B. E. SYLLABUS

ELECTRICAL & ELECTRONICS ENGINEERING

VII & VIII 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

VII Semester **28 Hours/week**

Sl.No.	Code	Course Title	Theory/Tuto. /Prac./ Self study	Total Hrs./Week	CIE	SEE	Credits
1	14EE701	Computer Techniques in Power System Analysis	3+2+0+0	5	50	50	4
2	14EE702	High Voltage Engineering	4+0+0+S	4	50	50	4
3	14EE703	Industrial Drives and Application	3+2+0+0	5	50	50	4
4	14EE704	Relay & H V Lab	0+0+3+0	3	50	50	2
5	14EE705	Power System Simulation Lab	0+0+3+0	3	50	50	2
6	14EE706	Major Project phase I	0+0+2+0	2	50	-	1
7	14EE71X	Elective – IV	3+0+0+0	3	50	50	3
8	14EE72Y	Elective - V	3+0+0+0	3	50	50	3
		TOTAL	**28**	**28**	**400**	**350**	**23**

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING
SCHEME OF TEACHING AND EXAMINATION

VIII Semester **33 Hours/week**

Sl. No.	Code	Course Title	Theory/Tuto. /Prac./ Self study	Total Hrs. /Week	CIE	SEE	Credits
1	14EE801	Industrial Management, Electrical Estimation & Economics	4+0+0+S	4	50	50	4
2	14EE802	Seminar	0+0+2+0	2	50	-	1
3	14EE803	Major Project	0+0+18+0	18	50	50	9
4	14EE81X	Elective – VI	3+0+0+0	3	50	50	3
5	14EE82Y	Elective – VII	3+0+0+0	3	50	50	3
6	14XX83x	Open Elective	3+0+0+0	3	50	50	3
TOTAL			**33**	**33**	**300**	**300**	**23**

ELECTIVES

ELECTIVE - IV	**14EE71X**	14EE711	HVDC Power transmission
		14EE712	Reactive Power Management
		14EE713	VLSI Circuits and Design
		14EE714	Robotics and Automation
		14EE715	Micro Electro Mechanical Systems
ELECTIVE - V	**14EE72Y**	14EE721	FACTS
		14EE722	Modern Power System Protection
		14EE723	Electrical Power Quality
		14EE724	Artificial Neural Networks
		14EE725	Operating System
ELECTIVE – VI	**14EE81X**	14EE811	Computer control of Electrical drives
		14EE812	Power Systems Operation and Control
		14EE813	Advanced Digital Signal Processing
		14EE814	Discrete Control Systems
		14EE815	Smart Electric Grid
ELECTIVE - VII	**14EE82Y**	14EE821	Modern Rectifiers and Resonant Converters
		14EE822	Electrical Power Utilisation
		14EE823	Embedded Systems
		14EE824	Power System Dynamics and Stability
		14EE825	Human Resource Management

COMPUTER TECHNIQUES IN POWER SYSTEM ANALYSIS

Sub Code : 14EE701 **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
ENT-I (14EE302), GTD (14EE505), TIM (14EE402), PSAS (14EE601)

Course Learning Objectives :

1. To introduce the concepts of network topology and graph theory
2. To Formulate the Y Bus and Z Bus
3. To Formulate and solve load flow problem of a power system network.
4. To justify the need of Economic operation of power system.
5. To introduce the concept of Transient stability and predict system stability

UNIT – I

NETWORK TOPOLOGY: Introduction, Elementary graph theory –oriented graph, tree, co-tree, basic cut-sets, basic loops; Incidence matrices –Element-node, Bus incidence, Branch – path, Basic cut-set, Augmented cut-set, Basic loop and Augmented loop; Primitive network – impedance form and admittance form. **8*+5 Hours**

UNIT – II

NETWORK MATRICES: Introduction, Formation of YBUS – by method of inspection, by method of singular transformation (YBUS = A^T [y] A); Formation of Bus Impedance Matrix by step by step building algorithm (without mutual coupling elements). **7*+5 Hours**

UNIT – III

LOAD FLOW STUDIES: Introduction, Power flow equations, Classification of buses, Data for load flow, Gauss-Seidal Method – Algorithm and flow chart for PQ and PV buses (numerical problem for one iteration only), Acceleration of convergence; Newton Raphson Method – Algorithm and flow chart for NR method in polar coordinates (numerical problem for one iteration only); Algorithm for Fast Decoupled load flow method; Comparison of Load Flow Methods. **8*+6 Hours**

UNIT – IV

ECONOMIC OPERATION OF POWER SYSTEM: Introduction, Performance curves, Economic generation scheduling neglecting losses and generator limits, Economic generation scheduling including generator limits and neglecting losses; Iterative techniques; Economic Dispatch including transmission losses – approximate penalty factor, iterative technique for solution of economic dispatch with losses; Derivation of transmission loss formula; Optimal

scheduling for Hydrothermal plants – problem formulation, solution procedure and algorithm. **8*+5 Hours**

UNIT – V

TRANSIENT STABILITY STUDIES: Numerical solution of Swing Equation – Point-by-point method, Modified Euler's method, Runge-Kutta method, Milne's predictor corrector method. Representation of power system for transient stability studies – load representation, network performance equations.Solution techniques with flow charts. **8*+5 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Illustrate the concepts and applications of network topology and graph theory
2. Represent a power system network using the concept of graph theory and formulate Y_{bus} and Z_{bus}
3. Formulate and solve load flow problem of a power system network using different load flow techniques.
4. Appreciate and justify the need of Economic operation of Power System and suggest economic generation scheduling.
5. Comprehend the concept of Transient stability and predict system stability using Numerical integration techniques

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			L							
CO3	H	H		H	H						M	L
CO4	H	H		M	M						M	H
CO5	H	H		H	H		L				H	L

TEXT BOOKS:

1. "Computer Methods in Power System Analysis", Stag, G. W., and EI-Abiad, A. H, McGraw Hill International Student Edition. 1968
2. "Modern Power System Analysis", Nagrath, I. J., and Kothari, D. P., -TMH,4th edition, 2011.

REFERENCE BOOKS:

1. "Advanced Power System Analysis and Dynamics" Singh, L. P., New Academic Science ,, New Delhi, 2012.
2. "Computer Aided Power System Operations and Analysis"- Dhar, R. N- TMH, New Delhi, 1984.
3. "Power System Analysis", Haadi Sadat, -TMH, 3rdedition , 2010.
4. "Elements of Power System Analysis", W.D Stevenson, 4TH edition,TMH,2001.

E-Books / MOOC:

1. http://nptel.ac.in/courses/108107028/
2. http://www.nptel.ac.in/syllabus/108105016/

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HIGH VOLTAGE ENGINEERING

Sub Code : 14EE702 **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
GTD (14EE505), SGP (14EE602), TIM (14EE402), DCSM (14EE303)

Course Learning Objectives :

1. To introduce the concept of high voltage technology
2. To familiarize with concept of HV breakdown phenomena of dielectrics
3. To study methods of generation of HVAC and HVDC voltages and concept of generation of impulse voltage and current
4. To introduce the concept of measurement of high voltages.
5. To study the non-destructive insulation techniques and high voltage tests on electrical apparatus.

UNIT – I

INTRODUCTION: Introduction to HV technology, advantages of transmitting electrical power at high voltages, need for generating high voltages in laboratory. Important applications of high voltage. **5 Hours**

BREAKDOWN PHENOMENA:
Classification of HV insulating media.Properties of important HV insulating media under each category.
Gaseous dielectrics: Ionizations: primary and secondary ionization processes. Criteria for gaseous insulation breakdown based on Townsend's theory.Limitations of Townsend's theory.Streamer's theory breakdown in non-uniform fields. Corona discharges. Breakdown in electro negative gasses.Paschen's law and its significance.
SS Topic: Time lags of Breakdown**.** **7 Hours**

UNIT – II

Breakdown in solid dielectrics: Intrinsic Breakdown, avalanche breakdown, thermal breakdown, and electromechanical breakdown.
Breakdown of liquids dielectric dielectrics: Suspended particle theory, electronic Breakdown, cavity breakdown (bubble's theory), electro convection breakdown
4 Hours

GENERATION OF HV AC AND DC VOLTAGE: HV AC-HV transformer; Need for cascade connection and working of transformers UNITs connected in cascade. Series resonant circuit- principle of operation and advantages.Tesla coil. HV DC- voltage doubler circuit,. Calculation of high voltage regulation, ripple and optimum number of stages for minimum voltage drop

SS Topic : Cock Croft- Walton type high voltage DC set **6 Hours**

UNIT – III

GENERATION OF IMPULSE VOLTAGE AND CURRENT:

Introduction to standard lightning and switching impulse voltages.Analysis of single stage impulse generator-expression for Output impulse voltage.Multistage impulse generator working of Marx impulse.Rating of impulse generator.Components of multistage impulse generator.

Triggering of impulse generator by three electrode gap arrangement. Triggering gap and oscillograph time sweep circuits. Generation of switching impulse voltage.

SS Topics: Generation of high impulse current. **10 Hours**

UNIT – IV

MEASUREMENT OF HIGH VOLTAGES: Electrostatic voltmeter principle, construction and limitation. Chubb and Fortescue method for HV AC measurement.Generating voltmeter-Principle, construction.Series resistance micro ammeter for HV DC measurements.Standard sphere gap measurements of HV AC, HV DC, and impulse voltages.

Potential dividers-resistance dividers capacitance dividers mixed RC potential dividers. Surge current measurement-Klydanograph and magnetic links.

SS Topics: Factors affecting the HV measurements. **10 Hours**

UNIT – V

NON-DESTRUCTIVE INSULATION TESTING TECHNIQUES:

Dielectric loss and loss angle measurements using Schering Bridge, Transformer ratio Arms Bridge. Need for discharge detection and PD measurements aspects. Factor affecting the discharge detection. Discharge detection methods-straight and balanced methods.

6 Hours

HIGH VOLTAGE TESTS ON ELECTRICAL APPARATUS:

Definitions of terminologies, tests on isolators, circuit breakers,

SS Topic: cables insulators and transformers **4 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Appreciate the necessity of high voltage for bulk power transmission.
2. Comprehend the theory of breakdown in insulting medium.
3. Justify the requirement of generation of HV AC/ DC and impulse voltages for testing the insulting medium.
4. Comprehend the principles of measurement of high voltages.
5. Explain the methods of testing of insulators and high voltage apparatus. And justify the application of Non Destructive Testing.

