B. E. SYLLABUS

ELECTRICAL & ELECTRONICS ENGINEERING

V & VI SEMESTER

With

Scheme of Teaching

& Examination

DEPARTMENT: ELECTRICAL & ELECTRONICS ENGINEERING

Sl. No	Name of Faculty	Qualification	Designation
1	Dr. Nagesh Prabhu	PhD	Professor & HOD
2	Dr. Sathyendra Kumar	Ph.D	Professor
3	Dr. Pius Pinto	Ph.D	Professor
4	K. Vasudeva Shettigar	M.Tech	Associate Professor
5	Suryanarayana K	M.Tech (on PhD)	Associate Professor
6	Nayana P Shetty	M.Tech (PhD)	Associate Professor
7	Naveen J	M.Tech	Asst. Prof Gd III
8	Pradeep Kumar	M.Tech (PhD)	Asst. Prof Gd III
9	Latha Shenoy	M.Tech (PhD)	Asst. Prof Gd III
10	Anitha Marina Colaco	M.Tech (on PhD)	Asst. Prof Gd II
11	Mahabaleshwara Sharma K	M.Tech	Asst. Prof Gd II
12	Raksha Adappa	M.Tech	Asst. Prof Gd II
13	Dinesh Shetty	M.Tech (PhD)	Asst. Prof Gd II
14	Raghavendra Prabhu	M.Tech	Asst. Prof Gd II
15	Girisha Joshi	M.Tech (PhD)	Asst. Prof Gd II
16	Soumya Rani Mestha	M.Tech (PhD)	Asst. Prof Gd I
17	Md. Abdul Raheman	M.E	Asst. Prof Gd I
18	Gururaj K	M.Tech	Asst. Prof Gd I
19	Ravikiran Rao	M.Tech	Asst. Prof Gd I
20	Swathi Hatwar H	M.Tech	Asst. Prof Gd I

DEPARTMENT: ELECTRICAL & ELECTRONICS ENGINEERING

Vision:

Pursuing excellence in Electrical & Electronics Engineering, creating a research environment to promote innovation and address global challenges.

Mission:

To equip students to face global challenges by excelling in professional career and higher education.

To offer high quality graduate and post graduate programs in electrical & electronics engineering.

To promote excellence in research, collaborative activities and contribute to social development with ethical values.

Programme Educational Objectives (PEOs):

Excel in professional career and / or higher education by acquiring knowledge in mathematical, electrical, electronics and computer engineering principles.

Analyze real life problems, design electrical and electronics & multidisciplinary engineering systems and solutions that are socially acceptable

Inculcate and exhibit ethical values, communication skills and provide supportive and leadership roles in their profession to emerge as excellent professionals and adapt to current trends by engaging in lifelong learning to promote research.

Programme Outcomes (PO)

At the end of B.E (E&E) program the students will have an ability to

PO1 **Engineering knowledge**: Apply the knowledge of mathematics, science and engineering fundamentals while practicing Electrical & Electronics Engineering.

PO2 **Problem analysis**: Identify, formulate, review research literature, analyze complex Electrical & Electronics Engineering problems and draw substantiated conclusions by applying the principles of mathematics, basic science and engineering sciences.

PO3 **Design/development of solutions**: Design solutions for electrical and electronics engineering problems to meet the specified needs, taking into consideration the public health, safety, cultural, societal, and environmental issues.

PO4 **Conduct investigations of complex problems**: Investigate Electrical & Electronics Engineering problems using design of experiments, analysis & interpretation of data, to provide valid conclusions.

PO5 **Modern tool usage**: Create, select, use and apply emerging technologies, skills, and modern engineering and IT tools necessary for practicing Electrical & Electronics Engineering with an understanding of the limitations.

PO6 **The engineer and society**: Apply the contextual knowledge to assess societal, health, safety, legal, cultural issues and the consequent responsibilities while practicing electrical and electronics engineering profession.

PO7 **Environment and sustainability**: Understand the impact of the professional engineering solutions on society and environment, and demonstrate the need for sustainable development.

PO8 **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9 **Individual and team work**: Function effectively as an individual/ member or as a leader in diverse teams and contribute to multidisciplinary project.

PO10 **Communication**: Communicate effectively by comprehending, writing effective reports/design documentation, making effective presentations, and giving & receiving clear instructions.

PO11 **Project management and finance**: Manage the multidisciplinary projects and finance economically, utilizing the gained knowledge of engineering and management principles.

PO12 **Life-long learning**: Update and strengthen the knowledge by engaging in lifelong learning to keep pace with technological change.

Program Specific Outcomes (PSO)

PSO1 An ability to demonstrate the electrical engineering concepts by developing working models.

PSO2 An ability to apply embedded system concepts to address electrical engineering problems.

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING
SCHEME OF TEACHING AND EXAMINATION

V Semester **33 Hours/week**

Sl.No.	Code	Course Title	Theory/Tuto. /Prac./ Self study	Total Hrs./Week	CIE	SEE	Credits
1	15EE501	Linear Integrated Circuits	4+0+0+0	4	50	50	4
2	15EE502	Digital Signal Processing	3+2+0+0	5	50	50	4
3	15EE503	Linear Control Systems	3+2+0+0	5	50	50	4
4	15EE504	Power Electronics	4+0+0+0	4	50	50	4
5	15EE505	Generation, Transmission and Distribution	4+0+0+S	4	50	50	4
6	15EE506	Transformers and Induction Machines Laboratory	0+0+3+0	3	50	50	2
7	15EE507	Circuit and Measurements Laboratory	0+0+2+0	2	50	50	1
8	15EE508	Linear System Simulation Laboratory	0+0+2+0	2	50	50	1
9	15EE51X	Elective - I	3+0+0+0	3	50	50	3
10	15IL001	Employability Skill Development -I	0+1+0+0	1	50	-	-
TOTAL			**33**	**33**	**500**	**450**	**27**

15EE51X	15EE511	Power Semiconductor Devices
	15EE512	Energy Management & Audit
	15EE513	Operating System
	15EE514	Fuzzy Logic Control
	15EE515	Advanced Instrumentation System

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING
SCHEME OF TEACHING AND EXAMINATION

VI Semester **29 Hours/week**

Sl. No.	Code	Course Title	Theory/Tuto. /Prac./ Self study	Total Hrs. /Week	CIE	SEE	Credits
1	15EE601	Power Systems Analysis & Stability	3+2+0+0	5	50	50	4
2	15EE602	Switchgear and Protection	4+0+0+S	4	50	50	4
3	15EE603	Electrical Machine Design and CAD	3+2+0+0	5	50	50	4
4	15EE604	Power Electronics Laboratory	0+0+3+0	3	50	50	2
5	15EE605	Electrical CAD Laboratory	0+0+2+0	2	50	50	1
6	15EE606	Linear IC and Control Systems Laboratory	0+0+3+0	3	50	50	2
7	15EE607	IGW*- will be held for one week during specified slot in the semester and will be a non-credit mandatory course.	-	-	50	-	-
8	15IL002	Employability Skill Development -II	0+1+0+0	1	50	-	-
9	15EE61X	Elective – II	3+0+0+0	3	50	50	3
10	15EE62Y	Elective – III	3+0+0+0	3	50	50	3
TOTAL			**29**	**29**	**500**	**500**	**23**

ELECTIVE – II

15EE61X	15EE611	Switched Mode Power Converter
	15EE612	Renewable Energy Sources
	15EE613	Introduction to ASIC and FPGA Design
	15EE614	Advanced Control Theory
	15EE615	Operations Research

ELECTIVE - III

15EE62Y	15EE621	Power Electronics System Design using ICs
	15EE622	OOPS using C++
	15EE623	ARM System Architecture
	15EE624	Programmable Logic Controllers
	15EE625	Illumination Technology

LINEAR INTEGRATED CIRCUITS

Sub Code	**: 15EE501**	**Credits**	**: 04**
Hrs/Week	**: 4+0+0+0**	**Total Hours**	**: 52**

Prerequisites
Basic Electronics (15EC112), Analog Electronics Circuits (15EE304)

Course Learning Objectives:

1. To differentiate ideal and practical op-amp and identify various practical op-amp specifications and measure offset error voltages / currents and other critical parameters.
2. To analyze and design the direct coupled and capacitor coupled operational amplifier circuits. And discuss op-amp circuit stability issues and frequency compensating methods.
3. To demonstrate the use of op-amp in signal processing applications, active filters and design such circuits.
4. To analyze the non-linear behavior of the op-amp and design op-amp circuits in open loop and with positive feedback.

UNIT – I

Operational Amplifier: The basic operational amplifier, Ideal Op-Amp concept, Practical Op-Amps, OP-AMP as a DC amplifier, Differential amplifier, Offset error voltages and currents. Measurement of operational amplifier parameters. **7 Hours**

OP-AMP as an AC Amplifier: Capacitor Coupled Voltage Follower, High Zin capacitor coupled voltage follower, capacitor coupled non-inverting amplifier, High Zin capacitor coupled non-inverting amplifier, Capacitor coupled inverting amplifier **4 Hours**

UNIT – II

Setting upper cut-off frequency, capacitor coupled difference amplifier, use of single polarity supply. **3 Hours**

OP-AMP Frequency Response and Compensation: Op-Amp circuit stability, frequency and phase response, frequency compensating methods, Manufacturer's recommended compensation, op-amp circuit bandwidth, slew rate effects, stray capacitance effects, load capacitance effects, Zin Mod compensation, Circuit stability precautions. **8 Hours**

UNIT – III

OP-AMP Nonlinear Circuits-1: Precision Half wave and full wave rectifiers, limiting circuits, Clamping circuits, peak detectors, sample and hold circuits. V/F and F/V Converters. **5 Hours**

OP-AMP Nonlinear Circuits-2: Op-Amps in switching circuits, crossing detectors, inverting Schmitt trigger circuits, Non-inverting circuits, Astable multivibrators, Monostable multivibrators, op-amp based SCR triggering circuit. **5 Hours**

UNIT – IV

Active Filters: First and Second order high pass and low pass filters. Band pass filter, Band stop filters. Higher order filters. **6 Hours**

Specialized IC Applications: Universal active filters, Phase locked loops, Power amplifiers. **3 Hours**

UNIT – V

555 TIMER - Monostable and Astable multivibrators and applications **3 Hours**

DC-Voltage Regulators: Voltage regulator basics, Voltage follower regulator, adjustable output regulator, Precision voltage regulator, Integrated Circuit voltage Regulator. **8 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Analyze the op-amp parameters and understand their limitations and applications as AC amplifier.
2. Discuss op-amp frequency dependence, circuit stability issues and frequency compensating methods.
3. Demonstrate the use of op-amp in signal processing applications, non-linear applications with positive feedback.
4. Design and use op-amp in an active filters circuits. Demonstrate the use of specialized IC's.
5. Analyze and design application circuits using 555 timers and study various voltage regulators.

Mapping of POs & COs:

Program Outcomes→ / ↓ Course Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
CO1	√								√			
CO2	√	√		√	√				√			
CO3	√			√	√				√			
CO4	√	√		√	√				√			
CO5	√	√		√	√				√		√	

TEXT BOOKS :

1. David A Bell, Operational Amplifier and Linear IC's, OXFORD UNIVERSITY PRESS-NEW DELHI, 3rd Edition, 2011.
2. Ramakanth Gayakwad, Operational Amplifiers and Linear IC's,4th edition — Prentice Hall, 2000..

REFERENCE BOOKS :

1. Roy Choudhry, Operational amplifiers and Linear Integrated circuits – New Age International,4th edition, April 2011.

2. Stanley William D., Operational amplifiers and Linear Integrated circuits –4th Edition, Pearson Education.2001.

E-Books / MOOC

1. Introductory Analog Electronics Laboratory (Spring 2007) by MIT Open Courseware | Reviews and Ratings
2. https://www2.mvcc.edu/users/faculty/jfiore/OpAmps/OperationalAmplifiersAndLinearICs_3E.pdf
3. http://freevideolectures.com/Course/2915/Linear-Integrated-Circuits
4. https://inst.eecs.berkeley.edu/~ee140/sp14/lectures.html
5. Texas Instrument Videos on Amplifiers Available at https://www.youtube.com/playlist?list=PLISmVLHAZbTS78B14s_uMovo0izTdSMCr

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DIGITAL SIGNAL PROCESSING

Sub Code : 15EE502 **Credits : 04**
Hrs/Week : 3*+2+0+0 **Total Hours : 39*+26**

***Note:** Lecture hours indicated are for teaching theoretical concepts. Illustrative examples and numerical problems are to be worked out in tutorial classes.

Prerequisites
VCTT (15EE301), PTNM (15EE401), ENT-I (15EE302), ENT-II (15EE405)

Course Learning Objectives:

1. To understanding the basic elements of dsp and review of DTFT and Z tranform
2. To understand the filtering of long sequence and the FFT algorithm for time and frequency domain.
3. To Illustrate the design and implementation of digital filters and spectral analyzers, and in their application to real signals.
4. To demonstrate the design and implementation of IIR filters and spectral analyzers.
5. To understand the different structures of IIR and FIR filter
6. To understand the concept of quantization, truncation and rounding

UNIT – I

Basic elements of DSP – concepts of frequency in Analog and Digital Signals – sampling theorem Discrete time signals, systems – Analysis of discrete time LTI systems – Review of DTFT and Z transform – Convolution – Correlation. **8*+5 Hours**

UNIT - II

FREQUENCY TRANSFORMATIONS

Introduction to DFT – Properties of DFT – Circular Convolution - Filtering methods based on DFT – FFT Algorithms - Decimation – in – time Algorithms, Decimation – in – frequency Algorithms – Use of FFT in Linear Filtering – DCT – Use and Application of DCT.

