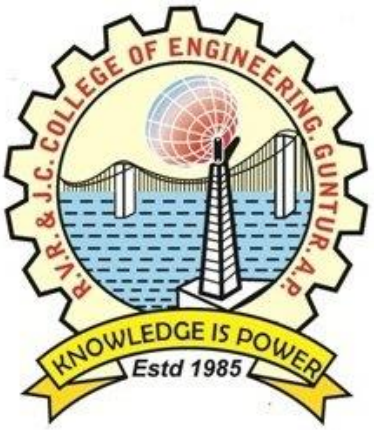
R.V.R. & J.C. COLLEGE OF ENGINEERING (AUTONOMOUS)

CHOWDAVARAM, GUNTUR – 522 019

ANDHRAPRADESH, INDIA



Regulations, Scheme of Instruction, Examination and Detailed Syllabi for

POWER SYSTEMS ENGINEERING

2-Year M.Tech Degree Course
In Electrical & Electronics Engineering
(Semester System)

w.e.f. : 2017-2018

R.V.R. & J.C. COLLEGE OF ENGINEERING :: GUNTUR
(Autonomous)

CHOICE BASED CREDIT SYSTEM REGULATIONS (R-17) for 2-YEAR MASTER OF TECHNOLOGY (M.Tech.) Degree Program

(w.e.f. the batch of students admitted into First Year M.Tech. from the academic year 2017-18)

1. MINIMUM QUALIFICATIONS FOR ADMISSION

The eligibility criteria for admission into M.Tech. programme is as per the guidelines of Andhra Pradesh State Council of Higher Education(APSCHE), Amaravathi.

1.1 Category – A Seats:

The seats under this category shall be filled by the Convener, PGCET Admissions.

1.2 Category – B Seats:

The seats under this category shall be filled by the College as per the guidelines of APSCHE

2. COURSES OF STUDY

M.Tech. Courses are offered in the following branches of study:

1	Civil Engineering	-	Structural Engineering
2	Computer Science & Engineering	-	Computer Science and Engineering.
3	Electrical & Electronics Engineering	-	Power Systems Engineering.
4	Electronics & Communication Engineering	-	Communication Engineering & Signal Processing
5	Information Technology	-	Computer Science & Technology
6	Mechanical Engineering	-	Machine Design

3. DURATION OF THE COURSE AND MEDIUM OF INSTRUCTION

3.1 The duration of the course is two academic years consisting of two semesters in each academic year.

3.2 The medium of instruction and examination is English.

4. MINIMUM INSTRUCTION DAYS

Each semester shall consist of a minimum number of 90 days of instruction excluding the days allotted for tests, examinations and preparation holidays.

5. REGISTERING THE COURSES OFFERED

5.1 A student has to register and secure 74 credits out of which 24 credits from laboratory courses including Dissertation.

5.2 The structure of the M.Tech. Programme comprises of two semesters of course work consisting of 6 Core subjects + 6 Elective subjects + 4 Labs or 3 Labs + 1 Seminar (or) 2 Labs + 2 Seminars, followed by two semesters of Dissertation.

5.3 MOOCS (Massive Open Online Courses) Requirements.

- Enrolment of MOOCS Course will be initiated from the date of commencement of class work for I Year I Semester.
- MOOCS course completion certificate of duration not less than 8 weeks, must be submitted on or before the last instruction day of II Year I Semester, for which 2 Credits will be awarded, otherwise his / her Semester End Examination results will not be declared.
- List of organizations offering MOOCS course(s) will be announced by the respective Board of Studies at the time of commencement of class work for I Year I Semester.

5.4 Internship / Industrial Training / Professional Certification:

- Internship / Industrial Training / Professional Certification should be taken up during the summer holidays for a period of 4 – 8 weeks.
- Internship / Industrial Training / Professional Certification completion certificate must be submitted along with a report and presentation during the II Year I Semester Internal evaluation, otherwise his / her Semester End Examination results will not be declared.

5.5 Dissertation shall be carried out under the Supervision of a Faculty Member in the concerned department. A student may, however, in certain cases, be permitted to work on his Dissertation at the place of employment, any recognized Institution/R&D Organization/Industry with the approval of the Head of the Department concerned and Head of the Organization. In such cases, the Dissertation shall be jointly supervised by a member of the faculty and a person from the Organization.

5.6 The student has to publish (or) get acknowledgement for acceptance of publication in at least one paper in a Conference / peer reviewed Journal related to his / her work to get eligibility to submit the Dissertation.

6. EVALUATION

6.1 The performance of the student in each semester is evaluated subject wise. In each Semester, there shall be two Internal Examinations consists of a Sessional Test for 30 Marks and an Assignment for 10 Marks. The semester end examination is conducted for 60 marks. The Internal Evaluation for Theory subjects is based on the 80% (24 out of 30 marks) weightage given to the best of the performances and the remaining 20% (6 out of 30 marks) for the least performance, in the two midterm examinations one held in the middle of the semester and the other held immediately after the completion of the instruction. The internal evaluation for practical subjects is based on the day to day performance and semester end internal practical Examination.

6.2 The marks for Seminar will be awarded by internal evaluation by a panel of the department.

6.3 For taking the Semester end examination in any theory or practical subject, students shall be required to obtain a minimum of 50% marks in Internal evaluation in that subject failing which he/she is required to repeat the subject when next offered.

6.4 For each theory subject, there is a comprehensive Semester End Examination at the end of each Semester.

6.5 For each Practical course the Semester End Examination is conducted by one internal and one external examiner appointed by the Principal of the College. The duration of the examination is specified in the detailed Schemes of Instruction & Examination.

6.6 Examination in Dissertation is conducted by one internal examiner and one external examiner appointed by the Principal.

6.7 The performance of the students in each semester is evaluated subject wise The distribution of marks between internal assessment and Semester End Examination is as follows:

Nature of the subject	Sessional Marks	Semester End Exam. Marks
Theory	40	60
Laboratory	40	60
Seminar / Internship / Professional Certification / Dissertation Review	100	--
Dissertation	40	60

7. LABORATORY / PRACTICAL COURSES

In any semester, a minimum of 10 experiments / exercises specified in the syllabus for laboratory course shall be completed by the student and get the record certified by the concerned Head of the Department, to be eligible to appear for the Semester End Examination in that Practical course.

8. ATTENDANCE

8.1 The student shall put up a minimum of 75% attendance in each subject.

8.2 Condonation of shortage in attendance up to 10% in any subject may be condoned by the Principal of the College for reasons of ill health and the

application is submitted through proper channel at the time of actual illness and is supported by a certificate from the authorized Medical Officer approved by the Principal.

8.3 If the student does not satisfy the attendance requirement in any subject he or she shall not be permitted to appear for the Semester End examination in that subject and has to repeat that subject when next offered.

9. CONDITION(S) FOR PROMOTION:

A student is eligible for promotion to next semester, if he/she satisfies the minimum requirements of attendance and sessional marks in 50% of the Theory Subjects, as stipulated in *Clauses 6 and 8*.

10. CONDITIONS FOR PASS

A student is declared to have passed in individual subject if he / she secures a minimum of 40% marks in theory and 50% marks in Laboratory / Dissertation in Semester End Examination and a minimum of 50% marks in both Sessional & Semester End Examination put together.

11. AWARD OF CREDITS

Credits are awarded for each Theory/Practical/Seminar/Dissertation Subject. Each theory subject is awarded 4 credits and each practical/Seminar subjects is awarded 2 credits. Dissertation seminar in II Year I Semester is awarded 4 credits and Dissertation at the end of II Year II Semester is awarded 10 credits.

11.1 AWARD OF GRADES

S.No.	Range of Marks	Grade	Grade Points
1.	≥90%	O	10.0
2.	80%-89%	A^+	9.0
3.	70%-79%	A	8.0
4.	60%-69%	B^+	7.0
5.	55%-59%	B	6.0
6.	50%-54%	C	5.0
7.	≤49%	F	0.0
8.	The grade 'W' represents withdrawal / absent (subsequently changed into pass or C to O or F grade in the same semester)	W	0.0

11.2 A student securing 'F' grade in any subject there by securing zero grade points has to reappear and secure at least 'C' grade in the subsequent examinations for that subject.

11.3 After each semester, Grade sheet will be issued which will contain the following

details:

- The list of subjects for each semester and corresponding credits and grades obtained
- The Semester Grade Point Average (SGPA) for each semester and
- The Cumulative Grade Point Average (CGPA) of all subjects put together up to that semester.

SGPA is calculated based on the following formula:

$$\frac{\sum[No.of\ credits \times Grade\ points]}{\sum No.of\ Credits}$$

CGPA will be calculated in a similar manner, considering all the subjects up to that semester.

11.4 A consolidated Grade Sheet shall be issued to the student, after completing all, indicating the CGPA of all the Four years put together.

11.5 Conversion of CGPA into equivalent Percentage of marks:

Percentage of Marks = 9.25 x CGPA.

12. ELIGIBILITY FOR AWARD OF M.TECH. DEGREE

The M.Tech. Degree shall be conferred on a student who satisfies the following requirements:

12.1 The student who satisfies the conditions for pass in all the subjects including labs of all the years as stipulated in ***Clauses 11***.

12.2 ***Maximum Time Limit for completion of M.Tech Degree***
A student, who fails to fulfil all the academic requirements for the award of the degree within four academic years from the year of admission, shall for feit his/her seat in M.Tech. Degree.

13. AWARD OF CLASS

A student who becomes eligible for the award of M.Tech. Degree as stipulated in ***Clause 12*** shall be placed in one of the following Classes.

S.No.	Class	CGPA
1	First Class With Distinction	8.0 or more
2	First Class	6.5 or more but less than 8.0
3	Second Class	5.0 or more but less than 6.5

14. AWARD OF RANK

The rank shall be awarded based on the following:

14.1 Ranks shall be awarded in each branch of study for the top ten percent of the students appearing for the Regular Semester End Examinations or the top two students whichever is minimum.

14.2 The Rank shall be awarded only to those studentss who completes their degree within two academic years.

14.3 For the purpose of awarding rank in each branch, only such students who passed all subjects in the first attempt shall be considered.

15. TRANSITORY REGULATIONS

A student, who is discontinued in any semester, on readmission shall be required to do all the subjects in the curriculum prescribed for such batch of students in which the students joins subsequently.

15.1 A student, studied under Acharya Nagarjuna University (ANU) regulations, discontinued at the end of the I Year I Semester, shall join in I Year I Semester of Autonomous batch of R-17 regulations.

15.2 A student, studied under ANU Regulations and discontinued at the end of the I year II Semester and also at the subsequent semesters will follow the same regulations of ANU and he/she has to complete the subject by appearing the examinations conducted by Acharya Nagarjuna University. The class will be awarded based on the academic performance of a student in ANU Regulations.

16. CONDUCT AND DISCIPLINE

16.1 Students shall conduct themselves within and outside the premises of the institute in a manner befitting the students of our institution.

16.2 As per the order of Hon'ble Supreme Court of India, ragging in any form is considered as a criminal offence and is banned. Any form of ragging will be severely dealt with.

16.3 The following acts of omission and / or commission shall constitute gross violation of the code of conduct and are liable to invoke disciplinary measures with regard to ragging.

a) Lack of courtesy and decorum, indecent behavior anywhere within or outside the campus.

b) Willful damage of college / individual property.

c) Possession, consumption or distribution of alcoholic drinks or any kind of narcotics or hallucinogenic drugs.

d) Mutilation or unauthorized possession of library books.

e) Noisy and unseemly behavior, disturbing studies of fellow students.

f) Hacking of computer systems (such as entering into other person's areas without prior permission, manipulation and / or damage of computer hardware and software or any other cyber-crime etc.)

g) Usage of camera / cell phone in the campus

h) Plagiarism of any nature

i) Any other acts of gross indiscipline as decided by the academic council from time to time.

16.4 Commensurate with the gravity of offense, the punishment may be reprimand, fine, expulsion from the institute / hostel, debar from examination, disallowing the use of certain facilities of the institute, rustication for a specified period or even outright expulsion from the institute or even handing over the case to appropriate law enforcement or the judiciary, as required by the circumstances.

16.5 For an offence committed in (i) a hostel (ii) a department or in a class room and (iii) elsewhere, the chief warden, the head of the department and the principal respectively, shall have the authority to reprimand or impose fine.

16.6 Cases of adoption of unfair means and / or any malpractice in an examination shall be reported to the principal for taking appropriate action.

16.7 All cases of serious offence, possibly requiring punishment other than reprimand, shall be reported to the academic council.

16.8 The institute level standing disciplinary action committee constituted by the academic council shall be the authority to investigate the details of the offence, and recommend disciplinary action based on the nature and extent of the offence committed.

16.9 The principal shall deal with any academic problem, which is not covered under these rules and regulations, in consultation with the department in an appropriate manner, and subsequently such actions shall be placed before the academic council for ratification. Any emergency modification of regulation, approved by the appropriate authority, shall be reported to the academic council for ratification.

16.10 "Grievance and Redressal Committee" (General) constituted by the Principal shall deal with all grievances pertaining to the academic / administrative / disciplinary matters.

17. MALPRACTICES

17.1 The Principal shall refer the cases of malpractices in internal assessment tests and semester-end examinations to a malpractice enquiry committee constituted by him / her for the purpose. Such committee shall follow the approved scales of punishment. The principal shall take necessary action, against the erring students basing on the recommendations of the committee.