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. "High Voltage Engineering Fundamentals"- E. Kuffel and W.S. Zaengl- 2nd edition, Elsevier, press, 2005.
2. "High Voltage Engineering"- M.S.Naidu and Kamaraju- 4th Edition, THM, 2008..
3. "High Voltage Engineering" -C.L.Wadhwa, New Age International Private limited, 3rd edition,2010.

REFERENCE BOOKS:

1. "Extra High Voltage AC Transmission Engineering" -Rakosh Das Begamudre, New academic science 2011.
2. "Transmission and Distribution Reference Book" -Westing House.,1964.
3. "High Voltage Technology" - L. L. Alston- BSB Publication, 2007.

E-Books / MOOC:

1. https://mycourses.aalto.fi/course/view.php?id=5252&section=1
2. http://www.nptel.ac.in/courses/108104048/

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INDUSTRIAL DRIVES & APPLICATIONS

Sub Code : 14EE703 **Credits : 04**
Hrs/Week : 3*+2+0+0 **Total Hours : 39*+26**

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

Prerequisites
PE (14EE504), TIM (14EE402), DCSM (14EE303)

Course Learning Objectives :

1. To study the basic principle of Industrial Drives, its requirements, its characteristics, selection and design and finally different applications.
2. To model an Electrical Drive and understand its steady state, transient behaviour

3. To understand the need of industrial drives, its control and design of different parameters
4. To differentiate the AC and DC drives and their selection based on requirements, and their characteristics.
5. To apply the knowledge in selection of drives for real Industrial applications.

UNIT – I

AN INTRODUCTION TO ELECTRICAL DRIVES & ITS DYNAMICS:
Electrical drives. Advantages of electrical drives. Parts of electrical drives, choice of electrical drives, status of dc and ac drives.
Dynamics of electrical drives, Fundamental torque equation, speed torque conventions and multi-quadrant operation. Equivalent values of drive parameters, components of load torques, nature and classification of load torques, calculation of time and energy loss in transient operations, steady state stability, load equalization. **8*+5 Hours**

UNIT – II

SELECTION OF MOTOR POWER RATING: Thermal model of motor for heating and cooling, Classes of motor duty, determination of motor rating. **4*+3 Hours**
DC MOTOR DRIVES:
Starting braking, transient analysis **3*+2 Hours**

UNIT – III

CONTROL OF DC MOTOR DRIVES:
Single phase fully controlled rectifier, control of dc separately excited motor, Single-phase half controlled rectifier control of dc separately excited motor.
Three phase fully controlled rectifier control of dc separately excited motor, three phase half controlled rectifier control of dc separately excited motor, multi-quadrant operation of dc separately excited motor fed form fully controlled rectifier. Rectifier control of dc series motor, chopper controlled dc drives, chopper control of separately excited dc motor, Chopper control of series motor. **8*+6 Hours**

UNIT – IV

INDUCTION MOTOR DRIVES:
(a) Operation with unbalanced source voltage and single phasing, operation with unbalanced rotor impedances, analysis of induction motor fed from non-sinusoidal voltage supply, starting braking, transient analysis.
(b) Stator voltage control variable voltage frequency control from voltage sources , voltage source inverter control, closed loop control, current source inverter control, current regulated voltage source inverter control, rotor resistance control, slip power recovery, speed control of single phase induction motors. **8*+6 Hours**

UNIT – V

SYNCHRONOUS MOTOR DRIVES: Operation form fixed frequency supply, synchronous motor variable speed drives, variable frequency control of multiple synchronous motors. Self-controlled synchronous motor drive employing load commutated thruster inverter.
4*+4 Hours
INDUSTRIAL DRIVES: Rolling mill drives, cement mill drives, paper mill dries and textile mill drives. **4*+0Hours**

Course Outcomes:

At the end of the course student will be able to

1. Analyze basic principle of Industrial Drives and their selection based on source / load requirements
2. Model the drive for thermal characteristics and study the transient analysis of DC drives.
3. Explain the power electronics based drives to control the DC Motors.
4. Develop steady / transient models of Induction motor drive to control using power electronics controllers.
5. Control the Synchronous Motor Drives using power electronics controllers. And apply the acquired knowledge in selection of drives for real world Industrial applications.

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		M								
CO3	H	H		M	L							
CO4	H	H		M	M						L	
CO5	H	H		L	L	M	M	L	L		M	L

TEXT BOOK:

1. "Fundamentals of Electrical Drives"- G.K Dubey – 2nd Edition, Narosa publishing house Chennai, 2010

REFERENCE BOOKS:

1. "Electrical Drives" - N.K De and P.K. Sen- PHI, 1st edition,2009
2. "A First Course On Electric Drives" - S.K Pillai-Wiley Eastern Ltd 1990.
3. "Power Electronics, Devices, Circuits and Industrial Applications" - V.R. Moorthi, "Oxford University Press, 2005.

E-Books / MOOC

1. http://nptel.ac.in/courses/108108077/
2. https://ocw.tudelft.nl/courses/electrical-machines-and-drives/?view=lectures

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RELAY AND HIGH VOLTAGE LABORATORY

Sub Code : 14EE704 **Credits : 02**
Hrs/Week : 0+0+3+0 **Total Hours : 39**

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

Course Learning Objectives :

1. To find breakdown voltage &dielectric strength of given transformer oil.
2. To demonstrate the operation of various relays like electromechanical and static relays.
3. To get the operating parameters of relays
4. To measure HVDC and HVAC by sphere gap
5. To measure HVAC by rod gap techniques.

List of Experiments

Total 10 experiments are to be conducted

PART – A (Choose at least two experiments)

1. Over current relay **:**
   - **a.** IDMT non-directional characteristics
   - **b.** Directional features
   - **c.** IDMT directional
2. IDMT characteristics of over voltage or under voltage relay. .(solid stare or electromechanical type
3. .
   a. To determine 50% probability flashover voltage for air insulation subjected to impulse voltage.
   b. Generation of standard lightning impulse voltage and to determine efficiency and energy of impulse generator. Operating characteristics of over voltage or under voltage relay. (Solid stare or electromechanical type).
4. Operation of negative sequence relay.
5. Bias characteristics of differential relay.
6. Current-time characteristics of fuse.

PART – B (Choose at least one experiment)

1. Operating characteristics of microprocessor based (numeric) over –current relay.
2. Operating characteristics of microprocessor based (numeric) distance relay.
3. Operating characteristics of microprocessor based (numeric) over/under voltage relay.

PART – C (Choose at least one experiment)

1. Generator protection –Merz-Price- protection scheme.
2. Feeder protection scheme-fault studies.

3. Motor protection scheme-fault studies.

PART – D (Choose at least two experiments)

1. Spark over characteristics of air insulation subjected to high voltage AC with spark over voltage corrected to STP.
2. Spark over characteristics of air insulation subjected to high voltage AC, with spark over voltage corrected to STP for uniform and non-uniform field configuration.
3. Spark over characteristics of air insulation subjected to high voltage dc – 4 Measurement of HVAC and HVDC using standard spheres.
4. Breakdown strength of transformer oil using oil-testing UNIT.
5. Field mapping using electrolytic tank for any one-model cable/capacitor/transmission line/ Sphere gap models.

Course Outcomes:

At the end of the course student will be able to

1. Find breakdown voltage &dielectric strength of given transformer oil.
2. Familiarize the principle of operation of relays like electromechanical and static relays.
3. Get desired values pertaining to the operation of relays
4. Measure HVDC and HVAC by sphere gap
5. Measure HVAC by rod gap techniques..

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 SYSTEM SIMULATION LABORATORY

Sub Code	**: 14EE705**	**Credits**	**: 02**
Hrs/Week	**: 0+0+3+0**	**Total Hours**	**: 39**

Course Learning Objectives :

1. To introduce the power angle diagram and swing curve of an alternator
2. To formulate the Y Bus and determine various bus parameters and line flows
3. To determine the parameters in a single transmission system with Y-Δ transformers at a specified location for various faults.
4. To perform Load flow analysis using various techniques.
5. To perform optimal generator scheduling for thermal power plants.

List of Experiments

Power system simulation using MATLAB (or equivalent) Software Packages and C++

PART – A (Choose at least two experiments)

1. Determination of Power angle diagrams for Salient and Non- Salient pole Synchronous machines, reluctance power, excitation e.m.f. and regulation.
2. Y Bus formation for power system with & without mutual coupling by Singular transformation.
3. Y Bus formation for power system by Inspection method.
4. Formation of Z bus using building algorithm.
5. ABCD Parameters:
6. a. For symmetric Π/T configuration.
   b. Verification of AD-BC = 1.
   c. Determination of Efficiency and Regulation.
7. Determination of bus current, bus power & line flows for a specified system voltage (bus) profile.
8. To determine fault current and voltage in a single transmission system with ΄Y-Δ transformers at a specified location for SLGF, DLGF and LLF
9. Load flow analysis using Gauss – Seidel method for both P –Q and P-V buses
10. Load flow analysis using NR method and Fast Decoupled method for both P –Q and P-V buses.
11. Optimal Generator scheduling for thermal power plants.
12. Plot swing curve for a single machine connected to infinite bus through a pair of identical transmission lines, for a 3 phase fault on one of the lines for variation of inertia constant/line parameters/fault location/clearing time/pre fault electrical output.

Course Outcomes:

At the end of the course student will be able to

1. Develop the power angle diagram and swing curve of an alternator
2. Formulate the Y Bus by various methods and determination of bus currents, bus power and line flows for a specified system
3. Determine the fault current and voltage in a single transmission system with Y-Δ transformers at a specified location for various faults
4. Perform Load flow analysis using various techniques.
5. Perform Optimal generator scheduling for thermal power plants..

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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MAJOR PROJECT PHASE I

Sub Code : 14EE706 **Credits : 01**
Hrs/Week : 0+0+2+0 **Total Hours : 26**

Course Learning Objectives :

1. To expose students to the 'real' working environment and get acquainted with the organization structure, business operations and administrative functions.
2. To apply the theoretical concepts into a practical working model.
3. To identify, define, model a problem and simulate the same to verify the designed parameters

Course Outcomes:

At the end of the course student will be able to

1. Identify real life problem and formulate appropriate solution.
2. Acquire System integration skills, Project management skills.
3. Use modeling and simulation tools to validate the designed parameters.
4. Involve in a team and contribute effectively for the completion of the project.
5. Develop oral as well as written presentation skills.

