TEACHING SCHEME

M.TECH DEGREE IN

POWER & ENERGY SYSTEMS

(Department of Electrical Engineering)

EFFECTIVE FROM 2024-2025

NATIONAL INSTITUTE OF TECHNOLOGY

DELHI

(NIT DELHI)

M. Tech (Power and Energy Systems) Course Structure

S.No	Course code	Course Title	L-T-P	C
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
		Total	**18-0-3**	**20**
S.No	**Course**	**Course Title**	**L-T-P**	**C**
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
		Total	**18-0-3**	**20**
S.No	**Course**	**Course Title**	**L-T-P**	**C**
1	EEPM 603	Dissertation-I		16
2		MOOCs Course – I/ Independent Study Course - I		3
3	EEPM 604	Seminar-I	0-0-2	1
		Total		**20**
S.No	**Course**	**Course Title**	**L-T-P**	**C**
1	EEPM 652	Dissertation-II		16
2		MOOCs Course – II/ Independent Study Course - II		3
3	EEPM 653	Seminar-II	0-0-2	1
		Total		**20**
		Total Credits		**80**

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 3rd and 4th 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 1st and 2nd semester are also allowed but their evaluation and marks to be credited during their 3rd and 4th semesters respectively as indicated above.

- If a student completes a MOOC course and submits the evaluation result by the end of 3rd and 4th semester respectively, the they will be exempted from appearing for the Institute examination in the respective Independent Study Course – I (in the 3rd semester) and Independent Study Course – II (in the 4th semester).

- A student failing to complete the MOOC courses will have to choose an Independent Study course-I (in the 3rd semester) and Independent Study Course – II (in the 4th 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
Elective-I			
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 Polices 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	
Elective-II			
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
Elective-III			
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

Elective-IV			
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
Elective-V			
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
Elective-VI			
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	C
1	EELM 605	Smart Grid: Basics to Advanced Technologies	3
2	EELM 606	Power Electronics Application in Power Systems	3
3	EELM 607	Microelectronics: Devices to Circuits	3
4	EELM 608	Design of Photovoltaic Systems	3

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	• Analyze the steady state condition of power system using load flow analysis. • Comprehend the concepts of scheduling different types of generation units. • Analysis the contingency on a power system and perform contingency studies using a power flow analysis. • Analyze State estimation problem of a power system.			
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		

	Author	Loi Lei Lai
	Publisher	John Wiley & Sons
	Edition	
3.	**Title**	
	Author	
	Publisher	
	Edition	
Content	**Unit– I: Transmission line model and performance** Characteristics and performance of short, medium and long Transmission Line, surge impedance loading, power flow through transmission line, line compensation. **Unit– II: Power Flow Analysis** 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. **Unit– III: Optimal System Operation** Optimal operation of generators on bus bar, optimal unit commitment, optimal generation scheduling, Unit commitment and Scheduling of Hydro thermal systems, **Unit– IV: Power System Security** System state classification, security analysis, contingency analysis, sensitivity factors. **Unit– V: State Estimation of Power System** Least Squares Estimation, static state estimation and tracking state estimation of power systems, computational considerations.	
Course Assessment	Continuous Evaluation - 25% Mid Semester- 25% End Semester - 50%	

Course No. EELM 506	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 Protection**			
Course Coordinator				
Course Objectives	• Recall the various Electromagnetic and static relays. • Outline the Input quantities for various types of distance relays. • Select the switching schemes for reduction in measuring devices. • Explain the importance of digital protection algorithms. • Use the microprocessor for implementation of digital protection algorithms.			
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**	Power System Protection and Switchgear		
	Author	Badri Ram		
	Publisher	Tata McGraw-Hill Education		
	Edition	3/e, 2011		
2.	**Title**	Power System Protection: Static Relays with microprocessor Applications		
	Author	Madhava Rao		
	Publisher	Tata McGrawHill Education		
	Edition	2/e, 2004		
Content	**Unit– I: Introduction to Protective Relays** 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. **Unit– II: Distance protection-I** Impedance, reactance, mho, angle impedance relays, Input quantities for			

	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. **Unit– III: Distance protection-II** 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. **Unit– IV: Digital relaying techniques** Digital relaying algorithms, differential equation technique, discrete Fourier transform technique, Walsh-Hadamard transform technique, rationalized Haar transform technique, removal of dc offset. **Unit– V: Microprocessor based protective relays** 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.
Course Assessment	Continuous Evaluation - 25% Mid Semester- 25% End Semester - 50%

