Microelectronics: Devices to Circuits	3-0-0
4	EELM 608	Design of Photovoltaic Systems	3-0-0
5	EELM 609	Advanced Linear Continuous Control Systems: Applications with MATLAB Programming and Simulink	3-0-0
6	EELM 610	DC Microgrid and Control System	3-0-0
7	EELM 611	Advance power electronics and Control	3-0-0
8	EELM 612	Energy Conversion Technologies (Biomass and Coal)	3-0-0
9	EELM 613	Sensor Technologies: Physics, Fabrication, And Circuits	3-0-0
10	EELM 614	An Introduction to Coding Theory	3-0-0
11	EELM 615	Technologies for Clean and Renewable Energy Production	3-0-0
12	EELM 616	Digital Switching - I	3-0-0
13	EELM 617	Introduction to Adaptive Signal Processing	3-0-0

14	EELM 618	Physical Modelling for Electronics Enclosures using Rapid prototyping	3-0-0
15	EELM 619	Advances in UHV Transmission and Distribution	3-0-0
16	EELM 620	Electronic Modules for Industrial Applications using Op-Amps	3-0-0
17	EELM 621	Electrical Equipment and Machines: Finite Element Analysis	3-0-0
18	EELM 622	System Design Through Verilog	3-0-0
19	EELM 623	VLSI Interconnects	3-0-0
20	EELM 624	Energy Economics and Policy	3-0-0
21	EELM 625	Solar Photovoltaics: Principles, Technologies and Materials	3-0-0



Course No. EELM 505	Open Course (Y/N)	HM Course (Y/N)	DC (Y/N)	DE (Y/N)
Type of the Course	N	N	Y	N
Course Title	Power System Analysis and Operation			
Course Coordinator				
Course Objectives	<ul style="list-style-type: none"><li>Analyze the steady state condition of power system using load flow analysis.</li><li>Comprehend the concepts of scheduling different types of generation units.</li><li>Analysis the contingency on a power system and perform contingency studies using a power flow analysis.</li><li>Analyze State estimation problem of a power system.</li></ul>			
POs				
Semester	Autumn		Spring	
	Lecture	Tutorial	Practical	Credits
Contact Hours	3	0	0	3
Pre-requisite course code as per proposed course members	Nil	Nil	Nil	0
Prerequisite credits				
Equivalent course codes as per proposed course and old course				
Overlap course codes as per proposed course numbers				
Text Book(s)				
1.	Title	Modern Power System Analysis		
	Author	D. P. Kothari and I. J. Nagrath		
	Publisher	Tata McGraw-Hill Education		
	Edition			
2.	Title	Power system analysis		
	Author	Hadi Sadat		
	Publisher	Tata Mcgraw Hill Education		
	Edition			
Reference Book(s)				
1.	Title	Modern Power system Analysis		
	Author	Grainmger and Stevenson		
	Publisher	Tata McGraw-Hill Education		
	Edition			
2.	Title	Power System Restructuring and Deregulation: Trading, Performance and Information		

	<b>Author</b>	Loi Lei Lai
	<b>Publisher</b>	John Wiley & Sons
	<b>Edition</b>	
<b>3.</b>	<b>Title</b>	
	<b>Author</b>	
	<b>Publisher</b>	
	<b>Edition</b>	
<b>Content</b>	<p><b>Unit– I: Transmission line model and performance</b>  Characteristics and performance of short, medium and long Transmission Line, surge impedance loading, power flow through transmission line, line compensation.</p> <p><b>Unit– II: Power Flow Analysis</b>  Network model formulation, Bus-Admittance Matrix, Solution of nonlinear algebraic equations: Gauss-Siedel, and Newton Raphson, Line Flow and Losses, data preparation, power flow solution.</p> <p><b>Unit– III: Optimal System Operation</b>  Optimal operation of generators on bus bar, optimal unit commitment, optimal generation scheduling, Unit commitment and Scheduling of Hydro thermal systems,</p> <p><b>Unit– IV: Power System Security</b>  System state classification, security analysis, contingency analysis, sensitivity factors.</p> <p><b>Unit– V: State Estimation of Power System</b>  Least Squares Estimation, static state estimation and tracking state estimation of power systems, computational considerations.</p>	
<b>Course Assessment</b>	Continuous Evaluation - 25% Mid Semester- 25% End Semester - 50%	

<b>Course No.</b> <b>EELM 506</b>	<b>Open Course</b> <b>(Y/N)</b>	<b>HM Course</b> <b>(Y/N)</b>	<b>DC</b> <b>(Y/N)</b>	<b>DE</b> <b>(Y/N)</b>
<b>Type of the Course</b>	N	N	Y	N
<b>Course Title</b>	<b>Power System Protection</b>			
<b>Course Coordinator</b>				
<b>Course Objectives</b>	<ul style="list-style-type: none"><li>• Recall the various Electromagnetic and static relays.</li><li>• Outline the Input quantities for various types of distance relays.</li><li>• Select the switching schemes for reduction in measuring devices.</li><li>• Explain the importance of digital protection algorithms.</li><li>• Use the microprocessor for implementation of digital protection algorithms.</li></ul>			
<b>POs</b>				
Semester	Autumn		Spring	
	Lecture	Tutorial	Practical	Credits
Contact Hours	3	0	0	3
Pre-requisite course code as per proposed course members	Nil	Nil	Nil	0
Prerequisite credits				
Equivalent course codes as per proposed course and old course				
Overlap course codes as per proposed course numbers				
<b>Text Book(s)</b>				
<b>1.</b>	<b>Title</b>	Power System Protection and Switchgear		
	<b>Author</b>	Badri Ram		
	<b>Publisher</b>	Tata McGraw-Hill Education		
	<b>Edition</b>	3/e, 2011		
<b>2.</b>	<b>Title</b>	Power System Protection: Static Relays with microprocessor Applications		
	<b>Author</b>	Madhava Rao		
	<b>Publisher</b>	Tata McGrawHill Education		
	<b>Edition</b>	2/e, 2004		
<b>Content</b>	<b>Unit– I: Introduction to Protective Relays</b> Current transformers for protection, Coupling capacitor voltage transformers, potential transformer, review of electromagnetic relays, static relays. Over current relays-time current characteristic, current setting time setting, directional relay, static over current relays.  <b>Unit– II: Distance protection-I</b> Impedance, reactance, mho, angle impedance relays, Input quantities for			

	<p>various types of distance relays, effect of arc resistance on the performance of distance relays, selection of distance relays, MHO relay with blinders, quadrilateral relay, elliptical relay, Restricted mho, impedance directional, reactance relays, Swiveling characteristics.</p> <p><b>Unit– III: Distance protection-II</b>  Compensation for correct distance measurement, reduction of measuring units, switched schemes, Pilot relaying schemes, Wire pilot protection, circulating current scheme, balanced voltage scheme, transley scheme, carrier current protection, phase comparison carrier current protection, carrier aided distance protection.</p> <p><b>Unit– IV: Digital relaying techniques</b>  Digital relaying algorithms, differential equation technique, discrete Fourier transform technique, Walsh-Hadamard transform technique, rationalized Haar transform technique, removal of dc offset.</p> <p><b>Unit– V: Microprocessor based protective relays</b>  Over current, directional, impedance, reactance relays, generalized mathematical expressions for distance relays, mho and offset mho relays, quadrilateral relay, Microprocessor implementation of digital distance relaying algorithms.</p>
<b>Course Assessment</b>	<p>Continuous Evaluation - 25%</p> <p>Mid Semester- 25%</p> <p>End Semester - 50%</p>

<b>Course No.</b> <b>EELM 509</b>	<b>Open Course</b> <b>(Y/N)</b>	<b>HM Course</b> <b>(Y/N)</b>	<b>DC</b> <b>(Y/N)</b>	<b>DE</b> <b>(Y/N)</b>
<b>Type of the Course</b>	N	N	Y	N
<b>Course Title</b>	<b>Applied Power Electronics</b>			
<b>Course Coordinator</b>				
<b>Course Objectives</b>				
<b>POs</b>				
Semester	Autumn		Spring	
	Lecture	Tutorial	Practical	Credits
Contact Hours	3	0	0	3
Pre-requisite course code as per proposed course members	Nil	Nil	Nil	0
Prerequisite credits				
Equivalent course codes as per proposed course and old course				
Overlap course codes as per proposed course numbers				
<b>Text Book(s)</b>				
<b>1.</b>	<b>Title</b>	Power Electronics		
	<b>Author</b>	Daniel W. Hart		
	<b>Publisher</b>	Tata McGraw-Hill		
	<b>Edition</b>	1 <sup>st</sup> Edition, 2011		
<b>2.</b>	<b>Title</b>	Power Electronics-Circuit Analysis and Design		
	<b>Author</b>	Issa Batarseh		
	<b>Publisher</b>	John Wiley		
	<b>Edition</b>	2 <sup>nd</sup> Edition, 2003		
<b>3.</b>	<b>Title</b>	Power Electronics: Converters, Applications, and Design		
	<b>Author</b>	William P. Robbins, Ned Mohan, Tore M. Undeland		
	<b>Publisher</b>	John Wiley		
	<b>Edition</b>	3 <sup>rd</sup> Edition, 2002		
<b>Reference Book(s)</b>				
<b>1.</b>	<b>Title</b>	Power Electronics: Devices, Drivers, Applications, and Passive Components		
	<b>Author</b>	Barry Williams		
	<b>Publisher</b>	McGraw Hill Higher Education		
	<b>Edition</b>	2 <sup>nd</sup> Edition, 1991		
<b>2.</b>	<b>Title</b>	Modern Power Electronics and AC motor Drives		
	<b>Author</b>	Bimal K Bose		

	<b>Publisher</b>	Pearson Publishers
	<b>Edition</b>	1 <sup>st</sup> Edition, 2015
<b>Content</b>	<p><b>Unit-I:</b> Power Electronic Devices: Power Diode, SCR, GTO, MOSFET, IGBT, IGCT, SiC and GaN devices –Structure and characteristics.</p> <p><b>Unit- II:</b> Non-Isolated DC-DC converters- Buck, Boost, Buck-Boost, Cuk, SEPIC and zeta converters, Isolated DC-DC converters- Flyback, Forward, Push-Pull, Half-bridge and Full-bridge converters, Switch Mode Power Supplies.</p> <p><b>Unit- III:</b> Improved power quality converters- Multi-pulse converters, buck, boost, buck-boost converters in AC-DC topology, PWM rectifiers and their control, Matrix Converters.</p> <p><b>Unit- IV:</b> Three phase AC voltage regulators and Cyclo-converters. Voltage Source Converters and their PWM techniques, Current Source Converters</p>	
<b>Course Assessment</b>	<p>Continuous Evaluation - 25%</p> <p>Mid Semester- 25%</p> <p>End Semester - 50%</p>	

