ACADEMIC CURRICULA

POST GRADUATE DEGREE PROGRAMMES

Master of Technology

(Choice Based Flexible Credit System)

Regulations 2021

Volume – 24
Syllabi for School of Electrical Engineering Programmes

Professional Core and Elective Courses

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

ACADEMIC CURRICULA

Power Electronics and Drives

Professional Core Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21EEC551T	Course Name	ADVANCED POWER SEMICONDUCTOR DEVICES AND PROTECTION	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*illustrate the construction and characteristics of current controlled devices*
CLR-2:	*interpret the construction and characteristics of voltage-controlled devices*
CLR-3:	*analyze the operation of driver and snubber circuits*
CLR-4:	*explore the thermal protection attributes for power converters*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Program Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*select the appropriate current controlled devices for power converters*	*3*	*1*	*2*
CO-2:	*choose the suitable voltage-controlled devices for power converters*	*3*	*1*	*2*
CO-3:	*design the firing and snubber circuits for power converters*	*3*	*2*	*2*
CO-4:	*design the thermal protection circuits for power converters*	*3*	*2*	*2*

Module 1 – Current Controlled Devices	***10 Hour***
BJT's —Basic structure and operation, Static and Dynamic Characteristics of BJT, Forward bias and Reverse Bias Safe Operating Area, Darlington Configuration, Thyristors- Static characteristics of thyristors, Dynamic Switching characteristics of thyristors, Thyristor Parameters, converter grade and inverter grade and other types, Thyristors ratings, Series and parallel operation of thyristors, comparison of BJT and Thyristor- Interpretation of data sheets.	
Module 2 – Voltage Controlled Devices	***15 Hour***
Power MOSFET Technologies - Diffusion process, Physical and structural MOSFET parameters, Power MOSFET Mechanism- static operation, Switching operation of MOSFET- Turn-on Turn-off characteristics of MOSFET, Safe operating of Power MOSFET, Wide band gap, Silicon Carbide devices-Forward mode operation of SiC – MOSFET, current mode operation of SiC – MOSFET, voltage blocking mode operation of SiC – MOSFET, Switching Characteristics of SiC – MOSFET, GaN devices, IGBT Technology - IGBT structure and operation, IGBT operation technique - continuous and dynamic characteristics, Sale operating area of IGBT. Basics of GTO, MCT, RCT and IGCT, Modelling of Power MOSFET and IGBT- MOSFET data sheet samples.	
Module 3 – Design of Driver and Snubber Circuits	***10 Hour***
Necessity of isolation, pulse transformer, optocoupler, Base drive circuits for BJT, Gate drive circuits: for thyristor, Gate drive circuits: for MOSFET, Gate drive circuit: for IGBT, Voltage stress in power switching devices, Current Stress in switching devices, Snubber circuits for diodes in rectifier circuits, Turn on Snubber circuit for BJT, Turn off Snubber circuit for BJT, Snubber circuits for Thyristors in power converters, IGBT - Snubber circuit, MOSFET-Snubber circuit, Design of Snubbers	
Module 4 –Thermal Protection of Power Electronic Devices	***10 Hour***

Thermal Protection- Heat dissipation by conduction, Heat transfer by convection, Heat transfer by radiation, Dynamics of heat transfer-thermal impedance, Protection — Need for voltage clamping, Active clamping in MOSFET and IGBT, Passive clamping in MOSFET, Over-voltage protection circuit of thyristors, Cooling-Necessity of cooling, liquid cooling, Vapor cooling, Guidance for heat sink selection, heat sink types, Mounting types.

Learning Resources	1. *Rashid M.H., Power Electronics Circuits, Devices and Applications, Pearson Education, Fourth Edition, 2014.* 2. *Ned Mohan, Tore M. Undeland, and William P. Robbins, Power Electronics: Converters, Applications, and Design, John Wiley & Sons, 3rd Edition, 2003* 3. *Robert Perret, Power Electronics: Semiconductor Devices, ISTE Ltd and John Wiley & Sons, Inc., First Edition, 2009*	4. *B. J. Baliga, Fundamentals of Power Semiconductor Devices, Springer, Second Edition, 2019.* 5. *Philip T. Krein, Elements of Power Electronics, Oxford University Press, Second Edition, 2016.* 6. *Bhimbra P.S., Power Electronics, Khanna Publishers, Seventh Edition, 2022.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*10%*	*-*	*20%*	*-*
Level 2	*Understand*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*20%*	*-*	*30%*	*-*	*20%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. N.Jayakumar, Danfoss, Industries Pvt. Ltd.*	1. *Dr. Bindu G R,, APJ Abdul Kalam Technological University*	1. *Dr. K. Mohanraj, SRMIST*
2. *Ms. Nivetha, Infenion Technologies.*	2. *Dr. R. Ramesh, CEG, Anna University*	2. *Dr. R. Sridhar, SRMIST*

Course Code	21EEC552J	Course Name	DESIGN AND ANALYSIS OF POWER CONVERTERS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*analyze single phase and three phase-controlled rectifiers*
CLR-2:	*investigate the operation and applications of DC -DC converters*
CLR-3:	*analyze the concepts of AC- AC converters*
CLR-4:	*examine the operation of various types of DC-AC inverters*
CLR-5:	*analyze the concepts of multilevel and resonant converters*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Program Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*develop circuits on single phase and three phase converters*	3	2	2
CO-2:	*design DC-DC converter topologies for a broad range of power conversion*	3	2	2
CO-3:	*build AC-AC converters for variable voltage and variable frequency applications*	3	2	2
CO-4:	*design DC –AC converters and its various types*	3	2	2
CO-5:	*develop multilevel and resonant converters*	3	2	2

Module 1 – Controlled Rectifiers	***15 Hour***
Review of emerging power semiconductor devices- Design and analysis of single phase and three phase controlled and half controlled rectifiers with R, RL, RLE loads -Effect of source inductance-input power factor and harmonic factor- dual converters, twelve pulse converters-power factor improvement schemes, – Gate drive and protection circuits. ***Laboratory practice:*** *Experiment on single phase half controlled and full wave-controlled converters, Experiment on three phase line commutated converter and Design and develop firing circuits for controlled rectifier.*	
Module 2 – DC-DC Converters	***15 Hour***
Non-isolated DC-DC converters: Design and Analysis of buck, boost, buck-boost converter, comparative analysis of CUK converter – SEPIC converter- continuous conduction operation discontinuous conduction mode, Isolated DC-DC converters: single switch and multiple switch converters – analysis and design. ***Laboratory practice:*** *Design and development of non-isolated dc-dc converters, Design and development of ferrite core transformer aided isolated dc-dc converters, Experiment of multiport converter realization*	
Module 3 – AC-AC Converters	***15 Hour***
Single phase AC-AC voltage regulator-analysis of Half controlled and fully controlled AC regulators, three Phase AC Voltage Controller: operation, - integral cycle controller. Cycloconverters -types-Output equation of cycloconverters, Matrix converters – Design, analysis, and application ***Laboratory practice:*** *Experimental analysis on cycloconverters, Experimental analysis on matrix converters, Experiment on Single phase & Three phase AC voltage regulators-Integral cycle controller*	

Module 4 – DC-AC Converters	*15 Hour*
Single-phase and three-phase inverters, Half bridge and full bridge single phase inverters, 120 and180 degree modes of operation, PWM techniques- sinusoidal PWM scheme for single and three phase inverter, Impact of harmonics-Harmonic elimination schemes- space vector modulation: Under and over modulation, Current source inverters, Boost inverters. ***Laboratory practice:*** *Design and development of single phase and three phase inverters, Experiment on various PWM techniques, Experiment on harmonic analysis and mitigation schemes.*	
Module 5 – Multilevel Inverters and Resonant Converters	***15 Hour***
Multilevel Inverter (MLI)- Single phase and three phase-Operation of diode clamped MLI, flying capacitor – cascaded type MLI, PWM techniques for MLI – sinusoidal PWM, Phase position and disposition PWM, Resonant converters-types- analysis of zero voltage switching converters (ZVS), and zero current switching converters (ZCS), Quasi and multi resonant converters, Modulation techniques for resonant converters, Applications of MLI and resonant converters. ***Laboratory practice:*** *Experiment on MLI and its PWM generation, design a resonant converter for a stipulated power rating for charging application, Loss calculation, gain derivation, reliability analysis, Case study on converters,*	

Learning Resources	1. *Rashid M.H., Power Electronics Circuits, Devices and Applications, Prentice Hall India, Fourth Edition, New Delhi, 2017.* 2. *Bimal K.Bose, Modern Power Electronics and AC Drives, Pearson Education, Second Edition, 2003* 3. *L Umanand, Power Electronics: Essentials & Applications, Wiley, First Edition,2010*	4. *Ned Mohan,T.M Undeland and W.P Robbin, Power Electronics: converters, Application and design, John Wiley and sons.Wiley India Third Edition, 2007* 5. *P.S.Bimbra, Power Electronics, Khanna Publishers, Seventh Edition, 2022*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life Long Learning CLA-2- Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*-*	*10%*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*-*	*10%*	*30%*	*-*
Level 3	*Apply*	*30%*	*-*	*-*	*20%*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*-*	*30%*	*20%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*20%*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*10%*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Srivishnu Ranganathan, HCL Technologies	*1. Dr. S. Chandrasekar, NIT Hamirpur*	*1. Dr. R. Sridhar, SRMIST*
2. Mr.R.Parthipan, Igarashi Motors India LTD	*2. Dr. B.ChittiBabu, IIITDM, Kanchipuram*	*2. Dr. N. Chellammal, SRMIST*

Course Code	21EEC553J	Course Name	ELECTRICAL MACHINE MODELING AND ANALYSIS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*comprehend the basics of transformation of machine variables and reference frames*
CLR-2:	*acquire knowledge on modeling and performance of DC electrical machines*
CLR-3:	*model and analyze the performance of induction machines*
CLR-4:	*illustrate the modeling and analyze the performance of synchronous machines*

Course Outcomes (CO):	***At the end of this course, the learners will be able to:***	***Program Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*apply the concepts of reference frames and transformations to model electrical machines*	*3*	*1*	*1*
CO-2:	*investigate the performance of DC machines using machine modeling concepts*	*3*	*2*	*2*
CO-3:	*examine the steady state and dynamic performance of induction machines using generalized theory*	*3*	*2*	*2*
CO-4:	*model and analyze the steady state and dynamic performance of synchronous machines*	*3*	*2*	*2*

Module 1 - Modeling Concepts — ***15 Hour***

Principle of electromechanical energy conversion: Expression for stored energy, Co-energy, Basic two pole representation of commutator machines: Transformer with a movable secondary, Transformer and speed voltages in armature, Kron's primitive machine: Leakage flux in machines, Voltage equations, Torque equation, Transformations in machines: Invariance of power, Transformation of machine variables

Module 2 - DC Machines — ***20 Hour***

Modeling of DC machines: Separately-excited DC motor, Steady state analysis, Transient analysis, Sudden application of inertia load, Transfer function: DC Series and Shunt motor, Torque-speed characteristics of DC motor, Linearization techniques for small perturbation, Small-signal behavior of DC machines

Laboratory Practice: *Modeling, Steady state and transient analysis of DC machines*

Module 3 - Induction Machines — ***20 Hour***

Reference Frame Theory: Arbitrary reference frame, Stator reference frame, Rotor reference frame, Synchronous rotating reference frame