Course No. EELM 509	Open Course (Y/N)	HM Course (Y/N)	DC (Y/N)	DE (Y/N)
Type of the Course	N	N	Y	N
Course Title	**Applied Power Electronics**			
Course Coordinator				
Course Objectives				
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**	Power Electronics		
	Author	Daniel W. Hart		
	Publisher	Tata McGraw-Hill		
	Edition	1^{st} Edition, 2011		
2.	**Title**	Power Electronics-Circuit Analysis and Design		
	Author	Issa Batarseh		
	Publisher	John Wiley		
	Edition	2^{nd} Edition, 2003		
3.	**Title**	Power Electronics: Converters, Applications, and Design		
	Author	William P. Robbins, Ned Mohan, Tore M. Undeland		
	Publisher	John Wiley		
	Edition	3^{rd} Edition, 2002		
Reference Book(s)				
1.	**Title**	Power Electronics: Devices, Drivers, Applications, and Passive Components		
	Author	Barry Williams		
	Publisher	McGraw Hill Higher Education		
	Edition	2^{nd} Edition, 1991		
2.	**Title**	Modern Power Electronics and AC motor Drives		
	Author	Bimal K Bose		

	Publisher	Pearson Publishers
	Edition	1st Edition, 2015
Content	**Unit–I**: Power Electronic Devices: Power Diode, SCR, GTO, MOSFET, IGBT, IGCT, SiC and GaN devices –Structure and characteristics. **Unit– II:** 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. **Unit– III:** Improved power quality converters- Multi-pulse converters, buck, boost, buck-boost converters in AC-DC topology, PWM rectifiers and their control, Matrix Converters. **Unit– IV:** Three phase AC voltage regulators and Cyclo-converters. Voltage Source Converters and their PWM techniques, Current Source Converters	
Course Assessment	Continuous Evaluation - 25% Mid Semester- 25% End Semester - 50%	

Course No. EEPM 508	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 Systems Simulation and Hardware Lab			
Course Coordinator				
Course Objectives				
POs				
Semester	Autumn		Spring	
	Lecture	Tutorial	Practical	Credits
Contact Hours	0	0	3	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				
Content	1) Power system simulation using MATLAB/ C or C ++ /Sci lab /octave a. Formation for symmetric π configuration for Verification of $D-BC$=1, Determination of Efficiency and regulation. b. Formation for symmetric T configuration for Verification of $AD-BC$=1, Determination of Efficiency and regulation. 2) Determination of Power Angle Diagrams, Reluctance Power, Excitation, Emf and Regulation for Salient and Non-Salient Pole Synchronous Machines 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. 4) Y Bus Formation for Power Systems with and without Mutual Coupling, by Singular Transformation and Inspection Method 5) Formation of Z Bus(without mutual coupling) using Z-Bus Building Algorithm. 6) Determination of Bus Currents, Bus Power and Line Flow for a Specified System Voltage (Bus) Profile.			

	7) Formation of Jacobian for a System not Exceeding 4 Buses (No PV Buses) in Polar Coordinates. 8) Load Flow Analysis using Gauss Siedel Method, NR Method and Fast Decoupled Method for Both PQ and PV Buses. 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 10) Optimal Generation Scheduling for Thermal power plants.
Course Assessment	Continuous Evaluation - 25% Mid Semester- 25% End Semester - 50%

Course no: EELM 555	**Open course**	**HM Course (Y/N)**	**DC (Y/N)**	**DE (Y/N)**
Type of course				Y
Course Title	**Renewable and Distributed Energy Systems**			
Course Coordinator				
Course objectives:	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.			
POs				
Semester				
	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	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
Content	**Unit I: Renewable Energy (RE) Sources** 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. **Unit II: Wind Energy** Power in the Wind – Types of Wind Power Plants (WPPs)–Components of WPPs-Working of WPPs- Siting of WPPs-Grid integration issues of WPPs. **Unit III: Solar PV and Thermal Systems** 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 & Quality of the Cell, series and parallel connections, maximum power point tracking, Applications. **Unit IV: Biomass Energy** 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. **Unit V: Other Energy Sources** 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.	

Course Assessment	Continuous Evaluation 25% Mid Semester 25% End Semester 50%

Course no: EELM 556	Open course	HM Course (Y/N)	DC (Y/N)	DE (Y/N)
Type of course				Y
Course Title	Distribution System Operation and Planning			
Course Coordinator				
Course objectives:	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.			
POs				
Semester	**Autumn**		**Spring: II Semester**	
	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 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.

Reference Books:		
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.
Content	**Unit I: Primary and Secondary Distribution System Layouts** 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. **Unit II: Reliability Assessment of Distribution Systems** Introduction, reliability modelling concept, different reliability indices, customer interruption cost evolution and customer damage function. **Unit III: Distribution System Planning** Introduction, different components of distribution system planning, different planning approaches, planning models and solution strategies. **Unit IV: Distribution System Automation and Smart Grid** 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. **Unit V: Integration of Distributed Generation (DG)** Introduction to DG, Effect of renewable energy sources on power distribution systems.	

Course Assessment	Continuous Evaluation 25% Mid Semester 25% End Semester 50%

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 impact concepts behind economic analysis and Load management. Energy management on various electrical equipment andmetering. 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 proposedcourse 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	5th 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.