17.2 Any action on the part of a student during an examination trying to get undue advantage or trying to help another, or drive the same through unfair means is punishable according to the provisions contained hereunder. The involvement of the staff, who are in-charge of conducting examinations, valuing examination papers and preparing / keeping records of documents relating to the examinations in such acts (inclusive of providing incorrect or misleading information) that infringe upon the course of natural justice to one and all concerned in the examination shall be viewed seriously and recommended for award of appropriate punishment after thorough enquiry.

18. AMENDMENTS

The College may from time to time, revise, amend, or change the Regulations, Schemes of Examinations, and / or Syllabus.

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RVR&JC College of Engineering (Autonomous)
GUNTUR :: 522019
FOUR SEMESTER M.TECH DEGREE COURSE
IN
POWER SYSTEMS ENGINEERING
CURRICULUM & DETAILED SYLLABI

S. No.	Course Number	Subject	Periods/ week		Internal marks	End Semester Examination		Credits	
			L+T	P		Duration	Marks		
First Semester									
1.	PS 511	Modern Control Theory	4	--	40	3	60	4	PC
2.	PS512	Advanced Power System Analysis	4	--	40	3	60	4	PC
3.	PS 513	Advanced Power System Protection	4	--	40	3	60	4	PC
4.		Elective – 1	4	--	40	3	60	4	PE
5.		Elective – 2	4	--	40	3	60	4	PE
6.		Elective – 3	4	--	40	3	60	4	PE
7.	PS 551	Power Systems Lab	--	3	40	3	60	2	PC
8.	PS 552	Simulation Lab – I	--	3	100	--	--	2	PC
		TOTAL	24	6	380	--	420	28	
Second Semester									
1.	PS 521	Flexible AC Transmission Systems	4	--	40	3	60	4	PC
2.	PS 522	Power System Stability	4	--	40	3	60	4	PC
3.	PS 523	Real time control of Power Systems	4	--	40	3	60	4	PC
4.		Elective – 4	4	--	40	3	60	4	PE
5.		Elective – 5	4	--	40	3	60	4	PE
6.		Elective – 6	4	--	40	3	60	4	PE
7.	PS 561	Simulation Lab – II	--	3	40	3	60	2	PC
8.	PS 562	Seminar	--	3	100	--	--	2	PC
		TOTAL	24	6	380	--	420	28	
Third Semester									
1.	PS 611	MOOCS (Self Learning)	--	--	--	--	--	2	PE
2.	PS651	Summer Internship Viva	--	--	100	--	--	2	PC
3.	PS 652	Project Presentation	--	--	100	--	--	4	PC
		TOTAL	--	--	200	--	--	8	
Fourth Semester									
1.	PS 661	Project Viva	--	24	40	--	60	10	PC
		TOTAL	--	24	40	--	60	10	

List of electives:

Subject Code	Subject Title	Prerequisite
PS 571	Optimization Techniques	
PS 572	Power System Planning & Reliability	--
PS 573	Advanced Microprocessors & Micro controllers	--
PS 574	Power Electronic Converters	--
PS 575	Computer Networks	
PS 576	High Voltage Engineering & Insulation	--
PS 577	EHV AC Transmission Systems	High Voltage Engineering & Insulation
PS 578	HVDC Transmission Systems	Power Electronic Converters
PS 579	Power Quality analysis & Improvement	--
PS 580	Digital Control Systems	Modern Control Theory
PS 581	Distribution Systems Planning & Automation	--
PS 582	Smart Grid Design and Analysis	--
PS 583	AI Techniques for PS applications	--
PS 584	Power System Deregulation	--
PS 585	Energy Conservation & Audit	--
PS 586	Renewable energy driven power systems	--
PS 587	Gas Insulated Systems (GIS)	--
PS 588	Distributed Generation & Microgrid	--
PS 589	Advanced Digital signal Processing	--
PS 590	Electrical Transients in Power systems	--

- ❖ 24 credits have to be achieved from Core Subjects.
- ❖ 24 credits have to be achieved from Elective Subjects.
- ❖ 8 credits have to be achieved from Labs.
- ❖ 2 Credits have to be achieved from Internship.
- ❖ 14 credits have to be achieved from Project.
- ❖ 2 credits have to be achieved from MOOCS
- ❖ Total 74 credits are required for Awarding the M.Tech. Degree.

		L	T	P	M	C
PS 511	**MODERN CONTROL THEORY***	**4**	**0**	**0**	**100**	**4**

COURSE OBJECTIVES:

1. To familiarize the students with the state space analysis of dynamic systems and observe their Controllability and Observability.
2. To make students understand the concepts of describing function analysis of nonlinear systems and analyze the stability of the systems
3. To familiarize the students with the concepts of optimal control.

COURSE OUTCOMES: Upon completion of the course, the student will be able to

1. Evaluate the design of state space analysis.
2. Evaluate the Controllability and Observability of State Model
3. Analyze non-linear control systems using describing functions.
4. Analyze the stability of Non-linear control systems using different techniques.
5. Evaluate the design of optimal control.

COURSE CONTENT:

UNIT –I **[Text Book – 1]**

STATE VARIABLE ANALYSIS: The concept of state – State Equations for Dynamic systems – Time invariance and Linearity – Nonuniqueness of state model – State diagrams for Continuous-Time State models. Linear Continuous time models for Physical systems– Existence and Uniqueness of Solutions to Continuous-Time State Equations – Solutions of Linear Time Invariant Continuous-Time State Equations– State transition matrix and its properties.

UNIT – II **[Text Book – 1]**

CONTROLLABILITY AND OBSERVABILITY: General concept of controllability – General concept of Observability – Controllability tests for Continuous-Time Invariant Systems – Observability tests for Continuous-Time Invariant Systems – Controllability and Observability of State Model in Jordan Canonical form – Controllability and Observability Canonical forms of State model.

UNIT- III **[Text Book – 1]**

NONLINEAR SYSTEMS: Introduction – Non Linear Systems - Types of Non-Linearities – Saturation – Dead-Zone - Backlash – Jump Phenomenon etc;– Singular Points – Introduction to Linearization of nonlinear systems, Properties of Non-Linear systems – Describing function–describing function analysis of nonlinear systems –Derivation of describing functions for common nonlinearities.

UNIT-IV **[Text Book – 1]**

STABILITY ANALYSIS: Stability in the sense of Lyapunov, Lyapunov's stability and Lypanov's instability theorems - Stability Analysis of the Linear continuous time invariant systems by Lyapunov second method– Direct method of Lyapunov – Generation of Lyapunov functions – Variable gradient and Krasoviskii's methods – estimation of transients using Lyapunov functions.

UNIT- V **[Text Book – 1]**

OPTIMAL CONTROL: Introduction to optimal control - Formulation of optimal control problems – calculus of variations – fundamental concepts, functionals, variation of functionals – fundamental theorem of Calculus of variations – boundary conditions – constrained minimization – formulation using Hamiltonian method – Linear Quadratic regulator.

TEXT BOOKS:

1. Modern Control System Theory by M.Gopal – New Age International -2/E
2. Modern Control Engineering by Ogata.K – Prentice Hall – 5th Edition

REFERENCE BOOKS:

1. Design of Feedback Control Systems by Stefani et.al. – Oxford – 4/E

*** CONTINUOUS-TIME SYSTEMS ONLY**

		L	T	P	M	C
PS 512	**Advanced Power System Analysis**	**4**	**0**	**0**	**100**	**4**

COURSE OBJECTIVES:

1. To create an idea in major components of power systems and their modeling
2. To know the importance and get solutions for Power Flow studies, short circuit analysis
3. To analyze the Contingency situations in the power system network
4. To train the students to have a solid foundation in mathematical and engineering fundamentals required to solve practical power system problems.
5. To prepare the students to get succeeded in research and industry

COURSE OUTCOMES: Upon completion of the course, the student will be able to:

1. Develop various models of power system for analysis.
2. Develop step by step procedure to conduct Load flow studies of power system network
3. Identify the significance to conduct short circuit analysis of power system network for selection of protective devices
4. Conduct contingency analysis
5. Develop power system software for power system studies

COURSE CONTENT:

UNIT-I: **[Text Book – 1]**

Network Matrices: Introduction– Graphs – incidence matrices formation – network matrices $-Y_{BUS}$ by singular transformation, linear transformation techniques (bus, branch, loop frame of references), Algorithm for building Z_{BUS}, Modification of existing Z_{BUS}.

UNIT-II: **[Text Book – 1]**

Modeling: Single phase modeling of transmission lines, off nominal transformer tap representation, phase shift representation, 3-phase models of transmission lines, modeling of loads, representation of synchronous machines.

UNIT-III: **[Text Book – 1]**

Power flow solutions: Review of power flow equations - GS, NR and FDC methods of solving power flow equations, Comparison between power flow solution methods. Power flow methods for contingency.

UNIT-IV: **[Text Book – 1]**

Fault Analysis: Symmetrical faults-Fault calculations using ZBUS- –Selection of circuit breakers- Unsymmetrical faults-Problems on various types of faults.

UNIT-V: **[Text Book – 2]**

ZBUS methods in Contingency Analysis: Adding and removing multiple lines (current injection methods), piece wise solution of interconnected systems, analysis of single and multiple contingencies, System Reduction for Contingency and Fault Studies.

***TEXT BOOKS*:**

1. Stagg G.Ward, El-Abiad: Computer methods in power system analysis. McGraw Hill, ISE, 1968.
2. J.J.Grainger, W.D.Stevenson JR, Power system analysis, TMH, Delhi 2007.

***REFERENCE BOOKS*:**

1. Nagarath&Kothari Modern power system analysis 4th Edition, TMH.
2. Nagsarkar&Sukhija, Power system analysis, Oxford press, New Delhi, 2007
3. J.Arrilaga and C.P.Arnold: Computer modeling of electric power systems, John Wiley & Sons, N.Y. 1983.
4. George Kusic, Computer Aided Power System Analysis, CRC Press, 2nd Edition,2008.

WEB RESOURCES:

1. http://nptel.ac.in/courses/108107028/
2. http://www.myopencourses.com/subject/computer-aided-power-system-analysis-2
3. ieeexplore.ieee.org/iel5/39/22132/01029972.pdf?arnumber. % reference forapplications
4. *courses.engr.illinois.edu/ece476/notes/html % Reference for power flow analysis*

		L	T	P	M	C
PS 513	**Advanced Power System Protection**	**4**	**0**	**0**	**100**	**4**

COURSE OBJECTIVES:

1. To provide the knowledge on zones of protection and comparators used in static relays.
2. To gain the knowledge on. static over current ,differential and distance relays.
3. To program Microprocessor based protection system for the power system network.

COURSE OUTCOMES:

Upon the completion of this course the student will be able to

1. Get an idea of zones of protection and essential qualities of protective scheme.
2. Gain knowledge on static relay components and amplitude comparators.
3. Analyze the various types of phase comparators used in relays.
4. Get the knowledge on static differential relays and static distance relays
5. Simulate the Microprocessor based protective system

COURSE CONTENT:

UNIT-I: [Text book-1]

Need for protection systems: Nature and causes of faults, types of faults, effects of faults, fault statistics, evolution of protective relays, zones of protection, primary & back up protection, essential qualities of protection.

STATIC RELAYS: Advantages of static relays-Basic construction of static relays-Level detectors-Replica impedance –Mixing circuits-General equation for two input phase and amplitude comparators-Duality between amplitude and phase comparators.

UNIT-II: [Text book-1]

AMPLITUDE COMPARATORS: Circulating current type and opposed voltage type- rectifier bridge comparators, Direct and Instantaneous comparators.

PHASE COMPARATORS : Coincidence circuit type- block spike phase comparator, techniques to measure the period of coincidence-Integrating type-Rectifier and Vector product type- Phase comparators.

UNIT-III: [Text book-2]

STATIC OVER CURRENT RELAYS: Instantaneous over-current relay-Time over-current relays-basic principles –definite time and Inverse definite time over-current relays.

DIFFERENTIAL RELAYS: Analysis of Static Differential Relays –Static Relay schemes –Duo bias transformer differential protection –Harmonic restraint relay.

STATIC DISTANCE RELAYS: Static impedance-reactance–MHO and angle impedance relay-sampling comparator –realization of reactance and MHO relay using sampling comparator.

UNIT-IV: [Text book-2]

Equipment Protection: Protection of Generators - Percentage differential protection, Protection against stator internal faults, stator overheating protection; Rotor Protection – Field ground fault protection, loss of excitation protection; protection against motoring and protection against voltage regulator failure.

Transformer Protection: Percentage differential protection, protection against magnetizing inrush current, Buchholz relay, over fluxing protection.

Bus Zone Protection: Differential current protection, high impedance relay scheme, frame leakage protection.

UNIT-V: [Text book-1]

MICROPROCESSOR BASED PROTECTIVE RELAYS: (Block diagram and flowchart approach only)-Over current relays–impedance relays-directional relay-reactance relay .Generalized mathematical expressions for distance relays-measurement of resistance and reactance –MHO and offset MHO relays-Realization of MHO characteristics-Realization of offset MHO characteristics -Basic principle of Digital computer relaying.

