R.V.R. & J.C. COLLEGE of ENGINEERING

(AUTONOMOUS)

CHOWDAVARAM, GUNTUR – 522 019

ANDHRA PRADESH, 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. : 2021-2022

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

CHOICE BASED CREDIT SYSTEMREGULATIONS (R-21) 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 2021-22)

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 68 credits out of which 30 credits from laboratory courses including Dissertation.

5.2 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.

A candidate has to register and secure at least minimum pass grade in Research Methodology & IPR Course in I Year II Semester, for which no credit is awarded.

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 12 weeks, must be submitted on or before the last instruction day of II Year I Semester, for which 2 Credits will be awarded. The Grade is awarded based on the marks obtained in the MOOCS performance.
- 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.

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/her 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/Industry. In such cases, the Dissertation shall be jointly supervised by a member of the faculty and a person from the Organization/Industry.

- The student is eligible for submission of M.Tech., dissertation report at the end of the II Year II Semester if he/she passed all the credit courses in the previous semesters.

- In a special case, if any student unable to submit his/her dissertation report at the end of II Year II Semester due to any other reason permitted by the head of the institution, he/she will be allowed to submit at a later date and the viva-voce examination will be conducted separately.

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. In addition to the regular semester end examinations held at the end of each semester, supplementary examinations will also be conducted during the academic year. Such candidates taking the Regular/ Supplementary examinations as supplementary candidates may have to take more than one examination per day.

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 (Phase-II) 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:

	Sessional	Semester End

Nature of the subject	Marks	Exam. Marks
Theory	40	60
Laboratory	40	60
Seminar / Internship /Mini Project/ Professional Certification /	100	–
Dissertation (Phase-I)	100	–
Dissertation (Phase-II)	40	60

7. LABORATORY / PRACTICAL COURSES

In any semester, a minimum of 8 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 / Project Work 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 / Internship / Professional Certification / Seminar / Dissertation / MOOCS. Each theory subject is awarded 3 credits and each Practical / Internship / Professional Certification / Seminar / Dissertation / MOOCS subjects are awarded 2 credits. Dissertation (Phase-I) in II Year I Semester is awarded 6 credits and Dissertation (Phase-II) at the end of II Year II Semester is awarded 14 credits.

11.1 AWARD OF GRADES

S.No.	Range of Marks	Grade	Grade Points
1.	≥90%	A^+	10.0
2.	≥80% - <90%	A	9.0
3.	≥70% - <80%	B	8.0
4.	≥60% - <70%	C	7.0
5.	≥55% - <60%	D	6.0
6.	≥50% - <55%	E	5.0
7.	<50%	F	0.0
8.	The grade 'W' represents withdrawal / absent	W	0.0

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

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

- The list of courses 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 courses 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 courses up to that semester.

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

11.5 Conversion of CGPA into equivalent Percentage of marks:

Percentage of Marks = (CGPA-0.50)*10.

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 10***.

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 forefeit 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 11*** shall be placed in one of the following Classes.

S.No.	Class	CGPA
1	First Class With Distinction	7.5 or more
2	First Class	6.5 or more but less than 7.5
3	Second Class	5.5 or more but less than 6.5
4	Pass Class	5.0 or more but less than 5.5

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 students 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

15.1 A student, studied under R-17 regulations of RVR & JCCE (Autonomous) curriculum and discontinued the I Year I Semester course, shall join in I Year I Semester of R-21 regulations.

15.2 A student, studied under R-17 Regulations of RVR & JCCE (Autonomous) curriculum and discontinued the I Year II Semester course and also at the subsequent semesters will follow the same R-17 regulations /

curriculum and he / she has to complete the subject by appearing the examinations conducted by the college under R-17 curriculum.

16. CONDUCT AND DISCIPLINE

16.1 Candidates 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.

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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DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

M.TECH POWER SYSTEMS ENGINEERING

(w.e.f. the batch of students admitted from the academic year 2021-2022)

COURSE STRUCTURE AND SCHEME OF EXAMINATION

S. No.	Course Number	Subject	Periods/ week		Internal marks	End Semester Examination		Credits	
			L+T	P		Duration	Marks		
First Semester									
1.	PS 511	Power System Analysis	3	--	40	3	60	3	PC
2.	PS512	Digital Protection of Power System	3	--	40	3	60	3	PC
3.	PS 513	Renewable Energy Driven Power Systems	3	--	40	3	60	3	PC
4.	PS 514	Professional Elective – 1	3	--	40	3	60	3	PE
5.	PS 515	Professional Elective – 2	3	--	40	3	60	3	PE
6.	PS 516	Professional Elective – 3	3	--	40	3	60	3	PE
7.	PS 551	Power System Protection Lab	--	4	40	3	60	2	PC
8.	PS 552	Power System Computation Lab	--	4	100	--	--	2	PC
		TOTAL	18	8	380	--	420	22	
Second Semester									
1.	PS 521	Flexible AC Transmission Systems	3	--	40	3	60	3	PC
2.	PS 522	Power System Stability	3	--	40	3	60	3	PC
3.	PS 523	Restructured Power Systems	3	--	40	3	60	3	PC
4.	PS 524	Professional Elective – 4	3	--	40	3	60	3	PE
5.	PS 525	Professional Elective – 5	3	--	40	3	60	3	PE
6.	PS 526	Professional Elective – 6	3	--	40	3	60	3	PE
7.	MC01	Research Methodology and IPR	2	--	100	--	--	--	MC
8.	PS 561	Power Systems Lab	--	4	40	3	60	2	PC
9.	PS 562	Power System Simulation Lab	--	4	100	--	--	2	PC
		TOTAL	20	8	480	--	420	22	
Third Semester									
1.	PS 611	MOOCS (Self Learning)	--	--	--	--	100	2	MO
2.	PS 651	Summer Internship Viva	--	--	100	--	--	2	PR
3.	PS 652	Dissertation (Phase-I)	--	--	100	--	--	6	PR
		TOTAL	--	--	200	--	100	10	
Fourth Semester									
1.	PS 661	Dissertation (Phase-II)	--	--	40	--	60	14	PR
		TOTAL	--	--	40	--	60	14	

List of electives:

Subject Code	Subject Title
EL01	Advanced Power Electronic Converters
EL02	Non Linear & Optimal Control Systems
EL03	HVDC Transmission
EL04	Electrical Power Distribution Systems & Automation
EL05	Artificial Intelligence Techniques
EL06	High Voltage Engineering
EL07	Electric Vehicles
EL08	Power Quality
EL09	Smart Grids
EL10	Advanced Micro-Controller Based Systems
EL11	Advanced Digital Signal Processing
EL12	Power System Dynamics
EL13	SCADA System and Applications
EL14	Power System Deregulation
EL15	Energy Conservation & Audit
EL16	Electrical Transients in Power systems
EL17	Industrial Load Modeling and Control
EL18	Distributed Generation & Micro grid
EL19	Gas Insulated Systems (GIS)
EL20	Power System Planning & Reliability

- 18 credits have to be achieved from Core Subjects.
- 18 credits have to be achieved from Elective Subjects.
- 8 credits have to be achieved from Labs.
- 2 Credits have to be achieved from Internship.
- 20 credits have to be achieved from Project.
- 2 credits have to be achieved from MOOCS
- Total 68 credits are required for Awarding the M.Tech. Degree.