Induction machine: Model of induction machine in arbitrary reference frame, Derivation of induction machine model in three different frames, Flux linkage equations, Electrical performance equations, Steady state and transient analysis, Analysis of equivalent circuit, Torque-slip characteristics, Effect of voltage and frequency variations on the induction motor performance, Transfer function formulation, Analysis of induction motor using transfer function model under various operating conditions, Small signal model and behavior of induction machines, Space vector formulation of induction machine equations, Single phase induction motor: Introduction, Operation of Single-phase induction motor, Revolving Field theory, Model of single-phase induction machine

Laboratory Practice: *Modeling, Steady state and transient analysis of single phase and three phase induction motors*

Module 4 - Synchronous Machines — ***20 Hour***

Three phase Synchronous Machine: Basic three phase Synchronous Machine parameters, Mathematical model of three phase synchronous Machine, Equivalent circuit, Power Invariance, Steady state analysis, Power angle characteristics, per unit system, Expression for electrical Torque, Torque in terms of a, b, c variables, Phasor diagram of synchronous machine with and without saliency

Transfer function formulation of synchronous machine, Transient analysis of synchronous machine using transfer function model under various operating conditions *PMSG: Operation principle of PMSG, Voltage, Torque equations of PMSG, Power equation of PMSG, DFIG: Operation principle of DFIG, Voltage, Power equations of DFIG.* ***Laboratory Practice:*** *Modeling, Steady state and transient analysis of PMSG and DFIG*

Learning Resources	1. *Bimbhra P.S., Generalized Theory of Electrical Machines, Khanna Book Publishing Company Private Limited, New Delhi, Seventh Edition, 2021.* 2. *Paul Krause, Oleg Wasynczuk, Scott Sudhoff, Steven Pekarek, Analysis of Electric Machinery and Drive Systems, John Wiley & Sons, Inc., Hoboken, New Jersey, Third edition, 2013.* 3. *R. Ramanujam, Modeling and Analysis of Electrical Machines, Dreamtech Press, First edition,2019.* 4. *Krishnan R., Electric Motor & Drives: Modeling, Analysis and Control, Pearson Education India; First edition,2015.*	5. *N Mohan, Advanced Electric Drives: Analysis, Control, and Modeling Using MATLAB / Simulink, First edition, John Wiley & Sons Inc, 2014.* 6. *Mrittunjay Bhattacharyya, Electrical Machines: Modelling and Analysis, First Edition Prentice Hall, 2016.* 7. *Stephen D. Umans, Fitzgerald & Kingsley's Electric Machinery, McGraw, Hill, Seventh edition, 2020.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (45%)		Life Long Learning CLA-2 (15%) Practice			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	-	10%	20%	-
Level 2	Understand	30%	-	-	30%	30%	-
Level 3	Apply	30%	-	-	30%	30%	-
Level 4	Analyze	20%	-	-	30%	20%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Patnana Hema Kumar, Tata Elxsi	1. Dr. Kamaraj, SSNCE	1. Dr. N. Chellammal, SRMIST
2. Mr. K. N. Balakrishnan, Magana Automotive India Pvt Ltd	2. Dr. Rijil Ramchand, NIT Calicut	2. Dr. Arun Noyal Doss, SRMIST

Course Code	21EEC554J	Course Name	CONTROLLERS FOR POWER ELECTRONIC SYSTEMS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explore the modelling and control schemes for power converters*
CLR-2:	*design appropriate controller for power converter operation*
CLR-3:	*explain various controllers for power inverter operation*
CLR-4:	*articulate the control schemes for various AC drives*
CLR-5:	*apply Digital Signal Processor for control of power converters*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Program Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*investigate various controller design and dynamic models for power converters*	*2*	*-*	*2*
CO-2:	*compare the performance of PI, hysteresis and predictive current controllers for DC/DC and AC/DC converter*	*3*	*2*	*3*
CO-3:	*design and implement various PWM schemes for inverter control*	*3*	*2*	*3*
CO-4:	*analyse the performance of vector control schemes for AC motor drives*	*3*	*3*	*3*
CO-5:	*realize power converter control scheme using Digital Signal Processor*	*3*	*3*	*3*

Module 1 - Overview of Controllers for Power Converters	***11 Hour***
Introduction to PE converters and control, Types and design of controllers: Proportional, Integral and Derivative, Merits and Demerits, Fractional order PID controller, Dynamic and output equations of the converter, Averaged Model of the converter: Steady state solution, small signal model of the converter control, transfer function of the converter, Generalized state space model of converter. ***Laboratory Practice:*** *Control pulse generation for DC/DC converters using DSP; Stability analysis of buck and boost converters control.*	
Module 2 – Design of Controllers for Power Converters	***17 Hour***
Introduction, Closed Loop Control: Control Requirements, Compensator Structure, Design of Compensator, Control system design for AC/DC and DC/DC converters, Design of Hysteresis and Predictive Current Controller for converters. ***Laboratory Practice:*** *Development of Proportional and Integral based closed-loop control for converters, Development of Hysteresis Current Control operated converters.*	
Module 3 – Inverter Control Strategies	***15 Hour***
Review of Inverter Operating Principle and mathematical modelling, Inverter PWM Switching: Unipolar and Bipolar, Concept of a Space vector modulation for three phase two level inverters, Multilevel inverters and control: Diode clamped inverter and cascaded H-bridge Inverter. ***Laboratory Practice:*** *Control pulse generation for DC/AC converters using DSP, Development of Space vector modulation control for two-level inverter.*	
Module 4 – Controllers for AC Motor Drives	***17 Hour***
Induction Motor Drives, Field Oriented Control (FOC) concept- Theory, DC drive analogy, Permanent Magnet Synchronous Motor (PMSM) dynamic modelling and operation through FOC, Direct torque control (DTC) control strategy, DTC of PMSM drive, Torque expression with stator and rotor fluxes, Design of Finite Control Set Model Predictive Controller for PMSM drives.	

Laboratory Practice: *Development of FOC operated PMSM drive, Development of DTC operated PMSM drive.*	
Module 5 – Digital Controller for Power Electronics	***15 Hour***
Introduction to Digital Signal Processor (DSP), Architecture of F28379D DSP, Hardware Configuration: Analog to Digital (ADC) Resolution, Device Pins, Digital-to-Analog Converter (DAC), Enhanced Pulse Width Modulator (ePWM) Module, Timers, Control design for power converters and motor drives. ***Laboratory Practice:*** *Voltage and current sensing through ADC of F28379D DSP, DSP Based Scalar control of Induction motor drive during run mode.*	

Learning Resources	*1. Hart, Daniel W., and Daniel W. Hart. Power electronics, First Edition Vol. 166. New York: McGraw-Hill, 2011.* *2. Buso, Simone, and Paolo Mattavelli. Digital control in power electronics, Second Edition, Morgan & Claypool Publishers, 2015.* *3. Abu-Rub, Haitham, Atif Iqbal, and Jaroslaw Guzinski. High performance control of AC drives with Matlab/Simulink, Second Edition, John Wiley & Sons, 2021.*	*4. De Doncker, Rik W., Duco WJ Pulle, and André Veltman. Advanced electrical drives: analysis, modeling, control, Second Edition, Springer Nature, 2020.* *5. Mohan, Ned, and Siddharth Raju. Power Electronics, a First Course: Simulations and Laboratory Implementations, Second Edition, John Wiley & Sons, 2022.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life Long Learning CLA-2- Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*-*	*10%*	*20%*	*-*
Level 2	*Understand*	*30%*	*-*	*-*	*20%*	*30%*	*-*
Level 3	*Apply*	*30%*	*-*	*-*	*20%*	*30%*	*-*
Level 4	*Analyze*	*20%*	*-*	*-*	*30%*	*20%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*10%*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*10%*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. Kusuma Eshwar, Danfoss industries Pvt ltd	*1. Dr. K V Praveen Kumar, SVNIT Surat*	*1. Dr. Ravi Eswar K M, SRMIST*
2. Dr. Patnana Hema Kumar, Tata Elxsi	*2. Dr. Hari Priya Vemuganti, NIT Raipur*	*2. Dr. Sridhar R, SRMIST*

Course Code	21EEC555J	Course Name	ELECTRIC DRIVE SYSTEMS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*elucidate the steady state operation and control of rectifier fed DC drives*
CLR-2:	*gain knowledge of closed loop operation and control schemes for chopper fed DC drives*
CLR-3:	*comprehend the concepts of stator side speed-controlled induction motor drives*
CLR-4:	*explore the various converter control schemes for induction motor drives*
CLR-5:	*illustrate the concepts of synchronous motor drives and its control*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Program Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*analyze the performance of rectifier fed DC drives and its control methods*	*3*	*2*	*2*
CO-2:	*examine the operation of chopper fed DC drives and its control methods*	*3*	*2*	*2*
CO-3:	*apply the concepts of stator side control for induction motor drives*	*3*	*1*	*2*
CO-4:	*analyze the speed control of induction motor drive by slip power recovery schemes*	*3*	*2*	*2*
CO-5:	*evaluate control methods of various synchronous motor drives*	*3*	*2*	*2*

Module 1 – Rectifier Fed DC Drives — ***15 Hour***

Introduction to motor Drives, Drive characteristics, Criteria for selection of drive components, Motor duty and its Types, Characteristics of DC motor Drives, elements of drive system, Dynamics of DC. motor drives, Steady-State stability of D.C. motor drives, principle of DC motor speed control, Phase controlled converters for DC. motor drives, steady state analysis of three phase converter-controlled DC motor Drive, Problems in three phase converter-controlled DC motor Drive, Two quadrant three phase-controlled DC drive, Implementation of braking schemes for DC drive, Principle and analysis of DC Drive employing dual converter, Power factor improvement of phase controlled converters.

Laboratory Practice: *Simulation of Rectifier based speed Control of separately excited DC motor (Field and armature control), Study of a four-quadrant DC motor drive*

Module 2 – Chopper Fed DC Drives — ***15 Hour***

Closed loop operation - speed regulation, speed loop, and current loop, Transfer function of separately and self -excited DC motors, Design of converters and choppers - firing scheme, Concept of speed reversal and torque reversal. Effect of saturation, Continuous and discontinuous armature current operations, Analysis of current ripple and its effect on performance operation with freewheeling diode, Performance analysis DC motor with different classes of choppers and Mult quadrant choppers, Operation of P, PI and PID Controllers in DC drives, Digital Control of DC Drives. Case study for DC drives in real time system.