	Unit II: Energy Management for Motors and Cogeneration Energy management for electric motors – Transformer and reactors - Capacitors and synchronous machines, energy management by cogeneration – Forms of cogeneration – Feasibility of cogeneration – Electrical interconnection. **Unit III: Lighting Systems** 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. **Unit IV: Metering for Energy Management** 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. **Unit V: Economic Analysis and Models** 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.
Course Assessment	Continuous Evaluation 25% Mid Semester 25% End Semester 50%

Course no: EEPM 558	Open course (Y/N)	HM Course (Y/N)	DC (Y/N)	DE (Y/N)
Type of course	N	N	Y	N
Course Title	Energy Simulation and Hardware Lab			
Course Coordinator				
Course Outcomes:				
POs				
Semester	**Autumn:**		**Spring: II**	
	Lecture	**Tutorial**	**Practical**	**Credits**
Contact Hours	0	0	3	3
Prerequisite course codeas per proposed course numbers				
Prerequisite credits				
Equivalent course codes as per proposed courseand old course				
Overlap course codes as per proposed course numbers				
Content	1. To draw the I-V and P-V characteristics of PV module with various radiation and temperature. 2. To draw the I-V and P-V characteristics of series and parallel combination of PV module 3. To analyze the effect of shading on solar module 4. Demonstration of the working of diode as bypass and blocking diode in PV modules. 5. To determine maximum power flow calculations of PV system of AC & DC load with battery 6. Testing and performance analysis of Grid connected and Standalone Solar Power System. 7. To analyze the performance tests on Induction generator-based Wind energy system. 8. To analyze the performance tests on PMSM based Wind energy system. 9. To draw the characteristics of Fuel Cell 10. To analyze the performance of hybrid Energy system.			

Course Assessment	Continuous Evaluation 25% Mid Semester 25% End Semester 50%

Course No. EELM 520	Open Course (Y/N)	HM Course (Y/N)	DC (Y/N)	DE (Y/N)
Type of the Course	N	N	N	Y
Course Title	**Smart Grid Technologies**			
Course Coordinator				
Course Objectives				
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**	Smart Grid: Fundamentals of Design and Analysis		
	Author	James A. Momoh		
	Publisher	Wiley-IEEE Press, ISBN-13: 978-0470889398		
	Edition	1st		
2.	**Title**	Smart Power Grids		
	Author	Ali Keyhani, Muhammad Marwali		
	Publisher	Springer Berlin, Heidelberg		
	Edition	1st		
Reference Book(s)				
1.	**Title**	Computer Relaying for Power Systems		
	Author	Dr. Arun G. Phadke, Dr. James S. Thorp		
	Publisher	Wiley		
	Edition			
2.	**Title**	Microgrids: Architectures and Control		
	Author	Nikos Hatziargyriou		
	Publisher	Wiley		
	Edition			
3.	**Title**	Renewable Energy Systems: Advanced Conversion Technologies and Applications		
	Author	Fang Lin Luo and Ye Hong		

	Publisher	CRC Press
	Edition	
Content	**Unit I: Introduction** Introduction to Smart Grid: Evolution of Electric Grid, Concept of Smart Grid, Difference between conventional & smart grid, Concept of Resilient & Self-Healing Grid, Present development & International policies in Smart Grid. Case study of Smart Grid, CDM opportunities in Smart Grid, Local Energy Networks, Electric Transportation, Low-Carbon Central Generation. **Unit II: Sensing, and Measurement Technologies** 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). **Unit III: Control and Automation Technologies** 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 & Building Automation, Phase Shifting Transformers. Smart Substations, Fault location, isolation and restoration, Voltage regulation. Feeder Automation, Geographic Information System(GIS), Intelligent Electronic Devices(IED) & their application for monitoring & protection. **Unit IV: Micro Grids And Distributed Energy Resources** Concept of micro grid, need & applications of micro grid, issues of interconnection, protection & 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. **Unit V: Power Quality Management** Power Quality & 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.	
Course Assessment	Continuous Evaluation - 25% Mid Semester- 25% End Semester - 50%	

Course no: EELM 521	Open course	HM Course (Y/N)	DC (Y/N)	DE (Y/N)
Type of course				Y
Course Title	**Grid Integration of Renewable Energy Systems**			
Course Coordinator				
Course objectives:	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			
POs				
Semester	**Autumn**		**Spring: II Semester**	
	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	Grid Integration of Renewable Energy
	Author	Glover, John D., Tamer M. El-Shenawy, and Mohamed S. El-Nasr
	Publisher	Wiley-IEEE Press
	Edition	1st 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	1st Edition, 24 August 2021

Reference Books:		
3.	Title	Integration of Renewable Energy Sources into the Power Grid
	Author	Morteza Zare Oskouei Behnam Mohammadi-Ivatloo
	Publisher	Springer,
	Edition	December 2019
Content	**Unit I: Introduction to Grid Integration** Power Grid Fundamentals, Need for Renewable Energy Integration, Challenges of Variable Renewable Energy Sources, Grid Stability and Reliability Concepts, Intermittency and Variability Management. **Unit II: Forecasting and Managing Renewables** 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. **Unit III: Energy Storage Technologies** Energy storage: technologies, operating strategies, degradation, Types of Energy Storage, Applications of Storage in Grid Integration, Techno-economic Analysis of Storage Solutions. **Unit IV: Economic and Policy Considerations** 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. **Unit V: Technologies for Grid Integration** Smart Grid Concepts and Technologies for Renewable Integration, Microgrids and Islanding Grid operation and control: voltage control, frequency regulation, optimal generation dispatch.	
Course Assessment	Continuous Evaluation 25% Mid Semester 25% End Semester 50%	