<b>Course No. EEPM 508</b>	<b>Open Course (Y/N)</b>	<b>HM Course (Y/N)</b>	<b>DC (Y/N)</b>	<b>DE (Y/N)</b>
<b>Type of the Course</b>	N	N	Y	N
<b>Course Title</b>	<b>Power Systems Simulation and Hardware Lab</b>			
<b>Course Coordinator</b>				
<b>Course Objectives</b>				
<b>POs</b>				
<b>Semester</b>	Autumn		Spring	
	Lecture	Tutorial	Practical	Credits
<b>Contact Hours</b>	0	0	3	3
<b>Pre-requisite course code as per proposed course members</b>	Nil	Nil	Nil	0
<b>Prerequisite credits</b>				
<b>Equivalent course codes as per proposed course and old course</b>				
<b>Overlap course codes as per proposed course numbers</b>				
<b>Content</b>	<ol style="list-style-type: none"> <li>1) Power system simulation using MATLAB/ C or C ++ /Sci lab /octave <ol style="list-style-type: none"> <li>a. Formation for symmetric <math>\pi</math> configuration for Verification of <math>D-BC=1</math>, Determination of Efficiency and regulation.</li> <li>b. Formation for symmetric T configuration for Verification of <math>AD-BC=1</math>, Determination of Efficiency and regulation.</li> </ol> </li> <li>2) Determination of Power Angle Diagrams, Reluctance Power, Excitation, Emf and Regulation for Salient and Non-Salient Pole Synchronous Machines</li> <li>3) To obtain Swing Curve and to Determine Critical Clearing Time, Regulation, Inertia Constant/Line Parameters /Fault Location/Clearing Time/Pre-Fault Electrical Output for a Single Machine connected to Infinite Bus through a Pair of identical Transmission Lines Under 3-Phase Fault On One of the two Lines.</li> <li>4) Y Bus Formation for Power Systems with and without Mutual Coupling, by Singular Transformation and Inspection Method</li> <li>5) Formation of Z Bus(without mutual coupling) using Z-Bus Building Algorithm.</li> <li>6) Determination of Bus Currents, Bus Power and Line Flow for a Specified System Voltage (Bus) Profile.</li> </ol>			

	<p>7) Formation of Jacobian for a System not Exceeding 4 Buses (No PV Buses) in Polar Coordinates.</p> <p>8) Load Flow Analysis using Gauss Siedel Method, NR Method and Fast Decoupled Method for Both PQ and PV Buses.</p> <p>9) To Determine Fault Currents and Voltages in a Single Transmission Line System With Star-Delta Transformers at a Specified Location for LG and LLG faults by simulation</p> <p>10) Optimal Generation Scheduling for Thermal power plants.</p>
<b>Course Assessment</b>	<p>Continuous Evaluation - 25%</p> <p>Mid Semester- 25%</p> <p>End Semester - 50%</p>



Course No. EELM 517	Open Course (Y/N)	HM Course (Y/N)	DC (Y/N)	DE (Y/N)
Type of the Course	N	N	N	Y
Course Title	AI Techniques and Applications			
Course Coordinator				
Course Objectives	<ul style="list-style-type: none"><li>To understand the principles of intelligent agents and rational decision-making</li><li>To solve problems using search, reasoning, and constraint satisfaction</li><li>To apply classical machine learning algorithms to data-driven problems</li><li>To introduce core deep learning models and architectures</li></ul>			
POs				
Semester	Autumn		Spring	
	Lecture	Tutorial	Practical	Credits
Contact Hours	3	0	0	3
Pre-requisite course code as per proposed course members	Nil	Nil	Nil	0
Prerequisite credits				
Equivalent course codes as per proposed course and old course				
Overlap course codes as per proposed course numbers				
Text Book(s)				
1.	Title	Artificial Intelligence: A Modern Approach		
	Author	Stuart Russell and Peter Norvig		
	Publisher	Pearson Education		
	Edition	4 <sup>th</sup> Edition		
2.	Title	Machine Learning		
	Author	Tom M. Mitchell		
	Publisher	McGraw-Hill Education		
	Edition			
Reference Book(s)				
1.	Title	The Elements of Statistical Learning		
	Author	T. Hastie, R. Tibshirani, and J. Friedman		
	Publisher	Springer		
	Edition	2nd Edition		
2.	Title	Neural Networks and Learning Systems		

	<b>Author</b>	Simon Haykin
	<b>Publisher</b>	Pearson Education
	<b>Edition</b>	3rd Edition
<b>3.</b>	<b>Title</b>	Introduction to Pattern Recognition and Machine Learning
	<b>Author</b>	M. Narasimha Murty and V. Susheela Devi
	<b>Publisher</b>	IISc Lecture Notes Series / World Scientific
	<b>Edition</b>	
<b>Content</b>	<p><b>Unit– I: Intelligent Agents and Problem Solving</b>  Introduction to Artificial Intelligence, Intelligent agents and environments, Concept of rationality, Agent architectures (overview), Problem formulation and state-space representation, Uninformed search: (Breadth First Search (BFS), Depth First Search (DFS)), Informed search: Greedy Best First Search, A* Search (admissible heuristics)</p> <p><b>Unit– II: Reasoning and Adversarial Search</b>  Local search techniques: hill climbing, Constraint Satisfaction Problems (CSPs) and backtracking, Game playing as search, Minimax algorithm, Alpha–beta pruning, Monte Carlo Tree Search,  <b>Knowledge representation:</b>  Propositional logic, First-order logic (introduction), Inference methods.</p> <p><b>Unit– III: Machine Learning</b>  Introduction to machine learning, Supervised learning models: Linear regression, Logistic regression, k-Nearest Neighbors (k-NN), Decision trees, Ensemble methods: Random Forests (overview), Unsupervised learning: k-means clustering, Principal Component Analysis (PCA)</p> <p><b>Unit– IV: Deep Learning Fundamentals</b>  Neural network basics: Perceptron and Multi-layer Perceptron (MLP), Activation functions, Backpropagation algorithm, Training deep networks: Gradient descent, Regularization (dropout, batch normalization – overview), Deep learning architectures: Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs) and LSTM.</p>	
<b>Course Assessment</b>	Continuous Evaluation - 25% Mid Semester- 25% End Semester- 50%	

<b>Course no: EELM 555</b>	<b>Open course</b>	<b>HM Course (Y/N)</b>	<b>DC (Y/N)</b>	<b>DE (Y/N)</b>
<b>Type of course</b>				Y
<b>Course Title</b>	<b>Renewable and Distributed Energy Systems</b>			
<b>Course Coordinator</b>				
<b>Course objectives:</b>	Understand the different energy sources and energy conservation methods, energy management techniques. Understand the solar energy and its uses. Understand the wind energy and biomass energy. Understand the renewable energy sources and working of nuclear power plants. Understand the geothermal energy and its sources.			
<b>POs</b>				
<b>Semester</b>				
	<b>Lecture</b>	<b>Tutorial</b>	<b>Practical</b>	<b>Credits</b>
<b>Contact Hours</b>	3	0	0	3
<b>Prerequisite course code as per proposed course numbers</b>				
<b>Prerequisite credits</b>				
<b>Equivalent course codes as per proposed course and old course</b>				
<b>Overlap course codes as per proposed course numbers</b>				
<b>Text Books:</b>				
1.	Title	Solar Energy		
	Author	H. P. Garg		
	Publisher	Tata McGraw Hill		
	Edition	2015		
2.	Title	Energy Resource Management		
	Author	Krupal Sing Jogi		
	Publisher	Sarup & sons		
	Edition	2007		
3.	Title	Renewable Energy Resources		
	Author	John Twidell		
	Publisher	Routledge, 2021		

	Edition	2021
<b>Content</b>	<p><b>Unit I: Renewable Energy (RE) Sources</b>  Environmental consequences of fossil fuel use, Importance of renewable sources of energy, Sustainable Design and development, Types of RE sources, Limitations of RE sources, Present Indian and international energy scenario of conventional and RE sources.</p> <p><b>Unit II: Wind Energy</b>  Power in the Wind – Types of Wind Power Plants (WPPs)– Components of WPPs-Working of WPPs- Siting of WPPs-Grid integration issues of WPPs.</p> <p><b>Unit III: Solar PV and Thermal Systems</b>  Solar Radiation, Radiation Measurement, Solar Thermal Power Plant, Central Receiver Power Plants, Solar Ponds.- Thermal Energy storage system with PCM- Solar Photovoltaic systems : Basic Principle of SPV conversion – Types of PV Systems- Types of Solar Cells, Photovoltaic cell concepts: Cell, module, array ,PV Module I-V Characteristics, Efficiency &amp; Quality of the Cell, series and parallel connections, maximum power point tracking, Applications.</p> <p><b>Unit IV: Biomass Energy</b>  Introduction-Bio mass resources –Energy from Bio mass: conversion processes-Biomass Cogeneration-Environmental Benefits. Geothermal Energy: Basics, Direct Use, Geothermal Electricity. Mini/micro hydropower: Classification of hydropower schemes, Classification of water turbine, Turbine theory, Essential components of hydroelectric system.</p> <p><b>Unit V: Other Energy Sources</b>  Tidal Energy: Energy from the tides, Barrage and Non-Barrage Tidal power systems. Wave Energy: Energy from waves, wave power devices. Ocean Thermal Energy Conversion (OTEC) - Hydrogen Production and Storage- Fuel cell: Principle of working- various types – construction and applications. Energy Storage System- Hybrid Energy Systems.</p>	

<b>Course Assessment</b>	Continuous Evaluation 25% Mid Semester 25% End Semester 50%
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<b>Course no: EELM 556</b>	<b>Open course</b>	<b>HM Course (Y/N)</b>	<b>DC (Y/N)</b>	<b>DE (Y/N)</b>
<b>Type of course</b>				Y
<b>Course Title</b>	Distribution System Operation and Planning			
<b>Course Coordinator</b>				
<b>Course objectives:</b>	This course provides an overview of modern power distribution systems. The course will start with the discussions of different components and layouts of power distribution systems, load models, different reliability assessment techniques, and different planning approaches. The conventional reactive power compensation techniques will also be covered. Then, the impact of distributed generation on distribution systems will be discussed. Modeling of different types of distributed generation units and storage will also be discussed. Finally, the evolution of distribution systems toward smart network will be covered.			
<b>POs</b>				
<b>Semester</b>	<b>Autumn</b>		<b>Spring: II Semester</b>	
	<b>Lecture</b>	<b>Tutorial</b>	<b>Practical</b>	<b>Credits</b>
<b>Contact Hours</b>	3	0	0	3
<b>Prerequisite course code as per proposed course numbers</b>				
<b>Prerequisite credits</b>				
<b>Equivalent course codes as per proposed course and old course</b>				
<b>Overlap course codes as per proposed course numbers</b>				
<b>Text Books:</b>				
1.	Title	Electric Power Distribution System Engineering,		
	Author	T. Gonen,		
	Publisher	CRC Press,		
	Edition	3rd Edition, 2014.		
2.	Title	Electric Power Distribution,		
	Author	A. S. Pabla,		
	Publisher	Tata Mcgraw-Hill Publishing Company Ltd.,		
	Edition	7th Edition, 2019.		