8*+5 Hours

UNIT – III

IIR FILTER DESIGN

Structures of IIR – Analog filter design – Discrete time IIR filter from analog filter – IIR filter design by Impulse Invariance, Bilinear transformation, Approximation of derivatives – (LPF, HPF, BPF, BRF) filter design using frequency translation. **8*+5 Hours**

UNIT – IV

FIR FILTER DESIGN: Symmetric & Antisymmetric FIR filters – Linear phase filter – Windowing technique – Rectangular, Kaiser windows – Frequency sampling techniques – Structure for FIR systems. **8*+5 Hours**

UNIT – V

FINITE WORD LENGTH EFFECTS IN DIGITAL FILTERS

Binary fixed point and floating point number representations – Comparison - Quantization noise – truncation and rounding – quantization noise power- input quantization error-coefficient quantization error –limit cycle oscillations-dead band- Overflow error-signal scaling. **7*+5 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Analyze the signals in discrete time domain Analyze the signals in discrete time domain
2. Convert the signals from analog domain to digital domain
3. Design and implement filters using infinite impulse response techniques
4. Design and implement filters using finite impulse response techniques
5. Analyze the various kinds of errors taking place while sampling

Mapping of POs & COs:

Program Outcomes→ ↓ Course Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
CO1	H			M	L							
CO2	H	L		M	L				L			
CO3	M	M	M	M					M			
CO4	M	H	M	M	M				M			
CO5	H	M										

TEXT BOOK :

1. John G Proakis and Dimtris G Manolakis, "Digital Signal Processing Principles, Algorithms and Application", Electronic Industry Press, 2013, 4TH Edition..

REFERENCE BOOKS :

1. Alan V Oppenheim, Ronald W Schafer and John R Buck, "Discrete Time Signal Processing", PHI/Pearson Education, 2000, 2nd Edition.
2. Johny R. Johnson, "Introduction to Digital Signal Processing", PEARSON, 2015.
3. Sanjit K.Mitra, "Digital Signal Processing: A Computer – Based Approach", Tata McGraw-Hill, 2007, 3RD Edition.

E-Books / MOOC:

1. The Scientist and Engineer's Guide to Digital Signal Processing By Steven W. Smith, Ph.D.
2. Digital Signal Processing Principles, Algorithms, and Applications John G. Proakis Northeastern University Dimitris G. Manolakis, Third Edition
3. https://ocw.mit.edu/resources/res-6-008-digital-signal-processing-spring-2011/video-lectures/
4. http://nptel.ac.in/courses/117102060/
5. https://www.mooc-list.com/course/applied-digital-signal-processing-dit?static=true
6. Sign up at http://www.coursera.org/course/dsp

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LINEAR CONTROL SYSTEMS

Sub Code	**: 15EE503**	**Credits**	**: 04**
Hrs/Week	**: 3*+2+0+0**	**Total Hours**	**: 39*+26**

***Note:** Lecture hours indicated are for teaching theoretical concepts. Illustrative examples and numerical problems are to be worked out in tutorial classes.

Prerequisites
VCTT (15EE301), PTNM (15EE401)

Course Learning Objectives :

1. To introduce modeling and analysis of electrical, electromechanical and mechanical systems.
2. To familiarize the students with analytical and graphical techniques to study the stability of control systems and design the control system.
3. To make the students familiar with the time domain and frequency domain analysis.

UNIT – I

Modeling of Systems: The control system, Mathematical models of physical systems – electrical Mechanical, electro-mechanical systems, (Mechanical accelerometer, Levered systems excluded), Gear trains, Analogous systems, Introduction to state space modeling simple systems. **8*+5 Hours**

UNIT – II

Block diagrams and signal flow graphs: Transfer functions, Block diagram algebra, Signal Flow graphs (State variable formulation excluded) **5*+3 Hours**

Time Response of feedback control systems: Standard test signals, UNIT step response of First and second order systems, Time response specifications, Time response specifications of second order systems, steady – static errors and error constants. **3*+2 Hours**

UNIT – III

Stability analysis: Concepts of stability, Necessary conditions for Stability, Routh- stability criterion, Relative stability analysis **4*+2 Hours**
Root–Locus Techniques: Introduction, The root locus concepts, Construction of root loci, effect of addition of poles and zeroes. **4*+3 Hours**

UNIT – IV

Frequency domain analysis:frequency response specification, Correlation between time and frequency response, Bode plots, All pass, minimum & non-minimum phase systems, Assessment of relative stability using Bode Plots, determination of transfer functions from bode plots. **7*+6 Hours**

UNIT – V

Polar plots, Nyquist Criteria: Mathematical preliminaries, Nyquist Stability criterion, Assessment of relative stability using Nyquist plots **4*+3 Hours**
Compensators and Controllers: Compensators, lead lag networks, Controllers P, PI, PID (qualitative analysis) **4*+2 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Develop mathematical model of linear systems and model reduction using block diagram and signal flow graphs.
2. Perform the time domain analysis of control system.
3. Demonstrate the concept of stability.
4. Analyze the transfer function of the physical systems for stability using different control techniques.
5. Expound the frequency domain analysis of given system.

Mapping of POs & COs:

Program Outcomes→ / ↓ Course Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
CO1	H	M										
CO2	H	M		M								
CO3	H	M		H								
CO4	H	M		H							L	
CO5	H			H					L			

TEXT BOOKS :

1. K. Ogata, "Modern Control Engineering ", Pearson Education Asia/ PHI, 4th Edition, 2002.
2. J. J. D'Azzo and C. H. Houpis; "Linear control system and Design using MATLAB" control system analysis and synthesis", Taylor and Francis,5th edition, 2003.

REFERENCE BOOKS :

1. J. Nagarath and M.Gopal, "Control Systems Engineering", New Age International (P) Limited, Publishers, 5th edition – 2007.
2. P. S. Satyanarayana, "Concepts of Control Systems", Dynaram publishers, Bangalore, 2001
3. M. Gopal, "Control Systems – Principles and Design", 4TH EDITION,2012.

E-Books / MOOC:

1. http://www.electrical4u.com/control-system-closed-loop-open-loop-control-system/#practical-examples-of-open-loop-control-system
2. http://www.facstaff.bucknell.edu/mastascu/eControlHTML/CourseIndex.html
3. https://see.stanford.edu/Course/EE263
4. http://en.wikibooks.org/wiki/Control_Systems
5. www.nptel.com/IITK
6. https://www.edx.org/course/
7. http://nptel.ac.in/courses/108103007/1

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POWER ELECTRONICS

Sub Code	**: 15EE504**	**Credits**	**: 04**
Hrs/Week	**: 4+0+0+0**	**Total Hours**	**: 52**

Prerequisites

Basic Electronics (15EC112), AEC (15EE304),

Course Learning Objectives :

1. To understand types and the characteristic of power semiconductor devices, converters
2. To familiarize the principle of operation of thyristors with their characteristics
3. To describe the principle of operation of AC voltage controller, controlled rectifiers circuits and evaluation of performance parameters.
4. To get acquainted with the different types of chopper configurations and methods of control.
5. To understand the principle of operation of single phase and three phase inverters circuits.

UNIT – I

Introduction, Power Semiconductor Devices: Applications of Power Electronics, Power semiconductor devices, Control Characteristics. Types of power electronic circuits. Peripheral effects. **4 Hours**

Power Transistors: Power BJT's – switching characteristics, switching limits, base drive control. Power MOSFET's – switching characteristics, gate drive. IGBT's, di/dt and dv/dt limitations. Isolation of gate and base drives. Simple design of gate and base drives.

7 Hours

UNIT – II

Thyristors : Introduction, characteristics. Two Transistor Model. Turn-on and turn-off. di/dt and dv/dt protection. Thyristor types. Series and parallel operation of Thyristors. Thyristor firing circuits, UJT, Sample design of firing circuits using UJT. **6 Hours**

Commutation Techniques: Introduction. Natural Commutation. Forced commutation: self-commutation, impulse commutation, resonant pulse commutation and complementary commutation. **5 Hours**

UNIT – III

AC Voltage Controllers: Introduction. Principle of ON-OFF and phase control. Single - phase bidirectional controllers with resistive and inductive loads. **5 Hours**

DC Choppers: Introduction. Principle of step-down and step-up chopper with R-L load. Performance parameters. Chopper classification. Analysis of impulse commutated thyristor chopper (only qualitative analysis) **5 Hours**

UNIT – IV

Controlled Rectifiers: Introduction. Principle of phase controlled converter operation. Single- phase semi-converters. Full converters. Three-phase half wave converters. Three-phase full-wave converters. **10 Hours**

UNIT – V

Inverters: Introduction. Principle of operation. Performance parameters. Single -phase bridge inverters. Three phase inverters. Voltage control of single-phase inverters – single pulse width, multiple pulse width, and sinusoidal pulse width modulation. Current source inverters. Variable D.C. link inverter **10 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Distinguish different types of power semiconductor devices, converters and their characteristics.
2. Explain the principle of operation of thyristors with their characteristics and analyze various thyristor firing circuits, commutation methods and protection circuits used.

3. Describe the principle of operation of AC voltage controller, controlled rectifiers circuits and evaluation of performance parameters.
4. Explain different types of chopper configurations and methods of control.
5. Describe the principle of operation of single phase and three phase inverters circuits.

Mapping of POs & COs:

Program Outcomes→ / ↓ Course Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
CO1	M	M										
CO2	L	L										
CO3	H	H		L								
CO4	H	H		L								
CO5	H	H		L								

TEXT BOOK :

1. M.H.Rashid "Power Electronics", 3Rd Edition, P.H.I. /Pearson, New Delhi, 2014..

REFERENCE BOOKS :

1. Ned Mohan, Tore M. Undeland, and William P. Robins, "Power Electronics – Converters, Applications and Design", Third Edition, John Wiley and Sons. 2010.
2. G.K. Dubey, S.R. Doradla, A. Joshi and R.M.K. Sinha, "Thyristorised Power Controllers", New Age International Publishers,2ND Edition,2012.

E-Books / MOOC:

1. E course material on power electronics available at nptel.ac.in/courses/108105066/
2. www.powerelectronics.com/learning-resources/ebooks
3. NPTEL Video Lecture on "Power Electronics" nptel.ac.in/courses/108101038/#
4. www.coursera.org/learn/power-electronics
5. ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-334-power-electronics-spring-2007/

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GENERATION, TRANSMISSION AND DISTRIBUTION

Sub Code : 15EE505 **Credits : 04**
Hrs/Week : 4+0+0+S* **Total Hours : 52**

***Self-Study Topics –** To be covered under the supervision of the course instructors.
Prerequisites: BEE (15EE105)

Course Learning Objectives :

1. To understand the concepts of various methods of generation of power.
2. To understand the concept of economic aspects and transmission and distribution schemes

3. To find various parameters pertaining to overhead transmission lines and select insulators
4. To calculate the parameters of the transmission line for different configurations and assess the performance of the line.
5. To understand the characteristics & performance of power transmission lines.

UNIT – I

Electrical Power Generation: Hydro Power generation-selection of site, classification of hydroelectric plants, general arrangement and operation, hydroelectric plant power station structure and control.
Thermal Power generation- Introduction, main parts, working, plant layout, Diesel Electric plants, Gas turbine plants-components, layout, advantages over steam turbine plant
Nuclear Power Station- Introduction, Adverse effects of fossil fuels, components of reactors, Description of fuel sources, Pros and Cons of nuclear power generation, Safety of nuclear power reactor
SS Topic: concept of co-generation **12 Hours**

UNIT – II

Economics Aspects: Introduction, Terms commonly used in system operation, Definitions of diversity factor, load factor, plant capacity factor, plant use factor, plant utilization factor, loss factor. Load duration curve, energy load curve and types of tariffs. **4 Hours**
Typical transmission & distribution systems scheme: General layout of power system, Standard voltages for transmission. Requirement of EHV transmission, Advantage of high voltage transmission. Feeders,
SS Topic: distributors & service mains.
Distribution: Requirements of power distribution, ac distribution - radial & ring main systems calculation for concentrated loads. **6 Hours**

UNIT – III

Overhead transmission lines: sag calculation in conductors a) suspended on level supports b) support at different levels. Effect of wind & ice tension & sag at erection, Line vibration damper. **6 Hours**
Insulators: Types, potential distribution over a string of suspension insulators. String efficiency & methods of increasing strings efficiency, Testing of insulators.
SS Topic: Insulation coordination – need and principle (qualitative)**.** **4 Hours**

UNIT – IV

Underground cables: Types, material used, insulation resistance, thermal rating of cables, charging current, Grading of cables, capacitance grading.
SS Topic: Inter sheath grading. **4 Hours**
Line parameters: calculation of inductance of single phase, 3phase lines with equilateral & unsymmetrical spacing. Inductance of composite conductor lines (GMR and GMD), capacitance calculation for single circuit and double circuit three-phase line with equilateral

& unsymmetrical spacing. **6 Hours**

UNIT – V

Characteristics & performance of power transmission lines: Short transmission lines, medium transmission lines- nominal T, end condenser and pi models,
SS Topic: long transmission lines **5 Hours**
ABCD constants of transmission lines, Ferranti effect, line regulation.
Introduction FACTS & HVDC Transmission **5 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Illustrate methods of generation of electrical power and their pros and cons
2. Appreciate the economic aspects of electrical power and typical transmission & distribution systems scheme.
3. Demonstrate the concepts associated with overhead transmission line and insulators
4. Interpret the concepts associated with underground cables and line parameters
5. Comprehend the characteristics & performance of power transmission lines and introduce the concept of FACTS and HVDC.

