ACADEMIC CURRICULA

Professional Elective Courses

ELECTRICAL AND ELECTRONICS ENGINEERING

Regulations - 2018

Volume – 4 (6)

(Detailed Syllabus for Third & Fourth Year Courses)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18EEE301T	Course Name	OPTIMIZATION TECHNIQUES IN POWER ELECTRONICS	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:*	Learning Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Introduce and classify different conventional optimization techniques.*			
CLR-2 :	*Understand the fundamentals of genetic algorithm and to apply appropriate algorithm for Power Electronic Applications.*			
CLR-3 :	*Outline the concept of particle swarm optimization and apply it in Power Electronic applications.*			
CLR-4 :	*Introduce other modern optimization algorithms for engineering applications.*			
CLR-5 :	*Extend multi objective optimization techniques to Power Electronics*			
CLR-6 :	*Introduce the concept of optimization design for Power Electronic Applications*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	1	2	3
CLO-1 :	*Categorize optimization problems and its techniques based on constraints and variables*	*1*	*75*	*75*
CLO-2 :	*Correlate Genetic algorithm with various power electronic application.*	*2*	*75*	*75*
CLO-3 :	*Interpret Particle swarm optimization and develop hybrid algorithm for power electronic applications*	*3*	*75*	*75*
CLO-4 :	*Gain knowledge about other modern optimization algorithms and integrate them for power electronic applications*	*3*	*75*	*75*
CLO-5 :	*Formulate multi objective optimization algorithm for power electronic applications.*	*3*	*75*	*75*
CLO-6 :	*Apply optimization techniques in modelling Power Electronic applications*	*3*	*75*	*75*

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*H*	*H*	*M*	*M*	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-3 :	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-4 :	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-5 :	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-6 :	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*H*	*H*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to optimization*	*Introduction – Genetic Algorithm*	*Particle Swarm Optimization*	*Bacterial foraging-Chemotaxis, Swarming*	*Multiobjective optimization*
	SLO-2	*Design vector – design constraints – constraint surface*	*Encoding – Methods for GA*	*Fundamental principle*	*Operation of Bacterial foraging*	*Concept of pareto optimality*
S-2	SLO-1	*Objective function – objective function surfaces*	*Fitness function*	*Velocity updating in PSO -Algorithm*	*Bees colony algorithm-Behavior of Honey bee swarm*	*Classical Methods – Weighted sum method,*
	SLO-2	*Classification of optimization problem*	*Maximization & Minimization*	*Algorithm for PSO*	*Algorithm for Bee colony optimization*	*ε-constraint method*
S-3	SLO-1	*Single variable optimization - optimalityconditions*	*Genetic operators*	*PSO – Parameter Selection*	*Differential evolution-Initialization, Mutation*	*Weighted metric methods,*
	SLO-2	*Single variable (unconstrained optimization) – Exhaustive search method*	*Crossover*	*Pseudocode*	*Recombination, Selection*	*Benson method.*
S-4	SLO-1	*Successive quadratic estimation method*	*Mutation*	*Implementation & Convergence issues in PSO*	*Ant colony optimization-Introduction*	*Multi objectiveGA*
	SLO-2	*Newton Raphson method*	*Parent Selection Roulette wheel selection*	*Advanced operators of PSO*	*Algorithm for Ant colony optimization*	*Fitnessassignment*
S-5	SLO-1	*Multi variable optimization – optimality conditions (unconstrained)*	*Stochastic universal selection,*	*Meta-Optimization- Behavioral parameters*	*Cuckoo Search Optimization*	*Sharing function*
	SLO-2	*Simplex search method*	*Tournament selection*	*Algorithm for Meta-Optimization*	*Algorithm for Cuckoo search Optimization*	*Convergence criterion*
S-6	SLO-1	*Cauchy's method*	*Rank selection*	*Applications of PSO*	*Firefly optimization-Working Principle*	*NSGA-II*
	SLO-2	*Steepest descent method*	*Issues in GA implementation*	*Harmonics Elimination in Inverters*	*Algorithm for Firefly optimization*	*Convergence criterion*
S-7	SLO-1	*Multivariable optimization (Constrained) Kuhn – Tucker Conditions*	*Applications of GA*	*Applications of PSO*	*Flower Pollination optimization-Introduction*	*Applications:Design of AC – DC Grid connected converter using Multi objective optimization*

	SLO-2	*Penalty Function Method*	*Passive Filter design using GA*	*PSO for single phase PWM Inverters*	*Algorithm for Flower pollination optimization*	*Algorithm for Design of AC – DC Grid connected converter*
S-8	SLO-1	*Method of Multipliers*	*Parameter tuning of DC-DC converter using genetic algorithm*	*Control of Dc-DC converters using PSO*	*Grey Wolfe optimization-Introduction*	*Multi objective optimization of power converters (NSGA-II)*
	SLO-2	*Linearized search Technique – Frank Wolfe method*	*Tuning of PI Controllers for Power electronic converters*	*Feedback controller design for boost converters*	*Algorithm for Grey Wolfe Optimization*	*Algorithm for Multi objective optimization of power converters*
S-9	SLO-1	*Non-Linearized Search Technique – Reduced gradient method*	*MPPT in Renewable Energy systems*	*HybridofGAandPSO*	*Comparison of various algorithms*	*Multi objective optimization for design and tuning of PID controllers*
	SLO-2	*Quadraticprogramming*	*Genetic Algorithm for MPPT*	*Algorithm for hybrid GA and PSO for selective harmonic elimination in VSI fed drives*	*Benchmark functions*	*Algorithm for Multi objective optimization for design and tuning of PID controllers*

Learning Resources	1. *SingiresuRaoS. Engineering Optimization–TheoryandPractice, John Wiley & Sons, Inc., New Jersey, 2009.* 2. *Kalyanmoy Deb, Muti-objective Optimization using Evolutionary Algorithms, WileyIndia Private Limited, 2010* 3. *Kalyanmoy Deb, Optimization of Engineering Desig", Prentice Hall of India, second Edition, 2012.* 4. *Jizhong Zhou, Optimization of Power System Operation, IEEE Press, Second Edition, 2015.*	5. *Xin - She Yang, Nature Inspired Optimization algorithms, Elsevier, 2014.* 6. *Chee Peng Lim, Lakhmi C. Jain, Satchidananda Dehuri, Innovations in Swarm Intelligence, Springer, Berlin, Heidelberg, 2009.* 7. *Design of AC – DC Grid connected converter using Multi objective optimization, Electrical Control & Communication Engineering, 2014* 8. *https://engineering.purdue.edu/~sudhoff/ee630/Lecture09.pdf* 9. *https://link.springer.com/content/pdf/10.1007%2F978-3-540-74205-0_68.pdf*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr.S.Paramasivam, Danfoss, Industries Pvt Ltd, paramsathya@yahoo.com	*Dr. R.Subha. Sir MVIT, subha.mvit@gmail.com*	*Mrs.Uthra.R, SRMIST*
Mr.Muralikrishna, National Instruments, emkkrishnan@gmail.com	*Dr.C.Nayanatara, Sri Sairam Engineering College, nayanathara.eee@sairam.edu.in*	*Dr.D.Suchitra, SRMIST*

Course Code	18EEE302T	Course Name	FINITE ELEMENT ANALYSIS FOR ELECTRICAL MACHINES	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Illustrate the basic concepts of CAD and its design consideration*			
CLR-2 :	*Derive the output equation of DC and AC machines*			
CLR-3 :	*Compute the torque and force for rotating and linear actuators*			
CLR-4 :	*Analyze the finite element method in solving electromagnetic field problem*			
CLR-5 :	*Enumerate the design concept of CAD in mathematical modelling*			
CLR-6 :	*Build the models of electrical machines*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Understand the basic design of electrical machines and the need for CAD*	*1*	*75*	*75*	*H*	*M*	*M*	-	-	-	-	-	-	-	-	-	*H*	*M*	-
CLO-2 :	*Make use of output equation for calculate main dimension of DC and AC machines*	*2*	*75*	*75*	*H*	*H*	*M*	*M*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-3 :	*Deduce the electromagnetic field equations for actuators*	*3*	*75*	*75*	*H*	*H*	*H*	*M*	-	-	-	-	-	-	-	-	*H*	*M*	-
CLO-4 :	*Examine the mathematical and physical basis of finite element method*	*3*	*75*	*75*	*H*	*M*	*H*	*M*	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-5 :	*Apply the design concept of CAD in mathematical modelling*	*3*	*75*	*75*	*H*	*H*	*M*	*M*	*M*	-	-	-	-	-	-	-	*H*	*M*	-
CLO-6 :	*Develop the models of switched reluctance motor and rotating actuators*	*3*	*75*	*75*	*H*	*H*	*M*	*M*	*M*	-	-	-	-	-	-	-	*H*	*M*	-

Duration (hour)		*9*	*9*	*9*	*9*	*9*
S-1	SLO-1	*CAD and its objectives*	*Maxwell's Equations*	*Finite element method*	*Organization of CAD package*	*Model building*
	SLO-2	*Conventional design procedure of machines*	*Integral form and differential form*	*Assumptions in FEM*	*Pre-processor*	*Modeling flowchart*
S-2	SLO-1	*Output equation of DC machines.*	*Significance of field equations,*	*Electromagnetic field equations in Finite element*	*Solver*	*Geometric modeling, drawing edges*
	SLO-2	*Specific loading values for DC machines*	*Electromagnetic equation-integral and differential form*	*Finite difference method*	*Post-processor in CAD package*	*Creating surface and creating components*
S-3	SLO-1	*Output equation of AC machines*	*Magnetic vector potential*	*Finite difference method for calculation of magnetic field in a linear medium*	*Applications of finite element analysis*	*Selecting edges surfaces and components*
	SLO-2	*Specific loading values for AC machines*	*Scalar potential form*	*Assumptions in linear medium*	*Considerations in problem modeling*	*Positioning the construction slice materials*
S-4	SLO-1	*Factors affecting the size of rotating machines*	*Energy stored in electromagnetic field*	*Finite difference method for calculation of magnetic field in a non-linear medium*	*Stator and rotor model*	*Boundary condition*
	SLO-2	*Specific loadings and its dependent factors*	*Energy stored in current carrying coil*	*Assumptions in non-linear medium*	*Model replication and air gap discretisation*	*Model solving*
S-5	SLO-1	*Variation of output and losses with dimension*	*Energy functional*	*Stiffness matrix*	*Post-processing of results-flux and flux linkage*	*Meshing: 2-D and 3-D*
	SLO-2	*Separation of main dimensions*	*Assumptions in energy functional*	*FEM and FDM functions*	*Numerical and graphical results using processors*	*Finite element mesh*
S-6	SLO-1	*Limitations of conventional methods of design*	*Electromechanical energy conversion*	*FEM-mathematical basis*	*Analytical calculation*	*Design of C-cored coil with rotating actuator*

	SLO-2	*Need for field analysis based design*	*Classification of electromechanical energy conversion*	*FEM- physical basis*	*Terminal inductance calculation.*	*Geometric modeling of C-core*
S-7	SLO-1	*Outline of finite element analysis*	*Force and torque calculation from energy*	*Energy functional*	*Co-energy calculation.*	*Design of doubly excited rotating actuator*
	SLO-2	*Necessity of FEA*	*Force and torque calculation from co-energy*	*Non-linear energy functional*	*Force and torque calculation*	*Design procedure and its assumptions*
S-8	SLO-1	*Computers in finite element analysis*	*Singly excited linear and rotating actuator*	*Discretization*	*Virtual work method*	*Design procedure of SRM*
	SLO-2	*Graphical users of FEA*	*Doubly excited rotating actuator*	*Shape function*	*Maxwell's stress tensor method*	*Geometric modeling*
S-9	SLO-1	*Engineering Optimisation*	*Force calculation on a current carrying conductor*	*Shape triangle calculation*	*Bil method*	*Material assigning*
	SLO-2	*Optimisation Methodology*	*Torque calculation on a current carrying conductor*	*Comparison of Finite difference and finite element method*	*Boundary conditions*	*Design of Switched reluctance motor by CAD package*

Learning Resources	1. *Silvester and Ferrari, Finite Elements for Electrical Engineers, Cambridge University press, 2012.* 2. *S.R.H. Hoole, Computer - Aided, Analysis and Design of Electromagnetic Devices, Elsevier, New York, Amsterdam, London, 1989.*	3. *S. Salon, Finite Element Analysis of Electrical Machines, springer, 1995.* 4. *Nicola Bianchi, Electrical Machine Analysis Using Finite Elements,1st Edition, CRC Press,2005.* 5. *https://www.classcentral.com/course/edx--finite-element-method-fem-analysis-and-applications-4064*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Bhaskarsahu, Schneider Electric Ltd, Bhaskar.sahu@schneider-electric.com	*1. Dr. K. S. Swarup, IITM, ksswarup@iitm.ac.isn*	*1.Dr. M. Arun Noyal Doss, SRMIST*
2. Mr. A.Kannan, Seshasayee paper and board limited akannan@sbppapers.com	*2. Dr. R.Ramesh, CEG, rramesh@annauniv.edu*	*2. Dr. C. Subramani, SRMIST*

Course Code	18EEE303T	Course Name	POWER CONVERTER ANALYSIS AND DESIGN	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18EEC302J	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:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Enrich the knowledge on design aspects of phase controlled converters*			
CLR-2 :	*Acquire knowledge in DC-DC converters and its performance*			
CLR-3 :	*Enrich the knowledge of flyback back converter and its design*			
CLR-4 :	*Acquire knowledge on the design techniques of the inverters*			
CLR-5 :	*Understand the concept of resonant converters and role of reactive elements in UPS*			
CLR-6 :	*Gain knowledge on power converter analysis and design*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Design single phase and three phase rectifiers*	*3*	*75*	*75*
CLO-2 :	*Understand the analysis and design aspects of DC-DC converters*	*3*	*75*	*75*
CLO-3 :	*Design flyback back converter and its various topologies*	*3*	*75*	*75*
CLO-4 :	*Design the inverter for various applications*	*3*	*75*	*75*
CLO-5 :	*Apply the knowledge on design concepts of resonant converters and UPS*	*3*	*75*	*75*
CLO-6 :	*Analyze and Design power converters*	*3*	*75*	*75*

		Program Learning Outcomes (PLO)														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Standards & Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Design single phase and three phase rectifiers*	*H*	*H*	*M*	*M*	*H*	-	-	-	-	-	-	-	*M*	*H*	-
CLO-2 :	*Understand the analysis and design aspects of DC-DC converters*	*H*	*H*	*M*	*M*	*H*	-	-	-	-	-	-	-	*M*	*H*	-
CLO-3 :	*Design flyback back converter and its various topologies*	*H*	*H*	*M*	*M*	*H*	-	-	-	-	-	-	-	*M*	*H*	-
CLO-4 :	*Design the inverter for various applications*	*H*	*H*	*M*	*M*	*H*	-	-	-	-	-	-	-	*M*	*H*	-
CLO-5 :	*Apply the knowledge on design concepts of resonant converters and UPS*	*H*	*H*	*M*	*M*	*H*	-	-	-	-	-	-	-	*M*	*H*	-
CLO-6 :	*Analyze and Design power converters*	*H*	*H*	*M*	*M*	*H*	-	-	-	-	-	-	-	*M*	*H*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to single phase controlled converter (rectifier)*	*Introduction to isolated and non isolated DC-DC converters.*	*Introduction - Linear versus switch mode power supplies.*	*Introduction to inverters for single phase application*	*Introduction to resonant converters*
	SLO-2	*Working principle of single phase full converter*	*Principles of step down converters and step up converters*	*Functional circuit blocks of an offline switches*	*Introduction to inverters for three phase application*	*Classification of resonant converters*
S-2	SLO-1	*Analysis of single phase controlled rectifier for R load*	*Introduction to buck , boost converters*	*Classification of Basics switch mode DC-DC converters:*	*Selection of switching devices*	*Quasi resonant converters: Operating principle*
	SLO-2	*Analysis of single phase controlled rectifier for RLload and RLE load*	*Buck boost converters*	*Switch mode DC-DC converters: Operating principles*	*Introduction to IPM modules*	*Load resonant converters*
S-3	SLO-1	*Introduction to three phase controlled converters*	*Analysis of Buck converter*	*Flyback converters: operating principle*	*PWM techniques for inverter*	*Series Resonant switch converters*
	SLO-2	*Operation & principle of three phase controlled rectifier*	*Buck converter Design*	*Forward Converter: operating principle*	*Impact of PWM techniques on inverter performance*	*Parallel Resonant switch converters*
S-4	SLO-1	*Analysis of three phase controlled rectifier for R Load*	*Analysis of boost converter*	*Half-Bridge converters and, SMPS : Operating principle*	*Protection circuits for switches*	*Concept of Zero Voltage Switching*
	SLO-2	*Analysis of three phase controlled rectifier for RL Load*	*Boost converter design*	*Full Bridge Converters : operating principle*	*Snubber circuit design*	*Concept of Zero Current Switching*
S-5	SLO-1	*Selection of converter components for specified load*	*Analysis of buck-boost converter*	*Push-Pull Converter and its working*	*Thermal design considerations*	*Multi resonant converters*
	SLO-2	*Design of filter circuit for single phase controlled rectifier*	*Buck-Boost converter design*	*SMPS with multiple outputs*	*Heat sink design*	*Zero Voltage Transition converters*
S-6	SLO-1	*Design of filter circuit-three phase*	*Introduction to SEPIC converter*	*Magnetic design: Properties of magnetic*	*Multilevel Inverter(MLI) concept*	*UPS: offline UPS, Online UPS*

		converter		*cores*		
	SLO-2	*Importance of driver circuits*	*Introduction to CUK converter*	*High frequency inductor and transformer design*	*Classification of MLI*	*Filters: Voltage filters*
S-7	SLO-1	*Pulse generation circuits*	*Analysis of SEPIC converter*	*Selection of output filter capacitor*	*Design of MLI*	*Series-parallel resonant filters, filter without series capacitors,*
	SLO-2	*Design of driver circuits*	*Analysis of CUK converter*	*Selection of switches*	*Pulse Width Modulation for MLI*	*Current filter, DC filters*
S-8	SLO-1	*Power factor study – Improvement techniques*	*Thermal design: temperature control*	*Snubber circuit design*	*Influence of PWM on inverter performance*	*Design of inductor and transformé of power electronic applications*
	SLO-2	*Harmonic analysis study*	*Heat sink design*	*Design of driver circuits.*	*PWM for low inverter loss*	*Selection of capacitors.*
S-9	SLO-1	*Simulation of fully controlled converters*	*Simulation of basic DC- DC converters*	*Simulation of isolated dc dc converter*	*Simulation of a typical three phase inverter*	*Simulation of resonant and quasi resonant converter*
	SLO-2	*Demonstration of a fully controlled converter for R , RL loads*	*Demonstration of DC DC converters*	*Demonstration on Closed Loop Control of SMPS*	*Demonstration on a three phase inverter*	*Demonstration of resonant converters*

Learning Resources	1. *Robert W. Erickson and Dragan Maksimovic, Fundamentals of Power Electronics, 3rd Ed., Springer (India) Pvt. Ltd., 2011.* 2. *Abraham I. Pressman, Keith Billings, and Taylor Morey, Switching Power Supply Design, 3rd Ed.,McGraw-Hill Professional, 1 May 2009* 3. *Rashid M.H., Power Electronics Circuits, Devices and Applications, Prentice Hall India, Third Edition, New Delhi, 2004.* 4. *V. Ramanarayanan, Switched Mode Power Conversion, 2007*	5. *Umanand L and Bhatt S R, Design of Magnetic Components for Switched Mode Power Converters, Wiley Eastern Publication, 2009.* 6. *Ned Mohan, Tore M. Undeland, William P. Robbins, Power Electronics Converters, Applications, and Design", 3rd Edition, Wiley India Pvt Ltd, 2010.* 7. *Simon Ang, Alejandro Oliva, Power-Switching Converters, Second Edition, CRC Press, Taylor & Francis Group, 2010* 8. *https://nptel.ac.in/courses/108108036/*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Muralikrishna, National Instruments, emkkrishnan@gmail.com	*1. Dr. Chandrasekaran Subramanian , NIT Hamirpur, chandru@nith.ac.in*	*1.Dr. R. Sridhar, SRMIST*
2. Mr.J.Sassikumar, Philips India Pvt Ltd, sassikumar.jj@gmail.com	*2.Dr.R.Ramesh, CEG, rramesh@annauniv.edu*	*2. Dr. K. Mohanraj, SRMIST*

Course Code	18EEE304T	Course Name	SWITCHED MODE POWER CONVERSION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18EEC302J	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Review the basics of the power semiconductor devices and their requirements for the design of SMPC.*			
CLR-2 :	*Explain the advantage of Switched mode Power supply over linear power Supply and the design of basic switched mode DC-DC converters.*			
CLR-3 :	*Illustrate the need of derived / isolated converters and the working of various types of derived converters.*			
CLR-4 :	*Introduce the control and compensating schemes for the design of SMPS and the procedure to be followed in the design of magnetic components.*			
CLR-5 :	*Demonstrate the use of resonant converters to implement the Zero voltage and Zero current switching concepts.*			
CLR-6 :	*Learn the basics and steady state operation of efficient switched mode power conversion and control techniques, including component design.*			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Determine the selection criteria of power semiconductor devices, evaluation of losses and their basic heat sink design.*	*1*	*75*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	*M*	*H*	-
CLO-2 :	*Design the basic switched-mode converters for the given design specifications.*	*2*	*75*	*75*	*H*	*M*	*M*	*L*	-	-		-	-	-	-	-	*M*	*H*	-
CLO-3 :	*Understand the steady state analysis and working of the Derived DC-DC isolated Converters.*	*2*	*75*	*75*	*H*	*M*	*M*	*L*	-	-	-	-	-	*M*	-	-	*M*	*H*	-
CLO-4 :	*Analyze of Control and Compensating network for SMPS, design high frequency inductor and transformers to be used with SMPS.*	*3*	*75*	*75*	*H*	*M*	*M*	*L*	-	-	-	-	-	*M*	-	-	*M*	*H*	-
CLO-5 :	*Analyze the working principle of resonant converters and understand the importance of Zero voltage and Zero current switching.*	*2*	*75*	*75*	*H*	*M*	*M*	*L*	-	-	-	-	-	*M*	-	-	*M*	*H*	-
CLO-6 :	*Become proficient with the analysis and design of Switched-Mode Converters, including selection of components based on the specification.*	*2*	*75*	*75*	*H*	*M*	*M*	*L*	-	-	-	-	-	*M*	-	-	*M*	*H*	-

Duration (hour)		*9*	*9*	*9*	*9*	*9*
S-1	SLO-1	*Introduction to switched mode power conversion*	*Basic concepts of Switched Mode power converters.*	*DC-DC converters with isolation.*	*Reactive elements in Power Electronic Systems*	*Basic resonant circuit concepts*
	SLO-2	*Industrial relevance of switched mode power conversion*	*Generalized comparison between switched mode and linear voltage regulator.*	*Requirement for isolation in the switch-mode converters*	*Design constraints of reactive elements in Power Electronic Systems*	*SMPS using resonant circuit*
S-2	SLO-1	*Requirements of power conversion system*	*DC-DC converters circuit elements, operating principles*	*Power circuit of flyback converters*	*Design of inductor, transformer and capacitors for power electronic applications*	*Resonant switch converters – Introduction*
	SLO-2	*Requirements of high performance modern power conversion system*	*DC-DC converters Characteristics*	*Steady-state analysis of flyback converters*	*Filter inductor design constraints, Transformer design constraints*	*Resonant switch converters – principle of operation*
S-3	SLO-1	*Review of power diodes, Schottky didoes, power MOSFETs &IGBTs*	*Operation and steady state performance of Buck Converter in continuous-conduction mode (CCM)*	*Power circuit of push-pull converters*	*Modeling of power converters*	*Buck converter with zero current switching*
	SLO-2	*Introduction to power semiconductor devices for SMPS*	*Buck converter - Discontinuous-conduction mode (DCM) and boundary between CCM and DCM operation*	*Steady-state analysis of push-pull converters*	*Generalized State Space Model of the switching power converter*	*Steady state conversion ratio – Buck converters*
S-4	SLO-1	*Recent developments in power devices*	*Operation and steady state performance of Boost Converter in continuous-*	*Power circuit of forward converters*	*Transfer Function of switching power converters*	*Boost converter with zero voltage switching*

			conduction mode (CCM)			
	SLO-2	*New devices: GaN & SiC for switch mode power supplies*	*Boost converter - Discontinuous-conduction mode (DCM) and boundary between CCM and DCM operation*	*Steady-state analysis of forward converters*	*EMI and filter design problem*	*Steady state conversion ratio – Boost converters*
S-5	SLO-1	*Gate drive basics*	*Operation and steady state performance of Buck - Boost Converter in continuous-conduction mode (CCM)*	*Power circuit and steady-state analysis of half-bridge DC-DC converters*	*Closed loop control of switching power converters*	*Series resonant DC-DC converters – principle*
	SLO-2	*Gate drive requirements*	*Buck - Boost Converter Discontinuous-mode (DCM) and boundary between CCM and DCM operation*	*Power circuit and steady-state analysis of full bridge DC-DC converters*	*Selection of controller parameters for converters*	*Series resonant DC-DC converters – Analysis and operation*
S-6	SLO-1	*Switching performance and snubber design*	*Operation and performance of Cuk Converters*	*Magnetic circuits in isolated topologies*	*Feedback compensators for converters*	*Parallel resonant DC-DC converters – principle*
	SLO-2	*Turn-on and Turn-off snubber*	*Operation and performance of SEPIC Converters*	*Utilization of Magnetic circuits in isolated topologies*	*Design of feedback compensators*	*Parallel resonant DC-DC converters – Analysis and operation*
S-7	SLO-1	*Selection of devices*	*Inductors current ripple design considerations*	*Comparison of different isolated topologies*	*Effect of parasitics on the switching converter design*	*Resonant DC link converters – principle*
	SLO-2	*Basic heat sink design for the devices*	*Output voltage ripple design considerations*	*Selection criteria of different isolated topologies*	*Stray inductance and inductive coupling effects*	*Resonant DC link converters – Analysis and operation*
S-8	SLO-1	*Sources of losses in SMPS*	*Effect of parasitic elements*	*Recent advancements of DC –DC converters (current mode, voltage mode)*	*Digital Control of power converter*	*Comparison of resonant converter configurations*
	SLO-2	*Conduction/Switching losses*	*Choice of switching frequency*	*Recent advancements of DC –DC converters (multiple output, high frequency output)*	*Quantization issues in digitally controlled power converters*	*Selection criteria of resonant converter configurations*
S-9	SLO-1	*Losses and efficiency in converters*	*Comparisons of DC –DC converter configurations*	*Applications of DC-DC converters*	*Practical issues in controller design*	*Applications of Resonant converters*
	SLO-2	*Realistic converter models*	*Selection criteria of DC –DC converter configurations*	*Seminar on Recent advancements and applications of DC –DC converters*	*Seminar on practical issues in controller design for power converters*	*Seminar on recent advancements and applications of Resonant converters*

Learning Resources	1. *Ned Mohan, Tore M. Undeland, William P. Robbins, Power Electronics Converters, Applications, and Design, 3rd Edition, Wiley India Pvt Ltd, 2010.* 2. *Abraham I. Pressman, Keith Billings, and Taylor Morey, Switching Power Supply Design, 3rd Ed.,McGraw-Hill Professional, 1 May 2009.*	3. *Umanand L and Bhatt S R, Design of Magnetic Components for Switched Mode Power Converters, Wiley Eastern Publication, 2009.* 4. *S.N.Singh, Electric power generation, transmission and distribution, 2nd ed., PHI, 2011* 5. *https://nptel.ac.in/courses/108108036/*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Sairajagopal Chandramouli, Armstrong Fluid technology, Canada, bbalaji231@gmail.com	*1. Dr B. Chitti Babu, IIITDM Kancheepuram, bcbabu@iiitdm.ac.in*	*1. Dr L.Padmavathi, SRMIST*
2.Jidhun K Murali, Project Engineer, CDAC, Trivandrum, jidhunkm@gmail.com	*2. Dr. A. Venkadesan, NIT Puducherry, venkadesan@nitpy.ac.in*	*2.Dr R Sridhar, SRMIST*

Course Code	18EEE305T	Course Name	DESIGN OF ELECTRICAL MACHINES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18EEC204J, 18EEC205J	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Enrich the students with basic principles and characteristics of various types of electrical machines.*			
CLR-2 :	*Examine the design of armature and field systems for D.C. machines.*			
CLR-3 :	*Outline the core, windings and cooling systems of transformers*			
CLR-4 :	*Analyze the design of stator and rotor of induction machines*			
CLR-5 :	*Understand the design of stator and rotor of synchronous machines and study their thermal behavior.*			
CLR-6 :	*Understand the overall design of electrical machines*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Understand the mmf calculation and thermal rating of various types of electrical machines.*	*2*	*80*	*75*
CLO-2 :	*Design DC machine parts such as armature, field, commutator and brushes.*	*3*	*80*	*75*
CLO-3 :	*Acquire knowledge on the design of transformers and its operating characteristics.*	*3*	*80*	*75*
CLO-4 :	*Interpret the induction motor stator and rotor design equations and magnetic leakage calculations.*	*3*	*80*	*75*
CLO-5 :	*Design the components of synchronous motor*	*3*	*80*	*75*
CLO-6 :	*Design the components of DC and AC machines*	*3*	*80*	*75*

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
H	*H*	*H*	*H*	*L*	-	-	*L*	-	-	-	-	*M*	*M*	*L*
H	*H*	*H*	*H*	*L*	-	-	-	-	-	-	-	*M*	*M*	-
H	*H*	*H*	*H*	*L*	-	-	-	-	-	-	-	*M*	*M*	-
H	*H*	*H*	*M*	*L*	-	-	-	-	-	-	-	*M*	*M*	-
H	*H*	*H*	*H*	*L*	-	-	-	-	-	-	-	*M*	*M*	-
H	*H*	*H*	*H*	*L*	-	-	*L*	-	-	-	-	*M*	*M*	*L*

Duration (hour)		*9*	*9*	*9*	*9*	*9*
S-1	SLO-1	*Major considerations, Design factors and limitations in machine design*	*Output Equation of DC machine*	*KVA output for single transformers*	*Output equation of three phase induction motor*	*Output equation of synchronous machine*
	SLO-2	*Limitations in machine design*	*Classification of magnetic materials*	*KVA output for three phase transformers*	*Main dimensions of induction motor*	*Main dimensions and pole constructions in synchronous machine*
S-2	SLO-1	*Electrical Engineering Materials introduction*	*Choice of Specific Electric Loading*	*Window space factor*	*Choice of Specific Electric Loading*	*Choice of Specific Electric and Magnetic Loading*
	SLO-2	*Electrical Engineering Materials classification*	*Choice of Specific Magnetic Loading*	*Core area factor*	*Choice of Specific Magnetic Loading*	*Influence of runaway speed*
S-3	SLO-1	*Magnetic Circuits Calculations*	*Problems with main dimensions*	*Design problems of core dimension for single phase transformer*	*Problems with main dimensions*	*Problems in main dimensions including runaway speed*
	SLO-2	*Problems under MMF Calculation*	*Problems with specific loading*	*Design problems of window dimension for single phase transformer*	*Problems with specific loading*	*Problems in main dimensions including pole constructions*
S-4	SLO-1	*Carter's Coefficient and net length of iron*	*Selection of number of poles*	*Design of core and winding*	*Influence of Length of air gap*	*Short Circuit Ratio (SCR) and Effect of SCR on machine performance*
	SLO-2	*Problems under net length of Iron*	*Design problems including pole design*	*Design problems in core and winding*	*Design problems including air gap length*	*Estimation of length of air gap*
S-5	SLO-1	*Real and Apparent flux densities*	*Armature Design procedure*	*Design of three phase transformer winding*	*Selecting rotor slots of squirrel cage machines*	*Problems in MMF*
	SLO-2	*Problems based on real and apparent flux densities*	*Problems in designing of armature*	*Problems on three phase transformer design*	*Design procedure of rotor bars, slots and end ring*	*Problems in SCR and air gap length*
S-6	SLO-1	*Temperature gradients in cores and conductors*	*Design of Commutator*	*Temperature rise in Transformers*	*Design procedure of slots*	*Armature design in synchronous machine*

	SLO-2	*Thermal resistivity of winding*	*Design of brushes*	*Transformer Tank design Procedure*	*Design procedure of end ring*	*Problems in armature design*
S-7	SLO-1	*Problems in temperature gradients*	*Problems in designing of commutator*	*Transformer Cooling tube design Procedure*	*Design problems in squirrel cage rotor*	*Procedure for Estimation of air gap length*
	SLO-2	*Problems in thermal resistivity*	*Problems in designing of brushes*	*Transformer Cooling tube design problems*	*Design procedure for wound rotor*	*Problems in air gap length*
S-8	SLO-1	*Indian Standard Specification for conductor, transformer*	*Computer Aided Design of DC machines – Main dimensions*	*Computer Aided Design of transformer-Core design*	*Computer Aided Design of three phase induction motor – Main dimension, stator design, squirrel cage rotor design*	*Overall design of stator*
	SLO-2	*International Electro- Technical commission Publications 34-1, 34-2*	*Computer Aided Design of DC machines –number of poles*	*Computer Aided Design of transformer-winding design*	*Computer Aided Design of three phase induction motor –squirrel cage rotor design*	*Overall design of rotor*
S-9	SLO-1	*Computer Aided Design introduction and uses*	*CAD – Armature design*	*CAD – Tank design*	*Design practices with software tools for stator design*	*CAD – Stator design*
	SLO-2	*Different approaches in Computer Aided Design*	*CAD – Field design*	*CAD – Cooling tube design*	*Design practices with software tools for rotor design*	*CAD – Rotor design*

Learning Resources	1. *Sawhney, A.K., A Course in Electrical Machine Design, Dhanpat Rai & Sons, New Delhi, 1984.* 2. *Deshpande, M. V.,Design and Testing of Electrical Machine Design, Wheeler Publications, 2010*	3. *Sen, S.K., Principles of Electrical Machine Designs with Computer Programmes, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, 1987.* 4. *https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-685-electric-machines-fall-2013/*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (50% weightage)*								*Final Examination (50% weightage)*	
		CLA – 1 (10%)		*CLA – 2 (15%)*		*CLA – 3 (15%)*		*CLA – 4 (10%)#*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

 # CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr. A.Kannan, Seshasayee paper and board limited akannan@sbppapers.com	*1. Dr.Chandramohan, CEG, Anna University. c_dramo@annauniv.edu*	*1. Dr. C. Subramani, SRMIST*
2. Mr.Muralikrishna, National Instruments, emkkrishnan@gmail.com	*2. Dr. A. Venkadesan, NIT Puducherry, venkadesan@nitpy.ac.in*	*2. Dr. Arun Noyal Doss, SRMIST*

Course Code	18EEE306T	Course Name	SPECIAL ELECTRICAL MACHINES	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Acquire knowledge on Stepper motor and its characteristics*			
CLR-2 :	*Understand the concepts of switched reluctance motor and its control.*			
CLR-3 :	*Gain knowledge on Permanent magnet DC and BLDC Motors*			
CLR-4 :	*Analyze the working principle , operation and control of permanent magnet synchronous motor*			
CLR-5 :	*Gain knowledge on the basics of various application based motors*			
CLR-6 :	*Understand the overall concepts of various special electrical machines*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Analyze the working and control of Stepper moor*	*3*	*75*	*75*
CLO-2 :	*Illustrate the operation and characteristics of SRM*	*2*	*75*	*75*
CLO-3 :	*Interpret knowledge on PMDC and BLDC motors for real time applications.*	*2*	*75*	*75*
CLO-4 :	*Evaluate the performance of PMSM*	*3*	*75*	*75*
CLO-5 :	*Understand the characteristics of application based motors*	*2*	*75*	*75*
CLO-6 :	*Summarize the characteristics of various special electrical machines.*	*2*	*75*	*75*

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
H	*M*	-	-	-	-	-	-	-	-	-	-	*H*	*H*	-
H	-	-	-	-	-	-	-	-	-	-	-	*L*	*L*	-
H	-	-	-	-	-	-	-	-	-	-	-	*L*	*L*	-
H	*M*	-	-	*M*	-	-	-	-	-	-	-	*H*	*H*	-
H	-	-	-	-	-	-	-	-	-	-	-	*L*	*L*	-
H	*M*	-	-	*M*	-	-	-	-	-	-	-	*M*	*M*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Stepper motor*	*Introduction to Switched reluctance motor.*	*Construction of PMDC motor*	*Construction, and types of PMSM*	*Construction of repulsion motors*
	SLO-2	*Variable reluctance motor-Construction-Single Stack*	*Elementary operation of SRM*	*Principle of Working PMDC motor*	*Operation of PMSM*	*Working and types of repulsion motors*
S-2	SLO-1	*Single Stack-Modes of Excitation-single phase*	*Machine topology*	*Moving Coil motors*	*EMF equation of PMSM*	*Torque equation of repulsion motor*
	SLO-2	*Half Step On mode*	*Operation of Linear SRM*	*Printed coil motors*	*Torque equation of PMSM*	*Phasor diagram of repulsion motor*
S-3	SLO-1	*Multi Stack Motor-Construction*	*Non Linear Analysis of SRM*	*Shell type motor*	*Voltage equation of PMSM*	*Characteristics of repulsion motor*
	SLO-2	*Modes of Excitation*	*Torque Production -SRM*	*BRUSHLESS –Classification of BLDC motor*	*Phasor diagram*	*Applications of repulsion motor*
S-4	SLO-1	*Hybrid stepper Motor-construction-working*	*Voltage and torque equation of SRM*	*Construction and operation of BLDC MOTOR*	*Performance Characteristics Characteristics of PMSM*	*Universal motor-construction and operation*
	SLO-2	*Types of Stepper motors-single phase stepper motor-Disc magnet type-Claw tooth stepper motor*	*Converter Circuit For SRM With Bifilar Winding*	*Equivalent Circuit And Torque Equation*	*Control of PMSM-Vector control*	*Speed control of universal motor*
S-5	SLO-1	*Torque Equation Of stepper Motor*	*Split Link Circuit -SRM*	*Performance Characteristics of BLDC motor*	*Self control of PMSM*	*Linear induction motor – construction*
	SLO-2	*Windings in stepper motor-Unipolar and Bipolar winding*	*C- Dump Circuit-SRM*	*BRUSHLESS –Classification of BLDC motor*	*Microprocessor based control of PMSM*	*Equivalent Circuit of LIM*
S-6	SLO-1	*Static Characteristics of stepper Motor*	*Converter topology - N + 1, (N +1) diodes*	*Construction and operation of BLDC MOTOR*	*Sensorless control of PMSM*	*Characteristics of LIM*

	SLO-2	*Dynamic Characteristics of stepper Motor*	*Control Of SRM -Rotor Position Sensor- Optical Position*	*Electronic commutation -180˚ with magnetic arc and 120˚ with square wave phase currents -star connection*	*POWER controllers - PMSM*	*Control of Linear Induction Motor*
S-7	SLO-1	*Open loop Control of Stepper motors*	*Hall Effect Sensing*	*Electronic commutation -180˚ with square wave phase currents and 120˚ with magnetic arc -Delta connection*	*Operation of PMSM using DC-AC Converter with 120° Mode*	*Linear Reluctance motor- Construction*
	SLO-2	*Closed loop Control of Stepper motors*	*Current Regulators-Hysteresis*	*Control of BLDC motor*	*Operation of PMSM using DC-AC Converter with 180° Mode*	*Linear Reluctance motor – working Principle*
S-8	SLO-1	*Microprocessor –based control of stepper motor*	*Voltage –PWM type regulators*	*Microprocessor based control of BLDC motor*	*Modelling of PMSM Using simulaton tool*	*Linear Reluctance motor Applications*
	SLO-2	*Problem Solving- torque- stepper motor*	*Microprocessor Based Control Of SRM*	*Comparison-Conventional and BLDC*	*Problem Solving - torque-PMSM*	*Ac Servo motors*
S-9	SLO-1	*Problem Solving- step angle-stepper motor*	*Advantages of SRM over other machines*	*Sensor -less Control of BLDC Motors*	*Problem Solving - speed- PMSM*	*Construction and Working*
	SLO-2	*Applications of Stepper Motors*	*Applications of SRM motors*	*Applications of BLDC Motors*	*Applications of PMSM*	*Torque speed characteristics of servomotor*

Learning Resources	1. *T.J.E. Miller, Permanent Magnet and Reluctance Motor Drives, Clarendon Press, Oxford.* 2. *T. Kenjo, Stepping Motors and Their Microprocessor Controls, Clarendon Press London, 2000.* 3. *R.Krishnan, Switched Reluctance Motor Drives – Modeling, Simulation, Analysis, Design and Application, CRC Press, New York, 2005.*	4. *P.P. Acarnley, Stepping Motors – A Guide to Motor Theory and Practice', Peter Perengrinus London, 4th edition 2001.* 5. *D.P.Kothari and I.J.Nagrath, Electric machines, Tata Mc Graw hill publishing company, New Delhi, Third Edition, 2004.* 6. *https://www.coursera.org/learn/motors-circuits-design*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. M.Jayakumar,Danfoss, Industries Pvt Ltd.,Jaya.kumar@danfoss.com	*1. Dr Bindu G R, Government College of Engineering, Kerala, bgr100@gmail.com*	*1. Ms. S.Vijayalakshmi, SRMIST*
2. Mr. A.Kannan, Seshasayee paper and board limited akannan@sbppapers.com	*2. Dr.Booma.N,Jerusalem College of Engineering, Chennai, booma_nagarajan@yahoo.com*	*2. Dr.ArunNoyal Doss, SRMIST*

Course Code	18EEE401T	Course Name	SOLID STATE DRIVES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18EEC302J	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 basics of electric drives*
CLR-2 :	*Explain the working of converter/ chopper fed DC drives*
CLR-3 :	*Design controllers for closed loop operation of DC motor drive*
CLR-4 :	*Acquire knowledge on operation and performance of induction motor drives*
CLR-5 :	*Enumerate the different control strategies of synchronous motor drive*
CLR-6 :	*Expose the students to various power converters associated with DC and AC drives*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Enrich the basics of electric drives, multi-quadrant operation*	*2*	*75*	*75*	*H*	*M*	*M*	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-2 :	*Study and analyze the operation of four quadrant chopper / rectifier and solve simple problems*	*3*	*75*	*75*	*H*	*M*	*M*	*M*	*M*	-	-	-	-	-	-	-	*M*	*M*	-
CLO-3 :	*Model closed loop DC motor drive and design the current and speed controllers*	*3*	*75*	*75*	*H*	*M*	*M*	*M*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-4 :	*Analyze the power electronic converter used for the speed control of induction motor drives*	*3*	*75*	*75*	*H*	*M*	*M*	*M*	*M*	-	-	-	-	-	-	-	*M*	*M*	-
CLO-5 :	*Analyze the various control schemes for the speed control of synchronous motor drives*	*3*	*75*	*75*	*H*	*M*	*M*	*M*	*M*	-	-	-	-	-	-	-	*M*	*M*	-
CLO-6 :	*Analyse the operation of DC and AC drives*	*3*	*75*	*75*	*H*	*M*	*M*	*M*	*M*	-	-	-	-	-	-	-	*M*	*M*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*ElectricDrives: Classification, advantages*	*Review of emf, torque and speed equations*	*Closed loop control of DC drive*	*Review of induction motor torque-speed characteristic*	*Review of synchronous motor torque-speed characteristic*
	SLO-2	*Components of electric drive*	*Review of torque-speed characteristics of DC machine*	*Separately excited DC motor transfer function*	*Equivalent circuit of Induction motor*	*Control of synchronous motor*
S-2	SLO-1	*Thermal loading*	*Conventional speed control techniques*	*Modelling closed loop speed control of DC drive using armature voltage control*	*Conventional speed control techniques-Stator side control*	*Separate control of Synchronous motor*
	SLO-2	*Thermal model of motor for heating and cooling*	*Armature and field side control*	*Block diagram of closed loop speed control of DC drive*	*Rotor side control*	*Self-control of synchronous motor*
S-3	SLO-1	*Classesofdutycycle*	*DC chopper control strategy*	*Modelling closed loop speed control with inner current controller(P)*	*Inverter control techniques: three-phase PWM generation*	*V/f control of synchronous motor*
	SLO-2	*Determinationofmotor rating – Continuous and intermittent duty*	*Constant and variable frequency control strategies*	*Block diagram of closed loop speed control with inner current controller(P)*	*Sinusoidal modulation*	*VSI fed synchronous motor drive*
S-4	SLO-1	*Simple problems on power rating estimation with Continuous and intermittent duty*	*Chopper fed dc motor for speed control-One,two quadrant operation*	*Modelling closed loop speed control with inner current controller(PI)*	*Introduction to vector control*	*Definition of marginal angle*
	SLO-2	*Determinationofmotor rating – short time duty*	*Chopper fed dc motor for speed control-four quadrant operation*	*Block diagram of closed loop speed control with inner current controller(PI)*	*Vector control of Induction motor drives*	*Marginal angle control*
S-5	SLO-1	*Determinationofmotor rating – intermittent periodic duty*	*Harmonics and ripple in motor current*	*Modelling closed loop speed control of DC drive with load torque disturbance*	*Conventional space vector modulation.*	*Power factor control*
	SLO-2	*Frequen2cy of operation subjected to intermittent loads*	*Effect on motor performance*	*Block diagram of closed loop speed control of DC drive with load torque*	*SVPWM for three phase VSI*	*Block diagram for power factor control*

				disturbance		
S-6	SLO-1	*Equations governing motor load dynamics*	*Single phase full converter fed separately excited DC motor*	*Modelling DC series motor*	*Introduction to FPGA*	*Recap of single and three phase cycloconverters*
	SLO-2	*Steady state stability at various operating points on Speed –Torque curve*	*Steady state analysis of the drive–continuous conduction*	*Block diagram of DC series motor*	*PWM pulse generation using FPGA*	*Cycloconverter fed synchronous motor*
S-7	SLO-1	*Multi-quadrant Operation*	*Single phase full converter fed separately excited DC motor*	*System response with filters*	*Squirrel cage induction motor: constant V/f control of induction motor*	*Comparison of VSI and CSI fed drives*
	SLO-2	*Real time example for four quadrant operation*	*Steady state analysis of the drive–discontinuous conduction*	*Phase locked loop control*	*Steady-state performance analysis based on equivalent circuit.*	*CSIfed synchronous motor*
S-8	SLO-1	*Components of Load Torques*	*Three phase full converter fed separately excited DC motor drive*	*Design of speed controller*	*Impact of rotor resistance on speed torque characteristics – rotor resistance control*	*Permanent magnet synchronous motor*
	SLO-2	*Nature and Classification of Load Torques*	*Steady state analysis of the drive - continuous conduction.*	*Simple problems*	*Derivation for equivalent resistance*	*Closed loop control of PMSM*
S-9	SLO-1	*Need for closed loop control*	*Introduction to software simulation of DC drives.*	*Design of current controller*	*Slip power*	*Simulation of induction motor characteristics*
	SLO-2	*Closed loop speed control of drives*	*Chopper based simulation*	*Simple problems*	*Slip power recovery schemes - Kramer's drive,Scherbius drive*	*Introduction to software simulation of AC drives.*

Learning Resources	1. *G.K. Dubey, Fundamentals of Electrical Drives, CRC Press,2nd edition, 2015* 2. *Ion Boldea, S.ANasar, Electric Drives, Third edition, CRC Press 2016.* 3. *R. Krishnan, Electric Motor Drives: Modeling, Analysis and Control, Prentice Hall,2001* 4. *S.K.Pillai, Analysis Of Thyristor Power-Conditioned Motors, Universities press,2005*	5. *G.K. Dubey, Power Semiconductor Controlled Drives, Prentice Hall, 1989.* 6. *W. Leonhard, Control of Electric Drives, Springer Science & Business Media, 2001.* 7. *P.C.Sen,Thyristor DC Drives,A Wiley-Interscience Publication* 8. *https://nptel.ac.in/courses/108104011/*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.S.Paramasivam, Danfoss, Industries Pvt Ltd.,paramsathya@yahoo.com	*1. Dr.R.Subha,, Sir MVIT, Bangalore, subha.mvit@gmail.com*	*1. Ms.D.Anitha, SRMIST*
2. Mr. A.Kannan, Seshasayee paper and board limited akannan@sbppapers.com (machines)	*2. Dr. A. Venkadesan, NIT Puducherry, venkadesan@nitpy.ac.in*	*2. Dr.K.Mohanraj, SRMIST*