<b>Reference Books:</b>		
3.	Title	Power Distribution Planning Reference Book,
	Author	R. H. Lee. Willis,
	Publisher	CRC press,
	Edition	2nd Edition, 2007.
4.	Title	Integration of Distributed Generation in the Power System,
	Author	Math Bollen and Fainan Hassan,
	Publisher	IEEE press,
	Edition	2011.
5.	Title	Reliability Evaluation of Power Systems,
	Author	R. Billington and R. Allan,
	Publisher	Springer, Berlin,
	Edition	2nd Edition, 1996.
<b>Content</b>	<p><b>Unit I: Primary and Secondary Distribution System Layouts</b></p> <p>Introduction, substation layout, substation location, construction, and bus schemes, the rating of distribution substation, overhead and underground distribution networks, distribution line construction, and distribution system line conductors.</p> <p><b>Unit II: Reliability Assessment of Distribution Systems</b></p> <p>Introduction, reliability modelling concept, different reliability indices, customer interruption cost evolution and customer damage function.</p> <p><b>Unit III: Distribution System Planning</b></p> <p>Introduction, different components of distribution system planning, different planning approaches, planning models and solution strategies.</p> <p><b>Unit IV: Distribution System Automation and Smart Grid</b></p> <p>Introduction to distribution system automation, the basic elements of distribution system automation, power market deregulation and distribution system automation, load management at different peak and off-peak duration, compatibility of load management with system design and operation, smart grid and smart metering.</p> <p><b>Unit V: Integration of Distributed Generation (DG)</b></p> <p>Introduction to DG, Effect of renewable energy sources on power distribution systems.</p>	

<b>Course Assessment</b>	Continuous Evaluation 25% Mid Semester 25% End Semester 50%
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Course no: EELM 557	Open course	HM Course (Y/N)	DC (Y/N)	DE (Y/N)
Type of course				
Course Title	Energy Auditing and Management			
Course Coordinator				
Course objective:	To impart concepts behind economic analysis and Load management. Energy management on various electrical equipment and metering. Concept of lighting systems and cogeneration.			
POs				
Semester	Autumn: I Semester		Spring	
	Lecture	Tutorial	Practical	Credits
Contact Hours	3	0	0	3
Prerequisite course code as per proposed course numbers				
Prerequisite credits				
Equivalent course codes as per proposed course and old course				
Overlap course codes as per proposed course numbers				
Text Books:				
1.	Title	Guide to Energy Management		
	Author	Barney L. Capehart, Wayne C. Turner, and William J. Kennedy,		
	Publisher	The Fairmont Press, Inc.		
	Edition	5 <sup>th</sup> Edition, 2006		
2.	Title	Energy Efficiency for Engineers and Technologists		
	Author	Eastop T.D & Croft D.R		
	Publisher	Logman Scientific & Technical		
	Edition	1990		
Content	Unit I: Introduction  Basics of Energy – Need for energy management – Energy accounting - Energy monitoring, targeting and reporting - Energy audit process.			

	<p><b>Unit II: Energy Management for Motors and Cogeneration</b></p> <p>Energy management for electric motors – Transformer and reactors - Capacitors and synchronous machines, energy management by cogeneration – Forms of cogeneration – Feasibility of cogeneration – Electrical interconnection.</p> <p><b>Unit III: Lighting Systems</b></p> <p>Energy management in lighting systems – Task and the working space - Light sources – Ballasts – Lighting controls – Optimizing lighting energy – Power factor and effect of harmonics, lighting and energy standards.</p> <p><b>Unit IV: Metering for Energy Management</b></p> <p>Metering for energy management – Units of measure - Utility meters – Demand meters – Paralleling of current transformers – Instrument transformer burdens – Multi tasking solid state meters, metering location vs requirements, metering techniques and practical examples.</p> <p><b>Unit V: Economic Analysis and Models</b></p> <p>Economic analysis – Economic models - Time value of money - Utility rate structures – Cost of electricity – Loss evaluation, load management – Demand control techniques – Utility monitoring and control system – HVAC and energy management – Economic justification.</p>
<b>Course Assessment</b>	<p>Continuous Evaluation 25%</p> <p>Mid Semester 25%</p> <p>End Semester 50%</p>

<b>Course no: EEPM 558</b>	<b>Open course (Y/N)</b>	<b>HM Course (Y/N)</b>	<b>DC (Y/N)</b>	<b>DE (Y/N)</b>
<b>Type of course</b>	N	N	Y	N
<b>Course Title</b>	Energy Simulation and Hardware Lab			
<b>Course Coordinator</b>				
<b>Course Outcomes:</b>				
<b>POs</b>				
<b>Semester</b>	<b>Autumn:</b>		<b>Spring: II</b>	
	<b>Lecture</b>	<b>Tutorial</b>	<b>Practical</b>	<b>Credits</b>
<b>Contact Hours</b>	0	0	3	3
<b>Prerequisite course code as per proposed course numbers</b>				
<b>Prerequisite credits</b>				
<b>Equivalent course codes as per proposed course and old course</b>				
<b>Overlap course codes as per proposed course numbers</b>				
<b>Content</b>	<ol style="list-style-type: none"> <li>1. To draw the I-V and P-V characteristics of PV module with various radiation and temperature.</li> <li>2. To draw the I-V and P-V characteristics of series and parallel combination of PV module</li> <li>3. To analyze the effect of shading on solar module</li> <li>4. Demonstration of the working of diode as bypass and blocking diode in PV modules.</li> <li>5. To determine maximum power flow calculations of PV system of AC &amp; DC load with battery</li> <li>6. Testing and performance analysis of Grid connected and Standalone Solar Power System.</li> <li>7. To analyze the performance tests on Induction generator-based Wind energy system.</li> <li>8. To analyze the performance tests on PMSM based Wind energy system.</li> <li>9. To draw the characteristics of Fuel Cell</li> <li>10. To analyze the performance of hybrid Energy system.</li> </ol>			

<b>Course Assessment</b>	Continuous Evaluation 25% Mid Semester 25% End Semester 50%
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<b>Course No.</b> <b>EELM 520</b>	<b>Open Course</b> <b>(Y/N)</b>	<b>HM Course</b> <b>(Y/N)</b>	<b>DC</b> <b>(Y/N)</b>	<b>DE</b> <b>(Y/N)</b>
<b>Type of the Course</b>	N	N	N	Y
<b>Course Title</b>	<b>Smart Grid Technologies</b>			
<b>Course Coordinator</b>				
<b>Course Objectives</b>				
<b>POs</b>				
<b>Semester</b>	Autumn		Spring	
	Lecture	Tutorial	Practical	Credits
<b>Contact Hours</b>	3	0	0	3
Pre-requisite course code as per proposed course members	Nil	Nil	Nil	0
Prerequisite credits				
Equivalent course codes as per proposed course and old course				
Overlap course codes as per proposed course numbers				
<b>Text Book(s)</b>				
<b>1.</b>	<b>Title</b>	Smart Grid: Fundamentals of Design and Analysis		
	<b>Author</b>	James A. Momoh		
	<b>Publisher</b>	Wiley-IEEE Press, ISBN-13: 978-0470889398		
	<b>Edition</b>	1 <sup>st</sup>		
<b>2.</b>	<b>Title</b>	Smart Power Grids		
	<b>Author</b>	Ali Keyhani, Muhammad Marwali		
	<b>Publisher</b>	Springer Berlin, Heidelberg		
	<b>Edition</b>	1 <sup>st</sup>		
<b>Reference Book(s)</b>				
<b>1.</b>	<b>Title</b>	Computer Relaying for Power Systems		
	<b>Author</b>	Dr. Arun G. Phadke, Dr. James S. Thorp		
	<b>Publisher</b>	Wiley		
	<b>Edition</b>			
<b>2.</b>	<b>Title</b>	Microgrids: Architectures and Control		
	<b>Author</b>	Nikos Hatziaergyriou		
	<b>Publisher</b>	Wiley		
	<b>Edition</b>			
<b>3.</b>	<b>Title</b>	Renewable Energy Systems: Advanced Conversion Technologies and Applications		
	<b>Author</b>	Fang Lin Luo and Ye Hong		

	<b>Publisher</b>	CRC Press
	<b>Edition</b>	
<b>Content</b>	<p><b>Unit I: Introduction</b> Introduction to Smart Grid: Evolution of Electric Grid, Concept of Smart Grid, Difference between conventional &amp; smart grid, Concept of Resilient &amp; Self-Healing Grid, Present development &amp; International policies in Smart Grid. Case study of Smart Grid, CDM opportunities in Smart Grid, Local Energy Networks, Electric Transportation, Low-Carbon Central Generation.</p> <p><b>Unit II: Sensing, and Measurement Technologies</b> Smart metering and demand-side integration, Introduction, Smart metering, Evolution of electricity metering, Key components of smart metering, Smart meters, Home-area network, Neighborhood area network, Data concentrator, Meter data management system, Protocols for communications, Demand-Side Integration(DSI).</p> <p><b>Unit III: Control and Automation Technologies</b> Smart Appliances, Automatic Meter Reading (AMR), Outage Management System(OMS), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Grid to Vehicle, Smart Sensors, Home &amp; Building Automation, Phase Shifting Transformers. Smart Substations, Fault location, isolation and restoration, Voltage regulation. Feeder Automation, Geographic Information System(GIS), Intelligent Electronic Devices(IED) &amp; their application for monitoring &amp; protection.</p> <p><b>Unit IV: Micro Grids And Distributed Energy Resources</b> Concept of micro grid, need &amp; applications of micro grid, issues of interconnection, protection &amp; control of micro grid. Islanding, different methods of islanding detection. Distributed Energy Resources: Small scale distributed generation, Distributed Generation Technology, Internal Combustion Engines, Gas Turbines, Combined Cycle Gas Turbines, Micro turbines, Fuel Cells, Solar Photovoltaic, Solar thermal, Wind power, Geothermal.</p> <p><b>Unit V: Power Quality Management</b> Power Quality &amp; EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit. Electrical Market and Tariff.</p>	
<b>Course Assessment</b>	<p>Continuous Evaluation - 25%</p> <p>Mid Semester- 25%</p> <p>End Semester - 50%</p>	

<b>Course no:</b> <b>EELM 521</b>	<b>Open course</b>	<b>HM Course (Y/N)</b>	<b>DC (Y/N)</b>	<b>DE (Y/N)</b>
<b>Type of course</b>				Y
<b>Course Title</b>	<b>Grid Integration of Renewable Energy Systems</b>			
<b>Course Coordinator</b>				
<b>Course objectives:</b>	This course explores the technical and economic challenges and opportunities associated with integrating renewable energy sources like solar, wind, hydro, etc., into the existing power grid infrastructure. We will delve into the operational aspects of balancing supply and demand with variable renewable energy sources, while ensuring grid stability and reliability. The course will also cover advanced grid technologies and strategies for facilitating a smooth transition towards a clean energy future			
<b>POs</b>				
<b>Semester</b>	<b>Autumn</b>		<b>Spring: II Semester</b>	
	<b>Lecture</b>	<b>Tutorial</b>	<b>Practical</b>	<b>Credits</b>
<b>Contact Hours</b>	3	0	0	3
<b>Prerequisite course code as per proposed course numbers</b>				
<b>Prerequisite credits</b>				
<b>Equivalent course codes as per proposed course and old course</b>				
<b>Overlap course codes as per proposed course numbers</b>				
<b>Text Books:</b>				
1.	Title	Grid Integration of Renewable Energy		
	Author	Glover, John D., Tamer M. El-Shenawy, and Mohamed S. El-Nasr		
	Publisher	Wiley-IEEE Press		
	Edition	1 <sup>st</sup> Edition, 2018.		
2.	Title	Integration of Renewable Energy Sources with Smart Grid		
	Editor	M. Kathiresh, A. Mahaboob Subahani, G.R. Kanagachidambaresan		
	Publisher	Scrivener Publishing LLC		
	Edition	1 <sup>st</sup> Edition, 24 August 2021		

<b>Reference Books:</b>		
3.	Title	Integration of Renewable Energy Sources into the Power Grid
	Author	Morteza Zare Oskouei Behnam Mohammadi-Ivatloo
	Publisher	Springer,
	Edition	December 2019
<b>Content</b>	<p><b>Unit I: Introduction to Grid Integration</b> Power Grid Fundamentals, Need for Renewable Energy Integration, Challenges of Variable Renewable Energy Sources, Grid Stability and Reliability Concepts, Intermittency and Variability Management.</p> <p><b>Unit II: Forecasting and Managing Renewables</b> Wind and solar resources: characteristics, variability, forecasting, Wind power: principles of wind energy extraction, electromechanical energy conversion, characteristics of wind turbines, voltage regulation, Photovoltaic cells: energy conversion principles, electrical modelling, optimal power extraction, shading, Solar thermal: operating principles, storage capability.</p> <p><b>Unit III: Energy Storage Technologies</b> Energy storage: technologies, operating strategies, degradation, Types of Energy Storage, Applications of Storage in Grid Integration, Techno-economic Analysis of Storage Solutions.</p> <p><b>Unit IV: Economic and Policy Considerations</b> Market Mechanisms for Renewable Energy Integration, Regulatory Frameworks and Policies Supporting Renewables Integration, Cost-benefit analysis of grid integration, Emerging Technologies and Future opportunities in renewable energy integration.</p> <p><b>Unit V: Technologies for Grid Integration</b> Smart Grid Concepts and Technologies for Renewable Integration, Microgrids and Islanding Grid operation and control: voltage control, frequency regulation, optimal generation dispatch.</p>	
<b>Course Assessment</b>	<p>Continuous Evaluation 25%</p> <p>Mid Semester 25%</p> <p>End Semester 50%</p>	