Mapping of POs & COs:

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

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HVDC POWER TRANSMISSION

Sub Code : 14EE711 **Credits : 03**
Hrs/Week : 3+0+0+0 **Total Hours : 39**

Prerequisites
PE (14EE504), GTD (14EE505), PSAS (14EE601)

Course Learning Objectives :

1. To introduce concepts of HVDC and HVAC generation transmission and comparison between them.
2. To choose converter and their control configuration for HVDC power transmission and their configuration.
3. To illustrate the bridge converter under different modes of operation
4. To explain the various methods to Control the HVDC converters.
5. To Identify different types of protection used for HVDC system.

UNIT – I

General aspects of DC transmission and comparison of it with Ac transmission: Historical sketch, constitution of EHV AC and DC links, Limitations and Advantages of AC and DC Transmission**.** **8 Hours**

UNIT – II

Converter circuits: Valve Characteristics, Properties of converter circuits, assumptions, single phase, three phase converters, choice of best circuits for HV DC circuits. **7 Hours**

UNIT – III

Analysis of the bridge converter:- Analysis with grid control but no overlap, Analysis with grid control and with overlap less than 60 deg, Analysis with overlap greater than 60 deg, complete characteristics of rectifier, Inversion. **8 Hours**

UNIT – IV

Control of HVDC converters and systems: grid control, basic means of control, power reversal, limitations of manual control, constant current versus constant voltage, desired feature of control, actual control characteristics, constant -minimum -Ignition –angle control, constant –current control, constant –extinction –angle control, stability of control. **8 Hours**

UNIT – V

Protection: general, DC reactor, voltage oscillations and valve dampers, current oscillations and anode dampers, DC line oscillations and line dampers, clear line faults and reenergizing the line. **10 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Compare the HVDC and HVAC transmission options, justify the advantages of HVDC power transmission. And classify HVDC power transmission system.
2. Analyze different converter circuits, the choice of converter and their control configuration for HVDC power transmission and also analyze bridge converter for different mode of operation
3. Analyze bridge converter for different modes of operation
4. Explain the various methods to Control the HVDC converters.
5. Identify different types of protection used for HVDC system.

Mapping of POs & COs:

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

TEXT BOOKS:

1. EW Kimbark, "Direct current Transmission" Wiley-Blackwell; Volume 1 edition,1971.
2. K.R Padiyar – HVDC Power Transmission Systems, New Age International Publishers 3/e,2014.
3. Prabha Kundur, "Power system stability and control" TMH, 9th reprint, 2007.

E-Books / MOOC /NPTEL:

1. http://nptel.ac.in/courses/108104013/

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REACTIVE POWER MANAGEMENT

Sub Code : 14EE712 **Credits : 03**
Hrs/Week : 3+0+0+0 **Total Hours : 39**

Prerequisites
ENT-1 (14EE302), GTD (14EE505), PSAS (14EE601)

Course Learning Objectives :

1. To introduce the concept of reactive power, its generation and absorption in power system.
2. To illustrate various methods of voltage or reactive power control.

3. To demonstrate the principle of transmission system compensation, Effect of harmonics on reactive power control.
4. To comprehend the concept of resonance, shunt capacitors and filters.
5. To explain the reactive power coordination techniques.

UNIT – I

Introduction, Importance of reactive power control in Electrical Power System, Generation and absorption of Reactive power, Relation between Voltage, Power and Reactive power at a node. **9 Hours**

UNIT – II

Methods of voltage or Reactive power control: Shunt reactor, Shunt capacitor, Series capacitor, Synchronous condenser, Static VAR system **8 Hours**

UNIT – III

Principles of Transmission system compensation. Effect of Harmonics on reactive power control: Harmonic sources. **7 Hours**

UNIT – IV

Resonance, Shunt capacitors and Filters, Telephonic Interference. **7 Hours**

UNIT – V

Reactive power coordination: Reactive power management, Transmission benefits, Reactive power dispatch and equipment impact. **8 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Know the Importance of reactive power, its generation and absorption in power system.
2. Explain various methods of voltage or reactive power control.
3. Demonstrate the principle of transmission system compensation, Effect of harmonics on reactive power control.
4. Analysis of resonance, shunt capacitors and filters.
5. Explain the reactive power coordination techniques..

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. T.J.E. Miler – Reactive Power Control in Electric Systems (John Wiley sons NY 1982)
2. B.M.Weedy – Electric Power Systems (John Wiley $ sons),2nd edition,2012.

REFERENCE BOOKS:

1. PrabhaKunder – Power System Stability and Control (TATA McGRAW-HILL),1st edition,2006.
2. IEEE Gude on Harmonic control & Reactive compensation of Power converters – IEEE student 519 – 1981.

E-Books / MOOC / NPTEL

1. http://nptel.ac.in/courses/108101040/20

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VLSI CIRCUITS AND DESIGN

Sub Code	**: 14EE713**	**Credits**	**: 03**
Hrs/Week	**: 3+0+0+0**	**Total Hours**	**: 39**

Prerequisites

ENT – 1 (14EE302), AEC (14EE304), DEC (14EE305)

Course Learning Objectives :

1. To introduce the VLSI Technology, its components and characteristics.
2. To examine the electrical characteristics of MOS transistors.
3. To demonstrate the design procedure, rule to be followed and the concept of MOSFET Scaling in VLSI.
4. To illustrate the Geometry Effects and characteristics of MOS Inverters and universal gates.
5. To discuss advanced techniques and applications to CMOS logic circuits.

UNIT – I

CMOS Processing: Introduction to IC Technology, Moore's law, VLSI design flow, VLSI Technology, Wafer fabrication process using Czochralski method, Photolithography, Well and Channel Formation, Gate oxide, Gate and Source/Drain formation, Contact & Metallization, fabrication of nMOS Transistor, Depletion type and Enhancement type MOS, CMOS n-well and P-well process, twin tub process, BiCmos **7 Hours**

UNIT – II

MOS TRANSISTORS (Electrical Characteristics) : Two terminal MOS structure, flat band voltage, MOS system under external bias, structure and operation of MOS transistors, threshold voltage, drain to source current I_{ds} verses V_{ds} relationships, body effect ,channel length modulation, mobility variation, Tunneling, punch through, hot electron effect MOS, models,small signal AC Characteristics **8 Hours**

UNIT – III

Design: Mask Layer, Stick Diagram, Symbolic diagram, Sheet resistance, capacitance layer, inverter delays, rise time, fall time, cascading and super buffer. RC delay model, Linear Delay Model, Logical effect, Parasitic Delay, Design Rules
Scaling: MOSFET SCALING AND GEOMETRY EFFECTS: Introduction, constant field scaling, constant voltage scaling, short channel Effects, narrow channel effects, Comparison of MOSFET parameters due to scaling **9 Hours**

UNIT – IV

Application-MOS Inverters Static Characteristics: Introduction, voltage transistor characteristics, noise immUNITy and noise margin, power and area considerations, resistive load inverter calculation of Voh, Vol, Vil, Vih, inverters with n type MOSFET load (enhancement, depletion) characteristics, CMOS inverter static characteristics(excluding derivation) design of CMOS inverter, latch up bulk CMOS **9 Hours**

UNIT – V

Application- 2 input NOR and NAND gates: MOS based 2 input NOR and NAND gate (with derivation), CMOS based 2 input NOR and NAND gate (excluding derivation)
Application- Other Forms Of CMOS Logic: PseodonMOS logic, dynamicCMOS logic, clocked CMOS logic, CMOS domino logic, parity generator, multiplexer, dynamic shift registers. **7 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Review the components, characteristics for VLSI technology.
2. Analyze electrical characteristics of MOS transistors.
3. Demonstrate the design procedure, rule to be followed and the concept of MOSFET Scaling in VLSI.
4. Analyze the Geometry Effects and characteristics of MOS Inverters and universal gates.
5. Discuss advanced techniques and applications to CMOS logic 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	√			√	√				√		√	

TEXT BOOKS:

1. CMOS integrated circuit analysis and design by Sang Mo Kang, Usuf Leblebici,3rd Edition, TATA McGraw hill edition,2002.
2. Basic VLSI design by Douglass a Pucknell, amran Esharaghian,3rd edition, PHI Publication,2009.
3. CMOS VLSI design by Neil Weste,David Harris 4th edition, Addison-Wesley,2010.

REFERENCE BOOKS

1. Wayne, Wolf, "Modern VLSI design: System on Silicon" Pearson Education, 2nd Edition,2005.
2. Carver Mead and Lynn Conway" Introduction to VLSI Systems" BS Publication,1st edition,1979.

E-Books / MOOC:

1. http://nptel.ac.in/courses/117106092/
2. https://www.coursera.org/learn/vlsi-cad-logic
3. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-374-analysis-and-design-of-digital-integrated-circuits-fall-2003/

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ROBOTICS AND AUTOMATION

Sub Code	**: 14EE714**	**Credits**	**: 03**
Hrs/Week	**: 3+0+0+0**	**Total Hours**	**: 39**

Course Learning Objectives :

1. To introduce the basic of composition of a robot.
2. To illustrate various robot sensors and construction of robot.
3. To introduce the concept of kinematics of the robot.
4. To enumerate the functions and advantages of the robot.
5. To introduce the robot programming concept.

UNIT – I

Introduction: Introduction to robotics, Components and Structure of Robots, robot classification, robot configurations, specifications, Common Kinematic arrangements, Rotations, Composition of Rotations, Properties, Homogeneous Transformation. **8 Hours**

UNIT – II

Robot sensors: Introduction, desirable features of sensors, magnetic sensors, fiber optic, tactile sensors, proximity and non- proximity sensors. **4 Hours**

Manipulators, Actuators and grippers: Construction of manipulators, types of actuators, grippers, classification, force analysis of gripper mechanism, designing of grippers.**4 Hours**

UNIT – III

Control: Introduction, Actuator dynamics, Set-Point Tracking, Drive Train Dynamics, Trajectory Interpolation, Feed forward Control and Computed Torque. **4 Hours**

Kinematics: Forward, inverse and velocity kinematics Denavit- Hartenberg Representation, Examples **4 Hours**

UNIT – IV

Dynamics: Euler Lagrange Equations, Expressions for kinetic and potential energy, Equation of Motions, Common configuration, Newton Euler Formulation.
Robot machine vision: Introduction, image processing and analysis. **9 Hours**

UNIT – V

Robot programming: Lead through programming methods, Robot programming languages-examples.
Case studies: Robot applications in manufacturing, robot cell design, machine interface, multiple robots, robot in assembly and inspection. **10 Hours**

Course Outcomes :

At the end of the course student will be able to

1. Know the basic of composition of a robot.
2. Understand the robot sensors and construction of robot.
3. Derive the kinematics of the robot.
4. Enumerate the functions and advantages of the robot.
5. Understand the robot programming.