Laboratory Practice: *Firing Pulse Generation Schemes for Two Pulse and Six Pulse Converters, DC motor drive control using four quadrant DC-DC, Transfer function modelling of DC motor and design of speed and current loop feedback controllers.*

Module 3 – Induction Motor Drives	*15 Hour*
Review on different ac power controllers, Torque-slip characteristics, operation with different types of loads, Stator voltage control of induction motor, Concept of Speed reversal and power –torque characteristic, Variable frequency and constant flux operation of three phase induction motors, Analysis of slip trajectory for induction motor control, Concept of V/f control, Performance analysis V/f control in VSI fed induction motor drive, Braking of CSI and VSI fed drives, dynamic and regenerative CSI and VSI fed drives, PWM for VSI fed drives. ***Laboratory Practice:*** *Three phase VSI based Stator voltage control of induction motor, Open Loop v/f control of PWM inverter based three phase Induction motor. FPGA based Closed Loop v/f control of PWM inverter fed three phase Induction motor.*	
Module 4 -Control of Induction Motor Drives	***15 Hour***
Introduction: Speed control through slip and rotor resistance, TRC strategy and characteristic relation between slip and chopper duty ratio. Design solution and Problems in chopper duty ratio verse slip control, rotor resistance control chopper controlled resistance, Combined stator voltage control and rotor resistance control, Analysis of power –torque characteristic, Introduction of Slip power recovery, Performance analysis torque slip characteristics during the Slip power recovery, sub -synchronous and super synchronous operation of Slip power recovery, power factor considerations using slip power recovery method, Introduction to Field oriented control of induction motor, Need for vector control, direct and indirect vector control for induction motor. ***Laboratory Practice:*** *Rotor resistance scheme in wound-rotor Induction motor, Slip Power recovery scheme in Wound rotor Induction Machine, vector control for induction motor drive.*	
Module 5 – Synchronous Motor Drives	***15 Hour***
Principle of Synchronous Motor Drives, starting methods, and Need for leading PF operation, Self-control, margin angle control, torque angle control of Synchronous Motor Drives, Open loop VSI fed Synchronous Motor Drives, Closed loop v/f control of VSI fed Synchronous Motor Drives, self-controlled synchronous motor with electronic commutation, self-controlled synchronous motor drive, Performance analysis torque slip characteristics during the Slip power, Power factor control, load commutated inverter (LCI) fed synchronous motor drives drive, Problems in LCI fed synchronous motor drives drive, Permanent Magnet Synchronous Machine (PMSM) Drives, Closed loop VSI fed PMSM Drives, Concept of Field oriented control (FOC), FOC for PMSM Drives, Drive for Brushless DC motor. Case study for AC drives in real time system. ***Laboratory Practice:*** *Open Loop v/f control of PWM inverter based three phase Induction motor, Study of self-controlled synchronous motor drive using load commutated thyristor inverter, Study of FOC for PMSM Drives.*	

Learning Resources	1. *G.K.Dubey, Power semiconductor controlled devices, Second Edition, Prentice Hall International New Jersey, 2009* 2. *R.Krishnan, Electric Motor Drives –Modeling, Analysis and Control, First Edition, Prentice-Hall of India Pvt. Ltd., New Delhi,2015.* 3. *J.M.D Murphy, F.G.Turnbull, Thyristor control of AC motors, Second Edition, Pergamon Press, Oxford, 1988.*	4. *Bimal K.Bose, Modern Power Electronics and AC Drives, First Edition, Pearson Education (Singapore) Pte. Ltd., New Delhi,2015* 5. *AustinHughes, Newnes, Electric Motors and Drives: Fundamentals, Types and Applications, Elsevier, Fourth Edition, January 2013* 6. *Buxbaum, A.Schierau, and K.Staughen, A design of control systems for DC drives, Second Edition, Springer-Verlag, 2015*

Learning Assessment							
	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (45%)		Life-Long Learning CLA-2- Practice (15%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	20%	-	-	20%	20%	-
Level 2	*Understand*	20%	-	-	20%	20%	-
Level 3	*Apply*	30%	-	-	30%	30%	-
Level 4	*Analyze*	30%	-	-	30%	30%	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr.Hariram Satheesh, ABB	1. Dr.D.Thanga Raj Chelliah, IIT Roorkee	1.Dr.N.Kalaiarasi, SRMIST
2.Mr.Balraj Vaithilingam, Valeo India Private Limited	2. Dr. B.Chitti Babu, IIITD, Kanchipuram	2. Dr. R.Sridhar, SRMIST

ACADEMIC CURRICULA

Power Electronics and Drives

Professional Elective Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21EEE671T	Course Name	CONTROL AND INTEGRATION OF RENEWABLE ENERGY SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*study about various distributed energy sources and microgrid*
CLR-2:	*analyze the issues in integrated renewable energy systems*
CLR-3:	*apply the control schemes for optimal energy management*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Program Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*acquire knowledge on the functional attributes of distributed energy sources and microgrid*	*3*	*-*	*-*
CO-2:	*design and integrate the renewable sources to grid*	*3*	*2*	*2*
CO-3:	*implement various control strategies for power management in distributed energy systems*	*3*	*2*	*2*

Module 1 - Distributed Energy Resources and Microgrid	***9 Hour***
Overview of Renewable energy Technology, Distributed energy resources-solar, wind, fuel cell, hydrogen etc., Trends in Energy Storage Types and their Characteristics, Microgrid-Types of microgrid, Power electronic converters for Microgrids and Smart grids, distributed storage and smart grid concepts, Reliability assessment and evaluation of Renewable Energy Systems, Application of DERs in electricity market.	
Module 2 – Distributed Energy Resources Integration and Grid Interconnection	***20 Hour***
Integration technologies for renewable energy, Recent trends in power electronic distributed generation interconnection, Stability problems of distributed generators, integration of Energy Storage Syster Renewable Energy Sources. Overview of Grid Connected Renewable Energy Systems, Standards and codes of interconnection-Broad classification of Grid Code Requirements, Grid Requirement for PV, WECS grid integration, Overview of Phase Locked Loop, Design of Phase Locked Loop, Converter for Renewable Energy Integration into Hybrid Grids, Design and Optimization of Grid Integrated Renewable Energy system, Optimization Methods for Grid Energy Storage Systems, Fault Ride Through of Grid Connected Power Converters, Simulation of grid-connected PV/Wind system, Case studies.	
Module 3 – Control and Energy Management	***16 Hour***
MPPT, High penetration of PV, Control of Distributed Generation power converters, Modelling and stability analysis of voltage and current control for distributed generation systems. Control of grid-connected photovoltaic and wind energy system-Vector Control and Direct Power Control, Energy Management techniques for Distributed Renewable Energy Integration, Energy Optimiza Management of Hydrogen Energy with Integrated Battery Storage and Solar Photovoltaic Systems. Case studies.	

Learning Resources	1. *Keyhani, Ali, et al. Integration of Green and Renewable Energy in Electric Power Systems, First Edition, United Kingdom, Wiley, 2010.* 2. *Mukhtar Ahmad. Operation and Control of Renewable Energy Systems, First Edition, John Wiley, 2018*	3. *Keyhani, Ali. Design of Smart Power Grid Renewable Energy Systems, First Edition, United States, Wiley, 2019.* 4. *Renewable Energy Integration: Challenges and Solutions. Germany, First Edition, Springer Nature Singapore, 2014.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Lifelong Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*30%*	-	*30%*	-	*30%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Jason Mano Raj, Technology and Strategy Services*	1. *Dr. A. Venkadesan, NITPY*	1. *Dr. J. Divya Navamani, SRMIST*
2. *Mr. Sitangshu Sekhar Biswas, Department of Atomic Energy*	2. *Dr. Balasingh Moses M, Anna University, BIT Campus*	2. *Dr. A. Lavanya, SRMIST*

Course Code	21EEE672T	Course Name	APPLICATIONS OF POWER CONVERTERS IN EMERGING TECHNOLOGIES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explore the advanced power converter topologies*
CLR-2:	*apply suitable control techniques for power electronic converters in emerging applications*
CLR-3:	*illustrate the artificial intelligence aided techniques for power applications*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Program Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*acquire knowledge on emerging power converters*	2	2	3
CO-2:	*analyze power electronic converters and their control for emerging applications*	2	2	3
CO-3:	*apply AI for power applications.*	2	-	2

Module 1 – Emerging Power Electronics Converters	***10 Hour***
DC-DC Power Converters: Z-source DC-DC converter, Bidirectional, and Multiport DC/DC Converter, Switched-Capacitor converters, High gain DC-DC converter using a coupled inductor, DC/DC Optimizer, Partial power converters, Solid State Transformer DC-DC Converter, DC-AC Power Converters: Transformer-less inverters, Switched-Capacitor-multilevel inverters, Microinverters, High-Fundamental Frequency Inverters, Modular Multilevel Converters (Inverter operation), Power Decoupling inverters, Solid State Transformer DC-AC Converter, AC-DC Power Converters: Power factor correction converters, Multi-level Rectifiers, Modular Multilevel Converter (Rectifier operation), Basic principle of Fault-Tolerant Operation on power electronics converters with an example *Case study: Selection and design of emerging power converters based on their applications using simulation tools*	
Module 2 – Advanced Power Electronics Applications and Their Controls	***20 Hour***
Advanced Control techniques: LQR/PR/PQ/ H-∞based grid-tied PV, Model predictive controls Based AC Drives, Bidirectional Battery Charger for an Electric Vehicle, Bidirectional Dual Active Converter for Vehicle to Grid, Single-phase PMSM Drives, Induction Heating, Theory and Control of Wireless Power Transfer Systems, Power Electronic Systems, and Control in Automobiles, Marines, Aircraft, and Satellites, Grid-forming inverters for PV and wind turbines, LVRT operation of single/three-phase PV/Wind systems, Solid-state transformer applied in electrified railway systems, Topologies and control for battery balancing applications, Operation and control of data centers, and UPS, Power converters and control of LEDs, Talkative Power Conversion Technologies. *Case study: Emerging power converters with power applications using advanced control algorithm*	
Module 3 – AI in Power Applications	***15 Hour***
Artificial intelligence–assisted data-driven control of power electronics systems, Electric vehicle charging technology and its control, Battery state-of-health estimation using machine learning, Neural network-based control of power electronic converters, Surrogate models for power electronic systems applying machine learning techniques, Cyber security in power electronic systems,	

Learning Resources		
	1. Frede Blaabjerg, Control of Power Electronic Converters and Systems, vol 1, Elsevier, 2014. 2. L. Umanand, Power Electronics: Essentials and Applications, Wiley,2010. 3. Mohan N., Underland T.M., and Robbins W.P., Power Electronics – Converters, Applications, and Design, Third Edition, Wiley India.	4. Francisco Díaz-González, Andreas Sumper, Oriol Gomis-Bellmunt, Energy Storage in Power Systems, Wiley Publication, Mar 2016. 5. Hu, Weihao; Zhang, Gouzhou; Zhang, Zhenyuan; Abulanwar, Sayed; Blaabjerg, Frede: AI for Power Electronics and Renewable Energy Systems, Energy Engineering, IET Digital Library,2024

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	10%	-	20%	-
Level 2	Understand	20%	-	30%	-	30%	-
Level 3	Apply	30%	-	30%	-	30%	-
Level 4	Analyze	30%	-	30%	-	20%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Arpan Hota, Schneider Electric, Mumbai	1. Prof. Vivek Agarwal, IIT Bombay	1. Dr. M. Jagabar Sathik, SRMIST
2. Dr. Vishal Anand, REFU Drive, Pune	2. Dr. N. Sandeep, MNIT, Jaipur	2. Dr. K. Saravanan, SRMIST

Course Code	21EEE673T	Course Name	SMART GRID TECHNOLOGIES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*analyze the functional attributes of smart grid*
CLR-2:	*implement smart metering, demand-side integration, and information security measures for smart grids*
CLR-3:	*examine distribution automation equipment, management systems, and transmission system operations.*
CLR-4:	*investigate sustainable energy options, variability issues, demand response, and the impact of electric vehicles.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Program Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*gain knowledge on the fundamentals of smart grid*	*3*	*-*	*1*
CO-2:	*examine various communication technologies in smart grid*	*2*	*2*	*2*
CO-3:	*utilize SCADA, outage management systems, and visualization techniques in distribution and transmission systems.*	*2*	*2*	*2*
CO-4:	*assess storage technologies, advanced metering, and the integration of renewable energy into microgrids.*	*3*	*2*	*1*

Module 1 - Introduction to Smart Grid	***10 Hour***
Evolution of electric grid, Definitions, Need for smart grid, Smart grid drivers, Functions of smart grid, Opportunities and barriers of smart grid, Difference between conventional grid and smart grid, Concept of resilient and self- healing grid. Components and architecture, Inter-operability, Impacts of smart grid on system reliability, Recent development and international policies in smart grid, Smart grid standards.	
Module 2 – Communication Technologies	***12 Hour***
Data communication: Dedicated and shared communication channels, switching techniques, Communication channels, Layered architecture and protocols. Communication technologies for the Smart Grid: Communication technologies, Standards for information exchange. Information security for the Smart Grid: Encryption and decryption, Authentication, Digital signatures, Cyber security standards. Smart metering and demand-side integration: An overview of the hardware used, Communications infrastructure and protocols for smart metering, Demand-side integration.	
Module 3-Distribution Technologies	***12 Hour***
Distribution automation equipment: Substation automation equipment, Faults in the distribution system, Voltage regulation. Distribution management systems: Data sources and associated external systems, SCADA, Customer information system, Modelling and analysis tools, Distribution system modelling, Applications, Outage management system (OMS). Transmission system operation: IEDs and SCADA, Data sources, Energy management systems, Wide area applications, On-line transient stability controller, Pole-slipping preventive controller Visualization techniques.	
Module 4 – Renewable Energy and Storage	***11 Hour***
Sustainable Energy Options for the Smart Grid, Penetration and Variability Issues Associated with Sustainable Energy Technology, Demand Response Issues, Electric Vehicles and Plug-in Hybrids, PHEV Technology - Impact of PHEV on the Grid, Vehicle to Grid (V2G), Grid to Vehicle (G2V), Environmental Implications, Storage Technologies, Advanced Metering, Microgrid with Renewable Energy. Case study: Substation automation, demand response management.	