Course no: EELM 522	Open course	HM Course (Y/N)	DC (Y/N)	DE (Y/N)
Type of course	N	N	Y	N
Course Title	Energy Policies and Planning			
Course Coordinator				
Course objectives:	This course examines the development and implementation of effective energy policies and planning strategies in the context of a sustainable energy future. We will delve into the economic, environmental, and social factors driving energy policy decisions. The course will explore various policy instruments, analyze energy markets and regulations, and equip students with the tools to evaluate and design future-oriented energy plans.			
POs				
Semester	Autumn: NA		Spring: II	
	Lecture	Tutorial	Practical	Credits
Contact Hours	3	0	0	3
Prerequisite course code as per proposed course numbers				
Prerequisite credits				
Equivalent course codes as per proposed course and old course				
Overlap course codes as per proposed course numbers				
Text Books:				
1.	Title	Energy Economics, Concepts, Issues, Markets and Governance		
	Author	Subhes C. Bhattacharyya		
	Publisher	Springer		
	Edition	1 <sup>st</sup> Edition, 2011.		
2.	Title	Energy Economics		
	Author	Peter M. Schwarz		
	Publisher	CRC Press		
	Edition	2 <sup>nd</sup> Edition, 2022.		
Reference Book:				
1.	Title	Energy Law And Policy in India		
	Author	Nawneet Vibhaw		

	Publisher	Lexis Nexis
	Edition	1 <sup>st</sup> Edition, 2014
2.	Title	New Energy and Future Energy Systems
	Editor	Grigorios L. Kyriakopoulos
	Publisher	IOS Press BV
	Edition	(NEFES 2023),
<b>Content</b>	<p><b>Unit I: Global Energy Scenario</b>  Role of energy in economic development and social transformation: Energy &amp; GDP, GNP and its dynamics, Discovery of various energy sources: Energy Sources and Overall Energy demand and availability, Energy Consumption in various sectors and its changing pattern, Exponential increase in energy consumption and Projected future demands, Energy Security.</p> <p><b>Unit II: Indian Energy Scenario</b>  Energy resources &amp; Consumption: Commercial and non-commercial forms of energy, Fossil fuels, Renewable sources including Bio-fuels in India, their utilization pattern in the past, present and future projections of consumption pattern, Sector wise energy consumption, Impact of Energy on Economy, Central and States Electricity Regulatory Commissions.</p> <p><b>Unit III: Energy Policy</b>  Global Energy Issues, National and State Level Energy Issues, National &amp; State Energy Policy, Industrial Energy Policy, Energy Security, Energy Vision, Energy Pricing &amp; Impact of Global Variations, Energy Productivity i.e. National and Sector wise productivity.</p> <p><b>Unit IV: Energy Policy Planning</b>  Key Elements of Energy Policy Planning: Force Field Analysis, Energy Policy-Purpose, Perspective, Contents and Formulation, Implementation of Energy Policy: Location of Energy Manager, Top Management Support, Managerial functions, Role and responsibilities of Energy Manager, Accountability, Motivation of employees.</p> <p><b>Unit V: Energy Economics</b></p>	

	Energy economics: Basic concepts, energy data, energy cost, energy balance, Energy accounting framework; Economic theory of demand, production and cost market structure; National energy map of India, Energy subsidy, National and international perspectives, Concepts of economic attributes involving renewable energy, Calculation of unit cost of power generation from different sources with examples, different models and methods.
<b>Course Assessment</b>	Continuous Evaluation 25% Mid Semester 25% End Semester 50%

Course no: EELM 524	Open course	HM Course (Y/N)	DC (Y/N)	DE (Y/N)
Type of course	N	N	Y	N
Course Title	Restructured and Deregulated Power Systems			
Course Coordinator				
Course objectives:	This course explores the evolution of the power sector from traditional, vertically integrated monopolies to restructured and deregulated markets. We will delve into the Philosophy of Market Models and Market power, Explain Transmission Congestion Management, Financial Transmission Rights (FTR), Pricing of transmission network usage. The course will also cover the Reforms in Indian power sector.			
POs				
Semester	Autumn: NA		Spring: II	
	Lecture	Tutorial	Practical	Credits
Contact Hours	3	0	0	3
Prerequisite course code as per proposed course numbers				
Prerequisite credits				
Equivalent course codes as per proposed course and old course				
Overlap course codes as per proposed course numbers				
Text Books:				
1.	Title	Operation of Restructured Power Systems		
	Author	Kankarbhattacharya, Math H.J. Bollen & Jaap E. Daalder		
	Publisher	Kluwer Academic Publishers		
	Edition	1 <sup>st</sup> Edition, 2001		
2.	Title	Power system Restructuring and Deregulation: Trading, Performance and Information Technology		
	Author	Loi Lei Lai		
	Publisher	John Wiley & Sons Ltd., England.		
	Edition	1 <sup>st</sup> Edition, 2001		
Reference Book:				
1.	Title	Restructured Power Systems		

	Author	S. A. Khaparde
	Publisher	Alpha Science
	Edition	1 <sup>st</sup> Edition, 2006
2.	Title	Restructured electrical Power systems
	Author	Mohammad Shahidehpour, and Muwaffaqalomoush,
	Publisher	Marcel Dekker, Inc.
	Edition	1 <sup>st</sup> Edition, 2001
<b>Content</b>	<p><b>Unit I: Introduction to Restructuring of Power Industry</b> Introduction, reasons for restructuring / deregulation of power industry, understanding the restructuring process, Introduction to issues involved in deregulation, Reasons and objectives of deregulation of various power systems across the world, Consumer behaviour, Supplier behaviour, Market equilibrium, Short-run and long-run costs, Various costs of production, Relationship between short-run and long-run average costs, perfectly competitive market.</p> <p><b>Unit II: Philosophy of Market Models</b> Introduction, Market models based on contractual arrangements, Comparison of various market models, Market architecture, Attributes of a perfectly competitive market, financial markets associated with electricity markets, Introduction to optimal bidding by a generator company, Optimal bidding methods, Different entities in deregulated electricity markets, Benefits from a competitive electricity market.</p> <p><b>Unit III: Transmission Congestion Management</b> Introduction, Classification of congestion management methods, Calculation of ATC, Non-market methods, Market based method, Nodal pricing, Inter-zonal Intra-zonal congestion management, Price area congestion management, Capacity alleviation method, Comparison and conclusion, Mathematical preliminaries, Introduction to Financial Transmission Rights, Risk Hedging Functionality of financial Transmission Rights, Simultaneous feasibility test and revenue adequacy.</p> <p><b>Unit III: Ancillary Service Management</b> Introduction to ancillary services, Types of ancillary services,</p>	

	<p>Classification of ancillary services, Load-generation balancing related services, Voltage control and reactive power support services, Black start capability service, Optimization of energy and reserve services, international comparison, Reactive power management in some deregulated electricity markets, Synchronous generators as ancillary service providers.</p> <p><b>Unit V: Reforms in Indian Power Sector</b>  Introduction, Framework of Indian power sector, Reform initiatives during 1990-1995, the availability-based tariff (ABT), The Electricity Act 2003.</p>
<b>Course Assessment</b>	<p>Continuous Evaluation 25%</p> <p>Mid Semester 25%</p> <p>End Semester 50%</p>

Course no: EELM 531	Open course	HM Course (Y/N)	DC (Y/N)	DE (Y/N)
Type of course	N	N	Y	N
Course Title	Power System Planning and Operation			
Course Coordinator				
Course objectives:	This course aims to provide a thorough understanding of power systems operations, emphasizing economic considerations and reliability. Students will analyze generator characteristics, transmission systems, and power flow to optimize operations. They will master various optimization algorithms and their application in power systems planning. The course also focuses on evaluating power systems reliability and exploring Energy Management Systems (EMS) for efficient operation. By the end, students will comprehend frequency control principles and possess analytical skills vital for addressing real-world power systems challenges.			
POs				
Semester	Autumn: NA		Spring: II	
	Lecture	Tutorial	Practical	Credits
Contact Hours	3	0	0	3
Prerequisite course code as per proposed course numbers				
Prerequisite credits				
Equivalent course codes as per proposed course and old course				
Overlap course codes as per proposed course numbers				
Text Books:				
1.	Title	Power Generation, Operation, and Control		
	Author	Allen J. Wood, Bruce F. Wollenberg, Gerald B. Sheble		
	Publisher	John Wiley & Sons, New York, NY,		
	Edition	3 <sup>rd</sup> Edition, 2013		
2.	Title	Power System Analysis and Design		
	Author	J. Duncan Glover, Mulukutla S. Sarma, Thomas J. Overbye		
	Publisher	Cengage Learning		
	Edition	6 <sup>th</sup> Edition, 2012		
Reference Book:				
1.	Title	Energy Storage for Power System Planning and Operation		

	Author	Zechun Hu
	Publisher	John Wiley & Sons Singapore Pte. Ltd.
	Edition	1 <sup>st</sup> Edition, 2020
<b>Content</b>	<p><b>Unit I: Introduction to Power Systems Operations</b>  Overview of power systems generation, operations, and reliability. Characteristics of generators: types, capacities, and efficiencies. Economic dispatch: basic principles and formulation.</p> <p><b>Unit II: Transmission System Analysis</b>  Characteristics of the transmission system: network topology, line parameters. Power flow analysis: formulation, methods (Gauss-Seidel, Newton-Raphson), and applications. Alternating current optimal power flow (ACOPF): theory and practical considerations.</p> <p><b>Unit III: Power Systems Optimization</b>  Unit commitment: formulation, objectives, and solution techniques. Hydrothermal coordination: modelling, constraints, and optimization methods. Production cost models: structure, variables, and applications</p> <p><b>Unit IV: Optimization Algorithms</b>  Unconstrained optimization: methods and applications. Constrained optimization: techniques and problem-solving approaches. Linear programming: fundamentals, simplex method, and applications. Dynamic programming: principles and applications in power systems. Lagrange relaxation and mixed integer programming: concepts and applications in power systems optimization.</p> <p><b>Unit V: Power Systems Reliability and Energy Management Systems (EMS)</b>  N-1 reliability: concept, assessment methods, and implications. Reserves: types, allocation, and utilization. Contingency selection procedures: criteria, algorithms, and applications. Energy Management Systems (EMS): components, functionalities, and applications. Frequency control: importance, methods, and challenges in power systems.</p>	
<b>Course Assessment</b>	Continuous Evaluation 25% Mid Semester 25% End Semester 50%	



Course no: EELM 532	Open course	HM Course (Y/N)	DC (Y/N)	DE (Y/N)
Type of course	N	N	Y	N
Course Title	Computer Aided Power System Analysis			
Course Coordinator				
Course objectives:	This course aims to advance students' proficiency in computer-aided power system analysis with a focus on sparsity techniques, load flow analysis including HVDC systems, short circuit studies, and state estimation methods. Through these objectives, students will gain comprehensive expertise in power system analysis and management using modern computational tools.			
POs				
Semester	Autumn: NA		Spring: II	
	Lecture	Tutorial	Practical	Credits
Contact Hours	3	0	0	3
Prerequisite course code as per proposed course numbers				
Prerequisite credits				
Equivalent course codes as per proposed course and old course				
Overlap course codes as per proposed course numbers				
Text Books:				
1.	Title	Power System State Estimation: Theory & Implementation		
	Author	Abur A. and Exposito A. G.		
	Publisher	Marcel Dekkar		
	Edition	1 <sup>st</sup> Edition, 2004		
2.	Title	Computer Modelling of Electrical Power Systems		
	Author	Arrillaga J. and Watson N.R.		
	Publisher	John Wiley & Sons		
	Edition	1 <sup>st</sup> Edition, 2001		
Reference Book:				
1.	Title	Power Generation, Operation and Control		
	Author	Wood A. J. and Wollenberg B.F.		