Course Code	18EEE402T	Course Name	MODELLING AND ANALYSIS OF ELECTRICAL MACHINES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18EEC204J, 18EEC205J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical & Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Illustrate the reference frame theory*	1	2	3
CLR-2 :	*Formulate the concept of modelling of DC machines*			
CLR-3 :	*Understand the theoretical model of synchronous machine*			
CLR-4 :	*Derive the mathematical model of poly phase induction machines*			
CLR-5 :	*Explain the generalized theory model of a single phase induction machine*			
CLR-6 :	*Derive the mathematical model of DC and AC machines*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Program Learning Outcomes (PLO) 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Outline the basics of rotating reference frame- synchronously and arbitrarily rotating reference frame transformation*	1	75	75	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Interpret the modelling of DC machines for dynamic and steady state operation*	2	75	75	H	H	H	M	M	-	-	-	-	-	-	-	M	H	-
CLO-3 :	*Construct the mathematical modelling of three phase synchronous machine*	3	75	75	H	H	H	M	H	-	-	-	-	-	-	-	M	H	-
CLO-4 :	*Inspect the mathematical model of poly phase induction machine for electrical simulation studies*	3	75	75	H	H	H	M	H	-	-	-	-	-	-	-	M	H	-
CLO-5 :	*Apply the generalized theory concept for the modelling of single phase induction machine*	3	75	75	H	H	H	M	H	-	-	-	-	-	-	-	M	H	-
CLO-6 :	*Develop a mathematical model of different types of DC and AC machines*	3	75	75	H	H	H	M	H	-	-	-	-	-	-	-	M	H	-

Duration (hour)		s	9	9	9	9
S-1	SLO-1	*Theory of transformation*	*Introduction to DC machine*	*Introduction to Three phase synchronous machine*	*Three phase induction machine- Types*	*Development of generalized theory*
	SLO-2	*Different reference frames*	*Back EMF equation*	*RMF, MMF waveform*	*MMF waveform*	*The general machine representation*
S-2	SLO-1	*Various sign conventions*	*Speed, torque equations*	*Winding model*	*Equivalent circuit*	*Sign Conventions*
	SLO-2	*Reference frame transformations*	*Terminal voltage equations*	*Modelling assumptions*	*Winding model*	*Voltage equations of a general machine*
S-3	SLO-1	*Illustration of how a transformation can result in constant inductances*	*DC machine types*	*Sign convention*	*Modelling assumptions*	*Flux linkage equations of a general machine*
	SLO-2	*Concept of stationary reference frame*	*Separately excited, self-excited-Equivalent circuits*	*Stator voltage equations in abc coordinates*	*Sign convention*	*Torque equation of a general machine*
S-4	SLO-1	*Illustration of transformation of stationary circuit variables*	*Speed - torque characteristics*	*Rotor voltage equations in abc coordinates*	*Stator voltage equations in abc coordinates*	*Illustration of application of generalized theory-DC machine model*
	SLO-2	*Concept of synchronously rotating reference frame*	*Electromechanical model of DC machine*	*Stator flux linkage equations in abc coordinates*	*Rotor voltage equations in abc coordinates, Induction machine: torque equations in abc*	*DC machine model-voltage and flux linkage equations*
S-5	SLO-1	*Concept of arbitrarily rotating reference frame*	*State equations of armature current and speed of DC motor*	*Rotor flux linkage equations in abc coordinates*	*Stator flux linkage equations in abc coordinates*	*DC machine model-Torque equation*
	SLO-2	*Transformation: stationary circuit variables to arbitrary reference frame*	*State-space model of DC machines*	*Stator self-inductance calculation*	*Rotor flux linkage equations in abc coordinates*	*Existing theories for explanation of single phase Induction motor operation, revolving field theory*
S-6	SLO-1	*Illustration of transformation of stationary*	*Transfer function model of DC machines*	*Stator to rotor Mutual-inductance*	*Stator self-inductance calculation*	*MMF and Flux waves, Torque*

		circuit variables-Resistive elements		*calculation*		*components*
	SLO-2	*Illustration of transformation of stationary circuit variables-Inductive elements*	*Steady state response of DC machines*	*Rotor to Stator Mutual-inductance calculation*	*Stator to rotor and Rotor to Stator, Mutual-inductance calculation*	*Application of generalized theory to single-phase induction motor*
S-7	SLO-1	*Illustration of transformation of stationary circuit variables-Capacitive elements*	*Dynamic characteristics of DC machines*	*Rotor self –inductance calculation*	*Rotor self –inductance calculation*	*Voltage equations of single-phase induction machine*
	SLO-2	*Transformations between reference frames x and y*	*The effect on speed for simultaneous change in input voltage and load torque of DC machine*	*Park's transformation*	*Reference frame transformation*	*Flux linkage equations single-phase induction motor*
S-8	SLO-1	*Transformation of a balanced set to an arbitrarily rotating reference frame (ARF)*	*Calculation of efficiency and starting torque of DC separately excited machine.*	*Voltage equations in dqo reference frame (Park's equations)*	*Voltage equations in arbitrary reference frame*	*Torque equation of single-phase induction motor*
	SLO-2	*Numerical example of transformation to arbitrary reference frame*	*Calculation of speed of DC machine from steady state equations*	*Flux linkage equations in (dqo) rotor reference frame*	*Flux linkage equations arbitrary reference frame,*	*Equivalent circuit of single phase induction machine*
S-9	SLO-1	*Transformation to a synchronously rotating reference frame (SRF), Balanced steady-state phasor relationships*	*Calculation of armature torque and load torque of DC separately excited machine*	*Synchronous machine torque equations in abc and dq variables , Steady state equations in dq variables*	*Induction machine: torque equations in reference frame variable, Steady state equations in dq variables*	*Numerical example to illustrate steady-state computation of single phase induction machine*
	SLO-2	*Summary – various reference frames*	*Computer simulation of DC machine dynamics using transfer function*	*Steady State analysis of Synchronous machine using simulation software*	*Computer simulation of induction motor dynamics in arbitrary reference frame*	*Validation of single phase induction machine model using simulation software*

Learning Resources	1. *Paul C. Krause, Oleg Wasyzczuk, Scott D. Sudhoff, Analysis of Electric Machinery and Drive Systems, IEEE Press, Third Edition, 2013.* 2. *R. Ramanujam, Modeling & Analysis of electrical machines."Ik International Publishing House, New Delhi, 2018.* 3. *P. S. Bimbhra, Generalized theory of Electrical Machines, Khanna Publishers, Sixth Edition, 1995.*	4. *R. Krishnan, Electric Motor Drives: Modelling, Analysis and Control, Prentice Hall of India, 2002.* 5. *Ned Mohan. Advanced electric drives: analysis, control, and modeling using MATLAB/Simulink, John wiley & sons; 2014.* 6. *Bernard Adkins, The General Theory of Electrical Machines, Imperial College of Science and Technology, 1974.* 7. *https://nptel.ac.in/courses/108106023/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Sharon Ravichandran, ABB Ltd., Chennai, sharonravi87@gmail.com	*1. Prof. K.Shanthi Swarup, IITM, Chennai, ksswarup@iitm.ac.in*	*1. Mr. D. Maharajan, SRMIST*
2. Dr.V.P.Boopathi, Powersys., Chennai, Boopathivp@gmail.com	*2. Prof. R.P.Kumudini Devi, Anna University, kumudini@annauniv.ac.in*	*2. Dr. M. Arun Noyal Doss. SRMIST*

Course Code	18EEE403T	Course Name	HYBRID ELECTRIC VEHICLES	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 & Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Classify the various types of EVs and the power flow involved*
CLR-2 :	*Explain and analyze the storage and battery technologies in EVs*
CLR-3 :	*Discuss and design the various power electronic (PE) topologies involved in EVs*
CLR-4 :	*Analyze the machines and its drives for the propulsion of EVs*
CLR-5 :	*Explain the emerging technologies in EVs*
CLR-6 :	*Create an EV with new and advanced PE topologies and storage systems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Infer knowledge about the basics of power flow in electric vehicles*	*2*	*75*	*75*
CLO-2 :	*Understand and model a battery energy storage system for EV*	*2*	*75*	*75*
CLO-3 :	*Acquire knowledge and develop the various PE converters involved in EV*	*3*	*75*	*75*
CLO-4 :	*Analyze the various machines and drives involved in EVs*	*3*	*75*	*75*
CLO-5 :	*Design and describe the future enhancement in EVs*	*3*	*75*	*75*
CLO-6 :	*Develop an EV with batteries, new PE topologies and drives*	*3*	*75*	*75*

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
H	*L*	*L*	-	-	-	-	-	-	-	-	-	-	*H*	-
H	*L*	*M*	*M*	*M*	-	-	-	-	-	-	-	*M*	*H*	*L*
H	*M*	*M*	*M*	*M*	-	-	-	*L*	-	-	-	*M*	*H*	-
H	*M*	*L*	*L*	*M*	-	-	-	*M*	-	-	-	*M*	*H*	-
H	*M*	*M*	*M*	*M*	*L*	*L*	-	*M*	-	-	-	*H*	*H*	*L*
H	*M*	*M*	*M*	*M*	*L*	*L*	-	*M*	-	-	-	*H*	*H*	*L*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Electric Vehicles*	*Introduction to Energy Storage system*	*Introduction to charging and requirements of a charging system*	*Introduction to starting system*	*Introduction to the emerging trends in EVs*
	SLO-2	*History of electric vehicles and hybrid electric vehicles*	*Battery Requirements for HEVs, PHEVs, and EVs.*	*Principles of charging system*	*Requirements of a starting system*	*Electric Vehicle Supply Equipments*
S-2	SLO-1	*Social and environmental importance of hybrid and electric vehicles*	*Types of batteries*	*Alternators and charging circuits*	*Principles of starting system*	*Smart vehicles in smart grid*
	SLO-2	*Key challenges of hybrid and electric vehicles*	*Battery characterization*	*Diagnosing charging system faults*	*Various drive system for the transmission of EV*	*Smart vehicles in smart grid*
S-3	SLO-1	*Basics of EV*	*Working principle and construction of lead-acid battery*	*Rectifiers/Inverters for HEV*	*DC/DC chopper based two, four quadrant operations of DC drives - Configuration*	*Vehicle-to-grid technologies*
	SLO-2	*Basics of HEV, PHEV*	*Working principle and construction of nickel cadmium battery*	*Battery chargers: High frequency transformer based bidirectional DC-DC converter*	*DC/DC chopper based two, four quadrant operations of DC drives - Control*	*Vehicle-to-grid technologies*
S-4	SLO-1	*Concept of EV*	*Working principle and construction of nickel metal hydride battery*	*Isolated bidirectional DC-DC converter*	*Inverter based V/f Operation (motoring and braking) of induction motor drive system - Configuration*	*Vehicle-to-grid technologies: Unidirectional*
	SLO-2	*Configurations of EV*	*Working principle and construction of lithium ion battery*	*Half bridge DC-DC converter*	*Inverter based V/f Operation (motoring and braking) of induction motor drive system - Control*	*Vehicle-to-grid technologies: Bidirectional*
S-5	SLO-1	*Concept of Series HEV*	*Diagnosing battery faults.*	*Full bridge DC-DC converter*	*Permanent magnet motor based vector control operation – Configuration*	*Charging Station Selection (CSS) server*

	SLO-2	*Configurations of Series HEV*	*Basic battery modeling: Static and dynamic electric circuit model*	*Four quadrant operation of DC-DC converter*	*Permanent magnet motor based vector control operation –Control*	*Need of Charging Station Selection (CSS) server*
S-6	SLO-1	*Concept of Parallel HEV*	*Battery charging control*	*Flyback converter*	*SRM drives – Configuration*	*Smart grid technologies*
	SLO-2	*Configurations of Parallel HEV (Mechanical Coupling)*	*Battery charging control*	*Cell balancing converters: Active and Passive balancing methods*	*SRM drives –Converter and modes of operation*	*Smart grid technologies: Applications and Benefits*
S-7	SLO-1	*Configurations of Parallel HEV (Torque Coupling)*	*Ultra-capacitor: Symmetrical and asymmetrical – Introduction and Operation*	*Wireless Charging –Inductive Charging*	*Types of starters for motors in EV*	*Smart meter*
	SLO-2	*Configurations of Parallel HEV (Speed Coupling)*	*Ultra-capacitor modeling*	*Wireless Charging –Conductive Charging*	*Diagnosing starter faults*	*Smart meter: Purpose and benefits*
S-8	SLO-1	*Power train components*	*Operation of flywheel and fuel cell*	*Advanced charging system technology*	*Advanced starting system technology*	*Smart charger*
	SLO-2	*Vehicle model*	*Operation of hydraulic energy storage system*	*New developments in charging systems*	*New developments in starting systems*	*Smart charger: Purpose and benefits*
S-9	SLO-1	*EV power train component sizing*	*Simulation of battery model*	*Simulation of any PE converter for EV*	*Simulation and implementation of PE converter fed drives for EVs*	*Technical talk on any new emerging trend in EVs*
	SLO-2	*EV power train component sizing*	*Simulation of ultra-capacitor model*	*Simulation of any PE converter for EV*	*Simulation and implementation of PE converter fed drives for EVs*	*Technical talk on any new emerging trend in EVs*

Learning Resources	1. *M. Ehsani, Y. GAO, and A. Emadi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design, Second Edition, CRC Press, ISBN: 978-1-4200-5398-2, Aug. 2009.* 2. *IqbalHussain, Electric & Hybrid Vehicles – Design Fundamentals, Second Edition, CRC Press, 2011.* 3. *Sheldon S. Williamson, Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles, Springer, 2013.*	4. *Chris Mi, M. AbulMasrur, David WenzhongGao, Hybrid Electric Vehicles Principles and Applications with Practical Perspectives, Wiley Publication, 2011.* 5. *Tom Denton, Automobile Electrical and Electronic Systems, Elsevier, Butterworth – Heinemann, Third Edition, 2004* 6. *https://nptel.ac.in/courses/108103009/*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. S.Archana, Valeo Pvt Ltd, archana.arc19@gmail.com	*1. Dr.G.Uma, CEG, uma@annauniv.edu*	*1.Dr. U. Sowmmiya, SRMIST*
2. Mr. Kopaka Chaitanya, Valeo Pvt Ltd, chaithu.239@gmail.com	*2.Dr.S.Hosimin Thilagar, CEG, shthilagar@gmail.com*	*2.Dr. A.Rathinam, SRMIST*

Course Code	18EEE307T	Course Name	SOLAR PHOTOVOLTAIC SYSTEM	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Learn the fundamental principle and fabrication of PV cell*			
CLR-2 :	*Study about PV characteristics and MPPT algorithms*			
CLR-3 :	*Utilize the various components and installation of standalone PV system*			
CLR-4 :	*Study about the PV integration with utility grid*			
CLR-5 :	*Know net metering and applications of Photovoltaic systems*			
CLR-6 :	*Model a solar photovoltaic system*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)													
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Understand the basics of PV energy conversion and cell fabrication*	*2*	*80*	*75*	*H*	*M*	*M*	*-*	*-*	*-*	*M*	*-*	*-*	*-*	*-*	*-*	*H*	*M*	*-*
CLO-2 :	*Acquire knowledge about PV module and MPPT techniques*	*3*	*80*	*75*	*H*	*M*	*M*	*-*	*M*	*-*	*M*	*-*	*-*	*-*	*-*	*-*	*M*	*M*	*-*
CLO-3 :	*Design stand-alone PV system*	*3*	*80*	*75*	*H*	*M*	*M*	*M*	*-*	*-*	*H*	*H*	*M*	*M*	*-*	*-*	*H*	*M*	*M*
CLO-4 :	*Analyze grid connected PV system*	*3*	*80*	*75*	*H*	*M*	*M*	*M*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*H*	*H*	*-*
CLO-5 :	*Develop a PV system for various applications*	*3*	*80*	*75*	*H*	*M*	*M*	*M*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*H*	*M*	*-*
CLO-6 :	*Design a photovoltaic on grid and off grid system*	*3*	*80*	*75*	*H*	*M*	*M*	*M*	*M*	*-*	*M*	*H*	*M*	*M*	*-*	*-*	*H*	*M*	*M*

Duration (hour)		*9*	*9*	*9*	*9*	*9*
S-1	SLO-1	*Global energy scenario*	*I-V,PV characteristics of a PV*	*Classification of PV systems*	*Grid Interactive PV System.*	*Need for Metering, Types of metering*
	SLO-2	*Indian energy scenario*	*Modelling of PV*	*Central Power Station System , Distributed PV System*	*Principle components in Grid –PV system*	*Concepts in Grid Tie systems*
S-2	SLO-1	*Historical development of PV*	*Short Circuit, Open Circuit and peak power parameters*	*Stand alone PV System*	*Classification of Grid Tie Inverters*	*Net metering and its importance*
	SLO-2	*Photovoltaic cell technologies*	*Datasheet study, Cell efficiency*	*Components of standalone PV connected system*	*Working Central inverter, String Inverter, Micro Inverter.*	*Net metering benefits, policies*
S-3	SLO-1	*Basics of energy from sun: Insolation, irradiance, Solar constant*	*Effect of irradiation and temperature*	*Charge controllers*	*Grid-connected single phase PV inverter schemes*	*PV potential and facilities in rural areas*
	SLO-2	*Insolation variation with time of day, Earth centric viewpoint and declination*	*Shading impacts ,Fill factor*	*Batteries*	*Grid-connected PV control*	*Electrifying rural and remote areas using PV*
S-4	SLO-1	*Solar geometry*	*Solar PV Module and its parameters*	*Inverter control topologies*	*Power processing schemes based on single string, multi-string*	*Introduction to hybrid PV system*
	SLO-2	*Description of the solar spectrum*	*Specifications of Solar PV Module*	*Stand-alone connection of PV modules to a battery and load*	*AC module technologies*	*Smart grid*
S-5	SLO-1	*Sun position, sun path diagrams, solar and clock times*	*Parallel and series connections. Identical cells Non-identical cells connection*	*Energy storage alternatives for PV systems.*	*Sizing the inverter*	*Case studies on Solar PV Power Plant*
	SLO-2	*Solar radiation measurements, resource of solar data.*	*Protecting cells in series and parallel, Interconnecting modules*	*Storage batteries, lead-acid, nickel-cadmium, nickel-metal-hydride and lithium type batteries.*	*PV system sizing, efficiency*	*Survey on existing solar PV system*
S-6	SLO-1	*Photovoltaic effect - Principle of direct*	*Estimation and Measurement of PV*	*Small storage systems employing ultra*	*Transformer less inverter topologies for*	*Design and Development of PV vehicle*

		solar energy conversion into electricity in a solar cell system.	*Module Power*	*capacitors, charging and discharging properties*	*grid connected PV applications*	*charging system*
	SLO-2	*Semiconductor properties semiconductor physics*	*Selection of PV Module, Interfacing PV modules to loads*	*Modeling of batteries load estimation, battery sizing*	*Centralized grid-connected three-phase inverters for large PV installations*	*PV powered lighting, Solar Lantern, LED for building etc*
S-7	SLO-1	*Solar cell - p-n Junction, Solar cell- basic structure*	*PV cell simulation*	*Design and Installation of a standalone PV system*	*Design related issues; grounding, dc arcing, islanding*	*PV water pumping, DC and AC pump drive*
	SLO-2	*Solar cell materials ,its properties and construction*	*Simulation of PV cells in series and parallel.*	*Mechanical Considerations for PV installation*	*Harmonic content, reactive power, wiring issues,electro-magnetic interference*	*PV applications in aircraft, power satellites.*
S-8	SLO-1	*Types of solar cells :crystalline, multi-crystalline, thin film silicon solar cells, etc*	*Maximum power point concept*	*Trouble shooting of Standalone Solar PV System*	*Interfacing with the power grid economic considerations*	*Socio-economic and environmental impacts of PV system*
	SLO-2	*Commercial Si solar cells, recent development in materials used for solar cell*	*Power conditioning and maximum power point tracking*	*Maintenance of Solar PV System*	*Energy yield of grid connected PV installation- Cost and Investment*	*PV in portable devices*
S-9	SLO-1	*Solar cells fabrication*	*MPPT basic Algorithms overview*	*Safety in installation of Solar PV System*	*Modeling of stand-alone and grid-connected PV systems*	*Impact of high PV penetration in power system*
	SLO-2	*Process involved solar cell fabrication technologies*	*MPPT algorithms based on buck- and boost-converter topologies*	*Codes and standards Related to PV Systems: National Electric Code(NEC) and IEEE Standard 1547*	*Simulation of stand-alone and grid-connected PV systems*	*Markets for photovoltaic systems*

Learning Resources	1. *Chetan Singh Solanki., Solar Photovoltaic: Fundamentals, Technologies and Application, PHI Learning Pvt., Ltd., 2nd edition 2011.* 2. *Rai, G.D., Solar Energy Utilization, Khanna Publishers, N. Delhi, 2010.*	3. *R. Messenger, J. Ventre, Photovoltaic Systems Engineering, CRC Press 3rd edition, 2010.* 4. *Sukhatme S.P., Solar Energy, Tata McGraw Hills P Co., 3rd Edition, 2008.* 5. *https://nptel.ac.in/courses/117108141/*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Dr.P.Kanagavel,NIWE,Chennai,pkanagavel.niwe@nic.in*	1. *P.Thamizhazhagan,University college of Engineering, Panruti,thamizhme@gmail.com*	1. *Ms A.Lavanya, SRMIST*
2. *Mr.Jason Manoraj , L&T Technology Services Limited,Bengaluru, Karnataka,jasonmanoraj@gmail.com*	2. *Dr. Subhransu Sekhar Dash, Government College of Engineering, Keonjhar, Subhransudash_fee@gcekjr.ac.in*	2. *Dr.R.Sridhar, SRMIST*

Course Code	18EEE308T	Course Name	ENERGY MANAGEMENT SYSTEM AND SCADA	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Impart knowledge on energy management and its planning*			
CLR-2 :	*Understand the efficient usage of electric energy for motor driven system*			
CLR-3 :	*Identify the strategies and control of energy management systems*			
CLR-4 :	*Expose to the concept of supervisory control and data acquisition*			
CLR-5 :	*Familiarize about Power System Automation and application of SCADA in power systems.*			
CLR-6 :	*Understand the concept of Energy management and SCADA*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Understand the values, importance, principles and effective utilization of energy*	*2*	*75*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-2 :	*Apply energy efficient schemes for motor under varying loads*	*2*	*75*	*75*	*H*	*M*	-	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-3 :	*Implement the energy management control strategies*	*2*	*75*	*75*	*H*	*M*	-	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-4 :	*Analyze the Functions and features of SCADA*	*3*	*75*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-5 :	*Infer the Applications and Standards of SCADA*	*2*	*75*	*75*	*H*	-	-	-	-	-	-	*L*	-	-	-	-	*M*	*M*	*L*
CLO-6 :	*Apply the knowledge of Energy management and SCADA in Industries*	*2*	*75*	*75*	*H*	*M*	-	-	-	-	-	*L*	-	-	-	-	*M*	*M*	*L*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Value of Energy Management*	*Power supply of an electrical motor driven system*	*Introduction to Energy management systems(EMS)*	*Introduction of SCADA*	*Introduction to Power System Automation*
	SLO-2	*Total Quality Management*	*Effects of Unbalanced Voltages on The Performance of Poly-phase Squirrel-Cage Induction Motors*	*Usage of EMS*	*SCADA Systems*	*Benefits of Power System Automation*
S-2	SLO-1	*Energy Management Profession*	*Glossary of frequently occurring motor terms*	*Direct Digital Control*	*Evolution of SCADA*	*Functional structure of Power System Automation*
	SLO-2	*Energy Management skills*	*Design , Load types and torque of motor*	*Objectives of an EMCS using DDC*	*Objectives of SCADA*	*Architecture For Power System Automation*
S-3	SLO-1	*Principles of Energy Management*	*Power factor of motor*	*Hardware used in Energy management systems*	*Benefits of SCADA*	*Classification of Power System Automation- Substation Automation*
	SLO-2	*Some Suggested Principles of Energy Management*	*Benefits and correction of power factor*	*Advantages of Hardware used in Energy management systems*	*SCADA in Process Control*	*Classification of Power System Automation- Distribution Automation*
S-4	SLO-1	*Introduction to Energy Management Program*	*Electric motor design to operate at varying load conditions*	*Software used in Energy management systems*	*Usage of SCADA*	*Implementation Of Power System Automation Using SCADA*
	SLO-2	*Components of Comprehensive Energy Management Program*	*Determining Electric Motor Operating Loads*	*Effectiveness of the Software Control Logic*	*Real-Time Monitoring and Control using SCADA*	*Implementation Of Power System Protection Using SCADA*
S-5	SLO-1	*Organizational Structure*	*Power meter to measure unit operation*	*Control Strategies*	*Functions of SCADA*	*SCADA Based Model for Automation*
	SLO-2	*Energy manager , Team and Employees*	*Selection of Equipment for Power Measurement and Surveys*	*Routines of Control Strategies*	*SCADA Applications*	*SCADA Based Model Digital Protection*
S-6	SLO-1	*Energy Policy Objectives and*	*Slip measurement of motor*	*Justification of Energy Management*	*SCADA Hardware*	*Introduction to Applications of SCADA*

		Accountability		*Control Systems(EMCSs)*		
	SLO-2	*Energy Policy Reporting and Training*	*Amperage Readings*	*EMCSs Functions*	*SCADA Hardware Functions*	*SCADA Applications in Power Systems:*
S-7	SLO-1	*Energy Planning*	*Amperage Readings of Electric motor*	*EMCS opportunity*	*RTU Standards*	*Expected Benefits of SCADA for Power Systems*
	SLO-2	*Audit Planning*	*Electric Motor efficiency*	*EMCS for an building*	*Difference between PLC and RTU*	*SCADA for Power Utility Network*
S-8	SLO-1	*Educational Planning*	*Comparing Motors based on efficiency*	*EMCS Retrofit*	*Features of SCADA*	*Components of SCADA Applications*
	SLO-2	*Strategic Planning*	*Sensitivity of Load To Motor Rpm*	*New Construction EMCS*	*Software of SCADA*	*Introduction to IEC 61850 Standard for SCADA*
S-9	SLO-1	*Energy Reporting*	*Motor Performance Management Process(MPMP)*	*System Integration*	*Protocols of SCADA, DNP (Distributed Network Protocol)*	*Intelligent Electronic Devices (IEDs)*
	SLO-2	*Energy Ownership*	*How To Start MPMP*	*Specifics of Software Logic*	*Protocols of SCADA, IEC (International Electro Technical Commission)*	*Substation Automation System (SAS) using IED:*

Learning Resources	1. *Wayne C. Turner, Steve Doty, Energy Management Hand book, The Fairmont Press, 6th Edition, 2007* 2. *Green, J. N, Wilson, R, Control and Automation of Electric Power Distribution Systems, Taylor and Francis, 2007* 3. *NPTEL Online Courses, Energy Management Systems and SCADA, IIT Madras. Link : "https://nptel.ac.in/courses/108106022/12"*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.P.Kanakavel,NIWET,pkanagavel.niwet@nic.in	*1. Dr. S. Arul Daniel, NIT Trichy, daniel@nitt.edu*	*1. Dr.S.Vidyasagar, SRMIST*
2. Mr. Tripathi patro,visam pvt ltd,btp@visom.co.in	*2. Dr. P. Somasundaram, CEG, Anna University, mpsomasundaram@annauniv.edu*	*2. Dr.V.Kalyanasundaram, SRMIST*

Course Code	18EEE309T	Course Name	DISTRIBUTED ENERGY RESOURCES	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Understand the basic operation of non conventional energy sources*			
CLR-2 :	*Gain the knowledge about PV system*			
CLR-3 :	*Acquire the knowledge of wind power Generation*			
CLR-4 :	*Explain the energy production from Biomass and OTEC*			
CLR-5 :	*Describe the working of Battery, Flywheel, Ultra Capacitors, micro-turbines*			
CLR-6 :	*Acquire the Knowledge of Nonconventional energy sources*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Describe the basic operation of PV,wind,Fuel cell, Micro turbine, Biomass, Tidal power generation*	*1*	*75*	*75*	*H*	-	-	-	-	-	*M*	-	-	-	-	-	*M*	*M*	*L*
CLO-2 :	*Develop the knowledge of PV collector types and know the technical parameters*	*2*	*75*	*75*	*H*	*M*	-	-	-	-	*M*	-	-	-	-	-	*M*	*M*	*L*
CLO-3 :	*Distinguish different types of wind turbine and know the technical parameters*	*2*	*75*	*75*	*H*	*M*	-	-	-	-	*M*	-	-	-	-	-	*M*	*M*	*L*
CLO-4 :	*Summarize the functions of Biomass and OTEC*	*1*	*75*	*75*	*H*	-	-	-	-	-	*M*	-	-	-	-	-	*M*	*M*	*L*
CLO-5 :	*Realize the functions of Battery, Flywheel, Ultra Capacitors, micro-turbines*	*2*	*75*	*75*	*H*	-	-	-	-	-	*M*	-	-	-	-	-	*M*	*M*	*L*
CLO-6 :	*Develop the knowledge of the fundamental operation of unconventional energy sources*	*2*	*75*	*75*	*H*	*M*	-	-	-	-	*M*	-	-	-	-	-	*M*	*M*	*L*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Definition, Concepts of Non Conventional Energy Sources*	*Definition, Solar radiation data*	*Energy available from wind*	*Biomass Resources*	*Energy storage, Battery – types*
	SLO-2	*Limitations of Non Conventional Energy Sources*	*Solar energy conversion in to heat*	*General formula, Lift and drag etc*	*Biofuels*	*Equivalent circuit*
S-2	SLO-1	*Energy needs of India, and energy consumption patterns*	*Solar Radiation Measurement*	*Basis of Wind energy conversion*	*Biomass Conversion Routes*	*Performance characteristics*
	SLO-2	*Worldwide Potentials of these sources.*	*Types of Measurement*	*Basic components of wind energy conversion*	*Combustion, Gasification*	*Battery design*
S-3	SLO-1	*Energy efficiency and energy security*	*Flat plate and Concentrating collectors*	*Effect of density, Frequency variances,*	*Anaerobic Digestion*	*Charging and charge regulators*
	SLO-2	*Energy and its environmental impacts*	*Principle of natural and forced convection*	*Angle of attack, Wind speed*	*Pyrolysis*	*Battery management*
S-4	SLO-1	*Technical impact of Distributed generation*	*Energy Storage of PV system*	*Choice of generators*	*Cogeneration*	*Flywheel-energy relations*
	SLO-2	*Economical impact of Distributed generation*	*Case studies of Solar thermal systems for residential water heating*	*Turbine rating, electrical load matching*	*Biogas plants*	*Components of Flywheel*
S-5	SLO-1	*Concept of distributed generations, topologies, selection of sources*	*Industrial heating*	*Variable speed operation*	*Energy recovery from Urban waste*	*Benefits over battery*
	SLO-2	*Regulatory standards/ framework*	*Solar power generation*	*Maximum power operation*	*Energy recovery from liquid waste*	*Introduction to Ultra Capacitors*
S-6	SLO-1	*Definition of Distributed Generation*	*Concept of Maximum Power Point Tracking*	*Control systems, system design features,*	*Types of Biomass plant*	*Working Principle of Ultra Capacitors*
	SLO-2	*Classification of Distributed Generation*	*Types of MPPT*	*Windmill rotors, Horizontal axis*	*Performance analysis of Biomass*	*Testing of Ultra capacitor*
S-7	SLO-1	*DG installation classes*	*DC Power Conditioning Converters*	*Vertical axis rotors*	*Testing Biomass systems*	*Applications*

	SLO-2	*Security issues in DG implementations.*	*Types of converter*	*Induction type generators,*	*Thermal applications*	*Fuel Cells – Principle of Operation*
S-8	SLO-1	*Distributed Generation Impact on Coordinated Relay Protection*	*AC Power Conditioning –Inverters*	*Working principle of wind power plant*	*Power generation*	*Performance characteristics*
	SLO-2	*Classification of NCES, Solar, Wind,*	*Types of inverter*	*Determination of torque coefficient*	*Principles of tidal and wave power generations*	*Applications*
S-9	SLO-1	*Geothermal, Biomass, Ocean energy sources,*	*Testing of PV systems*	*Standalone connected operations*	*Open cycle OTEC*	*Micro-turbines- Principle -of Operation*
	SLO-2	*Comparison of these energy sources*	*Type of testing of PV system*	*Grid connected operations*	*Closed cycle OTEC*	*Advantages and Disadvantages of Microturbine*

Learning Resources	1. *Rai, G.D.,Non Conventional sources of Energy, Khanna Publishers ,5th Edition, 2016.* 2. *Rao. S. & Pamlekar Dr.B.B. Energy Technology , Khanna Publishers, 3rd Edition, 2016* 3. *Khan. B.H, Non-Conventional Energy Resources, The McGraw Hills, Second edition, 2016.*	4. *D.P.Kothari, Renewable Energy Sources and Emerging Technologies, PHI Learning Private Limited, 4th Edition 2011.* 5. *Bansal NK, Kleeman and Meliss M, Renewable energy sources and conversion Techniques, Tata Mc Graw Hill, 1990.* 6. *https://www.toppr.com/guides/physics/sources-of-energy/non-conventional-sources-of-energy/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Bhaskarsahu, Schneider Electric Ltd, Bhaskar.sahu@schneider-electric.com	*1. Dr. K. S. Swarup, IITM, ksswarup@iitm.ac.isn*	*1.Dr.D.Sattianadan, SRMIST*
2. Dr.P.Kanakavel,NIWET,pkanagavel.niwet@nic.in	*2. Dr. R.Ramesh, CEG, rramesh@annauniv.edu*	*2.Dr.K.Vijayakumar, SRMIST*

Course Code	18EEE404T	Course Name	DISTRIBUTED GENERATION AND MICRO GRID	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Understand the basic operation of non-conventional energy sources*			
CLR-2 :	*Gain knowledge of IEEE rules applied for distributed generation*			
CLR-3 :	*Discuss the concept of microgrid*			
CLR-4 :	*Acquire the knowledge on the control algorithms of microgrid*			
CLR-5 :	*Examine the behavior of microgrid under Faulty condition*			
CLR-6 :	*Acquire the Knowledge of Micro grid*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Program Learning Outcomes (PLO)														
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
					Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Summarize the basic operation of PV, Wind, Fuel cell, Micro turbine, Biomass, Tidal power generation*	*1*	*75*	*75*	*H*	*M*	*M*	-	-	-	*H*	-	-	-	-	-	*M*	*M*	*H*
CLO-2 :	*Interpret the standards required for distributed Generation*	*1*	*75*	*75*	*H*	-	-	-	-	-	*H*	*H*	-	-	-	-	*M*	*M*	*H*
CLO-3 :	*Describe Islanding process and Distributed Generation impact on Coordinated Relay Protection*	*2*	*75*	*75*	*H*	*M*	*M*	-	-	-	*M*	-	-	-	-	-	*M*	*M*	*M*
CLO-4 :	*Apply the knowledge on the control concept and interface devices*	*2*	*75*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-5 :	*Analyze protection schemes adopted to the microgrid*	*3*	*75*	*75*	*H*	*M*	*M*	*L*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-6 :	*Develop the knowledge of fundamental operation of Micro grid*	*3*	*75*	*75*	*H*	*M*	*M*	*L*	-	-	*H*	*M*	-	-	-	-	*M*	*M*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Conventional power generation: advantages and disadvantages*	*Concept of distributed generations*	*Concept and definition of microgrid*	*Typical structure and configuration of a microgrid*	*Modelling of Microgrid*
	SLO-2	*Energy crises, Nonconventional energy (NCE) resources*	*Topologies, selection of sources, regulatory standards/ framework*	*Microgrid drivers and benefits*	*AC and DC microgrids*	*Concept of per unit*
S-2	SLO-1	*Review of Solar PV*	*Classification of Distributed Generation*	*Review of sources of microgrids*	*Control techniques applied to micrgrid*	*DC Microgrid*
	SLO-2	*Solar Radiation Measurement*	*DG installation classes*	*P-f and Q-V control*	*Concept of Space Vector Modulation*	*AC Microgrid*
S-3	SLO-1	*Introduction to Wind Energy systems*	*IEEE 1547 – Standard for Interconnecting Distributed Resources with Electric Power Systems*	*ISLANDING - Significance of Islanding Detection*	*Concept of synchronizing*	*Technical issues of Micro grid*
	SLO-2	*Basic components of wind energy conversion*	*Purpose and Limitations*	*Effects of Islanding Phenomena*	*Synchronizing methods*	*Power loss and Voltage raise*
S-4	SLO-1	*Types of wind energy collectors*	*IEEE 1547.1 standard Conformance Test*	*Islanding Detection Techniques- Active Detection*	*Enhanced Interface Devices*	*Protection scheme for grid-connected mode*
	SLO-2	*Concept of Maximum Power Point Tracking*	*Purpose and Limitations*	*Passive Detection*	*Dynamic Voltage Restorer*	*Thermal issues*
S-5	SLO-1	*Introduction to fuel cell*	*IEEE 1547.4 – Guide for Design, Operation and Integration*	*Optimal Power Sharing*	*Constant Voltage Transformers*	*Power quality issues in microgrids*
	SLO-2	*Fuel Cells – Principle of Operation*	*Purpose and Limitations*	*Microgrid with Multiple Distributed Generators*	*Noise Filters*	*Solution methods*
S-6	SLO-1	*Introduction to Micro turbines*	*IEEE 1547.8 Recommended practice for Establishing methods and Procedures*	*Optimal sizing and Sitting of DG*	*Isolation Transformers*	*Stability issues in micro grid*

	SLO-2	*Micro-turbines- Principle of Operation*	*Purpose and Limitations*	*Peak Shaving Potential of a Microgrid*	*Static VAR Compensators*	*Solution methods*
S-7	SLO-1	*Biomass- Biomass Resources, Biofuels*	*Energy storage elements - Batteries*	*Operating modes of DG- Grid connected*	*Harmonic Filters*	*Economic impact of DG*
	SLO-2	*Biomass Conversion Technologies*	*Principle of operation*	*Operating modes of autonomous mode*	*Microgrid Operation Strategies*	*Barriers to DG Development*
S-8	SLO-1	*Energy recovery from Urban waste*	*Ultra-capacitors*	*Concept of reverse power flow*	*MicroGrids and Traditional Power*	*Configuration of SCADA*
	SLO-2	*Energy recovery from liquid waste*	*Principle of operation*	*Distributed Generation Impact on Coordinated Relay Protection*	*System Economics*	*Energy Management System*
S-9	SLO-1	*Principles of tidal and wave power generations*	*Flywheels*	*Adaptive relaying*	*Case Studies : Microgrid Economics*	*Active distribution networks Distributed control system (DCS)*
	SLO-2	*Open cycle OTEC and closed cycle OTEC*	*Principle of operation*	*Fault Limiters*	*Economic Issues Between MicroGrids and the Bulk Power Systems*	*Impact of EV on micro grid*

Learning Resources	1. *AmirnaserYezdani, and Reza Iravani, Voltage Source Converters in Power Systems: Modeling, Control and Applications, IEEE John Wiley Publications,2009.* 2. *DorinNeacsu, Power Switching Converters: Medium and High Power, CRC Press, Taylor & Francis, 2006.* 3. *Chetan Singh Solanki, Solar Photo Voltaics, PHI learning Pvt. Ltd., New Delhi,2009.*	4. *J.F. Manwell, Wind Energy Explained, theory design and applications, J.G. McGowan Wiley publication, 2002.* 5. *D. D. Hall and R. P. Grover, Biomass Regenerable Energy, John Wiley, New York, 1987.* 6. *S.Chowdhury, S.P. Chowdhury, Microgrids and Active Distribution Networks, IET renewable energy series 6* 7. *https://www.powermag.com/the-smart-grid-and-distributed-generation-better-together/*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Dr.P.Kanakavel,NIWET,pkanagavel.niwet@nic.in	*2. Dr. B. K. Panigrahi, IIT Delhi, bkpanigrahi@ee.iitd.ac.in*	*2.Dr.K.Vijayakumar, SRMIST*

Course Code	18EEE405T	Course Name	POWER ELECTRONICS IN RENEWABLE ENERGY SYSTEM	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Educate the students on contemporary development in renewable energy studies*			
CLR-2 :	*Design and analyze the power converters for PV applications*			
CLR-3 :	*Understand the significance of the power converters for wind energy conversion system*			
CLR-4 :	*Create insights into the concept of fuel energy system and its power conditioning system*			
CLR-5 :	*Enrich the concept of hybrid renewable energy systems and multiport converters*			
CLR-6 :	*Create overall structure for integrating renewable electricity on the grid*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Acquire knowledge on renewable energy sources and their characteristics*	*2*	*80*	*75*
CLO-2 :	*Select and design the components of a power converter for PV system*	*3*	*80*	*75*
CLO-3 :	*Propose an appropriate power converter for wind energy conversion system*	*3*	*80*	*75*
CLO-4 :	*Choose a suitable converter topology for fuel cell-based energy system*	*3*	*80*	*75*
CLO-5 :	*Analyze various hybrid energy system for various applications*	*3*	*80*	*75*
CLO-6 :	*Design the building blocks of the renewable energy conversion system*	*3*	*80*	*75*

		Program Learning Outcomes (PLO)														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Acquire knowledge on renewable energy sources and their characteristics*	*H*	*M*	*M*	*-*	*-*	*-*	*M*	*-*	*-*	*-*	*-*	*-*	*H*	*M*	*-*
CLO-2 :	*Select and design the components of a power converter for PV system*	*H*	*M*	*M*	*-*	*M*	*-*	*M*	*-*	*-*	*-*	*-*	*-*	*M*	*M*	*-*
CLO-3 :	*Propose an appropriate power converter for wind energy conversion system*	*H*	*M*	*M*	*-*	*M*	*-*	*M*	*-*	*-*	*-*	*-*	*-*	*H*	*M*	*-*
CLO-4 :	*Choose a suitable converter topology for fuel cell-based energy system*	*H*	*M*	*M*	*-*	*-*	*-*	*M*	*-*	*-*	*-*	*-*	*-*	*H*	*H*	*-*
CLO-5 :	*Analyze various hybrid energy system for various applications*	*H*	*-*	*-*	*-*	*-*	*-*	*M*	*-*	*-*	*-*	*-*	*-*	*H*	*M*	*-*
CLO-6 :	*Design the building blocks of the renewable energy conversion system*	*H*	*M*	*M*	*-*	*M*	*-*	*M*	*-*	*-*	*-*	*-*	*-*	*H*	*M*	*-*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Present scenario of renewable energy sources in India*	*Photovoltaic system components*	*Components of a wind energy conversion system*	*Basic overview of fuel cell currently under development*	*Need for Hybrid Systems*
	SLO-2	*Solar, wind, ocean, Biomass, Fuel cell and geothermal resources.*	*Factor influencing output*	*Site selection consideration*	*Applications and markets- Portable and stationary application*	*Types of Hybrid system*
S-2	SLO-1	*Factors influencing the amount of GHG emission*	*Types of PV system*	*Wind generators-Introduction*	*Fuel cell design levels: The unit cell, the stack, and the system*	*wind-diesel hybrid system*
	SLO-2	*Impacts of renewable energy generation on environment*	*Stand-alone PV system and grid connected PV system*	*Classification of wind generators*	*Types of fuel cell and its comparative study*	*PV-Diesel hybrid system*
S-3	SLO-1	*Basic principle of photovoltaic Energy Conversion*	*PV and IV characteristics*	*Power output performance characteristics*	*Chemical reaction in various fuel cell*	*PV-hydro hybrid system*
	SLO-2	*PV materials*	*Modeling of PV system*	*Modeling of wind energy conversion system*	*Components of fuel cell- Electrolytes and catalyst*	*Biomass-PV-diesel hybrid system*
S-4	SLO-1	*Issues associated with the tapping of solar energy*	*Factors to be considered for the selection of inverter and batteries for solar energy conversion*	*Matrix converters*	*Thermodynamic and electrochemical principles of hydrogen fuel cell*	*Economic, technical and sustainability issues involved in the integration of hybrid renewable energy systems*
	SLO-2	*Limitations of solar power*	*Sizing the solar arrays*	*Limitations in the operation of matrix converter.*	*High temperature fuel cell*	*Current status of solar-wind hybrid renewable energy system*
S-5	SLO-1	*Wind resource assessment*	*Batteries for solar panel*	*Synchronized operation with grid supply*	*Fuel cell power system*	*Hybrid system characteristics*
	SLO-2	*Wind energy pattern for a particular location*	*Various aspects of battery sizing*	*Harmonic distortion*	*MPPT techniques for fuel cell*	*Various power quality issues hybrid renewable power system*
S-6	SLO-1	*Basic principle of wind energy*	*DC power conditioning converters*	*Standards used for grid integration- Grid*	*Design consideration of power*	*Merits of Hybrid RES over the isolated*

		conversion		*connection requirement of renewable power system.*	*electronics converters for fuel cell system*	*RES*
	SLO-2	*Power in wind –Betz limit*	*AC Power conditioning converters*	*Disturbances from power conditioning devices on the power grid- Power quality issues*	*Power conversion and control strategies*	*Case studies on wind-PV maximum power tracking system*
S-7	SLO-1	*Net metering concept*	*Basic non-isolated converters*	*Problems in grid integrated WECS*	*Issues in fuel cell power conditioning system*	*Multi-port DC-DC converter*
	SLO-2	*Repowering concept*	*Isolated dc-dc converters*	*Impact of wind power penetration in power grid*	*Fuel cell power conditioning for electric power applications*	*Flux additive dc-dc converter*
S-8	SLO-1	*Hydrogen energy system*	*Converter dynamics and control*	*Design and optimization of renewable energy system*	*High gain dc-dc converters for fuel cell based electric vehicle*	*Hybrid controller*
	SLO-2	*Hydrogen energy to generate electric power*	*Bidirectional inverter system*	*Simulation software for distributed generation power system*	*Operating principles of high gain dc-dc converter*	*Major features of hybrid system.*
S-9	SLO-1	*Working principle of fuel cell*	*Simulation of PV and IV characteristics*	*Simulation of Sizing, and analysis of WECS*	*Reliability study on fuel cell*	*Merits and demerits of various renewable energy technologies*
	SLO-2	*Fuel cell characteristics*	*Simulation of Sizing, and analysis of photovoltaic systems.*	*Simulation of power electronic converters for WECS*	*Recent research in fuel cell technology*	*Application of various renewable energy technologies.*

Learning Resources	*1. Rashid .M. H, Power Electronics Hand book, Academic press, Second edition, 2006.* *2. Gray, L. Johnson, Wind energy system, prentice hall linc, 1995*	*3. Fuchs, Ewald F., Masoum, Mohammad A.S, Power Conversion of Renewable Energy Systems, 978-1-4419-7978-0, springer, 2011.S.N.Singh, Electric power generation, transmission and distribution, 2nd ed., PHI, 2011* *4. Erickson, Robert W., Maksimovic, Dragan Fundamental of Power electronics, springer, 2001.* *5. https://nptel.ac.in/courses/108108034/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.P.Kanagavel, Additional Director, R & D, NIWE, Government of India, pkanagavel.niwe@nic.in	*1.Dr. Subhransu Sekhar Dash, Government College of Engineering, Keonjhar, Subhransudash_fee@gcekjr.ac.in*	*1. Dr.J.Divya Navamani, SRMIST.*
2. Mr.Jason Mano Raj, Consultant, L& T Technical services, Bangalore jasonmanoraj@gmail.com	*2.Dr.P.Thamizhagan, EEE department,University college of Engineering, Panruti, thamizhme@gmail.com*	*2.Dr.R.Sridhar, SRMIST*