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^{st} Edition, 2011.		
2.	Title	Energy Economics		
	Author	Peter M. Schwarz		
	Publisher	CRC Press		
	Edition	2^{nd} Edition, 2022.		
Reference Book:				
1.	Title	Energy Law And Policy in India		
	Author	Nawneet Vibhaw		

	Publisher	Lexis Nexis
	Edition	1st Edition, 2014
2.	Title	New Energy and Future Energy Systems
	Editor	Grigorios L. Kyriakopoulos
	Publisher	IOS Press BV
	Edition	(NEFES 2023),
Content	**Unit I: Global Energy Scenario** Role of energy in economic development and social transformation: Energy & 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. **Unit II: Indian Energy Scenario** Energy resources & 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. **Unit III: Energy Policy** Global Energy Issues, National and State Level Energy Issues, National & State Energy Policy, Industrial Energy Policy, Energy Security, Energy Vision, Energy Pricing & Impact of Global Variations, Energy Productivity i.e. National and Sector wise productivity. **Unit IV: Energy Policy Planning** 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. **Unit V: Energy Economics**	

	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.
Course Assessment	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	1st 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	1st Edition, 2001		
Reference Book:				
1.	Title	Restructured Power Systems		

	Author	S. A. Khaparde
	Publisher	Alpha Science
	Edition	1st Edition, 2006
2.	Title	Restructured electrical Power systems
	Author	Mohammad Shahidehpour, and Muwaffaqalomoush,
	Publisher	Marcel Dekker, Inc.
	Edition	1st Edition, 2001
Content	**Unit I: Introduction to Restructuring of Power Industry** 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. **Unit II: Philosophy of Market Models** 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. **Unit III: Transmission Congestion Management** 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. **Unit III: Ancillary Service Management** Introduction to ancillary services, Types of ancillary services,	

	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. **Unit V: Reforms in Indian Power Sector** Introduction, Framework of Indian power sector, Reform initiatives during 1990-1995, the availability-based tariff (ABT), The Electricity Act 2003.
Course Assessment	Continuous Evaluation 25% Mid Semester 25% End Semester 50%

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	3rd Edition, 2013		
2.	Title	Power System Analysis and Design		
	Author	J. Duncan Glover, Mulukutla S. Sarma, Thomas J. Overbye		
	Publisher	Cengage Learning		
	Edition	6th 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	1st Edition, 2020
Content	**Unit I: Introduction to Power Systems Operations** Overview of power systems generation, operations, and reliability. Characteristics of generators: types, capacities, and efficiencies. Economic dispatch: basic principles and formulation. **Unit II: Transmission System Analysis** 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. **Unit III: Power Systems Optimization** Unit commitment: formulation, objectives, and solution techniques. Hydrothermal coordination: modelling, constraints, and optimization methods. Production cost models: structure, variables, and applications **Unit IV: Optimization Algorithms** 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. **Unit V: Power Systems Reliability and Energy Management Systems (EMS)** 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.	
Course Assessment	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	1st Edition, 2004		
2.	Title	Computer Modelling of Electrical Power Systems		
	Author	Arrillaga J. and Watson N.R.		
	Publisher	John Wiley & Sons		
	Edition	1st Edition, 2001		
Reference Book:				
1.	Title	Power Generation, Operation and Control		
	Author	Wood A. J. and Wollenberg B.F.		

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

Course no: EELM 526	**Open course**	**HM Course (Y/N)**	**DC (Y/N)**	**DE (Y/N)**
Type of course	N	N	Y	N
Course Title	**Power System Transients**			
Course Coordinator				
Course objectives:	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.			
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	Electrical Transients in Power Systems		
	Author	Allan Greenwood		
	Publisher	Wiley Inter Science, New York,		
	Edition	2nd Edition, 1991		
2.	Title	Electromagnetic transients in Power System		
	Author	Pritindra Chowdhari		
	Publisher	John Wiley and Sons Inc.		
	Edition	2nd 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	2nd Edition, 2010
Reference Book:		
1.	Title	Power System Transient theory and applications
	Author	Akihiro ametani
	Publisher	CRC press
	Edition	1st Edition, 2013
Content	**Unit I: Introduction** 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. **Unit II: Switching Transients** 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. **Unit III: Lightning Transients** 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. **Unit IV: Traveling Waves on Transmission Line Computation Of Transients** Computation of transients, transient response of systems with series and shunt lumped parameters and distributed lines. Traveling wave concept, step response. **Unit V: Transients in Integrated Power System** 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	
Course Assessment	Continuous Evaluation 25% Mid Semester 25% End Semester 50%	