Mapping of POs & COs:

Program Outcomes→ / ↓ Course Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
CO1	H	H										
CO2	H	H										
CO3	H	H		H	L		L					
CO4	H	H		H			L					
CO5	H	H		H	L		L				L	

TEXT BOOKS :

1. S. M. Singh, Elements of Power Generation, Transmission and Distribution,2nd edition PHI, New Delhi. 2008
2. A. Chakarbarti, M.L. Soni and P.V. Gupta, U.S. Bhatnagar, Power system engineering, Published by Gagan Kanur, Dhanapat Rai and Co Pvt. Ltd,2013.
3. M.V. Deshpande, Elements of Power Station Design, 1st edition, PHI learning,2009.
4. S. L. Uppal "Electrical Power: Generation, Transmission, Distribution, Switchgear and Protection, Utilization of Electrical Energy and Electric Traction" Kanna Publishers,15th edition, 1995.

REFERENCE BOOKS :

1. Sivanagaraju S. Satyanarayana S.," Electric Power Transmission and Distribution" Pearson Learning, New Delhi, 2008.
2. Gupta J. B.," Transmission and Distribution of electrical energy, S.K. Kataria & Sons, New Delhi, 2012.

3. W.D. Stevenson, "Elements of Power System Analysis", 4th edition, 1994,.Mc.Graw - Hill. Comp. Ltd.

E-Books / MOOC

1. Energy scenario : https://beeindia.gov.in/sites/default/files/1Ch1.pdf
2. NPTEL courses in Electrical Engineering :Power system generation, Transmission& distribution: Video Lecture by Prof .D. P. Kothari, Centre for Energy Studies ,IIT New Delhi.
3. https://www.coursera.org/learn/electric-utilities

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TRANSFORMERS AND INDUCTION MACHINES LABORATORY

Sub Code	**: 15EE506**	**Credits**	**: 02**
Hrs/Week	**: 0+0+3+0**	**Total Hours**	**: 39**

Course Learning Objectives :

1. To familiarize the methods of testing transformer efficiency and regulation.
2. To understand the torque slip characteristics of an induction machine.
3. To perform the speed control of three phase induction machine.
4. To get acquainted to Parallel operation and three phase connections of single phase transformers.

List of Experiments

1. OC, SC test: 1- phase transformer, predetermination of efficiency & regulation.
2. Sumpner's test.
3. Parallel operation of two dissimilar (different KVA) 1-phase transformers.
4. Polarity test & connection of 3 single phase transformers in star – delta and determination of efficiency & regulation – for balanced direct loading for UPF.
5. Scott connection- for balanced and unbalanced two phases UPF loads.
6. Load test on 3-phase induction motor- performance evaluation (Torque- speed, BHP-efficiency, BHP_PF slip- BHP).
7. Circle diagram of 3-phase induction Motor- performance evaluation.
8. Obtain the equivalent circuit diagram of a 3-phase I.M. & from equivalent circuit diagram obtain its performance evaluation.
9. Speed control of 3-phase induction motor- stator voltage control & rotor resistance control (performance circuits for at least two different voltages/ two rotor resistance values).
10. Load test on- induction generator.
11. Load test on 1 phase induction motor.
12. Speed control of 3-phase induction motor by V/f method

Course Outcomes:

At the end of the course student will be able to

1. Test the transformer for its efficiency and regulation.
2. Determine torque slip characteristics of an induction machine.

3. Control the speed of three phase induction machine.
4. Parallel operation and three phase connections of single phase transformers
5. Performance evaluation of 3-phase induction machine using circle diagram and equivalent circuit analysis.

Mapping of POs & COs:

Program Outcomes→ / ↓ Course Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
CO1	√	√	√									
CO2	√	√	√									
CO3	√	√	√									
CO4	√	√	√									
CO5	√	√	√	√								

E Books

1. http://www.ee.iitkgp.ac.in/faci_em.php

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CIRCUITS AND MEASUREMENTS LABORATORY

Sub Code : 15EE507 **Credits : 01**
Hrs/Week : 0+0+2+0 **Total Hours : 26**

Course Learning Objectives :

1. To understand the process to Verify various network theorems
2. To measure circuit parameters using bridges.
3. To understand the procedures to Measure active and reactive power in three phase circuit.
4. To Know the calibration procedures for 1-phase energy meter and Determine ratio & phase angle error in CT.

List of Experiments

1. Measurement of low resistance using Kelvin Double Bridge.
2. Measurement of Inductance using Maxwell Bridge.
3. Measurement of Capacitance using Schering Bridge.
4. First order R-L and R-C circuits.
5. Second order RLC Circuits
6. Sinusoidal Steady State Analysis
7. Verification of Superposition and Reciprocity theorems
8. Verification of Thevenin's, Nortons' theorem
9. Verification of Maximum power transfer theorem
10. Measurement of active and reactive power in balanced 3-phase circuit using two-watt meter method.
11. Characteristics of series and Parallel resonance

12. Determination of ratio & phase angle error in CT.
13. Adjustment & calibration of 1-phase energy meter.

Course Outcomes:

At the end of the course student will be able to

1. Verify various network theorems and
2. Measure circuit parameters i.e resistances, capacitance and inductance using bridges
3. Measure active and reactive power in three phase circuit.
4. Verify the concept of resonance.
5. Adjust & calibrate 1-phase energy meter and Determine ratio & phase angle error in CT.

Mapping of POs & COs:

Program Outcomes→ ↓ Course Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
CO1	√	√	√									
CO2	√	√	√									
CO3	√	√	√									
CO4	√	√	√									
CO5	√	√	√	√								

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LINEAR SYSTEM SIMULATION LABORATORY

Sub Code : 15EE508 **Credits : 01**
Hrs/Week : 0+0+2+0 **Total Hours : 26**

Course Learning Objectives :

1. To verify various control systems concepts using simulation software.
2. To understand the signal processing concepts using simulation softwares

Following experiments to be simulated using MATLAB / Simulink (or Equivalent)

1. Simulation of a typical second order system and determination of step response and frequency response to evaluate time domain specifications & frequency domain specifications.
2. Simulate a D. C. position control system and obtain its step response.
3. Obtain the phase margin and gain margin for a given transfer function by drawing bode plots and verify the same.
4. To draw the root loci for a given transfer function and verification of breakaway point and imaginary axis cross axis.

5. To draw Polar plot, Nyquist plot for a given transfer function and verification of stability
6. Verification of Sampling theorem and obtaining Impulse response of a given system
7. Linear convolution of two given sequences by direct method and using DFT and IDFT
8. Circular convolution of two given sequences by direct method and using DFT and IDFT
9. Solving a given difference equation.
10. Computation of N point DFT of a given sequence and to plot magnitude and phase spectrum.
11. Design and implementation of FIR filter to meet given specifications.
12. Design and implementation of IIR filter to meet given specifications

Course Outcomes:

At the end of the course student will be able to

1.

Mapping of POs & COs:

Program Outcomes→ ↓ Course Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
CO1	√	√	√									
CO2	√	√	√									
CO3	√	√	√									
CO4	√	√	√									
CO5	√	√	√	√								

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POWER SEMICONDUCTOR DEVICES

Sub Code : 15EE511 **Credits : 03**
Hrs/Week : 3+0+0+0 **Total Hours : 39**

Prerequisites: Knowledge of Basic Semiconductor devices.

Course Learning Objectives :

1. To understand the principle of operation of MOSFET and IGBT with their characteristics and effect of reverse recovery transients on switching stresses & losses
2. To the construction and features of the emerging power electronic devices
3. To Illustrate the importance of gate drive circuits for power devices, design of snubber and heat sink.

UNIT – I

Introduction: Power switching devices overview – Attributes of an ideal switch, application requirements, circuit symbols; Power handling capability – (SOA); selection strategy – On-state and switching losses – EMI due to switching – Power diodes – Types, forward and reverse characteristics, switching characteristics – rating **6 Hours**

UNIT – II

Power MOSFET: Basic structure & operation**,** I-V Characteristics, On-state operation**,** Turn-on, turn-off process, Switching characteristics: Turn-on transient, dv/dt capability, Turn-off transient, turn-off time, Switching losses, Safe operating Area, Effect of reverse recovery transients on switching stresses & losses, dv/dt limitations. **8 Hours**

UNIT – III

Power IGBT: basic structure & operation**,** i-v characteristics**,** Latch-up in IGBT**,** Switching characteristics: turn-on**,** Turn-off transient, current tailing**,** Switching losses**,** Device limits & SOA**,** Over-current & short-circuit protection of IGBT **8 Hours**

UNIT – IV

Power Electronics Devices: Construction and features of - Phase Controlled thyristors, inverter graded thyristors, ASCR, RCT, SUS, SBS, SCS,GTO, MCT, SIT, IGCT, MTO, ETO, PIC. Comparison of power devices. **8 Hours**

UNIT – V

Firing and Protecting Circuits: Necessity of isolation, pulse transformer, optocoupler – Gate drives circuit: SCR, MOSFET, IGBTs and base driving for power BJT. - Over voltage, over current and gate protections; Design of snubbers, Guidance for heat sink selection, heat sink types and design – Mounting types. **9 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Overview of power semiconductor devices with selection strategy, types and characteristics of power diodes
2. Explain the principle of operation of MOSFET with their characteristics and effect of reverse recovery transients on switching stresses & losses
3. Explain the principle of operation of IGBT with their characteristics and protection against over-current & short-circuit
4. Demonstrate the construction and features of the emerging power electronic devices
5. Illustrate the importance of gate drive circuits for power devices, design of snubber and heat sink.

Mapping of POs & COs:

Program Outcomes→ ↓ Course Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
CO1	√	√										
CO2	√	√		√								
CO3	√	√		√			√					
CO4	√	√					√				√	
CO5	√	√									√	

TEXT BOOKS :

1. MD Singh and K.B Khanchandani, "Power Electronics", Tata McGraw Hill, 2nd edition,2001.
2. Mohan, Undeland and Robins, "Power Electronics – Converters, applications and Design, John Wiley and Sons, Singapore, 2000.

REFERENCE BOOKS :

1. Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2004.
2. B.W Williams 'Power Electronics Circuit Devices and Applications'. Palgrave publishers,1987.

E-Books / MOOC:

1. Module 1 of http://www.nptel.ac.in/courses/Webcourse-contents/IIT%20Kharagpur/Power%20Electronics/New_index1.html
2. https://www.coursera.org/learn/converter-circuits/lecture/b5VYY/sect-4-2-0-introduction-to-power-semiconductors

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ENERGY MANAGEMENT AND AUDIT

Sub Code	**: 15EE512**	**Credits**	**: 03**
Hrs/Week	**: 3+0+0+0**	**Total Hours**	**: 39**

Course Learning Objectives :

1. To understand the energy situation and need for energy economic analysis.
2. To know the concept of energy auditing.
3. To Comprehend various energy tariffs and understand the need for pf correction.
4. To understand the need for Electrical System Optimization.
5. To Implement the concept of Demand Side Management.

UNIT – I

Introduction: Energy situation – world and India, energy consumption, conservation. Codes, standards and Legislation. **4 Hours**

Energy Economic Analysis: The time value of money concept, developing cash flow models, payback analysis, depreciation, taxes and tax credit – numerical problems. **4 Hours**

UNIT – II

Energy Auditing: Introduction, Elements of energy audits, energy use profiles, measurements in energy audits, presentation of energy audit results. **8 Hours**

UNIT – III

Electrical Equipment and power factor –correction & location of capacitors, energy efficient motors, lighting basics, electrical rate tariff. **8 Hours**

UNIT – IV

Electrical System Optimization: The power triangle, motor horsepower, power flow concept. **7 Hours**

UNIT – V

Demand Side Management: Introduction to DSM, concept of DSM, benefits of DSM, different techniques of DSM – time of day pricing, multi-utility power exchange model, time of day models for planning, load management, load priority technique, peak clipping, peak shifting, valley filling, strategic conservation, energy efficient equipment. Management and Organization of Energy Conservation awareness Programs. **8 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Interpret the energy situation and need for energy economic analysis.
2. Illustrate the concept of energy auditing.
3. Comprehend various energy tariffs and understand the need for pf correction.

4. Outline the need for Electrical System Optimization.
5. Implement the concept of Demand Side Management

Mapping of POs & COs:

Program Outcomes→ ↓ Course Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
CO1	√											
CO2	√	√						√			√	
CO3	√	√					√					
CO4	√	√					√				√	
CO5	√	√									√	

TEXT BOOKS :

1. Larry C. White, Philip S. Schmidt, David R. Brown, "Industrial Energy Management Systems", Springer-verlag Berlin And Heidelberg Gmbh & Co. K, 1988
2. Albert Thumann, "Fundamentals of Energy Engineering," Prentice Hall Inc, Englewood Cliffs, New Jersey.1984.
3. Pabla "Electrical distribution", 6th edition,TMH, 2012..

REFERENCE BOOKS :

1. D.P.Sen, K.R.Padiyar, Indrane Sen, M.A.Pai, "Recent Advances in Control and Management of Energy Systems", Interline Publisher, Bangalore, 1993.
2. Ashok V. Desai, "Energy Demand – Analysis, Management and Conservation", Wiley Eastern Ltd., New Delhi.,1990.
3. Jyothi Prakash, "Demand Side Management", TMH Publishers.
4. Hand book on energy auditing - TERI (Tata Energy Research Institute)

E-Books / MOOC

1. https://www.coursera.org/learn/electric-utilities
2. http://www.nptel.ac.in/courses/108106022/

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OPERATING SYSTEM

Sub Code : 15EE513 **Credits : 03**
Hrs/Week : 3+0+0+0 **Total Hours : 39**

Course Learning Objectives:

1. To introduce the operating systems concepts.
2. To explain the concepts of structure of operating systems
3. To illustrate the process management and treads in operating systems
4. To illustrate the memory management and memory allocation in operating systems.
5. To introduce the concept of virtual memory in operating systems with example of UNIX.