		L	T	P	M	C
PS 511	**Power System Analysis**	**3**	**0**	**0**	**100**	**3**

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. Formulate the incidence, network matrices using singular transformation and bus impedance matrix.
2. Model the synchronous machine, transmission lines and transformer.
3. Perform load flow analysis using Gauss-Seidel, Newton-Raphson and Fast decoupled methods.
4. Apply bus impedance matrix for short circuit studies.
5. Analyze the power system for contingency.

COURSE CONTENT:

UNIT-I: **[Text Book – 1]**
12

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] 6**

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

UNIT-III: **[Text Book – 1] 10**

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

UNIT-IV: **[Text Book – 1] 8**

Fault Analysis: Short Circuit (SC) studies- Introduction – SC calculations using Z_{bus} - $-Z^{f}_{abc}$ – Y^{f}_{abc} – Z^{f}_{012} – Y^{f}_{012} matrices for various faults, SC calculations using Zbus for L-L-L, L-G, L-L and L-L-G faults.

UNIT-V: **[Text Book – 2] 6**

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

***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

L	T	P	M	C
3	0	0	100	3

PS 512 Digital Protection of Power System

3.ieeexplore.ieee.org/iel5/39/22132/01029972.pdf?arnumber. % reference for applications
courses.engr.illinois.edu/ece476/notes/html % Reference for power flow analysis

COURSE OBJECTIVES:

1. To provide the knowledge on various types of static relays.
2. To gain knowledge on equipment protection and microprocessor based protection system for the power system network.
3. To gain the knowledge on evolution of digital relays over conventional relays.

COURSE OUTCOMES:

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

1. Interpret static relay operation and various types of comparators.
2. Gain knowledge on different types of static relays.
3. Recognize the necessity and working principle of various protective schemes for electrical equipment.
4. Apply the suitable algorithms for microprocessor based protective relays.
5. Recognize the evolution of digital relays and sampling circuits.

COURSE CONTENT:

UNIT-I: [Text book-1] 12 CO1

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.

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-II: [Text book-1,2] 12 CO2

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-III: [Textbook-2]12 CO3

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-IV: [Text book-1,2] 12 CO4

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.

UNIT-V: [Text

book-3] 12 CO5
DIGITAL RELAYS: Architecture of the modern digital relay -Introduction to digital signal processing -the DSP signal processing chain - Analog to digital converters- Quantization error- ADC types
SAMPLING: Need for sample and hold circuit -Shannon's sampling theorem and aliasing- anti-aliasing filter Design of anti-aliasing filter- functional block diagram of numerical relay

TEXT BOOKS:

1. T.S. MadhavaRao, Power system protection: Static relays, TMH 2nd edition 1993.
2. Badri Ram and D.N.Vishwakarma, "Power system protection and Switch gear", TMH publication New Delhi 1995.
3. S.R.Bhide "Digital Power System Protection", PHI Learning Pvt. Ltd, New Delhi, 2014.

REFERENCE BOOKS:

1. Sunil S. Rao, "Switchgear and protection", Khanna Publishers,2019
2. Gerhard Zeigler, "Numerical Distance Protection", Siemens Publicis Corporate Publishing, 4th edition,2011.

WEB REFERENCES:

1. https://nptel.ac.in/courses/108/101/108101039
2. https://www.pes-psrc.org/kb/published/reports/UNTAR-Ed2.pdf
3. https://nptel.ac.in/content/storage2/courses/108101039/download/Lecture-1.pdf

		L	T	P	M	C
PS 513	**Renewable Energy Driven Power Systems**	**3**	**0**	**0**	**100**	**3**

COURSE OBJECTIVES:
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:
Upon completion 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]**

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]**

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 book2]**

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	C	SES	EXT
PS 551 POWER SYSTEM PROTECTION LAB	**0**	**0**	**4**	**2**	**40**	**60**

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 develop the procedures for high voltage testing techniques

COURSE OUTCOMES:

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

1. Obtain the parameters of transmission lines
2. Check the operation of Relaying equipment.
3. Obtain sequence networks of alternators and transformers and perform fault studies
4. Design and implement power factor correction equipment.
5. Determine supply harmonics at various locations.

List of Experiments

1. Evaluation of ABCD parameters for artificial transmission line
2. Evaluation of Surge Impedance Loading limits of transmission line
3. Verification of Characteristics of electromagnetic relays
4. Verification of Characteristics of microprocessor based relays
5. Verification of Characteristics of static relays
6. Evaluation of Sequence reactances of synchronous machine and performing fault studies
7. Evaluation of Sequence impedances of three phase transformer
8. Active and Reactive power control of synchronous machine connected to infinite bus
9. Reactive power control by tap changing transformer
10. Power factor correction in a three phase system
11. Performance analysis of Induction generator
12. H.V. testing of insulators
13. High voltage testing of Cables
14. Study of corona phenomenon
15. Harmonic analysis by Power network analyzer

*** Any Eight experiments are to be completed**

		L	T	P	M	C
PS 552	**POWER SYSTEM COMPUTATION LAB**	**0**	**0**	**4**	**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. Develop program for solution of simultaneous differential equations.
2. Formation of incidence matrices.
3. Develop program for Ybus matrix using Singular Transformation Method.
4. Develop program for formation of Ybus matrix by inspection method
5. Formation of Zbus by step by step algorithm.
6. Fault analysis in power system using matrix method.
7. Simulation of RLC circuit.
8. Simulation of transmission line using MATLAB
9. Power flow solution using Gauss seidel method
10. Simulation of 1-phase diode bridge rectifier
11. Simulation of 1-phase controlled rectifier
12. Simulation of Single Phase AC voltage Controller
13. Transfer function analysis of given system using Simulink
14. State space analysis of a control system using MATLAB
15. Simulation of PWM Converter.

*** Any Eight experiments are to be completed**

PS 521	FLEXIBLE AC TRANSMISSION SYSTEMS	L	T	P	M	C
		3	0	0	100	3

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
3	0	0	100	3

PS 522 POWER SYSTEM STABILITY

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.
4. 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 computation of steady state stability limit.
2. Analyze voltage stability.
3. Analyze transient stability.
4. Understand the effects on stability due to various factors.
5. Understand the methods of improving stability.

COURSE CONTENT:

UNIT – I **[Text Book–1]**

Steady state stability: Power Angle Equation - Steady state power limits of a two machine system – Analytical and graphical methods of calculating steady state stability limits

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.