Learning Resources	1. *Nick JenkinsStuart Borlase 'Smart Grid: Infrastructure, Technology and Solutions, First Edition, CRC Press 2017.* 2. *JanakaEkanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, 'Smart Grid: Technology and Applications, First Edition,Wiley, 2012.* 3. *Mini S. Thomas, John D McDonald, Power System SCADA and Smart Grids, First Edition, CRC Press, 2020.*	4. *Kenneth C.Budka, Jayant G. Deshpande, Marina Thottan, Communication Networks for Smart Grids, First Edition, Springer, 2014.* 5. *Smart Grid: Basics to Advanced Technologies, Online Course - NPTEL*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	20%	-	20%	-
Level 2	Understand	30%	-	30%	-	30%	-
Level 3	Apply	30%	-	30%	-	30%	-
Level 4	Analyze	20%	-	20%	-	20%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. K. Kumaresan, NTPC.*	1. *Dr. M.Balaji, SSN*	1. *Dr. D. Selvabharathi, SRMIST*
2. *Mr. A. Kannan, Seshasayee Paper Mills Ltd*	2. *Dr. A. Venkadesan, NITPY*	2. *Dr.R.Palanisamy, SRMIST*

Course Code	21EEE674T	Course Name	POWER CONVERTERS AND CONTROLLERS IN MICROGRID	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*conceptualize microgrid design, standards, and its control*
CLR-2:	*develop AC and DC microgrid converters and its control schemes*
CLR-3:	*assess the dynamics and stability of microgrid*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Program Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*illustrate the concept of microgrid architectures and their standards.*	2	-	1
CO-2:	*develop power converters and control techniques for AC and DC micro grid*	3	2	2
CO-3:	*evaluate dynamics and stability of microgrids.*	3	3	3

Module 1 – Introduction to Microgrid and its Control	***12 Hour***
Micro-Grid: Power system resilience, The concept of micro-grids, Types of micro-grids, Autonomous and non- autonomous grids, Sizing of micro-grids, Microgrid Modeling and Analysis, Micro-grids with multiple DGs. Standards and regulation issues associated with AC and DC microgrids, Comparison between AC and DC Microgrids. Micro-Grid control: Centralized control, Hierarchical principle: Primary, secondary and tertiary control – Distributed control, Protection issues and Communication based techniques.	
Module 2 – Control of AC and DC Microgrid	***18 Hour***
Basics of Voltage-frequency control and P-Q control in AC microgrid, control of grid-forming inverter, control of grid-feeding inverter, control of grid supporting power inverter, synchronization of inverters in ac microgrids. Voltage control and power control in DC microgrid, control of parallel DC-DC converters in a DC microgrid, Modeling of AC and DC microgrid and its dynamic studies, Power Management Strategy of AC-DC microgrid, Pertinent, deterministic algorithm, metaheuristic optimization, droop control strategy, Fault analysis AC/DC Microgrid.	
Module 3 – Stability Analysis in AC and DC Microgrid	***15 Hour***
System models and stability analysis of AC and DC Microgrid, stabilization strategies-impedance and admittance stability criteria, stabilization using nonlinear techniques-feedback linearization and sliding mode control, intelligent control of microgrids-fuzzy logic control and ANN control. Future Perspectives, Simulation analysis of grid-connected AC/DC microgrid, case study on emulation of AC and DC sub-grids using power converters, case study on multi-port hybrid AC/DC microgrid.	

Learning Resources		
	1. *Fusheng Li, Ruisheng Li, Fengquan Zhou, Microgrid Technology and Engineering Application, First Edition, Elsevier, 2015.* 2. *S. Chowdhury, P. Crossley, Microgrids and Active Distribution Networks, Second Edition, IET, 2019.* 3. *Nikos Hatziargyriou, Microgrids Architectures and Control, First Edition, John Wiley Sons, 2014.*	4. *Hassan Bevrani, Bruno François, Toshifumi Ise, Microgrid Dynamics and Control, First Edition, John Wiley Sons, 2017.* 5. *Manuela Sechilariu, Fabrice Locment, Intelligent Control and Power Flow Optimization, First Edition, Butterworth-Heinemann Inc, 2016.* 6. *Gevork B. Gharehpetian, S. Mohammad Mousavi Agah, Distributed Generation Systems: Design, Operation and Grid Integration, First Edition, Butterworth Heinemann Inc, 2017.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	20%	-	20%	-
Level 2	Understand	20%	-	20%	-	20%	-
Level 3	Apply	30%	-	30%	-	30%	-
Level 4	Analyze	30%	-	30%	-	30%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. K. Kumaresan, Senior Manager, NTPC.	1. Dr.S.S.Dash, GCE KJR	1. Dr.R.Palanisamy, SRMIST
2. Mr.A.Kannan, Seshasayee Paper Mills Ltd	2. Dr.A.Venkadesan, NITPY	2. Dr. D. Selvabharathi, SRMIST

Course Code	21EEE675T	Course Name	INTELLIGENT CONTROLLERS FOR POWER CONVERSION SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*analyze the neural network algorithms combined with pattern classification and regression problems*
CLR-2:	*comprehend the Fuzzy logic controller and neuro-fuzzy based systems used in real time application*
CLR-3:	*explore the* different Machine learning approaches for power conversion system *in real world applications*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Program Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*develop the algorithms in neural networks along with pattern classification and association for real world problem*	*3*	*2*	*3*
CO-2:	*apply fuzzy logic and reasoning to handle uncertainty and solve engineering problems*	*3*	*2*	*3*
CO-3:	*design and simulate power conversion systems using machine learning methods*	*3*	*2*	*3*

Module 1- ANN Based Controllers and its algorithms For Pattern Classification and Regression Problems	***15 Hour***
Basics of Neurons and Their Artificial Models, Learning Paradigms-Supervised, Unsupervised and reinforcement Learning, McCulloch-Pitt Neuron, Linear Separability, ANN training Algorithms-Training rules, Hebb rule-Algorithm, Perceptrons-Algorithm, Delta Rule, Adaline, Madaline algorithms, Back Propagation Algorithm-Derivation-, Hopfield network; Self-organizing network and Recurrent network; Neural Network based controllers and estimators. Application of ANN algorithms for wind energy conversion system and Solar energy conversion system. ANN based converters used in renewable energy sources like a fuel cell and solar cell Pattern Association-Hebb rule, delta Rule for pattern association, delta Rule for pattern association, Auto associative memories -iterative Associative Network, Hopfield Network -Energy Function, bidirectional associative memories Architecture (BAM), Competitive Learning Networks-Basics, Kohonen Self organizing Maps-Algorithm, Learning Vector Quantization (LVQ), basic architecture of Adaptive Resonance Theory, Case study on neural network controller for electrical applications.	
Module 2- Fuzzy System and Fuzzy Logic Based Power Conversion Application	***15 Hour***
Fuzzy Logic Systems, Fuzzy Representations, Training of Fuzzy Logic Systems, Classical Logic, Multivalued Logics, Fuzzy Propositions, Theory Fuzzy Qualifiers, linguistic Variables, Linguistic Hedges, Introduction to basic Fuzzy Arithmetic, Case study for open loop control of system with Fuzzy Logic, Aggregation Operations, fuzzy Logic controller- Basic block, Knowledge Base-Rule base-Inference system-Importance, Fuzzification, membership functions, defuzzification Methods-Weighted Average method, Centroid method, Center of sums, Mean max method, Learning Methods that Cross-fertilize ANFIS and RBFN Introduction to Architecture of Mamdani Type Fuzzy Control Systems, Takagi and Sugeno's approach, Fuzzy logic based MPPT for a Wind Energy using control modes, Fuzzy Knowledge Based renewable power conversion system, Fuzzy logic based battery storage system for a standalone wind energy conversion system, fuzzy-logic based predictive and adaptive control, Intelligence Techniques for Enhancing the Performance of Controllers in Power Converter	
Module 3 Machine Learning Method and Approach For Power Conversion Application	***15 Hour***
Deep learning, Unsupervised learning, Decision trees, Reinforcement learning, Support vector machines, Self-learning, Regression analysis, Feature learning, Bayesian networks, Sparse dictionary learning Genetic algorithm ,Anomaly detection ,Particle swarm optimization . Machine Learning for Predicting Wind Turbine Output Power in Wind Energy Conversion Systems,, Wind Power Forecasting Using Machine Learning, Machine Learning in Energy Conversion and Management, Control of Power Inverters in Renewable Energy using machine learning approach, forecasting the effectiveness of	

solar panels, wave height and wave energy conversion, and the effectiveness of windmills, PSO and GA based algorithm for Energy Conversion Systems, Intelligent control of grid-connected AC–DC–AC converters for power conversion.