TEXT BOOKS:

1. Badri Ram and D.N.Vishwakarma, "Power system protection and Switch gear", TMH publication New Delhi 1995.
2.T.S. MadhavaRao, Power system protection Static relays, TMH 2nd edition 1981

REFERENCE BOOKS:

1. Mason, The Art and Science of protective relaying, Wiley Eastern Ltd
2. C.L. Wadhwa, Electrical power systems, New age International (P) Limited
3. Sunil S. Rao, Switchgear and protection, Khanna Publications

		L	T	P	M	C
PS 551	**POWER SYSTEMS LAB**	**0**	**0**	**3**	**100**	**2**

COURSE OBJECTIVES:

1. To provide knowledge of power systems equipment in real time applications.
2. To analyse the characteristics of various relays.
3. To have through knowledge on operating conditions and compensation of transmission line.
4. To provide knowledge of various power factor correction systems.
5. To study the operation of power electronic converters used in power systems.
6. To ascertain the importance of renewable energy resources and their grid integration.

COURSE OUTCOMES:

Upon completion of the course, the student will be able to:

1. Gain knowledge on equipment used in power systems at various locations.
2. Appreciate the operation of Relaying equipment.
3. Analyse parameters, study the operation and design compensation equipment for transmission line.
4. Design and implement power factor correction equipment.
5. Realize the interconnection of renewable energy resources to power system network.

List of Experiments*

1. Evaluation of ABCD parameters for artificial transmission line
2. Sequence reactances and fault studies on synchronous machine
3. Sequence impedances of three phase transformer
4. Surge Impedance Loading limits of transmission line
5. Active and Reactive power control of synchronous machine connected to infinite bus
6. Reactive power control by tap changing transformer
7. Line and load compensation of power system network
8. Characteristics of electromagnetic relays
9. Characteristics of microprocessor based relays
10. Characteristics of static relays
11. Testing and performance study of Generator Protection System
12. Testing and performance study of Transformer Protection System
13. Testing and performance study of Feeder Protection System.
14. Testing and performance study of Transmission Line protective scheme
15. H.V. testing of insulators
16. High voltage testing of Cables
17. Study of corona phenomenon
18. Harmonic analysis by Power network analyzer
19. Grid synchronization of Solar PV Inverter
20. Grid Synchronization of Wind energy conversion system

*** Any Ten Experiments are to be completed**

		L	T	P	M	C
PS 552	**SIMULATION LAB – I**	**0**	**0**	**3**	**100**	**2**

COURSE OBJECTIVES:

1. To expose students to different software packages in designing solutions to various problems.
2. To understand the solutions for power systems under short circuit conditions.
3. To understand the design solutions for power system problems.
4. To familiarize the student with control system tool box in MATLAB.

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

1. Understand power industry practices for design, operation, and planning.
2. Use mathematical tools that are essential for system analysis and design.
3. Use commercial software packages in designing solutions to problems.
4. Have group participation in design and problem solving.
5. Exhibit expertise in usage of modern tools.

LIST OF EXPERIMENTS:

1. Solution of simultaneous algebraic equations of Electrical network
2. Solution of simultaneous differential equations of a given network
3. Formation of incidence matrices
4. Formation of network matrices by singular or non-singular transformations
5. Formation of Ybus by inspection method
6. Formation of Zbus by step by step algorithm using MATLAB
7. Fault analysis in power system using matrix method
8. Simulation of electric networks using MATLAB
9. Simulation of transmission line using MATLAB
10. Power flow solution using Gauss seidel method
11. Simulation of 1-phase diode bridge rectifier
12. Simulation of 1-phase controlled rectifier
13. Simulation of Single Phase AC voltage Controller
14. Transfer function analysis of given system using Simulink
15. State space analysis of a control system using MATLAB
16. Conversion of the given state system into a suitable diagonal form

*** Any Ten experiments are to be completed**

		L	T	P	M	C
PS 521	**FLEXIBLE AC TRANSMISSION SYSTEMS**	**4**	**0**	**0**	**100**	**4**

COURSE OBJECTIVES:

1. To understand the need for reactive power compensation and system stability in AC transmission system.
2. To become familiar with operation of various FACTS controllers and their impact on AC transmission system.

COURSE OUTCOMES:

Upon successful completion of the course, the student will be able to:

1. Understand the importance of FACTS controllers in transmission system to enhance the system performance, control strategies for different types of converters for static compensation.
2. Understand the objectives of shunt compensator and their types, comparison of transient and dynamic stability performance of different controllers.
3. Understand the objectives of series compensators and their types, performance of different controllers.
4. Know the importance of static voltage and phase angle regulators towards active, reactive power flow control and improvement of transient stability.
5. Understand the concept of UPFC and IPFC, control strategies for controlling P and Q.

COURSE CONTENT:

UNIT-I **[Text book-1]**

FACTS Concept and General system Considerations: Transmission Interconnections-Flow of power in an AC System-power flow and Dynamic stability Considerations of a Transmission Interconnection-Relative importance of Controllable Parameters-Basic Types of FACTS Controllers, Brief Description and definitions of FACTS Controllers. Voltage Source Converters, Single phase, three phase full wave bridge converters operation, Transformer connections for 12 pulse 24 and 48 pulse operation. Three level voltage source converter, pulse width modulation converter.

UNIT-II **[Text book-1]**

Static Shunt Compensators: Objectives of Shunt Compensation-Methods of variable Var Generation-Static Var Compensators: SVC and STATCOM- Operation and Control of TSC, TCR, STATCOM - Comparison between SVC and STATCOM - STATCOM for transient and dynamic stability enhancement.

UNIT-III **[Text book-1]**

Static Series Compensation: Objectives of series Compensation-Variable Impedance type series Compensators-Switching Converter Type series Compensators- GCSC, TSSC, TCSC and SSSC - Operation and Control - External (System) Control for series Reactive Compensators

UNIT-IV **[Text book-1]**

Static Voltage and Phase Angle Regulators: Objectives of Voltage and Phase Angle Regulators: Voltage and Phase angle regulation-power flow control by phase angle regulators-real and reactive loop power flow control-Improvement of transient stability with phase angle regulators-Functional requirements-TCVR and TCPAR - Operation and Control.

UNIT-V **[Text book-1]**

UPFC and IPFC: The unified Power Flow Controller – Operation - Comparison with other FACTS devices - control of P and Q - Dynamic Performance - Special Purpose FACTS controllers - Interline Power flow Controller - Operation and Control.

TEXT BOOKS:

1. Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems, IEEE Press, 2000 by N.G. Hingorani & L.Gyugyi

2. FACTS Controllers in power transmission and Distribution, K.R.Padiyar, New Age Int. Publisher, 2007

REFERENCE BOOKS:

1. Power Electronics by Ned Mohan et. al , John Wiley & sons
2. Reactive Power Control in Electric Systems by T.J.E. Miller , John Wiley & sons
3. Introduction to FACTS controllers by Kalyan K Sen, Mey Ling Sen – John Wiley 2009

WEB REFERENCES:

1. http://www.eetindia.co.in/VIDEO_DETAILS_700001240.html
2.http://nptel.iitm.ac.in
3.www.ece.unb.ca/sharaf/downloads/ppt/ppt_046.ppt

		L	T	P	M	C
PS 522	**POWER SYSTEM STABILITY**	**4**	**0**	**0**	**100**	**4**

COURSE OBJECTIVES:

At the end of the course the student is expected to

1. Learn the concepts of Stability, Excitation, SMIB of Power Systems.
2. Learn the modeling of synchronous machine, Excitation systems, Transmission lines.
3. Learn the requirements of power system modeling and stability.
5. Learn problem solving techniques for existing problems in power systems.

COURSE OUTCOMES:

Upon completion of the course, the student will be able to:

1. Learn the concepts of Stability, Excitation, SMIB of Power Systems.
2. Do machine modeling.
3. Do modeling of Excitation systems, Transmission lines.
4. Understand the effect of excitation system on small signal stability.
5. Understand the significance of power system stabilizer in power system stability.

COURSE CONTENT:

UNIT – I **[Text Book–1]**

Steady state stability: Steady state power limits of a two machine system and multi machine systems – Analytical and graphical methods of calculating steady state stability limits – analysis of SMIB system with excitation system .Power system Stabilizer.

UNIT – II **[Text Book–1]**

Voltage stability analysis: Voltage stability concepts – voltage collapse phenomenon – prevention of voltage collapse.

Voltage stability of Single machine connected to infinite bus system – PV curves – QV curves. Effect of compensation – Series, shunt and SVCs.

UNIT – III **[Text Book–1]**

Transient stability: Review of transient stability – numerical integration methods – Swing Equation and it's Solution by equal area criterion: Sudden change in mechanical input – Sudden loss of one of parallel lines – Short circuit at one end of line – Short circuit away from line ends – Line reclosure.

Swing Equation solution by point by point method – modified Euler's method and Gauss Seidel method.

UNIT – IV **[Text Book–1]**

Effects on stability due to losses: Governor action – inertia – saturation – SCR – saliency – damper windings – methods of grounding.

UNIT-V **[Text Book–1]**

Methods of improving stability: High speed fault clearing, Reduction of transmission system reactance, regulated shunt compensation, Dynamic braking, Reactor switching, Single pole switching, Steam turbine fast valving, Generator tripping, load shedding, High speed excitation systems, HVDC transmission links, SVC.

TEXT BOOKS:

1. PrabhaKundur., " Power system stability and control", Tata McGraw Hill
2. Kimbark E.W. " Power system stability and control – Vol III, synchronous machines", John Wiley & Sons

REFERENCE BOOKS:

1. Anderson P.M., and Foud A.," Power system control and stability" Galgotia publications
2. Kimbark E.W. " Power system stability and control – Vol I, Elements of stability calculations", John Wiley & Sons
3. Taylor C.W. " Power systems voltage stability", TMH
4. K.R. Padiyar, " Power systems Dynamics stability and control", Interline publishing Pvt., ltd., Bangalore.

	L	T	P	M	C
PS 523 REAL TIME CONTROL OF POWER SYSTEMS	**4**	**0**	**0**	**100**	**4**

COURSE OBJECTIVES:

1. To understand various methods of obtaining economic load dispatch optimally.
2. To gain the knowledge on load frequency control and to find response of a power system.
3. To understand SCADA and security control of a given network.
4. To gain knowledge on state estimation and weighted least square estimation method.

COURSE OUTCOMES:

Upon the completion of this course the student will be able to:

1. Understand various methods of obtaining economic load dispatch optimally.
2. Gain knowledge on load frequency control and to find steady state & dynamic response of a power system.
3. Understand the SCADA system and energy management system of a power system network.
4. Analyze the network by knowing generator and line outages with linear sensitivity factors.
5. Gain knowledge on state estimation and weighted least square estimation method

COURSE CONTENT:

UNIT-I: [Text book-1]

Economic dispatch: Economic importance - characteristics of thermal, nuclear and hydro-generator units - Economic dispatch problem – Thermal system dispatch with network losses - The first order gradient method –Newton's method -base point and participation factor method.

UNIT-II: [Text book-2]

Load frequency control: Necessity of keeping frequency constant-Definition of control area – single area control – Block diagram representation of an isolated power system – steady state analysis – dynamic response – proportional plus integral control of single area and its block diagram representation – steady state response – two area , multi area system modelling.

UNIT-III: [Text book-2]

Computer control of power systems: Energy control centre – various levels – SCADA system – computer configuration functions – monitoring – data acquisition and controls – EMS system – expert system applications for power system operation.

UNIT-IV [Text book-1]

Security control: Factors affecting power system security-Security analysis and monitoring – system operating states by security control functions – generator and line outages by linear sensitivity factors.

UNIT-V: [Text book-1]

State estimation: Power system state estimation – Maximum likelihood weighted least square estimation-introduction-maximum likelihood concepts-matrix formulation-weighted least squares estimation– detection and identification of bad measurements – network observability and pseudo measurements.

TEXT BOOKS:

1. Allen J. Wood and Bruce F. Wollenberg "Power Generation, Operation & Control" 2nd edition, John Wiley and Sons.
2. I.J. Nagarath& D. P. Kothari , "Modern power system analysis" 4th Edition, TMH

REFERENCE BOOKS:

1. I. Elgard , "Electric Energy Systems Theory – An Introduction" Tata McGraw Hill Publishing Company Ltd,Newdelhi, second edition,2003.
2. AbhijitChakrabarti&SunitaHalder" Power System Analysis operation and Control " 1st edition, PHI.
3. Mahalanabis A.K., Kothari D.P. and Ahson S.I., "Computer aided power system analysis and control", TMH

4. J.J.Grainger, W.D.Stevenson JR, "Power system analysis", Tata McGraw Hill N.D. 2007.

WEB RESOURCES:

https://www.powerworld.com/training/online-training/linear-sensitivity-analysis
http://electricalengineeringtutorials.com/load-frequency-control-in-power-systems

		L	T	P	M	C
PS 561	**SIMULATION LAB – II**	**0**	**0**	**3**	**100**	**2**

COURSE OBJECTIVES:

1. Apply computational methods for large scale power system studies
2. To introduce to students simulation of various power electronic circuits, control system circuits and analysis of steady state system for short circuits and stability using different packages available.
3. To simulate converter circuits using PSPICE.
4. To familiarize the student with control system tool box in MATLAB
5. To simulate power system networks for load flow and transient stability using MATLAB software.

COURSE OUTCOMES:

Upon completion of the course, the student will be able to:

1. Simulate different power electronic circuits using PSPICE.
2. Asses the different state estimation techniques.
3. Determine stability analysis of power systems using MATLAB.
4. Evaluate the economic dispatch of coordinated thermal unit.
5. Develop software for power system industry.