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. Mark W.Spong&M.Vidyasagar. Robot Dynamics and Control, Willey India Publisher, 2009.
2. Mikell P.G, Weiss M.Nagel R.N Odrey N.G, Industrial robotics, McGraw Hill Education India Private Limited; 2 edition (23 May 2012)
3. Lee, K.S. Fu, R.C. Gonzalez & C.S.G , Robotics , McGraw Hill,2008
4. Bruno Sicilian , Modelling and controlling of Robot manipulations, Springer,2000
5. Saeed B. Niku, Introduction to robotics, PHI,2005

6. Robert J. Schilling , Fundamentals of Robotics Analysis and control, PHI,1996

E-Books / MOOC /NPTEL:

1. http://nptel.ac.in/downloads/112101098/
2. http://nptel.ac.in/downloads/112101099/

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MICRO ELECTRO MECHANICAL SYSTEMS

Sub Code	**: 14EE715**	**Credits**	**: 03**
Hrs/Week	**: 3+0+0+0**	**Total Hours**	**: 39**

Prerequisites: Engg Physics (13PH102)

Course Learning Objectives:

1. To introduce the concept of MEMS Technology and need of scaling in micro domain
2. To illustrate different MEMS Materials microfabrication/ micromaching process
3. To illustrate the transcondution principle and MEMS modeling
4. To explain the characteristics of RF and Optical MEMS
5. To illustrate the MEMS devices through case studies and introduce Nanotechnology.

UNIT – I

Introduction: MEMS, Micro sensors, Microactuators, Microelectronics fabrication, Micromachining, Mechanical MEMS, Thermal MEMS, MOEMS, RF MEMS, Nanotechnology **7 Hours**

UNIT – II

Micromachining: Introduction, Photolithography, structural and sacrificial materials, other lithography methods, Thin film deposition, impurity doping, etching, Bulk micromachining, Surface micromachining, wafer bonding, LIGA **9 Hours**

UNIT – III

MEMS Modeling: Basic modeling elements in electrical, mechanical, thermal and fluid systems, analogy between 2nd order mechanical and electrical systems. **6 Hours**

UNIT – IV

Radio Frequency (RF) MEMS: Introduction, Review of RF-based communication systems, RF –MEMS, MEMS inductors, varactors, tuners/filters, resonators, switches, phase shifters, **5 Hours**

MOEMS: Introduction, Fundamental principal of MOEMS technology, Light modulators, Beam Splitter, Microlens, Micro Mirrors, Digital Micromirror Device(DMD), Optical Switch **5 Hours**

UNIT – V

Magnetic Sensors And Actuators: Introduction, Magnetic materials for MEMS and properties, Magnetic sensing and Detection, Magnetoresistive sensors, Magneto diodes, Magnetotransistors, MEMS magnetic sensor, MagMEMS actruators, Bidirectional Microactuators.

Nanotechnology And MEMS: Relation between micro and nanotechnologies. Need and issues in handling nano products with the help of MEMS **7 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Understand the concept of MEMS Technology and need of scaling in micro domain
2. List different MEMS Materials microfabrication/ micromaching process
3. Understand the transcondution principle and MEMS modeling
4. Enumerate the characteristics of RF and Optical MEMS
5. Understand the MEMS devices through case studies and introduce MEMS and Nanotechnology.

Mapping of POs & COs:

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

TEXT BOOK:

1. MEMS"-Nitaigour Premchand Mahalik, TMH, 2007, ISBN 13:978-0-07-063445-9

REFERENCE BOOKS:

1. "MEMS and Microsystems Design and Manufacture"-Tai, Ran Hsu, TMH, 2002, ISBN 0-07-239391-2.
2. "Foundations of MEMS"- Chang Liu, Pearson International Edition, 2006, ISBN 0-13-199204-X
3. "Modeling MEMS and NEMS"- John A. Pelesko, David H. Bernstein, Chapman & Hall/CRC, 2003, ISBN 1-58488-306-5
4. "The Science and Engineering of Microelectronic Fabrication"- Second Edition, Campbell, Oxford, 2001, ISBN 0-19-513605-5. (General Microfabrication Reference.)
5. "Fundamentals of Microfabrication"-Madou, CRC Press, 1997, ISBN 0-8493-9451-1

E-Books / MOOC /NPTEL

1. http://nptel.ac.in/courses/117105082/
2. http://nptel.ac.in/courses/112101098/download/lecture-37.pdf
3. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-777j-design-and-fabrication-of-microelectromechanical-devices-spring-2007/syllabus/

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FLEXIBLE AC TRANSMISSION SYSTEMS (FACTS)

Sub Code	**: 14EE721**	**Credits**	**: 03**
Hrs/Week	**: 3+0+0+0**	**Total Hours**	**: 39**

Prerequisites
PE (14EE504), GTD (14EE505), PSAS (14EE601)

Course Learning Objectives :

1. To introduce the concept of FACTS Controllers
2. To illustrate the requirement of High power Semiconductor devices for control of power Flow
3. To study the application of Current source and Voltage Source Converters
4. To illustrate the application of Shunt FACTS controllers for enhancement of power transfer capability and damping of power oscillations.
5. To identify the use of series FACTS controllers for controlling / routing the power through the desired transmission paths.

UNIT – I

FACTS Concepts and general system configuration: Transmission, interconnection, flow of power in AC system, power flow and dynamic stability consideration, of a transmission interconnection, relative importance of controllable parameters, basic types of FACTs controllers, shunt, series, combined shunt and series connected controllers. **8 Hours**

UNIT – II

POWER SEMICONDUCTOR DEVICES: types of high power devices, principle of high power device characteristics and requirements, power device material, diode, MOSFET, MOS turn OFF thryrirstor, emitter turn OFF thryristor, integrated gate commuted thyristor (GCT & IGCT) **8 Hours**

UNIT – III

VOLTAGE SOURCED CONVERTERS: basic concepts, single phase full wave bridge converter operation, square wave voltage harmonics for a single phase bridge 3 phase full wave bridge converter. **4 Hours**

SELF AND LINE COMMUTATED CURRENT SOURCE CONVERTER: basic concepts, 3 phase full wave diode rectifier, thyristor based converter, current sourced converter with turnoff devices, current sourced versus voltage source converter.

4 Hours

UNIT – IV

STATIC SHUNT COMPENSATOR SVC AND STATCOM: objective of shunt compensation, methods of controllable VAR generation, static VAR compensator, SVC and STATCOM, comparison between, SVC and STATCOM. **7 Hours**

UNIT – V

STATIC SERIES COMPENSATORS: GCSC, TSSC, TCSC and SSSC, objectives of series compensation; variable impedance type of series compensation, switching converter type series compensation, external control for series reactive compensators. **8 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Appreciate the need of FACTS Controllers
2. Justify the requirement of High power Semiconductor devices for control of power Flow
3. Appreciate the application of Current source and Voltage Source Converters
4. Justify the application of Shunt FACTS controllers for enhancement of power transfer capability and damping of power oscillations.
5. Justify the use of series FACTS controllers for controlling / routing the power through the desired transmission paths.

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. "Understanding Facts - Concepts and technology of flexible AC Transmission system"- Laszlo Gyugyi and Narain G. Hingorani, Wiley, 2011.
2. "FACTS Controllers in Power Transmission and Distribution" - K.R Padiyar – New Age Publications - 2009

REFERENCE BOOK:

1. "EHV – AC, HVDC Transmission & Distribution Engineering" 3rd edition- Sharma SS K KATARIA & SONS-NEW DELHI, 2013.

E Book / MOOC/NPTEL:

1. http://nptel.ac.in/syllabus/108104014/
2. https://www.research-collection.ethz.ch/bitstream/handle/20.500.11850/148438/eth-27620-01.pdf

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MODERN POWER SYSTEM PROTECTION

Sub Code : 14EE722 **Credits : 03**
Hrs/Week : 3+0+0+0 **Total Hours : 39**

Prerequisites
PSAS (14EE601), SGP (14EE602)

Course Learning Objectives :

1. To introduce various static relays used in PS protection.
2. To illustrate the need of Comparators and list out various comparators and their characteristics.
3. To explain the concept of static over current, timer and voltage relays.
4. To illustrate the use and implementation of distance relays.
5. To explain the Principles of Digital/ Numerical Relays

UNIT – I

Static Relays: Introduction, Basic construction, Classification, Basic Circuits, Smoothing Circuits, Voltage regulation, square wave Generator, Time delay Circuits, Level Detectors, Summation device, Sampling Circuits, Zero crossing detector, output devices. **7 Hours**

UNIT – II

Comparators: Replica impedance, Mains Transformers, General equation of phase and Amplifiers, Comparators, Realization of ohm, mho, Impedance and offset impedance characteristics, Dualist principal, Static amplifier comparator – Rectifier bridge circulations current type, sampling comparator, static phase comparator accidence circuits type Rectifier phase comparator, Block split comparator, Zen or diode phase comparator. **8 Hours**

UNIT – III

STATIC OVER CURRENT, TIMER AND VOLTAGE RELAYS:
Instantaneous over current Relay, Definite time lay relay, inverse time over current relay, static timer relay, Basic relay circuits, mono stable delay circuits Single phase Instantaneous over voltage and under voltage relays, instantaneous over voltage relay using Op amp**.**

8 Hours

UNIT – IV

Distance Relay: general Principal of operation, Zone discrimination, Fault area on impedance diagram, Basic measuring elements, Different characteristics used in distance relaying- Impedance, Reactance, Admittance. Ohm, Distance relay settings, Distance measurement Problems. **7 Hours**

UNIT – V

Principles of Digital/ Numerical Relays: Definition of Numerical Protection System, Advantages of Numerical relays, Block diagram of Numerical Relays, Processing UNIT, non

machines Interface, communication in protective relays, Information handling with substation monitoring system. **4 Hours**

Digital Relays: Block Schematic approach of microprocessor based relays, over current relay, Protection Transformer differential protection, Directional relay scheme, Impedance relay scheme. **5 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Enumerate various static relays used in PS protection.
2. Illustrate the need of Comparators and list out various comparators and their characteristics.
3. Explain the concept of static over current, timer and voltage relays.
4. Comprehend the use and implementation of distance relays.
5. Explain the Principles of Digital/ Numerical Relays.