Course Code	18EEE406T	Course Name	WIND AND SOLAR ENERGY SYSTEM	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 :	*Learn about PV technology and it principles*
CLR-2 :	*Enrich the solar energy concepts*
CLR-3 :	*Understand the various techniques involved in solar energy*
CLR-4 :	*Gain knowledge in Wind Energy technology*
CLR-5 :	*Acquire knowledge in various design of wind energy*
CLR-6 :	*Apply the concepts of solar and wind power in industrial applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Explain the principle of solar energy*	*2*	*80*	*75*	*H*	*M*	*L*	*-*	*-*	*-*	*L*	*-*	*-*	*-*	*-*	*-*	*H*	*M*	*-*
CLO-2 :	*Design the Solar PhotoVoltaic and shadow analysis*	*3*	*80*	*75*	*H*	*M*	*L*	*-*	*-*	*-*	*L*	*-*	*-*	*-*	*-*	*-*	*H*	*M*	*-*
CLO-3 :	*Analyze various solar application*	*3*	*80*	*75*	*H*	*M*	*L*	*-*	*-*	*-*	*L*	*-*	*-*	*-*	*-*	*-*	*H*	*M*	*-*
CLO-4 :	*Classify the various wind generators and their control techniques*	*3*	*80*	*75*	*H*	*M*	*L*	*-*	*-*	*-*	*L*	*-*	*-*	*-*	*-*	*-*	*H*	*M*	*-*
CLO-5 :	*Explain the various types of wind generators*	*3*	*80*	*75*	*H*	*M*	*L*	*-*	*-*	*-*	*L*	*-*	*-*	*-*	*-*	*-*	*H*	*M*	*-*
CLO-6 :	*Apply knowledge of solar and wind energy systems for various applications*	*3*	*80*	*75*	*H*	*M*	*L*	*-*	*-*	*-*	*L*	*-*	*-*	*-*	*-*	*-*	*H*	*M*	*-*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Solar radiation*	*Solar cell- module-array*	*Battery storage autonomy*	*Wind resources nature*	*Characteristics of WECS*
	SLO-2	*Beam and diffuse radiation*	*Electrical characteristics of the solar cell*	*State of Charge (SOC)*	*Occurrence of wind Power in the wind*	*Principle of operation and analysis of WECS*
S-2	SLO-1	*Solar constant, earth*	*Equivalent circuit*	*Depth of Discharge(DOD)*	*Wind characteristics*	*Types of generators: IG, PMSG, SCIG*
	SLO-2	*Sun angles*	*Modeling of solar cells including the effects of temperature*	*Types of battery*	*Principles of wind energy conversions*	*DFIG*
S-3	SLO-1	*Attenuation of solar radiation*	*Irradiation and series/shunt resistances on the open-circuit voltage*	*Types of mechanical tracking*	*Components of wind energy conversions system (WECS) Aerodynamics of wind turbine*	*Grid Connected WECS*
	SLO-2	*Measurement of solar radiation*	*Irradiation and series/shunt resistances on the short-circuit current.*	*Significance of MPPT*	*Wind data*	*Grid connectors concepts*
S-4	SLO-1	*Local solar time, derived solar angles*	*IV characteristics of solar cell*	*Types of MPPT*	*HAWT, VAWT, power developed,thrust, efficiency*	*Wind farm and its accessories*
	SLO-2	*Sunrise, sunset and day length. Flat plate collectors*	*Shadow effects*	*Mitigation techniques of shadow analysis*	*Rotor selection*	*Systems forfeeding into the grid*
S-5	SLO-1	*Declination angle*	*Bypass diodes*	*Street lighting*	*Rotor design considerations*	*Induction Generators for direct grid coupling*
	SLO-2	*Solar window, cosine law*	*Hot spot problem in a PV module*	*Solar distillation*	*Tip speed ratio*	*Challenges in Grid connected wind power*
S-6	SLO-1	*Calculation of angle of incidence*	*Safe operating area*	*Solar air heaters, types*	*Number of blades, blade profile*	*Asynchronousgenerators in static cascades*
	SLO-2	*Seasonal variations, daily variation*	*Temperature effects of solar PV module*	*Active solar heaters*	*Power regulation*	*Power evacuation issues*
S-7	SLO-1	*Hour Angle*	*Types of solar panels*	*Passive solar heaters*	*Yaw control, pitch angle control*	*Synchronous generators*

	SLO-2	*Latitude angle*	*Issues in the stand alone solar system*	*Solar pond*	*Stall control*	*Grid related problems*
S-8	SLO-1	*Longitude angle*	*Types of losses in solar panel.*	*Water pumping*	*Schemes for maximum power extraction.*	*Wind generatorcontrolling techniques*
	SLO-2	*Zenith angle*	*Solar Photovoltaic power plant.*	*Domestic lighting*	*Site Selection*	*Issues in hybrid of solar and wind power*
S-9	SLO-1	*Concentrating collectors.*	*Net metering concept*	*Grid connected PV systems*	*Environmental aspects*	*Different schemes*
	SLO-2	*Advantages and disadvantages of solar*	*Design :Panel requirements for a particular load*	*Challenges in Grid connected solar PV*	*Solidity*	*AC voltage controllers*

Learning Resources	1. *Rai ,G.D.,Non-Conventional sources of Energy, 5th Edition, Khanna Publishers , 2016* 2. *Khan. B.H, Non-Conventional Energy Resources, 2nd Edition,The McGraw Hills, , 2016* 3. *Rai, G.D.,Non-Conventional sources of Energy, 5th Edition, Khanna Publishers , 2016.* 4. *Khan. B.H, Non-Conventional Energy Resources, 2nd Edition, The McGraw Hills, 2016.*	5. *Thomas Ackermann, Wind Power in Power Systems, John Wiley & Sons, Ltd, 2005* 6. *Mukund R. Patel, "ind and Solar Power Systems, CRC Press, 1999* 7. *Muhammed H. Rashid, "ower Electronics Handbook" Academic Press, Second* 8. *Bansal N K, Kleeman and Meliss, "enewable energy sources and conversion Techniques, Tata McGraw hill, 1990.* 9. *https://onlinecourses-archive.nptel.ac.in/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

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Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Manjunath rao, Alstrom,manjunath.rao1103@gmail.com	*1. Dr.S.Senthilkumar, NIT Trichy, skumar@nitt.edu*	*1. Dr. K.Saravanan, SRMIST*
2. Mr.Srinath rao, Alstrom,sreenathr.rao@alstrom.com	*2. Dr. S. Ramareddy, Jerusalem College of Engineering,srr.victory@gmail.com*	*2. Dr.R.Sridhar, SRMIST*

Course Code	18EEE310T	Course Name	ENERGY CONSERVATION AND AUDITING	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			

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the current energy scenario and energy conservation.*
CLR-2 :	*Familiarize the basics of energy and its forms*
CLR-3 :	*Outline the concepts of energy management and audit*
CLR-4 :	*Discuss the methods of improving energy efficiency in different electrical machines*
CLR-5 :	*Describe the methods of improving energy efficiency in different industrial systems*
CLR-6 :	*Obtaining wide knowledge about energy management procedures in industrial system*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Relate the energy scenario and energy conservation*	*2*	*80*	*75*	*H*	*M*	*-*	*-*	*-*	*-*	*-*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*H*
CLO-2 :	*Explain about various energies and its conversions*	*3*	*80*	*75*	*H*	*M*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*M*	*-*
CLO-3 :	*Implement the procedure for energy audit*	*3*	*80*	*75*	*H*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*M*	*-*
CLO-4 :	*Assess the energy efficiency in electrical components*	*3*	*80*	*75*	*H*	*H*	*-*	*-*	*-*	*-*	*H*	*H*	*-*	*-*	*-*	*-*	*H*	*M*	*H*
CLO-5 :	*Assess the energy efficiency in industrial system*	*3*	*80*	*75*	*H*	*H*	*M*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*H*	*-*	*H*	*M*	*-*
CLO-6 :	*Apply energy saving concepts in electrical system*	*3*	*80*	*75*	*H*	*H*	*M*	*-*	*-*	*-*	*M*	*H*	*-*	*-*	*H*	*-*	*H*	*M*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Energy Classifications*	*Forms of energy*	*Energy management*	*Introduction to energy policy, synopsis of National energy policies in India, EC Act 2001.*	*Air condition and refrigeration*
	SLO-2	*Primary energy consumption*	*Energy conversion, Grades*	*Energy audit - types*	*ISO-50001, PDCA, PAT scheme*	*Diesel Generator*
S-2	SLO-1	*Indian energy scenario*	*Electrical energy*	*Conservation opportunities*	*BEE & State Development Agencies & EESL Programmes*	*Energy Efficiency in Building*
	SLO-2	*World energy scenario*	*Electrical energy conversion*	*Conservation opportunities*	*Ujala & SEEP Programs*	*Energy Efficiency in Building*
S-3	SLO-1	*Energy needs*	*Electricity Tariff – M.D.,*	*Energy costs, bench marking*	*Municipal & Agriculture DSM Initiatives*	*Savings opportunities in HVAC*
	SLO-2	*Energy pricing*	*Electrical Tariff T.O.D., P.F*	*Energy performance*	*Standards and Labelling Programme EEC initiatives in Other Sectors*	*Fans and blowers*
S-4	SLO-1	*Energy sector reforms*	*Electrical Tariff – two-part tariff and others*	*System efficiencies*	*Energy tariffs*	*Conservation opportunities*
	SLO-2	*Green house, climate change*	*Numerical Examples on electrical basics*	*Energy substitution*	*Energy Instrument*	*Pumps - CASE STUDY*
S-5	SLO-1	*Future effects*	*Numerical Examples on electrical tariff*	*Audit instruments*	*Energy Instrument*	*Control strategies*
	SLO-2	*Energy security*	*Thermal energy– temperature, pressure*	*Facility as an energy system*	*Measurement of harmonics*	*Conservation opportunities*
S-6	SLO-1	*Energy conservation*	*Heat transfer*	*Preparing process flow*	*Harmonics Analyzer*	*Cooling Tower -performance*
	SLO-2	*Material and energy balance*	*Latent heat, super heat*	*Energy efficiency in electrical system*	*Power quality analyzer, Thermal Imagining camera, Thermocouple*	*Efficient system operation*
S-7	SLO-1	*Energy balance calculations*	*Humidity*	*Electric motor, compressor, pump.*	*Hot wire anemometer, Energy meter.*	*Efficient system operation*
	SLO-2	*Restructuring energy sector*	*Conduction / convection / radiation / evaporation*	*Power factor improvement, Load management.*	*Combustion analyzer, Airflow meter, Ultrasonic leak detector*	*Validation of energy saving using application software*
S-8	SLO-1	*Energy strategy*	*Units and conversion – pressure, power,*	*Numerical Examples on power factor*	*Occupancy sensors,*	*Energy saving opportunities*

	SLO-2	*Air pollution*	*Units and conversion - energy units*	*Numerical Examples on power factor*	*Energy efficient lighting controls*	*Energy saving opportunities*
S-9	SLO-1	*Energy conservation act*	*Numerical example on energies*	*Numerical examples on harmonics*	*Energy saving potential of technology*	*Assessment of cooling towers*
	SLO-2	*Extracted features of the act*	*Numerical example on energies*	*Numerical examples on harmonics*	*Case study on energy saving technologies*	*Assessment of cooling towers*

Learning Resources	1. *Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-1, General Aspects (www.aipnpc.org/GuideBooks.aspx)* 2. *Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-3, Electrical Utilities (www.aipnpc.org/GuideBooks.aspx)*	3. *S. C. Tripathy, Utilization of Electrical Energy and Conservation, McGraw Hill, 1991.* 4. *Success stories of Energy Conservation by BEE, New Delhi (www.bee-india.org).* 5. *Chopra S.K, Energy Policy for India, Oxford & IBH Publishing, ISBN 812041604X* 6. *Alagiri, Dhandapani, Energy Security in India, icfai university press, ISBN8131404617*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. P.Dharmalingam, Former Director, NPC	*Dr.M.Premalatha , Professor, DEE,NIT-Trichy, latha@nitt.edu*	*Mr.D.Ravichandran,SRMIST*
Mr.J.Sathiyanarayanan,Senior engineer, Southern Railway, Railwayengineer1990@gmail.com	*Dr.Ruben sudhakar D, Assist. Prof.Grade-I,DEE, NIT-Trichy rubensudhakar@nitt.edu*	*Dr.C.Naveen,SRMIST*

Course Code	18EEE311T	Course Name	INDUSTRIAL POWER SYSTEM	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			

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Understand the wiring system for residential ,commercial and industrial consumers*			
CLR-2 :	*Acquire knowledge on standard methodologies for measuring energy in the workplace and energy audit instruments.*			
CLR-3 :	*Acquire knowledge about Electrical distribution system design aspects of industrial and commercial buildings*			
CLR-4 :	*Comprehend power quality issues and power factor correction*			
CLR-5 :	*Describe the various techniques in industrial automation*			
CLR-6 :	*Acquire knowledge on the methodologies and technologies of industrial automation*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Program Learning Outcomes (PLO)														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Design the different components of wiring system*	*H*	*M*	*M*	*M*	-	-	-	*L*	-	-	-	-	*M*	*L*	*L*
CLO-2 :	*Analyze the concept of energy audit and different loads*	*H*	*M*	*M*	*L*	-	-	-	-	-	-	-	-	*M*	*M*	*L*
CLO-3 :	*Evaluate and design of distribution system and address different Communication systems in industries*	*H*	*M*	*L*	*L*	-	-	-	*M*	-	-	-	-	*M*	*M*	-
CLO-4 :	*Address the different power quality problem and various methods of power factor correction*	*H*	-	-	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-5 :	*Identify, monitor and control using PLC and SCADA*	*H*	*M*	*M*	*L*	*M*	-	-	-	-	-	-	-	*M*	*M*	-
CLO-6 :	*Analyze the problem pertaining to power management and automation in industries*	*H*	*M*	*M*	*L*	*M*	-	-	*M*	-	-	-	-	*M*	*M*	*L*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*LT system wiring components*	*System approach and End use approach to efficient use of Electricity*	*Electrical System Design*	*Overview of power quality*	*Computer controlled systems Insulation coordination and Automation*
	SLO-2	*Selection of cables,wires,switches*	*Energy auditing: Types and objectives*	*Distribution System Design*	*Various issues in power quality*	*Modeling of system*
S-2	SLO-1	*Selection of distribution box.*	*Audit instruments- ECO assessment*	*Electrical Design Aspects of Industrial Buildings*	*Various standards of voltages*	*Simulation of switching surges*
	SLO-2	*Metering system*	*Economic methods*	*Commercials Buildings – Design aspects*	*Voltage sag-Definition and types*	*Capabilities; voltage acceptance criteria*
S-3	SLO-1	*Tariff structure*	*Specific energy analysis*	*Electrical Safety*	*System Data for power quality*	*Insulation coordination case study*
	SLO-2	*Protection components*	*Minimum energy paths*	*Earthing Practices at various voltage levels*	*Voltage Drop Calculations*	*Methods of minimizing switching transients*
S-4	SLO-1	*Fuse ,MCB inverse current characteristics*	*Electric motors*	*IS Code for earthing*	*Computer- Aided Analysis*	*Study role of Basic PLC*
	SLO-2	*Isolator ,Relay,MPCB*	*Energy efficient controls and starting efficiency*	*Distribution Automation System : Necessity, System Control Hierarchy*	*Power factor correction studies*	*Role of an automation*
S-5	SLO-1	*Electric shock and safety practices*	*Motor Efficiency*	*Basic Distribution Management System Functions*	*Introduction to over voltages*	*Advantages of process automation*
	SLO-2	*Types of Residential system*	*Load Analysis*	*Integration of Distributed Generation*	*Description and Modeling*	*PLC based control system design , Panel metering*
S-6	SLO-1	*Types of commercial wiring system*	*Variable speed drives*	*Custom Power components in distribution systems-*	*Acceptance Criteria-Frequency Scan Analysis*	*Introduction to SCADA*
	SLO-2	*Genaral rules for wiring system*	*Pumps and Fans-Efficient Control strategies*	*Distribution system Performance*	*Voltage Magnification Analysis*	*Common System Components*

S-7	SLO-1	*Guide lines for installation*	*Optimal selection and sizing*	*Reliability calculations*	*Sustained Over voltages*	*Various functions of SCADA System for distribution automation*
	SLO-2	*Load calculation*	*Optimal operation and Storage*	*Communication Systems for Control and Automation*	*Switching Surge Analysis*	*SCADA Architecture*
S-8	SLO-1	*Sizing of wire*	*Electric Energy Scenario*	*Wireless Communications*	*Back-to-Back Switching*	*Various control of SCADA System*
	SLO-2	*Rating of main switch and distribution board*	*Demand Side Management-Industrial Load Management*	*Wired Communications*	*KVAR calculation*	*Supervision and Control in SCADA*
S-9	SLO-1	*Earthing system calculation*	*Load Curves-Load Shaping Objectives-Methodologies-Barriers*	*DA Communication Protocols*	*Types of compensation*	*HMI, RTU and Supervisory Stations*
	SLO-2	*Requirements of commercial installation*	*Classification of Industrial Loads- -Load Modelling; Electricity pricing*	*Architectures and user interface*	*Over view of compensation*	*Trends in SCADA, Security Issues*

Learning Resources	1. *H. Joshi, Residential Commercial and Industrial Systems, McGraw Hill Education, 2008.* 2. *DONALD BEEMAN, Industrial Power Systems Handbook, McGRAW-HILL BOOK COMPANY, INC* *Rasamy Natarajan, Computer-Aided Power System Analysis, Marcel Dekker Inc., 2002* 3. *S.L. Uppal and G.C. Garg, Electrical Wiring, Estimating & Costing, Khanna publishers, 2008*	4. *Ra 5.James Northcote – Green, Robert Wilson, Control and Automation of Electrical Power Distribution Systems, CRC Press, New York, 2007.* 5. *Turan Gonen: .Electric Power Distribution System Engineering. McGraw Hill Company. 1986* 6. *M.V 7. James Northcote – Green, Robert Wilson, Control and Automation of Electrical Power Distribution Systems, CRC Press, New York, 2007.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Srinath rao, Alstrom,sreenathr.rao@alstrom.com	*1.Dr. P. Somasundaram, CEG, Anna University, mpsomasundaram@annauniv.edu*	*1.Dr.V.Kalyanasundaram,SRMIST*
2.Mr.Manjunath rao, Alstrom,manjunath.rao1103@gmail.com	*2.Dr. B. K. Panigrahi, IIT Delhi, bkpanigrahi@ee.iitd.ac.in*	*2.Dr.S.Vidyasagar, SRMIST*

Course Code	18EEE312T	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 :	*Outline the fundamentals of FACTS controllers*
CLR-2 :	*Discuss shunt and series compensation techniques and its objectives*
CLR-3 :	*Understand the concept of TCSC controllers*
CLR-4 :	*Learn basic idea of voltage and phase angle regulator in power system*
CLR-5 :	*Familiarize the concept of versatile FACTS controllers*
CLR-6 :	*Create overall structure of facts controllers and application of FACTS controller*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Summarize the concepts of FACTS controllers*	*1*	*80*	*75*
CLO-2 :	*Categorize the shunt and series compensation techniques used in facts controllers and its objectives*	*2*	*80*	*75*
CLO-3 :	*Examine the operation of TCSC and application of TCSC*	*2*	*80*	*75*
CLO-4 :	*Relate the various application of phase shift transformer and phase angle regulator*	*2*	*80*	*75*
CLO-5 :	*Gain knowledge the basic concept of STATCOM, UPSC and its application*	*2*	*80*	*75*
CLO-6 :	*Design a suitable FACTS controller to compensating of real and reactive power using FACTS devices*	*2*	*80*	*75*

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
H	-	-	-	-	-	-	-	-	-	-	-	*H*	*M*	-
H	-	-	-	-	-	-	-	-	-	-	-	*M*	*M*	-
H	-	-	-	-	-	-	-	-	-	-	-	*H*	*M*	-
H	-	-	-	-	-	-	-	*M*	*M*	-	-	*H*	*H*	-
H	-	-	-	*M*	-	-	-	-	-	-	-	*H*	*M*	-
H	-	-	-	*M*	-	-	-	*M*	*M*	-	-	*H*	*M*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Electrical Transmission Network*	*Introduction to passive compensation*	*Need for variable series compensation*	*Phase shifting transformer*	*Voltage source converters*
	SLO-2	*HVDC Vs HVAC*	*Objectives of shunt and series compensation*	*TCSC: Basic and practical module*	*Configurations of SPST*	*Current source converter*
S-2	SLO-1	*Conventional Control Mechanisms-Automatic Generation Control (AGC)*	*Introduction to Single-phase and three phase-Thyristor controlled Reactor (TCR)*	*Net reactance offered by TCSC,*	*Objectives of voltage and phase angle regulators*	*Static synchronous series compensator :*
	SLO-2	*Excitation Control-Transformer Tap-Changer Control-Phase-Shifting Transformers*	*The 12-Pulse TCR*	*Operation of TCSC: Basic principle*	*Real and reactive power of voltage and phase angle regulators*	*Principle of operation*
S-3	SLO-1	*System compensation*	*Analysis of single phase TCR*	*X-I and V-I characteristics of TCSC*	*Applications of Phase Angle Regulator*	*VI characteristics*
	SLO-2	*Analysis of Uncompensated Transmission system*	*SVC configurations- Fixed Capacitor*	*Different modes of Operation Explain TCSC*	*Approaches to Thyristor controlled voltage regulators*	*Applications*
S-4	SLO-1	*Necessity of FACTS controller*	*Thyristor-Controlled Reactor and its operating characteristics*	*Different modes of operation Explain MSC*	*Approaches to phase angle regulators*	*Introduction to Static synchronous compensator (STATCOM)*
	SLO-2	*Load and system Compensation*	*Operating Characteristics without Voltage Control*	*Analysis of TCSC*	*Continuously Controllable Thyristor Tap changers*	*STATCOM Principle of operation*
S-5	SLO-1	*Comparison between Series-Connected and Shunt-Connected Compensating Voltages*	*Operating Characteric With Voltage Control*	*Analysis of TSSC*	*Thyristor Tap Changer with Discrete Level Control*	*VI characteristics*
	SLO-2	*Modeling long transmission line*	*SVC voltage control operation*	*Capability Characteristics (single and multi-module TCSC) TCSC losses*	*Improvement of Transient Stability*	*Applications*

S-6	SLO-1	*Real and reactive power flows in AC system*	*Q-V characteristics*	*TCSC applications*	*Power Oscillation Damping*	*UPFC: basic module -capabilities*
	SLO-2	*Symmetrical lossless line Midpoint compensation*	*Thyristor Switched Capacitor (TSC)-operation-.*	*Modelling of TCSC for Stability Studies*	*Basic Issues in the Damping of Low Frequency Oscillations in Large Power Systems*	*UPFC Modes of operation*
S-7	SLO-1	*Surge Impedance Loading*	*Practical switching strategy V-I characteristics of TSC*	*Power flow enhancement*	*System Modelling for Small Signal Stability*	*Applications*
	SLO-2	*Classification of FACTS controllers controllable parameters*	*(TSC)-operation -VI characteristics*	*Variable reactance model for transient stability study*	*Damping of Power Oscillations Using Series FACTS Controllers*	*Introduction to Generalized unified power flow controller (GUPFC)*
S-8	SLO-1	*Applications of FACTS*	*(TCR)-operation -VI characteristics*	*TCSC: Open loop current control*	*Damping of Power Oscillations Using Shunt FACTS Controllers*	*Inter line power flow controller (IPFC)*
	SLO-2	*Relative Power Carrying Capability of AC and DC Transmission Lines*	*Advantages of slope in SVC dynamic characteristics*	*TCSC: closed loop current control*	*Switching Converter-Based Voltage and Phase Angle Regulators*	*Configuration of IPFC*
S-9	SLO-1	*The Impact of Distributed Generation*	*SVC Applications*	*Power flow incorporating with SVC and TCSC*	*Hybrid Phase Angle Regulators*	*Application*
	SLO-2	*The Effect of Electricity Deregulation*	*Enhancement of steady state and transient stability*	*Mitigation of Subsynchronous Resonance with TCSC*	*A Case Study of Damping Controllers in UPFC*	*Simulation of SVC and TCSC with SMIB system*

Learning Resources	1. *Mohan Mathur, R. & Rajiv K. Varma, Thyristor Based FACTS Controller for Electrical Transmission Systems, Wiley Interscience Publications, 2011.* 2. *Narain G. Hingorani& Laszlo Gyugyi, Understanding FACTS – Concepts & Technology of Flexible AC Transmission Systems, Standard Publishers, New Delhi, 2011.*	3. *Yong Hua Song and Allan T. Johns Flexible Ac Transmission Systems (FACTS), The Institution of Engineering and Technology 2008* 4. *https://nptel.ac.in/courses/108107114/* 5. *https://npti.gov.in/flexible-ac-transmission-system*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Manjunath rao, Alstrom,manjunath.rao1103@gmail.com	*1.Dr.D.Devaraj, Dean-Academic,Kalasalingam Academy of Research and Education, d.devaraj@klu.ac.in*	*1. Mr.D.Maharajan, SRMIST*
2.Dr. T. Prakash, TNEB, Mt. Road, prakash.thyagarajan@tnebnet.org	*2. Dr. S. Ramareddy, Jerusalem College of Engineering,srr.victory@gmail.com*	*2. Mr.V.Kubendran, SRMIST*

Course Code	18EEE313T	Course Name	HIGH VOLTAGE ENGINEERING	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Outline the concepts of over voltages and Insulation Co-ordination on power system*			
CLR-2 :	*Discuss the solid, liquid and gaseous dielectrics with its relevance to application of high voltages.*			
CLR-3 :	*Understand the concept of generation of high voltages*			
CLR-4 :	*Familiarize the concept on the measurement of high voltages and currents*			
CLR-5 :	*Describe the testing of high voltage equipments and its application.*			
CLR-6 :	*Create overall understanding of various types of overvoltages, high voltage generation, measurement and testing*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)													
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Gain knowledge on overvoltage protection and the importance on insulation co-ordination levels.*	*2*	*80*	*75*	*H*	-	-	-	-	-	*M*	-	-	-	-	-	*M*	-
CLO-2 :	*Understand the basics of dielectrics and its breakdown process on high voltage application*	*2*	*80*	*75*	*H*	*M*	*L*	*L*	-	-	*M*	-	-	-	-	-	*M*	*M*	-
CLO-3 :	*Acquire knowledge on high voltage generation*	*2*	*80*	*75*	*H*	*M*	*L*	*L*	-	-	-	-	*M*	*M*	-	-	*M*	*M*	-
CLO-4 :	*Gain knowledge on measurement of high voltage generation*	*2*	*80*	*75*	*H*	*M*	*L*	*L*	*L*	-	-	*H*	-	-	-	-	*M*	*M*	*M*
CLO-5 :	*Demonstrate the testing procedures of high voltage equipment and its application*	*3*	*80*	*75*	*H*	*M*	-	-	-	-	-	*H*	-	-	-	-	*M*	*M*	*H*
CLO-6 :	*Summarize the scenarios of over voltages and applications of high voltage equipments for generation ,measurement and testing*	*3*	*75*	*75*	*H*	*M*	*L*	*L*	*L*	-	*M*	*H*	*M*	*M*	-	-	*M*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Causes of over voltages*	*Gaseous breakdown in uniform and non-uniform fields*	*Generation of high DC voltages – Half-wave and full-wave rectifier circuits*	*HVDC measurement techniques Series Resistance microammeter*	*Testing of High voltage electrical apparatus*
	SLO-2	*Effects of overvoltages on power system*	*Conduction and breakdown in gases-Ionization process*	*Voltage doubler circuits*	*Resistance potential divider*	*Technical terms definition for high voltage testing*
S-2	SLO-1	*Parameters of lightning strokes*	*Townsend's current growth equation in the presence of secondary processes*	*Voltage multiplier circuits*	*Generating voltmeter*	*Testing procedures on insulators-Power frequency tests*
	SLO-2	*Characteristics of lightning strokes-Direct, indirect strokes and backflashover*	*Townsend's Criterion for breakdown*	*Van de Graff generator*	*Measurement of high A.C and impulse voltages-*	*Impulse tests*
S-3	SLO-1	*Origin of Switching overvoltages*	*Experimental determination of Townsend's coefficients*	*Generation of high alternating voltages*	*Series Impedance voltmeters*	*Testing procedures on bushings-Power frequency tests*
	SLO-2	*Characteristics of Switching overvoltages*	*Breakdown in electronegative gases*	*Cascaded transformer*	*Series capacitance voltmeter*	*Thermal test*
S-4	SLO-1	*Impact of switching surges in EHV and UHV systems*	*Time lags for breakdown*	*Resonant transformer-Series connection*	*Capacitance potential dividers and capacitance voltage transformers*	*Testing procedures on isolators*
	SLO-2	*Control of overvoltages due to switching overvoltages*	*Streamer Breakdown mechanism in gases*	*Resonant transformer-Parallel connection*	*Potential Transformer, Electrostatic voltmeter,*	*Short-circuit test*
S-5	SLO-1	*Causes of power frequency overvoltages in EHV and UHV systems*	*Paschen's law-Derivation*	*Generation of high frequency alternating voltages- Advantages*	*Peak reading ac voltmeter-Series capacitor, peak voltmeter*	*Testing procedures of cables-Preparation of cables-Dielectric power test*
	SLO-2	*Remedial measures adopted in EHV and UHV systems*	*Practical Considerations in using gases for insulation purposes*	*Tesla coil equivalent circuit*	*Digital peak voltmeter*	*High voltage test and Partial discharge test*
S-6	SLO-1	*Protection against Lightning overvoltages*	*Vacuum breakdown*	*Generation of impulse voltages-Standard*	*Measurement of high dc, ac and impulse*	*Testing procedures of transformers-e*

		and switching surges of short duration-Ground wires		*impulse waveshapes*	*voltages -Sphere gap measurement*	*overvoltage test, Partial discharge test*
	SLO-2	*Protection of transmission lines against over voltages-Ground rods and counter-poise wires*	*Liquid as insulators-Electrical properties*	*Waveshape Control Parameters*	*Factors influencing the spark over voltage of sphere gaps*	*Impulse testing of transformers-Procedures-Detection and location of fault*
S-7	SLO-1	*Protective devices-Rod gap, Expulsion gap*	*Conduction and breakdown in pure and commercial liquids*	*Multistage impulse generator-Marx circuit*	*Resistance Potential divider for impulse voltage measurements*	*Testing procedures of surge diverters*
	SLO-2	*Protector tubes, Surge arrester*	*Breakdown mechanisms in solid dielectrics-Intrinsic and Electromechanical breakdown*	*Marx circuit -simulation*	*Capacitance potential dividers for impulse voltage measurements*	*Radio Interference Measurements – Measurement of Radio Interference voltage*
S-8	SLO-1	*Principles of Insulation Coordination-Ideal requirements of a protective device*	*Breakdown mechanisms in solid dielectrics-Intrinsic and Electromechanical breakdown*	*Generation of impulse current-Definition-Circuits for producing impulse current waves*	*Measurement of high DC, AC and impulse measurements-High DC currents-DC current transformer-Hall generators*	*RIV measurement circuit*
	SLO-2	*Surge diverters,Equipment insulation level and insulation co-ordination of substation*	*Thermal breakdown, solid breakdown used in practice*	*Generation of rectangular current pulses*	*Measurement of high frequency and impulse currents- Resistive shunts*	*Non-destructive testing of materials and measurement of direct current resistivity*
S-9	SLO-1	*Insulation level at substation with protective zones*	*Breakdown in composite dielectrics-properties*	*Circuits for producing switching surge voltages*	*Rogowski coils,Magnetic links,Faraday Generator*	*Measurement of dielectric constant and loss factor. Partial discharge measurements*
	SLO-2	*Insulation Coordination in EHV and UHV systems*	*Mechanism of breakdown in composite dielectrics*	*Tripping and control of impulse generators- Trigatron gap*	*Cathode Ray Oscillographs for Impulse voltage and current measurements*	*Application of high voltage engineering in food processing and bio-medical industry*

Learning Resources	*1. Naidu.M.S, and Kamaraju, High Voltage Engineering, Tata McGraw Hill, 2014.* *2. Wadhwa.C.L, High Voltage Engineering New age international publishers Ltd.-New Delhi 2010.* *3. Ravindra Arora, Wolfgang Mosh, High Voltage and Electrical InsulationEngineering, Wiley-IEEE Press 2011.*	*4. G.V. Barbosa –Canovas, Pulsed electric fields in food processing: FundamentalAspects and applications, CRC Publisher Edition March 2001.* *5. H. L. M. Lelieveld and Notermans.S,et.al., Food preservation by pulsed electricFields: From research to application, Woodhead Publishing Ltd. October 2007.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Dr. S. Paramasivam, Danfoss Industries Pvt. Ltd., paramsathya@yahoo.com	*1.Dr. R. Sarathi, IITM, Chennai, sarathi@ee.iitm.ac.in*	*1.Dr. S. Padmini, SRMIST*
2.Mr.srinath rao, Alstrom,sreenathr.rao@alstrom.com	*2.Dr. P. Valsalal, Anna University , valsalal@annauniv.edu*	*2.Dr. A.Rathinam, SRMIST*

Course Code	18EEE314T	Course Name	POWER QUALITY	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Understand the characterization of electric power quality*			
CLR-2 :	*Study the sources of power quality events such as voltage sag, short and long duration variations*			
CLR-3 :	*Explain the reduction of PQ problems using custom power devices and harmonic filters*			
CLR-4 :	*Impart knowledge on various methods of power quality monitoring*			
CLR-5 :	*Illustrate the power quality issues in distributed generation*			
CLR-6 :	*Understand Power Quality events, Measuring equipments and their impact on Distributed Generation*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Program Learning Outcomes (PLO)														
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
					Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Describe the causes and effects of power quality problems and categorize the various electrical power quality issues in power systems*	*1*	*75*	*75*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*-*	*-*	*-*	*-*	*-*	*-*	*M*
CLO-2 :	*Identify the power quality major events like voltage sag, interruptions and harmonics*	*2*	*75*	*75*	*H*	*L*	*L*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*M*	*-*
CLO-3 :	*Design and simulate the custom power devices and harmonic filters*	*3*	*75*	*75*	*H*	*M*	*M*	*L*	*M*	*-*	*L*	*M*					*M*	*M*	*M*
CLO-4 :	*Interpret in usage of various PQ measuring instruments*	*2*	*75*	*75*	*H*	*-*	*-*	*-*	*L*	*-*	*M*	*M*	*-*	*-*	*-*	*-*	*L*	*M*	*M*
CLO-5 :	*Identify the various power quality issues in solar system and wind energy conversion system*	*2*	*75*	*75*	*H*	*L*	*L*	*-*	*-*	*-*	*M*	*-*	*-*	*-*	*-*	*-*	*M*	*M*	*-*
CLO-6 :	*Analyze PQ issues in wind and solar energy system and utilize the monitoring equipments for PQ events*	*3*	*75*	*75*	*H*	*L*	*L*	*L*	*M*	*-*	*M*	*M*	*-*	*-*	*-*	*-*	*M*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to power distribution system*	*Sources of Sag and Interruptions*	*Fundamentals of harmonics*	*Introduction to Power Quality monitoring*	*Introduction to Distributed Generation Technologies*
	SLO-2	*Power quality: concepts and definition*	*Classification of Voltage sag*	*Sources of harmonics*	*Power Quality Monitoring considerations*	*Resurgence of DG*
S-2	SLO-1	*Characterization of Transients*	*Estimating Voltage Sag performance – Area of Vulnerability, Equipment sensitivity to voltage sags*	*Definitions: Average value - RMS value - True power factor - phase sequence - Fourier series*	*Perspective of Power Quality Measuring equipments*	*Perspectives on DG benefits*
	SLO-2	*Causes and effects of Transients*	*Transmission system sag performance evaluation, Utility distribution system sag performance evaluation*	*Numerical example for harmonic analysis*	*Overview of Power Quality measurement equipments*	*Perspectives on Interconnection*
S-3	SLO-1	*Characterization, causes and effects of Short duration variations – interruptions*	*Fundamental principles of protection*	*Voltage and current distortions, Harmonics indices - (THD and TDD)*	*Power Quality Measurement Equipment: Power line disturbance analyzer*	*Interface to the Utility System*
	SLO-2	*Characterization, causes and effects of Short duration variations – Sags and Swells*	*Solutions of voltage sag at the end user level*	*Harmonics standards (IEEE, IEC)*	*Spectrum analyzer and Harmonic analyzer,*	*Various types of electrical system interfaces*
S-4	SLO-1	*Characterization of Long duration variations*	*Voltage sag and interruption indices*	*Harmonics sources from commercial load*	*Flicker meters*	*Power Quality issues of DG*
	SLO-2	*Causes and effects of Long duration variations*	*Basic Reliability evaluation techniques*	*Harmonics sources from industrial nonlinear load*	*Disturbance analyzer*	*Various types of Power Quality issues affected by DG*
S-5	SLO-1	*Characterization of Voltage imbalance*	*Motor-Starting sags*	*Effect of harmonics distortion*	*Transducer requirements*	*Operating conflicts*

		and Waveform distortion				
	SLO-2	*Causes and effects of Voltage imbalance and Waveform distortion*	*Motor-starting methods*	*Impact on capacitors, transformers, motors, teleCommunications, energy and demand metering*	*Demonstration of harmonic analyzer*	*Description of Operating conflicts results in Power Quality problems*
S-6	SLO-1	*Characterization of Voltage fluctuation and Power Frequency variations*	*Utility System Fault-Clearing Issues*	*Devices for controlling Harmonics - Inline choke*	*Assessment of Power Quality Measurement Data*	*DG on Low-Voltage Distribution networks*
	SLO-2	*Causes and effects of Voltage fluctuation and Power Frequency variations*	*Overview of Transient Faults*	*Zig Zag transformer*	*Off-line and On-line Power quality data assessment*	*Integration techniques for DG on networks*
S-7	SLO-1	*CBEMA*	*Overview of Permanent Faults*	*Harmonic filters: Passive, Active and Hybrid filters*	*Application of Intelligent Systems to power quality monitoring*	*Siting DG*
	SLO-2	*ITI curves*	*Voltage sag Mitigation methods*	*Design of filters - simulation*	*Design of expert systems for monitoring applications*	*Discussion on optimal DG siting problem*
S-8	SLO-1	*Introduction to Power Quality standards*	*Mitigation of sag - Dynamic Voltage Restorer (DVR)*	*Harmonic analysis*	*Requirements on industry Power Quality monitoring applications*	*DG Interconnection standards*
	SLO-2	*International Standards of Power Quality*	*Principle and configuration of DVR*	*Illustration of Harmonic analysis with an Industry case study*	*Web based Power Quality monitoring system*	*Interconnection requirements*
S-9	SLO-1	*Introduction to Power Quality events*	*Mitigation of sag - Distribution static synchronous compensator (DSTATCOM)*	*Seminar on Harmonic analysis*	*Power Quality monitoring standards*	*Power Quality issues in grid integrated Solar system*
	SLO-2	*Computer simulation of Power Quality events*	*Principle and configuration of DSTATCOM*	*Recent advancement in Harmonic distortion analysis*	*IEEE 1159 and IEC 61000-4-30*	*Power Quality issues in grid connected wind energy conversion system*

Learning Resources	1. *Roger C. Dugan, Mark Mc Granaghan, Surya Santoso, H.Wayne, H. Wayne Beaty, Electrical Power Systems Quality, Tata McGraw Hill, Third edition, 2012.* 2. *Math H J Bollen, Understanding Power Quality Problems: Voltage Sags and Interruptions, IEEE Press, New York, 2000.*	3. *Arindam Ghosh, Power Quality Enhancement Using Custom Power Devices, Kluwer Academic Publishers, 2002.* 4. *G.T.Heydt, Electric Power Quality, Stars in a Circle Publications, second edition, 1994.* 5. *https://nptel.ac.in/courses/108106025/Power%20quality_in_power_distribution_systems.pdf.*

Learning Assessment

	Bloom'sLevel of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.K.Karthikeyan, ABB India Ltd., k.karthikeyan@in.abb.com	*1. Dr.B.Chitti Babu, IIITDM Kanchipuram, bcbabu@iiitdm.ac.in*	*1. Dr.R.Ramya, SRMIST*
2. Mr.Manjunath rao, Alstrom,manjunath.rao1103@gmail.com	*2. Dr.K.Selvi, Thiagarajar College of Engineering, Madurai, kseee@tce.edu*	*2. Mr.D.Ravichandran, SRMIST*

Course Code	18EEE315T	Course Name	SMART GRID	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Describe the architecture of smart grid, standards and policies*			
CLR-2 :	*Examine the issues with renewable energy integration and energy management system*			
CLR-3 :	*Enrich the students with knowledge on measurement techniques in smart grid*			
CLR-4 :	*Understand power system studies in smart grid*			
CLR-5 :	*Acquire knowledge on Communication networks and security challenges*			
CLR-6:	*Understand the management and control of smart grid*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Program Learning Outcomes (PLO)														
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
					Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Understand the smart grid architecture and standards*	*1*	*80*	*75*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*H*	*-*	*-*	*-*	*-*	*M*	*H*	*M*
CLO-2 :	*Analyze the issues with renewable energy integration*	*2*	*80*	*75*	*H*	*L*	*-*	*-*	*-*	*-*	*M*	*H*	*-*	*-*	*-*	*-*	*M*	*H*	*M*
CLO-3 :	*Apply measurement techniques in smart grid*	*2*	*80*	*75*	*H*	*L*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*H*	*-*
CLO-4 :	*Explain the power system studies in smart grid*	*2*	*80*	*75*	*H*	*M*	*-*	*-*	*M*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*H*	*-*
CLO-5 :	*Summarize Communication networks and security issues*	*1*	*80*	*75*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*H*	*M*
CLO:6:	*Apply management and control strategies in smart grid*	*1*	*80*	*75*	*H*	*L*	*-*	*-*	*M*	*-*	*M*	*H*	*-*	*-*	*-*	*-*	*M*	*H*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Evolution of Electric Grid*	*Necessity of renewable power generation*	*Importance of measurement in smart grid*	*Basics of load flow studies*	*Role of Communication infrastructures in smart grid*
	SLO-2	*Definitions and Need for Smart Grid*	*Benefits of renewable generation in smart grid*	*Measurement parameters in smart grid*	*Extended load flow studies in smart grid*	*Types of Communication infrastructures*
S-2	SLO-1	*Basics of smart grid*	*Importance of PV system*	*Introduction to Smart Meters*	*Necessity of voltage stability analysis*	*Elements of data Communication networks*
	SLO-2	*Comparison of Power grid with Smart grid power system*	*Grid integration issues of PV system*	*Block diagram of smart meters*	*Voltage stability analysis in smart grid*	*Standards of data Communication networks*
S-3	SLO-1	*Smart grid components*	*Importance of wind system*	*Communication infrastructure for smart metering*	*Importance of state estimation*	*Wired networks in smart grid*
	SLO-2	*Smart grid driversfunctions*	*Grid integration issues of wind system*	*Communication protocols for smart metering*	*Approach of smart grid to state estimation*	*Wireless networks in smart grid*
S-4	SLO-1	*Opportunities, challenges and benefits*	*Basics of energy storage system*	*Basics of AMI drivers*	*Necessity of optimization techniques*	*Functional groups of smart grid Communications*
	SLO-2	*Functions of Smart Grid Components*	*Operation of independent Large-Scale Battery Storage system*	*Benefits of AMI drivers*	*Optimization techniques in smart grid-case study*	*Types of Communications in smart grid*
S-5	SLO-1	*Wholesale energy market in smart grid*	*Necessity of Battery management system*	*Necessity of WAMS network*	*Different intelligent techniques*	*Characterization of smart grid data*
	SLO-2	*Advantages of building integrated and distributed power systems*	*Types of Battery management system in smart grid*	*Wide area measurement system in smart grid*	*Applications of computational intelligence in smart grid*	*Secure data management in smart grid*
S-6	SLO-1	*Approach to smart grid interoperability standards*	*Necessity of energy management system*	*Introduction to Phasor measurement units*	*Transmission system automation*	*Applications of smart grid data*

	SLO-2	*IEEE standards for Smart Grid*	*Energy management system in smart grid*	*Architecture of Phasor measurement units*	*Components of transmission system automation*	*Impact of bad data in smart grid data*
S-7	SLO-1	*International policies in Smart Grid*	*Basics of demand side management*	*Communications in PMUs*	*Distribution system automation*	*Data cleaning in smart grid data*
	SLO-2	*National and International Initiatives in Smart Grid*	*Demand side management in smart grid*	*Implementation of dynamic visualization system for real time power system data*	*Components of Distribution system automation*	*Smart grid network interoperability*
S-8	SLO-1	*Operation of smart grid*	*Basics of demand response*	*Smart buildings in smart grid*	*PHEV in distribution network*	*Basics of cyber security*
	SLO-2	*Control strategies of smart grid*	*Demand response issues in smart grid*	*Components in smart buildings*	*Charging strategies in PHEV*	*Cyber security issues in smart grid*
S-9	SLO-1	*Basics of microgrid*	*Study of power quality parameters*	*ASHRAE standard for smart buildings*	*Discharging strategies in PHEV*	*Types of cyber attacks*
	SLO-2	*Micro grid importance in smart grid*	*Power quality issues associated with renewable energy in smart grid*	*Multi agent systems in smart grid*	*Impact of PHEV on the grid*	*Mitigation approach to cyber security attacks*

Learning Resources	1. *James Momoh, Smart Grid: Fundamentals of design and analysis, John Wiley & sons Inc, IEEE press 2012.* 2. *Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, Smart Grid: Technology and Applications, John Wiley & sons inc, 2012.* 3. *Fereidoon P. Sioshansi, Smart Grid: Integrating Renewable, Distributed & Efficient Energy, Academic Press, 2012.*	4. *Clark W.Gellings, The smart grid: Enabling energy efficiency and demand response, Fairmont Press Inc, 2009.* 5. *Kenneth C.Budka, Jayant G.Deshpande, Marina Thottan, and Communication networks for smart grids, Springer, 2014.* 6. https://onlinecourses.nptel.ac.in/noc18_ee42/course

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

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Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Sudharsan, L&T, sudharsand@Intecc.com	*1. Dr Subhransu Sekhar Dash, Government College of Engineering, Keonjhar, Subhransudash_fee@gcekjr.ac.in*	*1. Dr.J.Preetha Roselyn, SRMIST*
2. Dr.K.Karthikeyan, ABB India Ltd., k.karthikeyan@in.abb.com	*2. Dr. R.Ramesh, CEG, rramesh@annauniv.edu*	*2. Dr.K.Vijayakumar, SRMIST*

Course Code	18EEE316T	Course Name	VEHICULAR POWER SYSTEM	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Understand the importance of electric transportation system and the basics of electric vehicle components and design*			
CLR-2 :	*Acquire knowledge on battery technologies in transportation*			
CLR-3 :	*Gain knowledge on charging and starting systems in vehicular application*			
CLR-4 :	*Explain the importance of fuel cell and application*			
CLR-5 :	*Examine the working and control of electric propulsion systems*			
CLR-6 :	*Create overall structure of vehicular power system*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Examine on different transportation development strategies and architecture of hybrid drive train*	2	80	75
CLO-2 :	*Understand the construction, working and maintenance of battery*	2	80	75
CLO-3 :	*Summarize the charging and starting systems principle, diagnosing and advancements in automotive*	2	80	75
CLO-4 :	*Interpret the fuel cell structure, operation, types and characteristics of fuel cell technology*	2	80	75
CLO-5 :	*Outline different electric drives and its control techniques*	2	80	75
CLO-6 :	*Understand a vehicle's power system using components like energy storage system and power converters*	2	80	75