LIST OF EXPERIMENTS:

1. Power flow solution by NR method.
2. Power flow solution by FDC.
3. Contingency studies using load flows for generator & line outages.
4. Solution of Economic load dispatch problem.
5. Transient stability study of SMIB.
6. Contingency studies using ZBUS.
7. Simulation of State Estimator for power flow using WLSE method
8. Simulation of single area load frequency control.
9. Simulation of two area load frequency control.
10. Simulation of power system stabilizer.
11. Simulation of voltage stability problem.
12. Design of LQR state feed back for a given system
13. Design of State feedback controller and observer through Pole assignment.
14. PSPICE Simulation of Three phase full converter using RL &E loads.
15. PSPICE Simulation of Three phase inverter with PWM controller.
16. PSPICE Simulation of resonant pulse commutation circuit.
17. Load flow studies using PSCAD / MiPower
18. Stability studies using PSCAD /MiPower
19. Short circuit studies using PSCAD / MiPower
20. HVDC simulator using PSCAD

* Any Ten experiments are to be completed

		L	T	P	M	C
PS 571	**OPTIMIZATION TECHNIQUES**	**4**	**0**	**0**	**100**	**4**

COURSE OBJECTIVES

1. To introduce the fundamental concepts of optimization techniques i.e. to define an objective function and constraint functions in terms of design variables, and then state the optimization problem.
2. To state single variable and multi variable optimization problems, with and without constraints.
3. To understand the linear programming problems (LPP), solving those using graphical, simplex and dual simplex methods for feasibility & optimality conditions.
4. To study and explain non-linear programming techniques, unconstrained or constrained, and define exterior and interior penalty functions for optimization problems.
5. To explain Dynamic programming technique as a powerful tool for making a sequence of interrelated decisions.

COURSE OUTCOMES

On successful completion of this course the students will be able to:

1. understand the linear programming problems starting from formulation to the optimal solution
2. solve the two- dimensional LPP by graphical method & multi- dimensional LPP by simplex, dual simplex methods
3. know about special cases of LPP ; infeasible solution, unbounded solution, alternate solution
4. solve the problems of Project Management using CPM and PERT.
5. formulate and apply dynamic programming technique to inventory control, production planning, engineering design problems etc. to reach a final optimal solution from the current optimal solution.

COURSE CONTENT:

UNIT – I **[Text Book-1]**

Statement of an optimization problem - design vector - design constraints - objective function -classification of optimization problems. Advantages of optimization techniques. Single variable optimization - multi variable optimization without constraints, multi variable optimization with equality constraints and with inequality constraints.

UNIT – II **[Text Book-1]**

LINEAR PROGRAMMING: Standard form of a linear programming problem, Solution of LPP using graphical method, simplex method, dual simplex method. Duality in linear programming. Degeneracy, alternative optima, unbounded solution, infeasible solution.

UNIT – III **[Text Book-1,2]**

TRANSPORTATION PROBLEM: Introduction to the problem, LP formulation of a transportation problem. Basic feasible solution by north-west corner method, Vogel's approximation method, least cost method. Finding optimal solution by MODI method, degeneracy, unbalanced transportation matrix.

Non-linear programming: Kuhn-Tucker conditions.

UNIT- IV **[Text Book-1,2]**

PROJECT PLANNING THROUGH NETWORKS: Arrow (Network) Diagram representation. Rules for constructing an arrow diagram, Pert and CPM Critical path calculations, earliest start and latest completion times, Determination of critical path, determination of floats, Probability considerations in project.

UNIT-V **[Text Book-1,2]**

SIMULATION: Definition and applications. Monte Carlo simulation. Application problems in queuing and inventory.
DYNAMIC PROGRAMMING: Characteristics of D.P. model, solution of optimal sub-division problem.

TEXT BOOKS:

1. "Engineering optimization: Theory and practice"- S. S.Rao, New Age International (P) Limited, 3rd edition, 1998.
2. Operations Research – H.A. Taha, Pearson, 7th Edition, June 2002.

REFERENCE BOOKS:

1. "Optimization Methods in Operations Research and systems Analysis" – by K.V. Mittal and C. Mohan, New Age International (P) Limited, Publishers, 3rd edition, 1996.
2. Operations Research – S.D.Sharma, Kedarnath, Ramnath & Co.
3. "Introductory Operations Research" by H.S. Kasene & K.D. Kumar, Springer (India), Pvt. Ltd.
4. Introduction to Operations Research – Hiller and Liberman, MGH, 7th Edition, 2002.
5. Operations Research – R. Panner selvam, PHI, 2nd Edition, 2006.

		L	T	P	M	C
PS 572	**POWER SYSTEM PLANNING & RELIABILITY**	**4**	**0**	**0**	**100**	**4**

COURSE OBJECTIVES:

1. To be acquainted with the main concept power system planning.
2. To understand the economic analysis and load forecasting methodology.
3. To understand the methodology of reactive power planning and to perform generation and transmission planning.
4. To understand the concept of probability theory, distribution, network modeling and reliability analysis and to describe the reliability functions with their relationships and Markov modeling.
5. To study the fundamentals of Generation system, transmission system and Distribution system reliability analysis and to evaluate power system generation, transmission, distribution reliability.

COURSE OUTCOMES:

On successful completion of this course the students will be able to:

1. Have skill in planning and building reliable power system.
2. Perform load forecasting for better planning of system.
3. Comprehend the reliability of power system and do planning accordingly.
4. Evaluate reliability of engineering systems using various methods.
5. Analyze the generation system reliability and distribution system reliability.

COURSE CONTENT:

UNIT – I **[Text book 1]**

General power system planning issues, economic analysis, load forecasting, production cost modeling, generation expansion planning, substation expansion planning, network expansion planning, reactive power planning.

UNIT – II **[Text book 1]**

Deregulation of power systems, power system planning under uncertainty, risk based power system planning. Elements of Probability theory: Introduction, rules for combining probabilities of events, Bernoulli's trials; probability distributions: Random variables, density and distribution functions- Binomial, Poisson, normal and exponential distributions; expected value and standard deviation of Binomial distribution and exponential distribution – Bath tub curve.

UNIT – III **[Text book 2]**

Reliability of engineering systems: Component reliability, hazard models, reliability analysis of networks with non-repairable components- series, parallel, series- parallel configurations and non-series-parallel configurations- minimal tie-set, minimal cut-set and decomposition methods, reliability measures, MTTF, MTTR, MTBF.

UNIT- IV **[Text book 2]**

Markov Chains: Introduction; transition probabilities and the stochastic transition probability matrix; classification of states; evaluation of limiting state probabilities; Markov processes – one component repairable system, time dependent probability evaluation using Laplace Transform approach, evaluation of limiting state probabilities using STPM; two component repairable modes - frequency and duration concept-evaluation of frequency of encountering state, mean cycle time for one, two component repairable models, evaluation of cumulative probability and cumulative frequency of encountering merged states.

UNIT- V **[Text book 1, 2]**

Generation system reliability analysis- reliability model of generation system, recursive relation for unit addition and removal, load modeling, merging of generation model with load model, evaluation of transition rates for merged state model; cumulative probability, cumulative frequency of failure evaluation; LOLP. LOLE. Expected value of the Demand not served E (D) Distribution system reliability analysis- radial networks, weather effects on

transmission lines; evaluation of load and energy indices Composite system reliability – decomposition method.

TEXT BOOKS:

1. "Electrical Power Systems Planning", A. S. Pabla, McMillan Publishers, India, 1998.
2. "Reliability Evaluation of Power System" Roy Billinton and Ronald Norman Allan, Springer, India, 2006.

REFERENCE BOOKS:

1. "Electric Power System Planning: Issues, Algorithms and Solutions", Hossein Seifi, Mohammad Sadegh Sepasian, Springe –Verlag, Berlin, 2011.
2. "Modern Power System Planning", X. Wang and J. McDonald, McGraw Hill, London, 1994.
3. "Reliability Engineering", E Balaguruswamy, McGraw hill, 2002.
4. "Power System Planning", R. Sullivan, McGraw Hill, 1977.
5. "Probability, Random variables and Stochastic processes", Athanasios Papoulis and S. Unni Krishna Pillai, TMH.
6. "Reliability Engineering", K.K Aggarwal, Springer Pub, 1993.
7. "Economic Market Design and Planning for Electric Power Systems", James Momoh, Lamine Mili, John Wiley and Sons, New Jersey, 2010.

		L	T	P	M	C
PS 573	**ADVANCED MICROPROCESSORS & MICRO CONTROLLERS**	**4**	**0**	**0**	**100**	**4**

COURSE OBJECTIVES:

1. To understand 8086 family, and develop the programming skills for applying them on various applications of 8086 microprocessor.
2. . To understand Architectural features 80386,80486 and Pentium processors
3. To understand 8086 systems connections and programmable parallel ports
4. To understand Analog interfacing with 8086 and learn different programmable peripheral devices.
5. Understand architecture of 8051microcontroller.

COURSE OUTCOMES: After successful completion of the course, the students are able to

1. understand architecture and programming model of 8086 microprocessor.
2. understand Architectural features 80386,80486 and Pentium processors
3. understand 8086 system connections and Timings, Digital Interfacing.
4. understand Analog interfacing with 8086 and different programmable peripheral devices.
5. understand the architecture of 8051 microcontroller.

COURSE CONTENT:

UNIT – I **[Text Book-1]**

Microprocessors: Introduction to Microcomputers and Microprocessors, Introduction to 8086 microprocessor family, 8086 internal architecture, Addressing modes, Programming the 8086, Instruction descriptions, Assembler directives, Minimum and Maximum Mode and Bus Timings, Ready and Wait states and 8086 based micro- computing system.

UNIT – II **[Text Book-1]**

Advanced Processors

Architectural features of 80386, 486 and Pentium Processors their memory management, Introduction to Pentium Pro Processors their features.

UNIT – III **[Text Book-1]**

Digital & Analog Interfacing: Addressing memory and ports in Microcomputer system, 8086 interrupts and Interrupt Responses, Programmable parallel ports and Handshake input/output, interfacing a microprocessor to keyboards.

D/A converter operation, Interfacing and applications, A/D converter specifications types and interfacing.

UNIT – IV **[Text Book-1]**

Programmable Devices: Introduction to programmable peripheral devices: 8253/8254, 8259, 8251. The DMA data transfer, RISC Vs CISC, RISC properties, RISC evaluations, overview of RISC development and current schemes, Memory Interfacing (DRAM), PPI-Modes of operation of 8255.

UNIT – V **[Text Book-1]**

8051 Microcontrollers: Introduction to 8 bit and 16 bit microcontrollers; 8031/8051 microcontroller architecture and memory organization, Addressing modes, Instruction formats, CPU timings, Interrupt structure and interrupt priorities; port structures and operations. Accessing internal and external memories, Timer / Counter functions and different modes of operations. Interfacing of stepper motor , LED display , and robotic control.

TEXT BOOKS:

1. Dougles V Hall, Microprocessor and Interfacing: Programming and hardware, 2nd Edition, TMH 2003.
2. Barry B. Brey – The Intel Microprocessors 8086/ 8088, 80186/80188, 80286, 80386, 80486, Pentium and Pentium Preprocessor, Architecture, Programming and Interfacing, PHI, 4th Edition.

REFERENCE BOOKS:

1. Yu-Cheng Liu, Glenn A Gibson, Microcomputer systems: the 8086/8088 Family, Architecture, Programming and Design, 2nd Edition, PHI, 2003.
2. A K Ray, K M Bhurchandi, Advanced Microprocessors and Peripherals: Architecture, Programming and Interfacing, TMH 2004.
3. Deniel Tabak – Advanced Microprocessors, McGraw Hill , 2nd edition.

		L	T	P	M	C
PS 574	**POWER ELECTRONIC CONVERTERS**	**4**	**0**	**0**	**100**	**4**

COURSE OBJECTIVES:

1. To provide sufficient Knowledge on Power Electronic Converters
2. To provide sufficient Knowledge on modulation techniques of converters and multi level inverters

COURSE OUTCOMES:

Upon successful completion of the course, the student will be able to:

1. Understand the importance of FACTS controllers in transmission system to enhance the system performance, control strategies for different types of converters for static compensation.
2. Understand the objectives of shunt compensator and their types, comparison of transient and dynamic stability performance of different controllers.
3. Understand the objectives of series compensators and their types, performance of different controllers.
4. Get Importance of static voltage and phase angle regulators towards active, reactive power flow control and improvement of transient stability.
5. Understand the concept of UPFC and IPFC, control strategies for controlling P and Q.

COURSE CONTENT:

UNIT-I **[Text Book-1]**

LINE COMMUTATED CONVERTERS:AC to DC Converter- single phase controlled rectifier bridge type - with R load- RL load- with and without FWD- analysis & wave forms- three phase controlled rectifier bridge type with R, RL loads with & without FEWD- analysis & waveforms – performance factors of line commutated converters - advantages- applications - power factor improvements. twelve pulse converter.

UNIT-II **[Text Book-1]**

AC VOLTAGE CONTROLLERS: Single phase Ac voltage controllers- with R & RL loads- Analysis & waveforms- three phase AC voltage controllers- analysis& wave forms – AC synchronous tap changers – Matrix converters:- Principle of operation only.

CYCLO CONVERTER: Single phase – bridge type- R & RL loads- 3 phase bridge type principle of operation & wave forms.