Learning Resources	1. *T1. Zimmerman H.J.,Fuzzy set theory and its applications, Fourth Edition, Kluwer Academic Publishers,2001.* 2. *Simon Haykin, Neural Networks A comprehensive foundation, Pearson Education Asia, First Edition, 2002.* 3. *David E.Goldberg, Genetic Algorithms in search, optimization and machine learning, Pearson Education , First Edition,2022.* 4. *Teresa Orlowska, Kowalska, F. Blaabjerg, J.Rodriguez, Advanced and intelligent control in power electronics and drives, Springer, 2014*	5. *LaureneFausett. Fundamentals of Neural Networks-Architecture, Algorithms and Application, Prentice Hall International, First edition,1994.* 6. *Timothy J.Ross, Fuzzy Logic with Engineering Applications, John Wiley and sons Ltd. publication, Fourth edition,2016.* 7. *Spyros G. Tzafestas, Methods and Applications of Intelligent Control, Springer Dordrecht, First Edition,2012* 8. *By Kevin P. Murphy, Machine Learning: A Probabilistic Perspective, (MIT Press, First Edition,2021.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	20%	-	20%	-
Level 2	Understand	20%	-	20%	-	20%	-
Level 3	Apply	30%	-	30%	-	30%	-
Level 4	Analyze	30%	-	30%	-	30%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Manikandan P V, Intel Technology, India	1. Dr. Somasundaram, CEG, Anna university	1. Dr. R. Rajarajeswari, SRMIST
2. Mr. M Prakash, EDUTECH	2. Dr. V. Gomathi, CEG, Anna University	2. Dr. D. Suchitra, SRMIST

Course Code	21EEE676T	Course Name	DIGITAL CONTROL IN POWER ELECTRONIC SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*acquire the Knowledge of digital control in power electronics*
CLR-2:	*understand the concept of digital control in AC/ DC/AC Rectifiers*
CLR-3:	*inspect the theory of Digital Control of DC-DC converters*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Program Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*identify the concept of digital control in power electronic circuits*	1	-	-
CO-2:	*design of digital controlled single and three phase rectifiers/VSI inverters*	1	2	3
CO-3:	*construct the DC –DC converters with different controllers*	1	2	3

Module 1 -Digital Control in Power Electronic Circuits	***12 Hour***
Aspects and Developments, Laplace Transform, Z Transform, Relationship between s-plane and z-plane, Pulse Transfer Function, Pulse transfer function of closed loop system, Realization of pulse control in Hardware environment	
Module 2- Digital Control of AC/DC/AC Converters	***15 Hour***
Mathematical Modeling for AC/DC Rectifiers, Single Phase and Three Phase Full Wave Controlled Rectifiers, Design and simulation of front-end AC to DC converter with different controllers, αβ Transformation, Space Vector Modulation controlled VSI, Design of Rotating Reference Frame Current Controller in the continuous time domain for VSI, Three-phase digital current controller in the dq reference frame and a Stationary Frame Current Regulator with Zero Steady-State Error for VSI	
Module 3- Digital Control of DC-DC Converters	***18 Hour***
Fundamental DC- DC Converters, Fixed and variable frequency digital control architectures, State space modelling, Voltage mode control of Buck Converter, Simulation of Buck Converter under digital control in MATLAB, Digitization of Voltage mode control of Buck converter with feedback control Loop, Current Mode Controller of Buck , Boost DC- DC Converter, Single Phase PLL, Modeling the Internal Current Loop, Design of Voltage Controllers, Large Bandwidth Controllers - PI Controller, PID controller, Hysteresis controller, Implementation of Digital Control through DSPs and HIL	

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Learning Resources		
	1. *Simone Buso and Paolo Mattarella, Digital Control in Power Electronics, 2nd Edition, Morgan &Claypool Publishers, 2015.* 2. *Fang Lin Luo, Hong Ye and Muhammad Rashid B.S. Grewal, Digital power electronics and applications, Elsevier Academic Press, 2010.* 3. *Miguel Castilla, Control Circuits in Power Electronics, IET, 2016.*	4. *B. C.Kuo, Digital Control Systems, Second Edition, Oxford University Press, 2007* 5. *Buso, Simone, and Paolo Mattavelli. Digital control in power electronics. Morgan & Claypool Publishers, Second Edition, 2015.* 6. *Abu-Rub, Haitham, Atif Iqbal, and Jaroslaw Guzinski. High performance control of AC drives with Matlab/Simulink. John Wiley & Sons, 2021.* ,

Learning Assessment							
	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	20%	-	20%	-	20%	-
Level 2	*Understand*	20%	-	20%	-	20%	-
Level 3	*Apply*	30%	-	30%	-	30%	-
Level 4	*Analyze*	30%	-	30%	-	30%	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. Kusuma Eshwar, Danfoss industries Pvt ltd	1. Dr. K V Praveen Kumar, SVNIT Surat	1. Dr. S. Vijayalakshmi, SRMIST
2. Dr. Patnana Hema Kumar, Tata Elxsi, Telangana	2. Dr. S. Chandrasekaran, NIT,Hamirpur	2. Dr. Ravi Eswar K M, SRMIST

Course Code	21EEE677T	Course Name	REALIZATION OF POWER ELECTRONIC CONVERTERS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*acquire knowledge on various power electronic devices and control techniques*
CLR-2:	*develop different power electronic converters*
CLR-3:	*enrich knowledge on the fabrication of power supplies and power converters*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Program Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*identify and utilize the appropriate components and generate the switching pulses to drive power electronic switches.*	3	2	3
CO-2:	*design of various power converters*	3	2	3
CO-3:	*fabricate power supplies and converters*	3	2	3

Module 1 – Selection of Power Electronic Devices	***14 Hour***
Selection of power switching devices- Diodes, Transistors, MOSFET, IGBT; SiC and GaN devices for high frequency and high-temperature operation, Specifications from datasheet, AC/DC Voltage and current sensors, 8 bit ADC and DACs, Pulse-width modulation (PWM) and its applications in power electronics, Generation of switching signal using ICs, Gate Drive Circuits for Power Switches, Opto-coupler circuits, High-frequency digital PWM controller ICs	
Module 2 – Design of Power Converters	***14 Hour***
Design of power converters for stipulated applications: buck, boost, 3ϕ IGBT based inverter, Component selection, Design of inductor, high-frequency Inductor and transformer- materials and design steps, types of inductors and capacitors, Input filter design, design of capacitor, C, RC, RCD Snubber design, gate driver design – Low side, High side and Bootstrap half-bridge configuration	
Module 3 – Power Supplies, PCB Design, and Development	***17 Hour***
Design of LDO for power converter, Fixed and adjustable regulators, Flyback converter design with LM5021; PCB Design and Standards- Introduction to PCB design software, Steps in PCB Design, IPC-2221 standards, SMD and Through-Hole Components-Types of IC Packages (SMD and Through-Hole), Footprint-Related Data from the Datasheet, Design Rules for Pads and Routing, Schematics to PCB, 3D View of PCB, design considerations to avoid EMI, ESD, Design of PCB for basic converters	

Learning Resources		
Learning Resources	1. *Abraham I. Pressman, Keith Billings, Taylor Morey, Switching Power Supply Design, Third Edition, The McGraw-Hill Companies, 2009.* 2. *Bob Dobkin, Jim Williams, Analog Circuit Design: A Tutorial Guide to Applications and Solutions, Elsevier Inc, First Edition, 2011.* 3. *Robert A Pease, Troubleshooting Analog Circuits (EDN Series for Design Engineers), Newnes, Second edition, 2006* 4. *Ang S, Oliva A. Power-Switching Converters, Third Edition / Simon Ang, Alejandro Oliva. Third edition. CRC Press; 2010.*	5. *NPTEL online course: Design of Power Electronic Converters, IIT Guwahati, 2022.* 6. *D. Grahame Holmes; Thomas A. Lipo Pulse Width Modulation for Power Converters: Principles and Practice, Wiley-IEEE Press, Second Edition,2017* 7. *NPTEL online course: Pulse width Modulation for Power Electronic Converters by Dr. G. Narayanan, 2014* 8. *Ramanarayanan V, Course Material on Switched Mode Power Conversion, 2007*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	20%	-	20%	-	20%	-
Level 2	*Understand*	20%	-	20%	-	20%	-
Level 3	*Apply*	20%	-	20%	-	30%	-
Level 4	*Analyze*	20%	-	20%	-	30%	-
Level 5	*Evaluate*	10%	-	10%	-	-	-
Level 6	*Create*	10%	-	10%	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. Pragatheeswaran C, Danfoss Drives*	1. *Dr. S. Senthil kumar, NIT, Trichy,*	1. *Dr. C. Balaji, SRMIST*
2. *Mr. Bharadwaj R, Borgwarner*	2. *Dr. P. Srinivasa Rao Nayak, NIT, Trichy,*	2. *Dr. A. Dominic Savio, SRMIST*

ACADEMIC CURRICULA

Power Electronics and Drives & Power Systems

Common Professional Elective Courses

Regulations 2021

SRM
INSTITUTE OF SCIENCE & TECHNOLOGY
(Deemed to be University u/s 3 of UGC Act, 1956)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21EEE501T	Course Name	FLEXIBLE AC TRANSMISSION SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*impart in-depth knowledge on working and its characteristics of FACTS devices*
CLR-2:	*get insight of the mathematical representation of compensation techniques*
CLR-3:	*interpret the implementation of suitable FACTS controllers in real time applications*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Program Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*enumerate the operation, types and benefits of FACTS controllers*	*3*	*1*	*3*
CO-2:	*develop the modeling of compensators for different power system studies*	*3*	*1*	*3*
CO-3:	*interpret the functions of emerging FACTS controllers and its real time applications*	*3*	*2*	*1*

Module 1 - FACTS Concepts	***18 Hour***
Basics of power transmission networks, Uncompensated transmission lines, Flow of power in an ac system (parallel path and meshed system), Criteria for loading capability, power flow considerations, Dynamic stability considerations of a transmission interconnection, Importance of controllable parameters, Basic types of FACTS controllers, Application of FACTS controllers in distribution systems - HVDC and FACTS, Objectives of shunt compensation, Methods of controllable VAR generation, SVC, STATCOM, GCSC, TSSC, TCSC, SSSC, UPFC, IPFC, NGH SSR damper, TCBR, Case study on implementation of FACTS controller in distribution system and analyze small signal stability of the system	
Module 2 - Modeling of Compensators	***15 Hour***
Modelling of compensators for studies: load flow, small and large disturbance, sub-synchronous resonance, electromagnetic transients and harmonics performance, Modeling of multi-functional single converter FACTS: STATCOM, SSSC, SVC and TCSC, Modeling of multi-converter FACTS: UPFC and IPFC in nonlinear interior point optimal power flow analysis, Case study on open loop simulation of FACTS devices in transmission system	
Module 3 - Applications of Emerging FACTS Controller	***12 Hour***
Impact of FACTS devices on power system voltage stability, Congestion management and loss minimization, Power flow control in energy markets, Non-Intrusive System Control for regular and contingency operation, Autonomous Systems for Emergency and Stability Control, Impact of FACTS devices in Wide Area Monitoring and Control, Impact of FACTS installation and choice on small signal stability analysis and Transient stability analysis	

Learning Resources		
	1. Mohan Mathur, R. and Rajiv K. Varma, Thyristor Based FACTS Controller for Electrical Transmission Systems, Second Edition, Wiley Inderscience, 2016. *2. Narain G. Hingorani and Laszlo Gyugyi, Understanding FACTS – Concepts & Technology of Flexible AC Transmission Systems, Second Edition, Standard Publishers, New Delhi, 2011.* *3. X.P. Zang, C. Rehtanz and B. Pal, Flexible AC Transmission Systems: Modeling and Control, Birkhauser, 2014.*	*4. K R Padiyar, FACTS Controllers in Power Transmission and Distribution, Second Edition, New Age, 2021.* *5. Yong Hua Song and Allan T. Johns, Flexible Ac Transmission Systems (FACTS) The Institution of Engineering and Technology, 2008.*

Learning Assessment							
	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30%	-	30%	-	30%	-
Level 2	Understand	30%	-	30%	-	30%	-
Level 3	Apply	20%	-	20%	-	20%	-
Level 4	Analyze	20%	-	20%	-	20%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. S. Saravanan, S&S Engineering	1. Dr. P. Bhuvaneswari P, Sri Venkateswara College of Engineering & Technology, Chittoor	1. Dr. A. Geetha, SRMIST
2. Mr. Francis Suresh Balan, CGS Green Sustainergy Pvt. Ltd	2. Dr. M. Durairasan, University College of Engineering, Thirukkuvalai	2. Dr. S. Usha, SRMIST

Course Code	21EEE502T	Course Name	HIGH VOLTAGE DIRECT CURRENT TRANSMISSION SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*IEEE 1378-2022; IEC TR 63127; IEC 61975*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*describe the need and selection of HVDC system for bulk power transmission*
CLR-2:	*analyze the operation of converter for HVDC system*
CLR-3:	*describe the control and recent trends in HVDC transmission systems*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Program Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*illustrate HVDC system structure and components*	2	2	-
CO-2:	*demonstrate the converter topology and its characteristics*	2	3	2
CO-3:	*explain the control and recent trends of HVDC*	3	2	2