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*H*	*L*	*L*	-	-	-	-	-	-	-	-	-	*L*	*L*	-
CLO-2 :	*H*	*M*	*H*	-	-	-	-	-	*L*	-	-	-	*H*	*M*	-
CLO-3 :	*H*	-	*M*	-	-	-	-	-	*L*	-	-	-	*H*	*M*	-
CLO-4 :	*H*	*L*	*M*	-	-	-	-	-	*L*	-	-	-	*H*	*M*	-
CLO-5 :	*H*	-	*M*	-	-	-	-	-	-	-	-	-	*H*	*M*	-
CLO-6 :	*H*	*L*	*M*	-	-	-	-	-	*L*	-	-	-	*M*	*M*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*History of modern transportation*	*Introduction to energy storage systems*	*Requirements of charging system*	*Structure and operation of fuel cell*	*DC motor drives principle of operation*
	SLO-2	*Importance of different transportation development strategies to future oil supply*	*Battery requirements for HEVs, PHEVs and EVs*	*Charging system principles*	*Types of fuel cell (PAFC and PEM)*	*Analysis of DC motor drives performance*
S-2	SLO-1	*History of hybrid electric vehicles*	*Working principle and construction of lead-acid, nickel cadmium*	*Alternators basics and working*	*Types of fuel cell (MCFC and SOFC)*	*Chopper control techniques for DC motor drives*
	SLO-2	*History of electric vehicles*	*Working principle and construction of nickel cadmium*	*Charging circuits basics and working*	*Types of fuel cell (DMFC, AFC and ZAFC)*	*Rectifier control techniques for DC motor drives*
S-3	SLO-1	*Social and environmental importance of hybrid and electric vehicles*	*Working principle and construction of nickel metal hydride*	*Charging system testing instruments*	*Fuel cell based power processing systems introduction*	*Induction motor drives principle of operation*
	SLO-2	*Key challenges of hybrid and electric vehicles*	*Working principle and construction of lithium ion batteries*	*Diagnosing charging system faults*	*Benefits of power processing systems*	*Analysis of Induction motor drives performance*
S-4	SLO-1	*Specifications of PHEVs, BEVs, EVs and HEVs*	*Properties of battery*	*New developments in charging systems*	*Important properties of fuel cells for vehicles*	*Inverter control techniques for induction motor drives*
	SLO-2	*The future of electric vehicles*	*Characteristics of battery*	*Advanced charging systems*	*Alternate fuels for fuel cell vehicles*	*Cycloconverter control techniques for induction motor drives*
S-5	SLO-1	*Requirement of drive train*	*Maintenance of battery*	*Requirements of starting systems*	*Fuel cost and fuel economies comparison*	*Permanent magnetic brush-less DC motor drive operation*
	SLO-2	*Sizing of components in drive train*	*Visual inspection of battery*	*Starter motors and its circuits*	*Comparison of characteristics of fuel cells*	*Analysis of brush-less DC motor drives performance*
S-6	SLO-1	*Series configuration of HEVs*	*Battery testing instruments*	*Inertia starter and pre-engaged starter*	*Fuel cell based drive trains*	*Control techniques of BLDC motor drive*

	SLO-2	*Parallel configuration of HEVs*	*Diagnosing battery faults*	*Permanent magnet starter, integrated starter generator and electronic starter*	*Comparison of BEV, DHFC/EV and DMFC/EV*	*Implementing control techniques for BLDC motor drive*
S-7	SLO-1	*Power split configuration of HEVs*	*Introduction to supercapacitor*	*Starting system testing instrument*	*Transition from diesel to fuel cell engines*	*Sensorless control for BLDC drive introduction*
	SLO-2	*Merits and Demerits of different HEV configurations*	*Introduction to flywheel*	*Diagnosing in starting system faults*	*Fuel cell/battery hybrid power system*	*Different control techniques for BLDC drive introduction*
S-8	SLO-1	*Vehicle dynamics*	*Advanced battery technology*	*Advanced starting system technology*	*Fuel cell in domestic application*	*Switched reluctance motor drives principle of operation*
	SLO-2	*Problems using vehicle dynamics*	*Developments in electrical storage*	*New developments in starting systems*	*Fuel cell in industrial application*	*Analysis of switched reluctance motor drives performance*
S-9	SLO-1	*Modelling electric vehicle range*	*Case studies on battery technologies*	*Case studies in charging and starting systems*	*Case studies on fuel cell technologies*	*Control techniques of switched reluctance motor drive*
	SLO-2	*Problems under vehicle travel range*	*Software implementation of battery and its applications*	*Software implementation of charging and starting systems*	*Software implementation of fuel cell and its applications*	*Implementing control techniques for switched reluctance motor drive*

Learning Resources	1. *A. Emadi, M. Ehsani and John M. Miller, Vehicular Power Systems, Marcel Dekker, New York, 2004.* 2. *Ion Boldea and S.A Nasar, Electric drives, CRC Press, 2005.* 3. *Sandeep Dhameja, Electric Vehicle Battery Systems, Newnes, 2002.*	4. *Chris Mi, M. Abul Masrur, David Wenzhong Gao, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, Wiley, 2011.* 5. *Iqbal Husain, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2nd Edition, 2010.* 6. *https://www.diyguru.org/course/electric-vehicle/*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Dr.S.Sambath, TANGEDCO,Tamilnadu, eses.eng@gmail.com	*1. Dr.Chandramohan, CEG, Anna University, c_dramo@annauniv.edu*	*1. Mrs. A. Geetha, SRMIST*
2. Mr.Sudharsan, L&T, sudharsand@Intecc.com	*2. Dr. P. Somasundaram, CEG, Anna University, mpsomasundaram@annauniv.edu*	*2. Dr. C. Subramani, SRMIST*

Course Code	18EEE407T	Course Name	POWER SYSTEM HARMONICS	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Understand the fundamentals and standards of harmonics*			
CLR-2 :	*Study the various sources of harmonics*			
CLR-3 :	*Enumerate the effects of harmonics in various equipments*			
CLR-4 :	*Classify the methods of power system harmonics mitigation*			
CLR-5 :	*Explore the approach of harmonics system study*			
CLR-6 :	*Develop an overall knowledge about harmonics in power system*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Identify the harmonic indices and study the characteristics of harmonics*	*2*	*80*	*75*	*H*	-	-	-	-	-	-	*H*	-	-	-	-	-	-	*H*
CLO-2 :	*Understand the level of harmonics in equipments and devices*	*3*	*80*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	*Familiarize the harmonics effects in critical loads and equipments*	*3*	*80*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-4 :	*Study and compare the various filters used for harmonics mitigation*	*3*	*80*	*75*	*H*	*H*	*M*	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-5 :	*Simulate the harmonics analysis in a low/medium voltage system*	*3*	*80*	*75*	*H*	*H*	*M*	*M*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-6 :	*Design a harmonic mitigation for the industrial and commercial applications*	*3*	*80*	*75*	*H*	*H*	*M*	*M*	-	-	-	*M*	-	-	-	-	*M*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction*	*Traditional sources*	*Harmonics effects – Thermal losses*	*Harmonics Filters*	*Harmonics modeling of system components - Generator,*
	SLO-2	*Basics of harmonic theory*	*Transformers*	*Copper, core and dielectric losses*	*Passive filters*	*Harmonics modeling of Shunt capacitors*
S-2	SLO-1	*Representation of Harmonics*	*Rotating machines*	*Harmonics effects on power system equipment*	*Single tuned filters*	*Harmonics modeling of Loads*
	SLO-2	*Fourier series – coefficients*	*Arc furnaces*	*Capacitor bank*	*Double tuned filters*	*Harmonics modeling of Induction motor*
S-3	SLO-1	*Fourier transform*	*Modern sources*	*Transformers*	*Damped filters*	*Harmonics modeling of Transformer with network*
	SLO-2	*Discrete Fourier transform (DFT)*	*Power electronics devices*	*Neutral grounding overloading*	*Detuned filters*	*Harmonics modeling of Transformer with different configuration*
S-4	SLO-1	*Fast Fourier transform (FFT)*	*Rectifiers*	*Rotating machines*	*Series tuned filter design*	*Harmonics modeling of Transmission line model*
	SLO-2	*Examples of harmonic estimation using FFT*	*A.C. Regulators*	*Pulsating torque*	*Impedance plot of series tuned filter design*	*Harmonics modeling of Transmission line with network*
S-5	SLO-1	*Characteristics of harmonics in power system – Symmetry*	*Power converters – Six pulse converters*	*Power electronics devices*	*Second order damped filters*	*Examples – transmission line*
	SLO-2	*Phase sequence*	*Six pulse converters - Analysis*	*Power converters*	*Impedance plot of second order damped filter design*	*Examples – Problems on load*
S-6	SLO-1	*Voltage and current distortion factors - Total harmonic distortion (THD)*	*Twelve pulse converters*	*Harmonics on power system protection*	*Active filters*	*Harmonics analysis using spread sheet*

	SLO-2	*Real, Reactive and Apparent power*	*Twelve pulse converters - Analysis*	*Unexpected relay operation*	*Characteristics of active filters*	*Analysis of harmonics analysis using spread sheet*
S-7	SLO-1	*Distortion power; Power factor*	*Inverters*	*Harmonics effects on consumer equipment*	*Other methods of mitigation*	*Simulation of harmonics analysis*
	SLO-2	*Total influence factor (TIF) and I*T Product*	*Cycloconverters*	*UPS*	*Transformer connection*	*Harmonics resonance*
S-8	SLO-1	*Voltage THD limits – IEEE standards*	*Thyristor controlled reactors*	*Lighting loads*	*Network topology reconfiguration*	*Simulation of harmonics filters*
	SLO-2	*Voltage THD limits – IEC standards*	*Static VAR compensator*	*Electronics devices*	*Increase of supply mode stiffness*	*Analysis of simulation output of harmonics filters*
S-9	SLO-1	*Current THD limits – IEEE standards*	*Effect of transformer connection on harmonics*	*Harmonic interference with Communication*	*Harmonic cancellation through use of multi pulse converters*	*Case study*
	SLO-2	*Current THD limits – IEC standards*	*Star-Delta and Delta-Star*	*Microwave links, telephone interference*	*Series reactor as harmonic attenuator elements*	*Analysis of Case study*

Learning Resources	1. *Power system harmonics ,Fundamentals, Analysis and filter design – George J. Wakileh – Reprinted 2010* 2. *Power system harmonics, J. Arrillaga and N.R.Watson 1998 – Reprinted 2000* 3. *Power system harmonics, Francisco_De_La_Rosa – 2006*	4. *Elecrical power system quality, R C Dugan, Mark F.Mcgranaghan, Surya Santoso, H.Wayne Beaty* 5. *Harmonics analysis software user manual* 6. *https://web.ecs.baylor.edu/faculty/grady/Understanding_Power_System_Harmonics_Grady_April_2012*

Learning Assessment												
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Dr. K. Karthikeyan, ABB Ltd., k.karthikeyan@in.abb.com	*Dr.B.Chitti Babu, IIIT, bcbabu@iiitdm.ac.in*	*Mr. D.Ravichandran, SRMIST, ravichandran.d@ktr.srmuniv.ac.in*
Dr. Swaroop Gajare, Power Systems Technologies, Eaton Research Labs	*Dr. M.M. Rajan Sing ravel, NIT, rajan.singaravel@nitpy.ac.in*	*Dr. M. Senthilkumar, SRMIST, senthilkumar.mu@ktr.srmuniv.ac.in*

Course Code	18EEE408T	Course Name	HVDC AND EHVAC SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	i	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 :	*Outline the concepts of Extra High Voltage transmission systems*
CLR-2 :	*Explain the general background and operational concepts in EHVAC Transmission Systems*
CLR-3 :	*Give idea about the factors affecting EHV transmission and the protection of EHV lines*
CLR-4 :	*Impart knowledge about HVDC Transmission systems*
CLR-5 :	*Expose to the concept of harmonics and basis of protection for HVDC Systems.*
CLR-6 :	*Know the detailed background of extra high voltage AC transmission and high voltage DC transmission*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Understand the basic concepts of Extra High Voltage Transmission.*	*2*	*80*	*75*	*H*	-	-	-	-	-	*M*	*L*	-	-	-	-	*M*	*M*	*L*
CLO-2 :	*Analyze the general background of EHVAC Transmission Systems*	*3*	*80*	*75*	*H*	*M*	*M*	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-3 :	*Acquire knowledge in operational concepts and protection in EHVAC Transmission Systems*	*3*	*80*	*75*	*H*	*M*	*M*	-	-	-	*M*	*L*	-	-	-	-	*M*	*M*	*L*
CLO-4 :	*Infer the significance of HVDC Transmission and its modern trends and applications.*	*3*	*80*	*75*	*H*	-	-	-	-	-	-	-	*M*	*M*	-	-	*M*	*M*	-
CLO-5 :	*Gain idea in the general principle of HVDC control and harmonic elimination in HVDC Systems*	*3*	*80*	*75*	*H*	*M*	*M*	-	*M*	-	-	-	-	-	-	-	*M*	*H*	-
CLO-6 :	*Interprete the operational concepts of high voltage AC and DC transmission*	*3*	*80*	*75*	*H*	*M*	*M*	-	*M*	-	*M*	*L*	*M*	*M*	-	-	*H*	*M*	*L*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Brief Description of Energy Sources*	*Power handling capacity of AC transmission line*	*Effects of corona*	*Choice of HVDC Transmission*	*Pulse number*
	SLO-2	*Development of Energy sources*	*Line losses of AC transmission line*	*Attenuation of travelling waves due to corona loss*	*Basic outline of HVDC Transmission*	*Choice of Converter Configuration*
S-2	SLO-1	*Introduction to EHV transmission*	*Introduction to mechanical considerations in transmission line performance*	*Generation of audible noise*	*Comparison of Economics, Technical Performance of DC power Transmission*	*Introduction to Graetz circuit*
	SLO-2	*Standard Voltage levels of Transmission systems*	*Types of vibrations and oscillations*	*Characteristics and its limitations of audible noise*	*Comparison of Reliability of DC power Transmission*	*Simplified analysis of Graetz circuit*
S-3	SLO-1	*Hierarchical levels for Transmission systems*	*Concept of bundled conductors*	*Generation of corona pulses*	*Description of HVDC transmission system*	*Concept of HVDC link Control*
	SLO-2	*Costs of Transmission Lines And Equipment*	*Properties of Bundled conductors*	*Properties of corona pulses*	*Types of HVDC links*	*Principles of HVDC link control*
S-4	SLO-1	*Necessity for EHV transmission*	*Surface voltage gradient on single conductor bundles*	*Limits for radio interference fields*	*Components of a Converter station*	*DC Breaker – Basic concepts of DC circuit interruption*
	SLO-2	*Challenges involved in EHV transmission*	*Derivation of Surface voltage gradient on single conductor bundles*	*Evaluation of radio interference using Cigre Formula*	*Description of a Converter station*	*DC Breaker –Characteristics and Applicatiobns*
S-5	SLO-1	*Operational Aspects of EHV AC transmission*	*Surface voltage gradient on double conductor bundles*	*Concept of RL filter to block corona enery*	*Basic concepts of multi-terminal HVDC system.*	*AC Filter –Criteria of design*
	SLO-2	*Electrical characteristics of EHV cables*	*Derivation of Surface voltage gradient on double conductor bundles*	*Design of RL filter*	*Types and potential applications of multi-terminal HVDC system.*	*AC Filter –Ratings of filter components and protection of filters*
S-6	SLO-1	*Gas insulated EHV transmission lines*	*Basic concepts of reactive power*	*Intereference to TV reception from EHV*	*Effects of proximity of ac and dc*	*DC Filter –Criteria of design*

			compensation	*lines*	*transmission lines*	
	SLO-2	*Properties of SF_6 gas*	*Principles of shunt compensation*	*Discharges from an EHV line causing television interference*	*HVDC transmission based on Voltage Source Converters*	*DC Filter –Hybrid active filter for DC filtering*
S-7	SLO-1	*Effect of Power-Frequency Magnetic Fields on Human Health*	*Principles of series compensation*	*Concept of lightning strokes*	*Merits of HVDC System*	*Protection Against Over Currents, Over Voltages*
	SLO-2	*Effect of High Electro Static Field on Humans, Animals, and Plants*	*Sub-synchronous resonance in compensated lines*	*General principles of the lighting protection problem*	*Limitations of HVDC System*	*Protection Systems in HVDC Substation*
S-8	SLO-1	*Introduction to line parameters*	*Counter measures for Sub-synchronous resonance problem*	*Arresters used for EHV systems*	*Applications of HVDC transmission*	*Necessity of simulation of a dynamic system*
	SLO-2	*Determination of resistance of EHV lines*	*Improvement of system performance due to reactive power compensation.*	*Protective characteristics of lightning arresters*	*Modern Trends in HVDC transmission*	*Tools for simulation of a dynamic system*
S-9	SLO-1	*Determination of inductance of EHV lines*	*Comparison of Overhead and Underground lines*	*Operating characteristics of lightning arresters*	*Seminar on case Studies of HVDC links in the world- I*	*Digital Dynamic Simulation of Converters*
	SLO-2	*Determination of capacitance of EHV lines*	*Examples of Giant power pools in the world*	*Insulation Coordination based on lightning*	*Seminar on case Studies of HVDC links in the world- II*	*Digital Dynamic Simulation of DC Systems*

Learning Resources	1. *Rakosh Das Begamudre, Extra High Voltage AC Transmission Engineering, Fourth Edition , New Age International(P) Limited,Publishers.,2011* 2. *Padiyar K.R., HVDC Power Transmission Systems, Third Edition,New Age International (P) Limited Publishers.,2015.*	3. *Chakrabarti. A , M.L.Soni,P.V.Gupta,U.S.Bhatnagar, PowerSystem Engineering, DhanpatRai& Co., 2010.* 4. *Sunil S.Rao, Switchgear Protection and Power Systems,13th e dition, Khanna Publishers,2008. http://www.nptelvideos.com/course.php?id=480*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Dr.K.Karthikeyan, ABB India Ltd., k.karthikeyan@in.abb.com	*1. Dr Subhransu Sekhar Dash, Government College of Engineering, Keonjhar, Subhransudash_fee@gcekjr.ac.in*	*1. Ms. E. Annie Grace, SRMIST*
2. Mr.Senthilkumar,ATI,rskrd1962@gmail.com	*2.Dr. A. Venkadesan, NIT Puducherry, venkadesan@nitpy.ac.in*	*2. Dr. S. Padmini, SRMIST*

Course Code	18EEE409T	Course Name	POWER SYSTEM DYNAMICS	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 & Electronics Engineering	Data Book / Codes/Standards	NIL		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Enumerate the significance of stability study and its classification*			
CLR-2 :	*Explain the concept of detailed modelling of synchronous machine for stability studies*			
CLR-3 :	*Understand and model the various excitation system*			
CLR-4 :	*Examine the small-signal stability study of single-machine infinite bus (SMIB) system*			
CLR-5 :	*Discuss the Sub-synchronous oscillations and countermeasures for small-signal stability*			
CLR-6 :	*Develop the mathematical model of synchronous machine and assessment of small-signal stability*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Explain the basics of stability analysis and its types*	*1*	*75*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-2 :	*Apply the idea of Park's transformation and express the voltage and flux linkage equation, torque and power equation of synchronous machine in rotor reference frame.*	*3*	*75*	*75*	*H*	*H*	*L*	*H*	*H*	-	-	-	-	-	-	-	*M*	*M*	-
CLO-3 :	*Describe the excitation system, types and its modelling for stability studies*	*3*	*75*	*75*	*H*	*H*	*L*	*H*	*H*	-	-	-	-	-	-	-	*M*	*M*	-
CLO-4 :	*Analyze the small-signal stability for the SMIB system with classical model of synchronous machine*	*3*	*75*	*75*	*H*	*H*	*H*	*H*	*H*	-	-	-	-	*H*	-	-	*M*	*M*	-
CLO-5 :	*Infer Sub-synchronous oscillations and the enhancement methods of small-signal stability*	*3*	*75*	*75*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-6 :	*Design the mathematical model of synchronous machine and evaluate the small-signal stability*	*3*	*75*	*75*	*H*	*H*	*H*	*H*	*H*	-	-	-	-	*H*	-	-	*M*	*M*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction –Basic elements of power system*	*Introduction to Three phase synchronous machine*	*Excitation system requirements*	*Small-signal stability of dynamic Systems*	*Introduction to Sub-synchronous oscillations*
	SLO-2	*Structure of power system-power system control*	*RMF, MMF waveform*	*Basic functions of Excitation system*	*Local, finite and global stability*	*Turbine-generator torsional characteristics*
S-2	SLO-1	*Operating states of power system and control strategies*	*Winding model*	*Elements of an excitation system*	*Linearization*	*Structure of typical lumped mass shaft system model*
	SLO-2	*Normal design contingencies*	*Modelling assumptions,*	*Control functions of an excitation system*	*State-space representation*	*Shaft model representation*
S-3	SLO-1	*System design for stability*	*Sign convention*	*Protective functions of an excitation system*	*Mathematical analysis of stability*	*Equations of inertia constant-Torsional stiffness-Damping coefficient*
	SLO-2	*Classifications of stability*	*Stator voltage equations in abc coordinates*	*Types of Excitation System (ES)*	*Eigen properties of the state matrix*	*Derive the Shaft system equations between turbine and generators*
S-4	SLO-1	*The stability phenomena: small-signal and transient stability*	*Rotor voltage equations in abc coordinates*	*DC excitation system-(DC1A)*	*Eigenvalues of the state matrix*	*Computation of damping and stiffness coefficient for a five mass model system*
	SLO-2	*Basic assumptions made in stability studies*	*Stator flux linkage equations in abc coordinates*	*DC excitation system with amplidyne*	*Eigenvectors, participation factor, modal matrices*	*Computation of each shaft section torque for a five mass model system*
S-5	SLO-1	*Rotor dynamics and the swing equation*	*Rotor flux linkage equations in abc coordinates*	*AC Excitation system*	*Eigenvalues and stability-trajectory behaviour*	*Torsional natural frequencies*
	SLO-2	*Transient stability- Illustrate with Single machine connected to infinite bus (SMIB) system*	*Stator self-inductance calculation*	*Field-Controlled Alternator Rectifier ES*	*Mode shape and participation factor.*	*Example of torsional characteristics of coal-fired unit with static exciter*

S-6	SLO-1	*Numerical problem on transient stability analysis of SMIB system*	*Stator to rotor Mutual-inductance calculation*	*Stationary rectifier based AC Exciter*	*Controllability and observability-concept of complex frequency*	*Small-signal stability enhancement-methods*
	SLO-2	*Power versus rotor angle curve,Power-rotor angle equations-(during a fault, after fault clearing and removal of the faulted circuit)- Numerical problem*	*Rotor to Stator Mutual-inductance, Rotor self –inductance calculation*	*Alternator-supplied controlled-rectifier ES*	*State-space form of Synchronous machine's swing equation*	*Different types of Power system stabilizers (PSS)- Need of PSS*
S-7	SLO-1	*Transient stability assessment of SMIB system by Equal-Area Criterion*	*Park's transformation*	*Rotating type- Brush less Excitation system*	*Case study on small signal stability analysis of Single-Machine Infinite Bus (SMIB) with classical machine model*	*Stabilizers based on shaft speed signal*
	SLO-2	*Computation of Critical clearing angle-critical clearing time-Numerical problem*	*Voltage and flux linkage equations in dqo reference frame (Park's equations)*	*Static Excitation system*	*Block diagram representation of SMIB system*	*Delta-P-Omega stabilizer*
S-8	SLO-1	*Introduction to Voltage stability*	*Steady state analysis-voltage, Current, and flux linkage relationships.*	*Potential-source controlled rectifier-static type excitation system*	*Calculation of synchronizing torque coefficient, system matrix, eigenvalues and participation factor*	*Frequency based stabilizer, Digital stabilizer*
	SLO-2	*Voltage collapse- Illustrate with two bus radial system*	*Phasor representation-Steady state equivalent circuit.*	*Modelling and computer simulation of excitation system*	*The effect of damping torque in the stability of SMIB system with classical machine model*	*Enhancement of stability by Excitation control design*
S-9	SLO-1	*Large disturbance and small disturbance*	*Simplified model (constant flux linkage)-Classical machine model.*	*Detailed excitation system model- DCIA*	*Speed and rotor angle time response of SMIB system with classical machine model*	*Exciter gain, Phase-lead compensation, stabilizing signal washout, Stabilizer gain-Stabilizer limits*
	SLO-2	*Voltage stability- Mid-term and Long-term stability*	*Steady State analysis of Synchronous machine using simulation software*	*AC1A and AC4A model of excitation system*	*Synchronous machine model using suitable simulation software*	*General observation on excitation control design*

Learning Resources	*1. P.Kundur, Power System Stability and Control, McGraw Hill Inc, New York, 1995.* *2. R.Ramanujam, Power System Dynamics: Analysis and Simulation, PHI Publishers, Delhi, 2nd edition 2013.* *3. M.A.Pai and W.Sauer, Power System Dynamics and Stability, Pearson Education Asia, India, 2002.*	*4. K.R.Padiyar, Power System Dynamics, Stability & Control, 2nd Edition, B.S. Publications, Hyderabad, 2002.* *5. P.M Anderson and A.A Fouad, Power System Control and Stability, Iowa State University Press, Ames, Iowa, 1978.* *6. https://nptel.ac.in/courses/108102080/*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Dr. Sharon Ravichandran, ABB Ltd., Chennai,sharonravi87@gmail.com	*1. Prof. K.Shanthi Swarup, IITM, Chennai, ksswarup@iitm.ac.in*	*1.Mr. D. Maharajan, SRMIST*
2.Dr.V.P.Boopathi, Powersys., Chennai,Boopathivp@gmail.com	*2.Prof. R.P.Kumudini Devi, Anna University, kumudini@annauniv.ac.in*	*2.Dr. D. Sattianandan, SRMIST*

Course Code	18EEE410T	Course Name	MODERN POWER SYSTEM ANALYSIS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18EEC303T	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Explain the numerical method involved in for optimal power flow analysis*			
CLR-2 :	*Analyse the significance of contingency analysis and power system security states*			
CLR-3 :	*Outline the concepts of distribution system*			
CLR-4 :	*Understand and analyze the different concepts of stability*			
CLR-5 :	*Demonstrate the concepts of state estimation of power systems*			
CLR-6 :	*Evaluate the overall analysis of power system problems starting from transmission to distribution*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Acquire the knowledge on the numerical methods of optimal power flow analysis*	*3*	*75*	*75*	*H*	*M*	*M*	*M*	*M*	-	-	-	-	-	-	-	*M*	*M*	-
CLO-2 :	*Analyse the concepts of power system security*	*3*	*75*	*75*	*H*	*M*	*M*	*M*	*M*	-	-	-	-	-	-	-	*M*	*M*	-
CLO-3 :	*Familiarize the knowledge on distribution system and its application*	*3*	*75*	*75*	*H*	*M*	*M*	*M*	*M*	-	-	-	-	-	-	-	*M*	*M*	-
CLO-4 :	*Categorize the study of stability analysis*	*3*	*75*	*75*	*H*	*M*	*M*	*M*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-5 :	*Gain knowledge on the concept of state estimation in power systems*	*3*	*75*	*75*	*H*	*L*	*L*	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-6 :	*Create ,design and analyze the power system issues starting from transmission to distribution*	*3*	*75*	*75*	*H*	*M*	*M*	*M*	*M*	-	-	-	-	-	-	-	*M*	*M*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Formulation of power flow problem*	*Overview of security analysis*	*Basic concepts of stability*	*Introduction - Primary distribution systems*	*Need for state estimation*
	SLO-2	*Solution through Newton-Raphson method*	*Need for Power system Security*	*Classifications of stability*	*Types of primary distribution systems*	*Basic methods of state estimation*
S-2	SLO-1	*Problems solving- Newton-Raphson method*	*Factors affecting power system security*	*Small signal stability of a single machine infinite bus system*	*Secondary distribution systems*	*Comparison of power flow and state estimation problems*
	SLO-2	*Fast decoupled power flow solutions*	*Introduction to Contingency analysis*	*Small signal stability-solving numerical*	*Types of Secondary distribution systems*	*Least Square State Estimation*
S-3	SLO-1	*Problems solving-Fast Decoupled method*	*Contingency analysis-Addition and removal of one line*	*Transient stability-Runge kutta method*	*Ring main distribution systems*	*Weighted Least Square State Estimation*
	SLO-2	*Comparison of Load flow methods*	*Computation of bus impedance matrix from bus admittance matrix*	*Runge kutta method - Solving numericals*	*Ring main distribution systems-solving numerical*	*State estimation from Non-linear measurements*
S-4	SLO-1	*Power flow studies-simulation*	*Problem solving-contingency analysis*	*Runge kutta method - Solving numericals*	*Load flow of radial distribution networks-solving numerical*	*Static state estimation for power systems*
	SLO-2	*Power flow studies-simulation*	*Problem solving-contingency analysis*	*Runge kutta method - Solving numericals*	*Load flow of radial distribution networks - solving numerical*	*Weighted Least Square State Estimation –solving numericals*
S-5	SLO-1	*DC power flow solutions*	*Calculation of new bus voltage due to addition and removal of one line-simulation*	*Transient stability- Simulation*	*General design characteristics of distribution system*	*Detection of bad measurements*
	SLO-2	*AC-DC power flow model*	*Solving numericals*	*Voltage stability*	*Primary distribution system - design*	*Identification of bad measurements*
S-6	SLO-1	*Optimal Power Flow-Introduction*	*Linear sensitivity factors*	*Transmission characteristics*	*Primary distribution system - design*	*Detection and identification of bad measurements*

	SLO-2	*Gradient method*	*Problem solving-Linear sensitivity factors*	*Transmission characteristics*	*Voltage,scheme and feeder size selection*	*Solving numerical*
S-7	SLO-1	*Problem solving-Gradient method*	*Problem solving-Linear sensitivity factors*	*Generator characteristics*	*Secondary distribution system - design*	*Network observability*
	SLO-2	*Newton's method*	*AC power flow method*	*Generator characteristics*	*Lamp flicker-Origin*	*Problem solving Network observability*
S-8	SLO-1	*Security constrained optimal power flow*	*Problem solving-AC power flow method*	*Load characteristics*	*Types of flicker and remedial measures*	*Pseudo measurements*
	SLO-2	*Optimal generation scheduling*	*Contingency selection*	*Load characteristics*	*Design of capacitors to distribution systems*	*State estimation including Phasor measurement units*
S-9	SLO-1	*Problem solving-optimal generation scheduling*	*Contingency ranking*	*Characteristics of reactive compensating devices.*	*Design of capacitors to distribution systems-solving numerical*	*State estimation including Phasor measurement units*
	SLO-2	*Optimal unit committment*	*Security analysis and contingency evaluation*	*Typical scenario of voltage collapse*	*Design of capacitors to distribution systems-solving numerical*	*Application of state estimation in power system in load forecasting*

Learning Resources	1. *Pai M.A. and Dheeman Chatterjee, Computer Techniques in Power System Analysis, Mc Graw Hill Education (India) Private Limited, New Delhi, 2016.* 2. *John.J.Grainger, William D. Stevenson, Jr, Power System Analysis, Mc Graw Hill Education (India) Private Limited, New Delhi, 2015.*	3. *Allen Wood J.and Bruce.F. Wollenberg, Power Generation Operation and Control, 2nd Edition, John Wiley & Sons, New York, 1996.* 4. *Prabha Kundur, Power system stability and control, Electrical power research institute-power system engineering series.* 5. *Mukhtar Ahmad, Power System State Estimation, Lap Lambert Acad Publishers, 2013.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Dr.V.P.Boopathi, Powersys., Chennai,Boopathivp@gmail.com	*1.Dr. K. S. Swarup, IITM, Chennai, ksswarup@iitm.ac.in*	*1.Dr. S. Padmini, SRMIST*
2.Dr. T. Prakash, TNEB, Mt. Road, prakash.thyagarajan@tnebnet.org	*2.Dr. P. Somasundaram, Anna University, mpsomasundram@annauniv.edu*	*2.Dr. K. Vijayakumar, SRMIST*

Course Code	18EEE411T	Course Name	POWER SYSTEM DEREGULATION	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 & Electronics Engineering		Data Book / Codes/Standards	NIL	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the basics of deregulation and economics of power system*
CLR-2 :	*Learn Unit commitment, optimal power flow and its constraints*
CLR-3 :	*Understand the activity of GENCO and independent system operator*
CLR-4 :	*Get familiarized with the various transmission services*
CLR-5 :	*Gain knowledge on the role of security and congestion management in deregulated power system.*
CLR-6 :	*Create overall restructuring of power system starting from generation to power transmission and distribution*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Illustrate the basics of deregulation in conventional power system*	2	75	75	H	H	-	-	-	-	-		-	-	-	-	H	H	-
CLO-2 :	*Use the concept of Unit commitment, optimal power flow in electric power system*	2	75	75	H	H	-	-	-	-	-	M	-	-	-	-	H	H	M
CLO-3 :	*Apply the knowledge on the various role of ISO in deregulated environment*	2	75	75	H	M	-	-	-	-	-	-	-	-	-	-	H	H	-
CLO-4 :	*Analyze various transmission system problems*	2	75	75	H	M	--	-	-	-	-	-	-	-	-	-	H	H	-
CLO-5 :	*Utilize the basic role of security and congestion management and its solutions*	3	75	75	H	M	M	M	-	-	-	M	-	-	-	-	H	H	M
CLO-6 :	*Analyze the power system generation and transmission losses with various components in deregulated system*	3	75	75	H	M	M	M	-	-	-	M	-	-	-	-	H	H	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction- Deregulation*	*Optimal Power Flow problem model*	*Operational planning activities of ISO*	*Embedded cost based transmission pricing*	*Introduction to Congestion,*
	SLO-2	*Structure of a deregulated electricity system*	*Limits on Real and Reactive power flow*	*Single Auction Market*	*Postage stamp method*	*Reasons for transfer capability limitation*
S-2	SLO-1	*Different entities in deregulated electricity markets*	*OPF Examples (quantitative analysis)*	*Double Auction Market*	*MW mile method(quantitative analysis)*	*Importance of congestion management*
	SLO-2	*Power system Deregulation in different countries*	*Characteristic features of OPF & its applications*	*ISO in Pool markets*	*Incremental cost based transmission pricing*	*Features of congestion management*
S-3	SLO-1	*Competitive electricity markets*	*Unit commitment in conventional electricity market*	*ISO in Bilateral markets*	*Short run marginal cost based method*	*Classification of congestion management methods*
	SLO-2	*Benefits from a competitive electricity market*	*UC Constraints*	*Operational planning activities of GENCO*	*Long run marginal cost based method*	*Calculation of ATC*
S-4	SLO-1	*Classification of electricity markets*	*Price based Unit commitment Design in deregulated electricity market*	*GENCO in pool and bilateral markets*	*Revenue Reconciliation*	*Economic instruments for Handling congestion*
	SLO-2	*Pool co and Bilateral Markets*	*Constraints in price based Unit commitment*	*Market participation issues*	*Transmission open access and pricing mechanisms in various countries*	*Congestion pricing methods*
S-5	SLO-1	*Effects of deregulation*	*Competitive bidding., strategic bidding*	*Power exchange*	*Cost components of Transmission System Operator (TSO)*	*Market splitting*
	SLO-2	*Pre dispatch and instantaneous dispatch*	*Parameters affecting bidding strategies*	*Market operations*	*Transfer capability on open access transmission system*	*Counter trade*

S-6	SLO-1	*Review of Economic Load Dispatch problem (ELD)*	*Formation of power pools*	*Market power- standard cost*	*Developments in international transmission pricing*	*Transmission rights*
	SLO-2	*Constraints in ELD problem*	*Economic Exchange of Energy*	*Price forecasting*	*Transmission Security management in deregulated environment*	*Inter zonal congestion management*
S-7	SLO-1	*Economic Load Dispatch problem In Deregulation*	*Multi area Joint Dispatch (quantitative analysis)*	*Power wheeling*	*Scheduling of spinning reserves in deregulated electric market*	*Intra zonal congestion management*
	SLO-2	*Economic Load Dispatch problem (quantitative analysis)*	*Energy Brokerage system*	*Types of wheeling transactions*	*Introduction of ancillary services*	*Price area congestion management*
S-8	SLO-1	*Conditions for optimum*	*Role of Independent system operator (ISO),*	*Transmission open access and types*	*Types of Ancillary services*	*Capacity alleviation method*
	SLO-2	*Significance of Lagrange Multipliers*	*Types of electricity market*	*Cost components in transmission*	*Classification of ancillary services*	*Contingency reserve services*
S-9	SLO-1	*Security constrained Economic dispatch*	*Structure of UK Electricity deregulated market*	*Pricing of power transactions*	*Ancillary services management in various countries*	*Indian electricity act*
	SLO-2	*Preventive and corrective rescheduling*	*Structure of Nordic Electricity deregulated market*	*Ideal Wheeling Rate*	*Interruptible load options for security management*	*Indian power exchange*

Learning Resources	1. *KankarBhattacharya, Operation of Restructured Power Systems, Kluwer academic publishers, 2001.* 2. *Mohammad Shahidehpoura and Muwaffaq A lomoush, Restructured Electric Power System operation trading and volatility, Macsel Dekker Inc,2001* 3. *Zaccour.G. Deregulation of Electric Utilities, Kluwer academic publishers, 1998 .*	4. *Xiao ping Zhang, Restructured Electric Power Systems: Analysis of Electricity Markets with Equilibrium Models, IEEE press, 2010* 5. *THE ELECTRICITY ACT, 2003, http://www.cercind.gov.in/Act-with-amendment.pdf* 6. *https://nptel.ac.in/courses/108101005/.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Dr.S.Sambath, TANGEDCO,Tamilnadu, eses.eng@gmail.com*	*1.Dr. M.P.Selvan, NIT Trichy, selvanmp@nitt.edu*	*Mr. K.Selvakumar, SRMIST*
2. *Mr.Sudharsan, L&T, sudharsand@Intecc.com*	*2.Dr Subhransu Sekhar Dash, Government College of Engineering, Keonjhar, Subhransudash_fee@gcekjr.ac.in*	*Dr.K.Vijayakumar, SRMIST*

Course Code	18EEE317T	Course Name	SYSTEM THEORY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18EEC301J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical & Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Model and represent the systems in state variable form*
CLR-2 :	*Understand the need of controllability and observability*
CLR-3 :	*Provide adequate knowledge in the phase plane analysis*
CLR-4 :	*Give a basic knowledge in describing function analysis*
CLR-5 :	*Educate on stability analysis of systems using Lyapunov's theory*
CLR-6 :	*Create a mindset to model and analyze the system stability using system theory concepts*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Apply the state space method to model Linear and Nonlinear system*	*3*	*75*	*75*
CLO-2 :	*Test the controllability and observability of the system*	*3*	*75*	*75*
CLO-3 :	*Apply the concepts of phase plane analysis to linear and Nonlinear system*	*3*	*75*	*75*
CLO-4 :	*Formulate the Describing function for Nonlinear system*	*3*	*75*	*75*
CLO-5 :	*Determine the stability of Nonlinear system using Lyapunov and Variable- Gradiant Method*	*3*	*75*	*75*
CLO-6 :	*Apply system theory concepts to model and analyze real time system*	*3*	*75*	*75*

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
H	*H*	*M*	*M*	-	-	-	-	-	-	-	-	*M*	*M*	-
H	*H*	*M*	*M*	-	-	-	-	-	-	-	-	*M*	*M*	-
H	*H*	*M*	*M*	-	-	-	-	-	-	-	-	*M*	*M*	-
H	*H*	*M*	*M*	-	-	-	-	-	-	-	-	*M*	*M*	-
H	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*M*	*M*	-
H	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*M*	*M*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Concept of State-tate equation for Dynamic Systems*	*Concept of Controllability & Observability*	*Features of linear and non-linear systems*	*Basic concepts of describing functions*	*Introduction to Stability Analysis of Nonlinear System*
	SLO-2	*Time invariance and linearity- Non uniqueness of state model*	*Controllability Test for Time Varying and Time In varying Case: Minimum Energy Control*	*Common physical non-linearity's*	*Describing Function and Harmonic Balance*	*Equilibrium Points*
S-2	SLO-1	*State Diagram*	*Observability test for Time Varying and Time In- varying system*	*Methods of linearizing non-linear systems*	*Describing function analysis of nonlinear systems*	*Stability in the sense of Lyapunov*
	SLO-2	*Physical System: Linear Continuous Time model*	*Principle of Duality*	*Introduction to phase portraits*	*Importance of Describing Function*	*BIBO Stability*
S-3	SLO-1	*Physical System: Nonlinear system Model*	*Controllability of State model in Jordan Canonical Form*	*Concept of phase portraits*	*Derivation of describing functions for Hysteresis non-linearity*	*Stability of Linear Time Invariant Systems*
	SLO-2	*Local Linearization of Nonlinear Model*	*Observability of State model in Jordan Canonical Form*	*Singular points*	*Derivation of describing functions for Dead zone non-linearity*	*Problem Solving to find stability of Linear Time Invariant System*
S-4	SLO-1	*Solution of Nonlinear Continuous Time State Equation*	*Controllability and Observability Canonical Forms of State mode*	*Existence of Limit cycles*	*Basics of Backlash non-linearity*	*Introduction to Nonlinear Continuous Time Autonomous Systems*
	SLO-2	*Runge Kutta Method*	*Controllable Subspace, Unobservable Subspace*	*Use of Limit cycle in control system*	*Derivation of describing functions for Backlash non-linearity*	*Equilibrium Stability of Nonlinear Continuous Time Autonomous Systems*
S-5	SLO-1	*Solution of Linear Time Varying Continuous Time State Equation*	*Canonical Decomposition Theorem*	*Construction of phase portraits*	*Derivation of describing functions for Ideal Relay non-linearity*	*Basics of the Direct Method of Lyapunov*
	SLO-2	*The Homogeneous Solution*	*Input- Output Maps from State Model for Linear and Nonlinear System*	*Problem solving in phase portraits*	*Derivation of describing functions for Hysteretic Relay non-linearity*	*Direct Method of Lyapunov for Linear Continuous-Time Autonomous*

						Systems
S-6	SLO-1	*Evaluation of State Transition Matrix*	*Output Controllability*	*Phase plane analysis of linear System*	*Basics of Saturation non-linearity*	*Finding Lyapunov Functions for Nonlinear Continuous Time Autonomous Systems*
	SLO-2	*Non Homogeneous Solution*	*Dead-beat Controller*	*Problem solving in Phase plane for linear system*	*Derivation of describing functions for Saturation non-linearity*	*Krasovskii Method of Stability Analysis*
S-7	SLO-1	*Solution of Linear Time In-varying Continuous Time State Equation*	*Reducibility of Linear System*	*Phase plane analysis of Nonlinear System*	*General Conditions for stability of Nonlinear system*	*Finding Lyapunov Functions for Nonlinear Continuous Time Autonomous Systems*
	SLO-2	*Evaluation using Similarity Transform*	*Reducibility of Nonlinear System*	*Problem solving in Phase plane for Non-linear system*	*Describing function Conditions for stability of Nonlinear system*	*Variable- Gradient Method*
S-8	SLO-1	*Solution of Linear Time In-varying Continuous Time State Equation*	*Linear System Realizations: Phase Variable Canonical Form*	*Isocline method*	*Possibilities of Oscillations occurrence in Non Linear System*	*Transients in Non Linear System*
	SLO-2	*Evaluation using Cayley Hamilton Technique*	*Nonlinear System Realizations: Phase Variable Canonical Form*	*Importance of Isocline Method in Non Linear control system*	*Stability analyses of oscillations in Nonlinear system*	*Use of Lyapunov to Estimate Transients*
S-9	SLO-1	*Solution of Linear Time In-varying Continuous Time State Equation*	*Linear System Realizations: Jordan Canonical Form*	*Basics of Inverted Pendulum*	*Introduction to DC Motor Model*	*Stability Analysis Case Study related with Power Engineering Application*
	SLO-2	*Evaluation using Inverse Laplace Transform*	*Nonlinear System Realizations: Jordan Canonical Form*	*Example of Nonlinear System: Inverted Pendulum on a Cart*	*Describing function analysis of DC Motor with Permanent Magnet*	*Stability Analysis Case Study related with Power Engineering Application*

Learning Resources	1. *Katsuhiko Ogata, Modern Control Engineering,5th ed., Prentice Hall, 2017.* 2. *M. Gopal, Modern Control System Theory, 3rd ed., New Age International, 2014.* 3. *Marquez Horacio J Marquez, Nonlinear Control Systems: Analysis and Design, 2nd ed., Wiely Publications, 2012.*	4. *Zoran Vukic, Ljubomir Kuljaca, Dali Donlagic and Sejid Tesnjak, Nonlinear Control Systems, Marcel Dekker Inc, 2007.* 5. *Richard C.Dorf, Robert H.Bishop, Modern control system theory, 13th ed., Pearson Education Ltd, 2016.* 6. *https://www.edx.org/course/introduction-state-space-control-mitx-6-302-1x*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Ms.R.Vijayalakshmi, C2C Engineering, vijayalakshmi@c2cengineering.co.in	*Dr.S.K.Patnaik, CEG, Anna University, skpatnaik@annauniv.edu*	*Dr.R. Narayanamoorthi, SRMIST*
2. Dr. S. Paramasivam, Danfoss, Industries Pvt Ltd, paramsathya@yahoo.com	*Dr. A. Venkadesan, NIT, Pondicherry, venkadesan@nitpy.ac.in*	*Dr.N. Chellammal, SRMIST*

Course Code	18EEE318T	Course Name	ROBUST CONTROL SYSTEM	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18EEC301J	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 :	*Introduce the basics of Robust control principles*
CLR-2 :	*Solve the various problems in linear systems different stabilization methods*
CLR-3 :	*Compute the performance of linear systems by the measured parameters*
CLR-4 :	*Understand the performance and limitations of Feedback control*
CLR-5 :	*Identify the solutions for H∞ control and μSynthesis*
CLR-6 :	*Create a overall structure for Robust control system*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Understand the basics of Robust control principles*	*2*	*80*	*75*	*H*	*M*	*M*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*H*	*M*	*-*
CLO-2 :	*Calculate the parameters of Linear systems by using different stabilization methods*	*3*	*80*	*75*	*H*	*H*	*M*	*M*	*M*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*M*	*-*
CLO-3 :	*Analyze the performance of linear systems by the measured parameters*	*3*	*80*	*75*	*H*	*H*	*H*	*M*	*-*	*-*	*-*	*-*	*M*	*-*	*-*	*-*	*H*	*M*	*-*
CLO-4 :	*Acquire knowledge on Observer, Feedback control systems*	*3*	*80*	*75*	*H*	*M*	*H*	*M*	*-*	*-*	*-*	*-*	*M*	*M*	*-*	*-*	*H*	*H*	*-*
CLO-5 :	*Analyze the basics of H∞ control and μSynthesis and its solution*	*3*	*80*	*75*	*H*	*H*	*M*	*M*	*-*	*-*	*-*	*-*	*M*	*M*	*-*	*-*	*H*	*M*	*-*
CLO-6 :	*Design a Robust control system for Real time Control Applications*	*3*	*80*	*75*	*H*	*H*	*M*	*M*	*M*	*-*	*-*	*-*	*M*	*M*	*-*	*-*	*H*	*M*	*-*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction Engineering Background of RobustControl*	*Introduction Fundamentals ofLinearSystem*	*Introduction to Stabilization ofLinearSystems*	*Introduction to Performance Limitation ofFeedbackControl*	*Introduction to H ∞ Control &μSynthesis*
	SLO-2	*A Brief History of RobustControl*	*Structural Properties ofDynamicSystem*	*StateFeedback*	*PoissonIntegralFormula*	*ControlProblemand H ∞ Control Norm*
S-2	SLO-1	*Methodologies of RobustControl*	*Stability - Bounded-InputBounded-OutputStability*	*Observer - Full-OrderObserver*	*All-Pass and Minimum-PhaseTransferFunctions*	*Input–OutputRelationofTransferMatrix's H ∞ Norm*
	SLO-2	*Small-GainApproach*	*InternalStability*	*MinimalOrderObserver*	*Limitation on Achievable Closed-loopTransferFunction*	*Disturbance Control andWeightingFunction*
S-3	SLO-1	*Positive Real Method*	*Pole–Zero Cancellation*	*Parametrization ofStabilizingControllers*	*InterpolationCondition*	*LMI Solution 1:VariableElimination*
	SLO-2	*LyapunovMethod*	*StabilizabilityandDetectability*	*Generalized FeedbackControl System*	*Analysis ofSensitivityFunction*	*LMI Solution 2: VariableChange*
S-4	SLO-1	*Robust Regional PolePlacement*	*Problem solving session*	*Problem solving session*	*IntegralRelation*	*Problem solving session*
	SLO-2	*GainScheduling*	*LinearFractionalTransformation*	*ParametrizationofControllers*	*Problem solving session*	*Design of Generalized Plant andWeighting Function*
S-5	SLO-1	*Problem solving session*	*SystemPerformance*	*YoulaParametrization*	*Bode Integral RelationonSensitivity*	*μSynthesis*
	SLO-2	*Basics of Linear Algebra and Function Analysis*	*TestSignals*	*Structure ofClosed-LoopSystem*	*BodePhase Formula*	*Definition of μ andItsImplication*
S-6	SLO-1	*Trace, Determinant, Matrix Inverse, and BlockMatrix*	*Steady-StateResponse & TransientResponse*	*Structure of2-Degree-of-Freedom Systems*	*Limitation ofReference Tracking*	*Propertiesofμ*
	SLO-2	*Problem solving session*	*Comparison of Open-Loop andClosed-LoopControls*	*Implementation of 2-Degree-of-Freedom*	*1-Degree-& 2 Degree of-FreedomSystem*	*D–K IterationDesign*
S-7	SLO-1	*Linear VectorSpace*	*Problem solving session*	*SystemPerformance*	*Relation between Time Domain and FrequencyDomainProperties*	*RegionalPolePlacement*