UNIT – I

Introduction And Overview Of Operating Systems : Operating system, Goals of an O.S, Operation of an O.S, Resource allocation and related functions, User interface related functions, Classes of operating systems, O.S and the computer system, Batch processing system, Multi programming systems, Time sharing systems, Real time operating systems, distributed operating systems. **08 Hours**

UNIT – II

Structure of the Operating Systems: Operation of an O.S, Structure of the supervisor, Configuring and installing of the supervisor, Operating system with monolithic structure, layered design, Virtual machine operating systems, Kernel based operating systems, and Microkernel based operating systems. **8 Hours**

UNIT – III

Process Management: Process concept, Programmer view of processes, OS view of processes, Interacting processes, Threads, Processes in UNIX, Threads in Solaris. **7 Hours**

UNIT – IV

Memory Management: Memory allocation to programs, Memory allocation preliminaries, Contiguous and noncontiguous allocation to programs, Memory allocation for program controlled data, kernel memory allocation. **7 Hours**

UNIT – V

Virtual Memory: Virtual memory basics, Virtual memory using paging, Demand paging, Page replacement, Page replacement policies, Memory allocation to programs, Page sharing, UNIX virtual memory. Scheduling: Fundamentals of scheduling, Long-term scheduling, Medium and short term scheduling, Real time scheduling, Process scheduling in UNIX.

9 Hours

Course Outcomes:

At the end of the course student will be able to

1. Present an overview of operating systems and concepts related to it.
2. Explain the concepts of structure of operating systems.
3. Justify the concept of process management and treads in operating systems.
4. Illustrate the memory management and memory allocation in operating systems.
5. Introduce the concept of virtual memory in operating systems with example of UNIX.

Mapping of POs & COs:

Program Outcomes→ ↓ Course Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
CO1	√								√			
CO2	√				√				√			
CO3	√				√				√			
CO4	√				√				√			
CO5	√				√	√			√		√	

TEXT BOOKS:

1. D.M. Dhamdhare, "Operating Systems A Concept Based Approach" Mcgraw Hill Higher Education, 2nd Ed, 2007.
2. Operating System Principles – Abraham Silberschatz, Peter Baer Galvin, Greg Gagne, Wiley, 8th Edition, 2009.

REFERENCE BOOKS:

1. Silberschatz and Galvin, "Operating Systems Concepts", John Wiley, 5th Edition, 2001.
2. Operating Systems: A Concept Based Approach – D.M Dhamdhere, TMH, 2nd Edition,2006.
3. Operating Systems, P.C.P. Bhatt, PHI, 2nd Edition, 2008.
4. Operating Systems,Harvey M Deital,Pearson Education, 3rd Edition.
5. Silberschatz and Galvin, "Operating Systems Concepts", John Wiley, 5th Edition, 2001.

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FUZZY LOGIC CONTROL

Sub Code : 15EE514 **Credits : 03**
Hrs/Week : 3+0+0+0 **Total Hours : 39**

Course Learning Objectives :

1. To Know the basics of Fuzzy logic
2. To Differentiate between fuzzy and linguistic variables and study the concept of inference rules
3. To Demonstrate Fuzzy control systems.
4. To understand the fuzzy knowledge based controllers (FKBC)
5. To understand Process of performance monitoring, adaption mechanism.

UNIT – I

Introduction: Fuzzy sets, Properties of fuzzy sets, operation in fuzzy sets, fuzzy relations, cardinality operations on fuzzy relations, Fuzzy Cartesian product and composition, fuzzy Tolerance and equivalence relations. **7 Hours**

UNIT – II

Theory of approximate reasoning: Linguistic variables, linguistic hedges, Fuzzy if then statements, inference rules, compositional rule of inference. , graphical technique of inference, Fuzzification and defuzzification procedures**.** **8 Hours**

UNIT – III

Development of membership functions-intuition, inference, rank ordering, neural networks, genetic algorithm, inductive reasoning Assumptions in a Fuzzy control system design, Simple fuzzy logic controllers, Examples of fuzzy logic controllers. **10 Hours**

UNIT – IV

Fuzzy knowledge based controllers (FKBC): Basic concept structure of FKBC, choice of membership functions, scaling factors, rules, FKBC as a linear transient element, Design of P, PI, PD, PID controllers, , sliding mode FKBC, Sugeno FKBC. **8 Hours**

UNIT – V

ADAPTIVE FUZZY CONTROL: Process performance monitoring, adaption mechanisms, membership functions, tuning using gradient descent and performance criteria. Set organizing controller, Model based controller. **6 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Know the basics of Fuzzy logic
2. Differentiate between fuzzy and linguistic variables and study the concept of inference rules
3. Demonstrate Fuzzy control systems.
4. Interpret fuzzy knowledge based controllers (FKBC)
5. Analyze Process of performance monitoring, adaption mechanism.

Mapping of POs & COs:

Program Outcomes→ / ↓ Course Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
CO1	M											
CO2	M											
CO3	L		H	M	M							
CO4	M											
CO5	M											

TEXT BOOKS :

1. Timoty Ross, “Fuzzy Logic with engineering applications”, 3rd Edition, John Wiley And Sons , 2010.

2. D. Driankar, H. Hellendoom and M. Reinfrank- "An introduction to Fuzzy control", Narosa Publishers India, 1996.
3. G. J. Klir and T. A. Folger, "Fuzzy sets uncertainty and information" [Paris] : Didero publishers ,, 1996.

REFERENCE BOOKS :

1. R. R. Yaser and D. P. Filer "Essentials of Fuzzy modelling and control" John Wiley, 1994.
2. Yen, "Fuzzy Logic Intelligence control and Information" Pearson education. 1st edition,2002.
3. M Amirthavalli "Fuzzy logic and Neural networks", SciTech Publications (India) Pvt Limited, 2004

E-Books / MOOC/ NPTEL

1. http://nptel.ac.in/courses/108104049/
2. http://videolectures.net/acai05_berthold_fl/

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ADVANCED INSTRUMENTATION SYSTEM

Sub Code	**: 15EE515**	**Credits**	**: 03**
Hrs/Week	**: 3+0+0+0**	**Total Hours**	**: 39**

Prerequisites

BEE (15EE105), EEMI (15EE306)

Course Learning Objectives :

1. To Know the various aspects of instrumentation.
2. To understand the various measuring instruments and their characteristics.
3. To Comprehend with the working of various transducers.
4. To Appreciate the need of Data acquisition, conversion and transmission.

UNIT – I

Instrumentation: Frequency meter, measurement of time and frequency (mains), tachometer, phase meter, capacitance meter. Automation in digital Instrumentation.

7 Hours

UNIT – II

Analyzer: Wave analyzers and Harmonic distortion, Basic wave analyzer, Frequency selective wave analyzer, Harmonic distortion analyzer and Spectrum analyzer. **8 Hours**

UNIT – III

Measuring Instruments: Output power meters, Field strength meter Vector impedance meter, Q meter applications-Z, Z 0 and Q. Basic LCR bridge, RX meters. **5 Hours**

Measurement of power: Measurement of large amount of RF power (calorimetric method),measurement of power on a transmission line, standing wave ratio measurements. **4 Hours**

UNIT – IV

Transducers: Synchro's, Capacitance Transducers, Load cells, Piezo electrical Transducers, IC type temperature sensors, Pyrometers, Ultrasonic temperature Transducer, Reluctance pulse pick-ups, Flow measurement-mechanical Transducers; Magnetic flow meters, turbine flow meters. β-gauge. **8 Hours**

UNIT – V

Data acquisition and conversion: Generalized data acquisition system (DAS), Signal conditioning of inputs, single channel DAS, multi channel DAS, data loggers, compact data logger. **4 Hours**

Data transmission: universal serial bus,IEEE-1394.Long distance data transmission(modems).IEEE 488 bus. Electrical interface. **3 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Demonstrate various aspects of instrumentation.
2. Appreciate the need of analyzer.
3. List various measuring instruments and understand their characteristics. Also understand the concept of measurement of power.
4. Comprehend with the working of various transducers.
5. Appreciate the need of Data acquisition, conversion and transmission.

Mapping of POs & COs:

Program Outcomes→ ↓ Course Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
CO1	√	√										
CO2	√	√										
CO3	√	√										
CO4	√	√										
CO5	√	√										

REFERENCE BOOKS :

1. Electronic Instrumentation, H S Kalsi,MHE,3rd Edition,2010.
2. Modern Electronic Instrumentation and Measuring Techniques, Cooper D and A D Helfrick,PHI,2009
3. Student Reference Manual for Electronic Instrumentation Laboratories, Stanly Wolf, Richard F H,Smith,PHI,2nd Edition,2010.

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POWER SYSTEMS ANALYSIS & STABILITY

Sub Code : 15EE601 **Credits : 04**
Hrs/Week : 3*+2+0+0 **Total Hours : 39*+26**

*** Note:** Lecture hours indicated are for teaching theoretical concepts. Illustrative examples and numerical problems are to be worked out in tutorial classes.

Prerequisites
15EE105 (BEE), 15EE405 (NA), 15EE303 (DCSM)

Course Learning Objectives :

1. To gain the knowledge pertaining to network representation: per-UNIT system, balanced networks, and single line diagrams.
2. To introduce Power systems components and their modelling
3. To illustrate various symmetrical & unsymmetrical faults in power system, symmetrical components, selection of circuit breakers.
4. To introduce the concept of rotor dynamic, swing equation, and power system stability.
5. To illustrate transient stability phenomenon, System response to a short-circuit fault, Equal-area criterion, Methods for improving transient stability, solution of swing equation.

UNIT – I

REPRESENTATION OF POWER SYSTEM COMPONETS: Circuit models of Transmission line, Synchronous machines, Transformer and Load. One line diagram, Impedance diagram, Per UNIT notation, Selection and change of base for Per UNIT quantities, Per UNIT Impedance diagram of power system. **8*+5 Hours**

UNIT – II

SYMMETRICAL 3 PHASE FAULTS: Short Circuit currents and reactance of Synchronous machines, Short circuit current calculations of unloaded and loaded Generators and Power Systems, symmetric short circuit MVA calculations, Short circuit current computation through Thevinin's theorem, Selection of circuit breakers. **8*+5 Hours**

UNIT – III

SYMMETRICAL COMPONENTS: Symmetrical component transformation, Resolution of unbalanced phasors into their symmetrical components and vice-versa, Power in terms of symmetrical components, Phase shift of symmetrical components in Star – Delta transformer bank. Positive, Negative and Zero Sequence impedances and Sequence networks of power system elements (Transmission line, Synchronous machine and Transformer).

8*+5 Hours

UNIT – IV

UNSYMMETRICAL FAULTS: Symmetrical component analysis of Unsymmetrical faults, Line-To-Ground (L-G), Line-To-Line (L-L), Double Line-To-Ground (L-L-G) faults on an Unloaded Alternator and Power System with and without fault impedance and connections of sequence networks. Open conductor faults in power systems. **7*+6 Hours**

UNIT - V

POWER SYSTEM STABILITY: Steady-state and Transient stability, Rotor dynamics and the Swing equation, Power angle equation. Equal – Area criterion of stability and its applications. Numerical solution of swing equation. **8*+5 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Demonstrate the knowledge gained pertaining to network representation: per-UNIT system, balanced networks, single line diagrams.
2. Analyze Power systems components and modelling: transformers, transmission lines, cables, rotating machines, and loads.
3. Comprehend symmetrical & unsymmetrical faults in power system, symmetrical components, selection of circuit breakers.
4. Analyze Rotor dynamic, swing equation, concepts of power system stability.
5. Expound transient stability phenomenon: System response to a short-circuit fault, Equal-area criterion, Methods for improving transient stability, solution of swing equation.

Mapping of POs & COs:

Program Outcomes→ / ↓ Course Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
CO1	√	√								√		
CO2		√										
CO3	√	√							√			
CO4	√	√		√								
CO5	√	√		√								

TEXT BOOKS :

1. W.D Stevenson: Elements of Power System Analysis. 4TH edition,TMH,2001
2. Nagrath and Kothari: Modern Power System Analysis, 4TH edition, MHE 2011

REFERENCE BOOK :

1. Power System Analysis by Arthur Bergen, 2nd edition, Pearson , 1999

E Books / NPTEL / MOOC

1. http://nptel.ac.in/courses/108105067/
2. http://nptel.ac.in/courses/108106026/

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SWITCHGEAR AND PROTECTION

Sub Code : 15EE602 **Credits : 04**
Hrs/Week : 4+0+0+S* **Total Hours : 52**

*** Self Study to be exercised under the supervision of course instructor and to be restricted to not more than 10% of the total teaching hours.**

Prerequisites
Basic Electrical Engineering (15EE105), IM (15EE306)

Course Learning Objectives :

1. To understand the basic equipment in power system/substation.
2. To recognize the different grounding systems implemented in power systems.
3. To analyze the construction and working of different types of circuit breakers used in power systems.
4. To study the characteristics and working of various types of relays
5. To understand the various protection schemes.

UNIT – I

Switches and fuses: Isolating switch, load breaking switch, Fuse law, cut -off characteristics, Time current characteristics, fuse material, HRC fuse, liquid fuse, Application of fuse. **4 Hours**

Grounding Systems: Introduction, resistance grounding systems, neutral grounding, ungrounded system, resonant grounding, solid grounding, reactance grounding, resistance grounding, earthing transformer,
SS Topic: neutral grounding transformer. **7 Hours**

UNIT – II

Principals of circuit breakers: Principles of AC Circuit breaking, Principles of DC Circuit breaking, problems encountered in DC breaking, Initiation of arc, maintenance of arc, Arc interruption - high resistance and low resistance interruption, Arc interruption theories – Slepian's theory and energy balance theory, Re-striking voltage, recovery voltage, Rate of rise of Re-striking voltage, current chopping, capacitance switching, Rating of Circuit breakers. Operating mechanism of breakers. **10 Hours**
SS Topic: resistance switching.