Course No. EELM 511	Open Course (YN)	HM Course (Y/N)	DC (Y/N)	DE (Y/N)
Type of the Course	N	N	N	Y
Course Title	**Power Quality**			
Course Coordinator				
Course Objectives	The objectives of the course include introduction of the power quality definitions, voltage sags, interruptions, harmonic problems andmitigation.			
POs				
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				
Text Book(s)				
1.	**Title**	Electrical Power Systems Quality		
	Author	Roger C. Dugan, Mark F. McGranaghan, Surya Santoso, H.Wayne Beaty		
	Publisher	McGraw Hill Education		
	Edition	Third Edition		
Reference Book(s)				
1.	**Title**	Power System Harmonic Analysis		
	Author	Arrillaga J., Smith B. C., Watson N. R. and Wood A. R		
	Publisher	Wiley India		
	Edition	2nd Edition		
2.	**Title**	Power System Analysis		
	Author	Arthur R.B.		
	Publisher	Pearson Education		
	Edition	2nd Edition		
3.	**Title**	Power Quality		
	Author	Sanskaran		
	Publisher	C.R.C. Press		

	Edition	2nd Edition
Content	**Unit I: Concept of Power Quality** Frequency variations, voltage variations- sag and swell, waveform distortion –dc offset, harmonics, inter-harmonics, notching and noise. **Unit II: Fundamentals of Harmonics** Representation of harmonics, waveform, harmonic power, measures of harmonic distortion; Current and voltage limits of harmonic distortions: IEEE, IEC, EN, NORSOK. **Unit III: Causes of Harmonics** 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. **Unit IV: Effect of Harmonics** 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. **Unit V: Elimination/ Suppression of Harmonics** 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.	
Course Assessment	Continuous Evaluation - 25% Mid Semester- 25% End Semester - 50%	

<table>
<tr><td>Course No.
EELM 515</td><td>Open Course
(Yes/No)</td><td>HM Course
(Y/N)</td><td>DC
(Y/N)</td><td>DE
(Y/N)</td></tr>
<tr><td>Type of the Course</td><td>N</td><td>N</td><td>Y</td><td>N</td></tr>
<tr><td>Course Title</td><td colspan="4">Soft Computing and Applications</td></tr>
<tr><td>Course Coordinator</td><td colspan="4"></td></tr>
<tr><td>Course Objectives</td><td colspan="4">• Single and multi-layer perceptron understanding for classification in machine learning
• Develop and validate Matlab based mathematical models for data classification
• Comprehend neuro-fuzzy model implementation
• Learn to use machine learning model implementation</td></tr>
<tr><td>POs</td><td colspan="4"></td></tr>
<tr><td>Semester</td><td colspan="2">Autumn</td><td colspan="2">Spring</td></tr>
<tr><td></td><td>Lecture</td><td>Tutorial</td><td>Practical</td><td>Credits</td></tr>
<tr><td>Contact Hours</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td>Pre-requisite course code as per proposed course members</td><td>Nil</td><td>Nil</td><td>Nil</td><td>0</td></tr>
<tr><td>Prerequisite credits</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Equivalent course codes as per proposed course and old course</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Overlap course codes as per proposed course numbers</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5">Text Book(s)</td></tr>
<tr><td>1.</td><td>Title</td><td colspan="3">Neuro Fuzzy and Soft Computing</td></tr>
<tr><td></td><td>Author</td><td colspan="3">J.S.R. Jang, C.T. Sun and E. Mizutani</td></tr>
<tr><td></td><td>Publisher</td><td colspan="3">Prentice Hall</td></tr>
<tr><td></td><td>Edition</td><td colspan="3">3rd</td></tr>
<tr><td>2.</td><td>Title</td><td colspan="3">Neural Network & Learning Machines</td></tr>
<tr><td></td><td>Author</td><td colspan="3">Simon O. Haykin</td></tr>
<tr><td></td><td>Publisher</td><td colspan="3">Prentice Hall</td></tr>
<tr><td></td><td>Edition</td><td colspan="3">2nd Edition</td></tr>
<tr><td colspan="5">Reference Book(s)</td></tr>
<tr><td>1.</td><td>Title</td><td colspan="3">Soft Computing</td></tr>
<tr><td></td><td>Author</td><td colspan="3">Saroj Kaushik</td></tr>
<tr><td></td><td>Publisher</td><td colspan="3">Mc Graw Hill</td></tr>
<tr><td></td><td>Edition</td><td colspan="3"></td></tr>
</table>

2.	**Title**	Applied Machine Learning
	Author	M. Gopal
	Publisher	Mc Graw Hill
	Edition	
3.	**Title**	An Introduction to Genetic Algorithms
	Author	M. Mitchell
	Publisher	MIT Press
	Edition	

Content	**Unit I: Introduction** Basic mathematics of soft computing, Learning and statistical approach to regression and classification. **Unit II: Neural Networks:** Single layer perceptron, ADALINE, LMS algorithm, Multi-layer perceptron, Radial basis function, Associative Memory Networks, Hopfield Network, Principal component analysis, RNN, MATLAB Programming. **Unit III: Support Vector Machines(SVM)** Introduction to SVM, Binary classification, Regression by SVM: linear & nonlinear, Decomposing multiclass classification into binary classification. SVM MATLAB Applications **Unit IV: Hybrid Intelligent System: Neuro-Fuzzy** 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 **Unit V: Optimization Techniques** Introduction to Optimization, Genetic algorithms, Particle swarm optimization, Matlab programming.
Course Assessment	Continuous Evaluation - 25% Mid Semester- 25% End Semester - 50%