	SLO-2	*Norm and Inner Product of Vector*	*Basics of Convex Analysis and LMI*	*Problem solving session*	*Parseval'sTheorem*	*Convex Region and ItsCharacterization*
S-8	SLO-1	*LinearSubspace*	*Convex Set and Convex Function*	*TestSignals*	*Fourier Transform and InverseFourierTransform*	*Condition for RegionalPolePlacement*
	SLO-2	*Matrix and Linear Mapping*	*Control Problem andLMI*	*Steady-StateResponse*	*KYPLemma*	*CompositeLMIRegion*
S-9	SLO-1	*Eigenvalue and Eigenvector*	*Interior Point Method*	*TransientResponse*	*Problem solving session*	*Problem solving session*
	SLO-2	*Problem solving session*	*Problem solving session*	*Problem solving session*	*Case Study: Stabilization of aUnicycleRobot*	*Case Study: Transient Stabilization of aPowerSystem*

Learning Resources	*1. Kang zhi liu, Yu Yao, Robust Control – Theory and Applications, Wiley Publications, 2016.* *2. T. Glad and L. Ljung, Control Theory: Multivariable and Non-linear methods, Taylor and Francis, London, 2009.* *3. S. Skogstad and I. Postlethwaite, Multivariable Feedback Control, John Wiley and Sons, 2005.*	*4. B. Burl, Linear Optimal Control H2 and H∞ Methods, Addison Wesley, California, US.1999.* *5. K. Zhou, J. C. Doyle and K. Glover, Robust and Optimal Control, Prentice-Hall, 1999* *6. Online Course: https://swayam.gov.in/* *7. NPTEL: Control Engineering, Robust Control Systems. https://nptel.ac.in/courses/108103007/8*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Venkatarao Ryali, Electromechanical Control Systems Lab at GE Global Research, Bengaluru.	*1. Dr.S.K.Patnaik, CEG, Anna University, skpatnaik@annauniv.edu*	*1. Mr.S.Senthilmurugan, SRMIST*
2. Mr. Pugazhendhi K, Control & Instrumentation at ENMAS GB POWER SYSTEMS PROJECTS LTD.Chennai,	*2. Dr. B. K. Panigrahi, IIT Delhi, bkpanigrahi@ee.iitd.ac.in*	*2. Ms R.Rajarajeswari, SRMIST*

Course Code	18EEE319T	Course Name	FUNDAMENTALS OF ROBOTICS	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 & Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1	*Understand the concepts and basic structure of Robots*			
CLR-2	*Recognize the basics of end effectors and drive systems*			
CLR-3	*Enrich the students on the basics of Robotic manipulator and understand the kinematics of serial manipulators*			
CLR-4	*Analyze the basics of Sensors and its various applications in Robots.*			
CLR-5	*Design the Algorithms for mobile Robot navigation.*			
CLR-6	*Utilize the concepts in robotics for the understanding of automation technology*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1	*Interpret the basic structure of Robots and apply it to design the Robots.*	*2*	*75*	*75*	*H*	*H*	*M*	*L*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-2	*Acquire knowledge about end effectors and actuators systems*	*3*	*75*	*75*	*H*	*H*	*H*	*M*	-	-	-	-	-	-	-	-	*H*	*M*	-
CLO-3	*Select robotic manipulator and understand the kinematics of serial manipulators*	*2*	*75*	*75*	*H*	*H*	*H*	*M*	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-4	*Select and implement the sensors for various applications in Robots.*	*3*	*75*	*75*	*H*	*H*	*H*	*M*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-5	*Develop the algorithms for mobile Robot navigation.*	*3*	*75*	*75*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*H*	*M*	-
CLO-6	*Apply the concepts of robotics in real time applications*	*3*	*75*	*75*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*H*	*M*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Robotics: Definition Advantage and disadvantage of robots*	*Robot Drives- Actuators*	*Matrix representation*	*Robot Sensors*	*Localization*
	SLO-2	*History of robotics*	*Actuators selection.*	*Fixed – reference frame*	*Selection of sensor*	*Path Planning*
S-2	SLO-1	*Classification of robots*	*Characteristics of actuating system*	*Representation of frame at the origin of a fixed-reference frame*	*Contact and touch sensor*	*Examples oflocalization system*
	SLO-2	*Robot components,*	*Comparisons of actuating system*	*Representation of frame in a fixed reference frame*	*Tactile sensor*	*Brief representations*
S-3	SLO-1	*Robot characteristics*	*Electric Actuators: DC motor*	*Representation of rigid body*	*Gripping force sensing*	*Brief considerations*
	SLO-2	*Co-ordinate systems*	*Brushless DC motor*	*Robot Kinematics - Position analysis*	*Slip sensing*	*Mobile robot localization using practical filters*
S-4	SLO-1	*Robot reference frame*	*Hydraulic actuators*	*Representation of a pure transformation*	*Proximity sensor*	*Map representations*
	SLO-2	*Degrees of freedom*	*Pneumatic actuators*	*Representation of combined transformation*	*Range sensor*	*Map considerations*
S-5	SLO-1	*Configuration space*	*Robot end effectors*	*Calculation of transformations*	*Light sensors*	*Simultaneous planning localization and mapping (SLAM)*
	SLO-2	*Operational space*	*Classification of end-effectors*	*Transformations relative to the rotating frame*	*Pressure sensors*	*Path planning*
S-6	SLO-1	*Robots as mechanisms*	*Drive system for grippers*	*Inverse transformation matrix*	*Strain gauge based force-torque sensors*	*Path planning challenges*
	SLO-2	*Robot configurations-cartesian*	*Mechanical grippers*	*Inverse transformation matrix of the universe, robot, hand and end effectors frame*	*Position sensor*	*Types of Path planning algorithms*
S-7	SLO-1	*Robot configurations- cylinder*	*Magnetic grippers*	*Forward kinematics-2 DOF of kinematics analysis*	*Displacement sensor*	*Robotics applications with examples*
	SLO-2	*Robot\ configurations- polar*	*Vacuum grippers*	*Forward kinematics-3 DOF of kinematics analysis*	*Sensors-Vision systems*	*Material handling:Pick and place operation*

S-8	SLO-1	*Robot configurations- articulate*	*Adhesive grippers*	*Inverse kinematics- 2 DOF of kinematics analysis*	*Low level vision sensing and digitizing*	*Palletizing and depalletizing*
	SLO-2	*Robot wrist mechanism*	*Selection criteria for grippers*	*Inverse kinematics- 3 DOF of kinematics analysis*	*Vision cameras*	*Machine loading and unloading*
S-9	SLO-1	*Precision and accuracy of robot*	*Gripper force analysis and design*	*Euler angles*	*Charge coupled device line scan sensor*	*Welding, A sensor based joystick controlled teleoperated manipulator*
	SLO-2	*Simple problems in precision and accuracy of robot*	*Simple problems in Gripper*	*Issues in inverse kinematics*	*Applications of robotics vision system*	*A sensor based joystick controlled teleoperated manipulator*

Learning Resources	1. *S. R. Deb & Sankha Deb, Robotics Technology and Flexible Automation, 2nd ed., Tata Mcgraw Hill, 2010.* 2. *Niku, Saeed, Introduction to robotics", 2nd ed., John Wiley & Sons, 2010.* 3. *John J. Craig, Introduction to Robotics: Mechanics and Control, 4t., Addison Wesley, 2018.*	4. *Mikell. P. Groover, Industrial Robotics Technology, Programming and Applications", 3rd., McGraw Hill Co, 2008.* 5. *https://www.edx.org/learn/robotics*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr. K. Ashwin,Embedded engineer,Bosch India,ashwinstringed@gmail.com	*1.Dr. S. Ramareddy, Jerusalem College of Engineering,srr.victory@gmail.com*	*1.Mr.A.Dominic Savio, SRMIST*
2.Mr.Uday kumar,KPIT,udaykumar2495@gmail.com	*2.Dr.S.K.Patnaik, CEG, Anna University, skpatnaik@annauniv.edu*	*2.Dr.K.Mohanraj, SRMIST*

Course Code	18EEE320T	Course Name	SIGNALS AND 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 & Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Categorize the different types of continuous and discrete time signals*
CLR-2 :	*Classify the various types of continuous and discrete systems*
CLR-3 :	*Perform the discrete Fourier transform on signals*
CLR-4 :	*Perceive the digital IIR filters*
CLR-5 :	*Realize the digital FIR filters*
CLR-6 :	*Acquire knowledge on identification and creation of signals and systems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Identify the continuous and discrete time signals*	*2*	*80*	*75*	*H*	*H*	*L*	*L*	*L*	-	-	-	-	-	-	-	*H*	*M*	-
CLO-2 :	*Distinguish the various types of continuous and discrete systems*	*2*	*80*	*75*	*H*	*H*	*L*	*L*	*L*	-	-	-	-	-	-	-	*H*	*M*	-
CLO-3 :	*Assess the Discrete Fourier transform on signals*	*2*	*80*	*75*	*H*	*H*	*M*	*M*	-	-	-	-	-	-	-	-	*H*	*M*	-
CLO-4 :	*Develop the digital IIR filters*	*3*	*80*	*75*	*H*	*H*	*H*	*H*	*L*	-	-	-	-	-	-	-	*H*	*M*	-
CLO-5 :	*Design the digital FIR filters*	*3*	*80*	*75*	*H*	*H*	*H*	*H*	*L*	-	-	-	-	-	-	-	*H*	*M*	-
CLO-6 :	*Evaluate the various types of signals and systems*	*3*	*80*	*75*	*H*	*H*	*H*	*H*	*L*	-	-	-	-	-	-	-	*H*	*M*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Analog signals, discrete time signals and digital signals*	*Continuous time systems*	*System representation through differential equations*	*Design procedure of Analog Butterworth Filter*	*Design procedure of FIR filter by window technique*
	SLO-2	*Deterministic and random signals*	*Discrete time systems*	*System representation through difference equations*	*Design of Analog Butterworth Filter*	*Rectangular and Hamming windows*
S-2	SLO-1	*Periodic and aperiodic signals*	*Memory less and memory systems*	*Realization of discrete time systems: Direct form - I*	*Design procedure of Analog Chebyshev Filter*	*Hanning and Blackmann Windows*
	SLO-2	*Energy and power signals*	*Causal and non-causal systems*	*Realization of discrete time systems: Direct form - II*	*Design of Analog Chebyshev Filter*	*Kaiser window*
S-3	SLO-1	*Even-odd signals*	*Linear and non-linear systems*	*Realization of discrete time systems: Cascade form*	*Bilinear transform technique*	*Design of low pass FIR filter: Calculation of window coefficients*
	SLO-2	*Causal and non-causal signals*	*Time variant and time invariant systems*	*Realization of discrete time systems: Parallel form*	*Quantitative treatment of Bilinear transform technique*	*Design of low pass FIR filter: Calculation of filter coefficients*
S-4	SLO-1	*Standard continuous time signals: Unit step and Impulse signals*	*Stable and unstable systems*	*Discrete Fourier Transform (DFT)*	*Impulse invariance technique*	*Design of high pass FIR filter: Determination of window coefficients*
	SLO-2	*Standard continuous time signals: Sinusoidal and Exponential signals*	*FIR and IIR systems*	*Calculation of DFT*	*Quantitative treatment of Impulse invariance technique*	*Design of high pass FIR filter: Determination of filter coefficients*
S-5	SLO-1	*Standard discrete time signals: Unit step and Impulse signals*	*Recursive and non-recursive systems*	*DFT properties: Linearity, Periodicity, Circular convolution*	*Design of IIR Butterworth digital filters using bilinear transform technique*	*Design of band pass FIR filter: Calculation of window coefficients -*
	SLO-2	*Standard discrete time ignals:Sinusoidal and Exponential signals*	*System properties via the impulse response: Causality*	*DFT properties: Time reversal, Circular time shift, Parseval's theorem*	*Design of IIR Chebyshev digital filters using bilinear transform technique*	*Design of band pass FIR filter: Calculation of filter coefficients*
S-6	SLO-1	*Transformations of the independent*	*System properties via the impulse*	*DFT using DIT-FFT algorithm*	*Design of IIR Butterworth digital filters*	*Design of band stop FIR filter:*

		variable: Addition, Multiplication and Shifting	*response: Memory*		*using impulse invariance technique – Self study*	*Determination of window coefficients – Seminar*
	SLO-2	*Transformations of the independent variable: Scaling and Reversal*	*Relation between continuous and discrete time systems*	*Calculation of DFT using DIT-FFT*	*Design of IIR Chebyshev digital filters using impulse invariance technique – Self study*	*Design of band stop FIR filter: Determination of filter coefficients – Seminar*
S-7	SLO-1	*Sampling and Sampling Theorem*	*Continuous time convolution*	*DFT using DIF-FFT algorithm*	*Realization of IIR Butterworth digital filters*	*Realization of FIR filters: Transversal realization structure*
	SLO-2	*Quantization and Coding*	*Quantitative treatment of Continuous time convolution*	*Calculation of DFT using DIF-FFT algorithm -Assignment*	*Realization of IIR Butterworth digital filters*	*Realization of FIR filters: Linear phase realization structure*
S-8	SLO-1	*Aliasing*	*Discrete time convolution*	*Inverse DFT*	*Need of Pre-warping*	*Realization of FIR filters: Polyphase realization structure*
	SLO-2	*Effects of Aliasing*	*Quantitative treatment of Discrete time convolution*	*Calculation of IDFT*	*Pre warping – Frequency transformation in digital domain*	*Realization of FIR filters: Cascade structure*
S-9	SLO-1	*Simulation on continuous time signals*	*Simulation on Continuous time systems*	*Circular convolution*	*Simulation on digital IIR Butterworth filters*	*Simulation on digital FIR low and high pass filters*
	SLO-2	*Simulation on discrete time signals*	*Simulation on discrete time systems*	*Quantitative treatment of Circular convolution -Assignment*	*Simulation on digital IIR Chebyshev filters*	*Simulation on digital FIR band pass and band stop filters*

Learning Resources	*1. H. P. Hsu, Signals and systems, Schaum's series, McGraw Hill Education, 2010.* *2. S. Haykin and B. V. Veen, Signals and Systems, John Wiley and Sons, 2007.* *3. A. V. Oppenheim and R. W. Schafer, Discrete-Time Signal Processing, Prentice Hall, 2009.* *4. M. J. Robert, Fundamentals of Signals and Systems, McGraw Hill Education, 2007.*	*5. B. P. Lathi, Linear Systems and Signals, Oxford University Press, 2009.* *6. A. V. Oppenheim, A. S. Willsky and S. H. Nawab, Signals and systems, Prentice HallIndia, 1997.* *7. J. G. Proakis and D. G. Manolakis, Digital Signal Processing: Principles, Algorithms,and Applications, Pearson, 2006.* *8. https://extension.ucsd.edu/courses-and-programs/signals-and-systems*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Sharon Ravichandran, ABB Ltd., Chennai, sharonravi87@gmail.com	*1. Dr. M.Jaya Bharata Reddy, NIT, Trichy, jbreddy@nitt.edu*	*1. Dr.K.Mohanraj, SRMIST*
2. Mr.Sabari Ramanan, Manager, Siemens, Chennai, sabari.pm@siemens.com	*2. Dr. B. K. Panigrahi, IIT Delhi, bkpanigrahi@ee.iitd.ac.in*	*2. Dr.A.Rathinam, SRMIST*

Course Code	18EEE412T	Course Name	ADVANCED CONTROL THEORY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18EEC301J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electrical & Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Educate on the basic concepts of multivariable control system*	1	2	3
CLR-2 :	*Understand the design concepts in model predictive control techniques*			
CLR-3 :	*Provide adequate knowledge on preliminary concepts in Adaptive control schemes*			
CLR-4 :	*Provide knowledge on Variable Structure control techniques*			
CLR-5 :	*Educate on different optimal control practices*			
CLR- 6:	*Create a mindset to use the advanced control techniques in complex system*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Formulate the Multivariable control techniques to Multiple parameter system*	*3*	*75*	*75*
CLO-2 :	*Apply the model predictive control strategy to linear and Nonlinear systems*	*3*	*75*	*75*
CLO-3 :	*Articulate the basic adaptive control technique to a system*	*3*	*75*	*75*
CLO-4 :	*Design the sliding mode control to a dynamic system*	*3*	*75*	*75*
CLO-5 :	*Analyze and design the optimal control techniques for linear and Nonlinear systems*	*3*	*75*	*75*
CLO-6 :	*Apply the advanced control techniques in real time problems*	*3*	*75*	*75*

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CLO-1 :	*H*	*H*	*M*	*M*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-2 :	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-3 :	*H*	*H*	*M*	*M*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-4 :	*H*	*H*	*M*	*M*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-5 :	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-6 :	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*M*	*M*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basics of Classical Feedback Control*	*Introduction to Model Predictive control*	*Introduction to adaptive control*	*Introduction to Sliding Mode Control*	*Introduction to Optimal Control*
	SLO-2	*Introduction to multivariable control systems*	*MPC Strategy, Historical perspectives.*	*Effects of process variations*	*Properties of Sliding Motion*	*Importance of Optimal Control*
S-2	SLO-1	*Transfer functions for MIMO systems*	*MPC Elements: Prediction Model*	*Introduction to Adaptive control schemes*	*Pseudo Sliding With a Smooth Control*	*Basics of Parameter Optimization*
	SLO-2	*Negative Feedback Control system in MIMO system*	*MPC Elements: Objective Function*	*Types of Adaptive Control Schemes*	*State Space Approach in Sliding Mode*	*Parameter Optimization in Optimal Control*
S-3	SLO-1	*Multivariable frequency response analysis*	*Model forms for model predictive control Forms*	*Adaptive control problem*	*Sliding Mode Control: Problem Statement*	*Performance Index in Optimal Control*
	SLO-2	*Directions in Multivariable Systems*	*Dynamic Matrix Control*	*Non-parametric identification*	*Existence Solution and Equivalent Control*	*Constraints in Optimal Control*
S-4	SLO-1	*Introduction to multivariable system mapping-poles & zeros*	*Model predictive control Forms*	*Deterministic Self Tuning Regulators*	*Properties of Sliding Motion*	*Calculus of variance in Optimal Control*
	SLO-2	*Singular value decomposition*	*Model Algorithmic Control*	*Pole Placement in Adaptive Control*	*Properties of Sliding Motion*	*Basic Concepts, Functions in optimal Control*
S-5	SLO-1	*Limitations On Performance In MIMO Systems:: Functional controllability*	*Model predictive control Forms*	*Indirect Self Tuning Regulators*	*The reachability Problem in Sliding Mode Control*	*Optimum of a Function*
	SLO-2	*Limitations imposed by time delays*	*Predictive Functional Control*	*Continuous Time Self tuners*	*Single input Control Structure*	*Optimum of a Functional*
S-6	SLO-1	*Limitations On Performance In MIMO Systems*	*Generalized Predictive Control*	*Introduction to Stochastic Tuning Regulators*	*Unit Vector Approach: Existence in Ideal Sliding Mode*	*The basic variational Problem*
	SLO-2	*Limitations imposed by RHP zeros*	*Introduction and Formulation of*	*Predictive Self Tuning Regulators*	*Description of the sliding Motion by Unit*	*Second Variation Problem*

			Predictive Control		*Vector Approach*	
S-7	SLO-1	*Trade-offs in MIMO feedback design*	*Introduction to Multivariable Model Predictive Control*	*Stochastic Adaptive Problem*	*Introduction to types of Sliding Mode Design Approach (Qualitative)*	*Introduction to linear quadratic optimal control system*
	SLO-2	*Traditional LQG and LQR problems*	*Generalized Model of Multivariable Predictive Control*	*Dual Control in stochastic Predictive Control*	*Introduction to types of Sliding Mode Design Approach (Quantitative)*	*Linear quadratic optimal control system Model*
S-8	SLO-1	*Introduction to linear quadratic regulation (LQR) control*	*Constrained Model Predictive Control*	*Introduction to Auto Tuning of Controller*	*Direct Eigen Structure Assignment Approach (Qualitative)*	*Finite Time Linear Quadratic Regulator*
	SLO-2	*Robustness properties of LQR control*	*Constraint General Form, Example*	*PID Controller Auto Tuning*	*Direct Eigen Structure Assignment Approach (Quantitative)*	*Problem Formulation in Finite Time Linear Quadratic Regulator*
S-9	SLO-1	*Introduction to H_2 control*	*Introduction to Robust Model Predictive Control - Application*	*Introduction to Gain Scheduling - Application*	*Introduction to higher order sliding mode control*	*Introduction to LQR system for general performance Index*
	SLO-2	*Introduction to $H\infty$ control*	*Introduction to Robust Model Predictive Control - Application*	*Introduction to Gain Scheduling - Application*	*Problems in Higher order sliding mode control*	*Introduction to LQR system for general performance Index*

Learning Resources	1. *Sigurd Skogestad and Ian Postlethwaite, Multivariable Feedback Control: Analysis and Design, 2ed (WILEY-Interscience), 2014.* 2. *Eduardo F. Camacho, Carlos Bordons Alba, Model Predictive Control, Springer, 2013.* 3. *Karl J.Astrom and Bjorn Wittenmark, Adaptive Conrol, Pearson Education, 2nd Editon, 2013.*	*4. C Edwards, S Spurgeon Sliding Mode Control: Theory And Applications, CRC Press, 1998.* *5. Donald E. Kirk, Optimal Control Theory: An Introduction, Prentice – Hall networks series, New Jersey, 2012.* *6. https://www.cranfield.ac.uk/courses/short/energy-and-power/advanced-control-systems*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Ms.R.Vijayalakshmi, C2C Engineering, vijayalakshmi@c2cengineering.co.in	*1.Dr.S.K.Patnaik, CEG, Anna University, skpatnaik@annauniv.edu*	*1.Dr.R. Narayanamoorthi, SRMIST*
2.Dr. S. Paramasivam, Danfoss Industries Pvt.Ltd, paramsathya@yahoo.com	*2. Dr. B. K. Panigrahi, IIT Delhi, bkpanigrahi@ee.iitd.ac.in*	*2.Dr.N. Chellammal, SRMIST*

Course Code	18EEE413T	Course Name	DISTRIBUTED CONTROL 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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Learn the architecture, Organization and operation of PLC, SCADA and Distributed Control System (DCS)*			
CLR-2 :	*Impart knowledge about basic controllers and DCS controller Configuration*			
CLR-3 :	*Know the importance of Alarm features in DCSs*			
CLR-4 :	*Impart adequate knowledge onMaintenance and Troubleshooting procedures of DCS*			
CLR-5 :	*Learn the basics of Advanced Process Controllers in DCSs and Latest trends related to DCS*			
CLR-6 :	*Gain Knowledge about basic DCS controllers Alarm system management and advanced process controllers*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Familiarize the concepts and abstractions of distributed systems and their limitations*	*2*	*80*	*75*	*H*	*L*	*L*	*L*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-2 :	*Obtain the knowledge of basic controllers and DCS controller Configuration*	*2*	*80*	*75*	*H*	*L*	*L*	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-3 :	*Enrich the knowledge of Alarm features of DCS*	*2*	*80*	*75*	*H*	*L*	*M*	*L*	-	-	-	-	-	-	-	-	*M*	*L*	-
CLO-4 :	*Analyse the system for the awareness of the issues and procedures to perform DCS Maintenance and Troubleshooting*	*3*	*80*	*75*	*H*	*H*	*M*	*M*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-5 :	*Acquire the basics of Advanced Process Controllers in DCSs and Latest trends related to DCS*	*3*	*80*	*75*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-6 :	*Evaluate and specify DCSs to ensure efficient and optimum operation of Plant*	*3*	*80*	*75*	*H*	*H*	*M*	*M*	-	-	-	-	-	-	-	-	*M*	*M*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Programmable Logic Controller (PLC) – brief overview*	*Introduction to basic controller, Identification of the controller boards*	*Alarm system management: An alarm system, Functions of the plant or process operator*	*Introduction to Distributed control system reporting, Operation of advanced DCS using multi-screen display*	*Advanced Process Controllers:Feed forward Control*
	SLO-2	*Block Diagram of PLC*	*Discrete and logic control, Sequential and batch control*	*Functions of an alarm system, An effective alarm system*	*Cross screen invocation and linking*	*Cascade Control*
S-2	SLO-1	*An overview of SCADA systems: Introduction and Basics of SCADA system*	*Basic DCS controller configuration: Introduction and Control modes*	*Design overview*	*Alarm reporting, generation and acceptance*	*Statistical Process Control*
	SLO-2	*SCADA key features*	*Tracking and initialization in control slots used for cascade control*	*Human and ergonomic factors*	*Different types of logs and reports configurable on a DCS*	*Basics of advanced process control and optimization*
S-3	SLO-1	*Remote terminal units (RTUs)*	*Control functions*	*Structure of a good alarm system*	*Introduction to Distributed control system (DCS) configuration*	*Latest DCS Trends:Monitoring and control in the Field*
	SLO-2	*Typical requirements for an RTU system*	*Control algorithms*	*Safety integrity level (SIL)*	*System/project tree structure, DCS system database*	*Industrial Internet*
S-4	SLO-1	*PLCs used as RTUs and Consideration and benefits of SCADA system*	*Sequential Controllers for Batch Processing*	*Definition of strategy, Strategy for alarm system design*	*Configuration of control functions*	*Internet of Things*
	SLO-2	*DCS versus SCADA terminology*	*Defining equipment procedures*	*Strategy for alarm system maintenance and management at the site/plant, Generation of minimum design documentation for each alarm*	*Configuration of operator/monitoring functions*	*Mobile and remote devices*
S-5	SLO-1	*SCADA software package*	*Phase logic programming*	*Measurement of the alarms, Field measurements for deriving alarms*	*Configuration of system hardware structure*	*Cloud ProcessingMonitoring and control in the Cloud*

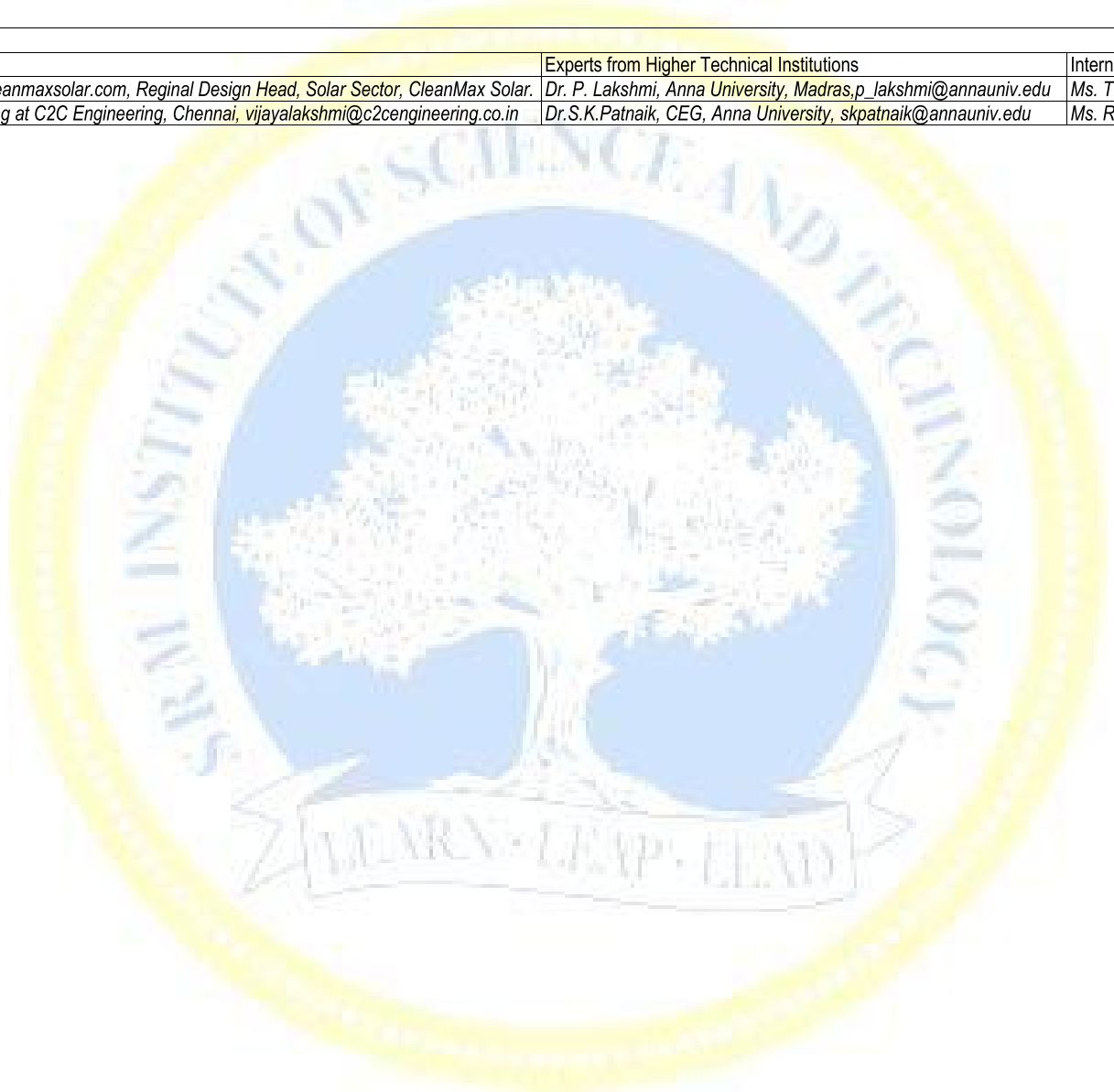
	SLO-2	*Hardware, software, system interfacing*	*Phase logic interface*	*Hardware for alarm processing, Alarm displays*	*Configuration of system software*	*Typical DCS and SCADA systems: Honeywell Plant Scape system*
S-6	SLO-1	*Overview of Distributed Control Systems: Introduction and Basic concepts of Distributed Computing*	*Logic block functions in advanced controller*	*Testing of alarms, Generation of various types of alarms*	*Documentation and Commissioning*	*Foxboro I/A series DCS*
	SLO-2	*Evolution of Distributed Computing System*	*DCS controller configuration*	*Selection of alarm settings*	*Introduction to Maintenance & Troubleshooting*	*Delta system*
S-7	SLO-1	*Present market trends in DCS*	*Introduction to Communications for DCS & SCADA systems: Purpose and Basic Communications principles*	*Setting alarm priority*	*Maintenance requirements of system and system elements*	*Citect*
	SLO-2	*Basic DCS specification*	*Balanced and unbalanced transmission lines*	*Design of field sensors for generating alarms*	*Requirements for in-built diagnostic and maintenance routines*	*Wonderware*
S-8	SLO-1	*General description of a commercial DCS*	*4 EIA-232 interface standards (CCITT V.24 interface standard)*	*Logical processing of alarms*	*Requirement for installation of UPS system*	*Distributed control system applications: Use of DCS in oil and gas processing environment*
	SLO-2	*Advantage of DCS systems*	*The EIA-485 interface standard*	*Design of alarm list displays*	*Recovery of a DCS following power outage*	*Use of DCS in pulp and paper environment*
S-9	SLO-1	*DCS selection criteria*	*Interoperability, ModBus protocol*	*Measurement of performance*	*Proper troubleshooting methods, identify typical Communication malfunctions and faults, Identifying failures, malfunctions, and faults*	*Use of DCS in petroleum-refining environment*
	SLO-2	*DCS architecture*	*HART protocol, The promise of FieldBus and DeviceNet and Benefits*	*Usefulness of alarms*	*Diagnostics of Communication faults*	*Distributed control systems project implementation*

Learning Resources	1. *Michael P. Lukas, Distributed Control Systems: Their Evaluation and Design, Van Nostrand Reinhold Co., 1986.* 2. *Boyer, S.A. SCADA: Supervisory Control and Data Acquisition. 4th Edition. International Society for Automation, Raleigh, USA, 2010.* 3. *Gene F. Franklin, J.David Powell, Abbas Emami, Feedback Control of Dynamic Systems, Naeini, Pearson* 4. *Srinivas Medida, Pocket Guide on Industrial Automation, For Engineers and Technicians, IDC Technologies.*	5. *Bela G. Liptak, Process Measurement and Analysis, Instrument Engineers' Handbook Fourth Edition, CRC Press.* 6. *Richard L. Shell, Ernest L. Hall, Handbook of Industrial Automation, University of Cincinnati Cincinnati, Ohio, 2000.* 7. *Practical Distributed Control Systems (DCS) for Engineers and Technicians, Revision 6.1, IDC Technologies.* 8. *www.isa.org*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Kranti kumar Chittiprolu, krantikumar.ch@cleanmaxsolar.com, Reginal Design Head, Solar Sector, CleanMax Solar.	*Dr. P. Lakshmi, Anna University, Madras,p_lakshmi@annauniv.edu*	*Ms. T.M. Thamizh Thentral, SRMIST*
Ms. Vijayalakshmi Ramani, Head-Engineering at C2C Engineering, Chennai, vijayalakshmi@c2cengineering.co.in	*Dr.S.K.Patnaik, CEG, Anna University, skpatnaik@annauniv.edu*	*Ms. R. Rajarajeswari, SRMIST*



Course Code	18EEE414T	Course Name	CONTROL SYSTEM DESIGN	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18EEC301J	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:*	Learning
CLR-1 :	*Gain knowledge on stability using frequency domain methods*	1
CLR-2 :	*Analyze state space analysis of mechanical systems*	1
CLR-3 :	*Impart knowledge on controllability/observability of control systems*	1
CLR-4 :	*Outline the concept and design of robust control systems*	1
CLR-5 :	*Examine stability of nonlinear autonomous systems by state space methods*	1
CLR 6 :	*Gain knowledge on the design, control and analysis of Linear and non-linear system.*	1

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Apply frequency domain methods for stability analysis*	*2*	*80*	*75*
CLO-2 :	*Evaluate linear dynamical systems by state space methods*	*3*	*80*	*75*
CLO-3 :	*Determine controllability/observability by rank test*	*3*	*80*	*75*
CLO-4 :	*Design robust control system for real time system*	*3*	*80*	*75*
CLO-5 :	*Analyse stability of nonlinear autonomous systems by state space methods*	*2*	*80*	*75*
CLO 6 :	*Design of compensators to analyse the system stability and performance of Control system.*	*3*	*80*	*75*

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*H*	*H*	*L*	*L*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-2 :	*H*	*H*	*M*	*M*	-	-	-	-	-	-	-	-	*H*	*M*	-
CLO-3 :	*H*	*H*	*L*	*L*	-	-	-	-	-	-	-	-	*L*	*L*	-
CLO-4 :	*H*	*H*	*L*	*L*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-5 :	*H*	*M*	*L*	*L*	-	-	-	-	-	-	-	-	*L*	*L*	-
CLO 6 :	*H*	*H*	*L*	*L*	-	-	-	-	-	-	-	-	*M*	*M*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Design of Feedback Control Systems*	*Introduction to Design of State Variable Feedback Systems*	*Introduction to Controllability and Observability*	*Introduction to Robust control system*	*Lyapunov's stability*
	SLO-2	*Approaches to System Design*	*Advantages of State Space Representation*	*Conditions for Controllability and Observability*	*Review of norms for signals and systems*	*Stability of Autonomous Systems*
S-2	SLO-1	*Cascade Compensation Networks*	*State-space Equations*	*Algebraic definitions for Controllability and Observability*	*Review of Nyquist Criterion and Classical Stability Margin*	*Stability of linear and non-linear autonomous systems*
	SLO-2	*System Design Using Integration Networks*	*State model of LTI and SISO linear systems*	*Full-state feedback control design*	*The small Gain Theorem and Applications of Small Gain Theorem to the Robust Control*	*Lyapunov's indirect method*
S-3	SLO-1	*Design procedure for Phase-Lead network Using the Bode Diagram*	*State space representation using physical variables*	*Need for Observer*	*Robust control systems and system sensitivity*	*Lyapunov's direct method*
	SLO-2	*Design example: Phase-Lead design for different types system*	*State space representation using phase variables*	*Structure and properties of observer*	*System sensitivities to parameter perturbations*	*Optimal control positive definite function*
S-4	SLO-1	*Design procedure for Phase-Lead network Using the root locus*	*State space models of DC motor*	*Integrated full-state feedback and observer*	*Analysis of robustness*	*Optimal control negative definite function*
	SLO-2	*Design example: Phase-Lead design for different types system*	*State space models of inverted pendulum*	*Pole placement for single-output systems*	*System with uncertain parameters of robust control system*	*Positive semi-definite functions*
S-5	SLO-1	*Design procedure for Phase-Lag network Using the Bode Diagram*	*Decomposition of Transfer Functions-Direct Decomposition*	*Compensator design by separation principle*	*Considerations in design of robust control system Design*	*Negative semi-definite functions*
	SLO-2	*Design example: Phase-Lag design for different types of system*	*Cascade and parallel Decomposition*	*Reference inputs*	*Design of robust PID controlled systems*	*Lyapunov stability criteria*

S-6	SLO-1	*Design procedure for Phase-Lag network Using the root locus*	*Similarity Transformation*	*Types of observer*	*Robust internal mode control systems*	*Introduction to optimal control*
	SLO-2	*Design example: Phase-Lag design for different types system*	*Solution of state equations*	*Compensator design using full order observer*	*Design of internal mode control systems*	*Riccatti Equation*
S-7	SLO-1	*Design on the Bode Diagram Using Analytical Methods*	*Computation of the State Transition Matrix by infinite series method*	*Optimal control systems*	*Loop shaping necessary and sufficient conditions.*	*Linear Quadratic Regulator*
	SLO-2	*System design using analytical technique*	*Computation of the State Transition Matrix by Laplace transformation*	*Determination of optimal control systems*	*Robust stability test.*	*Lasalle's invariance principle*
S-8	SLO-1	*Systems with a Pre-filter*	*Computation of the State Transition Matrix by Cayley-Hamilton Theorem*	*Optimal system with control energy consideration*	*Robust performance test.*	*Instability Theorem*
	SLO-2	*Design for Deadbeat Response*	*Computation of the State Transition Matrix by Canonical Transformation*	*Disturbances and tracking systems*	*Design Examples: the pseudo quantitative feedback system*	*Design Examples-Linear Harmonic Oscillator*
S-9	SLO-1	*System design using control design software*	*Computation of the State Transition Matrix by Sylvester's method*	*Design Examples-Automatic test system*	*Robust Control Systems using Control design software*	*Design Examples-Non-Linear Spring mass system with Damper*
	SLO-2	*Sequential design of disk drive read system*	*Transfer Function from the State-Model*	*Diesel Electric Locomotive control system*	*Sequential design of disk drive read system*	*Design Example-Pendulum with and without friction*

Learning Resources	1. *Richard C. Dorf and Robert H. Bishop, Modern Control Systems, Prentice Hall, Upper Saddle River, NJ, 2001* 2. *Katsuhiko Ogata, Discrete Time Control Systems, Pearson* 3. *Gene F.Franklin, J.David Powell, Abbas Emami, Feedback Control of Dynamic Systems, Naeini, Pearson*	4. *Bernard Friedland, Control System Design: An Introduction to State-Space Methods (Dover Books on Electrical Engineering), Dover Publications Inc., 2005.* 5. *Steen Toffner-Clausen, System Identification and Robust Control, Springer Verlag London Limited 1996.* 6. *R.M.Murray, Z.Li, S.S.Sastry, A Mathematical Introduction to Robotic Manipulations, CRC Press, 1993.* 7. *http://nptel.ac.in/courses/108103007/16*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Sharon Ravichandran, ABB Ltd., Chennai,sharonravi87@gmail.com	*1.Dr. P. Lakshmi, Anna University, Madras,p_lakshmi@annauniv.edu*	*1.Ms. T.M. Thamizh Thentral, SRMIST*
2.Ms. Vijayalakshmi Ramani, Head-Engineering at C2C Engineering, Chennai, vijayalakshmi@c2cengineering.co.in	*2.Dr.S.K.Patnaik, CEG, Anna University, skpatnaik@annauniv.edu*	*2. Ms. R. Rajarajeswari, SRMIST*

Course Code	18EEE415T	Course Name	DIGITAL CONTROL SYSTEM	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18EEC301J	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Enrich the students on the basics of time domain analysis*			
CLR-2 :	*Explain the procedure for stability analysis*			
CLR-3 :	*Outline the concepts of state space model, controllability and observability*			
CLR-4 :	*Gain knowledge on the design of classical compensators*			
CLR-5 :	*Understand the concepts of formulation and evaluation of regulators and filters*			
CLR-6 :	*Create overall control system structure for industrial applications*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Gain knowledge on Z transform techniques*	*2*	*80*	*75*	*H*	*M*	*M*	-	-	-	-	-	-	-	-	-	*H*	*M*	-
CLO-2 :	*Interpret the knowledge of sampling and design of controllers*	*3*	*80*	*75*	*H*	*M*	*M*	*M*	*M*	-	-	-	-	-	-	-	*M*	*M*	-
CLO-3 :	*Illustrate modelling and state variable analysis*	*3*	*80*	*75*	*H*	*M*	*M*	*M*	-	-	-	-	-	-	-	-	*H*	*M*	-
CLO-4 :	*Analyze the effects of compensators*	*3*	*80*	*75*	*H*	*M*	*M*	*M*	*M*	-	-	-	-	-	-	-	*H*	*H*	-
CLO-5 :	*Design of regulators and filters for practical system*	*3*	*80*	*75*	*H*	*M*	*M*	*M*	-	-	-	-	-	-	-	-	*H*	*M*	-
CLO-6 :	*Design a control system and analyze the stability of the real time system*	*3*	*80*	*75*	*H*	*M*	*M*	*M*	*M*	-	-	-	-	-	-	-	*H*	*M*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basic components of a control system*	*Introduction to sampling*	*Introduction to state variable model*	*Compensator design*	*Introduction- Pole placement*
	SLO-2	*Classification of control systems*	*Sampled data control systems*	*State variable concepts, First , second companion forms*	*Compensating networks types: Cascade and feedback*	*State observers*
S-2	SLO-1	*Elements of an automatic control system*	*Sampled signal flow graph*	*Various canonical forms*	*Cascade Lead compensator design using Bode plot*	*Controller Design by State Feedback*
	SLO-2	*Applications of control system*	*Sampling time and frequency domain description aliasing, hold operation,*	*Jordan canonical models*	*Problems related to lead compensators*	*Stability improvement by state feedback*
S-3	SLO-1	*Introduction to Z-transform*	*Mathematical modeling of sampling process and analysis*	*Analysis-state space models*	*Cascade Lag compensator design using Bode plot*	*Necessary and sufficient condition for arbitrary pole placement*
	SLO-2	*Z-transform Concept*	*First order hold, factors limiting the choice of sampling rate, reconstruction.*	*Problems related to state space model*	*Problems related to lag compensators*	*State regulator design*
S-4	SLO-1	*Properties of Z-transform*	*Sampling and reconstruction of continuous time signals*	*Discrete state variable models*	*Problems related to lead- lag compensators*	*Design of state observers*
	SLO-2	*Z-transform relation with Laplace transform*	*Stability analysis of discrete system*	*Elementary principles.*	*Digital implementation of lead and lag controllers*	*Full Order Observer Design*
S-5	SLO-1	*Inverse z-Transforms and Problems*	*Jury stability test*	*Characteristic equation, state transition matrix*	*Design of digital control systems with deadbeat response*	*Reduced Order Observer Design*
	SLO-2	*Mapping of s-plane to z-plane*	*Bi-linear transformation*	*Solution to discrete state equation*	*Practical issues with deadbeat response design*	*Evaluation of State Feedback Gain Matrix*
S-6	SLO-1	*Pulse transfer function*	*Problems related to stability analysis*	*Stability of discrete state space models*	*Sampled data control systems with*	*State feedback with integral control*

					deadbeat response	
	SLO-2	*Pulse transfer function of closed loop system*	*Digital PID controllers.*	*Cayley -Hamilton theorem*	*Introduction to software tools used in control system for compensator design*	*Digital control system with state feedback.*
S-7	SLO-1	*Introduction to the representation of discrete time systems*	*PID tuning and its importance*	*Controllability and observability*	*Coding in simulation software*	*Linear Quadratic Regulator (LQR) design*
	SLO-2	*Time response of discrete time systems*	*Techniques of controller tuning*	*Analysis of Controllability and observability*	*Exercises for solving problems related to compensators design*	*Formulation of LQR problem-*
S-8	SLO-1	*Time response specifications*	*Manual tuning Zeigler-Nichols method based on open loop and closed loop responses*	*Stability- Lyapunov stability theorem*	*Software implementation using microprocessors and microcontrollers*	*Optimal estimation- Kalman filter*
	SLO-2	*Application of the z transform for discrete time signals and systems.*	*Application of controllers used for control system*	*Analysis of Lyapunov stability*	*Microcontroller based temperature control systems*	*Solution to continuous and discrete systems - Design examples.*
S-9	SLO-1	*Problems related to time response for standard test signals*	*Controller design using root locus*	*Systems with dead time*	*Speed control of motor load system*	*Introduction to optimal control*
	SLO-2	*Problems related to time domain specifications*	*Root locus based controller design using software tools*	*Problems related to controllability and observability*	*Microcontroller based motor speed control systems.*	*Parameter optimization*

Learning Resources	1. *B. C. Kuo, Digital Control Systems, Oxford University Press, 2/e, Indian Edition, 2012.* 2. *Richard C Dorf and Robert H Bishop, Modern Control Systems, 13th edition, Pearson Education, 2016.*	3. *M. Gopal, Digital Control and State Variable Methods, Tata Mcgraw Hill, 2/e, 2017.* 4. *Norman S Nise, Control Systems Engineering, 7th edition, Wiley, 2015.* 5. *https://nptel.ac.in/courses/108103008/*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Dr. Sharon Ravichandran, ABB Ltd., Chennai,sharonravi87@gmail.com*	1. *Mr.P.Thamizhazhagan, Associate Professor, University college of Engineering, Panruti,thamizhme@gmail.com*	1. *Ms.A.Lavanya SRMIST*
2. *Mr.Jason Manoraj , L&T Technology Services Limited, Bengaluru, Karnataka, jasonmanoraj@gmail.com*	2. *Dr. B. K. Panigrahi, IIT Delhi, bkpanigrahi@ee.iitd.ac.in*	2. *Dr. Raja Vikram SRMIST*