UNIT – III

Circuits Breakers: Air Circuit breakers – Air break and Air blast Circuit breakers, oil Circuit breakers - Single break, double break and minimum OCB, SF6 breaker - Preparation of SF6 gas, Puffer and non Puffer type of SF6 breakers. **6 Hours**

Vacuum circuit breakers - Construction, principle of operation, advantages and disadvantages of different types of Circuit breakers, Testing of Circuit breakers, UNIT testing, synthetic testing

SS Topic: short circuit test lay out. **4 Hours**

UNIT – IV

Protective Relaying: Requirement of Protective Relaying, Zones of protection, primary and backup protection, Essential qualities of Protective Relaying, Classification of Protective Relays. Introduction to Numerical Relays (Block Diagram) **4 Hours**

Induction type relay: Non-directional and directional over current relays, IDMT and Directional characteristics. Differential relay – Principle of operation, percentage differential relay, bias characteristics, distance relay – Three stepped distance protection, Impedance relay, Reactance relay, Mho relay, Buchholz relay, Negative Sequence relay,
SS Topics: Microprocessor based over current relay – block diagram approach. **7 Hours**

UNIT – V

Protection Schemes:
Generator Protection - Merz price protection, prime mover faults, stator and rotor faults, protection against abnormal conditions – unbalanced loading, loss of excitation, over speeding. Transformer Protection - Differential protection, differential relay with harmonic restraint. **6 Hours**

SS Topic: Inter-turn faults
Induction motor protection – Protection against electrical faults such as phase fault, ground fault, Protection of Induction Motor against abnormal operating conditions such as single phasing, phase reversal, overload. **5 Hours**

Course Outcomes:
At the end of the course student will be able to

1. Justify the necessity of switches and fuses and the importance of grounding systems
2. Demonstrate the principles of circuit breaker and their types.
3. Comprehend the construction and working principle of different types of circuit breakers and relays.
4. Distinguish and apply various protection schemes.
5. Identify various protection schemes for generators and transformers.

Mapping of POs & COs:

Program Outcomes→ / ↓ Course Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
CO1	H	M		M		H	M					
CO2	M	M		L		M						
CO3	M	M				M						
CO4	H	M				M						
CO5		H										

TEXT BOOKS :

1. Sunil S.Rao "Switchgear & Protection" Khanna Publishers, (GS) ,13th edition,2008

2. Badriram & Viswa Kharma "Power System Protection & Switchgear", TMH, (GS),2nd edition,2013.
3. Y G. Painthankar and S R Bhide, "Fundamentals of power system protection" PHI publication, 2nd edition,2010.

REFERENCE BOOKS:

1. A. Chakarbarti, M.L. Soni and P.V. Gupta, U.S. Bhatnagar, Power system engineering, Published by Gagan Kanur, Dhanapat Rai and Co Pvt. Ltd,2013
2. Ravindarnath & Chandra "Power System Protection & Switchgear", New age Publications. (GS),1st edition,2011.

E Books /MOOCS /NPTEL:

1. http://nptel.ac.in/courses/Webcourse-contents/IIT%20Bombay/Power%20System%20Protection/TOC_M1.html
2. http://nptel.ac.in/downloads/108101039/

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ELECTRICAL MACHINE DESIGN & CAD

Sub Code : 15EE603 **Credits : 04**
Hrs/Week : 3*+2+0+0 **Total Hours : 39*+26**

*** Note:** Lecture hours indicated are for teaching theoretical concepts. Illustrative examples and numerical problems are to be worked out in tutorial classes.

Prerequisites

DCSM (15EE303), TIM (15EE402)

Course Learning Objectives :

1. To Describe the design process and basic CAD practices for engineering design and drawing.
2. To Analyze the design of DC machines
3. To illustrate the Design of single phase and three phase transformer.
4. To the Analyze the design of Synchronous machines..

UNIT – I

PRINCIPLES OF ELECTRICAL MACHINE DESIGN:
Introduction, considerations for the design of electrical machines, limitations. Different types of materials and insulators used in electrical machines. **3*+1 Hours**

Introduction to CAD:
Study of auto CAD graphics package. Exercises on computer aided electrical drawing - single line diagram for a typical substation. **3*+1 Hours**

UNIT – II

DESIGN OF DC MACHINES: Output equation, choice of specific loadings and choice of number of poles, design of Main dimensions of the DC machines, Design of armature slot

dimensions, commutator and brushes, magnetic circuit - estimation of ampere turns, design of yoke and poles, field windings – shunt, series and inter poles. **8*+6 Hours**

UNIT – III

DESIGN OF TRANSFORMERS (Single phase and three phase): Output equation for single phase and three phase transformers, choice of specific loadings, expression for volts/turn, determination of main dimensions of the core, types of windings and estimation of number of turns and cross sectional area of Primary and secondary windings, estimation of no load current, expression for leakage reactance and voltage regulation. Design of tank and cooling tubes (round and rectangular). **9*+6 Hours**

UNIT – IV

DESIGN OF INDUCTION MOTORS: Output equation, Choice of specific loadings, main dimensions of three phase induction motor, Stator winding design, choice of length of the air gap. Estimation of number of slots for the squirrel cage rotor, design of Rotor bars and end ring, design of Slip ring Rotor, Estimation of no load current and leakage reactance.

8*+6 Hours

UNIT– V

DESIGN OF SYNCHRONOUS MACHINES: Output equation, Choice of specific loadings, short circuit ratio, design of main dimensions, armature slots and windings, slot details for the stator of salient and non - salient pole synchronous machines, design of rotor of salient pole machines, magnetic circuits, dimensions of the pole body, design of the field winding, and design of rotor of non-salient pole machine. **8*+6 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Describe the design process and basic CAD practices for engineering design and drawing.
2. Analyze the design of DC machines
3. Illustrate the Design of single phase and three phase transformer.
4. Illustrate the Design of Induction machine.
5. Analyze the design of Synchronous machines.

Mapping of POs & COs:

Program Outcomes→ ↓ Course Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
CO1	√	√			√				√			
CO2	√	√										
CO3	√	√			√							
CO4	√	√										
CO5	√	√			√							

TEXT BOOKS :

1. A Course in Electrical Machine Design - A.K.Sawhney, Dhanpatt Rai& Sons,7TH EDITION, 2003.
2. Design of Electrical Machines - V. N. Mittle, Standard Publishers distributors ,4th edition,2009.
3. Electrical Engineering Drawing -Bhattacharya, S. K., New age International publishers,2nd edition,2009.
4. Electrical Drafting -Devalapur, S. F., Eastern Book Promoters, Belgaum, 2006.

REFERENCE BOOKS :

1. Performance and Design Of AC Machines - M.G.Say, CBS Publishers and Distributors Pvt. Ltd,3rd edition,2002.
2. Principles of Electrical Machine Design - R.K. Agarwal, SK Kataria and sons, 7th edition,2014.
3. Design Data Handbook - A. Shanmugasundarm, G. Gangadharan, R.Palani, Wiley Eastern Lt.
4. Manuals of Auto - CAD 2015.

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POWER ELECTRONICS LABORATORY

Sub Code	**: 15EE604**	**Credits**	**: 02**
Hrs/Week	**: 0+0+3+0**	**Total Hours**	**: 39**

Course Learning Objectives :

1. To know the Static characteristics of SCR.
2. To verify the Static characteristics of MOSFET and IGBT.
3. To CR turn-on circuit using synchronized UJT relaxation oscillator.
4. To verify the SCR Digital triggering circuit for a single -phase controlled rectifier /A.C. voltage controller.
5. To verify Single -phase full-wave rectifier with R and R-L loads..

List of Experiments

1. Static characteristics of SCR.
2. Static characteristics of MOSFET and IGBT.
3. SCR turn-on circuit using synchronized UJT relaxation oscillator.
4. SCR Digital triggering circuit for a single -phase controlled rectifier /A.C. voltage controller.
5. Single -phase full-wave rectifier with *R* and *R-L* loads.
6. A.C. voltage controller using TRIAC and DIAC combination connected to *R* and *R-L* loads.
7. Speed control of a separately excited D.C. motor using an IGBT/ MOSFET chopper.
8. Speed control of a stepper motor.
9. Speed control of a universal motor and a single -phase induction motor using A.C. voltage controller.
10. MOSFET/IGBT based single-phase full-bridge inverter connected to R load.

11. Auxiliary and LC commutation circuit.
12. DSP based speed control of motor

Course Outcomes:

At the end of the course student will be able to

1. Demonstrate the static characteristics of MOSFET, IGBT and SCR and identify different regions of operation.
2. Build SCR triggering circuit using UJT relaxation oscillator, digital circuit and SCR commutation circuit using LC, Auxiliary commutation.
3. Build AC voltage controller circuit using TRAIC DIAC combination and verify its application in speed control of IM and universal motor.
4. Test the performance of Single -phase full-wave rectifier with *R* / *R-L* loads. And MOSFET/IGBT based single-phase full-bridge inverter connected to R load.
5. Control the speed of a separately excited D.C. motor using an IGBT/ MOSFET chopper. And test stepper motor controller circuit..

Mapping of POs & COs:

Program Outcomes→ / ↓ Course Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
CO1	√	√								√		
CO2	√	√	√									
CO3	√	√	√	√								
CO4	√	√	√	√								
CO5	√	√		√								

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ELECTRICAL CAD LABORATORY

Sub Code : 15EE605 **Credits : 01**
Hrs/Week : 0+0+2+0 **Total Hours : 26**

Course Learning Objectives :

1. To introduce CAD tool for drawing design diagrams of electrical machines and apparatus.
2. To understand the practical aspects of electrical machine design and verify the same.

List of Experiments

1. Single line diagram of electrical substation.
2. DC Winding Diagrams Simplex Lap and Wave windings.
3. DC Winding Diagrams Duplex Lap and Wave windings.
4. AC Winding Diagrams: Integral and Fractional slot single layer Lap and Wave windings

5. AC Winding Diagrams: Integral and Fractional slot double layer Lap and Wave windings.
6. Transformers - sectional views of single and three phase core type transformers
7. Transformers - sectional views of single and three phase shell type transformers
8. D.C. machine - sectional views of different parts: yoke, field system, armature and commutator.
9. Induction motor: sectional view
10. Synchronous machine: sectional view

Course Outcomes:

At the end of the course student will be able to

1. Use the CAD tools to draw single line diagrams of electrical substation.
2. Use the electrical CAD software to draw the DC winding diagram and AC winding diagrams
3. Use the electrical CAD software to draw the sectional views of 3 phase, single phase shell / core transformers.
4. Use the electrical CAD software to draw the sectional views of different parts of DC machine.
5. Use the electrical CAD software to draw the sectional views of different parts of Induction, synchronous machines.

Mapping of POs & COs:

Program Outcomes→ / ↓ Course Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
CO1	√	√					√					
CO2	√	√					√					
CO3	√	√					√					
CO4	√	√					√					
CO5	√	√					√					

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LINEAR IC AND CONTROL SYSTEMS LABORATORY

Sub Code : 15EE606 **Credits : 02**
Hrs/Week : 0+0+3+0 **Total Hours : 39**

Course Learning Objectives:

1. To study various op-amp based circuits and their applications.
2. To understand working of Schmitt trigger, multivibrators circuit and filter using op-amp.
3. To understand voltage regulator and applications of 555 timers.
4. To study frequency response of Lag, Lead, Lag-lead networks and P, PI, PID controller.
5. To understand DC and AC Servo motor characteristics and Synchro transmitter-receiver pair.

List of Experiments

1. Application of Op- amps.
    a. Inverting and Non – inverting amplifiers.
    b. Inverting and Non Inverting Zero crossing detector
2. Application of Op- amps.
    a. Differentiator
    b. Inverting Non inverting Integrators
3. Inverting and Non Inverting Schmitt trigger for different hysteresis values using Op-amp.
4. Relaxation Oscillators- astable and monostable multivibrators using Op-amp
5. Precision Rectifiers-precision HWR and FWR using Op-amp, Transfer characteristics.
6. Voltage Regulators using
    a. IC 723 (high / low voltages)
    b. IC 78XX .
7. Timer IC 555 experiments: Monostable multivibrator, Astable multivibrator, Schmitt trigger
8. Butterworth Filter (2nd order): LPF and All pass filter. Use of Lissajous figures.
9. Frequency response of Lag, Lead networks.
10. Frequency response of Lag-lead networks.
11. DC and AC Servo motor characteristics, Synchro transmitter-receiver pair.
12. Performance characteristics of P, PI, and PID controller
13. PLL characteristics, Finding Lock Range and Capture Range.

Course Outcomes:

At the end of the course student will be able to

1. Use op-amp based basic circuits for various applications.
2. Analyze working of Schmitt trigger, multivibrators circuit and filter using op-amp.
3. Design and use voltage regulator and 555 timers.
4. Analyze the frequency response of Lag, Lead, Lag-lead networks and P, PI, PID controller.
5. Study DC and AC Servo motor characteristics and Synchro transmitter-receiver pair.

Mapping of POs & COs:

Program Outcomes→ ↓ Course Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
CO1	√		√		√							
CO2	√		√		√							
CO3	√		√		√							
CO4	√		√		√							
CO5	√		√		√							

E Learning / E Books

1. IIT Bombay Linear Integrated Circuits Virtual Lab
   http://iitb.vlab.co.in/?sub=43&brch=225

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ENTRY EDGE: IMMERSIVE GROUP WORKSHOP (IGW)

Sub Code: 15EE607 **Duration: 5 Days**
Timings : 9.00 AM to 12.30 PM, 1.15 PM to 4.45 PM

Module 1: Minds-on and hands-on simulation project

1. Understanding Task environment – Goals, responsibilities, Task focus
2. Working in Teams towards common goals
3. Organizational performance expectations–technical and behavioural competencies.