Course No. EELM 530	Open Course (Y/N)	HM Course (Y/N)	DC (Y/N)	DE (Y/N)
Type of the Course	N	N	N	Y
Course Title	**Machine Learning and Deep Learning - Fundamentals And Applications**			
Course Coordinator				
Course Objectives	• 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.			
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**	Introduction to Machine Learning, 3rd Edition,		
	Author	E. Alpaydin		
	Publisher	Prentice Hall (India)		
	Edition	2015		
2.	**Title**	Pattern Classification, 2nd Edition,		
	Author	R. O. Duda, P. E. Hart and D. G. Stork,		
	Publisher	Wiley India		
	Edition	2007		
Content	**Unit I: Decision Theory & Estimation** 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			

	Parametric and Non- Parametric Density Estimation – ML and Bayesian Estimation, Parzen Window and KNN **Unit II: Types of Models** 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) **Unit III: Types of Methods** 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 **Unit IV: Clustering & Neural Network** Fuzzy K-means clustering, Hierarchical Agglomerative Clustering, Mean-shift clustering, Neural network: Perceptron, multilayer network, backpropagation, RBF Neural Network, Applications, **Unit V: Deep Neural Networks** 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.
Course Assessment	Continuous Evaluation - 25% Mid Semester- 25% End Semester - 50%

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	1st Edition, 2002		
2.	Title	Operation of Restructured Power Systems		
	Author	Kankar Bhattacharya , Math H. J. Bollen , Jaap E. Daalder		
	Publisher	Springer		
	Edition	1st 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	1st Edition, 2001
Content	**Unit I: Introduction to Restructured Power Systems** Traditional Power System Structure and its Limitations, Drivers of Power Sector Restructuring (Economic Efficiency, Competition), Deregulation Models (Pool Models, Bilateral Contracts). **Unit II: Electricity Markets and Pricing Mechanisms** 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 **Unit III: Power System Control in Deregulated Markets** 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. **Unit IV: Ancillary Services Markets and System Reliability** 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. **Unit V: Advanced Topics and Future Trends** 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.	
Course Assessment	Continuous Evaluation 25% Mid Semester 25% End Semester 50%	

Course No. EELM 507	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 Reliability**			
Course Coordinator				
Course Objectives				
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**	Reliability Evaluation of Power Systems		
	Author	Roy Billinton , Ronald N. Allan		
	Publisher	Springer New York, NY Publishers		
	Edition	2nd Edition, 2013		
2.	**Title**	Reliability modelling in Electric Power System		
	Author	Eodrenyi, J.		
	Publisher	John Wiley		
	Edition			
Content	**Unit I: Generating System Reliability Analysis –I** 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. **Unit II: Generating System Reliability Analysis – II** 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. **Unit III: Bulk Power System Reliability Evaluation** Basic configuration – Conditional probability approach – System and load			

	point reliability indices – Weather effects on transmission lines – Weighted average rate and Markov model – Common mode failures. **Unit IV: Pro Distribution System Reliability Analysis – I (Radial Configuration)** 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. **Unit V: Distribution System Reliability Analysis - II (Parallel Configuration)** Basic techniques – Inclusion of bus bar failures, scheduled maintenance – Temporary and transient failures – Weather effects – Common mode failures – Evaluation of various indices – Examples.
Course Assessment	Continuous Evaluation - 25% Mid Semester- 25% End Semester - 50%

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	3rd Edition		
2.	Title	Electric Vehicle Engineering		
	Author	Per Enge, Nick Enge, and Stephen Zoepf		
	Publisher	McGraw Hill		
	Edition	1st Edition		
Reference Book:				
1.	Title	Electric and Hybrid Vehicles		
	Author	Tom Denton, Hayley Pells		

	Publisher	Routledge Taylor & Francis Group
	Edition	3rd 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	3rd Edition
Content	**Unit I: Vehicle Dynamics** 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. **Unit II: EV Battery Pack** 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. **Unit III: Battery Pack Design** Mechanical Design and Thermal Design, Electrical Design, BMS Design of Electric Vehicle, Cell Testing & Characterization. **Unit IV: EV Motors and Controllers** 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. **Unit V: EV Chargers** Introduction, Slow or Fast chargers, Battery Swapping, Standardization and on-board Chargers, Public Chargers, Bulk Chargers/Swap Stations.	
Course Assessment	Continuous Evaluation 25% Mid Semester 25% End Semester 50%	