Course Code	18EEE321T	Course Name	PHOTONICS	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 :	*Introduce the basics principles of photonics*
CLR-2 :	*Solve the various problems in Light beams and Variable polarization*
CLR-3 :	*Analyze the performance of surface and cavity nanophononics*
CLR-4 :	*Understand the process and performance of Multiphoton*
CLR-5 :	*Analyze the basics of Electromagnetic duality, Slow and fast light principles*
CLR-6 :	*Create a over all structure for Photonics system*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Understand the basics of photonics principles*	2	80	75	H	-	-	-	-	-	-	-	-	-	-	-	M	M	-
CLO-2 :	*Calculate the parameters of Light beams and Variable polarization*	2	80	75	H	-	-	-	-	-	-	-	-	-	-	-	M	M	-
CLO-3 :	*Compute the performance of surface and cavity nanophononics*	2	80	75	H	-	-	-	-	-	-	-	-	-	-	-	M	M	-
CLO-4 :	*Acquire knowledge on Multiphoton process*	2	80	75	H	-	-	-	-	-	-	-	-	-	-	-	H	H	-
CLO-5 :	*Identify the solutions for slow and fast light*	2	80	75	H	-	-	-	-	-	-	-	-	-	-	-	M	M	-
CLO-6 :	*Design a Photonics system for Real Time Applications*	2	80	75	H	-	-	-	-	-	-	-	-	-	-	-	M	M	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Photon in Perspective*	*Light Beams with Spatially Variable Polarization*	*Surface and Cavity Nanophononics*	*Multiphoton Processes*	*Lighting Principles*
	SLO-2	*Photon Localization*	*Poincare Modes of Beams*	*Basic Formalism*	*Molecular Two-Photon Absorption: Basic Principles*	*Introduction to Slow and Fast Light*
S-2	SLO-1	*Wavefunction*	*Polarization Singularities*	*Dipole Emitter Near Edge*	*Molecular Two-Photon Fluorescence*	*Mechanisms of Slow Light*
	SLO-2	*The Quantum Vacuum*	*Quantum Optics*	*Quantum Correlations*	*Applications and Future Prospects*	*Physics with Slow and Fast Light*
S-3	SLO-1	*Virtual Photons*	*Open Systems: Inputs and Outputs*	*Entanglement*	*Orbital Angular Momentum*	*Some Applications of Slow and Fast Light*
	SLO-2	*Structured Light*	*Photon Counting*	*Wedge Cavities*	*Historical Introduction*	*Fundamental Limits on Slow Light*
S-4	SLO-1	*Photon Number Fluctuations*	*Cavity*	*Quantum Electrodynamics*	*Creating Beams with OAM*	*Attosecond Physics*
	SLO-2	*Photon Number Phase*	*Circuit QED*	*Molecular QED: Principle of Minimal Electromagnetic Coupling*	*Micro-Manipulation through the Use of OAM*	*Attosecond Streaking Spectroscopy of Atoms and Solids*
S-5	SLO-1	*The Reality of Photonics*	*Squeezed Light*	*Multipolar Hamiltonian*	*Beam Transformations*	*Time-Resolved Photoemission from Atoms*
	SLO-2	*Coherence and Statistical Optics*	*Salient Features of Squeezed States*	*One-Photon Absorption*	*Measuring Beams with OAM*	*Streaked Photoemission from Solids*
S-6	SLO-1	*Classical Theory of Optical Coherence in the Space-Time Domain*	*Detection*	*Emission of Light: Spontaneous and Stimulated Processes*	*OAM in Classical Imaging*	*Attosecond Streaking from Nanostructures*
	SLO-2	*Classical Theory of Optical Coherence in the Space-Frequency Domain*	*Preparation*	*Linear Light-Scattering:*	*OAM in Nonlinear and Quantum Optics*	*Attosecond Physics*
S-7	SLO-1	*Cross-Spectrally Pure Optical Fields*	*Applications in Quantum Information*	*The Kramers–Heisenberg Dispersion Formula*	*Electromagnetic Duality Transformations in Optics*	*Attosecond Streaking Spectroscopy of Atoms and Solids*

	SLO-2	*Polarization Properties of Stochastic Beams*	*Electromagnetic Theory of Materials*	*Chiroptical Effects*	*Symmetries and Operators*	*Attosecond Streaking Spectroscopy of Solids*
S-8	SLO-1	*Remarks on Partially Coherent*	*Macroscopic Viewpoint*	*Two-Photon Absorption*	*Electromagnetic Duality*	*Introduction to Photoemission*
	SLO-2	*Partially Polarized*	*Constitutive Dyadic*	*Nonlinear Light-Scattering: Sum-Frequency and Harmonic Generation*	*Optical Helicity*	*Time-Resolved Photoemission from Atoms*
S-9	SLO-1	*Beams Basics of Quantum Theory of Optical Coherence*	*Linear Materials*	*Resonance Energy Transfer*	*Electromagnetic Duality Symmetry*	*Streaked Photoemission from Solids*
	SLO-2	*Polarization of singularities*	*Nonlinear Materials*	*Van der Waals Dispersion Energy*	*Duality Symmetry in Piecewise Homogeneous and Isotropic Media*	*Attosecond Streaking from Nanostructures*

Learning Resources	1. *David L. Andrews, Photonics, Volume 1: Fundamentals of Photonics and Physics, Wiley, 2015.* 2. *Lasers-Theory and Applications- Ghatak and Thyagarajan, McMillan (2010)* 3. *Optoelectronic devices and systems- S C Gupta ,Prentice Hall India (2008)* 4. *Understanding Fiber optics- J Hecht, Pearson Edu. Inc (2006)*	5. *Light Emitting Diodes-E Fred Scheubert ,Cambridge University Press,(2003)* 6. *Photonic switching technology - H T Mouftah, J M H Elmirghani - IEE Press (1999).* 7. *Online Course: IITM-NPTEL – Introduction to Photonics. https://nptel.ac.in/courses/108106135/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Danrajpurkar, Founder, Danano Photonics, Bengaluru, dananophotonics.com	*1.Dr.S.Selladurai, Physics, CEG, Anna University, ssdurai@annauniv.edu*	*1.Dr.Junaid masud lascar, SRMIST*
2.Mr.Satish Bhaker, Director, Sun Photonics, Newdelhi, info@sun-photonics.com	*2.Dr.A.Mujeeb, International School of Photonics, CUSAT,mujeeb@cusat.ac.in*	*2.S.Senthilmurugan, SRMIST*

Course Code	18EEE322T	Course Name	PRINCIPLES OF BIOMEDICAL INSTRUMENTATION	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Understand the physiological system of the body*			
CLR-2 :	*Have an in depth knowledge on the devices for physiological process measurements in the human body*			
CLR-3 :	*Acquire knowledge on the measurement of non-electrical parameters in the human body*			
CLR-4 :	*Enrich the students on the basic concepts of medical imaging, telemetry techniques and their applications*			
CLR-5 :	*Expose the students to medical assisting and therapy equipments*			
CLR-6 :	*Create overall structure of biomedical instrumentation starting from physiological system to measurements and assisting equipments*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Program Learning Outcomes (PLO)														
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
					Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Explain the various systems of the human body*	*1*	*80*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	*M*	-
CLO-2 :	*Use electrodes and transducers for physiological process measurements in the human body*	*2*	*80*	*75*	*H*	-	-	-	-	-	-	*L*	-	-	-	-	*M*	*M*	*L*
CLO-3 :	*Measure the non-electrical quantities of the human body*	*2*	*80*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-4 :	*Recognize the applications of medical imaging and telemetry techniques*	*2*	*80*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-5 :	*Relate the medical assisting and therapy equipments*	*2*	*80*	*75*	*H*	-	-	-	-	-	-	*L*	-	-	-	-	*H*	*M*	*L*
CLO-6 :	*Identify the physiological systems of the body along with various measurements and assisting equipments*	*2*	*80*	*75*	*H*	-	-	-	-	-	-	*L*	-	-	-	-	*M*	*M*	*L*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Physiological systems of the body*	*Electrode theory*	*Measurement of blood pressure- direct method*	*X-ray machine*	*Need for Cardiac pacemakers*
	SLO-2	*Cells and their structure*	*Needle and wire electrode*	*Measurement of blood pressure-indirect method*	*Physical parameters for X- ray detectors*	*External pacemakers: Types: Vetricular asynchronous , synchronous and inhibited pacemaker*
S-2	SLO-1	*Characteristics of living organisms*	*Surface and micro electrode*	*Introduction to the measurement of blood flow*	*Digital radiography*	*Atrial synchronous and sequential ventricular inhibited pacemaker*
	SLO-2	*General characteristics of a human cell*	*Metal micropipette electrode*	*Electromagnetic blood flow meter*	*Diagnostic ultrasound*	*Implantable pacemaker*
S-3	SLO-1	*Nernst equation*	*Resistive transducers, thermistor, strain gauge*	*Ultra sound blood flow meter*	*Echocardiography*	*Need for defibrillator*
	SLO-2	*Bioelectric potential*	*Inductive and capacitive transducer*	*Laser Doppler blood flow meter*	*Computer tomography*	*DC defibrillator*
S-4	SLO-1	*Electrical characteristics of the human cell*	*Basic recording system, direct writing recorder, Ink jet recorder*	*Dye dilution method of cardiac output measuring techniques*	*CT system components*	*Implantable defibrillator*
	SLO-2	*Bioelectric potential propagation*	*Potentiometric recorder , Digital recorder and instrumentation type recorder*	*Thermal dilution method of cardiac output measuring techniques*	*Patient dose in CT Scanners*	*Mechanics of respiration*
S-5	SLO-1	*Cardiovascular system*	*Lead system of electrocardiogram*	*Heart rate measurement*	*Principles of Magnetic resonance Imaging systems*	*Artificial ventilation*
	SLO-2	*Blood circulation*	*Standard bipolar leads and unipolar leads*	*Measurement of heart sounds*	*Basic MRI components*	*Types of ventilators: Pressure limited ventilator*
S-6	SLO-1	*Heart and its mechanical activities*	*Recording methods of electrocardiogram*	*Gas analysers*	*Image reconstruction techniques*	*Volume limited and servo controlled vetilators*

	SLO-2	*Electrical potentials generated within the heart*	*Typical waveforms of electrocardiogram*	*Blood gas analyser*	*Position Emission Tomography*	*Pressure volume flow diagram*
S-7	SLO-1	*Physiology of the respiratory system*	*Electromyography*	*Oximetry*	*Single Photon Emission Computed Tomography*	*Kidney machine, Artificial kidney*
	SLO-2	*Respiratory volumes and capacities*	*Measurement of conduction velocity*	*Ear oximeter*	*Thermography*	*Dialyzers, Types: Parallel flow dialyzer*
S-8	SLO-1	*Anatomy of the nervous system*	*Electroretinography*	*Pluse oximeter*	*Biotelemetry*	*Coil hemodialyzer, Hollw fiber hemodialyzer*
	SLO-2	*Excitation and inhibition potentials*	*Electrogastrography*	*Skin reflection oximeter*	*Wireless telemetry*	*Diathermy*
S-9	SLO-1	*Muscle action*	*Electroculography*	*Spirometry*	*Single channel telemetry system*	*Endoscopes*
	SLO-2	*Sensory system*	*Pneumotachography*	*Measurement of lung volume*	*Multichannel wireless telemetry system*	*Lasers in biomedical field*

Learning Resources	1. *Leslie Cromwell, Fred. J,Weibell and Ench APleiffer, Biomedical Instrumentation and measurements Prentice Hall of India, 2nd ed., 2004* 2. *Kandpur R.S, Handbook of Biomedical Instrumentation, Tata McGraw Hill, 2nd ed., 2011*	3. *C.Raja Roa & .K Guha, Principles of medical electronics and biomedical instrumentation, Universities press,2001* 4. *G.Webster, Medical Instrumentation Application and Design, 3rd ed., Wiley India edition, 2009.* 5. *https://swayam.gov.in/nd1_noc19_bt28/preview ,NPTEL Online Course-Bioelectricity*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr.Manjunath rao, Alstrom,manjunath.rao1103@gmail.com*	1. *Dr Subhransu Sekhar Dash, Government College of Engineering, Keonjhar, Subhransudash_fee@gcekjr.ac.in*	1. *Dr.Y.Jeyashree, SRMIST*
2. *Mr.Srinath rao, Alstrom,sreenathr.rao@alstrom.com*	2. *Dr. S. Ramareddy, Jerusalem College of Engineering,srr.victory@gmail.com*	2. *Mrs. R.Uthra, SRMIST*

Course Code	18EEE323T	Course Name	AUTOMOTIVE ELECTRONICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Enrich the students on the basics of batteries*			
CLR-2 :	*Understand the concepts of battery starting system*			
CLR-3 :	*Introduce the different methods of charging systems for batteries*			
CLR-4 :	*Learn the fundamentals of Automotive Electronic devices*			
CLR-5 :	*Understand different sensors and actuators used in automotive systems*			
CLR-6 :	*Get idea about real time automotive electronic systems*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Analyze the concept of batteries & it's working*	*3*	*80*	*75*	*H*	*M*	*M*	*M*	-	-	-	-	-	-	-	-	*M*	*L*	-
CLO-2 :	*Gain knowledge on the concepts of battery starting system*	*2*	*80*	*75*	*H*	*M*	*M*	*L*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-3 :	*Familiarize the principles of charging system for batteries*	*2*	*80*	*75*	*H*	*M*	*L*	*L*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-4 :	*Acquire knowledge on automotive Electronics*	*2*	*80*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-5 :	*Enhance the use of sensors and actuators in the field of automotive systems*	*2*	*80*	*75*	*H*	*M*	*M*	*L*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-6 :	*Apply the idea in real time automotive electronics*	*3*	*80*	*75*	*H*	*M*	*M*	*L*	-	-	-	-	-	-	-	-	*M*	*M*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Batteries and Accessories : Principle of lead acid battery*	*Starting System- introduction*	*Charging System - introduction*	*Introduction to Automotive Electronics*	*Sensors*
	SLO-2	*Batteries and Accessories : construction of lead acid battery*	*Starting System - Condition at starting*	*Charging System - Generation of direct current*	*Fundamentals of Automotive Electronics*	*Activators*
S-2	SLO-1	*Characteristics of battery*	*Behaviour of starter during starting*	*Evaluating state of battery health*	*Current trends in automotive electronic engine management system*	*Sensors- introduction*
	SLO-2	*Rating capacity and efficiency of batteries*	*Advantages and disadvantages*	*Fundamental in battery testing*	*Electric power Braking systems*	*Types of sensors: sensor for speed*
S-3	SLO-1	*Various tests on batteries*	*Series motor and its characteristics for starting system*	*Battery testing - Capacity*	*Electromagnetic interference suppression*	*Throttle position*
	SLO-2	*Visual inspection and voltage testing*	*Shunt motor and its characteristics for starting system*	*Battery testing – internal resistance*	*Electromagnetic compatibility*	*Exhaust oxygen level*
S-4	SLO-1	*Lighting system: insulated and earth return system*	*Principle and construction of starter motor*	*Battery testing – self discharging quantity*	*Electronic dashboard instruments*	*Manifold pressure*
	SLO-2	*Vehicle circuits and systems*	*Cranking motor construction*	*Factors for degradation and ageing process*	*Onboard diagnostic system*	*Crankshaft position*
S-5	SLO-1	*Earthing system: Types*	*Working of different starter drive units*	*Measurement methods of battery*	*Security and warning system*	*Coolant temperature*
	SLO-2	*Head light and side light*	*Care and maintenances of starter motor*	*Direct measurement method*	*Nano-electromechanical devices*	*Exhaust temperature*
S-6	SLO-1	*LED lighting system*	*Starter switches*	*Indirect measurement method*	*Engine Ignition*	*Air mass flow for engine application*
	SLO-2	*Control of LED lighting system*	*Optoelectronic devices- solar cells*	*Battery Maintenance*	*Fuel Injection*	*Solenoids*
S-7	SLO-1	*Horn system*	*Photodiodes*	*New developments on battery charging system*	*Collision Avoidance Systems*	*Various types of electric motors*

	SLO-2	*Wiper system and trafficator*	*Laser Diodes*	*Rate of charging*	*Safety Controls*	*Piezoelectric force generators*
S-8	SLO-1	*Maintenance on batteries*	*Light Absorption and Emission*	*Depth of charging*	*Security Alarms*	*Automatic transmission control systems*
	SLO-2	*Charging on batteries*	*Optical Fiber*	*Depth of discharging*	*Transmission Controls*	*Stepper motors*
S-9	SLO-1	*Health monitoring of batteries*	*Surface-Emitting Lasers*	*SoC and SoH*	*Navigation System*	*Relays- Types*
	SLO-2	*Battery monitoring methods*	*Array Lasers*	*Downfall modes*	*Applications of Automotive Electronics*	*Thermal Relay*

Learning Resources	1. *William B. Ribbens, Understanding Automotive Electronics, 5th Edition, Butterworth, Heinemann Woburn, 2009.* 2. *Tom Denton, Automobile Electrical and Electronics System, Elsevier, Third Edition, 2008.* 3. *Judge. A.W., Modern Electrical Equipment of Automobiles, Chapman & Hall, London, 2010.*	4. *Judge. A.W., Modern Electrical Equipment of Automobiles, Chapman & Hall, 2nd Edition London, 1992.* 5. *Vinal. G.W., Storage Batteries, John Wiley & Sons Inc., 4th Edition New York, 1985.* 6. *https://onlinecourses-archive.nptel.ac.in/.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Muralikrishna, National Instruments, emkkrishnan@gmail.com	*1. Dr. M.P.Selvan, NIT Trichy, selvanmp@nitt.edu*	*1. Mr.R.Palanisamy, SRMIST*
2. Mr.Senthilkumar,ATI,rskrd1962@gmail.com	*2. A. Venkadesan, NIT Puducherry, venkadesan@nitpy.ac.in*	*2. Dr.C.Subramani, SRMIST*

Course Code	18EEE324T	Course Name	ANALOG AND DIGITAL COMMUNICATION	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	i		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Understand various analog Communication techniques.*			
CLR-2 :	*Impart knowledge on data and pulse Communication techniques.*			
CLR-3 :	*Explain various digital Communication techniques*			
CLR-4 :	*Illustrate source and Error control coding*			
CLR-5 :	*Gain knowledge on multi-user radio Communication*			
CLR-6 :	*Apply the analog and digital Communication concepts in Communication industries*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Gain knowledge on basics of analog Communication techniques*	*2*	*80*	*75*
CLO-2 :	*Analyze data and pulse Communication techniques*	*2*	*80*	*75*
CLO-3 :	*Summarize digital Communication techniques*	*2*	*80*	*75*
CLO-4 :	*Interpret Source and Error control coding.*	*2*	*80*	*75*
CLO-5 :	*Understand multi-user radio Communication*	*3*	*80*	*75*
CLO-6 :	*Acquire the overall knowledge on analog and digital Communication*	*3*	*80*	*75*

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
H	*M*	*M*	-	-	-	-	-	-	*M*	-	-	*L*	-	-
H	*M*	*M*	*L*	-	-	-	*L*	-	*M*	-	-	-	*L*	*L*
H	*L*	-	-	-	-	-	-	-	*M*	-	-	-	-	-
H	*M*	*M*	*L*	-	-	-	*L*	-	*M*	-	-	*L*	*L*	*L*
H	*L*	-	-	-	-	-	-	-	*L*	-	-	-	-	-
H	*H*	*M*	*L*	-	-	-	*L*	-	*M*	-	-	*L*	*L*	*L*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Analog Communication:Introduction to Fourier Series*	*Pulse and data Communication:Introduction to Pulse Communication*	*Digital Communication:Introduction to digital Communication*	*Source coding and Error Control Coding: Introduction to coding*	*Multi-user radio Communication: Global System for Mobile Communications (GSM)*
	SLO-2	*Fourier Series Properties and applications*	*Introduction to Data Communication*	*Analog Communications versus digital Communications*	*Entropy and Properties of coding*	*Overview of GSM*
S-2	SLO-1	*Introduction to Fourier Transform*	*Pulse Amplitude Modulation (PAM)*	*Conversion of analog signal to digital form*	*Binary Symmetric Channel*	*Code division multiple access (CDMA)*
	SLO-2	*Fourier Transform properties*	*Pulse Time Modulation (PTM)*	*Baseband signal, band pass signal*	*Binary Erase Channel*	*Overview of CDMA*
S-3	SLO-1	*Modulation – Types*	*Pulse code Modulation (PCM)*	*Digital Communication systems – Functional description*	*Source Coding Theorem*	*Cellular Concept*
	SLO-2	*Need for Modulation*	*Differential pulse code modulation*	*Block diagram of digital Communications*	*Lossless data Compression Algorithms*	*Frequency Reuse*
S-4	SLO-1	*Noise: Source of Noise*	*Pulse position modulation(PPM)*	*Signal processing operations in digital Communications*	*Shannon fano coding*	*Channel Assignment*
	SLO-2	*External Noise, Internal Noise*	*Comparison of various Pulse Communication System (PAM – PTM– PCM)*	*Quantitative analysis of modulation schemes*	*Huffman Coding*	*Handover Techniques*
S-5	SLO-1	*Amplitude Modulation Theory*	*Data Communication: Introduction to Data Communication*	*Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK)*	*Algorithm and Problem in Shannon fano coding*	*Overview of Multiple Access Schemes*
	SLO-2	*Frequency spectrum of AM wave*	*History of Data Communication*	*Phase Shift Keying (PSK)*	*Algorithm and Problem in Huffman Coding*	*Types of Multiple access*

S-6	SLO-1	*Double Sideband (DSB) Suppressed Carrier (SC)*	*Standards Organizations for Data Communication*	*BPSK*	*Error Control Coding*	*IEEE802.11: Wireless LANs Using CSMA/CA*
	SLO-2	*Conventional AM*	*Data Communication Circuits*	*QPSK*	*Error detection*	*WLAN Fundamentals*
S-7	SLO-1	*Single Sideband Modulation (SSB)*	*Data Communication codes*	*Principles of MSK*	*Parity*	*Cellular Digital Packet Network*
	SLO-2	*Vestigial Sideband (VSB) Modulation*	*Error Control, Hardware*	*Principles of QAM*	*Redundancy*	*Overview of cellular digital packet network*
S-8	SLO-1	*Quadrature Amplitude Modulation*	*Serial Interfaces*	*Quadrature Amplitude Modulation (QAM) – 8 QAM*	*Error correction*	*Satellite Communication*
	SLO-2	*Concept synthesis for AM*	*Parallel interfaces*	*Quadrature Amplitude Modulation (QAM) -16 QAM*	*Forward Error Correction*	*Satellite Networking*
S-9	SLO-1	*Theory of Frequency and Phase Modulation*	*Data Modems – Asynchronous Modem*	*Bandwidth Efficiency*	*Application, Convolution Codes*	*Bluetooth*
	SLO-2	*Comparison of Analog Communication Systems (AM – FM – PM)*	*Synchronous Modem*	*Comparison of various Digital Communication System (ASK – FSK – PSK – QAM)*	*Block Codes*	*Bluetooth Applications*

Learning Resources	1. *Wayne Tomasi, Advanced Electronic Communication Systems, 6th Edition, Pearson Education, 2009* 2. *Simon Haykin and Michael Moher, Communication Systems, 5th Edition, John Wiley and Sons, Inc., New York, 2009*	3. *Blake, Electronic Communication Systems, Thomson Delmar Publications, 2002.* 4. *Martin S. Roden, Analog and Digital Communication System, 3rd Edition, PHI, 2002* 5. *https://nptel.ac.in/courses/117105143/* 6. *https://nptel.ac.in/courses/117105144/*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Senthilkumar,ATI,rskrd1962@gmail.com	*1.Dr. B. K. Panigrahi, IIT Delhi, bkpanigrahi@ee.iitd.ac.in*	*1.Mr. D. Selvabharathi, SRMIST*
2.Mr.Muralikrishna, National Instruments, emkkrishnan@gmail.com	*2.Dr. S. Ramareddy, Jerusalem College of Engineering,srr.victory@gmail.com*	*2.Dr. M. Jagabar Sathik, SRMIST*

Course Code	18EEE325T	Course Name	WAVELET TRANSFORM	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 :	*Introduce the learners to wavelets- its relevant fundamentals and significance*
CLR-2 :	*Establish the theory behind construction of wavelets using software tools*
CLR-3 :	*Gain knowledge on the details of discrete wavelet transform*
CLR-4 :	*Expose the students to the conceptual aspect of multi resolution analysis*
CLR-5 :	*Illustrate data compression /extraction and signal processing applications using wavelet transform*
CLR-6 :	*Introduce wavelet functions, the advancements in technology and applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Understand the theory and mathematics behind wavelet transform*	*1*	*75*	*75*
CLO-2 :	*Apply the coding for construction of Daubechies and other wavelet functions*	*2*	*75*	*75*
CLO-3 :	*Analyze use of wavelets and discrete wavelet transform for filter bank design.*	*2*	*75*	*75*
CLO-4 :	*Analyze use of wavelets for filter design and multi resolution analysis*	*2*	*75*	*75*
CLO-5 :	*Use software for various wavelet transform based applications*	*3*	*75*	*75*
CLO-6 :	*Evaluate existing and new wavelet transform based applications*	*3*	*75*	*75*

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*H*		-	-	-	-	-	-	-	-	-	-	*M*	-	-
CLO-2 :	*H*	*M*	*L*	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-3 :	*H*	*M*	*L*	-	*M*	-	-	-	-	-	-	-	*M*	*M*	-
CLO-4 :	*H*	*M*	*L*	-	*M*	-	-	-	-	-	-	-	*M*	*M*	-
CLO-5 :	*H*	*M*	*L*	-	*M*	-	-	-	-	-	-	-	*H*	*H*	-
CLO-6 :	*H*	*M*	*L*	-	*M*	-	-	-	-	-	-	-	*H*	*H*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Wavelets- General introduction*	*Construction of wavelets*	*Discrete wavelet transform(DWT) for filter design*	*Multi resolution analysis (MRA) - Formal definition*	*Audio compression – Audio masking*
	SLO-2	*Fields of applications, Heisenberg's un certainty*	*Relationship between two scale sequences*	*Signal decomposition- Analysis*	*Need for multi resolution based image analysis*	*Standards specifying sub band implementation*
S-2	SLO-1	*Classical wavelets, Wavelet packets, Local trigonometric bases, Multiwavelets, 2G Wavelets*	*Relationship between reconstruction and decomposition sequences*	*Filtering /Frequency response*	*Multi resolution spaces*	*Image compression*
	SLO-2	*Gaussian, Morlet, Daubechies, Mexican Hat, Symlets, Coiflets, Complex, Biorthogonal spline wavelets.*	*Construction of semi orthogonal spline wavelets*	*Decimation (Down sampling)*	*Orthogonal decomposition*	*The JPEG standard (ITU - T.81)*
S-3	SLO-1	*Wavelet transform – Translation*	*Construction of ortho- normal wavelets*	*Signal reconstruction- Synthesis*	*Bi orthogonal and Semi orthogonal decompostion*	*Spatial oriented tree (SOT) code and Generalized self-similarity tree (GST)*
	SLO-2	*Wavelet transform -Scaling and Shifting Operation*	*Shannon scaling function*	*Filtering and Stretching (Up sampling)*	*Two scale relations*	*Embedded zero tree wavelet (EZW) code*
S-4	SLO-1	*Continuous wavelet transform*	*Meyer scaling function*	*Computing input co- efficient*	*A wavelet basis for MRA*	*Huffman code*
	SLO-2	*Discrete wavelet transform*	*Battle- Lemarie scaling function*	*Lattices and Lifting*	*Functional subspace relation between scaling and wavelet functions*	*Run length encoding*
S-5	SLO-1	*Mathematical prelude – Fourier transform*	*Daubechies scaling function*	*Vanishing moments*	*Scaled and translated version of wavelet functions*	*Set partitioning in hierarchical tree (SPIHT)*
	SLO-2	*Parseval Plancherel theorem, Convolution, Dilation and its inverse…*	*Graphical display – Iteration method*	*Perfect reconstruction filter banks- Introduction*	*Wavelet series*	*Embedded block coding with optimized truncation (EBCOT)*

S-6	SLO-1	*Continuous time frequency representation of signals*	*Spectrum method*	*Spectral domain analysis of a 2 channel PR filter bank*	*PR banks- Coding tutorial - I*	*Médical Imaging*
	SLO-2	*The windowed Fourier transform*	*Eigen value method*	*Analysis and Synthesis*	*PR banks- Coding practice exercises-I*	*Other applications*
S-7	SLO-1	*Signal spaces*	*Daubechies wavelet construction-Coding tutorial - I*	*Quadrature mirror filter (QMF) approach*	*PR banks- Coding tutorial - II*	*Audio compression -Simulation using software tools – Tutorial*
	SLO-2	*Ortho-gonality and Ortho-normality in brief*	*Coding practice exercises*	*Half band filter (HBF) approach*	*PR banks- Coding practice exercises*	*Audio compression -Simulation using software tools – Practice*
S-8	SLO-1	*Haar wavelet and scaling function*	*Daubechies wavelet construction-Coding tutorial- II*	*Time domain analysis*	*PR banks- Coding tutorial - III*	*Image compression -Simulation using software tools – Tutorial*
	SLO-2	*Triangle scaling function*	*Coding practice exercises*	*PR filter requirements*	*PR banks- Coding practice exercises*	*Image compression -Simulation using software tools – Practice*
S-9	SLO-1	*Short time Fourier transform -Coding tutorial*	*Daubechies wavelet construction-Coding tutorial- III*	*Bi-orthogonal filter bank*	*PR banks- Coding practice tutorial- IV*	*Image compression -Simulation using software tools – Tutorial*
	SLO-2	*Coding practice exercises*	*Coding practice exercises*	*Simple problems(Qualitative) for practice*	*PR banks- Coding practice exercises*	*Image compression -Simulation using software tools – Practice*

Learning Resources	1. *K. P. Soman, K. I. Ramachandran ,N. G. Resmi, Insights Into Wavelets: From Theory to Practice, Third edition, PHI Learning Pvt. Ltd. 2010.* 2. *J. C. Goswami and A. K. Chan, Fundamentals of Wavelets: Theory, Algorithms and Applications, John Wiley and Sons, 2011.*	3. *Raguveer M Rao and Ajit S Bopardikar, Wavelet Transforms – Introduction and Applications, Pearson Education, 2008 S. Burns, A Ramesh, A Gopinath and Haitao Guo, Introduction to Wavelets and Wavelet Transform, Prentice Hall Inc.1998.* 4. *https://nptel.ac.in/courses/103106114/48*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Dr. S. Paramasivam, Danfoss Industries Pvt. Ltd, paramsathya@yahoo.com	*1.Dr R. Selvarasu, Adama Science and Technology University, Ethiopia, selvarasunaveen@gmail.com*	*1.Ms K Subha Sharmini, SRMIST*
2.Mr.Ravikumar A R, PayPal,ravikumar.venkataramani@gmail.com	*1.Dr A. Venkadesan, NIT,Pudhucherry, Karaikkal, venkadesan@nitpy.ac.in, avenkyeee@gmail.com*	*2.Dr K Mohanraj, SRMIST*

Course Code	18EEE326T	Course Name	ADVANCED CMOS DEVICES AND TECHNOLOGY	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 :	*Enrich the students to have basic knowledge in CMOS technology and scaling*
CLR-2 :	*Upgrade the students with the knowledge on design of CMOS devices*
CLR-3 :	*Buildup knowledge on fabrication and isolation of advanced CMOS*
CLR-4 :	*Outline the concept of layout dependent effect, bench marking and interconnects*
CLR-5 :	*Understand the basic of lithography and manufacturability*
CLR-6 :	*Upgrade the knowledge in Nano CMOS devices*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Describe the operation of CMOS devices and scaling technology*	*2*	*80*	*75*
CLO-2 :	*Interpret how modern CMOS devices are designed for better power performance*	*3*	*80*	*75*
CLO-3 :	*Perceive knowledge on basic fabrication process flow steps of advanced CMOS devices and isolation*	*3*	*80*	*75*
CLO-4 :	*Advance knowledge on layout dependent effect, bench marking and interconnects*	*3*	*80*	*75*
CLO-5 :	*Infer knowledge about advanced lithography and manufacturability*	*3*	*80*	*75*
CLO-6 :	*Gain knowledge to develop new improved CMOS devices*	*3*	*80*	*75*

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*H*	-	-	-	-	-	-	-	-	-	-	-	*L*	*H*	-
CLO-2 :	*H*	-	-	-	-	-	-	-	-	-	-	-	*H*	*M*	-
CLO-3 :	*H*	-	-	-	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-4 :	*H*	-	-	-	-	-	-	-	-	-	-	-	*H*	*M*	-
CLO-5 :	*H*	-	-	-	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-6 :	*H*	-	-	-	-	-	-	-	-	-	-	-	*H*	*H*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*History of silicon technology*	*Mobility enhancement techniques*	*Fabrication issues*	*Compact modeling of analog process*	*Basics of sub wavelength lithography*
	SLO-2	*Review of CMOS scaling, moore's law*	*Gate dielectric material*	*Process integration*	*Digital benchmarking of models*	*Advanced lithography*
S-2	SLO-1	*Junction diode*	*High K material and Material selection*	*Atomic layer integration*	*Layout dependent effects*	*Design for manufacturability (DFM)*
	SLO-2	*MOS capacitor*	*Electronic structure of transition metal and rare earth metals*	*Metal organic chemical vapor deposition*	*Metallization*	*Economic motives for DFM*
S-3	SLO-1	*Circuit considerations*	*Band gap energies*	*Physical vapor deposition*	*Gate electrodes*	*Lithographic techniques and tools for advanced technology nodes*
	SLO-2	*CMOS latch-up*	*Band off-set energies*	*Etching*	*Reduction in device parasitics*	*Optical proximity correction*
S-4	SLO-1	*MOS transistor classical models*	*Bond iconicity and dielectric constant*	*Fabrication of drain and source*	*Test structures for characterization*	*Lithography limited yield*
	SLO-2	*Threshold voltage and V-I characteristcs*	*Carrier effective masses*	*Ultra shallow junctions*	*Characterization variation effects on scaling*	*Catastrophic failures*
S-5	SLO-1	*Short channel effects*	*Thermal stability*	*Isolation techniques*	*Dopant activation methods*	*Lithography driven DEM solutions*
	SLO-2	*Drain induced barrier lowering*	*Disorders and defects*	*Device, well and dielectric isolation*	*Device isolation pitch*	*Classical approach*
S-6	SLO-1	*Gate leakage current*	*Extrinsic defects*	*Integration challenges*	*Interconnects*	*Printability checkers*
	SLO-2	*Tunneling*	*High –K / Si Interface traps*	*Dopant activation methods*	*Limits of interconnects*	*ASIC cell optimization*
S-7	SLO-1	*Sub-threshold conduction*	*Fermi level pinning*	*Reduction of parasitics*	*Current interconnect technologies*	*Case study on emerging technology*
	SLO-2	*Short channel modifications*	*Progress integration of high K gate dielectrics and metal gates*	*Types of stress elements*	*Optical interconnects*	*Applications of advanced CMOS devices*
S-8	SLO-1	*Features and uniqueness of MOS transistors*	*Effect of stress*	*Strained isolation oxide*	*Scaling of device isolation*	*Challenges of advanced CMOS devices*
	SLO-2	*MOS in Deca-Nano meters*	*Strain on the band structure of silicon*	*Ultra shallow junction resistance*	*Layout dependent effect*	*CMOS technology design for mobile*

						applications
S-9	SLO-1	*Device structure and channel engineering*	*Effect of gate length on stress effect*	*Solution to shallow junction resistance problem*	*Characterization*	*CMOS technology designed for wireless applications*
	SLO-2	*Source , drain and gate stack engineering*	*Mobility enhancements in strained silicon MOSFETS*	*Fermi level pinning effect of strain to improve the CMOS performance*	*Test structures used for characterization*	*Special MOS devices*

Learning Resources	1. *J. M. Pimbley, M. Ghezzo, H. Parks, Advanced CMOS Process Technology, Academia Press, 2012.* 2. *HeiWong, Nano-CMOS Gate Dielectric Engineering, CRC, 2012.*	3. *S. Deleonibus, Electronic Devices Architectures for the Nano-CMOS Era, Jenny Stanford, 2009.* 4. *B. Wong, F. Zach, V. Moraz, A. Mittal, G. Starr, A. Kahng, Nano-CMOS Design for Manufacturability, Wiley, 2009.* 5. *http://www.ee.iitb.ac.in/~slodha/advanced-cmos-devices/*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Akash Neel Dey, Grey Orange Pvt. Ltd, akash.d@greyorange.sg	*1. Dr. E. S. Sreeraj, NIT-Goa, sreeraj@nitgoa.ac.in*	*1. Dr. R. Femi, SRMIST*
2. Mr. Prakhar Kumar Verma, Xilinx India, prakhar10692@gmail.com	*2. Dr. Pravin Mane, BITS-Pilani, pravinmane@goa.bits-pilani.ac.in*	*2. Dr. M. Jagabar Sathik, SRMIST*

Course Code	18EEE327T	Course Name	SENSORS AND TRANSDUCERS	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Expose the students to various sensors and transducers for measuring quantities.*			
CLR-2 :	*Emphasize the general background and operational concepts in sensors and transducers*			
CLR-3 :	*Elicit the characteristics of inductive and capacitive transducers.*			
CLR-4 :	*Examine the advances in sensor technology.*			
CLR-5 :	*Facilitate the application of microsensors and actuautors*			
CLR-6 :	*Analyse the performance of various sensors and transducer*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)													
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Enumerate the basics of sensors and transducers*	2	75	75	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Summarize the underlying principles and performance of different sensors*	2	75	75	H	H	-	-	-	-	-	M	-	-	-	-	-	-	M
CLO-3 :	*Acquire knowledge on the basic conditioning circuits for inductive and capacitive transducers*	2	75	75	H	H	-	-	-	-	-	M	-	-	-	-	-	-	M
CLO-4 :	*Upgrade the knowledge in sensor technology*	2	75	75	H	-	-	-	-	-	-	M	-	-	-	-	-	-	M
CLO-5 :	*Attain a broad area of knowledge in Micro sensors and Actuators*	2	75	75	H	-	-	-	-	-	-	-	-	-	-	-	H	M	-
CLO-6 :	*Predict correctly the expected performance of various sensors and transducers*	2	75	75	H	H	-	-	-	-	-	M	-	-	-	-	H	M	M

Duration (hour)		9	9	9	9	9
CVVVS-1	SLO-1	*General concepts of measurement systems*	*Resistive Transducers*	*General factors governing the design of self-inductance transducer*	*Piezoelectric transducer*	*Introduction to Micro sensor*
	SLO-2	*Terminologies of measurement systems*	*Principle of operation, construction details*	*Variable inductance transducer*	*Hall Effect transducers*	*Transducers and its interface standard*
S-2	SLO-1	*Transducer classification based on principle of transduction*	*Potentiometer ,Characteristics*	*Linear Variable Differential Transformer*	*Magnetostrictive transducers*	*Evolution of micro-fabrication*
	SLO-2	*Flow rate sensing elements*	*Applications of potentiometer*	*Expression for mutual inductance variation*	*Fiber optic Sensors*	*Evolution of Micro system and Microelectronics*
S-3	SLO-1	*Classification of errors*	*Loading effect*	*Rotary variable differential transformer*	*Geiger counters*	*The multidisciplinary nature of MEMS, Miniaturization*
	SLO-2	*Error Analysis*	*Strain Gauge, Types of Strain gauges*	*Applications of LVDTs*	*Scintillation detectors.*	*Applications of micro systems in automotive, and health care*
S-4	SLO-1	*Units and standards of measurements*	*Applications of Strain gauges*	*Output input relationship*	*Film sensor*	*Applications of micro systems in aerospace, and teleCommunication fields*
	SLO-2	*General input and output configuration*	*Gauge Factor*	*Microsyn Transducer*	*Magneto elastic sensor*	*Biomedical sensors*
S-5	SLO-1	*Analog & digital modes of operation*	*Load cells*	*Control type Synchro system*	*Digital displacement sensors*	*Biosensors*
	SLO-2	*Null & deflection methods*	*Torque measurement using strain gauges.*	*Resolvers classification and application*	*Proximity sensors*	*Chemical sensors*
S-6	SLO-1	*Methods of correction for interfering & modifying inputs*	*Pressure measurement using strain gauges*	*Capacitive Transducer*	*Pneumatic sensors*	*Optical sensors*
	SLO-2	*Static characteristics of a measurement*	*Measurement of Linear Velocity*	*Variable Area Type Capacitive*	*Semiconductor sensor*	*Pressure sensors*

		system		*Transducers*		
S-7	SLO-1	*Dynamic characteristics of a measurement system*	*Resistance Thermometers*	*Variable Air Gap type Capacitive Transducers*	*Smart sensors*	*Acoustic wave sensors*
	SLO-2	*Statistical analysis of measurement data*	*Thermocouples*	*Variable dielectric constant type*	*Radiation sensors*	*Microactuators*
S-8	SLO-1	*Electric Transducer*	*Thermistors*	*Sensitivity factors*	*Pyroelectric type*	*Actuators using thermal forces*
	SLO-2	*Advantages of Electric Transducer*	*Thermistor material, shape, ranges and accuracy specification*	*Nonlinearity factors*	*Digital encoding Transducer*	*Actuators using shape memory alloy*
S-9	SLO-1	*Transducer actuating mechanism*	*Hotwire anemometers*	*Advantages of capacitive transducer*	*Photo optic Transducer*	*Actuators using piezoelectric crystals*
	SLO-2	*Factors influencing the choice of transducer*	*Temperature compensation*	*Applications of capacitive transducer*	*Environmental Monitoring sensors (Water Quality & Air pollution)*	*Actuators using electrostatic forces*

Learning Resources	*1. Sawhney. A.K, A Course in Electrical and Electronics Measurements and Instrumentation, 19th Edition, DhanpatRai& Company Private Limited,2014.* *2. Doebelin. E.A, Measurement Systems – Applications and Design, Tata McGraw Hill, New York, 2007..*	*3. PatranabisD, Sensors and Transducers, Prentice Hall of India, 2010.* *4. Joh. 4.P, Bentley, Principles of Measurement Systems, III Edition, Pearson Education, 2000* *5. https://nptel.ac.in/courses/112103174/3*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Muralikrishna, National Instruments, emkkrishnan@gmail.com	*1. Dr. A. Venkadesan, NIT Puducherry, venkadesan@nitpy.ac.in*	*Ms. S.Lourdu Jame,SRMIST*
2. Mr.Senthilkumar,ATI,rskrd1962@gmail.com	*2.Dr. S. Arul Daniel, NIT Trichy, daniel@nitt.edu*	*Dr.S.Padmini, SRMIST*

Course Code	18EEE416T	Course Name	MEDICAL ELECTRONICS	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Create knowledge on physiological system of the human body*			
CLR-2 :	*Learn the various biomedical sensor and amplifiers*			
CLR-3 :	*Identify the bio potential electrodes used for ECG, EEG, EOG and ENG measurements*			
CLR-4 :	*Understand the various analysis techniques of bio signals and data acquisition systems*			
CLR-5 :	*Expose the students to various medical application using optical electronics*			
CLR-6 :	*Demonstrate the physiological system, its measurements and application of electronics in the medical field*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Describe the physiological system of the body*	*2*	*80*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	*M*	-
CLO-2 :	*Use the biomedical sensor and amplifiers*	*3*	*80*	*75*	*H*	-	-	-	*H*	-	-	*L*	*L*	-	-	-	*L*	*M*	*L*
CLO-3 :	*Recognize the biopotential electrodes used for ECG,EEG,EMG,ERG and EOG measurements*	*2*	*80*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	*L*	*M*	-
CLO-4 :	*Apply and analyze bio signals and data acquisition system for biomedical application*	*3*	*80*	*75*	*H*	-	-	-	*H*	-	-	-	*L*	-	-	-	*L*	*M*	-
CLO-5 :	*Interpret the various medical application using optical electronics*	*2*	*80*	*75*	*H*	-	-	-	-	-	-	*L*	-	-	-	-	*H*	*M*	*L*
CLO-6 :	*Identify the human body physiological system along with various measurements and application of electronics in the medical field*	*3*	*80*	*75*	*H*	-	-	-	*H*	-	-	*L*	*L*	-	-	-	*H*	*M*	*L*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to the physiological system of the body*	*Sensor parameters*	*Electrode-electrolyte interface*	*Introduction to bio signal analysis*	*Introduction to medical application using optical electronics*
	SLO-2	*Cardiovascular system*	*Physical principle of sensing*	*Electrode types: Surface metal plate electrode*	*Analog and digital method*	*Charge coupled devices*
S-2	SLO-1	*Respiratory system*	*Strain gauge, Piezo electric transducer*	*Needle and wire electrode*	*Types of analog to digital converters*	*Interline transfer*
	SLO-2	*Parts of respiratory system*	*Load cell, pitot tube*	*Micro electrode*	*Flash type ADC*	*Fiber optics introduction*
S-3	SLO-1	*Nervous system*	*High impedance charge output*	*Electrocardiography: Lead system for recording ECG*	*Types of digital to analog converters*	*Fiber optics classification*
	SLO-2	*Structure of neuron and phenomenon of impulse transmission*	*Linear variable differential transformer*	*ECG measurement*	*Successive approximation DAC*	*Features of optical fibers*
S-4	SLO-1	*Sources of biomedical signals*	*Hall effect magnetic sensor*	*Electro cardio graph*	*Signal to noise improvement*	*Analysis of optical fiber*
	SLO-2	*Basic medical instrumentation system*	*Optical encoder*	*Electroencephalography: Signal sources*	*Amplitude measurements*	*The step-index fiber*
S-5	SLO-1	*Performance requirements of medical instrumentation system*	*Accelerometer*	*Placement of electrodes*	*Signal recovery*	*Graded index fiber*
	SLO-2	*Intelligent medical instrumentation system*	*RTD*	*EEG recording modes*	*Data acquisition*	*CT Scanners*
S-6	SLO-1	*Use of microprocessors in medical instruments*	*Thermistor*	*Electroencephalograph*	*Sample and hold conversion*	*Sectional imaging*
	SLO-2	*The microprocessor*	*Thermocouple*	*Electromyography: EMG electrodes*	*ECG acquisition*	*Digital imaging*
S-7	SLO-1	*The microcontroller*	*Sensor interfacing*	*Electromyograph*	*EMG acquisition*	*Endoscope*

	SLO-2	*Interfacing of analog signals to microprocessors*	*Driving bridges*	*Determination of conduction velocities in motor nerves*	*EOG acquisition*	*Digital X rays*
S-8	SLO-1	*PC based medical instruments*	*Signal conditioning amplifiers*	*Quantity of electricity associated with muscle contraction*	*EEG acquisition*	*Medical sensors from fiber optics*
	SLO-2	*General constrains in design of medical instrumentation systems*	*Instrumentation amplifiers*	*Electrical activity of EOG signal*	*ERG acquisition*	*Fiber optics for circulatory system*
S-9	SLO-1	*Regulations of medical devices*	*Isolation amplifiers*	*Electroretinograph*	*Pattern recognition*	*Fiber optics for respiratory system*
	SLO-2	*Types of standards*	*Simulation of pressure sensor*	*Electroocculograph*	*Simulation of flash type ADC*	*Lasers in biomedical field*