UNIT – III **[Text Book–1]**

Transient stability: Review of transient stability –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. Swing Equation solution by point by point method.

UNIT – IV **[Text Book–1]**

Effects on stability due to: 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, Reactor switching, Single pole switching, Steam turbine fast valving, Generator tripping, load shedding, High speed excitation systems, 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
3	0	0	100	3

PS 523 RESTRUCTURED POWER SYSTEMS

COURSE OBJECTIVES:

1. To introduce the restructuring of power industry and understand the operation of power system in competitive environment
2. Understand the role of ISO and Transmission pricing issues.
3. To understand management of congestion, ancillary services and open access same time information system.

COURSE OUTCOMES:

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

1. Understand restructuring of power industry.
2. Acquire knowledge in operation and planning policies, in deregulated environment.
3. Have knowledge of transmission pricing methodologies.
4. Acquire knowledge on ancillary service management.
5. Acquire the knowledge of open access same time information system

COURSE CONTENT:

UNIT I

INTRODUCTION TO RESTRUCTURING OF POWER INDUSTRY: [Text book – 1]

Introduction- Reasons for restructuring - Understanding the restructuring process - Issues involved in deregulation – reasons and objectives of deregulation of various power systems.

Restructuring Models: PoolCo Model, Bilateral Model, Hybrid Model: independent system operator (ISO), Role of ISO. Power exchange, market operations, market power, standard cost, transmission pricing, congestion pricing and management of congestion.

UNIT II

POWER SYSTEM OPERATION IN COMPETITIVE ENVIRONMENT: [Text book – 2]

Introduction – Independent System Operator - Operational planning activities of ISO, ISO in pool markets, ISO in bilateral markets, Operational planning activities of a GENCO, GENCO in pool markets, GENCO in bilateral markets Unit commitment in deregulated environment, Competitive bidding.

UNIT III

TRANSMISSION PRICING ISSUES: [Text book – 2]

Introduction - Power wheeling - transmission open access - cost components in transmission - pricing of power transactions, Transmission cost allocation methods.

UNIT IV

ANCILLARY SERVICE MANAGEMENT: [Text book – 1]

Types of ancillary services, classification of ancillary services, load generation balancing related services, frequency regulation, load following, voltage control and reactive power support service, black start capability service, Synchronous generators as ancillary service providers.

UNIT V
OPEN ACCESS SAME-TIME INFORMATION SYSTEM: [Text book – 1]

Structure of oasis, Posting of information, Transfer capability on oasis, Definitions- ATC, TTC, TRM, CBM, Methodologies to calculate ATC – Experiences with OASIS in some restructured models.

TEXT BOOKS

1**.** Mohammad Shahidehpour, Muwaffaq Alomoush, Marcel Dekker, "Restructured electrical power s ystems: 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.

REFERENCES

1. Sally Hunt," Making competition work in electricity", John Willey and Sons Inc. 2002
2. Steven Stoft," Power system economics: designing markets for electricity", John Wiley & Sons, 2002.
3.Lorrin Philipson, H. Lee Willis, "Understanding electric utilities and de-regulation", Marcel Dekker Pub., 1998.

		L	T	P	M	C
MC01	**RESEARCH METHODOLOGY AND IPR**	**2**	**0**	**0**	**100**	**0**

COURSE OBJECTIVES:

1. To develop understanding of the basic framework of research process.
2. To develop an understanding of various research designs and techniques.
3. To identify various sources of information for literature review and data collection.
4. To develop an understanding of the ethical dimensions of conducting appliedresearch.
5. To understand Intellectual Property rights, Procedure for grants of patents.

COURSE OUTCOMES:

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

1. To improve critical thinking about research problem and design.
2. To know various methods involved for data collection.
3. Usage of statistical methods for hypothesis testing in research process.
4. TO know how interpret the results and report writing.
5. Understand Intellectual Property rights and Procedure for grants of patents.

UNIT I

Foundations of Research: Meaning and significance, Objectives, Motivation, types of research. Characteristics of scientific method, Research Process, Criteria of Good Research. [3]

Research Problem: Definition, selection, Necessity, techniques involved in defining a problem. [2]

Research Design: Meaning of Research Design, Need for Research Design, Types of research Design. [3]

UNIT II

Design of Sample Surveys: Introduction, Sample Design, Sampling and Non-Sampling Errors. [2]

Data Collection: Introduction, Experiments and Surveys, Collection of Primary Data, Collection of Secondary Data, Selection of Appropriate Method for Data Collection, CaseStudy Method. [6]

UNIT III

Processing of Data: processing, statistics in research, frequency Distribution, hypothesis testing-parametric and non-parametric testing. [6]

Analysis of Data: Simple Regression Analysis, ANNOVA-Types. [2]

UNIT IV

Interpretation: Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, [4]

Report Writing: Significance of Report Writing, Different Steps in Writing Report, Layoutof the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report [4]

UNIT V

Ethical and Moral Issues in Research: Plagiarism, tools to avoid plagiarism – Intellectual Property Rights – Scope of Patent Rights, Licensing and transfer of technology, Patent information and databases, Geographical Indications Copy right laws. [3]

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. [3]

International Scenario: International cooperation on Intellectual Property. Procedure for grants ofpatents, patenting under PCT. [2]

LEARNING RESOURCES:

TEXT BOOKS:
1. Research Methodology: Methods and Techniques - C. R. Kothari, 2nd Edition, New Age International Publishers.
2. Research Methodology – P. Sam Daniel and Aroma G Sam, Kalpaz Publications

REFERENCE BOOKS:
1. Chawla, Deepak & Sondhi, Neena (2011). Research methodology: Concepts and cases, Vikas Publishing House Pvt. Ltd. Delhi.
2. Kerlinger, F.N., & Lee, H.B. (2000). Foundations of Behavioural Research (Fourth Edition), Harcourt Inc.

		L	T	P	C	SES	EXT
PS 561	**POWER SYSTEMS LAB**	**0**	**0**	**4**	**2**	**40**	**60**

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 develop the procedures for high voltage testing techniques

COURSE OUTCOMES:
Upon completion of the course, the student will be able to:
1. Obtain the parameters of transmission lines
2. Check the operation of Relaying equipment.
3. Obtain sequence networks of alternators and transformers and perform fault studies
4. Design and implement power factor correction equipment.
5. Determine supply harmonics at various locations.