5 Hours

Module 2: Re- enforcement of critical individual skills and behaviours

1. Application of individual effectiveness skills in team and organizational context – improving self awareness, goal setting, time management, communication and presentation skills.

7 Hours

Module 3: Etiquettes and Ethics

1. Professional etiquettes at workplace – dressing, telephone, e-mail, meeting and general behaviour
2. Basic honesty & respect for law / rules
3. Conflict of interest
4. Use of organizational resources
5. Misrepresentation and misappropriation
6. Intellectual property
7. Whistle blowing **7 Hours**

Module 4: Interpersonal Behaviour & relationship skills

1. Establishing trust based relationships in team & organizational environment
2. Trust equation – credibility, responsiveness, integrity, self-interest

3.5 Hours

Module 5: Dealing with Conflicts

Orientation towards conflicts in team and organizational environment

1. Understanding sources of conflicts
2. Conflict resolution styles and techniques

3.5 Hours

Pedagogical tools & techniques used in the workshop

Organizational templates for simulating a organizational context- structures, units, roles and activities
Metaphoric scenarios for simulating real –life tasks and dynamics in a team/project context
LEGO ^{TM} building blocks for simulating last-mile technical activity in teams
Case studies, Role play scenarios group learning activities, observation and feedback.

Note: Evaluation is done and a grade of P (pass) or NP (not pass) is awarded

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SWITCHED MODE POWER CONVERTERS

Sub Code	**: 15EE611**	**Credits**	**: 03**
Hrs/Week	**: 3+0+0+0**	**Total Hours**	**: 39**

Course Learning Objectives :

1. To introduce the concept of switched mode power converters.
2. To study the working of non-isolated and isolated DC-DC switching power converter.
3. To understand the working of switched mode DC-AC inverters
4. To understand the concept of resonant converter.
5. To study various power line disturbance and power conditioners.

UNIT – I

DC-DC switched mode converter topologies: Introduction, Control of dc-dc converters. Buck, Boost, Buck-Boost, Cúk dc-dc converter topologies, Full-bridge dc-dc converter.

8 Hours

UNIT – II

DC-DC switched mode converter comparison generalized comparison between switched mode and linear dc regulator, dc-dc converter with isolation – flyback converters, other flyback converter topologies, forward converter, push-pull converter, half and full bridge converter. **8 Hours**

UNIT – III

DC-AC switched mode inverters: Basic concept of switch-mode Inverters, single-phase inverter, three phase inverters. SPWM inverter, detailed theory, working principles, modes of operation with circuit analysis, ripple in the inverter output, switch utilization, problems.

8 Hours

UNIT – IV

Resonant switch converters: Classification of resonant converter, Resonant switch converter – ZCS, ZVS, ZVS-CV dc-dc converters; Resonant dc-link inverter with ZVS, problems.

7 Hours

UNIT – V

Power line disturbances, Power Conditioner and uninterruptible power supplies, solar power based bidirectional inverter- High frequency inductor and transformers design: specific inductor transformer design, Inductor and transformer design procedure. **8 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Illustrate the concepts of different types of DC-DC converters.
2. Compare linear and switched mode converters and understand the principle of operation of dc-dc converter with isolation
3. Analyze and understand the concepts of switched mode inverters
4. Illustrate the working of different resonant converter

5. Analyze the role of power conditioners to suppress various power line disturbances and understand the working of UPS, design of magnetic components..

Mapping of POs & COs:

Program Outcomes→ ↓ Course Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
CO1	√	√										
CO2	√	√	√									
CO3		√	√						√			
CO4	√	√							√			
CO5			√						√			

TEXT BOOKS :

1. Ned Mohan, Tore M. Undeland, and William P. Robins, "Power Electronics – Converters, Applications and Design", Third Edition, John Wiley and Sons. 2010.
2. Daniel W Hart, "Power Electronics", Tata McGraw Hill, 2011.

REFERENCE BOOKS :

1. Modern Power Electronics- Cyril Lander,3rd edition,TMH,2015
2. Christophe P. Basso, "Switch-Mode Power Supplies Spice Simulations and Practical Designs" Revised edition,TMH, 2014.
3. Umanand L and Bhatt S R, "Design of Magnetic Components for Switched Mode Power Converters", New Age International, New Delhi, 2009.

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RENEWABLE ENERGY SOURCES

Sub Code : 15EE612 **Credits : 03**
Hrs/Week : 3+0+0+0 **Total Hours : 39**

Course Learning Objectives :

1. To illustrate the principle of extraction of energy from conventional, nonconventional sources.
2. To demonstrate the working principle and applications of solar based thermal, electrical and PV systems
3. To justify the usage of energy storage techniques and Understand the process of design and implement of wind based energy conversion systems
4. To understand the process of design and implement of biomass based energy conversion systems.

UNIT – I

Energy Sources: Introduction, Importance of Energy Consumption as Measure of Prosperity, Per Capita Energy Consumption, Classification of Energy Resources; Conventional Energy

Resources - Availability and their limitations; Non-Conventional Energy Resources – Classification, Advantages, Limitations; Comparison of Conventional and Non-Conventional Energy Resources; World Energy Scenario; Indian Energy Scenario. **3 Hours**

Solar Energy Basics: Introduction, Solar Constant, Basic Sun-Earth Angles – definitions and their representation, Solar Radiation Geometry (numerical problems), Estimation of Solar Radiation of Horizontal and Tilted Surfaces (numerical problems); Measurement of Solar Radiation Data – Pyranometer and Pyrheliometer. **5 Hours**

UNIT – II

Solar Thermal Systems: Principle of Conversion of Solar Radiation into Heat, Solar Water Heaters (Flat Plate Collectors), Solar Cookers – Box type, concentrating dish type, Solar driers, Solar Still, Solar Furnaces, Solar Green House. **4 Hours**

Solar Electric Systems: Solar Thermal Electric Power Generation – Solar Pond and Concentrating Solar Collector (parabolic trough, parabolic dish, Central Tower Collector). Advantages and Disadvantages; Solar Photovoltaic – Solar Cell fundamentals, characteristics, classification, construction of module, panel and array.
Solar PV Systems – stand-alone and grid connected; Applications – Street lighting, Domestic lighting and Solar Water pumping systems. **4 Hours**

UNIT – III

Energy Storage: Introduction, Necessity of Energy Storage, and Methods of Energy Storage (classification and brief description using block diagram representation only). **4 Hours**

Wind Energy: Introduction, Wind and its Properties, History of Wind Energy, Wind Energy Scenario – World and India. Basic principles of Wind Energy Conversion Systems (WECS), Classification of WECS, Parts of a WECS, Derivation for Power in the wind, Electrical Power Output and Capacity Factor of WECS, Wind site selection consideration, Advantages and Disadvantages of WECS. **4 Hours**

UNIT – IV

Biomass Energy: Introduction, Photosynthesis process, Biomass fuels, Biomass conversion technologies, Urban waste to Energy Conversion, Biomass Gasification, Biomass to Ethanol Production, Biogas production from waste biomass, factors affecting biogas generation, types of biogas plants – KVIC and Janata model; Biomass program in India. **7 Hours**

UNIT – V

Energy from Ocean: Tidal Energy – Principle of Tidal Power, Components of Tidal Power Plant (TPP), Classification of Tidal Power Plants, Estimation of Energy – Single basin and Double basin type TPP (no derivations. Simple numerical problems), Advantages and Limitation of TPP. Ocean Thermal Energy Conversion (OTEC): Principle of OTEC system, Methods of OTEC power generation – Open Cycle (Claude cycle), Closed Cycle (Anderson cycle) and Hybrid cycle (block diagram description of OTEC); Site-selection criteria, Biofouling, Advantages & Limitation of OTEC. **5 Hours**

Emerging Technologies: Fuel Cell, Small Hydro Resources, Hydrogen Energy, and Wave Energy. (Principle of Energy generation using block diagrams, advantages and limitations).

3 Hours

Course Outcomes:

At the end of the course student will be able to

1. Illustrate the principle of extraction of energy from conventional, nonconventional sources.
2. Demonstrate the working principle and applications of solar based thermal, electrical and PV systems
3. Justify the usage of energy storage techniques and Understand the process of design and implement of wind based energy conversion systems
4. Explain the process of design and implement of biomass based energy conversion systems.
5. Outline the design and implement of tidal, OTEC based energy conversion systems and comprehend the emerging technologies in the area of RES.

Mapping of POs & COs:

Program Outcomes→ / ↓ Course Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
CO1	√											
CO2	√											
CO3	√	√	√									
CO4	√	√	√									
CO5	√	√	√									

TEXT BOOK :

1. Rai G. D., “Non-Conventional Sources of Energy”, 5th Edition, Khanna Publishers, New Delhi, 2014

REFERENCE BOOKS :

1. Mukherjee D. and Chakrabarti, S., “Fundamentals of Renewable Energy Systems”, New Age International Publishers, **5th edition,** 2011.
2. Khan, B. H., “Non-Conventional Energy Resources”, TMH, New Delhi,2ND Edition, 2009.
3. S. P. Sukhatme, J. K. Nayak “Solar Energy: Principles of Thermal Collection and Storage”, 3e McGraw-Hill Education (India) (2009).

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INTRODUCTION TO ASIC AND FPGA DESIGN

Sub Code	**: 15EE613**	**Credits**	**: 03**
Hrs/Week	**: 3+0+0+0**	**Total Hours**	**: 39**

Course Learning Objectives:

1. To study the design flow of different types of ASIC.
2. To familiarize the different types of programming technologies and logic devices.
3. To learn the architecture of different types of FPGA.
4. To gain knowledge about partitioning, floor planning, placement and routing including circuit
5. extraction of ASIC
6. To analyse the synthesis, Simulation and testing of systems. To understand the design issues of SOC.
7. To know about different high performance algorithms and its applications in ASICs.

UNIT – I

OVERVIEW OF ASIC AND PLD: Types of ASICs - Design flow – CAD tools used in ASIC Design – Programming Technologies: Antifuse – static RAM – EPROM and EEPROM technology, Programmable Logic Devices : ROMs and EPROMs – PLA–PAL. Gate Arrays – CPLDs and FPGAs. **8 Hours**

UNIT - II

ASIC PHYSICAL DESIGN: System partition -partitioning - partitioning methods – interconnect delay models and measurement of delay - floor planning -placement – Routing : global routing - detailed routing - special routing - circuit extraction – DRC **7 Hours**

UNIT - III

LOGIC SYNTHESIS, SIMULATION AND TESTING: Design systems - Logic Synthesis - Half gate ASIC -Schematic entry - Low level design language - PLA tools -EDIF- CFI design representation. Verilog and logic synthesis -VHDL and logic synthesis - types of simulation -boundary scan test – fault simulation - automatic test pattern generation.

8 Hours

UNIT - IV

FPGA: Field Programmable gate arrays- Logic blocks, routing architecture, Design flow technology - mapping for FPGAs, XilinxXC4000 - ALTERA's FLEX 8000/10000, ACTEL's ACT-1,2,3 and their speed performance Case studies: Altera MAX 5000 and 7000 - Altera MAX 9000 – Spartan II and Virtex II FPGAs - Apex and Cyclone FPGAs. **8 Hours**

UNIT – V

SOC DESIGN: Design Methodologies – Processes and Flows - Embedded software development for SOC – Techniques for SOC Testing –Configurable SOC – Hardware / Software codesign Case studies: Digital camera, Bluetooth radio / modem, SDRAM and USB. **7 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Comprehend the basics of ASIC and PLD.
2. Analyse the ASIC Physical Design
3. Analyse The Logic Synthesis, Simulation And Testing of ASIC And PLD:
4. Comprehend the architecture of different types of FPGA.
5. Analyse the design issues of SOC.

Mapping of POs & COs:

Program Outcomes→ ↓ Course Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
CO1	√											
CO2	√						√					
CO3		√			√				√			
CO4		√			√							
CO5		√			√							

REFERENCE BOOKS:

1. M.J.S .Smith, "Application Specific Integrated Circuits, Addison -Wesley Longman Inc.,1997
2. S. Trimberger, Field Programmable Gate Array Technology, Edr, Kluwer Academic Publications, 1994.
3. John V.Oldfield, Richard C Dore, Field Programmable Gate Arrays, Wiley Publications1995.
4. P.K.Chan & S. Mourad, Digital Design Using Field Programmable Gate Array, PrenticeHall, 1994.
5. Parag.K.Lala, Digital System Design using Programmable Logic Devices , BSP, 2003.

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ADVANCED CONTROL THEORY

Sub Code : 15EE614 **Credits : 03**

Hrs/Week : 3+0+0+0 **Total Hours : 39**

Prerequisites: Linear Control System (15EE503), VCTT (15EE301)

Course Learning Objectives :

1. To understand the state model, linearization of state equations.
2. To Apply state space technique for modeling of LTI systems, solve the state equation.
3. To Compute state transition matrix, the eigen values, eigen vectors.
4. To Analyze the system for controllability and observability and design the controller using pole placement techniques to ensure stability.