Learning Resources	1. *Leslie Cromwell, Fred. J,Weibell and Ench APleiffer, Biomedical Instrumentation and measurements Prentice Hall of India, 2nd ed., 2004* 2. *Kandpur R.S, Handbook of Biomedical Instrumentation, Tata McGraw Hill, 2nd ed., 2011*	3. *C.Raja Roa & .K Guha, Principles of medical electronics and biomedical instrumentation, Universities press,2001* 4. *Rrinaldo J. Perez, Design of medical electronic devices, Academic press 2002* 5. *https://swayam.gov.in/nd1_noc19_bt28/preview ,NPTEL Online Course-Biomedical nanotechnology*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Muralikrishna, National Instruments, emkkrishnan@gmail.com	*1.Dr. S. Ramareddy, Jerusalem College of Engineering,srr.victory@gmail.com*	*1. Dr.Y.Jeyashree, SRMIST*
2. Mr.senthilkumar,ATI,rskrd1962@gmail.com	*2.Dr Subhransu Sekhar Dash, Government College of Engineering, Keonjhar, Subhransudash_fee@gcekjr.ac.in*	*2. Mrs. R.Uthra, SRMIST*

Course Code	18EEE417T	Course Name	ADVANCED SEMICONDUCTOR DEVICES	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 :	*Outline the aspects of electrical properties of semiconductors*
CLR-2 :	*Learn about diode fabrication, properties, and characterization*
CLR-3 :	*Provide the fundamentals of MOSFET fabrication and scaling laws*
CLR-4 :	*Enrich the knowledge on structure quantum effects and development of advanced transistor devices*
CLR-5 :	*Upgrade knowledge on basic principle of operation of LED and solar cell*
CLR-6 :	*Understand the characteristics, operation and limitations of semiconductor devices*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Enrich the knowledge on semiconductor material, properties and classical semiconductor devices*	2	80	75	H	L	L	L	-	-	-	-	-	-	-	-	H	H	-
CLO-2 :	*Interpret the fabrication and characterization of PN diode*	3	80	75	H	L	L	L	-	-	-	-	-	-	-	-	M	H	-
CLO-3 :	*Perceive knowledge on advanced MOSFET devices, characteristics, application and fabrication*	3	80	75	H	L	L	L	-	-	-	-	-	-	-	-	H	H	-
CLO-4 :	*Gain knowledge of hetero structure, quantum effect and transport in the development of advanced transistor devices*	3	80	75	H	L	L	L	-	-	-	-	-	-	-	-	L	M	-
CLO-5 :	*Infer knowledge on optoelectronics, solar cell and photovoltaic*	3	80	75	H	-	-	-	-	-	-	-	-	-	-	-	H	M	-
CLO-6 :	*Gain knowledge to develop new semiconductor devices*	3	80	75	H	L	L	L	-	-	-	-	-	-	-	-	M	H	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Semiconductor materials*	*Structure of PN junction diode*	*Metal oxide semiconductor transistor structure*	*Bipolar transistor structure*	*Optoelectronic semiconductor devices*
	SLO-2	*Electrons and holes*	*Zero applied bias*	*Working of two terminal MOS structure*	*Principle and modes of operation*	*Optical absorption*
S-2	SLO-1	*Crystal structures*	*Reverse applied bias*	*Inversion channel MOSFET*	*Minority carrier distribution*	*Light emitting diode (LED)*
	SLO-2	*Atomic bonding and bond models*	*Fabrication process*	*MOSFET Scaling effect*	*Low frequency common base current gain*	*Vertical cavity surface emitting laser (VCSEL) diode*
S-3	SLO-1	*Equilibrium and non-equilibrium*	*Non uniform doped junction*	*Electrical and DC MOSFET characteristics*	*Nonlinear effects*	*Laser diode arrays*
	SLO-2	*Imperfections and Impurities in Solids*	*Equilibrium electrical properties of a PN junction*	*Capacitance - voltage characteristics*	*Equivalent circuit models*	*Hetero junction LED types*
S-4	SLO-1	*Statistical distribution*	*PN junction current*	*Current-voltage characteristics*	*Frequency limitations*	*Photoluminescence*
	SLO-2	*Drift and diffusion*	*DC electrical characteristics*	*Fabrication of MOSFET*	*Hetero structure and Quantum well*	*Electroluminescence*
S-5	SLO-1	*Generation and recombination*	*Small signal model of PN junction*	*Small signal analysis*	*Super lattice and modulation*	*Advanced semiconductors for solar cell and photovoltaic applications*
	SLO-2	*Principles of Quantum mechanics*	*Small signal characteristics*	*Frequency limitations*	*Two dimensional electron gas (2DEG)*	*Hetero junction solar Cell*
S-6	SLO-1	*Schrodinger's Wave Equation*	*Diode switching transients*	*Switching properties and circuit applications*	*Coulomb blockade effect, quantized transport*	*Amorphous Silicon solar Cells*
	SLO-2	*Extensions of the wave theory to atoms*	*Generation and recombination current*	*CMOS technology*	*Large signal switching*	*Photo detectors*
S-7	SLO-1	*Quantum theory of solids*	*Charge storage*	*Gallium nitride (GaN) and Silicon Carbide (SiC) based devices*	*Ballistic transport and Quantum capacitance*	*PIN photo diode and photo transistor*

	SLO-2	*Allowed and forbidden energy bands*	*Junction breakdown*	*Tunneling field effect transistor (TFET)*	*High electron mobility transistor (HEMT)*	*Optical switches and amplifiers*
S-8	SLO-1	*Electrical conduction in solids*	*Tunnel diode*	*Thin film transistor (TFT)*	*Modulation doped FET (MODFET)*	*Active nano crystalline devices*
	SLO-2	*Semiconductor in equilibrium*	*Schottky diode*	*Junction gate field effect transistor (JFET)*	*Single electron and hetero junction transistor*	*Nano electronics*
S-9	SLO-1	*Carrier transport phenomena*	*Metal-semiconductor junctions*	*Nonlinear effects*	*Ballistic transistor*	*Applications of nano electronics*
	SLO-2	*Non-equilibrium excess carriers in semiconductors*	*Hetero junctions*	*Threshold voltage modifications*	*Poly silicon emitter and silicon-germanium transistor*	*Organic semiconductors*

Learning Resources	*1. Donald A. Neanmen, Semiconductor Physics and Devices: Basic Principles, Fourth Edition, McGrewHill, 2012.* *2. Streetman, S. K. Banergee, Solid State Devices, Ed. 6, Prantice Hall, 2006.*	*3. S.M. Sze, Kwok K. Ng, Physics of Semiconductor Devices, Third Edition, Wiley, 2007* *4. Chih-Tang Sah, Fundamentals of Soild-State Electronics, World Scientific, 1996.* *5. http://www.ioffe.ru/SVA/NSM/Semicond/index.html*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Prakhar Kumar Verma, Xilinx India,, prakhar10692@gmail.com	*1. Dr. E. S. Sreeraj, NIT-Goa, sreeraj@nitgoa.ac.in*	*1. Dr. R. Femi, SRMIST*
2. Mr. Akash Neel Dey, Grey Orange Pvt. Ltd, akash.d@greyorange.sg	*2. Dr. Dipankar Pal, BITS-Pilani, dipankarp@goa.bits-pilani.ac.in*	*2. Dr. M. Jagabar Sathik, SRMIST*

Course Code	18EEE418T	Course Name	MOBILE COMMUNICATION	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:*	Learning
CLR-1 :	*Educate on Cellular Concepts and Wireless Standards*	1
CLR-2 :	*Understand the Statistical Multipath Channel Models.*	1
CLR-3 :	*Provide adequate knowledge on Digital Modulation & Multiple Access Schemes*	2
CLR-4 :	*Give a basic knowledge in Capacity of Wireless Channels*	2
CLR-5 :	*Educate on Multiple Antennas & Space Time Communications*	3
CLR-6 :	*Create overall understanding of cellular concepts, multiple antennas and space time Communication.*	3

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Program Learning Outcomes (PLO)														
					1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Gain Knowledge in the concepts of cellular Communication.*	*1*	*80*	*75*	*H*	*M*	-	-	-	-	-	*M*	-	-	-	-	*H*	*M*	*M*
CLO-2 :	*Comprehend the statistical multipath channel models*	*2*	*80*	*75*	*H*	*M*	-	-	-	-	-	-	-	-	-	-	*H*	*M*	-
CLO-3 :	*Infer the various schemes in the digital modulation and multiple access*	*2*	*80*	*75*	*H*	*M*	-	-	-	-	-	-	-	-	-	-	*M*	*L*	-
CLO-4 :	*Identify the capacity of wireless channels*	*2*	*80*	*75*	*H*	*M*	-	-	-	-	-	-	-	-	-	-	*H*	*L*	-
CLO-5 :	*Recognize the concepts on multiple antennas & space time Communications*	*3*	*80*	*75*	*H*	*M*	-	-	-	-	-	*M*	-	-	-	-	*H*	*M*	*M*
CLO-6 :	*Gain Knowledge on the overall Communication process involved in cellular Communication.*	*3*	*80*	*75*	*H*	*M*	-	-	-	-	-	*M*	-	-	-	-	*H*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Evolution of Mobile Radio Communication*	*Signal propagation*	*Multiple access schemes-FDMA (Frequency Division Multiple Access)*	*Capacity in Additive White Gaussian Noise Channel*	*MIMO*
	SLO-2	*Cellular Telephone Systems-Cell structures*	*Propagation mechanism- reflection,*	*Non-linear effects in FDMA*	*Capacity of flat fading channels-Channel and System Model*	*Space time signal processing*
S-2	SLO-1	*Frequency Reuse*	*Refraction*	*TDMA (Time Division Multi Access)*	*Channel and Distribution Information Known*	*Spatial multiplexing*
	SLO-2	*Example Problems in Frequency Reuse*	*Diffraction*	*Efficiency of TDMA and number of channels in TDMA system*	*Channel side information at receiver*	*Diversity/Multiplexingtradeoff*
S-3	SLO-1	*Improving Coverage and Capacity in Cellular Systems-Cell Splitting*	*Scattering*	*Spread spectrum multiple access: CDMA (Code-Division Multiple Access)*	*Shannon (Ergodic) Capacity*	*Performance measures- Outage*
	SLO-2	*Sectoring*	*Large scale signal propagation*	*Hybrid FDMA/CDMA(FCDMA)*	*Capacity with outage*	*Average SNR*
S-4	SLO-1	*Repeaters for Range Extension*	*Lognormal Shadowing*	*SDMA(Space Division Multiple Access)*	*Channel side information at transmitter and receiver*	*Average symbol*
	SLO-2	*A Microcell Zone Concept*	*Small-Scale Fading and Multipath -Small-Scale Multipath Propagation*	*Modulation schemes- BPSK (Binary Phase-shift keying)*	*Shannon Capacity*	*Bit error rate*
S-5	SLO-1	*Channel assignment Strategies*	*Doppler shift, Parameters of Mobile Multipath Channels*	*Spectrum and Bandwidth of BPSK*	*Zero-Outage capacity and channel inversion*	*Receiver structure*
	SLO-2	*Handoff Strategies - Prioritizing Handoffs*	*Types of Small-Scale Fading*	*QPSK (Quadrature Phase Shift Keying), Spectrum and Bandwidth of QPSK Signals*	*Outage capacity*	*Diversity receivers- selection*
S-6	SLO-1	*Practical Handoff Considerations*	*Statistical multipath channel models*	*QPSK Transmission and Detection*	*Truncated Channel Inversion*	*MRC receivers*
	SLO-2	*Interference and System Capacity*	*Narrowband Wideband Fading Models*	*Offset QPSK*	*Capacity with receiver Diversity*	*DFE*

S-7	SLO-1	*Channel Planning for Wireless Systems*	*Power delay profile*	*π/4 QPSK*	*Capacity comparisons*	*System examples- GSM*
	SLO-2	*Adjacent Channel Interference*	*Average and RMS delay spread*	*π/4 QPSK transmission and detection techniques*	*Channel and System Model*	*EDGE*
S-8	SLO-1	*Power Control for Reducing Interference- Power control of Cellular Circuits*	*Coherence bandwidth and Coherence time*	*QAM (quadrature amplitude modulation)*	*Capacity of frequency selective fading channels*	*GPRS*
	SLO-2	*Wireless Standards: Overview of 2G*	*Flat and Frequency selective fading*	*MSK (minimum-shift keying) and GMSK (Gaussian minimum shift keying)*	*Time Invariant Channels*	*IS-95*
S-9	SLO-1	*3G cellular standards*	*Slow and fast fading*	*Multicarrier Modulation*	*Time Varying Channels*	*CDMA 2000*
	SLO-2	*Channel Planning for Wireless Systems*	*Average fade duration and Level crossing rate*	*OFDM (Orthogonal Frequency-Division Multiplexing)*	*Optimal Power allocation of Block Frequency -Selective Fading*	*WCDMA.*

Learning Resources	1. *Andrea Goldsmith, Wireless Communications, Cambridge University Press, 2005.* 2. *Theodore Rappaport, Wireless Communications: Principles and Practice, 2nd edition, Prentice Hall, 2001.*	3. *David Tse and Pramod Viswanath, Fundamentals of Wireless Communication, Cambridge University Press, 2005.* 4. *Rishi Kappal and Milind Pande, Nex Gen Mobile Communication, Mc Graw, 2015.* 5. *https://www.youtube.com/playlist?list=PL1A4AFAC7AC1909C9*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. C. Madesh, Bharti Airtel, madesh.c@airtel.com	*1. Dr. G. Lakshmi Narayanan, NIT,Trichy, laksh@nitt.edu*	*1. Mr. T. Vigneswaran, SRMIST*
2. Mr. K .Muniyandi, Omantel TeleCommunication, muniyandi.kannadasan@omantel.com	*2. Dr. G. Thavasi Raja, NIT Trichy, thavasi@nitt.edu*	*2. Dr. M. Jagabar sathik, SRMIST*

Course Code	18EEE419T	Course Name	SATELLITE COMMUNICATION	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Educate on Elements of Satellite Communications and Orbital Aspects*			
CLR-2 :	*Understand the role of Satellite Link*			
CLR-3 :	*Provide adequate knowledge on Modulation for Satellite Links*			
CLR-4 :	*Extend knowledge on Multiple Access for Satellite Links*			
CLR-5 :	*Enlighten the Error Control For Digital Satellite Links*			
CLR-6 :	*Educate various concepts in Satellite Communication*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Gain knowledge on elements of satellite Communications and the concepts of Satellite Orbits*	*1*	*80*	*75*	*H*	*M*	-	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-2 :	*Relate the role of Satellite Link*	*2*	*80*	*75*	*H*	*M*	-	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-3 :	*Infer the necessity of Modulation for Satellite Links*	*2*	*80*	*75*	*H*	*M*	-	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-4 :	*Interpret the Multiple Access For Satellite Links*	*2*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-5 :	*Inspect Error Control For Digital Satellite Links*	*3*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-6 :	*Gain Knowledge on various concepts related to Satellite Communication*	*3*	*80*	*75*	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	*H*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Satellite systems-Attitude and Orbit Control System(AOCS)*	*Basic Transmission Theory*	*Frequency modulation, Waveform Equation for FM*	*Frequency Division Multiple Access (FDMA)*	*Error detection and correction*
	SLO-2	*Telemetry, Tracking, Command and Monitoring (TTC&M)*	*Example Problems in Transmission Theory*	*Bandwidth of FM Signals: Carson's Rule*	*Inter Modulation, Inter Modulation Example*	*Channel Capacity*
S-2	SLO-1	*Power Systems, Communication Subsystems*	*System noise temperature*	*Baseband S/N Ration for FM Signals*	*Calculation of C/N with Intermodulation*	*Error Control Coding*
	SLO-2	*Satellite Antennas*	*Calculation of System noise temperature*	*Pre-emphasis and de-emphasis*	*Time Division Multiple Access (TDMA)*	*Linear and Cyclic Block Codes*
S-3	SLO-1	*Transmission and Multiplexing*	*Noise figure and Noise Temperature*	*Analog FM Transmission by satellite*	*Bits, Sample and Channels*	*Golay Codes*
	SLO-2	*Modulation Multiple access-advent of Digital satellite Communications*	*G/T ratio for Earth Stations*	*Television Signals*	*TDMA Frame Structure*	*Performance of Block Error Correction Codes*
S-4	SLO-1	*The Equations of the Orbit*	*Design of Downlink*	*S/N Rations for FM Video Transmission*	*Synchronization in TDMA Networks*	*Convolution Codes*
	SLO-2	*Locating the Satellite in the Orbit*	*Link Budgets*	*FM Threshold, SCPC FM Links*	*Transmitter Power in TDMA Networks*	*Implementation of Error Detection on Satellite Links*
S-5	SLO-1	*Orbital elements*	*Design of Uplink*	*Concept of FM Squared of transmitting analog satellite audio*	*Satellite Switched TDMA*	*Concatenate Coding*
	SLO-2	*Look angle Determination- The Sub-satellite point*	*Limits on link performance*	*Digital Transmission*	*On-board Processing*	*Interleaving*
S-6	SLO-1	*Elevation angle Calculation*	*Design of Satellite links for specified*	*Baseband Digital Signals,*	*Baseband Processing Transponders*	*Turbo Codes*

			(C/N)			
	SLO-2	*Azimuth angle Calculation*	*Overall $(C/N)_0$ with Uplink and Downlink Attenuation*	*Base Band Transmission of Digital Data*	*Satellite Switched TDMA with Onboard Processing*	*Repetition Codes*
S-7	SLO-1	*Geostationary orbit*	*Uplink and Downlink Attenuation in Rain*	*Band-pass Transmission of Digital Data*	*Concept of Pre-assignment*	*Cyclic Codes*
	SLO-2	*Visibility*	*Uplink attenuation and $(C/N)_{up}$, Downlink attenuation and $(C/N)_{dn}$*	*Analysis of Digital Transmission*	*Demand Access Multiple Access (DAMA)*	*Basic of Convolution codes*
S-8	SLO-1	*Orbital perturbations Longitudinal Changes: Effects of the Earth's Oblateness*	*Satellite Design for Specific Performance*	*Digital Modulation*	*Random Access*	*Catastrophic Convolutional Code*
	SLO-2	*Inclination Changes: Effects of the Sun and the Moon*	*Satellite Communication Link Design Procedure*	*Digital Demodulation*	*Packet Radio Systems and Protocols*	*Performance of block error correction codes*
S-9	SLO-1	*Orbit Determination*	*Propagation effects and their Impact on Satellite-Earth Links Quantifying Attenuation and Depolarization: Rain and Ice efffects*	*Digital transmission of Analog signals PCM*	*Code Division Multiple Access (CDMA)*	*Implementation of Error Detection on Satellite Links.*
	SLO-2	*Orbital effects in Communication system performance*	*Prediction of Rain Attenuation*	*DPCM and DM*	*CDMA Capacity*	*Example Problem on Error Detection on Satellite Links*

Learning Resources	1. *Dennis Roddy, Satellite Communications, 4th Edition, Mc Graw-Hill, 2017.* 2. *Timothy Pratt, Charles W Bostian, and Jeremy Allnutt, Satellite Communications, John Wiley and Sons, New Delhi, 2008*	3. *Tri T Ha, Digital Satellite Communications, Tata McGraw Hill, New Delhi, 2010.* 4. *Richaria M, Satellite Communication Systems Design Principles, McGraw Hill, Inc., New York, 1999.* 5. *https://www.isro.gov.in/applications/satellite-Communication*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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1. Mr. C. Madesh, Bharti Airtel, madesh.c@airtel.com	*1. Dr. G. Lakshmi Narayanan, NIT,Trichy,laksh@nitt.edu*	*1. Mr. T. Vigneswaran,SRMIST*
2. Mr. K .Muniyandi, Omantel TeleCommunication, muniyandi.kannadasan@omantel.com	*2. Dr. G. Thavasi Raja, NIT Trichy, thavasi@nitt.edu*	*2. Dr. A.Rathinam, SRMIST*

Course Code	18EEE420T	Course Name	EMBEDDED SYSTEM	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Illustrate the concept of embedded system.*			
CLR-2 :	*Discuss the various Embedded Controllers with its Interfacing Components*			
CLR-3 :	*Explain the different Embedded System protocol layers and bit configurations.*			
CLR-4 :	*Understand the basics of the RTOS, its challenges and issues.*			
CLR-5 :	*Impart knowledge on the programming skills and execute the different programs using Embedded C*			
CLR-6 :	*Understand the concept of embedded system and develop code for real time applications*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Program Learning Outcomes (PLO)														
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
					Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Understand the fundamentals of Embedded System*	*1*	*75*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	*M*	-
CLO-2 :	*Comprehend the various bus and interfacing components in digital controller.*	*2*	*75*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	*M*	-
CLO-3 :	*Implement the embedded networking concept and various bus protocols*	*3*	*75*	*75*	*H*	*M*	*M*	*M*	-	-	-	*M*	-	-	-	-	*H*	*M*	*M*
CLO-4 :	*Analysis the concept of RTOS, the challenges and issues in RTOS.*	*3*	*75*	*75*	*H*	*M*	*H*	*M*	*H*	-	-	-	-	-	-	-	*M*	*M*	-
CLO-5 :	*Develop the embedded system programs for different Real Time applications*	*3*	*75*	*75*	*H*	*H*	*H*	*H*	*H*	-	-	*M*	-	-	-	-	*H*	*M*	*M*
CLO-6 :	*Design and development of Embedded coding for electrical engineering applications*	*3*	*75*	*75*	*H*	*M*	*H*	*H*	*H*	-	-	*M*	-	-	-	-	*H*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction To Embedded System: Embedded system,*	*Memory system mechanisms - Various memory systems*	*Serial Bus Communication protocols*	*Message Queues*	*Programming for LED Display*
	SLO-2	*Functional building block of embedded system*	*CPU bus - Memory devices - I/O devices*	*RS232 standard – RS422,RS 485*	*Mailboxes and Pipes*	*Embedded C Seven Segment Display*
S-2	SLO-1	*Characteristics of embedded system applications*	*Component interfacing Interrupt – Handler*	*Characteristics of RS232, RS422, RS423 and RS485*	*Time functions - Events*	*Communication Protocols:-I²C initialization and formation*
	SLO-2	*Reliability, life time, power consumption*	*Saving and Restoring the content - Disabling Interrupts.*	*CAN Bus with control word registers*	*Memory Management*	*Programming using embedded C*
S-3	SLO-1	*Challenges in embedded system design*	*The Shared data Problem – Shared data bug*	*Serial Peripheral Interface (SPI)*	*Interrupt Routine in RTOS Environment.*	*Programming Using SPI Protocols.*
	SLO-2	*Optimizing the Power Dissipation, reliability, upgradability*	*Atomic and Critical sections – Interrupt Latency*	*Inter Integrated Circuits (I²C)*	*Design Using RTOS : Design Principles – Short Interrupt Routines*	*Programming for CAN Bus Protocols*
S-4	SLO-1	*Embedded system design processes.*	*Embedded Software Architecture : Round – Robin and other cycles*	*ZigBee*	*RTOS Tasks – Tasks for Priority*	*Commercial Applications: Washing Machine,*
	SLO-2	*Characteristics of embedded system applications*	*Round-Robin with interrupts– A Communication Bridge as an Example*	*Bluetooth with various protocol*	*Tasks for Encapsulation*	*Vending machine with flow diagram*
S-5	SLO-1	*Types of embedded system with examples*	*Characteristics – Functions – Queue – Scheduling*	*Interfacing Protocols- GPIB*	*Creating and Destroying tasks*	*Laser Printer, underground tank monitor,*
	SLO-2	*Performance & Design issues*	*Various Queue and scheduling methods*	*FIREWIRE(IEEE 1394 standard)*	*Avoidance - Tank Monitoring System*	*Cordless Bar, Code Scanner*
S-6	SLO-1	*Performance & Design issues –*	*Software development process*	*Universal Serial Bus (USB)*	*Design as example – Time Scheduling*	*Power Electronics Applications:*

		Throughput – Response – Testability –	*Architecture – Assembly and compiling*			*Operation of DC/DC Converter*
	SLO-2	*Debuggability – Reliability – Memory space – Program Installation*	*Linking and loading, programme flow*	*Need for device drivers*	*Embedded Programming and Communication Protocols: Introduction*	*Embedded C programming for DC-DC Converter pulse generation.*
S-7	SLO-1	*Power Consumption – Processor Hogs – Cost*	*Basic compilation techniques*	*Real Time Operating Systems : Tasks and Task states*	*Importance of Communication protocol and types of protocols*	*Introduction to 180Degree mode Three phase inverter*
	SLO-2	*Small size and weight, Real time/reactive operation, End-product utility, System-level requirements*	*Program optimization*	*Tasks and Data share*	*Embedded C Programming for 8051*	*Various mode of operation and switching sequence*
S-8	SLO-1	*Embedded System Architecture : Computer architecture taxonomy*	*Difference between task and process Multiple tasks*	*Shared data problems – Re-entrancy-Reentrancy Rules*	*Various programming language and advantage of embedded C*	*Programming for Three phase 180◦ Mode Inverter PWM pulse generation*
	SLO-2	*Harvard , von Neumann, and hybrid architectures*	*Multiple processes with simple example*	*Semaphores and Shared data*	*Syntax, variable initialization and assigning a port address*	*Applications of Three phase inverter*
S-9	SLO-1	*CPUs, various processing unit and control units*	*Embedded Networking: Introduction, I/O ports*	*RTOS Semaphores*	*Header file inclusions, condition loop,*	*Basic concept of induction motor drive and speed control of V/F method*
	SLO-2	*Programming input and output, Supervisor mode, Exceptions & Traps, Co - processors*	*Different type of buses*	*Initializing semaphores Reentrancy and Semaphores – Multiple semaphores*	*Simple programme using embedded C*	*Controller Implementation for induction motor drive applications*

Learning Resources	1. *Wayne Wolf, Computers as Components: Principles of Embedded Computer Systems Design, The Morgan Kaufmann Series in Computer Architecture and Design, Elsevier Publications, 2008.* 2. *Rajkamal, Embedded Systems – Architecture, Programming and Design, Tata McGraw-Hill Publishing Company Ltd.,New Delhi, 3rd Edition 2010.*	3. *Sriram V Iyer, Pankaj Gupta, Embedded Real-time Systems Programming, Tata McGraw-Hill Publishing Company Ltd, New Delhi, 1st Edition 2017* 4. *David E.Simon, An Embedded Software Primer, Pearson Education, 1999.* 5. *Muhammad Ali Mazid, The 8051 Microcontrollers & Embedded Systems, Pearson, 2008* 6. *Kenneth Ayala, The 8051 Microcontroller & Embedded Systems using Assembly and C with CD* 7. *https://nptel.ac.in/courses/108102045/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. P.Pangayaselvan, Embedded Engineer, Verizon Technologies, vpangayaselvan@yahoo.co.in*	*1. Dr. S.Moorthi, NIT, Trichy, srimoorthi@nitt.edu*	*1. Dr. M.Jagabar Sathik,SRMIST*
2. *Mr. V.Suresh, Vi-Microsystem, Chennai*	*2. Dr.M.Manimara Boopathi, Vel Tech University*	*2. Dr.A.Rathinam,SRMIST*

Course Code	18EEE421T	Course Name	VLSI DESIGN	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:*	Learning Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Illustrate the MOS fabrication technologies and understand the electrical properties of MOS, CMOS and Bi CMOS circuits*	1	2	3
CLR-2 :	*Describe CMOS technology-specific layout rules in the placement and routing of transistors and interconnect and to verify the functionality, timing, power, and parasitic effects*			
CLR-3 :	*Describe the various parameters and its characteristics of CMOS technology*			
CLR-4 :	*Identify the real-time VLSI tools and its applications*			
CLR-5 :	*Interpret the various testing methods, design tools and chip-level design techniques*			
CLR-6 :	*Construct the digital logic gate using VLSI design tools*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Understand the steps for MOS fabrication technologies and analyze electrical behavior of MOS, CMOS and Bi CMOS circuits.*	*2*	*75*	*75*
CLO-2 :	*Draw the layout of integrated circuits following design rules*	*2*	*75*	*75*
CLO-3 :	*Analyze the different CMOS technology and its characteristics*	*3*	*75*	*75*
CLO-4 :	*Develop the coding for FPGA*	*3*	*75*	*75*
CLO-5 :	*Design a VLSI project having a set of objective criteria and design constraints*	*3*	*75*	*75*
CLO-6 :	*Design a digital components and basic logic gates circuits using VLSI tools*	*2*	*75*	*75*

Program Learning Outcomes (PLO)	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
	H	-	-	-	-	-	-	-	-	-	-	-	-	*M*	-
	H	-	-	-	-	-	-	-	-	-	-	-	-	*M*	-
	H	*H*	*H*	*H*	*M*	-	-	-	-	-	-	-	*M*	*H*	-
	H	*H*	*H*	*H*	*M*	-	-	-	-	-	-	-	*H*	*H*	-
	H	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	*H*	*H*	-
	H	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	*H*	*M*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to IC Technology–MOS*	*VLSI circuit design processes: MOS Layers- Mask Layout, Layer contact mask layout representation*	*Gate level design: Transmission Gates*	*Introduction to design tools FPGAs (Xilinx 4000series)–Features and basic details of FPGA*	*Design Approach*
	SLO-2	*Introduction to IC Technology -PMOS*	*Coloured Stick Diagrams:- capabilities and limitations of stick diagram*	*Gate level design: Alternate gate circuits*	*Various functional block diagram with merits and demerits*	*VLSI Design Flows & Design Verification*
S-2	SLO-1	*Introduction to IC Technology NMOS, CMOS*	*Types of Design Rules VLSI circuit design*	*Basic circuit concepts: Sheet Resistance RS*	*Different syntax of fpga coding and variables*	*Design methods, Design capture tools*
	SLO-2	*Introduction to IC Technology Bi-CMOS Historical Perspective& Bi-CMOS technologies.*	*Layout of circuit diagram*	*Concept of RS in MOS*	*Simple basic programme*	*Design Flow, Design Languages, High-level Synthesis (HLS)*
S-3	SLO-1	*Basic electrical properties: Basic Electrical Properties of MOS Circuits:*	*Layer Representations*	*Area Capacitance Units, Calculations, Delays*	*CPLDs (Xilinx 9500series)- Features and basic details*	*Design Verification Tools*
	SLO-2	*Basic electrical properties: Basic Electrical Properties of Bi-CMOS Circuits:*	*Example of layer presentation*	*Estimation of Delay and INVERTER DELAYS Estimation of CMOS inverter delay Rise & Fall time estimation*	*Various functional block diagram with merits and demerits*	*Various Steps of verifications with one example*
S-4	SLO-1	*Ids-Vds relationships*	*CMOS Design rules for wires*	*Capacitance Modeling Driving large Capacitive Loads*	*Different syntax of CPLDs coding and variables*	*CMOS Testing:- Fault models, Test pattern generation*
	SLO-2	*Ids-Vds its characteristics*	*Layout Design rules & Lambda (λ)*	*Sizing Factor (s) , Inverter gain, Delay Optimization Problem*	*Simple basic programme*	*Need for testing:- Physical defects*
:S-5	SLO-1	*MOS characteristics - transistor threshold Voltage,Wo*	*Design rules of Contacts*	*Wiring Capacitances, Fan-in and fan-out*	*Programmable Array Logic: introduction and applications*	*Test Principles, Design Strategies for test*

	SLO-2	*MOS characteristics -gm, gds characteristics*	*Design rules of Transistors*	*Effect of Capacitive Loading,Propagation Delay in Timing Diagrams*	*Operation and logic with simple problem*	*Fault Modeling, Design-for-Testability*
S-6	SLO-1	*Basic design parameters:- Figure of merit, Pass transistor*	*Layout Diagrams for NMOS Inverters and Gates*	*Choice of layers. SUBSYSTEM DESIGN: Shifters,*	*Design Approach with various steps*	*Chip-level Test Techniques*
	SLO-2	*MOS Transistor circuit model, Latch-up in CMOS circuits*	*Example layout of basic logic gates*	*Choice of layers. Adders, ALUs*	*Fuse mapping examples*	*Moving test up the flowFlop Factor*
S-7	SLO-1	*Characteristics of NMOS Inverter, Various pull ups*	*Layout Diagrams :-CMOS Inverters and Gates*	*Choice of layers. Multipliers*	*Multiplier logic*	*System-level Test Techniques*
	SLO-2	*Resistive Load, Inverter with N type MOSFET Load*	*Example layout of CMOS inverters*	*Choice of layers. Parity generators*	*Alternate representation of high Fan-in structures*	*Characterization Test, Functional Board Testing, In-circuit testing*
S-8	SLO-1	*CMOS Inverter circuit operation*	*Scaling of MOS circuits*	*Comparators, Zero/One Detectors*	*Parameters influencing low power design*	*Layout Design for Improved Testability*
	SLO-2	*CMOS and complex CMOS logic circuit*	*Figure(s) of Merit (FoM) for scaling, Scaling factors for device parameters*	*Example of problems*	*Dynamic Power Consumption, Leakage power dissipation*	*Bridge Fault Model, Bridge Fault Simulation, Test Generation for Bridge Fault*
S-9	SLO-1	*Performance of the BiCMOS Inverter*	*Implications of scaling ondesign of Scaling*	*High-Density Memory Elements*	*Low Power Strategies: Sources of Power Dissipation*	*Observability and controllability*
	SLO-2	*Power Consumption, Designing BiCMOS Digital Gates*	*Limitations of Scaling*	*Bitline IO Circuit, SRAM*	*Degrees of Freedom, Supply Voltage Scaling, Ultra Low Power System Design*	*False Path problem*

Learning Resources	*1. K. Eshraghian Eshraghian. D, A.Pucknell, Essentials of VLSI Circuits and Systems,, Edition II PHI, 2009.* *2. Modern VLSI Design: Ip - Based Design 4th Edition, 2015, PHI.* *3. Basic VLSI Design, 2009, reprint 2017, PHI*	*3. N.H.E Weste, K.Eshraghian, Principals of CMOS VLSI Design, 2nd ed., Adisson Wesley, 1993.* *4. Neil Weste,David Harris,CMOS VLSI Design: A Circuits and Systems Perspective ,4th Edition, 2011* *5. http://nptel.ac.in/courses/117106092/#*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1 Mr.V.Pangayselvan. Aricent Technologies,Senior analysist, Chennai, pangaya.v@aricent.com	*1. Dr .Shady Abdel Aleem. Higher Institute of Engineering, Mathematical, Physical and Engineering Sciences Department, Cairo, Egypt. engyshady@ieee.org*	*1. Dr. M.Jagabar Sathik, SRMIST*
2.Mr. M.Sathisk Kumar, Senior Manager and Programme Specialist, ORCALE DB ,Bangalore	*2. Dr. B.Moorthy, Associate professor, NIT Trichy*	*2. Dr.A.Rathinam, SRMIST*

Course Code	18EEE328T	Course Name	DATA STRUCTURES	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Illustrate the basic concepts of data structures, Search techniques and their algorithms*			
CLR-2 :	*Educate with the basic knowledge of stacks and queues*			
CLR-3 :	*Discuss the concepts of linked lists*			
CLR-4 :	*Impart knowledge on trees and its algorithm*			
CLR-5 :	*Outline the basics of sorting and graph*			
CLR-6 :	*Create an overall knowledge of different data structure algorithms*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Program Learning Outcomes (PLO)														
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
					Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Implement and analyze the different searching algorithms*	2	80	75	H	H	M	-	-	-	-	-	-	-	-	-	H	M	-
CLO-2 :	*Employ different stacks and queues algorithms*	2	80	75	H	H	M	-	-	-	-	-	-	-	-	-	M	M	-
CLO-3 :	*Analyze the different linked list algorithms*	2	80	75	H	H	M	-	-	-	-	-	-	-	-	-	H	M	-
CLO-4 :	*Determine the time and computation complexity in Binary tree and AVL tree*	2	80	75	H	M	M	-	-	-	-	-	-	-	-	-	H	H	-
CLO-5 :	*Develop an algorithm for graph and compare the performance of sorting methods*	2	80	75	H	H	M	-	-	-	-	-	-	-	-	-	H	M	-
CLO-6 :	*Develop application using data structure algorithms*	2	80	75	H	H	M	-	-	-	-	-	-	-	-	-	H	M	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basic Terminologies*	*Array implementation of Stack ADT*	*Singly linked lists*	*Basic Tree Terminologies*	*Basic Terminologies of Graph*
	SLO-2	*Elementary Data Organizations*	*Stack ADT operations with example*	*Singly linked lists - Representation in memory*	*Basic Tree Operations*	*Representations of Graph*
S-2	SLO-1	*Abstract data type*	*Application of Stack: Infix to Postfix Conversion*	*Algorithm of Traversing operation*	*Binary Tree operations*	*Graph traversal algorithms - breadth first search with example*
	SLO-2	*Abstract data type Example*	*Infix to Postfix Conversion Algorithm*	*Algorithm of Searching operation*	*Algorithm of Binary Tree operations*	*Graph traversal algorithms - depth first search with example*
S-3	SLO-1	*Data Structure Operations*	*Application of Stack: Evaluation of postfix expression*	*Insertion into linked list*	*Binary Search Tree - operations - insertion*	*Prims Minimum spanning tree algorithm*
	SLO-2	*Types of Data Structure Operations*	*Evaluation of postfix expression Algorithm*	*Algorithm of Insertion into linked list*	*Algorithm of Binary Search Tree - insertion*	*Prims Minimum spanning tree algorithm - Example*
S-4	SLO-1	*Analysis of an Algorithm*	*Application of Stack: Balancing symbols*	*Deletion from linked list*	*Binary Search Tree - operations - deletion*	*Kruskal's Minimum spanning tree algorithm*
	SLO-2	*Applications: Analysis of an Algorithm*	*Balancing symbols Algorithm with example*	*Algorithm of Deletion from linked list*	*Algorithm of Binary Search Tree - deletion*	*Kruskal's Minimum spanning tree algorithm – Example*
S-5	SLO-1	*Asymptotic Notations*	*Queue ADT- OperationsIntroduction*	*Linked representation of Stack*	*Binary tree traversal*	*Bubble sort*
	SLO-2	*Properties of Asymptotic Notations*	*Queue ADT- Operations Examples*	*Linked representation of Stack - Example*	*Binary tree traversal - inorder, preorder, postorder*	*Bubble sort – Example*
S-6	SLO-1	*Time-Space trade off*	*Simple Queue- Operations*	*Linked representation of Queue*	*Example of Binary tree traversal*	*Insertion Sort algorithm*
	SLO-2	*Time-Space trade off Example*	*Algorithm of Simple Queue – Operations with examples*	*Linked representation of Queue - Example*	*Applications of Binary Trees*	*Insertion Sort algorithm – Example*

S-7	SLO-1	*Linear Search Technique*	*Circular Queue - Operations*	*Doubly linked list*	*AVL Tree- operations: Rotations*	*Selection Sort algorithm*
	SLO-2	*Linear Search Technique Example*	*Algorithm of Circular Queue - Operations*	*Operations on Doubly linked list*	*AVL Tree- operations: Rotations - Example*	*Selection Sort algorithm – Example*
S-8	SLO-1	*Complexity analysis of Linear Search Technique*	*Example of Circular Queue - Operations*	*Example of Doubly linked list*	*AVL Tree- operations: Insertion*	*Merge sort algorithm*
	SLO-2	*Example of Linear Search Technique*	*Priority Queue - Operations*	*Circular Linked List*	*AVL Tree- operations: Insertion - Example*	*Merge sort algorithm – Example*
S-9	SLO-1	*Binary Search Technique*	*Algorithm of Priority Queue - Operations*	*Circular Linked List algorithms*	*AVL Tree- operations: Deletion*	*Quick sort algorithm*
	SLO-2	*Complexity analysis of Binary Search Technique*	*Example of Priority Queue - Operations*	*Circular Linked List example*	*AVL Tree- operations: Deletion – Example*	*Quick sort algorithm – Example*

Learning Resources	1. *Aaron M.Tenenbaum, Yedidyah Langsam and Moshe J.Augenstein, Data Structures Using C, Seventh Edition, 2009, Pearson Education in South Asia.* 2. *G A Vijayalakshmi Pai, Data Structures and Algorithms - Concepts, Techniques and Applications, Tata McGraw-Hill Publishing Company Limited, 2008.*	3. *https://www.youtube.com/watch?v=coxWfcz_sIk&list=PLrjkTql3jnm8ikiQIeIHrMYCaBfkBkfYR&index=1* 4. *Mark Allen Weiss, "Data Structures and Algorithm Analysis in C++", Third Edition, 2009, Pearson Education in South Asia.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Balachandrasekar.K,CTS,dyaksha@gmail.com	*1.Dr. B. K. Panigrahi, IIT Delhi, bkpanigrahi@ee.iitd.ac.in*	1. *Dr.R.Annie Uthra, SRMIST*
2.Mr. Tripathi patro,visam pvt ltd,btp@visom.co.in	*2.Dr. M.P.Selvan, NIT Trichy, selvanmp@nitt.edu*	2. *Mr.P.Kanakaraj, SRMIST*

Course Code	18EEE329T	Course Name	COMPUTER SYSTEM ARCHITECTURE	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:*	Learning
CLR-1 :	*Acquire knowledge about the modern computer organization technologies*	1
CLR-2 :	*Educate the students' on machine instructions*	
CLR-3 :	*Explain the modern Acorn RISC Machine (ARM) Instruction set*	
CLR-4 :	*Impart knowledge about the interfacing devices*	
CLR-5 :	*Identify potential of memory unit*	
CLR-6 :	*Educate the students' onadvances in computer technology*	

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Program Learning Outcomes (PLO)														
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
					Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Understand the concepts of modern computer organization*	2	75	75	*H*	*H*	*M*	*L*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-2 :	*Analyze the machine instruction concept and operation*	2	75	75	*H*	*H*	*M*	*L*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-3 :	*Examine and solve issues related to Acorn RISC Machine (ARM) Instruction set*	2	75	75	*H*	*H*	*M*	*L*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-4 :	*Describe the operation of input and output units*	2	75	75	*H*	*H*	*M*	*L*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-5 :	*Examine and solve issues related to memory mapping techniques*	2	75	75	*M*	*H*	*M*	*L*	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-6 :	*Acquire knowledge on the recent trends in computer technologies*	2	75	75	*H*	*H*	*M*	*L*	-	-	-	-	-	-	-	-	*M*	*M*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Computer types*	*Numbers ,arithmetic operations and characters*	*Memory access and data transfer*	*Accessing I/O devices*	*Semiconductor RAM memories*
	SLO-2	*Functional units of computer architecture*	*Memory locations*	*Acorn RISC Machine(ARM)- Registers*	*Interrupts*	*Read only memories*
S-2	SLO-1	*Operational concepts*	*Memory addresses*	*Arithmetic and logic instructions*	*ARM Interrupt structure*	*Speed size and cost*
	SLO-2	*Bus structures*	*Addressing mode*	*Branch Instructions*	*Direct memory access*	*Mapping techniques*
S-3	SLO-1	*Software Performance*	*Instructions and sequencing*	*Setting condition codes*	*Buses-Synchronous bus*	*Hit rate and miss penalty*
	SLO-2	*Performance and metrics*	*Assembly language*	*Loop program*	*Asynchronous bus*	*Caches on the processor chip*
S-4	SLO-1	*Compiler*	*Basic input/output operations*	*Pseudo instructions*	*Interface circuits-Serial port*	*Virtual memories*
	SLO-2	*Uniprocessors to multiprocessors*	*Subroutines*	*Byte sorting*	*Parallel port*	*Memory management requirements*
S-5	SLO-1	*Operations and operands*	*Logic instructions*	*Linked list insertion subroutines*	*Standard I/O interfaces*	*Second storage system*
	SLO-2	*Representing instructions*	*Branch Instructions*	*Linked list deletion subroutines*	*PCI buses*	*Memory hierarchy*
S-6	SLO-1	*Logical operations*	*Execution of a complete instruction*	*Data hazards*	*Universal serial bus*	*Memory technologies*
	SLO-2	*Control operations*	*Addition algorithm*	*Instruction hazards*	*Overview of parallelism*	*Cache basics*
S-7	SLO-1	*Multiple bus organization*	*Subtractionalgorithm*	*Influence on instruction sets*	*Instruction-level-parallelism*	*Measuring cache performance*
	SLO-2	*Hardwired control*	*Multiplicationalgorithm*	*Data path and control considerations*	*Parallel processing challenges*	*Improving cache performance*
S-8	SLO-1	*Micro programmed control*	*Divisionalgorithm*	*Performance considerations of pipelining*	*Flynn's classification*	*Virtual memory*
	SLO-2	*Multi computers*	*Floating Point operations*	*Overview of data path control*	*Hardware multithreading*	*Translation Lookaside Buffer*
S-9	SLO-1	*Multiprocessors*	*Sub-word parallelism*	*Pipelined datapath and control*	*Analysis of parallelism methods*	*Direct Memory Access*
	SLO-2	*Nano programming*	*Write-through and Write-back cache write method*	*Exception handling*	*Multi-core computing in parallelism*	*Interrupts*

Learning Resources	1. *M. Morris R. Mano Computer System Architecture, Pearson publishers,3rd Edition, 2007.* 2. *Carl hamachar Computer Architecture and Organization, Tata McGraw hill,5th edition, 2015.*	3. *David A. PattersonComputer Organization and Design MIPS Edition: The Hardware/Software Interface (The Morgan Kaufmann Series in Computer Architecture and Design)Morgan Kaufmann; 5 edition 2013.* 4. *https://ocw.mit.edu/courses/electrical-engineering-and-computer-science*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Balachandrasekar.K,CTS,dyaksha@gmail.com	*1.Dr.S.K.Patnaik, CEG, Anna University, skpatnaik@annauniv.edu*	*1.Mr.S.George Fernandez, SRMIST*
2.Mr.Ravikumar A R, PayPal,ravikumar.venkataramani@gmail.com	*2.Dr. S. Ramareddy, Jerusalem College of Engineering,srr.victory@gmail.com*	*2.Ms.R.Rajarajeswari, SRMIST*

Course Code	18EEE330T	Course Name	COMPUTER NETWORKING	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Understand the protocols of modern networking technologies*			
CLR-2 :	*Educate the students' on data format& data transfer at high speed Communication*			
CLR-3 :	*Explain the modern transport layer technologies*			
CLR-4 :	*Identify advances in technology that may solve the actual limitations with existing networks*			
CLR-5 :	*Impart knowledge about modern technologies used in application layer*			
CLR-6 :	*Educate the students on network security*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Acquire knowledge about the protocols of modern networking technologies*	*2*	*75*	*75*	*H*	*H*	*M*	*L*	-	-	-	*M*	-	-	-	-	*H*	*M*	*M*
CLO-2 :	*Analyze the physical properties and performance characteristics of Communication media*	*2*	*75*	*75*	*H*	*H*	*M*	*L*	-	-	-	*M*	-	-	-	-	*H*	*M*	*M*
CLO-3 :	*Examine and solve issues related to congestion management*	*2*	*75*	*75*	*H*	*H*	*M*	*L*	-	-	-	*M*	-	-	-	-	*H*	*H*	*M*
CLO-4 :	*Describe the importance of reliability and quality of service, for error recovery, traffic differentiation and prioritization.*	*2*	*75*	*75*	*H*	*H*	*M*	*L*	-	-	-	*M*	-	-	-	-	*H*	*H*	*M*
CLO-5 :	*Develop an appreciation of the theory of common application layer.*	*2*	*75*	*75*	*H*	*H*	*M*	*L*	-	-	-	*M*	-	-	-	-	*H*	*M*	*M*
CLO-6 :	*Acquire knowledge about the network security system.*	*2*	*75*	*75*	*H*	*H*	*M*	*L*	-	-	-	*M*	-	-	-	-	*H*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Historical perspective of computer networking*	*Theoretical basis for data Communication*	*Overview of Transport layer*	*Causes of errors on data transmission*	*Traditional applications*
	SLO-2	*Theoretical models of network architecture*	*Guided transmission media*	*Elements of transport protocol*	*Impact of errors on data transmission*	*Electronic Mail*
S-2	SLO-1	*Practical models of network architecture*	*Bounded type transmission mode*	*Functions of transport layer*	*Single bit errors*	*Simple Mail Transfer Protocol*
	SLO-2	*Introduction to ISO*	*Unbounded type transmission mode*	*Addressing modes*	*Burst errors*	*POP3*
S-3	SLO-1	*ISO OSI Seven-layer model*	*Magnetic Media*	*Service point addressing*	*Need for error detection*	*Web Services*
	SLO-2	*TCP protocol*	*Issues with magnetic media*	*Segmentation process*	*Error detection strategies*	*Http*
S-4	SLO-1	*IP protocol*	*Need for cable transmission modeS*	*Reassembling process*	*Overview of error correction*	*Multimedia*
	SLO-2	*Comparison of OSI and TCP/IP reference models*	*Twisted Pair cable*	*User datagram protocol*	*Error correction strategies*	*Domain Name System*
S-5	SLO-1	*Synchronous transfer mode protocol*	*Baseband Coaxial Cable*	*Reliable byte stream*	*Parity Checks*	*Simple Network Management Protocol*
	SLO-2	*Asynchronous transfer mode protocol*	*Broadband Coaxial Cable*	*Connection management*	*Block sum Check*	*File Access and Management*
S-6	SLO-1	*Frame relay protocol*	*Narrowband ISDN*	*Causes of Congestion*	*Sliding window protocol*	*Overview of Network security*
	SLO-2	*Frame Relay and the OSI Reference Model*	*Broadband ISDN*	*Retransmission*	*Elementary data link protocol*	*Cryptography*
S-7	SLO-1	*Digital subscriber line technology*	*Microwave transmission*	*Congestion Control*	*Protocol identification*	*Symmetric key algorithm*
	SLO-2	*Variation in DSL technology*	*Electromagnetic Spectrum*	*Flow control*	*Protocol verification*	*Public key algorithm*
S-8	SLO-1	*2G technology*	*Radio transmission*	*Performance issues*	*Forward error control*	*Digital signature*
	SLO-2	*3G,4G technology*	*Fiber optics*	*Quality of service*	*Backward error control*	*Management of public keys*