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. T.S. MadavaRao, "Power System protection, Static relays with microprocessor applications", TMH, Second edition, 2004.
2. Wassington A. R. and Van C , "Protective relays and protection" Vol, I & II Chapman and Hell, 1968.

REFERENCE BOOKS:

1. Patra. S.P. Basu. S.K. Chandhri.S. "Power system protection". Oxford, and IBH Publications Co-1983.
2. Ravindarnath& Chandra "Power System Protection & Switchgear", New age Publications. (GS),1st edition,2011.
3. Badriram&ViswaKharma "Power System Protection & Switchgear", TMH, (GS),2nd edition,2013.
4. Y G. Painthankar and S R Bhide, "Fundamentals of power system protection" PHI publication, 2nd edition,2010.
5. Computer Relaying IEEE Press (Tutorial on Computer Relaying) 1989.

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ELECTRICAL POWER QUALITY

Sub Code : 14EE723 **Credits : 03**
Hrs/Week : 3+0+0+0 **Total Hours : 39**

Prerequisites
PSAS (14EE601), PE (14EE504)

Course Learning Objectives :

1. To introduce the concept of power quality and their classes.
2. To illustrate the voltage sags and interruptions, their sources, estimation and protection
3. To explain the transient over voltages, fundamentals of harmonics, harmonic sources and effects of harmonic distortions.
4. To illustrate the power quality bench marking process and Utility interface
5. To explain the monitoring considerations and standards.

UNIT – I

Definitions: general classes of power quality problems, Transients, long duration voltage variation, short duration voltage variations, voltage imbalance, waveform distortion, power quality terms **5 Hours**

Voltage sags and interruptions: Sources of sags and interruptions, estimating voltage sag performance, fundamental principles of protection, monitoring sags. **3 Hours**

UNIT – II

Transients over voltages: Sources of transient over voltages, principles of overvoltage protection, utility capacitor switching transients, Fundamentals of harmonics: Harmonic distortion, voltage versus transients, harmonic indexes, harmonic sources from commercial loads, harmonic sources from Industrial loads, effects of harmonic distortion, intraharmonics **8 Hours**

UNIT – III

Applied harmonics: harmonic distortion evaluations, principles for controlling harmonics, harmonic studies, devices for controlling harmonic distortion, harmonic filters, standards of harmonics **7 Hours**

UNIT – IV

Power quality benchmark : introduction, benchmark process, power quality contract, power quality state estimation, including power quality in distribution planning, Interface to utility system, power quality issues, interconnection standards **8 Hours**

UNIT – V

Power quality monitoring: Monitoring considerations, power quality measurement equipments, assessment of power quality measurement data, application of intelligent systems, power quality monitoring standards. **8 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Introduce the power quality problems and their classes.
2. Analyze the voltage sags and interruptions, their sources, estimation and protection
3. Analyze of transient over voltages, fundamentals of harmonics, harmonic sources and effects of harmonic distortions.
4. Illustrate the power quality bench marking process, power quality contract and estimation, interface to utility
5. Explain the Monitoring considerations and standards, measurement equipment, and application of intelligent systems.

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. Dugan, Roger C , Santoso, Surya , McGranaghan, Mark F/ Beaty, H. Wayne “Electric Power Quality” McGraw-Hill professional publication ,3rd edition,2012

REFERENCE BOOKS:

1. G.T.Heydt, “Electric power quality”, stars in a circle publications 1991.
2. M.H.Rashid “Modern Power Electronics” TATA McGraw Hill 2002.
3. Math H. J. Bollen. “Understanding power quality problems voltage sags and interruptions” IEEE Press, 2000.

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ARTIFICIAL NEURAL NETWORKS

Sub Code : 14EE724 **Credits : 03**
Hrs/Week : 3+0+0+0 **Total Hours : 39**

Course Learning Objectives :

1. To introduce the concept and use of ANN
2. To explain the concept of supervised learning and various leaning algorithms.
3. To illustrate the use of Accelerating learning process and need of prediction network
4. To illustrate the concept of Learning vector quantizing and associative modeling
5. To illustrate the need of optimization and different optimization algorithms

UNIT – I

Introduction, history, structure and function of single neuron, neural net architectures, neural learning, use of neural networks. **7 Hours**

UNIT – II

Supervised learning, single layer networks, perceptrons, linear separability, perceptron training algorithm, guarntees of success, modifications. **4 Hours**
Multiclass networks-I, multilevel discrimination, preliminaries, back propagation, setting parameter values, theoretical results. **5 Hours**

UNIT – III

Accelerating learning process, application, mandaline, adaptive multilayer networks. **4 Hours**
Prediction networks, radial basis functions, polynomial networks, regularization, unsupervised learning, winner take all networks. **4 Hours**

UNIT – IV

Learning vector quantizing, counter propagation networks, adaptive resonance theorem, topologically organized networks, distance based learning, neocognition. **4 Hours**

Associative models, hop field networks, brain state networks, Boltzmann machines, hetero associations. **4 Hours**

UNIT – V

Optimization using hop filed networks, simulated annealing, random search, evolutionary computation. **7 Hours**

Course Outcomes:
At the end of the course student will be able to
1. Appreciate the concept and use of ANN.

2. Explain the concept of supervised learning and various leaning algorithms.
3. Justify the use of accelerating learning process and need of prediction network
4. Illustrate the concept of Learning vector quantizing and associative modeling
5. Illustrate the need of optimization and different optimization algorithms.

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. KishanMehrotra, C. K. Mohan, Sanjay Ranka, Elements of artificial neural networks, 2nd Edition, Penram International Publishing India Pvt. Ltd, 2009
2. Martin T. Hagan, Demuth and Beale, "Neural network design", 2nd Edition, Cengage Learning, 2008.

REFERENCE BOOKS:

1. R, Schalkoff, Artificial neural networks, 2nd Edition, Tata McGraw - Hill Education, 1998.
2. J. Zurada, "Introduction to artificial neural systems", Jaico, 2003
3. Simon Haykin, Neural networks, 3rd Edition, PHI LEARNING PVT. LTD-NEW DELH, 2010
4. Hertz, Krogh, Palmer, Introduction to theory of neural computation, Addison Wesley, 1991.

E-Books / MOOC

1. http://nptel.ac.in/courses/117105084/
2. http://nptel.ac.in/courses/117108048/module8/Lecture26.pdf
3. http://cse22-iiith.vlabs.ac.in/

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OPERATING SYSTEM

Sub Code : 14EE725 **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. **8 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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INDUSTRIAL MANAGEMENT, ELECTRICAL ESTIMATION & ECONOMICS

Sub Code : 14EE801 **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 : BEE (14EE105)

Course Learning Objectives :

1. To introduce the concept of management in engineering and technology.
2. To explain the management and behavioral approach, Personnel / Production Management in industry.
3. To list and estimate the electrical related works for various interior and exterior Lighting and power circuits.
4. To prepare an estimate of the materials and costing as applied to electrical installations.
5. To illustrate the need of provision for depreciation fund and evaluation of asset value and depreciation.

UNIT – I

INTRODUCTION: Historical prospective, contribution of Taylor, Henry Foyol, Gilberth and HL Gnatt to the evolution of management as a scientific discipline concept of scientific management and it relevance in the Indian context.
ORGANIZATION: Types of organization; their merits and demerits
MANAGEMENT FUNCTIONS: Planning, organizing,
SS Topics: staffing, directing, controlling. **10 Hours**

UNIT – II

MANAGEMENT AND BEHAVIORAL APPROACH: contribution of Elton mayo and skinner and others to behavioral science, skills of a manager at various levels in an organization and inter related systems, understanding past behavior, predicting future behavior, directing, changing and controlling behavior; Maslow's hierarchy of needs and satisfaction, goal oriented behavior
Integration of organizational goals and needs of employees, Hawthorn's studies and its finding,
SS Topic: theory X and Y **12 Hours**

UNIT – III

PERSONAL MANAGEMENT: Recruitment and selection, training of personnel employer and employee relationship, causes and settlement of disputes.
PRODUCTION MANAGEMENT: Plant location, plant lay-out, CPM and PERT strategies, line balancing, automation statistical quality control;
SS Topics: control chart, motion study. **10 Hours**

UNIT – IV

INTERIOR WIRING SYSTEM: Wiring system and estimation of wiring installation.
POWER INSTALLATION: Load calculation, wire size selection, wiring materials for power circuits,
SS Topics: Need of Earthing, and types of Earthing **10 Hours**

UNIT – V

The estimate for motor installation, pump set, workshop, theater etc., Depreciation and valuation of machinery, Inventory
SS Topics: Economic order quantity, break-even analysis **10 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Comprehend the concept of management in engineering and technology and apply managerial / entrepreneurship skill in designing, planning and operation of an Industry.
2. Understand the management and behavioral approach, Personnel / Production Management in industry.
3. List and estimate the electrical related works for various interior and exterior Lighting and power circuits.
4. Prepare an estimate of the materials and costing as applied to electrical installations.
5. Justify the need of provision for depreciation fund and evaluation of asset value and depreciation.

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. "Introduction to Management"-S. S. Chatterjee,
2. "Engineering Economics and Management" - N. Narasimhaswamy, 2001
3. "Electrical Estimation and Electrical Wiring Systems"- RaghavendraRao.

REFERENCE BOOK:

1. "Industrial Organization and Engineering Economics"-T. R. Banga& S. C. Sharma.

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SEMINAR

Sub Code : 14EE802 **Credits : 01**
Hrs/Week : 0+0+2+0 **Total Hours : 26**

Course Learning Objectives :

1. To understand various technological advances happening in the field of electrical and electronics engineering
2. To identify a topic on the advanced electrical and electronics engineering field by extensive literature survey
3. To prepare a document on the selected topic and present in a technical way.