List of Experiments

1. Line and load compensation of power system network
2. Remote monitoring and control of transmission network
3. Static Var Compensation of transmission network
4. Performance study of Transmission Line protection scheme
5. Performance study of Generator Protection System
6. Performance study of Transformer Protection System
7. Testing and performance study of Feeder Protection System
8. Performance characteristics of PV panels
9. Grid synchronization of Solar PV Inverter
10. Grid Synchronization of Wind energy conversion system
11. Performance analysis of Multilevel Inverter
12. Performance analysis of Bidirectional Inverter
13. Performance analysis of DFIG based wind energy conversion system
14. Performance study of Campus solar power plant
15. Study of campus smart grid

*** Any Eight experiments are to be completed**

		L	T	P	M	C
PS 562	**POWER SYSTEM SIMULATION LAB**	**0**	**0**	**4**	**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. Simulation of State Estimator for power flow using WLSE method
7. Simulation of single area load frequency control.
8. Simulation of two area load frequency control.
9. Simulation of power system stabilizer.
10. Design of LQR state feedback for a given system
11. Design of State feedback controller and observer through Pole assignment.
12. PSPICE Simulation of Three phase full converter using RL &E loads.
13. PSPICE Simulation of Three phase inverter with PWM controller.
14. PSPICE Simulation of resonant pulse commutation circuit.
15. Load flow studies using PSCAD / MiPower
16. Voltage Instability Analysis using PSCAD /MiPower
17. Short circuit studies using PSCAD / MiPower
18. HVDC simulator using PSCAD
19. Harmonic Analysis using MiPower
20. Modelling and simulation SVC for stability studies.

*** Any Eight experiments are to be completed**

			L	T	P	M	R21 C
EL 01	**ADVANCED POWER ELECTRONIC CONVERTERS**		**3**	**0**	**0**	**100**	**3**

Course objectives:

1. To describe the operation of advanced power electronic converters
2. To comprehend the modulation techniques of converters and multi-level inverters

Course Outcomes:

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

1. Illustrate and analyse the operation of various line commutated converters.
2. Understand the concepts of analyse the operation of various isolated DC-DC converters.
3. Illustrate and analyse the operation of various AC-AC converters.
4. Understand the operation of various inverters and apply various PWM techniques.
5. Analyse the importance of multilevel inverters.

COURSE CONTENT:

UNIT-I [Text Book-1]

LINE COMMUTATED CONVERTERS: Single phase fully controlled converters with RL load-analysis & wave forms, Evaluation of input power factor and harmonic factor-Continuous and Discontinuous load current, Power factor improvements, Extinction angle control, symmetrical angle control, PWM control. Three Phase AC-DC Converters, fully controlled converters feeding RL load with continuous and discontinuous load current-analysis & wave forms, Evaluation of input power factor and harmonic factor-Twelve pulse converter.

UNIT-II [Text Book-1]

DC-DC CONVERTERS: principle of operation of buck, boost, buck-boost, Cuk, fly back, forward, push-pull, half bridge, full bridge Converters with continuous and discontinuous operation

UNIT-III [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.

UNIT-IV [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.

VOLTAGE CONTROL OF THREE PHASE INVERTERS: Sinusoidal PWM – Third Harmonic PWM – 60 degree PWM – Space Vector Modulation.

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
3	0	0	100	3

EL 02 NON LINEAR & OPTIMAL CONTROL SYSTEM

COURSE OBJECTIVES:

1. To familiarize the students with the state space analysis of dynamic systems and observe their controllability and observability.
2. To make the 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.
4. To know the optimal feedback control design using various approaches.

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

1. Evaluate the design of state space analysis.
2. Identify 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 feedback control.

COURSE CONTENT:

UNIT I:

STATE SPACE ANALYSIS: The concept of state – State Equations for Dynamic Systems, Solutions of Linear Time Invariant Continuous-Time State Equations– State transition matrix and its Properties, State Space Representation in Canonical forms – Controllable canonical form – Observable canonical form – Diagonal Canonical Form - Jordan Canonical Form – General concept of controllability and observability, Controllability and observability tests: Kalman's and Gilbert's Tests.

UNIT – II:

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 – III:

NONLINEAR SYSTEM 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 -Variable gradient and Krasoviskii's methods.

UNIT–IV:

INTRODUCTION TO OPTIMAL CONTROL: Introduction to optimal control - Formulation of optimal control problems – Calculus of variations- Minimization of functional of single function – Constrained minimization –formulation using Hamiltonian method, Minimum principle – Control variable inequality constraints – Control and state variable inequality constraints.

UNIT –V:

OPTIMAL FEEDBACK CONTROL DESIGN: Linear Quadratic Regulator (LQR) problem formulation – Optimal regulator design by Continuous Time Algebraic Riccatti equation (CARE), Optimal regulator design by parameter adjustment (Lyapunov method) –- Optimal controller design using Linear Quadratic Gaussian (LQG) framework.

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 E. **R21**

REFERENCE BOOKS:

1. Nonlinear and Optimal Control Systems by Walter J. Grantham (Author), Thomas L. Vincent - Wiley-Interscience- 1st edition.
2. Design of Feedback Control Systems by Stefani et.al. – Oxford – 4/E

R21

		L	T	P	M	C
EL 03	**HVDC TRANSMISSION**	**3**	**0**	**0**	**100**	**3**

COURSE OBJECTIVES:

1. To give an introduction to DC power transmission, converters and describe the methods for compensating the reactive power demanded by the converter.
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. Get idea about basic components of a converter, the methods for compensating the reactive power demanded by the converter
2. Gain knowledge on converters design and control.
3. Understand the filters for eliminating harmonics and the characteristics of the system impedance resulting from AC filter designs.
4. Gain knowledge on the main components of an HVDC system.
5. Explain the protection of HVDC system, advanced converter configurations and recent trends for HVDC applications.

COURSE CONTENT:

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

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: 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, HVDC Control Functions, Reactive Power and Voltage Stability.

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

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 **[Text Book-1]**

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

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

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, Multi-Terminal DC Transmission.

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

TEXT BOOKS:

1. HVDC Transmission: Power Conversion Applications in Power Systems, Chan-Ki Kim, Vijay K.Sood, Gil-Soo Jang, Seong-Joo Lim and Seok-Jin Lee, 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_{R21}
EL 04	**ELECTRICAL POWER DISTRIBUTION SYSTEMS & AUTOMATION**	**3**	**0**	**0**	**100**	**3**

COURSE OBJECTIVES:

1. To provide sufficient theoretical and analytical background to understand the concepts of electric distribution system at various voltage levels.
2. Planning, design of sub transmission lines and distribution substation.
3. To develop skills for applying them in future on various engineering applications.
4. To teach the analysis and design of primary and secondary systems.
5. To be aware of the co-ordination of protection devices used in electrical distribution system.
6. To give an idea on calculation of voltage drops, power losses.
7. To get familiarization on Electrical distribution Automation.

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

1. Explain the concepts of distribution system Planning and load characteristics.
2. Design simple distribution system, sub transmission lines, primary feeder and Secondary feeders.
3. Categorize the design consideration of secondary distribution systems and coordination of protective devices.
4. Calculate the distribution feeder costs and identify best and optimum capacitor location.
5. Get Knowledge on Distribution Automation.

COURSE CONTENT:

UNIT – I **[Text Book – 1 & 2] [10]**

Distribution systems planning: Distribution systems planning – Factors affecting systems planning – Present distribution system planning techniques-distribution system planning models - present and future role of computers in distribution system planning.