UNIT – I

State variable analysis & design, canonical representation and transfer function, linearization of state equations, State space representation using physical variables. State space representation using phase variables & canonical variables, Derivation of transfer function from state model, Solution of state equation. **7 Hours**

UNIT – II

State transition matrix & its properties, computation using Laplace transformation, Cayley-Hamilton method (only computation), Eigen values, Eigen vectors, generalized Eigen vectors, diagonalization. **7 Hours**

UNIT – III

Concept of controllability & observability, methods of determining the same.
Pole placement techniques: stability improvements by state feedback, necessary & sufficient conditions for arbitrary pole placement. **8 Hours**

UNIT – IV

Introduction, behavior of non-linear system, common physical non linearity-saturation, friction, backlash, dead zone, relay, multi variable non-linearity, Phase plane method, singular points, stability of nonlinear system, limit cycles, construction of phase trajectories by Isocline method and Delta method. **9 Hours**

UNIT – V

Lyapunov's stability criteria for linear as well as nonlinear systems, stability definitions, theorems, sign definiteness, direct method, second method, krasovskii's method, variable gradient method and for linear systems for state variable models. **8 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Introduce the state model, linearization of state equations.
2. Compute state transition matrix, the eigen values, eigen vectors space technique for modeling of LTI systems, solve the state equation.
3. Analyze the system for controllability and observability and design the controller using pole placement techniques to ensure stability
4. Comprehend the behavior and stability analysis of non linear system
5. Analyse the Stability of linear and nonlinear system using Liapunov criteria.

Mapping of POs & COs:

Program Outcomes→ ↓ Course Outcomes	a	b	c	d	e	f	g	h	i	j	k	l
CO1	√											
CO2	√	√										
CO3	√	√										
CO4	√	√			√							
CO5	√	√			√							

TEXT BOOKS :

1. J. Nagarath and M.Gopal, "Control Systems Engineering", New Age International (P) Limited, Publishers, 5th edition – 2007
2. M. Gopal "Digital control & state variable methods" 4th edition, Tata. Mc Graw Hill 2012.
3. M. N. Bandyopadhyay, "Control Engineering: Theory and Practice", PHI Learning Pvt. Ltd. 2002

REFERENCE BOOKS :

1. Katsuhiko Ogata, "State Space Analysis of Control Systems", Prentice Hall Inc,1967.
2. Benjamin C. Kuo & Farid Golnaraghi, "Automatic Control Systems" 9th edition, John Wiley & Sons 2009.
3. Katsuhika Ogata, " Modern Control Engineering" PHI ,6th edition,2010.

E Books /MOOC/ NPTEL:

1. http://nptel.ac.in/courses/108103007/
2. https://www.coursera.org/learn/designing-organization/lecture/Md2km/4-2-2-traditional-control-systems
3. https://www.edx.org/course/introduction-control-system-design-first-mitx-6-302-0x

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OPERATIONS RESEARCH

Sub Code : 15EE615 **Credits : 03**
Hrs/Week : 3+0+0+0 **Total Hours : 39**

Prerequisites
PTNM (15EE401)

Course Learning Objectives :

1. To understand the model and obtain solution to the Linear Programming Problems.
2. To Solve the dual of LPP and compare the results of dual and primal. Also apply replacement theory for efficient operations.
3. To Solve transportation and assignment problems and to solve game theory problems
4. Build the network and crash it effectively and efficiently using PERT / CPM methods.

UNIT – I

Introduction: definition, OR models, characteristics and phases of OR. **2 Hours**

Linear programming and Graphic Solution: Linear Programming: Formulation of Two variable LPP model, Graphical solution of two variables LPP, special cases in graphic solution: multiple optimal solution, infeasibility and unboundedness, simplex method: conditions and solutions to LPP using Simplex method, Big M method, Special cases in simplex method: multiple optimal, infeasibility, unboundedness, Degeneracy, sensitivity analysis. **7 Hours**

UNIT – II

Duality: Definition of the dual problem, primal to dual relationships, economic interpretation of duality. **3 Hours**

Replacement Theory: Introduction, Replacement policy for equipment which deteriorates gradually, replacement of items that fail suddenly, staff replacement. **5 Hours**

UNIT – III

Transportation Model: definition of transportation model, basic Feasible solution by NW Corner method, Least Cost method and MODI method, optimal solutions: stepping stone method, MODI method, the assignment model, traveling salesman problem. **8 Hours**

UNIT – IV

GAME THEORY: Formulation of two - person, zero sum games, solving simple games, the Max-min min-max principles, graphical solution procedure, solving by linear programming. **7 Hours**

UNIT – V

PERT & CPM TECHNIQUES: Network representation, critical path computation, construction of the time schedule, variation under probabilistic models, crashing of simple networks, PERT calculations. **7 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Formulate, model and obtain solution to the Linear Programming Problems.
2. Solve the dual of LPP and compare the results of dual and primal. Also apply replacement theory for efficient operations.
3. Solve transportation and assignment problems.
4. Formulate and solve game theory problems
5. Build the network and crash it effectively and efficiently using PERT / CPM methods.

Mapping of POs & COs:

Program Outcomes→ ↓ Course Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
CO1	√	√										
CO2	√	√										
CO3	√	√										
CO4	√	√										
CO5	√	√							√			√

TEXT BOOKS :

1. "Quantitative Techniques in Management"- N.D. Vohra Tata McGraw Hill Publications, 4th Edition,2009.
2. "Operation Research An Introduction"-Hamdy A Taha, Pearson Education, 9th edition, 2012

REFERENCE BOOK :

1. Engineering Optimization: Theory and Practice / Edition 4, byS. S. Rao, Wiley (2009)

E Books/ MOOC/ NPTEL:

1. https://www.doc.ic.ac.uk/~br/berc/linearprog.pdf
2. https://www.coursera.org/learn/wharton-operations
3. http://nptel.ac.in/courses/112106134/
4. http://nptel.ac.in/courses/112106131/
5. https://onlinecourses.nptel.ac.in/noc17_mg10/preview

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POWER ELECTRONICS SYSTEM DESIGN USING ICS

Sub Code : 15EE621 **Credits : 03**
Hrs/Week : 3+0+0+0 **Total Hours : 39**

Prerequisites
PE (15EE504), LIC (15EE501)

Course Learning Objectives :

1. To understand the measurement techniques to measure various electrical parameters
2. To Illustrate the working and characteristics of Switching Regulator Control Circuits
3. To understand the various Commercial PWM Control ICs and their Applications
4. To know the significance of 555 timers, PLL, ADC, DAC circuits in the implementation of different gating / power electronics circuits.

UNIT – I

Introduction: Measurement techniques for voltages, current, power, power factor in power electronic circuits, other recording and analysis of waveforms, sensing of speed. **7 Hours**

UNIT – II

Switching Regulator Control Circuits: Introduction, isolation techniques of switching regulator systems, PWM systems. **8 Hours**

UNIT – III

Commercial PWM Control ICs and their Applications: TL 494 PWM Control IC, UC 1840 Programmable off line PWM controller, UC 1524 PWM control IC, UC1846 current mode control IC, UC 1852 resonant mode power supply controller. **8 Hours**

UNIT – IV

Switching Power Supply Ancillary, Supervisory & Peripheral Circuits and Components: Introduction, Opto-couplers, self-biased techniques used in primary side of reference power supplies, Soft/Start in switching power supplies, current limit circuits, over voltage protection, AC line loss detection. **8 Hours**

UNIT – V

Phase – Locked Loops (PLL) & Applications: PLL Design using ICs, 555 timer & its applications, analog to digital converter using IC's, digital to analog converters using ICs, implementation of different gating circuits. **8 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Analyze measurement techniques to measure various electrical parameters
2. Illustrate the working and characteristics of Switching Regulator Control Circuits
3. Appreciate various Commercial PWM Control ICs and their Applications
4. Explain Switching Power Supply Ancillary, Supervisory & Peripheral Circuits and Components
5. Use the 555 timer, PLL, ADC, DAC circuits in the implementation of different gating / power electronics circuits.

Mapping of POs & COs:

Program Outcomes→ ↓ Course Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
CO1	√	√										
CO2	√	√			√							
CO3	√	√	√									

CO4	√	√										
CO5	√	√	√	√	√				√			

REFERENCE BOOKS :

1. G. K. Dubey, S. R. Doradla, A. Johsi, and R. M. K. Sinha, "Thyristorised Power Controllers", 2ndEdition, New Age International, 2012.
2. Chryssis "High Frequency Switching Power Supplies", 2ndEdition, MGH, 1989.
3. UNITrode application notes: http://www.smps.us/UNITrode.html
4. Christophe P Basso "Switch Mode Power Supply", First Edition, BPB Publications,2010
5. Abraham I. Pressman "Switching Power Supply Design", 3rd Edition, McGraw Hill Publications, 2009
6. Marty Brown, "Power Sources and Supplies - World Class Designs", Elsevier, First Indian Reprint 2010.

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OBJECT ORIENTED PROGRAMMING USING C ++

Sub Code : 15EE622 **Credits : 03**
Hrs/Week : 3+0+0+0 **Total Hours : 39**

Prerequisites: CCP (15CS111), CCP Lab (15CS116)

Course Learning Objectives:

1. To demonstrate the concept of Object Oriented programming and its realization in C++.
2. To explain the concept of functions and classes.
3. To illustrate the concepts of objects constructors and destructors
4. To introduce the meaning of operator overloading type conversion and inheritance.

UNIT – I

Principles of Object-Oriented Programming: Review of Procedure Oriented Programming, Basic concepts of Object Oriented Programming – Object, Class, Encapsulation, Inheritance, Polymorphism; Benefits of OOPs, Applications of OOP's. **3 Hours**

The Basic Language C++: A comparison of C and C++, Structure of C++ program with Class, Preprocessor directives, C++ Statements – Input/Output, Comments, Tokens, Keywords, Identifiers, Constants, Data types – string, pointer, reference, boole, enumeration, array, complex number; typedef names, type compatibility, type conversion, qualifier – const, volatile; Operators in C++, Operator Precedence and Operator Overloading; C++ expressions – New and Delete. **5 Hours**

UNIT – II

Functions in C++: Introduction, The main() function, Function prototype, Call by reference, Return by reference, Inline functions, Default arguments, const Arguments, Function Overloading, Friend and Virtual functions, pointer to functions. **4 Hours**

Classes: Introduction – declaration and definition of a Class, defining member functions, C++ program with a Class, Making an outside function Inline, Nesting of member functions, Arrays within a class, Static data members, static member functions **4 Hours**

UNIT – III

Objects: global & local objects, scope & lifetime, memory allocation for objects, dynamically allocated objects, pointers to objects, arrays of objects, function arguments with objects, returning objects; const member functions. **3 Hours**

Constructors and Destructors: Introduction, Constructors, Parameterized Constructors, Multiple constructors in a class, Constructors with default arguments, Dynamic initialization of objects, Copy constructor, Constructing two-dimensional arrays, const Objects, Destructors. **4 Hours**

UNIT – IV

Operator Overloading and Type Conversion: Introduction, Defining operator overloading, Overloading unary operators, Overloading binary operators, Overloading binary operators using Friends, Rules for overloading operators, overloading a comma operator, overloading the output operator , Type conversion. **5 Hours**

Inheritance: Introduction, Defining derived classes, Single inheritance, Making a private member Inheritable, Multilevel inheritance, Multiple inheritance, Hierarchical inheritance, Hybrid inheritance, Virtual base classes, Abstract classes. **3 Hours**

UNIT – V

Pointer, Virtual Functions and Polymorphism: Introduction, Pointers, Pointers to Objects, this pointer, Pointers to derived classes, type-checking pointers, pointers to members, Virtual functions, Pure virtual functions. **4 Hours**

Managing Console I/O and File I/O: C++ streams, C++ stream classes, examples of formatted and unformatted I/O operations, Classes for file stream operations, Methods of Opening and Closing a File, Examples of Opening file using constructor open(), file modes (simple programming exercises). **4 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Demonstrate the concept of Object Oriented programming and its realization in C++.
2. Comprehend the concept of functions and classes.
3. Illustrate the concepts of objects constructors and destructors
4. Enumerate the meaning of operator overloading type conversion and inheritance.
5. Summarize the concepts of pointers virtual functions and polymorphism and importance of managing console I/O, File I/O.

Mapping of POs & COs:

Program Outcomes→ / ↓ Course Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
CO1	√								√			
CO2	√								√			
CO3	√								√			
CO4	√			√	√				√			
CO5	√			√	√				√		√	

TEXT BOOKS:

1. Object Oriented Programming with C++- Balagurusamy, E, TMH,6th th edition, 2013.
2. C++, The Complete Reference -Herbert Schildt, , TMH, 4th edition ,2002
3. Object Oriented Programming with C++, Farrell,Cengage Learning,Fourth Edition,2009.

REFERENCE BOOKS:

1. The C++ programming language,Bjarne Stroustrup, Pearson Education, 4th edition,2013.
2. Objected oriented programming with C++,Bhave, Pearson Education, First Edition,2012.

E-Books / MOOC /NPTEL

1. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-088-introduction-to-c-memory-management-and-c-object-oriented-programming-january-iap-2010/lecture-notes/
2. http://nptel.ac.in/courses/106105151/
3. https://onlinecourses.nptel.ac.in/noc16_cs19/preview

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ARM SYSTEM ARCHITECTURE

Sub Code : 15EE623 **Credits : 03**
Hrs/Week : 3+0+0+0 **Total Hours : 39**

Prerequisites :MC (15EE403)

Course Learning Objectives :

1. To introduce the assembly instructions of ARM7TDMI processor and its internal functioning, enabling students to understand any other processor architectures at ease.
2. Provide good understanding of how coprocessors are interfaced with ARM core and how coprocessors can be programmed.

3. Provide an in-depth understanding of the Floating point representation and the VFP coprocessor implementation in particular.
4. Cover the details of cache architectures, AMBA bus, virtual memory management concepts with the detailed explanation on the Memory Management UNIT (MMU) and Memory Protection UNIT (MPU)
5. Give good overview of various peripherals used with ARM core and it basic functioning. Touch upon later versions of ARM7 processor and their features and new developments.