UNIT-III **[Text Book-1]**

INVERTERS: Bridge type- Single phase Inverters. MC Murray- Bedford inverter- and their analysis & waveforms – Bridge type three phase Inverters –analysis of 180 degree & 120 degree conduction modes. Current Source Inverter- some applications- comparison of VSI & CSI

UNIT-IV **[Text Book-1]**

VOLTAGE CONTROL OF SINGLE PHASE INVERTERS: Single PWM – Multiple PWM – sinusoidal PWM – modified PWM – phase displacement Control – Advanced modulation techniques for improved performance – Trapezoidal, staircase, stepped, harmonic injection and delta modulation –Advantage – application

VOLTAGE CONTROL OF THREE PHASE INVERTERS: Sinusoidal PWM – Third Harmonic PWM – 60 degree PWM – space vector modulation – Comparison of PWM techniques – harmonic reductions

UNIT-V **[Text Book-1]**

MULTILEVEL INVERTERS: Multilevel concept – Classification of multilevel inverters – Diode clamped multilevel inverter - Flying capacitors multilevel inverter - Cascaded multilevel inverter Up to three levels only. Multilevel inverter applications.

TEXT BOOKS:

1. Power Electronics – Mohammed H. Rashid – Pearson Education – Third Edition – First Indian reprint 2004.
2. Power electronics – V R Moorthy – Oxford Publications

REFERENCE BOOKS:

1. Power Electronics – Ned Mohan, Tore M. Undeland and William P. Robbins – John Wiley & Sons – Second Edition.

		L	T	P	M	C
PS 575	**COMPUTER NETWORKS**	**4**	**0**	**0**	**100**	**4**

COURSE OBJECTIVES:

1. To describe the uses of computer networks, network interfaces and different types of networks.
2. To analyze and evaluate the network reference model suitable for any organization.
3. To identify protocol stack and design Issues for the different Layers.

COURSE OUTCOMES:

Upon completion of the course, the student will be able to:

1. Analyze and determine the requirements and appropriate protocols for developing a network and design a network architecture considering interfaces, services and protocols.
2. Apply contemporary issues in networking technologies for various applications; understand the Data link layer protocols.
3. Implement various routing algorithms like distance vector routing, flooding and Shortest Path.
4. Analyze congestion Control algorithms, IP protocol and Internet control protocols.
5. Describe the operation of Transport Layer and Application Layer protocols etc.

COURSE CONTENT:

UNIT – I **[Text Book–1]**

Introduction: Uses of Computer networks, Network Hardware, Network Software, Reference Models (OSI and TCP/IP only).

Physical Layer: Introduction to Guided Transmission Media, Wireless Transmission

UNIT – II **[Text Book–1]**

Data Link Layer: Data Link Layer design issues, Error detection and correction, Elementary Data link Protocols, Sliding window protocols.

Medium Access Control Sub layer: The channel Allocation problem, Multiple Access Protocols, Ethernet, Wireless LANs, Broadband wireless, Bluetooth, Data Link Layer Switching.

UNT – III **[Text Book-1]**

Network Layer: Network layer Design Issues, Routing Algorithms – (The Optimality Principle, Shortest Path Routing, Flooding, Distance Vector Routing, Link State Routing, Hierarchical Routing, Broadcast Routing, Multicast Routing, Routing for Mobile Hosts)

UNIT – IV **[Text Book–1]**

Congestion Control Algorithms, Quality of Service - (Requirements, Techniques for Achieving Good Quality of Service), Internetworking, The Network layer in the internet- (The IP Protocol, IP Address, Internet Control Protocols, OSPF, BGP)

UNIT – V **[Text Book–1]**

Transport Layer: Elements of Transport Protocols, TCP, UDP,RTP.

Application Layer: DNS, Electronic Mail, The World Wide Web (Architectural Overview only) Multimedia.

TEXT BOOKS:

1. A.S Tanenbaum, Computer Networks, 5th Edition, PHI, 2013.
2. Behrouz A. Foruzan, Data communication and Networking, 4thEdition,TMH, 2004.

WEB REFERENCES:

1. Wireshark Packet Analyzer (http://www.wireshark.org/)
2. Computer Networks on Wikipedia http://en.wikipedia.org/wiki/Computer_network)
3. RFCs - Request For Comments (http://www.rfc-editor.org/rfc-index2.html)
4. Novell Networking Primer (http://www.novell.com/info/primer/primer.html)
5. History of the Internet (www.youtube.com/watch?v=9hIQjrMHTv4)
6. BGP at 18: Lessons in Protocol Design (www.youtube.com/watch?v=HAOVNYSnL7k)

		L	T	P	M	C
PS 576	**HIGH VOLTAGE ENGINEERING & INSULATION**	**4**	**0**	**0**	**100**	**4**

COURSE OBJECTIVES:

1. To impart the knowledge on breakdown mechanism in the insulators used in the power system network
2. To gain the knowledge on generations and measurement of D.C voltages ,A.C voltages and impulse Voltages.
3. To find out various method of testing electrical apparatus used in the transmission and distribution.

COURSE OUTCOMES:

Upon the completion of this course the student will be able to

1. Understand the breakdown mechanism of gas, liquid and solid insulators.
2. Know various methods of generating and measuring various types of voltages and currents.
3. Understand different methods of measuring various types of voltages and currents.
4. Gain knowledge on testing of various electrical apparatus.
5. Get an idea of insulation coordination and causes of over voltages at high voltage level.

Course Content:

UNIT I **[Text book-1]**

Breakdown in Dielectric materials:

Ionization process, Twonsend's current growth equation, current growth in the secondary processes, Twonsend's criterion for breakdown, streamer theory of breakdown in gases, Paschen law, breakdown in non uniform fields and corona discharge.

Liquid as Insulator, pure and commercial liquids, breakdown in pure and commercial liquids.

UNIT-II **[Text books-1&2]**

Intrinsic breakdown, electromechanical breakdown, thermal breakdown, breakdown of solid dielectrics in practice, Breakdown in composite dielectrics, solid dielectrics used in practice.

Generation of High Voltage and Currents:

Generation of high D.C., alternating voltages, impulse voltages, generation of impulse currents, tripping and control of impulse generators.

UNIT-III **[Text book-1]**

Measurement of high voltage and currents:

Measurement of high d.c.voltages, Measurement of high a.c. and impulse voltages, Measurement of high d.c., a.c. and impulse currents. Cathode Ray Oscilloscope for impulse voltage and current measurements.

UNIT IV: **[Text book-1]**

Testing of Materials and Apparatus:

Measurement of D.C. resistivity, measurement of dielectric constant and loss factor, partial discharge measurements, testing of insulators, bushing, circuits breakers, transformers and surge diverters.

UNIT-V: **[Text book-2]**

OVER VOLTAGES & INSULATION CO-ORDINATION

Natural causes for over voltages – Lightning phenomenon, Overvoltage due to switching surges,

system faults and other abnormal conditions, Principles of Insulation Coordination on High voltage and Extra High Voltage power systems.

TEXT BOOKS:

1. High Voltage Engineering by M.S.Naidu and V.Kamaraju – TMH.
2. High Voltage Engineering fundamentals by Kuffel and Zungel, Elsevier Publications

REFERENCE BOOKS:

1. Fundamentals of Gaseous Ionization and plasma Electronics by Essam Nasser – Wiley - Inter Science.
2. High Voltage and Electrical Insulation engineering by R Arora, W Mosch John Wiley – 2011
3. High voltage Engineering by CL Wadhwa 3rd Edition-New Age International

Web References:

1. http://www.elect.mrt.ac.lk/HV_Chap1.pdf
2. http://www.synergy.ac.in/intranet/classnotes/L-24.pdf
3. http://nptel.ac.in/courses/108104048/25

		L	T	P	M	C
PS 577	**EHV AC TRANSMISSION SYSTEMS**	**4**	**0**	**0**	**100**	**4**

COURSE OBJECTIVES:

1**.** To provide the knowledge on power handling capacities of the transmission lines and capacitance calculation of multi-conductor and bundle conductor lines.
2. To give awareness of measurement of field and voltage gradients for three phase single and double circuit lines
3. To impart the knowledge of Corona loss in E.H.V. lines and measurements of radio interference due to Corona

COURSE OUTCOMES:

Upon the completion of this course the student will be able to

1. Get an idea of standard transmission voltages and power handling capacities of the lines
2. Obtain knowledge on capacitance calculation of multi-conductor and bundle conductor lines
3. Measure the voltage gradients for three phase single and double circuit lines
4. Understand the power frequency voltage control and static VAR system
5. Calculate Corona loss in E.H.V. lines and measure the radio interference due to Corona.

COURSE CONTENT:

Unit I **[Text book-1]**

E.H.V. A.C. Transmission , line trends and preliminary aspects ,standard transmission voltages – power handling capacities and line losses – mechanical aspects.

Unit II **[Text book-2]**

Line capacitance calculation : capacitance of two conductor line, and capacitance of multi conductor lines, potential coefficients for bundled conductor lines, sequence inductances and capacitances and diagnolization.

Unit III **[Text book-2]**

Electrostatic induction in un-energized lines – measurements of field and voltage gradients for three phase single and double circuit lines – un-energized lines.

Unit IV **[Text book-1]**

Power Frequency voltage control : Problems at power frequency, generalized constants, No load voltage conditions and charging currents, voltage control using synchronous condenser, cascade connection of components : Shunt and series compensation, sub synchronous resonance in series – capacitor compensated lines

Static reactive compensating systems : Introduction, SVC schemes, Harmonics injected into network by TCR, design of filters for suppressing harmonics injected into the system.

Unit-V **[Text book-2]**

Corona in E.H.V. lines – Corona loss formulae attention of travelling waves due to Corona – Audio noise due to Corona, its generation, characteristic and limits

Measurements of audio noise, radio interference due to Corona RF properties of radio noise – frequency spectrum of RI fields – Measurements of RI and RIV.

TEXT BOOKS:

1. Extra High Voltage AC Transmission Engineering – Rakosh Das Begamudre, Wiley Eastern Ltd., New Delhi
2. EHV Transmission line reference book – Edision Electric Institute (GEC) 1986.

REFERENCE BOOKS:

1 EHV AC/ DC Transmission engineering and practice by S.Rao, Khanna publications

WEB REFERENCES:

https://www.researchgate.net/publication/3484913_Bundled_Conductor_Voltage_Gradient_Calculations

		L	T	P	M	C
PS 578	**HVDC TRANSMISSION SYSTEMS**	**4**	**0**	**0**	**100**	**4**

COURSE OBJECTIVES:

1. To give an introduction to DC power transmission and describe the basic components of a converter, and describe the methods for compensating the reactive power demanded by the converter and the methods for simulation of HVDC systems.
2. To describe the types of filters for removing harmonics and the characteristics of the system impedance resulting from AC filter designs and different methods of control of HVDC converter and system.
3. To explain the design techniques for the main components of an HVDC system.
4. To explain the protection of HVDC system and other converter configurations used for the HVDC transmission and the recent trends for HVDC applications.

COURSE OUTCOMES:

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

1. Describe the basic components of a converter, the methods for compensating the reactive power demanded by the converter
2. Explain the methods for simulation of HVDC systems and its control.
3. Describe filters for eliminating harmonics and the characteristics of the system impedance resulting from AC filter designs
4. Explain the design techniques for the main components of an HVDC system.
5. Explain the protection of HVDC system and other converter configurations used for the HVDC transmission.
6. Explain the recent trends for HVDC applications.

COURSE CONTENT:

Unit-I **[Text Book-2]**

HVDC Technology: Introduction, Advantages of HVDC Systems, HVDC System Costs, Overview and Organization of HVDC Systems, Review of the HVDC System Reliability, HVDC Characteristics and Economic Aspects.

Power Conversion: Thyristor, 3-Phase Converter, 3-Phase Full Bridge Converter, 12-Pulse Converter.

Unit-II **[Text Books-1&2]**

Control of HVDC Converter and System: Converter Control for an HVDC System, Commutation Failure, HVDC Control and Design

Control of HVDC Converter and System (continued): HVDC Control Functions, Reactive Power and Voltage Stability.

Unit-III **[Reference Books – 1& 2]**

Harmonics of HVDC and Removal: Introduction, Determination of Resulting Harmonic Impedance, Active Power Filter.

Interactions between AC and DC Systems: Definition of Short Circuit Ratio and Effective Short Circuit Ratio, Interaction between HVDC and AC Power System.

Unit-IV **[Reference Book – 2]**

Main Circuit Design: Converter Circuit and Components, Converter Transformer, Cooling System, HVDC Overhead Line, HVDC Earth Electrodes, HVDC Cable, HVDC Telecommunications Current Sensors, HVDC Noise and Vibration.

Unit-V **[Text Books 1&2]**

Fault behaviour and Protection of HVDC System: Valve Protection Functions, Protective Action of an HVDC System, Protection by Control Actions, Fault Analysis. Other Converter Configurations for HVDC Transmission: Introduction, Voltage Source Converter (VSC), CCC and CSCC HVDC System, 10.4 Multi-Terminal DC Transmission.

Trends for HVDC Applications: Wind Farm Technology, Modern Voltage Source Converter (VSC) HVDC Systems, 800 kV HVDC System.

TEXT BOOKS:

1. HVDC Transmission: Power Conversion Applications in Power Systems, Chan-Ki Kim, Wiley 2009.
2. Direct Current Transmission, E.W. Kimbark, Wiley1971.

REFERENCE BOOKS:

1. HVDC Power Transmission Systems, K.R.Padiyar, New Age International, 2012.
2. High Voltage Direct Current Transmission, J. Arrilaga, IET.2nd Edition, 1998.
3. HVDC and FACTs Controllers; Applications of Static Converters in Power Systems, Vijay K Sood, BSP Books,2013.
4. HVDC Transmission, S. Kamakshaiah, Mc Graw Hill, 2011.