Module 1 – HVDC Power Transmission	***5 Hour***
Overview of HVDC transmission, Comparison between DC and HVDC systems, HVDC standard transmission voltage, Need for power system interconnections, Evolution of AC and DC transmission systems. Comparison of EHV AC and DC transmission, description of DC transmission systems, modern trends in AC and DC transmission; Components of HVDC transmission system, Case study on comparison between traditional and modern HVDC systems	
Module 2 – HVDC Converters and Control	***20 Hour***
Analysis of HVDC Converters, Rectifier and Inverter operation of Graetz circuit configurations, Choice of converter configuration, 6-pulse and 12-pulse rectifiers and inverters and their characteristics, Operation principle of VSC based HVDC Transmission, Comparison of Line Commutated Converter and Voltage Source Converter, Standards-IEEE 1378-2022, IEC TR 63127, Design of HVDC converter station, Components and functions, Design factors and challenges, Equivalent circuit of HVDC link, DC link control, Converter control characteristics, Types of control techniques for HVDC system, Constant current control, Constant excitation angle control, Constant ignition angle control, Individual phase control and equidistant pulse control, Valve blocking and by-passing, Starting, stopping and power flow reversal, Higher level controllers, Case study on performance analysis of HVDC converter system	
Module 3 – Design, Testing of HVDC System and Recent Trends	***20 Hour***
Harmonics in HVDC system, Harmonics Filters, EMI Filters, Design of AC filters and DC filters, Power loss analysis of HVDC system, Efficiency improvement for long distance transmission, HVDC system testing, Standards-IEC 61975, Types of HVDC system testing, Converter maloperations, Faults in HVDC System and their protection, Recent developments in HVDC systems, Issues encountered in traditional systems, Multi Terminal DC systems, HVDC Light technology, Growth of HVDC market, HVDC Transmission market size and industry analysis, HVDC in future sustainable energy system, Renewable energy source interconnection, Design of VSC based HVDC with Offshore Wind Farms, Modeling and simulation studies to facilitate offshore wind and HVDC Systems, Case study on HVDC project, planning and analysis	

Learning Resources		
	1. K. R. Padiyar, HVDC Power Transmission Systems: Technology and System Reactions, New Age International, third edition, 2017. *2. Arrillaga, Jos, and Jos Arrillaga. High voltage direct current transmission, Vol. 29. Iet, Second Edition, 1998.* *3. S. Rao, EHVAC and HVDC Transmission Engineering and Practice, third Edition, Khanna Publisher,1993*	*4. R. D. Begamudre, Extra High Voltage AC Transmission Engineering, Third Edition, New Age Publishers, 2009* *5. Kamakshaiah, S and Kamaraju, V, HVDC Transmission, First Edition, Tata McGraw Hill Education (India), New Delhi 2011.*

Learning Assessment							
	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	20%	-	20%	-
Level 2	Understand	30%	-	30%	-	30%	-
Level 3	Apply	30%	-	30%	-	30%	-
Level 4	Analyze	20%	-	20%	-	20%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Jason Manoraj, L&T Technology Services Limited	1. Dr. P. Thamizhazhagan, University college of Engineering, Tindivanam	1. Dr. A. Lavanya, SRMIST
2. Mr. Sitangshu Sekhar Biswas, Department of Atomic Energy	2. Dr. A. Venkadesan, NIT Puducherry	2. Dr. J. Divya Navamani, SRMIST

Course Code	21EEE503T	Course Name	APPLICATIONS OF MACHINE LEARNING FOR ENERGY SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*identify the concepts of renewable energy systems and need for machine learning*
CLR-2:	*develop in-depth knowledge on statistical machine learning concepts*
CLR-3:	*demonstrate the forecasting models of power generation and load availability of energy systems*
CLR-4:	*formulate and classify the faults involved in solar and wind energy systems*
CLR-5:	*summarize switching device characteristics involved in advanced solid-state switches*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Program Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*enumerate the concepts of renewable energy systems*	*2*	*-*	*2*
CO-2:	*summarize the concepts behind statistical machine learning techniques*	*2*	*-*	*1*
CO-3:	*demonstrate the forecasting methods for power generation and load availability through learning algorithms*	*2*	*1*	*2*
CO-4:	*develop fault classification models for solar and wind energy systems*	*2*	*1*	*2*
CO-5:	*formulate the switching device design involved for advanced solid-state devices*	*2*	*1*	*2*

Module 1 – Electrical Energy Systems	***5 Hour***
Conventional source of electrical energy, Basic layout of thermal power generation and its setbacks, Basic layout of sustainable energy resources, Importance of Solar PV and wind energy systems, Electrical characteristics of solar PV, Modeling of solar cells including the effects of temperature, shadow effects and mitigation techniques, Significance of MPPT and types of MPPT, Solar PV based grid tied systems and integration issues; Principles of wind energy conversions and components of WECS, Aerodynamic modeling and wind characteristics, HAWT, VAWT, Wind energy based islanded and grid tied systems and related issues	
Module 2 – Statistical Machine Learning	***10 Hour***
Statistical terminology for model building and validation, Machine Learning, Machine learning model development and deployment, Linear Regression, Logistic Regression, Bias versus variance trade-off, Train and test data, Machine learning losses, Feature Selection and Extraction, Explicit Semantic Analysis, Non-Negative Matrix Factorization, Singular Value Decomposition and Principal Component Analysis, Convergence Criteria, Train and test validation, Cross-validation and its techniques, K-Fold, Grid Search, Performance Metrics	
Module 3 – Power Generation & Load Forecasting for Energy Systems	***10 Hour***
Power generation and load forecasting, Types of data: Sensor/SCADA/Simulation based dataset, Solar irradiance data (GHI, DNI, Diffuse), Wind energy data, Data visualization, Energy demand model, Forecast methods based on physical, numerical weather prediction, Persistence/Statistical Forecasting, Short term forecasting methods: similar day approach, time series approach, auto regression and moving average models, ARMA, ARIMA, ARIMAX , Simple and multivariant regression, SVM, Markov chain models, ensemble methods, hybrid methods, Case Study on Solar PV Power Generation Forecasting, Load Forecasting for Islanded systems with solar PV, Wind	
Module 4 – Fault Study in Energy Systems	***10 Hour***
Introduction to faults in solar PV and wind energy systems, Types of faults, Faults in Solar PV based islanded and grid tied systems, Faults in wind energy based islanded and grid tied systems, Regression based classifier, Bayes based classifier, k-NN based classifier, Random forest classifier, Support vector machine based classifier, Condition monitoring of energy system - Reactive maintenance, Preventive maintenance, Predictive maintenance, Case Study on Prediction and classification of faults in solar PV and wind energy systems	
Module 5 – Characteristic study of Advanced Power Devices	***10 Hour***

Recent advancements in power switching devices, SiC Device: Construction and Characteristics, GaN Device: Construction and Characteristics, Panasonic Device: Construction and Characteristics, Transform Device: Construction and Characteristics, Comparison of all devices, Collection of device data, Data processing, analytics and visualization, Device capability check using regression model, Bayes model, kNN, SVM, Single variant and Muti-variant analysis, Case Study on prediction of power losses in power switches

Learning Resources	1. Rai G.D., non-conventional energy resources, Khanna publishers, 2019. 2. Wadwa. C.L., Electric Power Systems, Fifth Edition, Wiley Eastern Ltd, New Dellhi 2017. 3. Tom M. Mitchell, Machine Learning, First Edition, McGraw-Hill Education (India) Private Limited, 2017.	4. Ethem Alpaydin, Introduction to Machine Learning (Adaptive Computation and Machine Learning), Third Edition, The MIT Press 2020. 5. Stephen Marsland, Machine Learning: An Algorithmic Perspective, Second Edition, CRC Press, 2015

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	40%	-	40%	-	40%	-
Level 2	Understand	40%	-	40%	-	40%	-
Level 3	Apply	10%	-	10%	-	10%	-
Level 4	Analyze	10%	-	10%	-	10%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Srikanth Vasamshetti, CSIR-CSIO	1. Dr. D. Devaraj, KARE	1. Dr. U. Sowmmiya, SRMIST
2. Dr. S. Archana, Valeo India Pvt Ltd	2. Dr.R. Geetha, Vellammal Engineering College	2. Dr. J. Preetha Roselyn, SRMIST

Course Code	21EEE504T	Course Name	POWER QUALITY ASSESSMENT AND ENHANCEMENT	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*identify the fundamental concepts, and industry standards of power quality*
CLR-2:	*provide the knowledge to assess power quality in industrial applications*
CLR-3:	*explain the importance of mitigating methods to enhance power quality*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Program Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*enumerate power quality terms, IEEE regulations, standards and recommended practices*	*3*	*-*	*-*
CO-2:	*analyze power quality in various industrial applications*	*3*	*2*	*3*
CO-3:	*apply the different mitigating technologies to enhance power quality*	*3*	*2*	*3*

Module 1 – Fundamentals and Standards of Power Quality	***9 Hour***
Overview of power quality terms, Types of Power Quality Disturbances: Harmonic Distortion, Voltage Sag and Swell, Interruptions, Transients, Effects of poor power quality on equipment and economics, Power quality standards and key standards: IEEE 519, IEC 61000, EN 50160, Power quality indices: THD, Voltage Flicker, Voltage Sag and Swell Indices, Interruption Indices, Overview of power quality measuring instruments, Impact of renewable energy sources on power quality, Power quality challenges and solutions.	
Module 2 – Power Quality Assessment in Industrial Applications	***18 Hour***
Industrial Power Factor Correction, Power quality in Smart grids, Microgrids, Electric vehicles and Data centers, Impact of non-linear loads, Energy storage impact on power quality, Power quality and energy efficiency, Economic impact of power quality problems, Power quality audits, Principles of operation and performance analysis of harmonics filters, Proactive and passive compensation, Advanced software tools for power quality assessment, IoT-based power quality monitoring, Flicker assessment in critical process industries, Motor staring analysis, Power quality challenges in industrial automation and process control, Advanced power quality monitoring techniques, Case study on examination of power quality issues in various manufacturing plants, hands-on practice with power quality analyzers.	
Module 3 – Power Quality Enhancement	***18 Hour***
Utility-Customer interface, Different configurations of harmonic filters: passive, active and hybrid filters, Different configurations of custom power devices: Network reconfiguring Devices, Operation and control, Distribution Static Compensator (DSTATCOM) for load compensation and voltage regulation, Series compensation with Dynamic Voltage Restorer (DVR), Unified Power Quality Conditioner (UPQC) for shunt and series compensation, Hybrid custom power devices, Power quality improvement in distribution systems, Renewable Energy in Power Quality Enhancement, Impact of smart grids and IoT on Power Quality, Software tools for designing the filters, Practice on design of passive filters and active filters, Case study on problem identification, analysis and implementation of custom power devices in manufacturing plant, challenges and mitigation strategies to enhancing power quality in renewable energy plants.	