Load characteristics: Definitions, Coincidence Factor, Contribution Factor Loss Factor - Relationship between the Load Factor and Loss Factor, Classification of Loads (Residential, Commercial, Agricultural and Industrial) and their characteristics.

UNIT – II **[Text Book – 1] [12]**

Deign of sub transmission lines and distribution substations: Introduction – types of 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] [10]**

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

Distribution system Protection: Basic definitions - over current protection devices - fuses, protection - coordination of protective devices - Fuse to Fuse co-ordination, Fuse to circuit breaker coordination, reclosure to circuit breaker co-ordination.

UNIT-IV **[Text Book – 1] [10]**

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.

Application 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.

UNIT-V **[Reference Book – 2] [12]**

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. **R21**

Learning Resources:

Text Books:

1. Electric Power Distribution System Engineering. By Turan Gonen, MGH.
2. Electrical Distribution Systems by Dr. V. Kamaraju, Right Publishers.

Reference Books:

1. Electric Power Distribution by A.S. Pabla, TMH, 4th Ed., 1997.
2. Electrical Power Distribution Automation by Sivanagaraju & Sankar, Dhanpatrai & Sons.

Web Resources:

1. https://nptel.ac.in/courses/108/107/108107112/
2. https://electrical-engineering-portal.com/electrical-distribution-systems

EL 05 ARTIFICIAL INTELLIGENCE TECHNIQUES

L	T	P	M	C
3	0	0	100	3

COURSE OBJECTIVES:

1. To provide students with basic concepts of artificial intelligent techniques
2. To enable the students to have knowledge about artificial neural networks and fuzzy logic systems.
3. To enable the students to have a fair knowledge about genetic, PSO, ant colony algorithms.
4. To apply the AI techniques in some engineering problems.

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

1. Get an idea of artificial intelligence and techniques.
2. Analyze the conceptual knowledge of neural networks and fuzzy logic controllers.
3. Describe various evolutionary algorithms to provide optimal solutions.
4. Apply the conceptual knowledge of neural networks and fuzzy logic controllers, evolutionary algorithms in hybrid intelligent controllers to analyze and develop the suitable controller for solving engineering problems.

COURSE CONTENT:

Unit I
Neural Networks: The concept and importance of AI, Introduction to Neural Networks, Organization of the Brain, Biological Neuron, Biological and Artificial Neuron Models. Neural network models: architectures-knowledge representation-learning process-learning tasks. Feed Forward and Feed Back Neural Networks, 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 -Hope field networks.

Unit II
Fuzzy Logic Systems: Introduction to classical sets – properties- Operations and relations; Fuzzy sets-Operations, properties, fuzzy relations, cardinalities, membership functions. Fuzzy Logic System Components- Fuzzification, Development of rule base, Defuzzification, Defuzzification methods.

Unit III
Genetic Algorithm: Introduction-encoding-fitness function - reproduction operators-simple GA, Flow chart, operators in GA, encoding, selection, crossover, mutation, constraints in GA, fitness
function, advantages and limitations of GA.

UNIT IV
Swarm Intelligence: Introduction to swarm intelligence, Swarm intelligence algorithms-Ant colony optimization: Biological and artificial ant colony systems, Algorithm of Ant colony system. Particle swarm optimization: The basic PSO method, characteristic features of PSO, PSO algorithm, Optimum parameter setting for the best performance of PSO, Comparison with other evolutionary computing techniques.

UNIT V
Application of AI Techniques: Neural network application in process identification and load forecasting. Fuzzy logic application in load frequency control, speed control of separately excited DC motor, optimal allocation of DG using GA, MPPT of solar PV system by using PSO.

TEXT BOOKS:

3. S N Sivanandam, S N Deepa " Principles of soft computing ", John Wiley 2007.
4. Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications by Rajasekharan and Pai – PHI Publication.

REFERENCE BOOKS:

3. J.S.R. Jang, C.T. Sun, E. Mizutani, Neuro-fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence, Pearson Education Taiwan Limited, 2004.
4. Fakhreddine O. karray, Clarence De Silva, Soft computing and Intelligent systems Design, Theory, tools and applications, Pearson Education Limited, 2009.
5. Kenneth V. Price · Rainer M. StornJouni A. Lampinen, Differential Evolution, A Practical Approach to Global Optimization, Springer,2005.

		L	T	P	M	C	R21
EL06	**HIGH VOLTAGE ENGINEERING**	**3**	**0**	**0**	**100**	**3**	

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 DC, AC and impulse voltages and currents.
3. Understand different methods of measuring DC, AC and impulse voltages and currents.
4. Gain knowledge on indirect and direct 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]12 CO1**

BREAKDOWN IN GASES AND LIQUIDS:

Ionization process, Townsend's current growth equation, current growth in the secondary processes, Townsend's criterion for breakdown, streamer theory of breakdown in gases, Paschen's 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]12 CO1,CO2**

BREAKDOWN IN SOLIDS:

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]12 CO3**

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 ,peak reading voltmeters. Cathode Ray Oscilloscope for impulse voltage and current measurements.

UNIT IV: **[Text book-2]12 CO4**

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]12 CO5**

OVER VOLTAGES & INSULATION CO-ORDINATION

Natural causes for over voltages – Lightning phenomenon, Overvoltage due to switchingsurges, system faults and other abnormal conditions, Protection against lightning over voltages and switching surges of short duration, Principles of Insulation Coordination on Highvoltage and Extra High Voltage power systems.

TEXT BOOKS:

1. High Voltage Engineering by M.S.Naidu and V.Kamaraju – TMH.5th Edition,2005

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
EL 07	**ELECTRIC VEHICLES**	**3**	**0**	**0**	**100**	**3**

R21

COURSE OBJECTIVES:

1. To introduce the fundamental concepts, principles, analysis and design of electric vehicles.

2. To introduce various aspects of electric drive train such as their configuration, types of electric machines that can be used.

3. To study different energy storage devices that can be used.

COURSE OUTCOMES:

1. After completion of this course the students will be able to:
2. Understand the concepts of analysis of electric vehicles.
3. Understand the concepts of design of electric vehicles.
4. Understand electric drive train and their configuration.
5. Identify suitable electrical machine for an electric vehicle.
6. Identify suitable energy storage devices.

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

INTRODUCTION TO ELECTRIC VEHICLES: Introduction, Layout of an Electric Vehicle, Performance of Electric Vehicles a) Traction Motor Characteristics b) Tractive Effort and Transmission Requirements c) Vehicle Performance, Energy Consumption, Advantages and Limitations, Specifications, System Components, Electronic Control System.

UNIT II: **[Text Book1**]

HYBRID VEHICLES: Concepts of Hybrid Electric Drive Train, Architectures of Series Hybrid Electric Drive Trains, Architectures of Parallel Hybrid Electric Drive Trains, Merits and Demerits, Series Hybrid Electric Drive Train Design, Parallel Hybrid Electric Drive Train Design.