Course Outcomes:

At the end of the course student will be able to

1. Gain knowledge of fast and rapidly changing Electrical and Electronics Engineering by self-learning
2. Identify a topic on the advanced electrical and electronics engineering field after extensive literature survey
3. Write technical documents and give oral presentations on the selected using modern tools.
4. Develop the interpersonal skills, presenting skills, soft skills and creativity.
5. Appreciate the importance of professional Etiquette.

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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MAJOR PRJECT

Sub Code : 14EE803 **Credits : 09**
Hrs/Week : 0+0+18+0

Course Learning Objectives :

1. To expose students to the 'real' working environment and get acquainted with the organization structure, business operations and administrative functions.
2. To set the stage for future recruitment by potential employers.

3. The capacity to observe astutely and propose and defend opinions and ideas with tact and conviction is the invaluable learning outcome for the Collegiate Seminar student. Not a mere recipient of ideas, the student is a participant in discovery and inquiry.

Course Outcomes:

At the end of the course student will be able to

1. Design, build, and test electrical and electronics based project.
2. Apply project management skills (scheduling work, procuring parts, and documenting expenditures and working within the confines of a deadline).
3. Develop and demonstrate troubleshooting ability.
4. Demonstrate and Communicate technical information by means of written, oral reports and presentations.

Mapping of POs & COs:

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

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COMPUTER CONTROL OF ELECTRICAL DRIVES

Sub Code : 14EE811 **Credits : 03**
Hrs/Week : 3+0+0+0 **Total Hours : 39**

UNIT – I

REVIEW OF MICRO CONTROLLERS IN INDUSTRIAL DRIVES
SYSTEM: Typical Micro controller's 8 bit 16 bit (only block diagram) Digital Data Acquisition system, voltage sensors, current sensors, frequency sensors and speed sensors.
4 Hours

EVOLUTION OF POWER ELECTRONICS IN DRIVES: Power semiconductors devices used for drives control, Ratings, comparison and their applications. Block diagram of power integrated circuit for DC motor drives. **4 Hours**

UNIT – II

AC MACHINE DRIVES: general classification and National Electrical Manufacturer Association (NEMA) classification, Speed control of Induction motors with variable voltage constant frequency, constant voltage variable frequency, (v/f) constant operation, drive operating regions. Variable stator current operation.Effect of Harmonics. **8 Hours**

UNIT – III

SYNCHRONOUS MACHINE DRIVES: Wound field machine, comparison of Induction and wound field synchronous machines, Torque angle characteristics of salient pole synchronous machines, synchronous reluctance permanent magnet synchronous machines (SPM), variable reluctance machines (VRM). **5 Hours**

PHASE CONTROLLED CONVERTERS: Converter controls, Linear firing angle control, cosine wave crossing control, phase locked Oscillator principle, **2 Hours**

UNIT – IV

Electromagnetic Interference (EMI) and line power quality problems, cyclo converters, voltage fed converters, Rectifiers, Current fed Converters. **3 Hours**

PRINCIPALS OF SLIP POWER RECOVERY SCHEMES: Static Kramer's drive system, block schematic diagram, phasor diagram and limitations, Static Scherbins scheme system using D.C link converters with cyclo converter modes of operation, modified Scherbins Drive for variable source, constant frequency (VSCF) generation **5 Hours**

UNIT – V

PRINCIPLE OF VECTOR CONTROL OF A C DRIVES: Phasor diagram, digital Implementation block diagram, Flux vector estimation, indirect vector control block diagram with open loop flux control, synchronous motor control with compensation. **4 Hours**

EXPERT SYSTEM APPLICATION TO DRIVES (ONLY BLOCK DIAGRAM): Expert system shell, Design methodology, ES based P-I tuning of vector controlled drives system, Fuzzy logic control for speed controller inverter control drives,, structure of fuzzy control in feedback system. **4 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Review the applications micro controllers and power electronics in industrial drives
2. Explain the classification and control of AC drive using digital logic
3. Illustrate the control of synchronous machine and phase controlled converters.
4. Explain the principals of slip power recovery schemes and effect of EMI.
5. Identify the use of expert system application to drives and understand the concept of vector control of ac drives.

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. "Power Electronics & Motor Drives"-Bimal Bose, Elsevier 2006
2. "Modern Power Electronics & Drives"-Bimal K. Bose, Pearson Education 2003.

REFERENCE BOOKS

1. "Advanced Microprocessor and Interfacing"- Badri Ram TMH,2001
2. "Microcomputer Control of Power Electronics & Drives" – BK Bose, IEEE press 1987.

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POWER SYSTEMS OPERATION AND CONTROL

Sub Code : 14EE812 **Credits : 03**
Hrs/Week : 3+0+0+0 **Total Hours : 39**

Prerequisites
ENT-I (14EE302), GTD (14EE505), PSAS (14EE601), DCSM (14EE303)

UNIT – I

CONTROL CENTER OPERATION OF POWER SYSTEMS:
Introduction to SCADA, control center, digital computer configuration, automatic generation control, area control error, operation without central computers, expression for tie-line flow and frequency deviation, parallel operation of generators. **8 Hours**

UNIT – II

AUTOMATIC GENERATION CONTROL: Automatic voltage regulator, automatic load frequency control, AVR control loops of generators, performance of AVR, ALFC of single area systems, concept of control area, multi-area systems, POOL operation-two area systems. **8 Hours**

UNIT – III

CONTROL OF VOLTAGE AND REACTIVE POWER: Introduction, generation and absorption of reactive power, relation between voltage, power and reactive power at a node, single machine infinite bus systems, methods of voltage control, sub synchronous resonance, voltage stability, voltage collapse. **8 Hours**

UNIT – IV

UNIT COMMITMENT: Statement of the problem, need and importance of UNIT commitment, methods-priority lists method, dynamic programming method, constraints, spinning reserve, and examples. **7 Hours**

UNIT – V

POWER SYSTEM SECURITY Factors affecting power system security, power system contingency analysis, detection of network problems, network sensitivity methods, calculation of network sensitivity factor, contingency ranking. **8 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Explain the importance of Control Center and SCADA system in Power system operation.
2. Enumerate the operation of Automatic Generation Control system in Power system.
3. Analyze and enumerate the operation of power system components and control area problems and Justify the importance of reactive power, generation, control
4. Know the Importance of UNIT commitment and study of various methods
5. Enumerate various methods and Study of System optimization and security.

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. "Computer Aided Power System Analysis"- G.L.Kusic, PHI,4th edition,2010.
2. "Electrical Energy Systems Theory" – 0.I.Elgard, TMH,second edition,
3. "Power generation, operation and control"- Wood & B A J F Woollenberg. John Wiley and Sons, 2nd edition,1996
4. "Electric Power Systems"-B. M. Weedy, Wiley-Blackwell publication,5th edition,2012.
5. "Power Systems Operation and Control" – P.S.R.Murthy, TMH

REFERENCE BOOKS:

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

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ADVANCED DIGITAL SIGNAL PROCESSING

Sub Code : 14EE813 **Credits : 03**
Hrs/Week : 3+0+0+0 **Total Hours : 39**

Prerequisites: ENT-I (14EE302), DSP (14EE502)

Course Learning Objectives :

1. To study the parametric methods for power spectrum estimation.
2. To study adaptive filtering techniques using LMS algorithm and to study the applications of adaptive filtering.
3. To study multirate signal processing fundamentals.
4. To study the analysis of speech signals.
5. To introduce the student to wavelet transforms.

UNIT – I

PARAMETRIC METHODS FOR POWER SPECTRUM ESTIMATION
Relationship between the auto correlation and the model parameters – The Yule – Walker method for the AR Model Parameters – The Burg Method for the AR Model parameters – unconstrained least-squares method for the AR Model parameters – sequential estimation methods for the AR Model parameters – selection of AR Model order. **8 Hours**

UNIT – II

ADAPTIVE SIGNAL PROCESSING
FIR adaptive filters – steepest descent adaptive filter – LMS algorithm – convergence of LMS algorithms – Application: noise cancellation – channel equalization – adaptive recursive filters – recursive least squares. **8 Hours**

UNIT – III

MULTIRATE SIGNAL PROCESSING
Decimation by a factor D – Interpolation by a factor I – Filter Design and implementation for sampling rate conversion: Direct form FIR filter structures – Polyphase filter structure.
7 Hours

UNIT – IV

SPEECH SIGNAL PROCESSING
Digital models for speech signal : Mechanism of speech production – model for vocal tract, radiation and excitation – complete model – time domain processing of speech signal:- Pitch period estimation – using autocorrelation function – Linear predictive Coding: Basic Principles – autocorrelation method – Durbin recursive solution. **8 Hours**

UNIT – V

WAVELET TRANSFORMS

Fourier Transform : Its power and Limitations – Short Time Fourier Transform – The Gabor Transform - Discrete Time Fourier Transform and filter banks – Continuous Wavelet Transform – Wavelet Transform Ideal Case – Perfect Reconstruction Filter Banks and wavelets – Recursive multi-resolution decomposition – Haar Wavelet – Daubechies Wavelet.

8 Hours

Course Outcomes:

At the end of the course student will be able to

1. Explain the parametric methods for power spectrum estimation.
2. Illustrate the adaptive filtering techniques using LMS algorithm and to study the applications of adaptive filtering.
3. Explain multirate signal processing fundamentals.
4. Perform the analysis of speech signals.
5. Introduce the concept of wavelet transforms.

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. John G.Proakis, DimitrisG.Manobakis, Digital Signal Processing, Principles, Algorithms and Applications, 4th edition, (2007) PHI.
2. Monson H.Hayes – Statistical Digital Signal Processing and Modeling, Wiley, 2008.

REFERENCE BOOKS:

1. L.R.Rabiner and R.W.Schaber, Digital Processing of Speech Signals, 1st Edition, Pearson India 2003.
2. Roberto Crist, Modern Digital Signal Processing, Thomson Brooks/Cole (2004)
3. Raghuveer. M. Rao, AjitS.Bopardikar, Wavelet Transforms, Introduction to Theory and applications, Pearson Education, Asia, 2000.