		L	T	P	M	C
PS 579	**POWER QUALITY ANALYSIS & IMPROVEMENT**	**4**	**0**	**0**	**100**	**4**

COURSE OBJECTIVES:

1. To understand the various Power quality problems
2. To become familiar with Power Quality considerations in Industry.
3. To gain knowledge on Power Quality and EMC standards.

COURSE OUTCOMES:

Upon successful completion of the course, the student will be able to:

1. Understand the importance the severity of power quality problems in power system.
2. Understand the different types interruptions, origin of short interruptions, predictions and precautions
3. Analyze voltage sag problems and suggest preventive techniques.
4. Analyze Power Quality considerations in Industrial Power Systems
5. Understand and analyze power quality and EMC standards

COURSE CONTENT:

UNIT-I **[Text book-1]**

INTRODUCTION: Introduction of the Power Quality (PQ) problem, Terms used in PQ: Voltage, Sag, Swell, Surges, Harmonics, over voltages, spikes, Voltage fluctuations, Transients, Interruption, overview of power quality phenomenon, Remedies to improve power quality, power quality monitoring.

UNIT-II **[Text book-1]**

LONG & SHORT INTERRUPTIONS: Interruptions – Definition – Difference between failures, outage, Interruptions – causes of Long Interruptions – Origin of Interruptions – Limits for the Interruption frequency – Limits for the interruption duration – costs of Interruption – Overview of Reliability evaluation to power quality, comparison of observations and reliability evaluation.

SHORT INTERRUPTIONS: definition, origin of short interruptions, basic principle, fuse saving, voltage magnitude events due to re-closing, voltage during the interruption, monitoring of short interruptions, difference between medium and low voltage systems. Multiple events, single phase tripping – voltage and current during fault period, voltage and current at post fault period, stochastic prediction of short interruptions.

UNIT III **[Text book-1]**

Single and Three - PHASE VOLTAGE SAG CHARACTERIZATION: Voltage sag – definition, causes of voltage sag, voltage sag magnitude, and monitoring, theoretical calculation of voltage sag magnitude, voltage sag calculation in non-radial systems, meshed systems, and voltage sag duration. Three phase faults, phase angle jumps, magnitude and phase angle jumps for three phase unbalanced sags, load influence on voltage sags.

UNIT-IV **[Text book-1]**

POWER QUALITY CONSIDERATIONS IN INDUSTRIAL POWER SYSTEMS: Voltage sag – equipment behavior of Power electronic loads, induction motors, synchronous motors, computers, consumer electronics, adjustable speed AC drives and its operation. Mitigation of AC Drives, adjustable speed DC drives and its operation, mitigation methods of DC drives.

UNIT-V **[Text book-1]**

MITIGATION OF INTERRUPTIONS & VOLTAGE SAGS: Overview of mitigation methods – from fault to trip, reducing the number of faults, reducing the fault clearing time changing the power system, installing mitigation equipment, improving equipment immunity, different events and mitigation methods. System equipment interface –

voltage source converter, series voltage controller, shunt controller, combined shunt and series controller.

POWER QUALITY AND EMC STANDARDS: Introduction to standardization, IEC Electromagnetic compatibility standards, European voltage characteristics standards, PQ surveys.

TEXT BOOKS:

1. Understanding Power Quality Problems by Math H J Bollen. IEEE Press.
2. Electrical Power Systems Quality: Roger C. Dugan, MF McGranaghan, Surya Santoso and HW Beaty, TMH, 2/E

REFERENCE BOOKS:

1. Power Quality: Problems and Mitigation Techniques Bhim Singh et. al. John Wiley & Sons, 16-Feb-2015
2. Handbook of power quality by Angelo Baggini , John Wiley 2008.
3. Power Quality by C. Sankaran - CRC PRESS.
4. Power System Harmonics, Jos Arrillaga, Neville R. Watson, John Wiley & Sons, 2003.
5. Power Quality VAR Compensation in Power Systems, R. SastryVedam Mulukutla S. Sarma, CRC Press.
6. G.T.Heydt, "Electric Power Quality", Stars in a Circle Publications, 1994(2nd edition).
7. Angelo Baggini 'Handbook of Power Quality' – Wiley.

		L	T	P	M	C
PS 580	**DIGITAL CONTROL SYSTEMS**	**4**	**0**	**0**	**100**	**4**

COURSE OBJECTIVES

1. To understand the concepts of digital control systems and assemble various components associated with it. Advantages compared to the analog type.
2. The theory of z–transformations and application for the mathematical analysis of digital control systems.
3. To provide the representation of discrete-time systems by pulse transfer function and state space models and evaluation of state transition matrix.
4. To examine the stability of the system using different tests.
5. To identify and develop the design of digital controllers and realize discrete time controller.

COURSE OUTCOMES

On successful completion of this course the students will be able to:

1. Know the implementation of Z- Transform.
2. Representation of discrete time systems with the approach of pulse transfer function and state space models.
3. Know the modelling aspects of digital control devices and systems.
4. Compute the stability of discrete time systems.
5. Implement the design of digital controller via classical, state space techniques and realization of discrete time systems.

COURSE CONTENT:

UNIT – I
INTRODUCTION &SAMPLING **[Text Book-1]**

Introduction to analog and digital control systems – Advantages of digital systems – Typical examples – Signals and processing – Sample and hold devices – Sampling theorem and data reconstruction – Frequency domain characteristics of zero order hold.

UNIT – II
Z–PLANE ANALYSIS **[Text Book-1]**

Review of Z-transforms
Z-Transform method for solving difference equations; Pulse transforms function, block diagram analysis of sampled – data systems, mapping between s-plane and z-plane: Primary strips and Complementary Strips.

UNIT – III
STATE SPACE ANALYSIS **[Text Book-2]**

State Space Representation of discrete time systems, Pulse Transfer Function Matrix solving discrete time state space equations, State transition matrix and its Properties, Methods for Computation of State Transition Matrix, Discretization of continuous time state – space equations.
Concepts of Controllability and Observability, Tests for controllability and Observability. Duality between Controllability and Observability, Controllability and Observability conditions for Pulse Transfer Function.

UNIT- IV **[Text Books-1,2]**

STABILITY ANALYSIS

Stability Analysis of closed loop systems in the Z-Plane.Jury stability test – Stability analysis by use of the Bilinear Transformation and Routh Stability criterion. Stability analysis using Lyapunov theorems.

DESIGN OF DISCRETE TIME CONTROL SYSTEM BY CONVENTIONAL METHODS

Design of digital control based on the frequency response method – Bilinear Transformation and Design procedure in the w-plane, Lead, Lag and Lead-Lag compensators and digital PID controllers. Design digital control through dead beat response method.

UNIT- V **[Text Books-1,2]**

STATE FEEDBACK CONTROLLERS AND OBSERVERS

Design of state feedback controller through pole placement – Necessary and sufficient conditions, Ackerman's formula. State Observers – Full order and Reduced order observers.

LINEAR QUADRATIC REGULATORS

Min/Max principle, Linear Quadratic Regulators

TEXT BOOKS:

1. Discrete-Time Control systems - K. Ogata, Pearson Education/PHI, 2nd Edition.
2. Digital Control and State Variable Methods by M.Gopal, TMH

REFERENCE BOOKS:

1. Digital Control Systems, Kuo, Oxford University Press, 2nd Edition, 2003
2. Digital Control Engineering, M. Gopal
3. Digital Control Systems, P.N. Paraskevopoulos, Prentice Hall, 1996.

		L	T	P	M	C
PS 581	**DISTRIBUTION SYSTEMS PLANNING & AUTOMATION**	**4**	**0**	**0**	**100**	**4**

COURSE OBJECTIVES:

1. To gain knowledge of Electrical distribution systems planning
2. To analyze and design primary and secondary distribution networks
3. To be aware of the co-ordination of protection devices used in electrical distribution system.
4. To impart knowledge on capacitive compensation/voltage control.
5. To get familiarization on Electrical distribution Automation.

COURSE OUTCOMES: After completion of this course the students will be able to

1. Know about various factors to be considered for planning of distribution systems
2. Analyze and Design Primary and Secondary distribution networks
3. Identify various protective devices in Distribution system
4. Calculate losses and Voltage drops , Design Compensation/ Voltage control equipment
5. Get Knowledge on Distribution Automation

COURSE CONTENT:

UNIT – I **[Text Book-1]**

Distribution systems planning: Planning and forecast techniques - Present and future role of computers in distribution system planning - Load characteristics and Load models - Load growth – tariffs.

UNIT – II **[Text Book-1]**

Deign of sub transmission lines and distribution substations: Introduction – sub transmission systems - distribution substation – Substation bus schemes - description and comparison of switching schemes – substation location and rating - Application of network flow techniques in rural distribution networks to determine optimum location of sub-station.

Design considerations on primary systems: Introduction - types of feeders - voltage levels - Radial type feeders - feeders with uniformly distributed load and non uniformly distributed loads.

UNIT – III **[Text Book-1]**

Design considerations of secondary systems: Introduction - secondary voltage levels - Secondary banking - existing systems improvement.

Distribution system Protection: Basic definitions - over current protection devices - fuses, automatic circuit reclosures, automatic line sectionalizers - objectives of distribution system protection - coordination of protective devices - Fuse to Fuse coordination, Fuse to circuit breaker coordination, Reclosure to circuit breaker coordination.

UNIT-IV **[Text Book-1]**

Voltage drop and power loss calculations: Three phase primary lines - non 3 phase primary lines - 4 wire multi grounded primary lines - copper loss – Distribution feeder costs - loss reduction and voltage improvement in rural distribution networks.
Applications of Capacitors to distribution systems: Effect of series and shunt capacitors - Power factor correction - economic justification for capacitors – a computerized method to determine the economic power factor - Procedure to determine the best and optimum capacitor location
Distribution System Voltage Regulation: Basic definitions - Quality of service - voltage control - line drop compensation.

UNIT –V **[Reference Book – 2]**
Distribution Automation: Introduction – description – benefits – distribution automation components – distribution SCADA – distribution management system – functions of DMS- Distribution management- Data dependency and sustainability – Functional requirements of DSCADA – DA/Management functionalities – Mapping of Function Vs Benefit
Communication systems for DA: Introduction – Communication requirements – Communication Systems used

TEXT BOOKS:
1. TuranGonen —Electric Power Distribution Engineering, 3rd Edition, CRC Press-2014.
2. V. Kamaraju —Electrical power distribution systems, TMH - 2009.

REFERENCE BOOKS:
1. A.S. Pabla —Electric Power Distribution, 5th Edition, TMH – 2005.
2. S. Sivanagaraju and V. Sankar, —Electrical distribution and automation, Dhanpat rai & Co – 2006.

		L	T	P	M	C
PS 582	**SMART GRID DESIGN AND ANALYSIS**	**4**	**0**	**0**	**100**	**4**

COURSE OBJECTIVES:

1. To explore the functions and evolution of smart electric grid.
2. To summarize the smart electric grid architecture.
3. To describe the concepts of dynamic energy systems.
4. To create awareness on smart electric grid policies.
5. To give knowledge on creating efficient electric grid with alternative technologies.

COURSE OUTCOMES:

After completion of this course the students will be able to:

1. Understand the necessity and evolution of a smart electric grid system.
2. Explore the architecture of smart grid.
3. Get acquainted with control and energy management of dynamic energy systems.
4. Extend their knowledge for employing smart electric grid policies.
5. Interpret the concepts of efficient electric grid with alternative technologies.

COURSE CONTENT:

UNIT–I: [TEXT BOOK-1]

INTRODUCTION: Introduction to smart grid- Electricity network-Local energy networks- Electric transportation- Low carbon central generation-Attributes of the smart grid- Alternate views of a smart grid.

SMART GRID TO EVOLVE A PERFECT POWER SYSTEM: Introduction- Overview of the perfect power system configurations- Device level power system- Building integrated power systems- Distributed power systems- Fully integrated power system -Nodes of innovation.

UNIT–II: [TEXT BOOK-1]

DC DISTRIBUTION AND SMART GRID: AC vs DC sources-Benefits of and drives of DC power delivery systems - Powering equipment and appliances with DC-Data centers and information technology loads-Future neighborhood- Potential future work and research.

INTELLIGRID ARCHITECTURE FOR THE SMARTGRID: Introduction- Launching intelligrid- Intelligrid today- Smart grid vision based on the intelligrid architecture-Barriers and enabling technologies.

UNIT–III: [TEXT BOOK-1]

DYNAMIC ENERGY SYSTEMS CONCEPT: Smart energy efficient end use devices-Smart distributed energy resources-Advanced whole building control systems-Integrated communications architecture-Energy management-Role of technology in demand response- Current limitations to dynamic energy management-Distributed energy resources-Overview of a dynamic energy management-Key characteristics of smart devices- Key characteristics of advanced whole building control systems-Key characteristics of dynamic energy management system.

UNIT – IV: [TEXT BOOK-1]

ENERGY PORT AS PART OF THE SMART GRID: Concept of energy -Port, generic features of the energy port.

POLICIES AND PROGRAMS TO ENCOURAGE END – USE ENERGY EFFICIENCY: Policies and programs in action - multinational - national-state-city and corporate levels.

MARKET IMPLEMENTATION: Framework-factors influencing customer acceptance and response - program planning-monitoring and evaluation.