UNIT III: **[Text Book1]**

ELECTRIC PROPULSION SYSTEM AND MOTOR CONTROL SYSTEM: DC Motors Characteristics, Speed and Torque Control, Regenerative Braking. AC Motors Characteristics, Speed and Torque Control. PM- BLDC Motors Characteristics, Speed and Torque Control, SRM characteristics, Speed and torque control.

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

ENERGY STORAGES: Electrochemical Batteries: Types of Batteries, Lead-Acid Batteries, Nickel Based Batteries, Lithium Based Batteries, Electro Chemical Reactions, Thermodynamic Voltage, Specific Energy, Specific Power, Energy Efficiency, Ultra Capacitors.

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

SIZING THE DRIVE SYSTEM: Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems. Energy Management Strategies: Introduction to energy management strategies used in electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies. Case Studies: Design of an Electric Vehicle (EV), Design of a Battery Electric Vehicle (BEV).

Text Books:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
2. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.

References:

1. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
2. Chris Mi, M. Abul Masrur, David Wenzhong Gao, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, John Wiley & Sons Ltd. , 2011.
3. Ronald K Jurgen, "Electric and Hybrid – Electric Vehicles", SAE, 2002.
4. Ron Hodkinson and John Fenton, "Light Weight Electric/Hybrid Vehicle Design", Butterworth – Heinemann, 2001.

EL 08 POWER QUALITY 3 0 0 100 3

COURSE OBJECTIVES: **R21**

To impart knowledge about the following topics:

1. Definition of power quality and different terms of power quality.
2. Study of voltage power quality issue – short and long interruption.
3. Causes & Mitigation techniques of various PQ events.
4. Various Active & Passive power filters.

COURSE OUTCOMES:

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

1. Ability to understand various sources, causes and effects of power quality issues, electrical systems and their measures and mitigation.
2. Ability to understand the concepts about Voltage and current distortions, harmonics.
3. Ability to study about the various Active & Passive power filters.
4. Ability to analyze the causes & Mitigation techniques of various PQ events.
5. Ability to acquire knowledge on compensation techniques.
6. Ability to acquire knowledge on DVR**.**

COURSE CONTENT:

UNIT I

INTRODUCTION TO POWER QUALITY: Terms and definitions & Sources – Overloading, under voltage, over voltage - Concepts of transients - Short duration variations such as interruption - Long duration variation such as sustained interruption - Sags and swells - Voltage sag - Voltage swell - Voltage imbalance – Voltage fluctuations - Power frequency variations - International standards of power quality – Computer Business Equipment Manufacturers Associations (CBEMA) curve.

UNIT II

VOLTAGE SAG AND SWELL: Estimating voltage sag performance - Thevenin's equivalent source - Analysis and calculation of various faulted condition - Estimation of the sag severity - Mitigation of voltage sag, Static transfer switches and fast transfer switches. - Capacitor switching – Lightning - Ferro resonance - Mitigation of voltage swell.

UNIT III

HARMONICS: Harmonic sources from commercial and industrial loads - Locating harmonic sources – Power system response characteristics - Harmonics Vs transients. Effect of harmonics – Harmonic distortion - Voltage and current distortions - Harmonic indices - Inter harmonics – Resonance Harmonic distortion evaluation, IEEE and IEC standards.

UNIT IV

PASSIVE POWER COMPENSATORS: Principle of Operation of Passive Shunt and Series Compensators, Analysis and Design of Passive Shunt Compensators Simulation and Performance of Passive Power Filters Limitations of Passive Filters Parallel Resonance of Passive Filters with the Supply System and Its Mitigation. Fundamentals of load compensation – voltage regulation & power factor correction.

UNIT V

POWER QUALITY MONITORING & CUSTOM POWER DEVICES : Monitoring considerations - Monitoring and diagnostic techniques for various power quality problems - Quality measurement equipment - Harmonic / spectrum analyzer - Flicker meters Disturbance analyzer - Applications of expert systems for power quality monitoring. Principle& Working of DSTATCOM – DSTATCOM in Voltage control mode, current control mode, DVR Structure – Rectifier supported DVR – DC Capacitor supported DVR -Unified power quality conditioner.

TEXT BOOKS:

1. Roger. C. Dugan, Mark. F. Mc Granagham, Surya Santoso, H.WayneBeaty, "Electrical Power Systems Quality", McGraw Hill,2003
2. Bhim Singh, Ambrish Chandra, Kamal Al-Haddad," Power Quality Problems & Mitigation Techniques" Wiley, 2015.

REFERENCES:

1. C. Sankaran, "Power Quality" CRC Press
2. G.T. Heydt, "Electric Power Quality", 2nd Edition. (West Lafayette, IN, Stars in a Circle Publications, 1994.
3. M.H.J Bollen, "Understanding Power Quality Problems: Voltage Sags and Interruptions", (New York: IEEE Press), 2000

		L	T	P	M	C
EL 09	**SMART GRIDS**	**3**	**0**	**0**	**100**	**3**

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] [12]

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] [12]

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] [12]

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] [12]

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] [12]

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.

R21

TEXT BOOKS:

1. Clark W Gellings, "The Smart Grid, Enabling Energy Efficiency and Demand Side Response"- CRC Press, 2009.
2. James Momoh, "Smart Grid: Fundamentals of Design and analysis"- Wiley, IEEE Press, 2012.

REFERENCE BOOKS:

1. Janaka Ekanayake, Kithsiri Liyanage, Jianzhong.Wu, Akihiko Yokoyama, Nick Jenkins, "Smart Grid: Technology and Applications"- Wiley, 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=electrical eng-facpubs
4. http://energy.sandia.gov/energy/ssrei/gridmod/renewable-energy-integration/smart-grid-tools- andtechnology/

https://www.ieee-pes.org/presentations/gm2014/PESGM2014P-001876.pdf

		L	T	P	M	R21 C
EL 10	**ADVANCED MICRO-CONTROLLER BASED SYSTEMS**	**3**	**0**	**0**	**100**	**3**

COURSE OBJECTIVES:

1. To introduce Arm architecture and programming
2. To analyze different models of embedded systems
3. To understand memory management in arm
4. To know general purpose embedded and multiprocessing in embedded systems

COURSE OUTCOMES:

After learning the course the students should be able to:

1. Understand how microcontroller and its peripherals function.
2. Program an embedded system in assembly
3. Design, implement and test a general purpose embedded systems for real-time applications
4. Implement multiprocessing in Embedded system.

COURSE CONTENT:

UNIT-I: ARM Architecture and Programming

ARM Processor Modes, ARM CPU Registers, Instruction Pipeline, ARM Instructions . ARM System Emulators, ARM Programming, ARM Exceptions, Interrupts and Interrupts Processing, Vectored Interrupts, Nested Interrupts.