Course no: EELM 562	**Open course**	**HM Course (Y/N)**	**DC (Y/N)**	**DE (Y/N)**
Type of course				Y
Course Title	Special Electrical Machines			
Course Coordinator				
Course objectives:	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.			
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	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
Content	**Unit I: Synchronous Reluctance Motors** Constructional features – Types – Axial and Radial flux motors – Operating principles – Variable Reluctance Motors – Voltage and Torque Equations - Phasor diagram - performance characteristics –Applications **Unit II: Stepper Motors** 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. **Unit III: Switched Reluctance Motors (SRM)** 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 **Unit IV: Permanent Magnet Brushless D.C. Motors** 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. **Unit V: Permanent Magnet Synchronous Motors (PMSM)** 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.	
Course Assessment	Continuous Evaluation 25% Mid Semester 25% End Semester 50%	

<table>
<tr><td rowspan="2">Course no.
EELM 568</td><td colspan="2">Open course
(Yes/No)</td><td colspan="2">HM Course
(Y/N)</td><td>DC
(Y/N)</td><td>DE
(Y/N)</td></tr>
<tr><td colspan="2">N</td><td colspan="2">N</td><td>N</td><td>Y</td></tr>
<tr><td>Type of course</td><td colspan="6">Theory</td></tr>
<tr><td>Course Title</td><td colspan="6">Energy Storage Devices</td></tr>
<tr><td>Course Objectives:</td><td colspan="6"></td></tr>
<tr><td>Semester</td><td colspan="2"></td><td colspan="4"></td></tr>
<tr><td></td><td colspan="2">Autumn:</td><td colspan="4">Spring: Yes</td></tr>
<tr><td></td><td>Lecture</td><td>Tutorial</td><td>Practical</td><td>Credits</td><td colspan="2">Teaching Hours</td></tr>
<tr><td>Contact Hours</td><td>03</td><td>0</td><td>0</td><td>03</td><td colspan="2">36</td></tr>
<tr><td>Prerequisite course code as per proposed course number</td><td></td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>Prerequisite credits</td><td></td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>Equivalent course codes as per proposed course and old course</td><td></td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>Overlap course codes as per proposed course numbers</td><td></td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td colspan="2">Text Books:</td><td colspan="5"></td></tr>
<tr><td rowspan="4">1.</td><td>Title</td><td colspan="5">Energy Storage for Power Systems</td></tr>
<tr><td>Author</td><td colspan="5">A.G.Ter-Gazarian</td></tr>
<tr><td>Publisher</td><td colspan="5">The Institution of Engineering and Technology (IET) Publication, UK, (ISBN - 978-1 84919-219-4),2011.</td></tr>
<tr><td>Edition</td><td colspan="5">Second Edition</td></tr>
<tr><td rowspan="4">2.</td><td>Title</td><td colspan="5">Energy Storage in Power Systems</td></tr>
<tr><td>Author</td><td colspan="5">Francisco Díaz-González, Andreas Sumper, Oriol Gomis-Bellmunt</td></tr>
<tr><td>Publisher</td><td colspan="5">Wiley Publication, ISBN: 978-1-118-97130-7, Mar 2016.</td></tr>
<tr><td>Edition</td><td colspan="5"></td></tr>
<tr><td rowspan="4">3.</td><td>Title</td><td colspan="5">The Physics of solar cell</td></tr>
<tr><td>Author</td><td colspan="5">Jenny Nelson</td></tr>
<tr><td>Publisher</td><td colspan="5">Imperial college Press</td></tr>
<tr><td>Edition</td><td colspan="5">1st</td></tr>
<tr><td rowspan="4">4.</td><td>Title</td><td colspan="5">Energy Storage Benefits and Market Analysis</td></tr>
<tr><td>Author</td><td colspan="5">James M. Eyer, Joseph J. Iannucci and Garth P. Corey</td></tr>
<tr><td>Publisher</td><td colspan="5">Sandia National Laboratories, 2004.</td></tr>
<tr><td>Edition</td><td colspan="5"></td></tr>
<tr><td>Reference Books:</td><td>Title</td><td colspan="5">Behaviour of Lithium-Ion Batteries in Electric Vehicles: Battery Health, Performance, Safety, and Cost.</td></tr>
</table>

1.	Author	Pistoia, Gianfranco, and Boryann Liaw.
	Publisher	Springer International Publishing AG, 2018.
	Edition	

Content	**Unit I : Introduction to energy storage in power systems** 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. **Unit II : Energy storage technologies and renewable power sources** Electrochemical energy: Batteries, Fuel cells, Electrostatic energy (Super Capacitors), Electromagnetic energy (Super conducting Magnetic Energy Storage), Comparative analysis, Environmental impacts of different technologies. **Unit III : Features of Energy Storage Systems** 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). **Unit IV : Applications** Utility use (conventional power generation, grid operation & 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.
Course Assessment	Theory: Continuous Evaluation 25%, Mid Semester 25%, End Semester 50%. 100% weightage to theory for overall grading. Continuous evaluation shall depend on course coordinator.