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DISCRETE CONTROL SYSTEM

Sub Code	**: 14EE814**	**Credits**	**: 03**
Hrs/Week	**: 3+0+0+0**	**Total Hours**	**: 39**

Prerequisites: Linear Control System (14EE503)

Course Learning Objectives :

1. To model the discrete-time systems by pulse transfer function
2. To study the stability of discrete time systems and the time response of discrete systems.
3. To examine the response of discrete time systems and the controllability observability and stability of discrete state space model.
4. To introduce the concept of state feedback system and the digital control systems with deadbeat response.
5. To analyse the sampled data control systems using root locus and bode plot techniques

UNIT – I

Introduction to digital control: Introduction, Discrete time system representation, Mathematical modeling of sampling process, Data reconstruction

Modeling discrete-time systems by pulse transfer function: Revisiting Z-transform, Mapping of s-plane to z-plane, Pulse transfer function, Pulse transfer function of closed loop system, Sampled signal flow graph. **8 Hours**

UNIT – II

Stability analysis of discrete time systems: Jury stability test, Stability analysis using bi-linear transformation

Time response of discrete systems: Transient and steady state responses, Time response parameters of a prototype second order system. **8 Hours**

UNIT – III

Discrete state space model: Introduction to state variable model, Various canonical forms, Characteristic equation, state transition matrix, Solution to discrete state equation

Controllability, observability and stability of discrete state space models: Controllability and observability, Stability, Lyapunov stability theorem**.** **8 Hours**

UNIT – IV

State feedback design: Pole placement by state feedback, Set point tracking controller, Full order observer, Reduced order observer.

Deadbeat response design: Design of digital control systems with deadbeat response, Practical issues with deadbeat response design, Sampled data control systems with deadbeat response **7 Hours**

UNIT – V

Illustration of design procedures of sampled data control systems: Root locus method, Nyquist stability criteria, Bode plot, Controller design using root locus, Lead compensator design using Bode plot, Lag compensator design using Bode plot, Lag-lead compensator design in frequency domain (qualitative). **8 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Model the discrete-time systems by pulse transfer function
2. Analyze the stability of discrete time systems and the time response of discrete systems.
3. Analyze the response of discrete time systems and the controllability observability and stability of discrete state space model.
4. Design the state feedback system and the digital control systems with deadbeat response.
5. Design the sampled data control systems using root locus and bode plot techniques

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. K. Ogata, Discrete Time Control Systems, Pearson Education, 2/e, 2015.
2. M. Gopal, Digital Control and State Variable Methods, Tata Mcgraw Hill, 2/e, 2003.

REFERENCE BOOKS:

1. B. C. Kuo, Digital Control Systems, OXFORD UNIVERSITY PRESS-NEW DELHI, 2/e, Indian Edition, 2012.
2. G. F. Franklin, J. D.Powell and M. L. Workman, Digital Control of Dynamic Systems, Pearson Education 3rd Edition, 2005
3. Addison Wesley, 1998, Pearson Education, Asia, 3/e, 2000.
4. K. J. Astroms and B. Wittenmark, Computer Controlled Systems - Theory and Design, Prentice Hall, 3/e, 1997.
5. NPTEL - Course on Digital Control Systems

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SMART ELECTRIC GRID

Sub Code : 14EE815 **Credits : 03**
Hrs/Week : 3+0+0+0 **Total Hours : 39**

Course Learning Objectives :

1. To study the Information and Communication Technologies related to smart grid.
2. To understand the Information security and different sensing and automation techniques.
3. To know the principles of Distribution management systems and transmission system operation for smart equipment's.
4. To study the power quality issues and their management in smart grid
5. To know the importance of micro grids and distributed energy resources.

UNIT – I

The Smart Grid: Introduction,Overview of the technologies required for the Smart Grid. **Information and Communication Technologies:** Data communication, Switching techniques, Communication channels, Layered architecture and protocols Ethernets, Wireless Lan, Bluetooth and Zigbee communication technology. **8 Hours**

UNIT – II

Information security for the Smart Grid – Introduction,Encryption and decryption, Authentication, Digital signatures, Cyber security standards **4 Hours**

Sensing, Measurement, Control and Automation Technologies: Smart metering - An overview of the hardware used, Communications infrastructure and protocols for smart metering. **4 Hours**

UNIT – III

Distribution automation equipment and Management systems – Introduction, Data sources and associated external systems, Modelling and analysis tools,
Transmission system operation - Phasor measurement UNITs, Wide area applications **8 Hours**

UNIT – IV

Power electronics in Smart Grid – Introduction, Renewable energy generation, Photovoltaic systems, Wind, hydro and tidal energy systems, Fault current limiting. **8 Hours**

UNIT – V

Energy storage – Introduction, Energy storage technologies, Shunt compensator with energy storage, Case study **7 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Introduce the Information and Communication Technologies related to smart grid
2. Illustrate the Information security and different sensing and automation techniques
3. Explain the principles of Distribution management systems and transmission system operation for smart equipment's.
4. Illustrate the interfacing of power electronics devices to integrate the renewable energy sources into smart grid.
5. Comprehend the importance of shunt compensation with energy storage.

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. "Smart Grid - Technology And Applications", JanakaEkanayake, KithsiriLiyanage, John Wiley & Sons, Ltd., Publication, 2012

REFERENCE BOOKS

1. "Power Electronics in Smart Electrical Energy Networks", Ryszard Strzelecki, GrzegorzBenysek, Springer Publication, ISBN-13: 9781848003170, 2008
2. "The Smart Grid: Enabling Energy Efficiency and Demand Response" Clark W. Gellings, P.E, The Fairmont Press, Inc.2009
3. "SMART GRID - Fundamentals of Design and Analysis" James Momoh, IEEE Press, A JOHN WILEY & SONS, INC., PUBLICATION - 2012

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MODERN RECTIFIERS AND RESONANT CONVERTERS

Sub Code : 14EE821 **Credits : 03**
Hrs/Week : 3+0+0+0 **Total Hours : 39**

Prerequisites:
Power Electronics, Switched Mode Power Converter

Course Learning Objectives :

1. To understand various power system harmonics and study the working of line commutated rectifiers
2. To introduce the concept of pulse width modulated rectifiers
3. To study the working of various resonant converters
4. To perform dynamic analysis of switching converters
5. To understand various control schemes associated with resonant converters

UNIT – I

POWER SYSTEM HARMONICS & LINE COMMUTATED RECTIFIERS:
Average power-RMS value of a waveform-Power factor-AC line current harmonic standards IEC 1000-IEEE 519- The Single phase full wave rectifier (Review) -Continuous Conduction Mode-Discontinuous Conduction Mode-Behavior when C is large Minimizing THD when C is small-Three phase rectifiers(Review) - Continuous Conduction Mode Discontinuous Conduction Mode-Harmonic trap filters. **8 Hours**

UNIT – II

PULSE WIDTH MODULATED RECTIFIERS:
Properties of Ideal rectifiers -Realization of non-ideal rectifier-Control of current waveform-Average current control-Current programmed Control- Hysteresis control Nonlinear carrier control-Single phase converter system incorporating ideal rectifiers Modeling losses and efficiency in CCM high quality rectifiers-Boost rectifier Example - expression for controller duty cycle-expression for DC load current-solution for converter Efficiency η. **8 Hours**

UNIT – III

RESONANT CONVERTERS: Review of Parallel and Series Resonant Switches.
Soft Switching- Zero Current Switching - Zero Voltage Switching -Classification of Quasi resonant switches-Zero Current Switching of Quasi Resonant Buck converter, Zero Current Switching of Quasi Resonant Boost converter, Zero Voltage Switching of Quasi Resonant Buck converter, Zero Voltage Switching of Quasi Resonant Boost converter: Steady State analysis. **8 Hours**

UNIT – IV

DYNAMIC ANLYSIS OF SWITCHING CONVERTERS:
Review of linear system analysis-State Space Averaging-Basic State Space Average Model-State Space Averaged model for an ideal Buck Converter, ideal Boost Converter, ideal Buck Boost Converter, for an ideal Cuk Converter. **7 Hours**

UNIT – V

CONTROL OF RESONANT CONVERTERS:
Pulse Width Modulation-Voltage Mode PWM Scheme-Current Mode PWM Scheme Design of Controllers: PI Controller, Variable Structure Controller, Optimal Controller for the source current shaping of PWM rectifiers. **8 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Analyse various power system harmonics and explain the line commutated rectifiers
2. Explain the operation of Pulse Width modulated rectifiers
3. Analyse the working of various resonant converters
4. Perform a dynamic analysis of switching converters
5. Analyse various control techniques used in resonant converters.

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. Ned Mohan "Power Electronics: -Converters, Applications, And Design, 3rd Edition, Wiley India Pvt Ltd, 2010.

REFERENCE BOOKS:

1. Robert W. Erickson & Dragon Maksimovic "Fundamentals of Power Electronics" Second Edition, 2001 Springer science and Business media
2. William Shepherd and Li zhang "Power Converters Circuits" MarceldEkkerin,C.
3. Simon Ang and Alejandro Oliva "Power- Switching Converters" Taylor & Francis Group

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ELECTRICAL POWER UTILIZATION

Sub Code : 14EE822 **Credits : 03**
Hrs/Week : 3+0+0+0 **Total Hours : 39**

Prerequisites: Electrical Machines, PSAS, IDA

Course Learning Objectives :

1. To understand the types and working of various heating and welding equipment.
2. To know about the electrolysis process and its control using electrical power
3. To introduce various traction equipment, their selection, characteristics and control
4. To understand illumination requirements, types of lamps and their construction
5. To introduce electric and hybrid vehicles and associated technologies

UNIT – I

HEATING AND WELDING: Advantages and methods of electric of heating, resistance ovens, induction heating, dielectric heating, the arc furnace, heating of building, electric welding, resistance and arc welding, control device and welding equipment **9 Hours**

UNIT – II

ELECTROLYTIC PROCESS: Fundamental principles, extraction, refining of metals, electroplating. Factors affecting electro deposition process, power supply for electrolytic process. **7 Hours**

UNIT – III

ELECTRIC TRACTION: System of traction, speed time curve, tractive effort at /co-efficient of adhesions, selection of traction motors, method of speed control, energy saving by series parallel control, **7 Hours**

UNIT – IV

AC traction equipment.AC series motor, characteristics, regenerative braking, linear induction motor and their use. AC traction, diesel electric equipment, train lighting system, specific energy, factors affecting specific energy consumption.