UNIT-II: Models of Embedded Systems

Program Structures of Embedded Systems, Super-Loop Model, Event-Driven Model, Process Models, design methodology of embedded system software.

UNIT-III: Memory Management in ARM

Memory Management Unit (MMU) in ARM, MMU Registers, Accessing MMU Registers, Virtual Address Translations, Translation of Page References.

UNIT – IV: General Purpose Embedded Operating Systems

Develop an Embedded GPOS for ARM, Startup Sequence of EOS, Device Drivers, Timer Service in EOS, File System.

UNIT-V: Multiprocessing in Embedded Systems

SMP System Requirements, ARM MPcore Processors, ARM Cortex-A9 MPcore Processor, Generic Interrupt Controller, Demonstration of GIC Programming.

Text book:

1. K.C.Wang by Embedded and real-time operating systems: springer

R21

		L	T	P	M	C
EL 11	ADVANCED DIGITAL SIGNAL PROCESSING	3	0	0	100	3

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: Upon completion of the course, the student will 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: 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: 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: 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: 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:

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-Nonparametric 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. Digital Signal Processing – J.S. Chitode – First Edition, 2008, Technical Publications.

		L	T	P	M	C
EL 12	**POWER SYSTEM DYNAMICS**	**3**	**0**	**0**	**100**	**3**

COURSE OBJECTIVES

1. To understand the fundamental dynamic behavior and controls of power systems
2. To analyze steady state performance of synchronous machine and to know various types of excitation systems and controllers.
3. To gain knowledge on small signal analysis of single machine system and transient stability by different solution methods.

COURSE OUTCOMES

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

1. Understand the fundamental dynamic behavior and controls of power systems to perform basic stability analysis.
2. Comprehend modeling and steady state performance of synchronous machine. Know the modelling aspects of digital control devices and systems.
3. Interpret various types of excitation systems and controllers
4. Gain knowledge on small signal analysis of single machine system
5. Interpret digital simulation of transient stability by different solution techniques

.

COURSE CONTENT:

UNIT- I **Text Book-1 [12] CO1**

Basic Concepts: Power system stability states of operation and system security – system dynamics – problems, system model – analysis of steady State stability and transient stability – simplified representation of excitation control.

UNIT- II **Text Book-1 [12] CO2**

Modeling of Synchronous Machine: Synchronous machine – park's Transformation-analysis of steady state performance per-unit quantities-Equivalent circuits of synchronous machine, determination of parameters of equivalent circuits.

UNIT- III **Text Book-1 [12] CO3**

Excitation Systems : Rotating self-excited exciter with direct acting rheostatic type voltage regulator – rotating main and pilot exciters with indirect acting rheostatic type voltage regulator – rotating main exciter, rotating amplifier and static voltage regulator – static excitation scheme – brushless excitation system.

UNIT- IV **Text Book-2 [12] CO4**

Analysis of Single Machine System: Small signal analysis with block diagram – Representation Characteristic equation and application of Routh Hurwitz criterion-synchronizing and damping torque analysis-small signal model – State equations.

UNIT – V **Text Book-2 [12] CO5**

Digital Simulation of Transient Stability : Swing equation machine equations – Representation of loads – Alternate cycle solution method – Direct method of solution – Solution Techniques : Modified Euler method – Runge Kutta method – Concept of multi machine stability.

Learning Resources:

Text Books:

1. K. R. Padiyar," Power system dynamics "- B.S. Publications, Second edition,2008
2. Machowski, Bialek, Bumby, "Power system Dynamics and stability", John Wiley& Sons,1997

Reference Books:

1. R. Ramanujam, "Power Systems Dynamics"- PHI Learning Pvt.Ltd,2010
2. Computer Applications to Power Systems–Glenn.W.Stagg & Ahmed. H.El.Abiad
3. Power Systems Analysis & Stability – S.S.Vadhera, Khanna Publishers,2005

		L	T	P	M	C	
EL 13	**SCADA SYSTEM AND APPLICATIONS**	**3**	**0**	**0**	**100**	**3**	**R21**

COURSE OBJECTIVES:

1. To understand about the SCADA system components and SCADA communication protocols.
2. To provide knowledge about SCADA applications in power system.

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

1. Understand the importance of SCADA systems.
2. Describe various SCADA system components.
3. Identify various SCADA system architectures.
4. Analyse SCADA communication protocols.
5. Enumerate SCADA applications in power systems.

COURSE CONTENT:

UNIT I: SCADA: Data acquisition system, evaluation of SCADA, communication technologies, monitoring and supervisory functions.

UNIT II: SCADA system components: Schemes, Remote Terminal Unit, Intelligent Electronic Devices, Communication Network, SCADA server.

UNIT III: SCADA Architecture - Various SCADA Architectures, advantages and disadvantages of each system, single unified standard architecture IEC 61850 SCADA / HMI Systems.

UNIT IV: SCADA Communication - Various industrial communication technologies- wired and wireless methods and fiber optics, open standard communication protocols.

UNIT V: Operation and Control Of Interconnected Power System-Automatic substation control, SCADA configuration, Energy management system, system operating states, system security, state estimation, SCADA applications Utility applications, transmission and distribution sector operation, monitoring analysis and improvement. Industries oil gas and water. Case studies, implementation, simulation exercises.

TEXT BOOKS:

1. Ronald L. Krutz, "Securing SCADA System", Wiley Publications.
2. Stuart A Boyer, "SCADA supervisory control and data acquisition", ISA, 4th Revised
3. Gordan Clark, Deem Reynders, "Practical Modern SCADA Protocols", ELSEVIER.

REFERENCES:

1. William T. Shaw, Cybersecurity for SCADA systems, PennWell Books, 2006.
2. David Bailey, Edwin Wright, Practical SCADA for industry, Newnes, 2003.
3. Michael Wiebe, A guide to utility automation: AMR, SCADA, and IT systems for electric Power, PennWell 1999.
4. S. K. Singh, "Computer Aided Process Control", PHI
5. S. Gupta, JP Gupta, "PC interface For Data Acquiring & Process Control", 2nd Ed., Instrument Society of America.
6. John W. Web, Ronald A. Reis, "Programmable Logic Controllers" 5th Edition, PHI
7. Liptak, B. G. (E.d.), "Instrument Engineers Handbook", vol. I to III, Chilton Book Co.
8. Bhatkar, Marshal, "Distributed Computer control & Industrial Automation", Dekker Publication
9. Frank D. Petruzella, "Programmable Logic Controllers", 3rd Edition, McGraw Hill
10. Edition Sunil S. Rao, "Switchgear and Protections", Khanna Publications.

List of Open Source Software/learning website:

1. https://www.kth.se/social/upload/535629dcf2765437a2fd88f3/Lecture%209%20-%20SCADA%20System.pdf.
2. https://silo.tips/download/industrial-automation-chapter-9-scada.