Course no: EELM 575	Open Course (Y/N)	HM Course (Y/N)	DC (Y/N)	DE (Y/N)
Type of course	N0	N0	Yes	No
Course Title	**Statistical Signal Processing**			
Course Coordinator				
Course objectives:	• Understand the fundamental principles of statistical signal processing, including probability theory, random variables, and stochastic processes, to analyze and manipulate signals in uncertain environments. • 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. • 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			
POs				
Semester			Spring: NA	
	Lecture	Tutorial	Practical	Credits
Contact Hours	3	0	0	3
Prerequisite course code as per proposed course numbers	Nil			
Prerequisite credits	Nil			
Equivalent course codes as per proposed course and old course	Nil			
Overlap course codes as per proposed course numbers	Nil			

Text Books:

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

<table>
<tr><td></td><td>Edition</td><td>1996</td></tr>
<tr><td colspan="3">Reference Book:</td></tr>
<tr><td rowspan="4">1.</td><td>Title</td><td>Fundamentals of Statistical Signal Processing: Estimation theory</td></tr>
<tr><td>Author</td><td>Steven M. Kay</td></tr>
<tr><td>Publisher</td><td>Upper: Prentice-Hall</td></tr>
<tr><td>Edition</td><td>1993</td></tr>
<tr><td rowspan="4">2.</td><td>Title</td><td>Random variables and Stochastic Processes</td></tr>
<tr><td>Author</td><td>Papoulis, probability</td></tr>
<tr><td>Publisher</td><td>McGraw Hill</td></tr>
<tr><td>Edition</td><td>1983</td></tr>
<tr><td>Content</td><td colspan="2">Unit I: Signal Models And Characterization
Types and properties of statistical models for signals and how they relate to signal processing, common second-order methods of characterizing signals.

Unit II: Stochastic Processes
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.

Unit III: Spectral Estimation
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.

Unit IV: Parametric Signal Modeling And Estimation
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.

Unit V: Optimum Linear Filters
Linear Mean square error estimation, optimum IIR filters, optimum IIR filters, Inverse filtering and deconvolution, order recursive algorithms for optimum FIR filters, Algorithms of Levinsion, Levinsion-Durbin and Schiir, Triangularization and inversion of Toeplitz matrices, Wiener filtering and Kalman filtering.</td></tr>
<tr><td>Course Assessment</td><td colspan="2">Theory: Continuous Evaluation 25%, Mid Semester 25%, End Semester 50%.
100% weightage to theory for overall grading.
Continuous evaluation shall depend on course coordinator.</td></tr>
</table>

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	• Gain comprehensive understanding of the digital control in switch-mode converters • Develop and validate Matlab based mathematical models for digital control • Comprehend digital control implementation • Learn to use embedded control implementation platforms			
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	3rd		
2.	**Title**	Digital Control in Power Electronics		
	Author	Simone Buso, Paolo Mattavelli		
	Publisher	Springer		
	Edition	2nd		
Reference Book(s)				
1.	**Title**	Computer Techniques for Dynamic Modeling of DC-DC Power Converters		
	Author	Farzin Asadi		
	Publisher	Springer Cham		
	Edition	1st		
2.	**Title**	Dynamics and Control of DC-DC Converters		

	Author	Farzin Asadi, Kei Eguchi
	Publisher	Springer Cham
	Edition	1st
3.	**Title**	Digital Control of High-Frequency Switched-Mode Power Converters
	Author	Luca Corradini, Dragan Maksimovic, Paolo Mattavelli, Regan Zane
	Publisher	Wiley-IEEE Press
	Edition	
Content	**Unit I:** Introduction to digital control in switched mode power converters (SMPCs), Fixed and variable frequency digital control architectures **Unit II:** Modeling techniques and model validation using MATLAB, MATLAB custom model development for simulation under digital control **Unit III:** Frequency and time domain digital control design approaches. Digital control implementation blocks and steps for FPGA based prototyping **Unit IV:** 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 **Unit V:** 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	
Course Assessment	Continuous Evaluation - 25% Mid Semester- 25% End Semester - 50%	

Course no: EELM 576	Open course (YES/NO)	HM Course (Y/N)	DC(Y/N)	DE(Y/N)	
Type of course				YES	
Course Title	**Smart Grid Resiliency and Cyber Security**				
Course Coordinator					
Course objectives:	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.				
POs					
Semester	**Autumn: Yes**		**Spring:**		
	Lecture	**Tutorial**	**Practical**	**Credits**	**Teaching Hours**
Contact Hours	3	0	0	3	36
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	Smart Grid Security			
	Author	Gilbert N. Sorebo and Michael C. Echols			
	Publisher	CRC Press			
	Edition	1st			
2.	Title	Smart Grid Applications, Communications and Security			
	Author	Lars T. Berger and Krzysztof Iniewski			
	Publisher	Wiley			
	Edition	1st			

Content	**Unit I: Overview of Smart Grid** 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. **Unit II: Communication Technologies for Smart Grid** 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. **Unit III: Security of Smart Grid** 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. **Unit IV: IoT and Big Data Management for Smart Grid Applications** 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. **Unit V: AI Techniques in Smart Grid** 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.
Course Assessment	Continuous Evaluation: 25% Mid-Semester Examination: 25% End-Semester Examination: 50%