UNIT – V

ILLUMINATION: Laws of illumination, lighting calculation, factory lighting, flood lighting, street lighting, different types of lamps, incandescent, fluorescent, vapor and CFL and their working, Glare and its remedy **6 Hours**

INTRODUCTION ELECTRIC AND HYBRID VEHICLES:
Configuration and performance of electrical vehicles, traction motor characteristics, tractive effort, transmission requirement, vehicle performance and energy consumption **3 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Enumerate different methods of electrical heating and electrical welding practices.
2. Illustrate various state of the art electrolytic processes.
3. Comprehend the role of electric motors for traction.
4. Explain various AC traction equipment including electric and hybrid vehicles.
5. Describe various lighting systems and energy conservation methods for illumination. And understand the working of Electric, Hybrid Vehicles.

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. Utilization Of Electric Energy- E.O. Taylor, Rao V V L, ORIENT BLACKSWAN PVT LTD.-NEW DELHI, 1st Edition
2. Modern Electric, Hybrid Electric and Fuel Cell Vechiles- Mehrdad, Ehsani, YiminGao, Sabastien. E. Gay, Ali Emadi- CRC Press,2nd edition,2009

REFERENCE BOOKS:

1. A Course in Electrical Power- Soni Gupta and Bhatnager- DhanapatRai& sons.2008
2. Electrical Power by Dr. S.L.Uppal Khanna Publications,3rd edition,2009.

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EMBEDDED SYSTEMS

Sub Code : 14EE823 **Credits : 03**
Hrs/Week : 3+0+0+0 **Total Hours : 39**

Prerequisites
MC (14EE603)

Course Learning Objectives :

1. To introduce concept of embedded system
2. To know various processing elements of embedded system and their structure
3. To understand the need of various memory elements in embedded systems
4. To understand various interfacing devices available to be used with embedded systems

5. To introduce concept of Real Time Operating Systems

UNIT – I

Introduction: Embedded systems overview-design challenge-optimizing metrics-processor technology-IC technology- design technology- automation- synthesis- verification: hardware /software co-simulation, trade-offs. **8 Hours**

UNIT – II

Processing Elements: Custom single purpose processor design-RT level custom single purpose processor design-optimizing custom single purpose processors -General purpose processor's software: architecture, operation, programmer's view and development environment – ASIPs - selecting a microprocessor - general purpose processor design. **8 Hours**

UNIT – III

Memory: Introduction-memory write ability and storage Permanence-common memory types-composing memory-memory hierarchy and caches-advanced RAM. **7 Hours**

UNIT – IV

Interfacing: Introduction-communication basics-microprocessor interfacing: I/O addressing, interrupts, DMA-Arbitration-multilevel bus architectures-advanced communication principles-serial protocols-parallel protocols-wireless protocols-Standard single purpose processor's peripherals: timers, counters, watchdog timers, UART, PWM, LCDcontrollers, keypad controllers, stepper motor controllers, ADC and RTC. **8 Hours**

UNIT – V

RTOS: Principles of RTOS, Task, Task Scheduling, Semaphore, Priorities
Case Study: Digital Camera Example, Tank level monitor using RTOS **8 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Explain the overview of embedded system and associated technologies
2. Illustrate the various processing element in an embedded system and their design
3. Appreciate the necessity of memory devices which can be used with the embedded system
4. Illustrate the concepts of interfacing and the type of devices that can be interfaced.
5. Appreciate the importance of RTOS and understand some generally used embedded systems.

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. Frank Vahid and Tony Givargis, Embedded system design: A unified hardware/Software introduction,Third edition, John Wiley & sons, 2010
2. Embedded System Premier, David E Simon, Addison Wesley
3. Embedded System 2nd Edition by Raj Kamal , Tata McGraw-Hill Education

REFERENCE BOOKS:

1. Wayne Wolf, Computers as Components: Principles of Embedded Computing System Design, MorganKaufman Publishers, 2008.
2. Santanuchattopadhyay, Embedded system Design, PHI Learning Pvt. Ltd., 2010
3. Steave Heath, Embedded system Design, Second edition, 2003
4. Daniel D. Gajski, Samar. Abdi, Andreas. Gerstlauer Embedded system design: Modeling, synthesis andverification", Springer, 2009
5. Jonathan.W.Valvano, Embedded Microcomputer systems: Real Time Interfacing, Third edition, cengagelearning,2012

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POWER SYSTEM DYNAMICS AND STABILITY

Sub Code : 14EE824 **Credits : 03**
Hrs/Week : 3+0+0+0 **Total Hours : 39**

Prerequisites
PSAS (14EE601), DCSM (14EE303)

Course Learning Objectives :

1. To understand the system modelling and dynamics of synchronous generator
2. To model the load connected to power system and analyse its small signal stability
3. To introduce various excitation and prime mover controllers
4. To model various prime movers
5. To carry out transient analysis of power system and understand the importance of stability controllers

UNIT – I

SYSTEM MODELING AND DYNAMICS OF SYNCHRONOUS GENERATOR: Basic concepts, Review of classical methods, modeling of synchronous machine, Swing equation, Park's transformation – Park's voltage equation, Park's mechanical equation (torque). Applications– (a) Voltage build up in synchronous machine, and (b) Symmetrical short circuit of generator. Solution for transient analysis, Operational impedance, Relationship between Tdo' and Tdo" **8 Hours**

UNIT – II

LOAD MODELING: Introduction, Two approaches – Polynomial model and Exponential model. Small Signal Angle Stability: Small signal angle stability with SMIB system, detailed model of SMIB. **7 Hours**

UNIT – III

EXCITATION AND PRIME MOVER CONTROLLERS: Introduction, Types of excitation, AVR with and without ESS, TGR, Amplifier PSS, Static exciters. **8 Hours**

UNIT – IV

MODELING OF PRIME MOVERS: Introduction, Three major components, Block diagram, Hydraulic turbine, Steam turbine. **8 Hours**

UNIT – V

TRANSIENT STABILITY ANALYSIS: Simulation for Transient stability Evaluation, Transient stability controllers. **8 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Perform the system modeling understand the dynamics of synchronous generator
2. Explain the concept of load modeling.
3. Illustrate the concept of excitation and prime mover controller.
4. Model the different types of prime movers
5. Perform the transient stability analysis and understand the importance of stability controller.

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. "Power System Dynamics, Stability and Control"-Padiyar K.R., BPB Publicatons, 2002.
2. "Power System Stability and Control"- PrabhaKundur. McGraw- Hill Publishing Company, 1ST Edition, 2006

REFERENCE BOOKS:

1. "Dynamics and Control of Large Electric Power Systems"- MarijaIlic; John Zaborszky, , IEEE Press and John Wiley & Sons, Inc.2000
2. "Power System Control and Stability Revised Printing"-Paul M. Anderson and A. A. Fouad, John Wiley & Sons, Inc. 2002
3. "Power System Analysis "- Arthur Bergen, Second Edition. Pearson India 2002

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HUMAN RESOURCE MANAGEMENT

Sub Code : 14EE825 **Credits : 03**
Hrs/Week : 3+0+0+0 **Total Hours : 39**

Course Learning Objectives :

1. To introduce the concept of human resource management for engineering fraternity.
2. To stress upon the importance of training and development, placement, procurement
3. To do a job analysis and design and appreciate the importance of job satisfaction
4. To understand the concept of integration and maintenance

UNIT - I

HRM Introduction: meaning, features, nature of HRM, functions , objectives, difference between personnel management and HRM

Job Analysis: Job Design, analysis, description and specification, uses of job analysis

Human Resource Planning: definition, objectives, nature and benefits of HRP, process of HRP, requirements of successful HRP

Recruitment: Definition, Objectives, process, factors affecting recruitment, sources of recruitment, recruitment techniques. **8 Hours**

UNIT – II

Selection, placement and induction: selection-factors affecting selection, selection procedure, placement and induction

Performance appraisal: meaning, need, purpose, methods, uses

Training: meaning, need, objectives, stages/types of training
Career planning and development: career-stages, need and process of career planning, elements and steps in career development **8 Hours**

UNIT – III

Job evaluation: meaning, objectives, principle, procedure, evaluation methods and advantages of job evaluation
Wage administration: definition, factors, objectives, wage boards and pay commissions, wage incentives
Promotion and transfers: Meaning, types, purpose, benefits, advantages and disadvantages
Absenteeism and Labor Turnover: meaning, type, causes and effects
Social security and welfare: meaning, need, evolution, types- fringe benefit, retirement benefit, old age benefit, non-monetary benefit, employee security-security and health
8 Hours

UNIT – IV

Motivation: Definitions of Motivation, Objectives of Motivation, Theories of Motivation — Maslow's Theory of Hierarchy of Needs — Herzberg's Two Factor Theory — Vroom's Expectancy Theory of Motivation — Alderfer's ERG Theory — The Porter and Lawler Model Expectancy Theory — Equity Theory of Work Motivation
Job Satisfaction — Meaning — Factors of Job Satisfaction
Morale: definition, importance, factors affecting morale
Communication: meaning, purpose, importance, types, barriers
Leadership: meaning, leader Vs manager, theories and types of leader **8 Hours**

UNIT – V

Industrial Relations: meaning, objectives, characteristics and code of IR
Grievance: meaning, need, procedure, collective bargaining, employee counseling
Quality of work life and TQM: meaning, importance, principle and effects
Recent techniques in HRM **7 Hours**

Course Outcomes:

At the end of the course student will be able to

1. Introduce the concept of human resource management, understand the human resource planning and the concept of recruitment
2. Differentiate and explain Selection, Placement and induction and need for performance appraisal, training and career planning & development.

3. Analyze the various aspects of Job evaluation, social security and welfare of an employee.
4. Comprehend the need for Motivation and analyze the importance of job satisfaction.
5. Expound the need for Industrial Relations and alanyze future challenges for Human Resource 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 BOOK:

1. P. Subba Rao, Essentials of Human Resource Management and Industrial Relations, Himalaya Publishing House, 2011

REFERENCE BOOKS:

1. T. N. Chhabra- Human Resource Management, Dhanpat Rai & Co, 2014
2. Lowin B. Flippo - Principles of personnel Management McGraw-Hill, 2010
3. R.C. Saxena - Labour Problems and social welfare (K. Math & Co.)
4. A Minappa and M. S. Saiyada - Personnel Management (Tata Mc. Graw-Hill)
5. C.B. Mamoria - Personnel Management (Himalaya Publishing House, Bombay)
6. T.N. Bhagotiwal - Economics of Labour and Industrial Relations (Sahitya Bhawan Agra)

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