Learning Resources	*1. Arrillaga J., Smith B. C., Watson N. R. and Wood A. R., Power System Harmonic Analysis, Wiley India, 2nd edition, 2008.* *2. Dugan R. C., McGranaghan M. F. and Beaty H. W., Electrical Power System Quality, McGraw-Hill International Book Company, 2004*	*3. Bhim Singh, Ambrish Chandra, Kamal Al-Haddad, Power Quality Problems and Mitigation Techniques, Wiley Publications, 2015.* *4. Arindam Ghosh and Gerard Ledwich, Power quality enhancement using custom power devices, Springer Science & Business Media, 2022.*

Learning Assessment							
	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30%	-	20%	-	30%	-
Level 2	Understand	30%	-	20%	-	30%	-
Level 3	Apply	20%	-	30%	-	20%	-
Level 4	Analyze	20%	-	30%	-	20%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Sridher, Schwing Stetter (India) Pvt. Ltd., Chennai	1. Dr. A Venkatesan, NITPY	1. Dr. T. M. Thamizh Thendral, SRMIST
2. Mr. K. Karthikeyan, BHEL-Trichy	2. Dr. Ganesh Kumar, Anna University	2. Mr. D. Ravichandran, SRMIST

Course Code	21EEE505T	Course Name	ELECTRIC VEHICLE AND ENERGY STORAGE SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*context of an electric vehicle architecture, configuration, and rationale policies and regulations*
CLR-2:	*enrich the knowledge of electric motor drives and their control techniques*
CLR-3:	*summarize the different energy storage systems and various modes of energy storage*
CLR-4:	*acquaint the electric vehicle charging systems*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Program Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*acquire knowledge of various parts of the electric vehicle and their functions*	*1*	*2*	*2*
CO-2:	*develop EV Traction Motors and their Control Techniques*	*2*	*3*	*3*
CO-3:	*analyze the characteristics and parameters of batteries, battery management systems, and Hydrogen Fuel Cell Technologies*	*3*	*3*	*3*
CO-4:	*comprehending Electric Vehicle Charging Systems, regulation and Adoptions*	*2*	*3*	*3*

Module 1 - Electric Vehicle and its Components, Rationale Policies and Regulations ***9 Hour***

Introduction to Electric Vehicle (EV), Comparison of EV with ICE based Vehicle, Outline to EV components and systems, Introduction of Driving Cycle, Vehicle Dynamics of EV, Problem Solving in Vehicle Dynamics - Fundamental of vehicle transmissions, and Trends in transmission design, Transmission losses and efficiency - Hybrid Electric Vehicle (HEV) and its Types, Fuel Cell Electric Vehicle (FCEV) - Economic rationale for EV policy and regulation, Environmental implications of EVs and regulatory responses- Government Policies and Incentives.

Module 2 – Electric Vehicle Traction Motors and their Control Techniques ***12 Hour***

Introduction to EV Drive Train, EV Motor drive and load profile, Selection of traction Motor, Dynamics of Electric drives - Fundamental torque equations, Components of load torques - Selection of motor power rating, Thermal model of motor for heating and cooling - Classes of Power train motor configurations and components: Mid drive, hub, and In-wheel motor drive configuration - - Electrical Barking. Type of Motor drive: BLDC, PMSM mid-drive type, and Axial Flux PMSM, SRM Motor drive - Schematic motor controller, Modeling and control of advanced control techniques for EV drive motors - Testing: Thermal management testing for motors, Noise, vibration, and harshness (NVH) Durability and EMI reliability, IP65 and IP67 testing

Module 3 – Energy Storage Systems in Electric Vehicle ***12 Hour***

Electrochemistry of the Cells and Batteries - General approach to modeling batteries - Traction battery pack design - Electrical Requirements, Thermal Requirements, Mechanical Requirements, Automotive Drive cycles - EV Batteries Specifications, Internal structure, Charging and Discharging of : Lithium Iron Phosphate Battery (LFP), Nickel Cobalt Aluminum Oxide (LNCA), Lithium Nickel Manganese Cobalt Oxide (LNMC), lithium iron phosphate battery (LiFePO 4), and Sodium Battery- Selection of battery for EVs and HEVs – Hydrogen Fuel Cell Technologies, Types of Fuel Cell and operations - Fuel cell and Battery (FC + B) - Fuel Cell + Ultra capacitor (FC + UC) - Fuel Cell + Battery + Ultra capacitor (FC + B + UC) - Battery state of charge estimation methods - Battery cell equalization problem - Thermal control - Energy and Power estimation - Battery management system: Definition, Parts: Power Module, Battery, DC/DC Converter, load - Communication channel - Battery pack safety - Battery standards and tests - Cell balancing: Causes of imbalance, Active Balancing, Passive balancing - Thermal Runway: High discharge rates, short circuits, charging and discharging - Environment and Human Health impact assessments of batteries

Module 4 – Electric Vehicle Charging System ***12 Hour***

Types of EV supply equipment (EVSE), components of EV battery chargers, charging infrastructure challenges, classification based on charging levels (region-wise), modes, plug types, standards related to connectors, communication, supply equipment, EMI/EMC - Electric Vehicle (EV) Standards, Overview of international standards (ISO, IEC) for EV technology, National standards for EV technology in India, global standards (SAE, CHAdeMO, CCS) for EVs – Charging Modes: CV and CV - Onboard charging systems, types of AC-DC converters; working principles, modulation, design, and closed loop control of power factor correction converters (PFC): Boost type PFC, Totem-pole PFC, active front-end converter. Types of Off Chargers: AC chargers, DC chargers, and fast chargers – Wireless charging: Types, Operation, Control, and

standards - Communication architecture for EV charging - -V2G, V2V connectivity, Criteria for connecting EV to the utility for AC level 1 and level 2 charging - Nature and scope of policies to stimulate widespread EV adoption - Policy formulation and implementation at various levels of government.

Learning Resources	*1. Ronald Jurgen, Electric and Hybric-Electric Vehicles: Fuel Cell Hybrid EVs SAE, First Edition, 2011.* *2. Mehrdad Ehsani, Yimin Gao, sebastien E. Gay and Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, First Edition, CRC Press, 2009* *3. Wu, Yuping, Lithium-ion Batteries Fundamentals and Applications, CRC Press, Taylor and Francis, first edition, 2015.* *4.San Ping Jiang, Fundamentals and Application of Lithium-ion Battery Management in Electric Drive Vehicles, Wiley, first edition, 2015.* *5. James Larminie, John Lowry, Electric Vehicle Technology Explained, John Wiley and Sons Ltd, second edition, 2012*	*6. Shuiwen Shen, Qiong-zhong Chen, Practical Control of Electric Machines for EV/HEVs Design, Analysis, and Implementation, Springer, first edition, September 2023* *7. Tiago, Traction Control in Electric Vehicles Paperback, Lambert Academic Publishing, first edition, 2017.* *8. Neeraj Priyadarshi, P. Sanjeevikumar, Farooque Azam,C. Bharatiraja, Rajesh Singh, Advanced Power Electronics Converters for Future Renewable Energy Systems, CRC Press, Taylor and Francis, first edition, 2023.* *9.Thandavarayan Maiyalagan, Perumal Elumalai, Chokkalingam Bharatiraja, Rechargeable Lithium-Ion Batteries Trends and Progress in Electric Vehicles, CRC Press, Taylor and Francis, first edition, 2020*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	10%	-	20%	-
Level 2	Understand	30%	-	10%	-	30%	-
Level 3	Apply	30%	-	20%	-	30%	-
Level 4	Analyze	20%	-	20%	-	20%	-
Level 5	Evaluate	-	-	20%	-	-	-
Level 6	Create	-	-	20%	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Marrand, Expert Engineer-Volvo Group, India	1. Dr. Deepak Ronanki, IITM	1. Dr. C.Bharatiraja, SRMIST
2. Dr.Amit Kumar Gupta, Rolls-Royce-Electrical	2. Dr. Sheldon Williamson, University of Ontario	2. Dr. K.Vijayakumar, SRMIST

Course Code	21EEE506T	Course Name	ADVANCED DIGITAL SIGNAL PROCESSING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand advanced digital signal processing techniques*
CLR-2:	*apply advanced algorithms for real-time signal processing*
CLR-3:	*apply statistical methods to analyze random signals*
CLR-4:	*analyze advanced digital signal processing algorithms in practical scenarios*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Program Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*apply advanced methods for signal reconstruction, filtering and analyze in frequency domain*	*2*	*-*	*2*
CO-2:	*utilize Fast Fourier transform and wavelet transforms for signal analysis*	*2*	*-*	*3*
CO-3:	*apply estimation and probability theory to signal processing problems*	*2*	*1*	*3*
CO-4:	*analyze digital signal processing for image and video processing in communications and control systems*	*2*	*1*	*3*

Module 1 - Introduction to Digital Signal Processing	***12 Hour***
Fourier Transform: Continuous Fourier Transform, Discrete Fourier Transform and its properties, Fast Fourier Transform algorithms (Radix-2, Radix-4), Laplace Transform, Z-transform, Adaptive Filters: Least Mean Squares and Recursive Least Squares algorithms, Multirate Signal Processing: Decimation and interpolation, Polyphase filters and their design	
Module 2 – Signal Processing Techniques	***10 Hour***
FFT Algorithms: Split-radix FFT, Mixed-radix FFT, FFT for non-power-of-2 lengths: Bluestein's FFT algorithm, Prime-factor FFT algorithms, Wavelet Transforms: Continuous Wavelet Transform, Discrete Wavelet Transform, Wavelet packet decomposition and reconstruction, JPEG Compression: Discrete Cosine Transform, Quantization and encoding, MP3 Compression: Subband coding, Psychoacoustic modelling	
Module 3 - Statistical Signal Processing	***12 Hour***
Random Processes, Probability Distributions, Stationary and non-stationary random processes, Gaussian and non-Gaussian distributions, Markov processes and their properties - Parameter estimation: Maximum Likelihood Estimation, Bayesian estimation, Linear and non-linear least squares estimation, Cramer-Rao lower bound, Kalman Filtering, Kalman filter formulation and applications, Extended Kalman Filter (EKF) and Unscented Kalman Filter, Kalman filtering for state estimation and control.	
Module 4 - Digital Signal Processing Applications	***11 Hour***
Image Filtering: Spatial domain filtering (smoothing, sharpening), Frequency domain filtering (FFT-based filtering), Image Compression: Wavelet-based image compression techniques, JPEG2000 standard - Video Processing: Motion estimation and compensation, Video coding standards (H.264, HEVC), Speech and Audio Processing, Speech Recognition: Hidden Markov Models, Deep learning approaches (Recurrent Neural Networks), Audio Effects: Echo cancellation and noise reduction techniques, DSP in Communications, Digital Modulation Techniques: Amplitude Shift Keying, Frequency Shift Keying, Phase Shift Keying, Orthogonal Frequency Division Multiplexing, Equalization Techniques: Linear and non-linear equalization methods, Adaptive equalization algorithms.	