	Publisher	John Wiley & Sons
	Edition	3 <sup>rd</sup> Edition, 2013
<b>Content</b>	<p><b>Unit I: Sparsity Techniques and Parallel Inversions</b> Storage of sparse matrices, Sparsity directed inversion methods, Parallel inversion techniques.</p> <p><b>Unit II: Load Flow Analysis</b> Balanced AC load flow, DC system modelling, Incorporation of control equations, Inverter operation, Unified and sequential solution techniques, Three-phase AC-DC load flow.</p> <p><b>Unit III: Short Circuit Studies</b> Z-bus building algorithm, Derivation of fault admittance matrices, Three-phase model of transmission lines, Analysis of unbalanced faults, Three-phase model of synchronous machines</p> <p><b>Unit IV: State Estimation and Bad Data Processing</b> State estimation of linear and nonlinear systems, Pseudo-measurements, Recursive and weighted least square estimation methods, Detection and identification of bad measurements, Network observability</p> <p><b>Unit V: Reactive Power Management</b> Sources of reactive power, Reactive power capability curve, FACT devices, Modelling of reactive power allocation problem, Solution techniques</p>	
<b>Course Assessment</b>	<p>Continuous Evaluation 25%</p> <p>Mid Semester 25%</p> <p>End Semester 50%</p>	

<b>Course no:</b> <b>EELM 526</b>	<b>Open course</b>	<b>HM Course (Y/N)</b>	<b>DC (Y/N)</b>	<b>DE (Y/N)</b>
<b>Type of course</b>	N	N	Y	N
<b>Course Title</b>	<b>Power System Transients</b>			
<b>Course Coordinator</b>				
<b>Course objectives:</b>	This course offers a thorough understanding of power system transients. Students will review the importance of transient studies, analyze RL circuit transients, and explore their impact on system planning. It covers switching transients, including overvoltage's and effective suppression methods. The course also delves into lightning transients, traveling waves on transmission lines, and addresses transients in integrated power systems, ensuring stability and reliability through qualitative application.			
<b>POs</b>				
<b>Semester</b>	<b>Autumn: NA</b>		<b>Spring: II</b>	
	<b>Lecture</b>	<b>Tutorial</b>	<b>Practical</b>	<b>Credits</b>
<b>Contact Hours</b>	3	0	0	3
<b>Prerequisite course code as per proposed course numbers</b>				
<b>Prerequisite credits</b>				
<b>Equivalent course codes as per proposed course and old course</b>				
<b>Overlap course codes as per proposed course numbers</b>				
<b>Text Books:</b>				
1.	Title	Electrical Transients in Power Systems		
	Author	Allan Greenwood		
	Publisher	Wiley Inter Science, New York,		
	Edition	2 <sup>nd</sup> Edition, 1991		
2.	Title	Electromagnetic transients in Power System		
	Author	Pritindra Chowdhari		
	Publisher	John Wiley and Sons Inc.		
	Edition	2 <sup>nd</sup> Edition, 2009		
3.	Title	Power System Transients – A statistical approach		
	Author	C.S. Indulkar, D.P.Kothari, K. Ramalingam		

	Publisher	PHI Learning Private Limited
	Edition	2 <sup>nd</sup> Edition, 2010
<b>Reference Book:</b>		
1.	Title	Power System Transient theory and applications
	Author	Akihiro ametani
	Publisher	CRC press
	Edition	1 <sup>st</sup> Edition, 2013
<b>Content</b>	<p><b>Unit I: Introduction</b> Review and importance of the study of transients, causes for transients. RL circuit transient, double frequency transients, basic transforms of the RLC circuit transients. Different types of power system transients.</p> <p><b>Unit II: Switching Transients</b> Over voltages due to switching transients, resistance switching and the equivalent circuit for interrupting the resistor current, load switching and equivalent circuit, waveforms for transient voltage across the load and the switch, Current suppression - current chopping - effective equivalent circuit. Capacitance switching.</p> <p><b>Unit III: Lightning Transients</b> Review of the theories in the formation of clouds and charge formation, rate of charging of thunder cloud, mechanism of lightning discharges and characteristics of lightning strokes.</p> <p><b>Unit IV: Traveling Waves on Transmission Line Computation Of Transients</b> Computation of transients, transient response of systems with series and shunt lumped parameters and distributed lines. Traveling wave concept, step response.</p> <p><b>Unit V: Transients in Integrated Power System</b> Short line and kilometric fault, distribution of voltages in a power system, Line dropping and load rejection, voltage transients on closing and reclosing lines, over voltage induced by faults, switching surges on integrated system</p>	
<b>Course Assessment</b>	<p>Continuous Evaluation 25%</p> <p>Mid Semester 25%</p> <p>End Semester 50%</p>	

<b>Course No. EELM 511</b>	<b>Open Course (Y/N)</b>	<b>HM Course (Y/N)</b>	<b>DC (Y/N)</b>	<b>DE (Y/N)</b>
<b>Type of the Course</b>	N	N	N	Y
<b>Course Title</b>	<b>Power Quality</b>			
<b>Course Coordinator</b>				
<b>Course Objectives</b>	The objectives of the course include introduction of the power quality definitions, voltage sags, interruptions, harmonic problems and mitigation.			
<b>POs</b>				
Semester	Autumn		Spring	
	Lecture	Tutorial	Practical	Credits
Contact Hours	03	0	0	3
Pre-requisite course code as per proposed course members	Nil	Nil	Nil	0
Prerequisite credits				
Equivalent course codes as per proposed course and old course				
Overlap course codes as per proposed course numbers				
<b>Text Book(s)</b>				
<b>1.</b>	<b>Title</b>	Electrical Power Systems Quality		
	<b>Author</b>	Roger C. Dugan, Mark F. McGranaghan, Surya Santoso, H.Wayne Beaty		
	<b>Publisher</b>	McGraw Hill Education		
	<b>Edition</b>	Third Edition		
<b>Reference Book(s)</b>				
<b>1.</b>	<b>Title</b>	Power System Harmonic Analysis		
	<b>Author</b>	Arrillaga J., Smith B. C., Watson N. R. and Wood A. R		
	<b>Publisher</b>	Wiley India		
	<b>Edition</b>	2 <sup>nd</sup> Edition		
<b>2.</b>	<b>Title</b>	Power System Analysis		
	<b>Author</b>	Arthur R.B.		
	<b>Publisher</b>	Pearson Education		
	<b>Edition</b>	2 <sup>nd</sup> Edition		
<b>3.</b>	<b>Title</b>	Power Quality		
	<b>Author</b>	Sanskaran		
	<b>Publisher</b>	C.R.C. Press		

	<b>Edition</b>	2 <sup>nd</sup> Edition
<b>Content</b>	<p><b>Unit I: Concept of Power Quality</b> Frequency variations, voltage variations- sag and swell, waveform distortion –dc offset, harmonics, inter-harmonics, notching and noise.</p> <p><b>Unit II: Fundamentals of Harmonics</b> Representation of harmonics, waveform, harmonic power, measures of harmonic distortion; Current and voltage limits of harmonic distortions: IEEE, IEC, EN, NORSOK.</p> <p><b>Unit III: Causes of Harmonics</b> 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.</p> <p><b>Unit IV: Effect of Harmonics</b> Parallel and series resonance, effect of harmonics on static power plant – transmission lines, transformers, capacitor banks, rotating machines, harmonic interference with ripple control systems, power system protection, consumer equipment and communication systems, power measurement.</p> <p><b>Unit V: Elimination/ Suppression of Harmonics</b> High power factor converter, multi-pulse converters using transformer connections (delta, polygon) Passive Filters: Types of passive filters, single tuned and high pass filters, filter design criteria, double tuned filters, damped filters and their design. Active Power Filters: Compensation principle, classification of active filters by objective, system configuration, power circuit and control strategy. Shunt Active Filter: Single-phase active filter, principle of operation, expression for compensating current, concept of constant capacitor voltage control; Three-phase active filter: Operation, analysis and modelling; Instantaneous reactive power theory. Three-phase Series Active Filter: Principle of operation, analysis and modelling.</p>	
<b>Course Assessment</b>	<p>Continuous Evaluation - 25%</p> <p>Mid Semester- 25%</p> <p>End Semester - 50%</p>	

<b>Course No.</b> <b>EELM 515</b>	<b>Open Course</b> <b>(Yes/No)</b>	<b>HM Course</b> <b>(Y/N)</b>	<b>DC</b> <b>(Y/N)</b>	<b>DE</b> <b>(Y/N)</b>
<b>Type of the Course</b>	N	N	Y	N
<b>Course Title</b>	<b>Soft Computing and Applications</b>			
<b>Course Coordinator</b>				
<b>Course Objectives</b>	<ul style="list-style-type: none"><li>• Single and multi-layer perceptron understanding for classification in machine learning</li><li>• Develop and validate Matlab based mathematical models for data classification</li><li>• Comprehend neuro-fuzzy model implementation</li><li>• Learn to use machine learning model implementation</li></ul>			
<b>POs</b>				
Semester	Autumn		Spring	
	Lecture	Tutorial	Practical	Credits
Contact Hours	3	0	0	3
Pre-requisite course code as per proposed course members	Nil	Nil	Nil	0
Prerequisite credits				
Equivalent course codes as per proposed course and old course				
Overlap course codes as per proposed course numbers				
<b>Text Book(s)</b>				
<b>1.</b>	<b>Title</b>	Neuro Fuzzy and Soft Computing		
	<b>Author</b>	J.S.R. Jang, C.T. Sun and E. Mizutani		
	<b>Publisher</b>	Prentice Hall		
	<b>Edition</b>	3 <sup>rd</sup>		
<b>2.</b>	<b>Title</b>	Neural Network & Learning Machines		
	<b>Author</b>	Simon O. Haykin		
	<b>Publisher</b>	Prentice Hall		
	<b>Edition</b>	2nd Edition		
<b>Reference Book(s)</b>				
<b>1.</b>	<b>Title</b>	Soft Computing		
	<b>Author</b>	Saroj Kaushik		
	<b>Publisher</b>	Mc Graw Hill		
	<b>Edition</b>			

2.	<b>Title</b>	Applied Machine Learning
	<b>Author</b>	M. Gopal
	<b>Publisher</b>	Mc Graw Hill
	<b>Edition</b>	
3.	<b>Title</b>	An Introduction to Genetic Algorithms
	<b>Author</b>	M. Mitchell
	<b>Publisher</b>	MIT Press
	<b>Edition</b>	
<b>Content</b>	<p><b>Unit I: Introduction</b> Basic mathematics of soft computing, Learning and statistical approach to regression and classification.</p> <p><b>Unit II: Neural Networks:</b> Single layer perceptron, ADALINE, LMS algorithm, Multi-layer perceptron, Radial basis function, Associative Memory Networks, Hopfield Network, Principal component analysis, RNN, MATLAB Programming.</p> <p><b>Unit III: Support Vector Machines(SVM)</b> Introduction to SVM, Binary classification, Regression by SVM: linear &amp; nonlinear, Decomposing multiclass classification into binary classification. SVM MATLAB Applications</p> <p><b>Unit IV: Hybrid Intelligent System: Neuro-Fuzzy</b> Introduction, Models of Neuro-fuzzy system (NFS), Interpretation of NFS layers, Adaptive N-F Inference system (ANFIS) Architecture, T-S Fuzzy system, Mamdani Fuzzy System, ANFIS MATLAB Applications</p> <p><b>Unit V: Optimization Techniques</b> Introduction to Optimization, Genetic algorithms, Particle swarm optimization, Matlab programming.</p>	
<b>Course Assessment</b>	<p>Continuous Evaluation - 25%</p> <p>Mid Semester- 25%</p> <p>End Semester - 50%</p>	