		L	T	P	M	CR21
EL 14	**POWER SYSTEM DEREGULATION**	**3**	**0**	**0**	**100**	**3**

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. **R21**
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.

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
EL 15	**ENERGY CONSERVATION & AUDIT**	**3**	**0**	**0**	**100**	**3**

COURSE OBJECTIVES:

1. To facilitate the students with the knowledge on energy audit of industries, buildings.
2. Understand in detail about the organization of energy management with proper controllers.
3. Understand the energy efficient motors.
4. To enable the students to have a fair knowledge about power factor improvement methods.
5. To analyze the 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 Book – 1] [12]**

Basic Principles of Energy Audit - Energy audit and its benefits- 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 Book – 1] [10]**

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 Book – 1] [10]**

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 Book – 1] [10]**

Power Factor Improvement, Lighting and Energy Instruments - Power factor – methods of improvement, location of capacitors, Pf with nonlinear 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 Book – 1] [12]**

Economic Aspects and Analysis - Economics Analysis-Depreciation Methods, time value of money, rate of return , present worth method, replacement analysis, life cycle costing analysis - 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. Energy management by W.R. Murphy and G. Mackay Butter worth, Elsevier publications, 2012.
2. Electric Energy Utilization and Conservation by S C Tripathy , Tata McGraw hill publishing

company Ltd. New Delhi. **R21**

Reference Books:

1. Energy management by Paul o' Callaghan, Mc- Graw Hill Book company- 1st edition, 1998.
2. Energy management hand book by W. C. Turner. John Wiley and sons.
3. Energy efficient electric motors by John. C. Andreas, Marcel Inc Ltd- 2nd edition. 1995.

Web Resources:

1. https://www.emanz.org.nz/energy-management-audits/what-energy-audit
http://energy.gov/energysaver/professional-home-energy-audits

		L	T	P	M	C	
EL 16	**ELECTRICAL TRANSIENTS IN POWER SYSTEMS**	**3**	**0**	**0**	**100**	**3**	**R21**

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.

		L	T	P	M	C
EL 17	**INDUSTRIAL LOAD MODELING AND CONTROL**	**3**	**0**	**0**	**100**	**3**

COURSE OBJECTIVES:

1. Understand the energy demand scenario.
2. Understand the modeling of load and its ease to study load demand industrially.
3. Analyze Electricity pricing models.
4. Study Reactive power management in Industries.

COURSE OUTCOMES:

1. Upon successful completion of the course, the student will be able to:
2. Gain knowledge about load control techniques in industries and its application.
3. Learn different types of industrial processes and optimize the process using tools like LINDO and LINGO
4. Apply load management to reduce demand of electricity during peak time
5. Apply different energy saving opportunities in industries

UNIT – I **[Text book-1]**

Electric Energy Scenario-Demand Side Management-Industrial LoadManagement, Load Curves-Load Shaping Objectives, Methodologies-Barriers
Classification of Industrial Loads, Continuous and Batch processes -Load Modelling.

UNIT – II **[Text book-1, 2]**

Electricity pricing – Dynamic and spot pricing -Models, Direct load control- Interruptible load control, Bottom - up approach- scheduling- Formulation of loadModels,Optimization and control algorithms - Case studies.

UNIT – III **[Text book-1]**

Reactive power management in industries-Controls-power quality impactsApplication of filters Energy saving in industries.

UNIT – IV **[Text book-1, 2]**

Cooling and heating loads, load profiling, Modelling- Cool storage, Types-Control strategies, optimal operation, and Problem formulation- Case studies.

UNIT –V **[Text book-1]**

Operating and control strategies, Power Pooling- Operation models, Peak load saving, Constraints Problem formulation- Case study, Integrated Load management for Industries.

TEXT BOOKS:

1. C.O. Bjork "Industrial Load Management - Theory, Practice and simulations", Elsevier, theNetherlands, 1989.
2. C.W. Gellings and S.N. Talukdar, Load management concepts. IEEE Press, New York, 1986.

REFERENCE BOOKS:

1. Y. Manichaikul and F.C. Schweppe ," Physically based Industrial load", IEEE Trans. on PAS,April 1981.
2. H. G. Stoll, "Least cost Electricity Utility Planning", Wiley Interscience Publication, USA, 1989.
3. I.J.Nagarath and D.P.Kothari, .Modern Power System Engineering., Tata McGraw Hill publishers, NewDelhi, 1995.
4. IEEE Bronze Book- "Recommended Practice for Energy Conservation and cost effective planning in Industrial facilities", IEEE Inc, USA.

		L	T	P	M	CR21
EL 18	**DISTRIBUTED GENERATION & MICRO GRID**	**3**	**0**	**0**	**100**	**3**

COURSE OBJECTIVES:

1 To illustrate the concept of Distributed Generation
2 To analyze the impact of grid integration
3 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*.*

		L	T	P	M	C
EL 19	**GAS INSULATED SYTEMS (GIS)**	**3**	**0**	**0**	**100**	**3**

R21

Course objectives:
1. To present a comprehensive overview on the GIS concepts and principles.
2. To give much emphasis on the transient phenomenon, problems and diagnostic methods in GIS.

Course Outcomes: Upon the completion of the subject, the student will be able to
1. Enumerate various properties of the SF_6 gas.
2. Describe various advancements and planning of GIS.
3. Understand design issues of GIS.
4. Analyse problems and diagnostic methods of GIS.

UNIT – I: Introduction to GIS and Properties Of SF_6: Characteristics of GIS - Introduction to SF_6 – Physical properties- Chemical properties – Electrical properties-Specification of SF_6 gas for GIS application – Handling of SF_6 gas before use – Safe handling of SF_6 gas in electrical equipment – Equipment for handling the SF_6 Gas – SF_6 and environment.

UNIT – II: Layout of GIS Stations: 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: 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: 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: Introduction – particles their effects and their control- Insulating Spacers and their Reliability – SF_6 Gas Decomposition – Characteristics of imperfections in insulation – Insulation Diagnostic methods – PD Measurement and UHF Method.

TEXT BOOKS:

1. M. S. Naidu," Gas Insulated Substations"- IK International Publishing House.
2. Hermann J. Koch, "Gas Insulated Substations", June 2014, Wiley-IEEE Press.

REFERENCES:

1. Olivier Gallot – Lavellee, "Dielectric materials and Electrostatics", Wiley-IEEE Press.
2. Jaun Martinez, "Dielectric Materials for Electrical Engineering", Wiley-IEEE Press.

List of Open Source Software/learning website:
1. https://www.elprocus.com/gas-insulated-switchgear-working/
https://www.entsoe.eu/Technopedia/techsheets/gas-insulated-substation

		L	T	P	M	C	R21
EL 20	**POWER SYSTEM PLANNING & RELIABILITY**	**3**	**0**	**0**	**100**	**3**	

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. **R21**

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.