UNIT–V: **[TEXT BOOK-1]**

EFFICIENT ELECTRIC END – USE TECHNOLOGY ALTERNATIVES: Existing technologies – lighting - Space conditioning - Indoor air quality - Domestic water heating - hyper efficient appliances - Ductless residential heat pumps and air conditioners – Variable refrigerant flow air conditioning-Heat pump water heating - Hyper efficient residential appliances - Data center energy efficiency- LED street and area lighting - Industrial motors and drives - Equipment retrofit and replacement - Process heating - Cogeneration, Thermal energy storage - Industrial energy management programs - Manufacturing process-Electro-technologies, Residential, Commercial and industrial sectors.

TEXT BOOKS:

1. Clark W Gellings, "The Smart Grid, Enabling Energy Efficiency and Demand Side Response"- CRC Press, 2009.
2. Janaka Ekanayake, Kithsiri Liyanage, Jianzhong.Wu, Akihiko Yokoyama, Nick Jenkins, "Smart Grid: Technology and Applications"- Wiley, 2012.

REFERENCE BOOKS:

1. James Momoh, "Smart Grid: Fundamentals of Design and analysis"- Wiley, IEEE Press, 2012.

WEB REFERENCES:

1. http://www.smartgridnews.com/story/understanding-and-designing-smart-grid/2012-02-07
2. http://w3.usa.siemens.com/smartgrid/us/en/transmission-grid/products/grid-analysis-tools/pages/gridanalysis-tools.aspx
3.http://digitalcommons.georgiasouthern.edu/cgi/viewcontent.cgi?article=1021&context=electricaleng-facpubs
4.http://energy.sandia.gov/energy/ssrei/gridmod/renewable-energy-integration/smart-grid-tools-andtechnology/
5. https://www.ieee-pes.org/presentations/gm2014/PESGM2014P-001876.pdf

		L	T	P	M	C
PS 583	**AI TECHNIQUES FOR PS APPLICATIONS**	**4**	**0**	**0**	**100**	**4**

COURSE OBJECTIVES:

1. To provide students with strong foundation on the classification of architectures of artificial neural networks.
2. To enable the students to have a fair knowledge about genetic algorithm.
3. To enable the students to have a fair knowledge about Fuzzy logic and fuzzy logic controllers.

COURSE OUTCOMES: Upon completion of the course, the student will be able to:

1. Get an idea of artificial neural networks and algorithms.
2. To gain the knowledge of production of best generations by using different genetic operators.
3. Get the complete idea of fuzzy logic controllers.
4. Get the idea of fault diagnosis and load forecasting.
5. Get the knowledge of applications of fuzzy logic.

COURSE CONTENT:

Unit I: **[Text Book-1]**

Introduction to Neural Networks Introduction, Humans and Computers, Organization of the Brain, Biological Neuron, Biological and Artificial Neuron Models. Introduction - neural network models architectures-knowledge representation-learning process-learning tasks.

Feed Forward Neural Networks Introduction, Perceptron Models: Discrete, Continuous and Multi-Category, Training Algorithms: Discrete and Continuous Perceptron Networks, Perception Convergence theorem, Limitations of the Perceptron Model, Applications. ANN paradigm-back propagation-RBF algorithms-Hope field networks

Unit II: **[Text Book-1]**

Genetic algorithms-introduction-encoding-fitness function-reproduction operators Genetic modelling-genetic operators-cross over and mutation-generational cycle convergence of genetic algorithm

Unit III: **[Text Book-1]**

Classical AND Fuzzy Sets Introduction to classical sets - properties, Operations and relations; Fuzzy sets, Membership, Uncertainty, Operations, properties, fuzzy relations, cardinalities, membership functions. Fuzzy Logic System Components Fuzzification, Membership value assignment, development of rule base and decision making system, Defuzzification to crisp sets, Defuzzification methods.

UNIT IV : **[Publications]**

Neural network applications: Process identification, Function Approximation, control and Process Monitoring, fault diagnosis and load forecasting.

UNIT V : **[Publications]**

Fuzzy logic applications: Fuzzy logic control and Fuzzy classification specific applications to power systems load frequency control, fault diagnosis.

TEXT BOOKS:

1. Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications by Rajasekharan and Pai – PHI Publication.
2. Chennakesava R Alavala "Fuzzy logic and neural networks", New Age International Publishers.
3. S N Sivanandam, S N Deepa " Principles of soft computing ", John Wiley 2007

REFERENCES:

1. Neural and Fuzzy Systems: Foundation, Architectures and Applications, - N. Yadaiah and S. Bapi Raju, Pearson Education

2. Neural Engineering by C.Eliasmith and CH.Anderson, PHI
3. Introduction to Artificial Neural Systems - Jacek M. Zuarda, Jaico Publishing House, 1997.

		L	T	P	M	C
PS 584	**POWER SYSTEM DEREGULATION**	**4**	**0**	**0**	**100**	**4**

COURSE OBJECTIVES:

1. To enable the students to understand the process and operation of restructured power system
2. To impart knowledge on fundamental concepts of congestion management.
3. To analyze the concepts of locational marginal pricing and financial transmission rights. To Illustrate about various power sectors in India

COURSE OUTCOMES:

Upon completion of the course, the student will be able to:

1. Understand the concept of deregulated power systems.
2. Determine the available transfer capability in deregulated power systems.
3. Explore issues like congestion management, Transmission pricing, Ancillary Services Management.

COURSE CONTENT:

UNIT I **[Text Book-1]**

INTRODUCTION TO RESTRUCTURING OF POWER INDUSTRY

Introduction: Deregulation of power industry, Restructuring process, Issues involved in deregulation, Deregulation of various power systems – Market models: Comparison of various market models, OASIS: Open Access Same–time Information System – structure of oasis – pooling of information – transfer capability on OASIS.

UNIT II

TRANSMISSION CONGESTION MANAGEMENT **[Text Book-2]**

Introduction: Definition of Congestion, reasons for transfer capability limitation, Importance of congestion management, Features of congestion management – Classification of congestion management methods'

Definitions transfer capability issues: – ATC – TTC – TRM – CBM calculations – methodologies to calculate ATC.

UNIT III **[Text Book-1]**

LOCATIONAL MARGINAL PRICES AND FINANCIAL TRANSMISSION RIGHTS

Mathematical preliminaries: -Locational marginal pricing– Lossless DCOPF model for LMP calculation – Loss compensated DCOPF model for LMP calculation – ACOPF model for LMP calculation – Financial Transmission rights.

UNIT IV **[Text Book-2]**

ANCILLARY SERVICE MANAGEMENT AND PRICING OF TRANSMISSION NETWORK

Introduction of ancillary services – Types of Ancillary services – Classification of Ancillary services – Load generation balancing related services – Voltage control and reactive power support devices – Black start capability service - ancillary service –Co-optimization of energy and reserve services - International comparison - Transmission pricing – Principles – Classification – Role in transmission pricing methods – Marginal transmission pricing paradigm – Composite pricing paradigm – Merits and demerits of different paradigm.

UNIT V **[Reference 1 & Web resources]**

REFORMS IN INDIAN POWER SECTOR: Introduction – Framework of Indian power sector – Reform initiatives - Availability based tariff – Electricity act 2003 – Open access issues – Power exchange – Reforms in the near future.

TEXT BOOKS:

1. Mohammad Shahidehpour, Muwaffaq Alomoush, Marcel Dekker, "Restructured electrical power systems: operation, trading and volatility" Pub., 2001.
2. Kankar Bhattacharya, Jaap E. Daadler, Math H.J. Boolen, "Operation of restructured power systems", Kluwer Academic Pub., 2001.

REFERENCE BOOKS:

1. Ajay Pandey Sebastian Morris, Electricity Reforms and Regulations -A Critical Review of Last 10 Years Experience, Indian Institute of Management Ahmedabad, 2009.
2. Loi Lei Lai, 'power system restructuring and Deregulation' , John Wiley & Sons Ltd., England
3. Sally Hunt, "Making competition work in electricity", John Willey and Sons Inc. 2002.
4. Steven Stoft, "Power system economics: designing markets for electricity", John Wiley & Sons, 2002.
5.

WEB RESOURCES:

1. http://nptel.ac.in/courses/108101005/1
2. https://www.iitk.ac.in/ime/anoops/IEX%202015%20Training/IITK%20-%20PPTs%20-%202015/Day%20-%201%20IITK/1%20-%20Anoop%20Singh%20-%20Power%20Sector%20Reform%20&%20Regulation%20in%20India%20-%202015.pdf

		L	T	P	M	C
PS 585	**ENERGY CONSERVATION & AUDIT**	**4**	**0**	**0**	**100**	**4**

Course Objectives:

1. To facilitate the students with the knowledge on energy audit of industries, buildings and organisation of energy management with proper controllers.

2. To enable the students to have a fair knowledge about power factor improvement methods and economical aspects of the industrial electrical equipment.

Course Outcomes:

Upon successful completion of the course, the student will be able to:

1. Gain the knowledge on various methods of energy auditing of industries, buildings along with the conservation schemes.
2. Understand the energy management schemes and controlling methods.
3. Understand variable speed , variable duty cycle systems and unbalanced voltage systems with compensating methods.
4. Gain the knowledge on power factor improvement methods and operation of energy instruments.
5. Understand the economics analysis and aspects of the apparatus with different techniques.

COURSE CONTENT:

UNIT-I: [Text Book1]

BASIC PRINCIPLES OF ENERGY AUDIT Energy audit- definitions, concept , types of audit, energy index, cost index ,pie charts, Sankey diagrams, load profiles, Energy conservation schemes-

Energy audit of industries-energy saving potential, energy audit of process industry, thermal power station, building energy audit.

UNIT-II: [Text Book1]

ENERGY MANAGEMENT Principles of energy management, organizing energy management program, initiating, planning, controlling, promoting, monitoring, reporting

Energy manger, Qualities and functions, language, Questionnaire – check list for top management.

UNIT-III: [Text Book1]

ENERGY EFFICIENT MOTORS Energy efficient motors , factors affecting efficiency, loss distribution , constructional details ,characteristics - variable speed , variable duty cycle systems, RMS hp- voltage variation-voltage unbalance- over motoring- motor energy audit

UNIT-IV: [Text Book1]

POWER FACTOR IMPROVEMENT, LIGHTING AND ENERGY INSTRUMENTS

Power factor – methods of improvement, location of capacitors, Pf with non linear loads, effect of harmonics on power factor, power factor motor controllers

Good lighting system design and practice, lighting control ,lighting energy audit - Energy Instruments- wattmeter, data loggers, thermocouples, pyrometers, lux meters, tongue testers ,application of PLC's.

UNIT-V: [Text Book1]

ECONOMIC ASPECTS AND ANALYSIS Economics Analysis-Depreciation Methods, time value of money, rate of return , present worthmethod , replacement analysis, life cycle costing analysis

Energy efficient motors- calculation of simple payback method, net present worth method- Power factor correction, lighting -Applications of life cycle costing analysis, return on investment.

Learning Resources:

Text Books:

1. W.R. Murphy and G. Mackay Butter worth, Energy management, Heinemann publications.
2. Paul o' Callaghan, Energy management, Mc-graw Hill Book company-1st edition, 1998

Reference Books:

1. John .C. Andreas, Marcel Dekker, Energy efficient electric motors, Inc Ltd-2nd edition, 1995-
2. W.C. Turner, Energy management hand book, John wiley and sons
3. Energy management and good lighting practice : fuel efficiency- booklet12-EEO

Web Resources:

1. http://www.enernoc.com/our-resources/term-pages/what-is-an-energy-audit
2. http://energy.gov/energysaver/professional-home-energy-audits
3. http://www.cpri.in/about-us/departmentsunits/energy-efficiency-and-renewable-energy- division-ered/energy-audit-services.

		L	T	P	M	C
PS 586	**RENEWABLE ENERGY DRIVEN POWER SYSTEMS**	**4**	**0**	**0**	**100**	**4**

Course objectives:
This course makes the student to

1. Aware of various forms of renewable energy.
2. Understand in detail different types of energy conversion systems.
3. Design different power converters for renewable energy conversion and integration.

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

1. Appraise the need and possibility of extracting solar energy and converting into electrical energy using PV cell and solar concentrators.
2. Describe the dynamics of wind turbine and electrical generator.
3. Explain the methods of conversion of bio-mass, Geothermal, Wave and tidal energy into electrical energy.
4. Design renewable energy systems that meet specific energy demands.

Course content:

Unit-I **[Text Book 1]**
Design and Operation of Solar Energy Conversion Systems
Solar Photovoltaic Power System: The PV cell, Module and Array, Equivalent Electrical circuit, Open Circuit Voltage and Short Circuit Current, I-V and P-V Curves, Array Design, Peak Power Point operation, Components of Standalone and Grid connected PV systems.
Solar Thermal systems: Energy Collection, Solar Central receiver systems, Solar Pond, Distributed Systems.

Unit-II **[Text Book 1]**
Design and Operation of Wind Energy Conversion Systems
Wind Power System: Wind Energy Conversion Systems and their classification, Wind Power System components, rating, Electrical Load Matching, Variable-speed Operation, System Design features, Maximum Power operation, System Control Requirements, Rate Control and Environmental aspects. Components of Standalone and Grid connected Wind Power Systems, Self-Exited Induction Generator for Isolated Power Generators.

Unit-III **[Text Book 1& Reference book 2]**
Power Conditioning for Solar and Wind Energy Conversion Systems
Switching Devices for Energy Conversion, DC Power Conditioning Converters, Introduction to Maximum Power Pint Algorithms, AC Power Conditioners, Line Commutated Inverters, Synchronized operation with Grid, Harmonic Reduction and Power Factor Improvement.