<b>Course No.</b> <b>EELM 530</b>	<b>Open Course</b> <b>(Y/N)</b>	<b>HM Course</b> <b>(Y/N)</b>	<b>DC</b> <b>(Y/N)</b>	<b>DE</b> <b>(Y/N)</b>
<b>Type of the Course</b>	N	N	N	Y
<b>Course Title</b>	<b>Machine Learning and Deep Learning - Fundamentals And Applications</b>			
<b>Course Coordinator</b>				
<b>Course Objectives</b>	<ul style="list-style-type: none"><li>In this course we will start with traditional Machine Learning approaches, e.g., Bayesian Classification, Multilayer Perceptron etc. and then move to modern Deep Learning architectures like Convolutional Neural Networks, Autoencoders etc. We will learn about the building blocks used in these Deep Learning based solutions. Specifically, we will learn about feedforward neural networks, convolutional neural networks, recurrent neural networks and attention mechanisms. On completion of the course students will acquire the knowledge of applying Machine and Deep Learning techniques to solve various real-life problems.</li></ul>			
<b>POs</b>				
<b>Semester</b>	Autumn		Spring	
	Lecture	Tutorial	Practical	Credits
<b>Contact Hours</b>	3	0	0	3
<b>Pre-requisite course code as per proposed course members</b>	Nil	Nil	Nil	0
<b>Prerequisite credits</b>				
<b>Equivalent course codes as per proposed course and old course</b>				
<b>Overlap course codes as per proposed course numbers</b>				
<b>Text Book(s)</b>				
<b>1.</b>	<b>Title</b>	Introduction to Machine Learning, 3rd Edition,		
	<b>Author</b>	E. Alpaydin		
	<b>Publisher</b>	Prentice Hall (India)		
	<b>Edition</b>	2015		
<b>2.</b>	<b>Title</b>	Pattern Classification, 2nd Edition,		
	<b>Author</b>	R. O. Duda, P. E. Hart and D. G. Stork,		
	<b>Publisher</b>	Wiley India		
	<b>Edition</b>	2007		
<b>Content</b>	<b>Unit I: Decision Theory &amp; Estimation</b> Introduction to ML, Performance Measures, Bias-Variance Trade off, Linear Regression, Bayes Decision Theory, Normal Density and Discriminant Function, Bayes Decision Theory - Binary Features, Bayesian Belief Network, Parametric and Non-Parametric Density Estimation			

	<p>Parametric and Non- Parametric Density Estimation – ML and Bayesian Estimation, Parzen Window and KNN</p> <p><b>Unit II: Types of Models</b>  Perceptron Criteria and Discriminative Models  Perceptron Criteria, Discriminative models, Support Vector Machines (SVM), Logistic Regression, Decision Trees and Hidden Markov Model  Logistic Regression, Decision trees, Hidden Markov Model (HMM)</p> <p><b>Unit III: Types of Methods</b>  Ensemble methods: Ensemble strategies, boosting and bagging, Random Forest, Dimensionality Problem  Dimensionality Problem, Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA), Mixture Model and Clustering  Concept of mixture model, Gaussian mixture model, Expectation Maximization Algorithm, K- means clustering</p> <p><b>Unit IV: Clustering &amp; Neural Network</b>  Fuzzy K-means clustering, Hierarchical Agglomerative Clustering, Mean-shift clustering, Neural network: Perceptron, multilayer network, backpropagation, RBF Neural Network, Applications,</p> <p><b>Unit V: Deep Neural Networks</b>  Introduction to deep neural network, Convolutional Neural Networks, AlexNet, VGGNet, Google Net, Recent Trends in Deep Learning  Recent Trends in Deep Learning Architectures, Transfer Learning, Residual Network, Skip Connection Network, Auto encoders and relation to PCA, Recurrent Neural Networks, Semi-supervised learning, Applications and Case studies.</p>
<b>Course Assessment</b>	<p>Continuous Evaluation - 25%</p> <p>Mid Semester- 25%</p> <p>End Semester - 50%</p>

Course no: EELM 533	Open course	HM Course (Y/N)	DC (Y/N)	DE (Y/N)
Type of course	N	N	Y	N
Course Title	Operation and Control of Restructured Power System			
Course Coordinator				
Course objectives:	This course examines the operation and control challenges associated with restructured power systems, where traditional monopolies have given way to competitive markets. We will delve into the impact of deregulation on system operation, analyze market mechanisms for electricity trading, and explore control strategies for maintaining grid reliability in this dynamic environment. The course will also equip students with an understanding of ancillary services markets and their crucial role in ensuring system stability.			
POs				
Semester	Autumn: NA		Spring: II	
	Lecture	Tutorial	Practical	Credits
Contact Hours	3	0	0	3
Prerequisite course code as per proposed course numbers				
Prerequisite credits				
Equivalent course codes as per proposed course and old course				
Overlap course codes as per proposed course numbers				
Text Books:				
1.	Title	Power System Economics: Deregulation and Market Power		
	Author	Steven Stoft		
	Publisher	Wiley-IEEE Press		
	Edition	1 <sup>st</sup> Edition, 2002		
2.	Title	Operation of Restructured Power Systems		
	Author	Kankar Bhattacharya , Math H. J. Bollen , Jaap E. Daalder		
	Publisher	Springer		
	Edition	1 <sup>st</sup> Edition, 2001		
Reference Book:				
1.	Title	Restructuring Electric Power Systems: Achievements and		

	Challenges
Author	Mohammad Shahidehpour and Mohammad Al-Saggaf
Publisher	Power Engineering Willis
Edition	1 <sup>st</sup> Edition, 2001
<b>Content</b>	<p><b>Unit I: Introduction to Restructured Power Systems</b> Traditional Power System Structure and its Limitations, Drivers of Power Sector Restructuring (Economic Efficiency, Competition), Deregulation Models (Pool Models, Bilateral Contracts).</p> <p><b>Unit II: Electricity Markets and Pricing Mechanisms</b> Market Participants and Functions in a Deregulated System (Generators, Retailers, Market Operators), Wholesale Electricity Markets (Spot Market, Forward Contracts), Marginal Cost Pricing and Locational Marginal Pricing (LMP), Congestion Management Techniques and Market-based Solutions</p> <p><b>Unit III: Power System Control in Deregulated Markets</b> Automatic Generation Control (AGC) for Frequency Regulation in Real-Time, Supervisory Control and Data Acquisition (SCADA) Systems for Monitoring and Control, Voltage Control Strategies and Reactive Power Management, Intermittent Renewables and their Impact on System Control Requirements.</p> <p><b>Unit IV: Ancillary Services Markets and System Reliability</b> Definition and Categories of Ancillary Services (Regulation, Reserves) Market Mechanisms for Ancillary Services Procurement and Pricing Reliability Assessment Techniques and Contingency Planning Role of Ancillary Services in Maintaining System Security and Stability.</p> <p><b>Unit V: Advanced Topics and Future Trends</b> Impact of Distributed Generation and Microgrids on System Operation and Control, Smart Grid Technologies for Improved Market Efficiency and System Reliability, Optimization Techniques for Real-Time Dispatch and Market Clearing, The Future of Restructured Power Systems: Decentralization and Market Innovations.</p>
<b>Course Assessment</b>	<p>Continuous Evaluation 25%</p> <p>Mid Semester 25%</p> <p>End Semester 50%</p>

<b>Course No.</b> <b>EELM 507</b>	<b>Open Course</b> <b>(Y/N)</b>	<b>HM Course</b> <b>(Y/N)</b>	<b>DC</b> <b>(Y/N)</b>	<b>DE</b> <b>(Y/N)</b>
<b>Type of the Course</b>	N	N	Y	N
<b>Course Title</b>	<b>Power System Reliability</b>			
<b>Course Coordinator</b>				
<b>Course Objectives</b>				
<b>POs</b>				
<b>Semester</b>	Autumn		Spring	
	Lecture	Tutorial	Practical	Credits
<b>Contact Hours</b>	3	0	0	3
Pre-requisite course code as per proposed course members	Nil	Nil	Nil	0
Prerequisite credits				
Equivalent course codes as per proposed course and old course				
Overlap course codes as per proposed course numbers				
<b>Text Book(s)</b>				
<b>1.</b>	<b>Title</b>	Reliability Evaluation of Power Systems		
	<b>Author</b>	Roy Billinton , Ronald N. Allan		
	<b>Publisher</b>	Springer New York, NY Publishers		
	<b>Edition</b>	2 <sup>nd</sup> Edition, 2013		
<b>2.</b>	<b>Title</b>	Reliability modelling in Electric Power System		
	<b>Author</b>	Eodrenyi, J.		
	<b>Publisher</b>	John Wiley		
	<b>Edition</b>			
<b>Content</b>	<b>Unit I: Generating System Reliability Analysis –I</b> Generation system model – Capacity outage probability tables – Recursive relation for capacitive model building – Sequential addition method – Unit removal – Evaluation of loss of load and energy indices – Examples.  <b>Unit II: Generating System Reliability Analysis – II</b> Frequency and Duration methods – Evaluation of equivalent transitional rates of identical and non identical units – Evaluation of cumulative probability and cumulative frequency of non-identical generating units – 2-level daily load representation - Merging generation and load models – Examples.  <b>Unit III: Bulk Power System Reliability Evaluation</b> Basic configuration – Conditional probability approach – System and load			

	<p>point reliability indices – Weather effects on transmission lines – Weighted average rate and Markov model – Common mode failures.</p> <p><b>Unit IV: Pro Distribution System Reliability Analysis – I (Radial Configuration)</b>  Basic Techniques – Radial networks – Evaluation of Basic reliability indices, performance indices - Load point and system reliability indices – Customer oriented, loss and energy oriented indices – Examples.</p> <p><b>Unit V: Distribution System Reliability Analysis - II (Parallel Configuration)</b>  Basic techniques – Inclusion of bus bar failures, scheduled maintenance – Temporary and transient failures – Weather effects – Common mode failures – Evaluation of various indices – Examples.</p>
<b>Course Assessment</b>	<p>Continuous Evaluation - 25%</p> <p>Mid Semester- 25%</p> <p>End Semester - 50%</p>

Course no: EELM 567	Open course	HM Course (Y/N)	DC (Y/N)	DE (Y/N)
Type of course	N	N	Y	N
Course Title	Electric Vehicles			
Course Coordinator				
Course objectives:	Comprehend the basics concepts of electric vehicles, their architecture, and technologies. Able to understand the operation of battery driven and designing of Battery Pack. Able to interpret the working of different electrical machines in electric vehicles and their control technique. Ability to understand the control and configurations of EV chargers and charging stations.			
POs				
Semester	Autumn: NA		Spring: II	
	Lecture	Tutorial	Practical	Credits
Contact Hours	3	0	0	3
Prerequisite course code as per proposed course numbers				
Prerequisite credits				
Equivalent course codes as per proposed course and old course				
Overlap course codes as per proposed course numbers				
Text Books:				
1.	Title	Electric and Hybrid Vehicles		
	Author	Iqbal Husain		
	Publisher	Routledge Taylor & Francis Group		
	Edition	3 <sup>rd</sup> Edition		
2.	Title	Electric Vehicle Engineering		
	Author	Per Enge, Nick Enge, and Stephen Zoepf		
	Publisher	McGraw Hill		
	Edition	1 <sup>st</sup> Edition		
Reference Book:				
1.	Title	Electric and Hybrid Vehicles		
	Author	Tom Denton, Hayley Pells		