S-9	SLO-1	*Wi-Fi technology*	*Microwave Transmission*	*Application requirements*	*Statistical analysis of the effectiveness of error detection code*	*Communication security*
	SLO-2	*Wi-MAX technology*	*Comparison of transmission medium*	*Design issues with transport layer*	*Statistical analysis of the effectiveness of error correction code*	*Social issues*

Learning Resources	1. *Andrew S. Tanenbaum, Computer Networks, 4th edition, Prentice Hall, 2003.* 2. *William Stallings, Data and Computer Communications, 5th edition, PHI, 2005.*	3. *James F. Kurose, Computer networking : a top-down approach, 6th ed.Pearson publishers.* 4. *https://ocw.mit.edu/courses/electrical-engineering-and-computer-science*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Ravikumar A R, PayPal,ravikumar.venkataramani@gmail.com	*1. Dr. A. Venkadesan, NIT Puducherry, venkadesan@nitpy.ac.in*	*1. Mr.George Fernandez.S, SRMIST*
2. Mr.Balachandrasekar.K,CTS,dyaksha@gmail.com	*2.Dr Subhransu Sekhar Dash, Government College of Engineering, Keonjhar, Subhransudash_fee@gcekjr.ac.in*	*2. Dr.J.Divyanavamani, SRMIST*

Course Code	18EEE331T	Course Name	INTERNET OF THINGS	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Outline the basic architectural overview of IoT .*			
CLR-2 :	*Enable the students to differentiate between IoT and M2M.*			
CLR-3 :	*Enrich the knowledge about IoT platforms and design methodology*			
CLR-4 :	*Examine the various hardware platforms of IoT*			
CLR-5 :	*Acquire the concept of IoT in application sectors.*			
CLR-6 :	*Enable the students to acquire the basic knowledge of IoT architecture, various platforms and applications.*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Understand the issues and design challenges in IoT architecture*	*1*	*75*	*75*	*H*	-	-	-	-	*H*	-	-	-	-	-	-	*H*	*M*	*H*
CLO-2 :	*Gain knowledge on M2M and IoT*	*1*	*75*	*75*	*H*	-	-	-	*M*	*H*	-	-	-	-	-	-	*M*	*M*	*M*
CLO-3 :	*Interpret about various network topologies and design methodologies*	*1*	*75*	*75*	*H*	-	-	-	*M*	*H*	-	*M*	-	-	-	-	*H*	*M*	*M*
CLO-4 :	*Analyze on hardware platforms relevant to IoT.*	*2*	*75*	*75*	*H*	-	-	-	*M*	*H*	-	-	-	-	-	-	*H*	*H*	*M*
CLO-5 :	*Apply knowledge of IoT in various applications.*	*2*	*75*	*75*	*H*	-	-	-	*M*	*H*	-	-	*H*	-	-	*H*	*H*	*M*	*M*
CLO-6 :	*Understand IoT platforms, interfacing and applications.*	*2*	*75*	*75*	*H*	-	-	-	*M*	*H*	-	*M*	*H*	-	-	*H*	*H*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Definitions of IoT*	*M2M towards IoT - the global context,*	*IoT platforms*	*IoT Physical Devices & Endpoints*	*Case Studies- IoT Design and Cloud incorporation*
	SLO-2	*Functional requirements of IoT.*	*Game changers*	*IoT platforms design methodology*	*Basic building blocks of an IoT Device*	*Introduction to IoT Design*
S-2	SLO-1	*Building an IoT architecture- SOA based architecture*	*M2M to IoT - building an architecture*	*IoT design methodology - Purpose & Requirements Specification, Process Specification*	*Exemplary Device: Raspberry Pi*	*Home Automation – smart lighting, smart appliances*
	SLO-2	*API oriented architecture*	*Main design principles and needed capabilities*	*Domain Model Specification, Information Model Specification*	*Linux on Raspberry Pi*	*Intrusion detection, Smoke /Gas detectors*
S-3	SLO-1	*Physical things of IoT- Things in IoT,*	*IoT architecture outline*	*Service Specifications, IoT Level Specification, Functional View Specification*	*Raspberry Pi Interfaces - serial*	*Cities –Smart Parking, Smart Lighting, Smart Roads*
	SLO-2	*IoT Protocols*	*Standard considerations*	*Operational View Specification, Device & Component, Application development.*	*Raspberry Pi Interfaces - SPI, I2C*	*Structural health Monitoring, Surveillance, Emergency Response*
S-4	SLO-1	*Logical Design of IoT - IoT functional Blocks,*	*Introduction to M2M*	*IoT Design methodology-case study on IoT system for Weather Monitoring*	*Programming Raspberry Pi with Python – controlling LED with Raspberry pi*	*Environment - Weather Monitoring, Air Pollution Monitoring*
	SLO-2	*Communication model, Communication APIs*	*Difference between IOT and M2M*	*Case study on IOT system for Weather Monitoring*	*Programming Raspberry Pi with Python – interfacing an LED and switch with Raspberry pi*	*Noise Pollution Monitoring, Forest Fire Detection, River Floods Detections*
S-5	SLO-1	*IoT enabling technologies- wireless sensor networks*	*Software defined networking (SDN)*	*Python data types*	*Programming Raspberry Pi with Python- interfacing a light sensor with Raspberry Pi*	*Energy - Smart grids , Renewable Energy Systems, Prognostics*

	SLO-2	*Cloud Computing*	*Network function visualization (NFV) for IOT.*	*Python data structures.*	*Other IoT Devices- pcDuino, BeagleBone Black*	*Retail - Inventory Management, Smart Payment, Smart Vending Machines*
S-6	SLO-1	*IoT enabling technologies - Embedded Systems,*	*Needs for IoT system management*	*Logical Design using Python- control flow*	*Other IoT Devices - Cubieboard*	*Smart Vending Machines*
	SLO-2	*Big data analytics*	*Simple Network Management Protocols (SNMP)*	*Logical Design using Python - functions*	*Controlling LED with Raspberry Pi*	*Logistics - Route Generation and scheduling, Fleet Tracking*
S-7	SLO-1	*IoT enabling technologies - Communication protocols for IoT,*	*Limitations of SNMP*	*Logical Design using Python - modules*	*Controlling LED with Myrio*	*Shipment Monitoring, Remote Vehicle Diagnotics*
	SLO-2	*Embedded systems*	*Network operator requirements*	*Logical Design using Python - packages*	*Interfacing an LED and Switch with Raspberry Pi*	*Agriculture - Smart irrigation, Green House Control*
S-8	SLO-1	*IoT levels and deployment templates- level 1, level 2,level 3*	*Network configuration protocol (NETCONF) layer*	*Logical Design using Python - file handling,*	*Interfacing an LED and Switch with Myrio*	*Industry – Machine Diagnosis and prognosis*
	SLO-2	*IoT levels and deployment templates- level 4, level 5, level 6*	*YANG data modelling language.*	*Logical Design using Python - date/time operations, classes*	*Interfacing a Light Sensor (LDR) with Raspberry Pi Other IoT Devices - BeagleBone Black,*	*Indoor Air Quality Monitoring*
S-9	SLO-1	*IoT data management and Analytics- IoT and the cloud*	*IOT system management with NETCONF - YANG*	*Python Packages of Interest for IoT - JSON,XML*	*Interfacing a temperature and humidity sensors with Raspberry Pi Other IoT Devices -BeagleBone Black*	*Health and lifestyle - Health and fitness Monitoring*
	SLO-2	*IoT data management and Analytics- Real time analytics in IoT and Fog computing*	*NETOPEER*	*Python Packages of Interest for IoT - XML*	*Interfacing a temperature and humidity sensors with Raspberry Pi Other IoT Devices -BeagleBone Black*	*Wearable Electronics*

Learning Resources	1. *Arshdeep Bahga, Vijay Madisetti, Internet of Things – A hands-on approach, Universities Press, 2015* 2. *Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis Karnouskos, David Boyle, From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence, Elsevier, 1st Edition ,2014* 3. *Rajkumar Buyya , James Broberg, Andrzej Goscinski, Cloud Computing Principles and Paradigms, Willey, 1st Edition 2014.*	4. *Honbo Zhou, The Internet of Things in the Cloud: A Middleware Perspective ,CRC Press 2013.* 5. *Soyata, Tolga, Enabling Real-Time Mobile Cloud Computing through Emerging Technologies, IGI Global, 2015* 6. *https://www.cse.wustl.edu/~jain/cse570-15/ftp/iot_prot/index.html*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Muralikrishna, National Instruments, emkkrishnan@gmail.com	*1. Dr.D.Devaraj, Dean (Academics),Kalasalingam Academy of Research and Education,deva230@yahoo.com*	*1. Mrs.C.Nithya, SRMIST*
2. Mr.Ravikumar A R, PayPal,ravikumar.venkataramani@gmail.com	*2. Dr.B.ChittiBabu, IIITD, Kanchipuram,chittibabu@gmail.com*	*2. Dr.J.Preetha Roselyn, SRMIST*

Course Code	18EEE332T	Course Name	PRINCIPLES OF OBJECT ORIENTED PROGRAMMING	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Explain the basics of OOPS*			
CLR-2 :	*Demonstrate and develop the concepts of C++*			
CLR-3 :	*Illustrate the importance of the advancements in C++*			
CLR-4 :	*Explain the basics of JAVA*			
CLR-5 :	*Elaborate the advanced features of JAVA*			
CLR-6 :	*Discover the basics of C++ and JAVA*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Identify the basic concepts of OOPS*	*2*	*75*	*75*
CLO-2 :	*Classify and utilize the concepts of C++*	*3*	*75*	*75*
CLO-3 :	*Develop potential applications from the advancements in C++*	*3*	*75*	*75*
CLO-4 :	*Discover the basics of JAVA*	*3*	*75*	*75*
CLO-5 :	*Apply and analyze the advanced features of JAVA*	*3*	*75*	*75*
CLO-6 :	*Design and develop applications based on C++ and JAVA*	*3*	*75*	*75*

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*H*	-	-	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-2 :	*H*	*M*	*M*	*L*	*M*	-	-	-	-	-	-	-	*M*	*M*	-
CLO-3 :	*H*	*H*	*H*	*M*	*M*	-	-	-	-	-	-	-	*M*	*M*	-
CLO-4 :	*H*	*L*	*L*	*L*	*M*	-	-	-	-	-	-	-	*M*	*M*	-
CLO-5 :	*H*	*H*	*H*	*H*	*M*	-	-	-	-	-	-	-	*M*	*M*	-
CLO-6 :	*H*	*H*	*M*	*M*	*M*	-	-	-	-	-	-	-	*M*	*M*	-

Duration (hour)		*9*	*9*	*9*	*9*	*9*
S-1	SLO-1	*Need of Object-Oriented Programming*	*Introduction to Classes*	*Pointers*	*Java platform features-Data types, Key words, Scoping rules*	*Finalize() method*
	SLO-2	*Characteristics of Object-Oriented Languages*	*Introduction to Objects*	*Pointers with arrays and functions*	*Automatic Type Conversion, Type Casting and Arrays*	*Finalize() method: Implementation*
S-2	SLO-1	*Introduction to the principles of object-oriented programming*	*Class fundamentals*	*Virtual Functions*	*Java platform features*	*Overloading methods*
	SLO-2	*Data Types, Variables*	*Structure of class*	*Friend Functions*	*Data types, Key words, Scoping rules*	*Constructors*
S-3	SLO-1	*Constants - Type Conversion*	*Declaring objects*	*Programs using pointers and arrays*	*Operators Precedence*	*Nested classes*
	SLO-2	*Basic Program Construction*	*Simple object creation*	*Programs using functions*	*Associativity, Expression*	*Inner classes*
S-4	SLO-1	*Operators*	*Objects and messages*	*Introduction to STL: Containers, Algorithms*	*Enhanced for loop, switch statements*	*Potential problems with methods and classes*
	SLO-2	*Constants , Strings, Expressions and Data types*	*Constructors and its types*	*Introduction to STL: Iterators*	*Handling Strings*	*Potential problems with constructors and classes*
S-5	SLO-1	*Library Functions*	*Destructors*	*Potential problems with STL: Containers, Algorithms*	*Declaring objects*	*Packages*
	SLO-2	*Loops and Decisions*	*Passing arguments to Functions*	*Potential problems with STL: Iterators*	*Assigning object reference variable*	*Interfaces*
S-6	SLO-1	*Structures*	*Passing Objects as Function arguments*	*Encapsulation*	*Methods & Method Signatures*	*Potential programs with packages*
	SLO-2	*Functions : Simple Functions*	*Returning values from Functions*	*Implementation of Encapsulation*	*Method retuning Values, Method with parameters*	*Potential programs with interfaces*
S-7	SLO-1	*Passing arguments, Returning values*	*Returning Objects from Functions*	*Polymorphism*	*Variable arguments in Java*	*Event handling*
	SLO-2	*Reference Arguments*	*Operator Overloading*	*Operator and method overloading*	*I/O Basics: Byte stream& Character*	*Errors and Exception handling*

					Stream	
S-8	SLO-1	*Recursion, Inline Functions*	*Inheritance: Basics*	*Event handling*	*Getting user input: Reading console input & Writing console output,*	*Introduction to Threads*
	SLO-2	*Default Arguments*	*Inheritance: Method overriding from operator overriding*	*Errors and Exception handling*	*Reading and Writing files-new file system*	*Multithreaded programming*
S-9	SLO-1	*Storage Classes*	*Potential programming using functions, constructors and destructors*	*Potential programs using encapsulation, polymorphism*	*Constructors: Default Constructor,*	*Potential programs using threads*
	SLO-2	*Arrays – Strings*	*Potential programming using overloading and inheritance*	*Potential programs using exception handling*	*Parameterized constructor*	*Potential programs using multithreads*

Learning Resources	1. *D Deitel, C++ How to Program, 6th edition, PHI publication, 2008.* 2. *R. Subburaj, Object Oriented Programming With C++ , Vikas Publishing House, New Delhi, Revised Edition, 2013* 3. *Bjarne Stroustrup ,The C++ Programming Language, 4th Edition, Addison Wesley, 2015*	4. *Herbert Schildt, The Complete Reference (Fully updated for jdk7), Oracle press Ninth Edition, 2014.* 5. *Deitel & Deitel, Java How to Program, Prentice Hall, 10th Edition, 2016.* 6. *Herbert Schildt, Java: A Beginner's Guide, Sixth Edition, Oracle Press, 2014.* 7. *https://docs.oracle.com/javase/tutorial*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Balachandrasekar.K,CTS,dyaksha@gmail.com	*1.Dr.P.Ganesh Kumar, Anna University, ganesh23508@gmail.com*	*1.Dr. U. Sowmmiya, SRMIST*
2.Mr.Ravikumar A R, PayPal,ravikumar.venkataramani@gmail.com	*2.Dr.N.Sripriya, SSN College of Engineering, sripriyan@ssn.edu.in*	*2.Dr. G. Niranjana, SRMIST*

Course Code	18EEE422T	Course Name	MODERN OPTIMIZATION TECHNIQUE	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 & Electronics Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Introduce and classify different conventional optimization techniques.*			
CLR-2 :	*Understand the fundamentals of genetic algorithm and to apply appropriate algorithm for Engineering optimization problems*			
CLR-3 :	*Outline the concept of particle swarm optimization and its hybrid approach to Engineering applications*			
CLR-4 :	*Interpret other modern optimization algorithms for engineering applications*			
CLR-5 :	*Extend optimization techniques to multi objective optimization*			
CLR-6 :	*Introduce the concept of optimization design for Engineering problems*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Categorize optimization problems and its techniques based on constraints and variables*	*1*	*75*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Apply Genetic algorithm for various Engineering application*	*2*	*75*	*75*	*H*	*H*	*M*	*M*	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-3 :	*Utilize Particle swarm optimization to Engineering applications*	*3*	*75*	*75*	*H*	*M*	*M*	*M*	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-4 :	*Gain knowledge about other modern optimization algorithms*	*3*	*75*	*75*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-5 :	*Formulate multi objective optimization algorithm for various applications*	*3*	*75*	*75*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*H*	*H*	-
CLO-6 :	*Apply optimization techniques in modelling Engineering problems*	*3*	*75*	*75*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*H*	*H*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to optimization*	*Introduction – Genetic Algorithm*	*Particle Swarm Optimization*	*Bacterial foraging-Chemotaxis, Swarming*	*Multiobjective optimization*
	SLO-2	*Classification of optimization problem*	*Encoding – Methods for GA*	*Fundamental principle*	*Operation of Bacterial foraging*	*General form of MOOP*
S-2	SLO-1	*Single variable optimization – optimalityconditions*	*Fitness function*	*Velocity updating in PSO*	*Bees colony algorithm-Behavior of Honey bee swarm*	*Pareto optimality*
	SLO-2	*Single variable (unconstrained optimization) – Exhaustive search method*	*Maximization & Minimization*	*Algorithm for PSO*	*Algorithm for Bee colony optimization*	*Dominance test*
S-3	SLO-1	*Successive quadratic estimation method*	*Genetic operators – Crossover*	*PSO – Parameter Selection*	*Differential evolution-Initialization, Mutation*	*Classical Methods – Weighted sum method, ε-constraint method*
	SLO-2	*Newton method*	*Single point crossover, Two-point crossover*	*Pseudocode*	*Recombination, Selection*	*Weighted metric methods, Benson method.*
S-4	SLO-1	*Multi variable optimization – optimality conditions*	*Uniform Crossover, Arithmetic Crossover*	*Implementation & Convergence issues in PSO*	*Ant colony optimization-Introduction*	*Multi objectiveGA*
	SLO-2	*Multi variable optimization (unconstrained) – Simplex search method*	*Mutation*	*Advanced operators of PSO*	*Algorithm for Ant colony optimization*	*Fitnessassignment*
S-5	SLO-1	*Cauchy's method*	*Parent SelectionMethods*	*Meta-Optimization-Behavioral parameters*	*Simulated Annealing optimization-Components and control parameters*	*Sharing function*
	SLO-2	*Steepest Descent Method*	*Rank selection, Roulette wheel selection, Stochastic universal selection, Tournament selection*	*Algorithm for Meta Optimization*	*Algorithm for Simulated Annealing*	*Convergence criterion*
S-6	SLO-1	*Multivariable optimization (Constrained*	*Issues in GA implementation*	*Application of PSO*	*Firefly optimization-Working Principle*	*NSGA-II-Fitness assignment*

		Kuhn – Tucker Conditions				
	SLO-2	*Transformation Method –Method of Multipliers*	*Applications of GA –Filter design*	*Harmonics Elimination*	*Algorithm for Firefly optimization*	*Sharing Function*
S-7	SLO-1	*Linearized search Technique*	*Automatic Load Frequency Control (ALFC)*	*Applications of PSO*	*Flower Pollination optimization-Introduction*	*Dynamic neighborhood PSO-Introduction*
	SLO-2	*Frank Wolfe method*	*Automatic Voltage Regulation (AVR)*	*Maximum Power Point Tracking*	*Algorithm for Flower pollination*	*Algorithm for Dynamic neighborhood PSO*
S-8	SLO-1	*Non-Linearized Search Technique*	*Evolutionary Algorithm*	*Application of PSO*	*Grey Wolfe optimization-Introduction*	*Vector evaluated PSO*
	SLO-2	*Reduced gradient method*	*Evolutionary Programming*	*Reactive power control using PSO*	*Algorithm for Grey Wolfe optimization*	*Applications – Economic load Dispatch*
S-9	SLO-1	*Quadraticprogramming-Objective Function*	*Evolutionary Strategy-Non-Recombinative strategy*	*HybridAlgorithm of GA and PSO*	*Comparison of various algorithms*	*Unit Commitment,*
	SLO-2	*Algorithm*	*Recombinative strategy*	*GAandPSO operators*	*Benchmark functions*	*Robot Path Planning*

Learning Resources	1. *SingiresuRaoS, EngineeringOptimization–TheoryandPracticebyJohn Wiley & Sons, Inc., New Jersey, 2009.* 2. *Kalyanmoy Deb, Muti-objective Optimization using Evolutionary Algorithms, WileyIndia Private Limited, 2010* 3. *Kalyanmoy Deb, Optimization of Engineering Design, Prentice Hall of India, second Edition, 2012.*	4. *Jizhong Zhou, Optimization of Power System Operation, IEEE Press, Second Edition, 2015.* 5. *Xin - She Yang, Nature Inspired Optimization algorithms, Elsevier, 2014.* 6. *Chee Peng Lim, Lakhmi C. Jain, Satchidananda Dehuri, Innovations in Swarm Intelligence, Springer, Berlin, Heidelberg, 2009.* 7. *https://engineering.purdue.edu/~sudhoff/ee630/Lecture09.pdf*

Learning Assessment												
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Understand										
Level 2	Apply	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Dr.S.Paramasivam, Danfoss, Industries Pvt Ltd, paramsathya@yahoo.com	*1.Dr. R.Subha, Associate Prof. Sir MVIT, subha.mvit@gmail.com*	*1.Mrs.Uthra.R, SRMIST*
2.Mr.Sudharsan, L&T, sudharsand@Intecc.com	*2.Dr. B. K. Panigrahi, IIT Delhi, bkpanigrahi@ee.iitd.ac.in*	*2.Dr.D.Suchitra, SRMIST*

Course Code	18EEE423T	Course Name	NEURO FUZZY AND GENETICS PROGRAMMING	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:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Acquire knowledge on neural network.*			
CLR-2 :	*Understand the neural network algorithms for pattern classification and regression problems*			
CLR-3 :	*Introduce the basics of fuzzy logic and its reasoning.*			
CLR-4 :	*Study the architecture of Fuzzy logic controller and neuro-fuzzy based systems.*			
CLR-5 :	*Develop the knowledge on genetic algorithm for optimization problems*			
CLR-6 :	*Demonstrate the application of neural network, fuzzy logic and Genetic algorithm in real world*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Illustrate the working of various learning algorithms of Neural network.*	*3*	*75*	*75*	*H*	*H*	*M*	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-2 :	*Develop and analyze neural networks for pattern classification and pattern association.*	*3*	*75*	*75*	*H*	*H*	*M*	*L*	*H*	-	-	-	-	-	-	-	*M*	*M*	-
CLO-3 :	*Apply fuzzy logic and reasoning to handle uncertainty and solve engineering problems*	*3*	*75*	*75*	*H*	*H*	*M*	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-4 :	*Develop the process of approximate reasoning using Fuzzy logic controller and Neuro-Fuzzy Modeling.*	*3*	*75*	*75*	*H*	*H*	*M*	*L*	*H*	-	-	-	-	-	-	-	*M*	*M*	-
CLO-5 :	*Formulate a mathematical background to carry out optimization using genetic algorithm.*	*3*	*75*	*75*	*H*	*H*	*M*	*L*	*H*	-	-	-	*L*	*L*	-	-	*M*	*M*	-
CLO-6 :	*Design and perform experiments on real life problems using Neural network, Fuzzy logic and Genetic algorithm*	*3*	*75*	*75*	*H*	*H*	*M*	*L*	*H*	-	-	-	*L*	*L*	-	-	*M*	*M*	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Biological Neurons and Their Artificial Models*	*Pattern Association-Hebb rule*	*Introduction to Fuzzy Logic, Uncertainty based Information*	*Introduction to Fuzzy Reasoning*	*Difference between Traditional optimization Algorithms and genetic algorithm*
	SLO-2	*Models of Artificial Neural Networks, Architectures*	*Delta Rule for pattern association*	*Chances / randomness versus Fuzziness*	*Fuzzy rule generation. Aggregation Operations*	*The basic operation of genetic algorithm*
S-2	SLO-1	*Setting Weights, Activation functions, Learning Processes*	*Hetero associative memories - Architecture-Algorithm*	*Classical/crisp set*	*Fuzzy Logic controller- Basic block*	*Pseudo code of GA*
	SLO-2	*Learning Paradigms-Supervised, Unsupervised and reinforcement Learning*	*Example Problem-Application*	*Properties and operations of classical set*	*Knowledge Base-Rule base-Inference system-Importance*	*Schema theorem*
S-3	SLO-1	*McCulloch-Pitt Neuron*	*Auto associative memories -Architecture-Algorithm*	*Fuzzy set- Representation of fuzzy sets*	*Fuzzification*	*Encoding operation*
	SLO-2	*Linear Separability*	*Example Problem-Application-Storage Capacity*	*Properties and Operations of Fuzzy Sets*	*Assignment of membership functions*	*Binary, Octal, Hexadecimal , Permutation and Tree encoding*
S-4	SLO-1	*ANN training Algorithms-Training rules*	*Iterative Associative Net- Discrete Hopfield Network -Energy Function*	*Measure of Fuzziness and Inaccuracy of fuzzy set*	*Defuzzification Methods-Weighted Average method*	*Importance of Selection and Reproduction operators of GA*
	SLO-2	*Hebb rule-Algorithm -Application*	*Continuous Hopfield Network-Energy Function*	*Cartesian Product- Fuzzy Relations-Composition of fuzzy Relations*	*Centroid method, Center of sums, Mean max method*	*Selection operators of GA-Roulette Wheel, Tournament selection, Boltzmann selection and Rank Selection*
S-5	SLO-1	*Perceptrons-Algorithm*	*Bidirectional associative memories-Architecture (BAM)*	*Fuzzy Max-Min Composition*	*Introduction to Architecture of Mamdani Type Fuzzy Control Systems*	*Crossover operators of GA-Single point*

	SLO-2	*Application of Perceptron algorithm*	*BAM Algorithm-Analysis*	*Fuzzy Max-Product Composition*	*Fuzzy Reasoning approach*	*Two point-multiple point-Uniform crossovers*
S-6	SLO-1	*Delta Rule*	*Competitive Learning Networks-Basics*	*Types of fuzzy sets-Terms of fuzzy sets*	*Takagi and Sugeno's approach*	*Mutation operators of GA*
	SLO-2	*Derivations--Adaline Algorithm*	*Kohonen Self organizing Maps-Algorithm*	*Types of Membership Function distributions*	*Introduction to Fuzzy Clustering*	*Sample Problem to demonstrate the working of GA*
S-7	SLO-1	*Back Propagation Algorithm-Derivation*	*Learning Vector Quantization (LVQ)*	*Classical Logic, Multivalued Logics*	*Fuzzy Knowledge Based Systems for real world applications.*	*GA convergence analysis*
	SLO-2	*Sample problem for BPN*	*LVQ-Architecture-Algorithm*	*Fuzzy Propositions*	*Design of controllers using Simulation Software*	*Application of Genetic Algorithm.*
S-8	SLO-1	*Radial Basis Function Networks-Basics*	*Basic architecture of Adaptive Resonance Theory (ART)*	*Fuzzy Qualifiers*	*Hybrid Model implementing Fuuzy and Neuro*	*Hybrid Algorithms using GA*
	SLO-2	*Algorithm of RBF*	*Basic Operation of ART*	*Linguistic Variables, Linguistic Hedges*	*Adaptive Neuro-Fuzzy Inference Systems*	*Basics of GA-Fuzzy Logic, GA-Neural Network*
S-9	SLO-1	*Multilayer Perceptron Model*	*Applications of Artificial Neural Networks.*	*Introduction to basic Fuzzy Arithmetic*	*Architecture of adaptive neuro fuzzy Hybrid Learning Algorithm*	*GA-Fuzzy-Neural Network*
	SLO-2	*Madaline*	*Design of controllers using Simulation Software*	*Extension Principle.*	*Learning Methods that Cross-fertilize ANFIS and RBFN*	*Case study on real time application using Neuro/Fuzzy/Genetics*

Learning Resources	1. *Laurene Fausett., Fundamentals of Neural Networks-Architecture, Algorithms and Application, Prentice Hall International, First edition, 1994.* 2. *Timothy J.Ross, Fuzzy Logic with Engineering Applications, John Wiley and sons Ltd. publication, Fourth edition,2016.* 3. *Kalyanmoy Deb, Optimization for Engineering Design: Algorithms and Examples, Prentice Hall of India, second edition, 2012.* 4. *David E. Goldberg, Genetic Algorithms in search, optimization and machine learning, Pearson Education Inc, First edition, 1989.*	5. *Anderson, James A., an Introduction to Neural Networks, Prentice Hall of India, ISBN: 978-81-203-13514, 2008.* 6. *Zimmerman H.J, Fuzzy set Theory-and its applications, Kluwer Academic Publishers, second edition, 1991.* 7. *Hertz J. Krogh, R.G. Palmer, Introduction to the Theory of Neural Computation, Addison- Wesley, ISBN 9780201515602, 1991.* 8. *G.J. Klir& B. Yuan,Fuzzy Sets & Fuzzy Logic, Prentice Hall of India, 2006,ISBN: 978-81-203-1136-7* 9. *http://www.myreaders.info/html/soft_computing.html*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Roosefart Mohan, Nelcast Limited, Chennai,roosefart@gmail.com	*1. Dr. R.Subha, Associate Prof. ,Sir MVIT, subha.mvit@gmail.com*	*1. Dr. D.Suchitra,, SRMIST*
2.Mr.Muralikrishna, National Instruments, emkkrishnan@gmail.com	*2. Dr. C.Nayanatara, Shri Sairam Engineering College, nayanatara.eee@sairam.edu.in*	*2. Dr.J.Preetha Roselyn, SRMIST*

Course Code	18EEE424T	Course Name	ARTIFICIAL INTELLIGENCE	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 :	*Impact the knowledge on AI and its different Heuristic solution strategies*
CLR-2 :	*Provide adequate knowledge on the technology of knowledge-based agents and Game Playing*
CLR-3 :	*Describe the different planning approaches*
CLR-4 :	*Discuss the different learning algorithms*
CLR-5 :	*Understand the basics of machine learning algorithm*
CLR-6 :	*Create an overall knowledge of different artificial intelligence approaches*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Illustrate the concept of AI and different Heuristic methodologies*	2	80	75	H	H	-	-	-	-	-	-	-	-	-	-	H	M	-
CLO-2 :	*Recall different technologies in knowledge-based agents and Game Playing*	2	80	75	H	H	-	-	-	-	-	-	-	-	-	-	M	M	-
CLO-3 :	*Analyze the different planning approaches*	2	80	75	H	H	-	-	-	-	-	-	-	-	-	-	H	M	-
CLO-4 :	*Apply the different learning algorithms for real time systems*	2	80	75	H	M	-	-	-	-	-	-	-	-	-	-	H	H	-
CLO-5 :	*Implement the machine learning algorithm for clustering and regression*	2	80	75	H	H	-	-	-	-	-	-	-	-	-	-	H	M	-
CLO-6 :	*Utilize a perfect artificial intelligence approach for different applications*	2	80	75	H	H	-	-	-	-	-	-	-	-	-	-	H	M	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Artificial Intelligence (AI)*	*Games as Search Problems*	*The Planning Problem*	*Representing Knowledge in an Uncertain Domain*	*Types of Machine Learning: Supervised Learning Reinforcement*
	SLO-2	*The Foundations of AI*	*Optimal Decisions in Games*	*Planning with State-Space Search*	*The Semantics of Bayesian Networks*	*Unsupervised Learning Reinforcement*
S-2	SLO-1	*The History of AI*	*Alpha-Beta Pruning*	*Partial-Order Planning, Planning Graphs*	*Efficient Representation of Conditional Distributions*	*Over fitting and linear regression*
	SLO-2	*The State of the Art*	*Imperfect Decisions, State-of-the-Art Game Programs*	*Planning with Propositional Logic*	*Exact Inference in Bayesian Networks*	*Learning Curve*
S-3	SLO-1	*Structure of Intelligent Agents*	*Knowledge-Based Agents*	*Analysis of Planning Approaches*	*Approximate Inference in Bayesian Networks*	*Parametric vs. non-parametric models*
	SLO-2	*Problem-Solving Agents*	*The Wumpus World*	*Hierarchical Task Network Planning*	*Relational and First-Order Probability Models*	*Linear models*
S-4	SLO-1	*Formulating Problems*	*Logic, Propositional Logic*	*Planning and Acting in Nondeterministic Domains*	*Forms of Learning*	*Bayesian hierarchical clustering*
	SLO-2	*Searching for Solutions*	*Reasoning Patterns in Propositional Logic*	*Conditional Planning*	*Supervised Learning*	*Clustering datapoints and features*
S-5	SLO-1	*Uninformed Search Strategies*	*Effective propositional inference*	*Execution Monitoring and Re-planning*	*Learning Decision Trees*	*K-Means clustering*
	SLO-2	*Informed (Heuristic) Search Strategies*	*Agents Based on Propositional Logic*	*Continuous Planning*	*Ensemble Learning*	*K-Medoids clustering*
S-6	SLO-1	*Heuristic Functions*	*Syntax and Semantics of First-Order Logic*	*Multi-Agent Planning*	*A Logical Formulation of Learning*	*Neural network Representation*
	SLO-2	*Local Search Algorithms*	*Unification and Lifting*	*Acting under Uncertainty*	*Knowledge in Learning*	*Perceptrons, Feed forward networks*
S-7	SLO-1	*Optimization Problems*	*Forward Chaining*	*Basic Probability Notation*	*Explanation-Based Learning*	*Back Propagation Algorithms*
	SLO-2	*Local Search in Continuous Spaces*	*Backward Chaining*	*The Axioms of Probability*	*Learning Using Relevance Information*	*Recurrent networks*

S-8	SLO-1	*Online Search Agents*	*Resolution, Ontological Engineering*	*Inference Using Full Joint Distributions*	*Inductive Logic Programming*	*Linear Regression*
	SLO-2	*Constraint Satisfaction Problems*	*Categories and Objects*	*Independence*	*Statistical Learning*	*Logistic Regression*
S-9	SLO-1	*Backtracking Search for CSPs*	*Mental Events and Mental Objects*	*Bayes' Rule and Its Use*	*Learning with Complete Data*	*Maximum Likelihood estimation (least squares)*
	SLO-2	*Local Search for Constraint*	*The Internet Shopping World*	*The Wumpus World Revisited*	*Learning with Hidden Variables: The EM Algorithm*	*Online learning and stochastic optimization*

Learning Resources	*1. Stuart Russell and Peter Norvig, Artificial Intelligence – A Modern Approach, Pearson Education Press, 2010.* *2. Kevin Knight, Elaine Rich, B. Nair, Artificial Intelligence, McGraw Hill, 2008.* *3. George F. Luger, Artificial Intelligence, Pearson Education, 2001.*	*4. Kevin P. Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012.* *5. Stephen Marsland, Machine Learning –An Algorithmic Perspective, CRC Press, 2009.* *6. https://www.youtube.com/playlist?list=PL6EE0CD02910E57B8.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr. Tripathi patro,visam pvt ltd,btp@visom.co.in	*1.Dr.P.Ganesh Kumar, Anna University, ganesh23508@gmail.com*	*1.Dr.J.Preetha Roselin, SRMIST*
2.Mr.Balachandrasekar.K,CTS,dyaksha@gmail.com	*2.Dr. C.Nayanatara, Shri Sairam Engineering College, nayanatara.eee@sairam.edu.in*	*2.Mr.P.Kanakaraj, SRMIST*

Course Code	18EEE425T	Course Name	FUNDAMENTALS OF BIG DATA ANALYTICS	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 :	*Introduce big data and its role in various domains*
CLR-2 :	*Learn and analyze the big data analytical tools*
CLR-3 :	*Introduce Hadoop and its components*
CLR-4 :	*Implement Map Reduce technique*
CLR-5 :	*Study the security concerns of big-data*
CLR-6 :	*Create an overall knowledge in big data with different environment*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Familiarize with applications of Big Data Analytics in various domains*	*1*	*80*	*75*	*H*	-	-	-	-	-	-	*M*	-	-	-	-	*H*	*M*	*M*
CLO-2 :	*Practice open source big data analytical tools*	*2*	*80*	*75*	*H*	*H*	*H*	*H*	*H*	-	-	*M*	-	-	-	-	*M*	*M*	*M*
CLO-3 :	*Install and operate the open source Distributed File System Hadoop*	*2*	*80*	*75*	*H*	*H*	*M*	*M*	*H*	-	-	-	-	-	-	-	*H*	*M*	-
CLO-4 :	*Solve simple problems using Map Reduce Technique*	*2*	*80*	*75*	*H*	*H*	*M*	*M*	*H*	-	-	-	-	-	-	-	*H*	*H*	-
CLO-5 :	*Analyze the log file in security aspects*	*2*	*80*	*75*	*H*	*H*	*M*	*M*	-	-	-	*H*	-	-	-	-	*H*	*M*	*H*
CLO-6 :	*Design a big data platform for different applications*	*2*	*80*	*75*	*H*	*H*	*M*	*M*	*M*	-	-	*M*	-	-	-	-	*H*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Big Data Platform*	*Data Analytics Lifecycle*	*History of Hadoop*	*Developing a Map Reduce Application*	*Introduction to Security Analytics*
	SLO-2	*Challenges of Conventional Systems*	*Overview of Data Analytics Lifecycle*	*Hadoop Distributed File System*	*How MapReduce Works*	*Challenges in Security Analytics*
S-2	SLO-1	*Intelligent data analysis*	*Successful Analytics Project*	*Components of Hadoop*	*Unit Tests*	*Concepts in Data Analytics*
	SLO-2	*Nature of Data*	*Key Roles for a Successful Analytics Project*	*Analyzing the Data with Hadoop*	*Unit Tests with MapReduce Unit*	*Techniques in Data Analytics*
S-3	SLO-1	*Analytic Processes and Tools*	*Background of Data Analytics Lifecycle*	*Scaling Out, Hadoop Streaming*	*Test Data*	*Data for Security Analysis*
	SLO-2	*Industry Examples of Big Data*	*Global Innovation Network and Analysis*	*Design of HDFS*	*Local Tests*	*Analysis in Everyday Life*
S-4	SLO-1	*Web Analytics*	*Case Study: Global Innovation Network and Analysis*	*Java Interfaces to HDFS Basics*	*Anatomy of a Map Reduce Job Run*	*Scenarios in Intrusion*
	SLO-2	*Big Data and Marketing*	*Introduction to R*	*Data Flow, Hadoop I/O*	*Classic MapReduce*	*Challenges in Intrusion*
S-5	SLO-1	*Fraud and Big Data*	*Introduction to SQL*	*Data Integrity*	*YARN*	*Incident Identification*
	SLO-2	*Risk and Big Data*	*Charts*	*Compression, Serialization*	*Failures in Classic MapReduce*	*Analysis of Log File*
S-6	SLO-1	*Credit Risk Management*	*Graphs*	*Avro, File Based Data Structures*	*Failures in YARN*	*Loading the Data*
	SLO-2	*Big Data and Algorithmic Trading*	*Data tools*	*Pig, Hive*	*Job Scheduling*	*Simulation*
S-7	SLO-1	*Big Data and Healthcare*	*Statistical Methods*	*Hbase*	*Shuffle and Sort*	*Security Process*
	SLO-2	*Big Data in Medicine*	*Clustering*	*Data Model and Implementations*	*Task Execution*	*Access Analytics*
S-8	SLO-1	*Advertising and Big Data*	*Association Rules Regression*	*Hbase Clients, Hbase Examples*	*MapReduce Types*	*Security Analysis*

	SLO-2	*Different advertising in Big Data*	*Classification*	*Praxis, Cassandra*	*MapReduce Formats*	*Security Analysis with Text Mining Security Intelligence*
S-9	SLO-1	*Big Data Technologies*	*Time Series Analysis*	*Cassandra Data Model*	*MapReduce Features*	*Security Breaches*
	SLO-2	*Classification of different technologies in Big Data*	*Text Analysis*	*Cassandra Clients, Cassandra Examples*	*Hadoop environment*	*Security Breaches Examples*

Learning Resources	1. *David Dietrich, Barry Heller and Beibei Yang, Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data, Reprint 2015, EMC Education Services, Wiley, ISBN:9788126556533.* 2. *Tom White, Hadoop: The Definitive Guide, Third Edition, O'reilly Media, 2012.*	3. *https://www.tutorialspoint.com/big_data_analytics/index.htm* 4. *https://www.youtube.com/playlist?list=PLFW6lRTa1g813lyYHLRP_bWJEKQDeEcSP* 5. *Mark Allen Weiss, Data Structures and Algorithm Analysis in C++, Third Edition, 2009*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr. Tripathi patro,visam pvt ltd,btp@visom.co.in	*1.Dr.P.Ganesh Kumar, Anna University, ganesh23508@gmail.com*	*1. Dr.E.Poovammal, SRMIST*
2.Mr.Balachandrasekar.K,CTS,dyaksha@gmail.com	*2.Dr. C.Nayanatara, Shri Sairam Engineering College, nayanatara.eee@sairam.edu.in*	*2. Mr.P.Kanakaraj, SRMIST*

Course Code	18EEE426T	Course Name	FUNDAMENTALS OF CLOUD COMPUTING	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Outline cloud computing and its model*			
CLR-2 :	*Explain the cloud-enabling technology and its applications*			
CLR-3 :	*Educate on different cloud computing architectures*			
CLR-4 :	*Understand the cost metrics and cloud management*			
CLR-5 :	*Provide adequate knowledge in cloud security*			
CLR-6 :	*Create application by utilizing cloud platforms*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Recall the basic concepts of cloud computing and its model*	*1*	*80*	*75*
CLO-2 :	*Acquire knowledge on the cloud enabling technologies and its applications*	*2*	*80*	*75*
CLO-3 :	*Illustrate the basic concepts of cloud computing architecture*	*1*	*80*	*75*
CLO-4 :	*Analyze the cost metrics and recall the concepts of cloud management*	*2*	*80*	*75*
CLO-5 :	*Realize the security threats in cloud*	*2*	*80*	*75*
CLO-6 :	*Design a perfect cloud platform for different applications*	*2*	*80*	*75*

Course Learning Outcomes (CLO):	Program Learning Outcomes (PLO)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*H*	-	-	-	-	-	-	-	-	-	-	-	*H*	*M*	-
CLO-2 :	*H*	*H*	*M*	*M*	*M*	-	-	*L*	-	-	-	-	*M*	*M*	*L*
CLO-3 :	*H*	-	-	-	-	-	-	-	-	-	-	-	*H*	*M*	-
CLO-4 :	*H*	*H*	*M*	*M*	-	-	-	*M*	-	-	-	-	*H*	*H*	*M*
CLO-5 :	*H*	*H*	*H*	*M*	-	-	-	*M*	-	-	-	-	*H*	*M*	*M*
CLO-6 :	*H*	*H*	*M*	*M*	*M*	-	-	*M*	-	-	-	-	*H*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Cloud*	*Key Drivers to Adopting the Cloud*	*Requirements of Cloud computing architecture*	*Cost Metrics*	*Infrastructure Security*
	SLO-2	*Overview of Cloud*	*Examples of Key Drivers to Adopting the Cloud*	*Introduction to Cloud computing architecture*	*Pricing Models*	*The Network Level Infrastructure Security*
S-2	SLO-1	*Basic Concepts of Cloud*	*The Impact of Cloud Computing*	*Workload Distribution Architecture*	*Business Cost Metrics*	*The Host Level Infrastructure Security*
	SLO-2	*Basic Terminology of Cloud*	*The Impact of Cloud Computing on Users*	*Example*	*Cloud Usage Cost Metrics*	*The Application Level Infrastructure Security*
S-3	SLO-1	*Goals*	*Broadband Networks*	*Resource Pooling Architecture*	*Cost Management*	*Data Security and Storage*
	SLO-2	*Benefits*	*Internet Architecture*	*Example*	*Considerations of Cost Management*	*Aspects of Data Security*
S-4	SLO-1	*Risks*	*Data Center Technology*	*Dynamic Scalability Architecture*	*Service Quality Metrics*	*Data Security Mitigation*
	SLO-2	*Challenges*	*Virtualization Technology*	*Example*	*Different types of Service Quality Metrics*	*Provider Data*
S-5	SLO-1	*Cloud service provider*	*Web Technology*	*Elastic Resource Capacity Architecture*	*SLA*	*Provider Data Security*
	SLO-2	*Cloud service consumer*	*Multitenant Technology*	*Example*	*SLA Guidelines*	*Encryption*
S-6	SLO-1	*Cloud Characteristics*	*Service Technology*	*Service Load Balancing Architecture*	*Identity and Access Management*	*Hashing*
	SLO-2	*Issues in Cloud Computing*	*Different Applications of Cloud Computing*	*Example*	*Trust Boundaries*	*Digital Signature*
S-7	SLO-1	*Cloud Computing*	*Healthcare*	*Cloud Bursting Architecture*	*IAM*	*Public Key Infrastructure (PKI)*
	SLO-2	*Grid Computing*	*Energy systems*	*Example*	*IAM Challenges*	*Example*
S-8	SLO-1	*Comparative study of Cloud Computing and Grid Computing*	*Transportation systems*	*Elastic Disk Provisioning Architecture*	*Relevant IAM Standards for Cloud Services*	*Single Sign On (SSO)*
	SLO-2	*Cloud Service Models*	*Manufacturing industry*	*Example*	*Relevant IAM Protocols for Cloud Services*	*Kerberos authentication - One-time password*

S-9	SLO-1	*IaaS, PaaS and SaaS*	*Education*	*Redundant Storage Architecture*	*IAM Practices in the Cloud*	*Example*
	SLO-2	*Cloud Deployment Models*	*Mobile Communication*	*Example*	*Cloud Authorization Management*	*Cloud Based Security Groups*

Learning Resources	1. *Thomas Erl, Zaigham Mahmood, Richardo Puttini, Cloud Computing: Concepts, Technology & Architecture, Fourth Printing, Prentice Hall/PearsonPTR, 2014, ISBN: 9780133387520.* 2. *Tim Mather, Subra Kumaraswamy, Shahed Latif, Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance, O'Reilly Media, Inc.", Computers - 338 pages.* 3. *https://www.youtube.com/channel/UCK73enkjfQNDwdBqMyaMtRg/videos*	4. *ArshdeepBahga, Vijay Madisetti, Cloud Computing: A Hands-On Approach, University Press, 2016, ISBN: 9780996025508.* 5. *K.Chandrasekaran, Essentials of Cloud Computing, Chapman and Hall/CRC Press, 2014, ISBN 9781482205435.* 6. *Thomas Erl, Robert Cope, Amin Naserpour, Cloud Computing Design Patterns, Prentice Hall/Service Tech Press, Pearson, 2015, ISBN: 978-0133858563.*

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Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

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