UNIT – I

ARM Introduction and Pipeline structures: Types of computer Architectures, ISA's and ARM History. Embedded System Software and Hardware, stack implementation in ARM, Endianness, and condition codes. Processor core VS CPU core, ARM7TDMI Interface signals, Memory Interface, Bus Cycle types, Register set, Operational Modes. Instruction Format, ARM Core Data Flow Model, ARM 3 stage Pipeline, ARM family attribute comparison. ARM 5 stage Pipeline, Pipeline Hazards, Data forwarding - a hardware solution. **8 Hours**

UNIT – II

ARM7TDMI assembly instructions and modes: ARM ISA and Processor Variants, Different Types of Instructions, ARM Instruction set, data processing instructions. Shift Operations, shift Operations using RS lower byte, Immediate value encoding. Data processing Instructions. AddressingMode-1, Addressing Mode -2. Addressing Mode -2, LDR/STR, Addressing mode -3 with examples. Instruction Timing, Addressing Mode - 4 with Examples. Swap Instructions, Swap Register related Instructions, Loading Constants. Program Control Flow, Control Flow Instructions, B & BL instructions, BX instruction. Interrupts and Exceptions, Exception Handlers, Reset Handling. Aborts, software Interrupt Instruction, undefined instruction exception. Interrupt Latency, Multiply Instructions, and Instruction set examples. Thumb state, Thumb Programmers model, Thumb Implementation, Thumb Applications. Thumb Instructions, Interrupt processing. Interrupt Handling schemes, Examples of Interrupt Handlers. **8 Hours**

UNIT – III

ARM Coprocessor Interface and VFP ARM coprocessor interface and Instructions, Coprocessor Instructions, data Processing Instruction, data transfers, register transfers. Number representations, floating point representation (IEEE754). Flynn's Taxonomy, SIMD and Vector Processors, Vector Floating Point Processor (VFP), VFP and ARM interactions, An example vector operation. **7 Hours**

UNIT – IV

Cache and Memory Management and Protection: Memory Technologies, Need for memory Hierarchy, Hierarchical Memory Organization, Virtual Memory. Cache Memory, Mapping Functions. Cache Design, Unified or split cache, multiple level of caches, ARM cache features, coprocessor 15 for system control. Processes, Memory Map, Protected Systems, ARM systems with MPU, memory Protection UNIT (MPU). Physical Vs Virtual Memory,

Paging, Segmentation. MMU Advantage, virtual memory translation, Multitasking with MMU, MMU organization, Tightly coupled Memory (TCM). **8 Hours**

UNIT – V

ARM tools and Peripherals ARM Development Environment, Arm Procedure Call Standard (APCS), Example C program. Embedded software Development, Image structure, linker inputs and outputs, memory map, application startup. AMBA Overview, Typical AMAB Based Microcontroller, AHB bus features, AHB Bus transfers, APB bus transfers, APB bridge. DMA, Peripherals, Programming Peripherals in ARM. ARM ISAs, ARMv5, ARMv6, ARM v7, big. little technology, ARMv8. ARM ISAs, ARMv5, ARMv6, ARM v7, big .little technology, ARMv8. **8 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Comprehend ARM7TDMI assembly instructions and their formats and usage.
2. Develop ARM7 based assembly level programming skills and understand the various coprocessors interfaced in an SoC.
3. Explain the cache design, virtual memory and memory protection concepts and their implementation details in a typical SoC designs.
4. Comprehend on AMBA bus architecture, various HW peripherals in SoCs and how they can be used or to be designed.
5. Use any processor Software tool chains for embedded software solution development.

Mapping of POs & COs:

Program Outcomes→ ↓ Course Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
CO1	√	√										
CO2	√	√		√								
CO3	√	√										√
CO4	√	√		√	√						√	√
CO5	√	√		√	√		√				√	√

TEXT BOOK :

1. ARM System Developer's Guide : Designing and Optimizing System Software (English) 1st Edition, Andrew Sloss, Dominic Symes, Chris Wright, Morgan Kaufmann Publishers 2011

REFERENCE BOOKS :

1. Arm System-on-chip Architecture, 2nd Edition, Steve Furber, Pearson publication, 2013
2. Arm Assembly Language, Fundamentals and Techniques, 2nd edition, William Hohl, Christppher Hinds, CRC Press, 2014

3. ARM Assembly Language Programming & Architecture By. Muhammad Ali Mazidi, Kindle edition
4. Operating Systems, 5th Edition,By William Stallings
5. Manuals and Technical Documents from the ARM Inc, web site.

E Books / MOOC / NPTEL

1. http://electro.fisica.unlp.edu.ar/arq/downloads/Papers/ARM/Addison%20Wesley%20-%20ARM%20System-on-Chip%20Architecture,%202Ed.pdf
2. http://eee.guc.edu.eg/Courses/Electronics/ELCT912%20Advanced%20Embedded%20Systems/Lectures/ARM%20System%20Developer%27s%20Guide.pdf
3. http://nptel.ac.in/courses/108102045/
4. http://nptel.ac.in/courses/117106111/

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PROGRAMMABLE LOGIC CONTROLLERS

Sub Code	**: 15EE624**	**Credits**	**: 03**
Hrs/Week	**: 3+0+0+0**	**Total Hours**	**: 39**

Prerequisites : DEC (15EE305)

Course Learning Objectives :

1. To Justify the role of PLC in automation, SCADA and the hardware capabilities of PLC in industrial automation.
2. To Program a PLC using adder Diagram, Functional Block Diagram (FBD).
3. To understand the Sequential Functions Charts (SFC) and Structured Text (ST) methods incorporating internal relays.
4. To Program a PLC Program a PLC using shift registers, data handling instructions.

UNIT – I

INTRODUTION: Introduction to Programmable logic controller (PLC), role in automation (SCADA), advantages and disadvantages, hardware, internal architecture, sourcing and sinking, characteristics of I/O devices, list of input and output devices, examples of applications. I/O processing, input/output UNITs, signal conditioning, remote connections, networks, processing inputs I/O addresses. **8 Hours**

UNIT – II

PROGRAMMING: Ladder programming- ladder diagrams, logic functions, latching, multiple outputs, entering ladder programs, functional blocks, program examples, location of stop and emergency switches. **7 Hours**

UNIT – III

PROGRAMMING LANGUAGES: Instruction list, sequential functions charts, structured text

INTERNAL RELAYS: ladder programs, battery- backed relays, one - shot operation, set and reset, master control relay, example programs, jump and call subroutines**.** **9 Hours**

UNIT – IV

Timers and counters: Types of timers, programming timers, OFF- delay timers, pulse timers, programming examples,forms of counter, programming, up and down counting, timers with counters, sequencer. **8 Hours**

UNIT – V

Shift register and data handling: shift registers, ladder programs, registers and bits, data handling, arithmetic functions, closed loop control, temperature control and bottle packing applications. **7 Hours**

Note: Discussing the programming should be restricted to only one type of PLC (Mitsubhishi)

Course Outcomes:

At the end of the course student will be able to

1. Justify the role of PLC in automation / SCADA and the hardware capabilities of PLC in industrial automation and identify various I/O devices and their characteristics for interfacing with PLC.
2. Program a PLC using Ladder Diagram, Functional Block Diagram (FBD).
3. Program a PLC using Instruction list (IL), Sequential Functions Charts (SFC) and Structured Text (ST) methods incorporating internal relays.
4. Incorporating timers /counters to program a PLC
5. Program a PLC using shift registers, data handling instructions, Comprehend the real world industrial applications of PLC using ladder diagram and instruction list.

Mapping of POs & COs:

Program Outcomes→ / ↓ Course Outcomes	1	2	3	4	5	6	7	8	9	10	11	12
CO1	M		L						H			
CO2	H	M	M									
CO3	H		M	H								
CO4	H		M	M					H			
CO5	H		M	M					H			

TEXT BOOKS :

1. "Programmable Logic controllers"-W Bolton, 6th edition, Elsevier- newness, 2015.
2. "Programmable logic controllers - principles and applications"-John W Webb, Ronald A Reis, -5th edition, 2nd impression, Pearson education, 2009.

REFERENCE BOOKS :

1. "Programmable Controller Theory and Implementations"-L. A Bryan, E. A Bryan, - 2nd edition, 2003..
2. "Programmable Controllers – An Engineers Guide"-E. A Paar, 3rd edition, newness, 2003.

E Books / MOOC/ NPTEL

1. http://library.automationdirect.com/plc-handbook/
2. https://www.coursera.org/learn/intelligent-machining/lecture/fGz3r/programmable-logic-controllers-plc
3. https://www.udemy.com/plc-programming-from-scratch/
4. http://nptel.ac.in/courses/112102011/
5. http://nptel.ac.in/courses/112103174/

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ILLUMINATION TECHNOLOGY

Sub Code	**: 15EE625**	**Credits**	**: 03**
Hrs/Week	**: 3+0+0+0**	**Total Hours**	**: 39**

Course Learning Objectives :

1. To understand the importance of Light- Eye & Vision in designing luminaries
2. To Comprehend the Propagation of light & photometric UNITs
3. To Demonstrate the process of Production of radiation and their characteristics
4. To Enumerate the principle of Artificial light sources.
5. To Design the objectives and methods for Interior lighting.

UNIT – I

Light- Eye & Vision: Electromagnetic spectrum- Visible spectrum- Structure of the eye-Retina- Rodes & Cones- Distribution & functions of rods & cones-Photoscopic, scotoscopic & mesopic visions- Purkinje shift color-vision, vision functions – accommodation, adaptation & Convergence- luminance contrast & color contrasts- Metamerism. **7 Hours**

UNIT – II

Propagation of light & photometric UNITs: Light Propagation-Reflection-Specular-diffuse, spread, compound, scattered & selective reflections-Absorption-Transmission-Refraction-Polarization.

Inter relation between the various photometric quantities –Luminous efficacy, spectral eye sensitivity Curve-Light Watt-Brightness-Luminous Existence-Radiometric quantities &UNITs-point by point method of luminance calculations –simple problems. **8 Hours**

UNIT – III

Production of radiation: Sources of radiation-Generation-Coherent & Incoherent radiations-Incandescence -Thermal Radiation-Black body radiator-Spectral energy distribution-(Energy-Wavelength) diagram-color temperature-c.c.t-selective radiators-color appearance & color rendering Luminescence- Fluorescence-low pressure & high pressure gaseous discharges-Glow & arc discharges – V-I characteristics. **8 Hours**

UNIT – IV

Artificial light sources: construction- principle of operation- luminous efficiency- lamp life & color characteristics of incandescence, Tungsten halogen, fluorescent, High pressure mercury vapor, High Pressure sodium vapor and metal halide lamps- new trends in lamp technology. **7 Hours**

UNIT – V

Interior lighting design: Lighting design objectives-safely and health performance-appearance & comport lighting design flow chart.
Lighting for commercial and public buildings such as offices, hotels teaching establishments and hospital lighting
Lighting for industrial buildings, low & high bay area's general lighting designs.
Lighting for display-Shops & super markets, art galleries, museum lighting, lumen method of calculations-simple problems. **9 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Explain the importance of Light- Eye & Vision in designing luminaries
2. Comprehend the Propagation of light & photometric UNITs
3. Demonstrate the process of Production of radiation and their characteristics
4. Enumerate the principle of Artificial light sources.
5. Explain the Design objective and methods for Interior lighting.

Mapping of POs & COs:

Program Outcomes→ ↓ Course Outcomes	a	b	c	d	e	f	g	h	i	j	k	l
CO1	√	√										
CO2	√											
CO3	√											
CO4	√	√		√	√	√	√				√	√
CO5	√	√		√		√	√				√	√

TEXT BOOK :

1. M.A. Cayless and A.M Marsden-Lamps and Lighting (Ed.3) Oxford and IBH Publishing , 4th edition,1996.

REFERENCE BOOKS :

1. Ronald N. Helms- Illumination Engineering for Energy Efficiency Luminous Environment PH ,1980.
2. H.Ziji-Illumination Engineering Course-Philips Technical Lab,1955
3. Brain Fitt and Joe Thornley-Lighting by Design –A Technical Guide-Focal Press,Boston,1992

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EMPLOYABILITY SKILL DEVELOPMENT

Sub Code : 15IL001/ 002 **Credits : Nil (MLC)**
Hrs/Week : 0+1+0+0 **Total Hours : 12**

UNIT – I

Analytical Aptitude Skill: concept of analytical skill, definition-logical thinking and testing of Analytical Aptitude

UNIT – II

Quantitative Aptitude skill-Concept-definition-Preliminary requirement for development of quantitative skill- testing of quantitative skill.

UNIT – III

Verbal and ability skill – Knowledge and Vocabulary and grammar-comprehension-Verbal Reasoning skill

REFERENCE BOOKS:

1. Aggarwal R.S “Modern Approach to Logical Reasaning” S. Chanda Publication ,2008.
2. Aggarwal R.S “Quantitative Aptitude” S. Chand Publication ,2014.
3. Aggarwal R.S “Modern Approach to verbal and non verbal reasoning” S. Chanda Publication ,2013
4. Arun Sharma “Verbal ability and reading comprehension CAT” TMH Publications,2014
5. Ethnus Consultancy Pvt. Ltd “ APTIMTRA: Your friend for cracking aptitude test”, MGH Publications ,2014
6. Aggarwal R.S “Advanced objective general knowledge” S. Chanda Publication ,2014.

Examination pattern:

This course is a mandatory learning course without credit. Continuous internal examination (CIE) consists of 2 internal exams (20 marks each) and tasks (10 marks). There is no semester end examination (SEE). The student will be awarded PP or NP grade as per autonomous regulations.

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