	Publisher	Routledge Taylor & Francis Group
	Edition	3 <sup>rd</sup> Edition
2.	Title	Modern Electric, Hybrid Electric, and Fuel Cell Vehicles
	Author	Mehrdad Ehsani, Yimin Gao, Stefano Longo, Kambiz Ebrahimi
	Publisher	Routledge Taylor & Francis Group
	Edition	3 <sup>rd</sup> Edition
<b>Content</b>	<p><b>Unit I: Vehicle Dynamics</b> Forces and aerodynamic drag, rolling resistance and uphill resistance, power and torque to accelerate, concept of drive cycles and energy, design of EV drive train.</p> <p><b>Unit II: EV Battery Pack</b> Introduction to battery parameters, Li-Ion battery cells, SoH and SoC estimation and self-discharge, battery pack development, computation of effective cost of battery and batteries charging.</p> <p><b>Unit III: Battery Pack Design</b> Mechanical Design and Thermal Design, Electrical Design, BMS Design of Electric Vehicle, Cell Testing &amp; Characterization.</p> <p><b>Unit IV: EV Motors and Controllers</b> Vehicle Dynamics, Power and Efficiency, Torque Production, Speed and Back EMF, Field oriented control of induction machines, BLDC motor, Modelling of PMSM Drives, Vector Control of PMSM Drives.</p> <p><b>Unit V: EV Chargers</b> Introduction, Slow or Fast chargers, Battery Swapping, Standardization and on-board Chargers, Public Chargers, Bulk Chargers/Swap Stations.</p>	
<b>Course Assessment</b>	<p>Continuous Evaluation 25%</p> <p>Mid Semester 25%</p> <p>End Semester 50%</p>	



<b>Course no: EELM 562</b>	<b>Open course</b>	<b>HM Course (Y/N)</b>	<b>DC (Y/N)</b>	<b>DE (Y/N)</b>
<b>Type of course</b>				Y
<b>Course Title</b>	Special Electrical Machines			
<b>Course Coordinator</b>				
<b>Course objectives:</b>	To impart knowledge on Construction, principle of operation and performance of synchronous reluctance motors. To impart knowledge on the Construction, principle of operation, control and performance of stepping motors. To impart knowledge on the Construction, principle of operation, control and performance of switched reluctance motors. To impart knowledge on the Construction, principle of operation, control and performance of permanent magnet brushless D.C. motors. To impart knowledge on the Construction, principle of operation and performance of permanent magnet synchronous motors.			
<b>POs</b>				
<b>Semester</b>	<b>Autumn: I Semester</b>		<b>Spring</b>	
	<b>Lecture</b>	<b>Tutorial</b>	<b>Practical</b>	<b>Credits</b>
<b>Contact Hours</b>	3	0	0	3
<b>Prerequisite course code as per proposed course numbers</b>				
<b>Prerequisite credits</b>				
<b>Equivalent course codes as per proposed course and old course</b>				
<b>Overlap course codes as per proposed course numbers</b>				
<b>Text Books:</b>				
1.	Title	Special Electrical Machines		
	Author	K.Venkataratnam		
	Publisher	Universities Press (India) Private Limited		
	Edition	2008		
2.	Title	Brushless Permanent Magnet and Reluctance Motor Drives		

	Author	T.J.E. Miller
	Publisher	Clarendon Press, Oxford
	Edition	1989
<b>Content</b>	<p><b>Unit I: Synchronous Reluctance Motors</b></p> <p>Constructional features – Types – Axial and Radial flux motors – Operating principles – Variable Reluctance Motors – Voltage and Torque Equations - Phasor diagram - performance characteristics –Applications</p> <p><b>Unit II: Stepper Motors</b></p> <p>Constructional features – Principle of operation – Variable reluctance motor – Hybrid motor – Single and multi-stack configurations – Torque equations – Modes of excitation – Characteristics – Drive circuits – Microprocessor control of stepper motors – Closed loop control-Concept of lead angle– Applications.</p> <p><b>Unit III: Switched Reluctance Motors (SRM)</b></p> <p>Constructional features – Rotary and Linear SRM - Principle of operation – Torque production – Steady state performance prediction- Analytical method -Power Converters and their controllers –Methods of Rotor position sensing – Sensor less operation – Characteristics and Closed loop control</p> <p><b>Unit IV: Permanent Magnet Brushless D.C. Motors</b></p> <p>Permanent Magnet materials – Minor hysteresis loop and recoil line-Magnetic Characteristics – Permeance coefficient -Principle of operation – Types – Magnetic circuit analysis – EMF and torque equations – Commutation - Power Converter Circuits and their controllers – Motor characteristics and control–Applications.</p> <p><b>Unit V: Permanent Magnet Synchronous Motors (PMSM)</b></p> <p>Principle of operation – Ideal PMSM – EMF and Torque equations – Armature MMF – Synchronous Reactance – Sine wave motor with practical windings - Phasor diagram – Torque/speed characteristics -Power controllers - Converter Volt-ampere requirements– Applications.</p>	
<b>Course Assessment</b>	<p>Continuous Evaluation 25%</p> <p>Mid Semester 25%</p> <p>End Semester 50%</p>	

Course no. EELM 568	Open course (Yes/No)		HM Course (Y/N)		DC (Y/N)	DE (Y/N)
	N		N		N	Y
Type of course	Theory					
Course Title	Energy Storage Devices					
Course Objectives:						
Semester						
	Autumn:		Spring: Yes			
	Lecture	Tutorial	Practical	Credits	Teaching Hours	
Contact Hours	03	0	0	03	36	
Prerequisite course code as per proposed course number						
Prerequisite credits						
Equivalent course codes as per proposed course and old course						
Overlap course codes as per proposed course numbers						
Text Books:						
1.	Title	Energy Storage for Power Systems				
	Author	A.G.Ter-Gazarian				
	Publisher	The Institution of Engineering and Technology (IET) Publication, UK, (ISBN - 978-1 84919-219-4),2011.				
	Edition	Second Edition				
2.	Title	Energy Storage in Power Systems				
	Author	Francisco Díaz-González, Andreas Sumper, Oriol Gomis-Bellmunt				
	Publisher	Wiley Publication, ISBN: 978-1-118-97130-7, Mar 2016.				
	Edition					
3.	Title	The Physics of solar cell				
	Author	Jenny Nelson				
	Publisher	Imperial college Press				
	Edition	1 <sup>st</sup>				
4.	Title	Energy Storage Benefits and Market Analysis				
	Author	James M. Eyer, Joseph J. Iannucci and Garth P. Corey				
	Publisher	Sandia National Laboratories, 2004.				
	Edition					
Reference Books:	Title	Behaviour of Lithium-Ion Batteries in Electric Vehicles: Battery Health, Performance, Safety, and Cost.				

<b>1.</b>	Author	Pistoia, Gianfranco, and Boryann Liaw.
	Publisher	Springer International Publishing AG, 2018.
	Edition	
<b>Content</b>	<p><b>Unit I : Introduction to energy storage in power systems</b>  Importance of energy storage in modern energy systems, renewable and non-renewable resources, Types of energy storage systems: Electrochemical, mechanical, thermal, and chemical, Applications of energy storage, Challenges and future trends in energy storage.</p> <p><b>Unit II : Energy storage technologies and renewable power sources</b>  Electrochemical energy: Batteries, Fuel cells, Electrostatic energy (Super Capacitors), Electromagnetic energy (Super conducting Magnetic Energy Storage), Comparative analysis, Environmental impacts of different technologies.</p> <p><b>Unit III : Features of Energy Storage Systems</b>  Classification of energy storage systems, Mechanical storage systems, Pumped hydro storage (PHS), Compressed air energy storage (CAES), Flywheel energy storage (FES), Electrochemical storage systems, Secondary batteries, Flow batteries, Chemical energy storage, Hydrogen, Synthetic natural gas (SNG).</p> <p><b>Unit IV : Applications</b>  Utility use (conventional power generation, grid operation &amp; service), Consumer use (uninterruptable power supply for large consumers), Internal configuration of battery storage systems, External connection of energy storage systems, Aggregating energy storage systems and distributed generation (Virtual Power Plant), Battery SCADA–aggregation of many dispersed batteries.</p>	
<b>Course Assessment</b>	<p>Theory: Continuous Evaluation 25%, Mid Semester 25%, End Semester 50%.</p> <p>100% weightage to theory for overall grading.</p> <p>Continuous evaluation shall depend on course coordinator.</p>	

<b>Course no: EELM 575</b>	<b>Open Course (Y/N)</b>	<b>HM Course (Y/N)</b>	<b>DC (Y/N)</b>	<b>DE (Y/N)</b>
<b>Type of course</b>	N0	N0	Yes	No
<b>Course Title</b>	<b>Statistical Signal Processing</b>			
<b>Course Coordinator</b>				
<b>Course objectives:</b>	<ul style="list-style-type: none"> <li>Understand the fundamental principles of statistical signal processing, including probability theory, random variables, and stochastic processes, to analyze and manipulate signals in uncertain environments.</li> <li>Gain proficiency in advanced signal processing techniques such as estimation, detection, and classification, utilizing statistical methods to extract meaningful information from noisy or incomplete data.</li> <li>Apply theoretical knowledge to practical scenarios by designing and implementing signal processing algorithms for real-world applications, fostering critical thinking and problem-solving skills in signal analysis and interpretation</li> </ul>			
<b>POs</b>				
<b>Semester</b>			Spring: NA	
	Lecture	Tutorial	Practical	Credits
<b>Contact Hours</b>	3	0	0	3
<b>Prerequisite course code as per proposed course numbers</b>	Nil			
<b>Prerequisite credits</b>	Nil			
<b>Equivalent course codes as per proposed course and old course</b>	Nil			
<b>Overlap course codes as per proposed course numbers</b>	Nil			
<b>Text Books:</b>				
1.	Title	Statistical and Adaptive Signal Processing		
	Author	D.G. Manolakis, V.K. Ingle, S.M. Kogon		
	Publisher			
	Edition	2000		
2.	Title	Statistical Digital Signal Processing and Modeling		
	Author	Monsoon H.Hayes		
	Publisher	Wiley		

	Edition	1996
<b>Reference Book:</b>		
1.	Title	Fundamentals of Statistical Signal Processing: Estimation theory
	Author	Steven M. Kay
	Publisher	Upper: Prentice-Hall
	Edition	1993
2.	Title	Random variables and Stochastic Processes
	Author	Papoulis, probability
	Publisher	McGraw Hill
	Edition	1983
<b>Content</b>	<p><b>Unit I: Signal Models And Characterization</b> Types and properties of statistical models for signals and how they relate to signal processing, common second-order methods of characterizing signals.</p> <p><b>Unit II: Stochastic Processes</b> Wide sense stationary processes, orthogonal increment processes, Wiener process, and the Poisson process, Doob decomposition, KL expansion. Ergodicity, Mean square continuity, mean square derivative and mean square integral of stochastic processes.</p> <p><b>Unit III: Spectral Estimation</b> Moving average (MA), autoregressive (AR), autoregressive moving average (ARMA), various non-parametric approaches, non-parametric methods for estimation of power spectral density, autocorrelation, cross-correlation, transfer functions, and coherence from finite signal samples.</p> <p><b>Unit IV: Parametric Signal Modeling And Estimation</b> A review on random processes, A review on filtering random processes, Examples, Maximum likelihood estimation, maximum a posterior estimation, Cramer-Rao bound Pisarenko, MUSIC, ESPRIT, Higher order statistics.</p> <p><b>Unit V: Optimum Linear Filters</b> Linear Mean square error estimation, optimum IIR filters, optimum FIR filters, Inverse filtering and deconvolution, order recursive algorithms for optimum FIR filters, Algorithms of Levinson, Levinson-Durbin and Schiir, Triangularization and inversion of Toeplitz matrices, Wiener filtering and Kalman filtering.</p>	
<b>Course Assessment</b>	<p>Theory: Continuous Evaluation 25%, Mid Semester 25%, End Semester 50%. 100% weightage to theory for overall grading. Continuous evaluation shall depend on course coordinator.</p>	