Unit-IV **[Text Book 2]**
Wave Energy: Theory-Devices for Energy Extraction.
Tidal Energy: Tidal Current Energy, Tidal Barrage method, Tidal Turbine Method for Energy Extraction
Ocean Thermal Energy Conversion: Closed Cycle, Open Cycle & Hybrid OTEC Systems, By products of OTEC Systems.

Unit-V **[Text Book 2]**

Bioenergy: Types of Biomass, Electric Power Generation using biomass, Bio-methane, Biofuels-Biodiesel Production.
Geothermal Energy: Resource Identification, Geothermal System, Geothermal Resources for Electricity Generation.

Learning Resources:
Text Books:

1. Mukund R. Patel "Wind and Solar Power Systems" CRC Press, 1999.
2. Tushar K. Ghosh, Mark A. Prelas "Energy Resources and Systems Volume 2: Renewable Resources" Springer, 2011.

Reference Books:

1. Rai G.D., "Non – Conventional Energy Sources", Khanna Publishers, 1993.
2. Nicola Femia, Giovanni Petrone "Power Electronics and Control Techniques for Maximum energy Harvesting in Photovoltaic Systems" CRC Press, 2013.

Web Resources:

1. https://energy.gov/science-innovation/energy-sources
2. https://www.nrel.gov/workingwithus/learning.html
3. http://www.alternative-energy-tutorials.com/

		L	T	P	M	C
PS 587	**GAS INSULATED SYSTEMS (GIS)**	**4**	**0**	**0**	**100**	**4**

COURSE OBJECTIVES:

- Understand the function of electrical switchgear
- Understand the difference of GIS and AIS
- Understand the principles of SF6 and the procedures for gas handling
- Know the main working principles

COURSE OUTCOMES:

Upon completion of the course, the student will be able to:

1. Know the design and function of GIS
2. Familiar with construction of the GIS and its components
3. Understand the functionality of the components
4. Perform GIS maintenance and testing

COURSE CONTENT:

UNIT–I: INTRODUCTION TO GIS AND PROPERTIES OF SF6 [Textbook-1]

Characteristics of GIS- Introduction to SF6 - Physical properties-Chemical properties - Electrical properties-Specification of SF6 gas for GIS application - Handling of SF6 gas before use - Safe handling of Sf6 gas in electrical equipment - Equipment for handling the SF6 Gas - SF6 and environment.

UNIT–II: LAYOUT OF GIS STATIONS [Textbook-1]

Advancement of GIS station - Comparison with Air Insulated Substation - Economics of GIS - User Requirements for GIS - Main Features for GIS - Planning and Installation components of a GIS station.

UNIT–III: DESIGN AND CONSTRUCTION OF GIS STATION [Textbook-1]

Introduction - Rating of GIS components - Design Features - Estimation of different types of Electrical Stresses -Design Aspects of GIS components - Insulation Design for Components - Insulation Design for GIS - Thermal Considerations in the Design of GIS - Effect of very Fast Transient Over-voltages (VFTO) on the GIS design - Insulation Coordination systems - Gas handling and Monitoring System Design.

UNIT-IV: FAST TRANSIENT PHENOMENA IN GIS [Textbook-1]

Introduction- Disconnector Switching in Relation to Very fast Transients-Origin of VFTO Propagation and Mechanism of VFTO-VFTO Characteristics- Effects of VFTO-Testing of GIS for VFTO.

UNIT–V: SPECIAL PROBLEMS IN GIS AND GIS DIAGNOSTICS [Textbook-1]

Introduction - particles their effects and their control- Insulating Spacers and their Reliability - SF6 Gas Decomposition - Characteristics of imperfections in insulation - Insulation Diagnostic methods - PD Measurement and UHF Method.

TEXT BOOK:

1. M. S. Naidu," Gas Insulated Substations"- IK International Publishing House.

		L	T	P	M	C
PS 588	**DISTRIBUTED GENERATION & MICROGRID**	**4**	**0**	**0**	**100**	**4**

COURSE OBJECTIVES:

- To illustrate the concept of Distributed Generation
- To analyze the impact of grid integration
- To study concepts of Microgrid and its configuration

COURSE OUTCOMES:

After completion of this course the students will be able to:

1. Understand the current scenario of Distributed Generation and the need to implement DG sources.
2. Appraise the technical impacts of DGs upon transmission and distribution systems.
3. Evaluate various control aspects and techniques of distributed generation sources.
4. Associate different types of micro-grids and analyze the transients and protection related issues in micro-grids.
5. Evaluate Power quality issues in microgrids

COURSE CONTENT:

UNIT I **[Text Book – 1]**

INTRODUCTION: Conventional power generation: advantages and disadvantages, Energy crises, Non-conventional energy (NCE) resources: review of Solar PV, Wind Energy systems, Fuel Cells, micro-turbines, biomass, and tidal sources.

UNIT II **[Text Book – 1,2]**

DISTRIBUTED GENERATIONS (DG): Concept of distributed generations, topologies, selection of sources, regulatory standards/ framework, Standards for interconnecting Distributed resources to electric power systems: IEEE 1547. DG installation classes, security issues in DG implementations. Energy storage elements: Batteries, ultra-capacitors, flywheels. Captive power plants.

UNIT III **[Text Book – 1]**

IMPACT OF GRID INTEGRATION: Requirements for grid interconnection, limits on operational parameters,: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues.

UNIT IV **[Text Book – 1]**

MICROGRIDS: Concept and definition of microgrid, microgrid drivers and benefits, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids, communication infrastructure, modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques.

UNIT V **[Text Book – 1]**

POWER QUALITY ISSUES IN MICROGRIDS: Power quality issues in microgrids-Modelling and Stability analysis of Microgrid, regulatory standards, Microgrid economics, Introduction to smart microgrids.

TEXT BOOKS:.

1. S. Chowdhury, S.P. Chowdhury and P. Crossley, 'Microgrids and Active Distribution Networks', The Institution of Engineering and Technology,

2. H. Lee Willis, Walter G. Scott , 'Distributed Power Generation – Planning and Evaluation', Marcel Decker Press, 2000.
3. Robert Lasseter, Paolo Piagi, ' Micro-grid: A Conceptual Solution', PESC 2004, June 2004.

REFERENCE BOOKS:

1. AmirnaserYezdani, and Reza Iravani, "*Voltage Source Converters in Power Systems: Modeling, Control and Applications*", IEEE John Wiley Publications,2009.
2. DorinNeacsu, "*Power Switching Converters: Medium and High Power*", CRC Press, Taylor & Francis, 2006.
3. Chetan Singh Solanki, "*Solar Photo Voltaics*", PHI learning Pvt. Ltd., New Delhi,2009.
4. J.F. Manwell, "*Wind Energy Explained, theory design and applications*," J.G. McGowan Wiley publication,2002.
5. D. D. Hall and R. P. Grover, "*Biomass Regenerable Energy*", John Wiley, New York, 1987.
6. John Twidell and Tony Weir, "*Renewable Energy Resources*" Tyalor and Francis Publications, 2005.
7. M.Godoy Simoes, Felix A.Farret, 'Renewable Energy Systems – Design and Analysis with Induction Generators', CRC press.
8. F. Katiraei, M.R. Iravani, 'Transients of a Micro-Grid System with Multiple Distributed Energy Resources', International Conference on Power Systems Transients (IPST'05) in Montreal, Canada on June 19-23, 2005.
9. Z. Ye, R. Walling, N. Miller, P. Du, K. Nelson, 'Facility Microgrids', General Electric Global Research Center, Niskayuna, New York, Subcontract report, May 2005.

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PS 589	**ADVANCED DIGITAL SIGNAL PROCESSING**	**4**	**0**	**0**	**100**	**4**

COURSE OBJECTIVES:

1. To familiarize the students to analyze, design and represent the digital filters.
2. To make students understand the concepts of DSP algorithm implementation.
3. To make students understand the concepts of estimation of Power Spectrum.

COURSE OUTCOMES:

After completion of this course the student should be able to

1. Realize different structures of FIR & IIR Filters.
2. Design IIR & FIR Filters using different techniques.
3. Use Filter implementation techniques and explain numerical round-off effects.
4. Estimate Power Spectrum using different techniques.

COURSE CONTENT:

UNIT-I: Digital Filter Structure [Text Book-1]

Block diagram representation-Equivalent Structures-FIR and IIR digital filter Structures All pass Filters-tunable IIR Digital Filters-IIR tapped cascaded Lattice Structures-FIR cascaded Lattice structures-Parallel-Digital Sine-cosine generator-Computational complexity of digital filter structures.

UNIT-II: Digital filter design [Text Book-1]

Preliminary considerations-Bilinear transformation method of IIR filter design-design of Low pass highpass- Bandpass, and Band stop- IIR digital filters-Spectral transformations of IIR filters- FIR filter design-based on Windowed Fourier series- design of FIR digital filters with least –mean- Square-error-constrained Least-square design of FIR digital filters

UNIT-III: DSP algorithm implementation [Text Book-1]

Computation of the discrete Fourier transform- Number representation-Arithmetic operations-handling of overflow-Tunable digital filters-function approximation.

UNIT-IV Analysis of finite Word length effects [Text Book-1]

The Quantization process and errors- Quantization of fixed -point and floating -point Numbers-Analysis of coefficient Quantization effects - Analysis of Arithmetic Round-off errors-Dynamic range scaling-signal- to- noise ratio in Low -order IIR filters-Low-Sensitivity Digital filters-Reduction of Product round-off errors using error feedback-Limit cycles in IIR digital filters- Round-off errors in FFT Algorithms.

UNIT V: Power Spectrum Estimation [Text Book-1]

Estimation of spectra from Finite Duration Observations signals – Non-parametric methods for power spectrum Estimation – parametric method for power spectrum Estimation-Estimation of spectral form-Finite duration observation of signals-Non-parametric methods for power spectrum estimation-Walsh methods-Blackman & torchy method.

TEXT BOOKS:

1. Digital signal processing-sanjit K. Mitra-TMH second edition
2. Discrete Time Signal Processing – Alan V.Oppenheim, Ronald W.Shafer - PHI-1996 1st edition-9th reprint

REFERENCE BOOKS:

1. Digital Signal Processing principles, algorithms and Applications – John G.Proakis -PHI –3rd edition-2002
2. Digital Signal Processing – S.Salivahanan, A.Vallavaraj, C. Gnanapriya – TMH - 2nd reprint-2001
3. Theory and Applications of Digital Signal Proceesing-LourensR. Rebinar&Bernold
Digital Filter Analysis and Design-Auntonian-TMH

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PS 590	**ELECTRICAL TRANSIENTS IN POWER SYSTEMS**	**4**	**0**	**0**	**100**	**4**

COURSE OBJECTIVES:

1. To understand the various types of transients and its analysis in power system.
2. To learn about the various protective devices against transients.

COURSE OUTCOMES:

Upon completion of the course, the student will be able to:

1. Understand fundamental concepts for the study of switching over voltages.
2. Understand power system circuit interruption and switching over voltages.

COURSE CONTENT:

UNIT I **[Text Book-1]**

REVIEW OF TRAVELLING WAVE PHENOMENA

Lumped and Distributed Parameters – Wave Equation – Reflection, Refraction, Behaviour of Travelling waves at the line terminations – Lattice Diagrams – Attenuation and Distortion.

UNIT II **[Text Book-1]**

LIGHTNING, SWITCHING AND TEMPORARY OVERVOLTAGES

Lightning over voltages: interaction between lightning and power system- ground wire voltage and voltage across insulator; switching overvoltage: Short line or kilometric fault, energizing transients - closing and re-closing of lines, methods of control; temporary over voltages: line dropping, load rejection; voltage induced by fault; very fast transient overvoltage (VFTO).

UNIT III **[Text Book-1]**

PARAMETERS AND MODELLING OF OVERHEAD LINES

Review of line parameters for simple configurations: series resistance, inductance and shunt capacitance; bundle conductors: equivalent GMR and equivalent radius; modal propagation in transmission lines: modes on multiphase transposed transmission lines, α-β-0 transformation and symmetrical components transformation, modal impedances; analysis of modes on un transposed lines; effect of ground return and skin effect; transposition schemes.

UNIT IV **[Text Book-1]**

PARAMETERS OF UNDERGROUND CABLES

Distinguishing features of underground cables: technical features, electrical parameters, overhead lines versus underground cables; cable types; series impedance and shunt admittance of single-core self-contained cables, impedance and admittance matrices for three phase system formed by three single-core self-contained cables; approximate formulas for cable parameters.

UNIT V **[Text Book-1]**

COMPUTATION OF POWER SYSTEM TRANSIENTS - EMTP

Digital computation of line parameters: why line parameter evaluation programs? salient features of mtline; constructional features of that affect transmission line parameters; elimination of ground wires bundling of conductors; principle of digital computation of transients: features and capabilities of EMTP; steady state and time step solution modules: basic solution methods.

TEXT BOOKS:

1. Allan Greenwood, "Electrical Transients in Power System", Wiley & Sons Inc. New York, 1991.
2. Rakosh Das Begamudre, "Extra High Voltage AC Transmission Engineering", (Second edition) Newage International (P) Ltd., New Delhi, 1990.

References:

1. Naidu M S and Kamaraju V, "High Voltage Engineering", Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.
2.Hermann W. Dommel, EMTP Theory Book, second Edition, Microtran Power System A nalysis Corporation, Vancouver, British Columbia, Canada, May 1992, Last Update: A pril 1999.
3. EMTP Literature from www.microtran.com.