Learning Resources	1. *John G. Proakis and Dimitris G. Manolakis, Digital Signal Processing Principles, Algorithms, and Applications, 4th Edition, Pearsons, 2007.* 2. *Guy Nason, Wavelet Methods in Statistics with R, First Edition, Springer, 2006.*	3. *Monson H. Hayes. Statistical Digital Signal Processing and Modeling, Wiley, Third edition, 2012.* 4. *Bernard Sklar, Digital Communications: Fundamentals and Applications, Pearson Prentice Hall, third edition, 2017.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Ms.Nivedha, Infineon Technologies	*1. Dr. Velmurugan P G S, Thiagarajar College of Engineering*	*1. Dr. Pradeep V, SRMIST*
2. Mr.Ragul S, Temenos	*2. Dr. Arvind R Singh, Shandong University*	*2. Dr. Sureshkumar A, SRMIST*

Course Code	21EEE507T	Course Name	ENERGY AUDIT AND MANAGEMENT FOR ELECTRICAL SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*gain expertise in energy audit methodologies for enhancement and saving expenses*
CLR-2:	*develop electrical systems to improve efficiency and to effectively manage resources*
CLR-3:	*establish energy conservation measures by using practical approaches*
CLR-4:	*understand energy use trends to prioritize efficiency improvements*
CLR-5:	*present research results and execute economical strategies for energy management.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Program Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*analyze energy usage and identify efficiency opportunities*	*2*	*2*	*1*
CO-2:	*optimize electrical systems for improved efficiency*	*2*	*2*	*1*
CO-3:	*implement energy conservation techniques in electrical systems.*	*2*	*2*	*1*
CO-4:	*apply energy audit methodologies and tools effectively*	*2*	*2*	*2*
CO-5:	*prepare comprehensive energy audit reports and implement cost-effective solutions.*	*2*	*2*	*3*

Module 1-Introduction to Energy Audit and Management	***9 Hour***
Energy Audit, Importance of Energy Audit, Objectives of Energy Audit, Types of Energy Audit, Preliminary Energy Audit, Detailed Energy Audit, Investment, Grade Audit, Energy Management, Concepts and Principles, Energy conservation versus energy efficiency, Energy policy and regulations, Energy management standards (ISO 50001), Industry trends and innovations in energy management	
Module 2- Energy Efficiency in Electrical System	***9 Hour***
Analyzing electrical systems, Load assessment and profiling, Load curve analysis, Demand factor determination, Power quality analysis, Voltage fluctuations, Harmonic distortion, Power factor improvement, Energy conservation opportunities, Energy efficient lighting solutions, Variable frequency drives (VFDs) for motors, Energy efficient HVAC systems, Energy efficient air compression system, Benchmarking, Industry practices in electrical system optimization, IEEE 519, IEC 61000-4-30	
Module 3- Energy Conservation Techniques in Electrical Systems	***9 Hour***
Implementing energy conservation measures, Lighting systems optimization, LED lighting retrofits, Daylight Harvesting Techniques, Lighting Control Systems, Motor and Drive System Efficiency, -Variable Speed Drives (VSDs), Motor Management Programs, HVAC System Equipment Selection, Building Automation Systems (BAS), HVAC Best Efficiency Practices, Renewable Energy Integration, Case study on energy efficiency, ASHRAE Standards: ASHRAE 90.1 - ISO standards	
Module 4 - Energy Audit Techniques and Tools	***9 Hour***
Energy Audit Methodologies, Measurement and Verification Techniques, Direct Measurement Techniques, Indirect Measurement Techniques, Energy Monitoring Systems, SCADA Systems, Smart Meters, Data Loggers, Energy Performance Indicators, Specific Energy Consumption, Energy Intensity Indicators, Energy Audit Instruments, Power Analyzers, Thermal Imaging Cameras, Energy Management Software, Hands-on training with energy audit instruments, Advanced Tools and Techniques in Energy Audits, ISO standards, Fluke Energy Analyze Plus	
Module 5- Energy Audit Reporting and Implementation	***9 Hour***
Reporting and Implementing Audit Findings, Energy Audit Report Preparation, Executive Summary, Energy Consumption Analysis, Energy Saving Recommendations, - Cost-Benefit Analysis - Payback Period Calculation, Return on Investment (ROI) Analysis, Life Cycle Costing, Prioritizing Energy Efficiency Measures, Project Management for Implementation, Post-Implementation Monitoring, Feedback Mechanisms, Assessing and evaluating performance of equipment, energy auditing in specific industries, Modern Reporting and Implementation Techniques, ISO standards	

Learning Resources	1. *Wayne C. Turner, Energy Management Handbook, The Fairmount Press, Inc, ninth edition, 2018.* 2. *Barney L. Capehart, Wayne C. Turner and William J. Kennedy, Guide to Energy Management, The Fairmont Press Inc., seventh edition, 2012.*	3. *Energy Manager Training Manual (4 Volumes) available at www.energymanager training.com, a website administered by the Bureau of Energy Efficiency (BEE), a statutory body under the Ministry of Power, Government of India, 2015*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. R. Viswanathan, Power Grid corporation	*1. Dr.K. Keerthivasan, HCT, Oman*	1. *Dr. D.Ravichandran, SRMIST*
2. Er.Mohanan Pillai , MAPS	*2. Dr. A. Venkadesan, NIT Puducherry*	2. *Dr.V.Kalyanasundaram, SRMIST*

Course Code	21EEE508T	Course Name	SOFT COMPUTING TECHNIQUES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the foundational concepts of soft computing and differentiate from hard computing*
CLR-2:	*explore artificial neural networks, architectures, learning algorithms, and applications in electrical engineering.*
CLR-3:	*gain insights into the applications of fuzzy logic and its operations in electrical engineering problems*
CLR-4:	*explore problem-solving using genetic algorithms, schema theorem, and applications of genetic algorithms in various fields*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Program Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*identify components and applications of soft computing techniques*	*2*	*2*	*2*
CO-2:	*modeling and implementation of artificial neural network models to solve problems in electrical engineering*	*2*	*3*	*3*
CO-3:	*apply fuzzy logic concepts to solve problems related to electrical engineering and design fuzzy logic controllers*	*3*	*3*	*3*
CO-4:	*analyze and apply genetic algorithms to optimize solutions in various fields*	*2*	*3*	*2*

Module 1 -Foundations of Soft Computing	***6 Hour***
Introduction to Computing Systems, Soft Computing versus Hard Computing, Characteristics and Importance of Soft Computing, Components of Soft Computing, Applications of Soft Computing Techniques	
Module 2 –Artificial Neural Networks and Applications	***13 Hour***
Biological neurons, Basic models of artificial neural networks, Connections, Learning, Activation Functions, McCulloch and Pitts Neuron, Hebb network, Perceptron networks, Learning rule, Training and testing algorithm, Adaptive Linear Neuron, Back propagation Network, Architecture, Training algorithm, supervised and unsupervised learning, Single-layer perceptron, Multi-layer perceptron, Back Propagation Neural network, Recurrent neural networks, Convolutional neural networks, Application of neural network in Electrical engineering.	
Module 3 –Fundamentals of Fuzzy Logic and Applications	***13 Hour***
Fuzzy logic, fuzzy sets, properties, operations on fuzzy sets, fuzzy relations, Logic operations on fuzzy relations, Fuzzy membership functions, fuzzification, Methods of membership value assignments, intuition, inference, rank ordering, Lambda, cuts for fuzzy sets, Defuzzification methods, Truth values and Tables in Fuzzy Logic, Fuzzy propositions, Formation of fuzzy rules, Decomposition of rules, Aggregation of rules, Fuzzy Inference Systems, Mamdani and Sugeno types, Neuro-fuzzy hybrid systems : Characteristics, classification, application of fuzzy logic controller in electrical engineering.	
Module 4 –Genetic Algorithms: Theory and Applications	***13 Hour***
Biological Background, Traditional optimization and search techniques, genetic algorithm and search space, genetic algorithm versus traditional algorithms, basic terminologies, simple genetic algorithm, general genetic algorithm, operators in genetic algorithm, stopping condition for genetic algorithm flow, constraints in genetic algorithm, problem solving using genetic algorithm, schema theorem, classification of genetic algorithm, Holland classifier systems, genetic programming, Multi-Objective Optimization applications of genetic algorithm.	

Learning Resources	1. *Pradhan, B. K., Soft Computing: Techniques and its Applications in Electrical Engineering, Pearson Education India, 2018.* 2. *Aggarwal, Charu C., Neural Networks and Deep Learning: A Textbook, Springer, 2018* 3. *Ross, Timothy J., Fuzzy Logic with Engineering Applications, Wiley-Blackwell, 2010.*	4. *Sivanandam, S. N., Sumathi, S., and Deepa, S. N., Introduction to Fuzzy Logic using MATLAB, Springer, 2007* 5. *Goldberg, David E., Genetic Algorithms in Search, Optimization, and Machine Learning, Addison-Wesley Professional, 1989*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*10%*	-	*20%*	-
Level 2	*Understand*	*30%*	-	*30%*	-	*30%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*20%*	-	*30%*	-	*20%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr.A.Kannan, Seshasayee Paper Mills Ltd, Tirunelveli*	1. *Dr . M.Balaji, SSN*	1. *Dr. K.Selvakumar, SRMIST*
2. *Mr. K.Kumaresan, Senior Manager, NTPC*	2. *Dr.B. Bijukumar, NITPY*	2. *Dr. R.Sridhar, SRMIST*

Course Code	21EEE509T	Course Name	SPECIAL MACHINES AND THEIR CONTROLLERS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electrical and Electronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*acquire knowledge on permanent magnet brushless dc motor and its characteristics*
CLR-2:	*gain knowledge on the concepts of permanent magnet synchronous motor and its control.*
CLR-3:	*analyze the working principle, operation and control of axial flux permanent magnet machines*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Program Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*analyze the working and control of permanent magnet brushless dc motor*	*3*	*2*	*2*
CO-2:	*illustrate the operation and characteristics of permanent magnet synchronous motor*	*3*	*2*	*2*
CO-3:	*interpret knowledge on control of axial flux permanent magnet machines*	*3*	*2*	*2*

Module 1 - Permanent Magnet Brushless DC Motor	***15 Hour***
Construction and operation of PMDC and BLDC motor with features, Comparison of mechanical and electronic commutation, permanent magnet materials, BLDC motor classifications, Rotor magnet design topology in BLDC motor, electronic commutation in Star and Delta connected stator winding - EMF and Torque Equation - Torque - speed characteristics, Controller Design-Transfer function, Sensor and Sensor-less control, computer aided design approach in surface mounted type BLDC motor for electric vehicle, Applications.	
Module 2 - Permanent Magnet Synchronous Motor	***15 Hour***
Characteristic features between square and sine wave machines, PMSM classifications, Rotor magnet design topology in PMSM motor, EMF and Torque equation, Torque - speed characteristics, Phasor representation, Control of PMSM: vector and self-control, Power controllers, evaluation of control characteristics- design of current and speed controllers, FEA design in interior type PMSM motor for electric vehicle, Digital controllers, Sensor and Sensor-less control, Applications.	
Module 3 – Axial Flux Permanent Magnet Machines	***15 Hour***
Features of Axial Flux Permanent Magnet Machines and its classifications, Development of Axial Flux Permanent Magnet Machines, Comparison with Radial Flux Machines- Topologies and Geometries, Axial magnetic field excited by PMs, Principle of Operation, Torque production, Performance characteristics, Design of Axial Flux machines with and without cores, FEM approach, Control of trapezoidal and sinusoidal AFPM machine, Sensor-less position control, Applications.	

Learning Resources		
	1. Jacek F. Gieras, Rong-Jie Wang Maarten J. Kamper, Axial Flux Permanent Magnet Brushless Machines, Springer Netherlands, 2008. *2. Ramu Krishnan, Permanent Magnet Synchronous and Brushless DC Motor Drives, First Edition, CRC Press, 2010.*	*3. E.G. Janarthanan, Special Electrical Machines, PHI Learning Private Limited, Delhi, Second Edition, 2014.* *4. T.J.E. Miller, Brushless magnet and Reluctance motor drives, Clarendon press, London, 1989.*

Learning Assessment							
	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Sassikumar J – Ola Electric.*	1. *Dr.R.Ramesh, CEG - Anna University*	1. *Dr. M. Arun Noyal Doss, SRMIST*
2. *Mr. K.N. Balakrishnan, Magana Automotive*	2. *Dr.M.Sudhakaran, PEC*	2. *Dr.K.Mohanraj, SRMIST*