Course no: EELM 577	Open course (Y/N)	HM course (Y/N)	DC (Y/N)	DE (Y/N)
Type of course	N	N	N	Y
Course Title	Power Electronic Converters for Renewable Energy Systems			
Course Coordinator				
Course objectives:	<ul style="list-style-type: none"><li>Understand and analyze the design and operation of solar photovoltaic and wind energy generation systems.</li><li>Understand the working principles of fuel cells and various energy storage systems.</li><li>Explain and apply power converter topologies used in renewable energy systems.</li><li>Understand and evaluate the operation and control of multi-source renewable energy systems.</li></ul>			
POs				
Semester	Autumn:		Spring: 2nd Semester	
	Lecture	Tutorial	Practical	Credits
Contact Hours	3	0	0	3
Prerequisite course code as per proposed course numbers	NA			
Prerequisite credits	NA			
Equivalent course codes as per proposed course and old course	NA			
Overlap course codes as per proposed course numbers	NA			
Text Books:				
1.	Title	Power Electronics for Renewable and Distributed Energy Systems		
	Author	Sudipta Chakraborty, Marcelo G. Simoes, William E Kramer		
	Publisher	Springer		
	Edition	-		
2.	Title	Non-Conventional Energy Resources		
	Author	S. N. Singh		
	Publisher	Pearson		
	Edition	-		
Reference Book:				
1	Title	Power Electronics for Renewable Energy Systems, Transportation, and Industrial Application		
	Author	Haitham Abu-Rub, Mariusz Malinowski, Kamal Al-Haddad		
	Publisher	IEEE Press, Wiley		
	Edition	-		
2	Title	Wind Power Technology		
	Author	Joshua Earnest		
	Publisher	PHI		
	Edition	2nd		

<b>3</b>	Title	Solar Photovoltaics (Fundamental, Technologies, and Applications)
	Author	Chetan S. Solanki
	Publisher	PHI
	Edition	2nd
<b>4</b>	Title	Renewable Energy, Power for Sustainable Future
	Author	Godfrey Boyle
	Publisher	Oxford
	Edition	3rd
<b>5</b>	Title	Grid Converters for Photovoltaic and Wind Power Systems
	Author	Remus Teodorescu, Marco Liserre, Pedro Rodriguez
	Publisher	Wiley-IEEE Press
	Edition	2011
<b>6</b>	Title	Power Electronic Converters for Microgrids
	Author	Suleiman M. Sharkh, Mohammad A. Abu-Sara, Georgios I. Orfanoudakis, Babar Hussain
	Publisher	Wiley-IEEE Press
	Edition	2014
Content		<p><b>Unit-I: Introduction</b> Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment. Qualitative study of different renewable energy resources: Solar, Wind, Tidal, Small-hydro, Biomass, Hydrogen energy systems (Fuel cell) and hybrid renewable energy systems.</p> <p><b>Unit-II: Solar Photovoltaic Systems</b> Construction and working, mathematical models (single-diode and two-diode), I- V and P-V characteristics. Concept of maximum-power, maximum-power point tracking algorithms (P&amp;O and InC). Power converter configurations and their selection for solar PV application: DC-DC converters and solar inverters. Grid connected and off-grid PV systems with and without storage. Grid synchronization and PLLs. Battery and PV array sizing.</p> <p><b>Unit-III: Wind Energy System, Fuel Cell System and Energy Storage Fuel cells</b> a) <b>Wind:</b> Wind energy basics, aerodynamic power, Betz limit. On-shore and Off-shore wind farms. Wind turbines and generators: types of wind turbines-HAWT, VAWT: construction and operation. Control of wind turbines: pitch control, stall control, yaw control, and speed variation. Power electronics for wind power: power converter and inverter configuration, partial rated power electronics, soft-starters etc. Introduction to IG, PMSG, SEIG, and DFIG. b) <b>Fuel Cell System and Energy Storage Fuel cells:</b> Construction and working, types of fuel cells, characteristics. Power converter configurations for integrating fuel cells. Energy-storage solutions for renewable energy systems.</p> <p><b>Unit-IV: Hybrid Renewable Energy Systems</b> Need for hybrid renewable energy systems, block-diagram representation, demonstration of operation and control of</p>



	multi-source (Solar PV, Wind, Fuel-cell and Battery) hybrid AC/DC Nano-Grid in grid connected and islanded mode. Control of hybrid renewable energy sources, current, voltage control for standalone and grid parallel operations. Grid connection issues.
Course Assessment	Theory: Continuous Evaluation 25%, Mid Semester 25%, End Semester 50%. Continuous evaluation shall depend on course coordinator.

Course No. EELM 593	Open Course (Y/N)	HM Course (Y/N)	DC (Y/N)	DE (Y/N)
Type of the Course	N	N	N	Y
Course Title	Digital Control in Switched Mode Power Converters and FPGA-based Prototyping			
Course Coordinator				
Course Objectives	<ul style="list-style-type: none"><li>• Gain comprehensive understanding of the digital control in switch-mode converters</li><li>• Develop and validate Matlab based mathematical models for digital control</li><li>• Comprehend digital control implementation</li><li>• Learn to use embedded control implementation platforms</li></ul>			
POs				
Semester	Autumn		Spring	
	Lecture	Tutorial	Practical	Credits
Contact Hours	3	0	0	3
Pre-requisite course code as per proposed course members	Nil	Nil	Nil	0
Prerequisite credits				
Equivalent course codes as per proposed course and old course				
Overlap course codes as per proposed course numbers				
Text Book(s)				
1.	Title	Fundamentals of Power Electronics		
	Author	R. W. Erickson and D. Maksimovic		
	Publisher	Springer, 2020		
	Edition	3 <sup>rd</sup>		
2.	Title	Digital Control in Power Electronics		
	Author	Simone Buso, Paolo Mattavelli		
	Publisher	Springer		
	Edition	2 <sup>nd</sup>		
Reference Book(s)				
1.	Title	Computer Techniques for Dynamic Modeling of DC-DC Power Converters		
	Author	Farzin Asadi		
	Publisher	Springer Cham		
	Edition	1 <sup>st</sup>		
2.	Title	Dynamics and Control of DC-DC Converters		

	<b>Author</b>	Farzin Asadi, Kei Eguchi
	<b>Publisher</b>	Springer Cham
	<b>Edition</b>	1 <sup>st</sup>
<b>3.</b>	<b>Title</b>	Digital Control of High-Frequency Switched-Mode Power Converters
	<b>Author</b>	Luca Corradini, Dragan Maksimovic, Paolo Mattavelli, Regan Zane
	<b>Publisher</b>	Wiley-IEEE Press
	<b>Edition</b>	
<b>Content</b>	<p><b>Unit I:</b> Introduction to digital control in switched mode power converters (SMPCs), Fixed and variable frequency digital control architectures</p> <p><b>Unit II:</b> Modeling techniques and model validation using MATLAB, MATLAB custom model development for simulation under digital control</p> <p><b>Unit III:</b> Frequency and time domain digital control design approaches. Digital control implementation blocks and steps for FPGA based prototyping</p> <p><b>Unit IV:</b> Introduction to Verilog HDL and simulation using Xilinx Webpack. Digital controller implementation using fixed point arithmetic and Verilog HDL. Digital Control Implementation using STM32/C2000 Series Microcontrollers</p> <p><b>Unit V:</b> FPGA prototyping of digital voltage mode and current mode control. Design and validation case studies using digital voltage and current mode control. Hardware case studies of advanced digital control techniques and course summary</p>	
<b>Course Assessment</b>	<p>Continuous Evaluation - 25%</p> <p>Mid Semester- 25%</p> <p>End Semester - 50%</p>	

<b>Course no:</b> <b>EELM 576</b>	<b>Open course</b> <b>(YES/NO)</b>		<b>HM Course</b> <b>(Y/N)</b>	<b>DC(Y/N)</b>	<b>DE(Y/N)</b>
<b>Type of course</b>					YES
<b>Course Title</b>	<b>Smart Grid Resiliency and Cyber Security</b>				
<b>Course Coordinator</b>					
<b>Course objectives:</b>	To study the components and architecture of smart grid. To study the various communication technologies and protocols used for smart grid. To understand different security threats and defense mechanism for smart grid security. To understand the role of IoT and big data management in smart grid applications. To learn the application of AI techniques in smart grid.				
<b>POs</b>					
<b>Semester</b>	<b>Autumn: Yes</b>		<b>Spring:</b>		
	<b>Lecture</b>	<b>Tutorial</b>	<b>Practical</b>	<b>Credits</b>	<b>Teaching Hours</b>
<b>Contact Hours</b>	3	0	0	3	36
<b>Prerequisite course Code as per proposed course numbers</b>					
<b>Prerequisite credits</b>					
<b>Equivalent course codes as per proposed course and Old course</b>					
<b>Overlap course codes as per proposed Course numbers</b>					
<b>Text Books:</b>					
1.	Title	Smart Grid Security			
	Author	Gilbert N. Sorebo and Michael C. Echols			
	Publisher	CRC Press			
	Edition	1 <sup>st</sup>			
2.	Title	Smart Grid Applications, Communications and Security			
	Author	Lars T. Berger and Krzysztof Iniewski			
	Publisher	Wiley			
	Edition	1 <sup>st</sup>			

<b>Content</b>	<p><b>Unit I: Overview of Smart Grid</b>  Definition and Elements of Smart Grid, Evolution of Smart Grid, Characteristics and functions of Smart Grid, Components, Architecture and Networks, Smart Grid Technologies, Smart Grid Challenges and applications, Future of the Smart Grid.</p> <p><b>Unit II: Communication Technologies for Smart Grid</b>  QoS requirements for Smart Grids, Interoperability and Standards, Communication Network Structure, Smart Grid Communication Technologies: Wired Communication and Wireless Communication, Communication protocols for power systems, Challenges of Smart Grid Communication: Reliability, Security and Privacy.</p> <p><b>Unit III: Security of Smart Grid</b>  Smart Grid security objectives, Cyber security requirements, Network security threats, Smart Grid as a cyber-physical system, Cyber-physical perspective of smart grid security, Cyber-physical attacks on Smart Grid, Defense against cyber-physical attacks, Attack-resilient designs.</p> <p><b>Unit IV: IoT and Big Data Management for Smart Grid Applications</b>  Driving factor of IoT for Smart Grid, IoT applications in Smart Grid, Integrated IoT Architectures in Smart Grid, Requirements for Using IoT in Smart Grid, IoT-based Smart Grid security issues, Big data characteristics in smart grid, Data analysis techniques, Big data analytics in smart grid, Energy big data attacks.</p> <p><b>Unit V: AI Techniques in Smart Grid</b>  Overview of AI techniques, Application of AI techniques: load forecasting, fault detection, security and identification of compromised meters, Challenges, Cloud-based mitigation, Countermeasures based on Blockchain.</p>
<b>Course Assessment</b>	Continuous Evaluation: 25% Mid-Semester Examination: 25% End-Semester Examination: 50%