ACADEMIC REGULATIONS
COURSE STRUCTURE
AND
DETAILED SYLLABUS

M. Tech.
POWER SYSTEMS

(Applicable for the batches admitted from 2015 - 2016)

TAMASOMA JYOTIRGAMAYA
Estd. 1995

VALLURUPALLI NAGESWARA RAO VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

An Autonomous Institute, Accredited by NAAC with 'A' Grade
NBA Accreditation for CE, EEE, ME, ECE, CSE, EIE, IT B.Tech. Programmes
Approved by AICTE, New Delhi, Affiliated to JNTUH
Recognized as "College with Potential for Excellence" by UGC
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VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY
HYDERABAD
An Autonomous Institute

Academic Regulations - M.Tech. Programme
(Applicable for the batches admitted from the academic year 2015-2016)

1. Introduction

Academic programmes of the institute are governed by rules and regulations as approved by the Academic Council of the institute.

These academic rules and regulations are effective from the academic year 2015-16, for the students admitted into two year post graduate programme offered by the college leading to Master of Technology (M. Tech.) degree in different specializations offered by the departments of Civil Engineering, Electrical and Electronics Engineering, Mechanical Engineering, Electronics and Communication Engineering, Computer Science and Engineering, Information Technology and Electronics and Instrumentation Engineering.

The M.Tech. degree of Jawaharlal Nehru Technological University Hyderabad shall be conferred on students who are admitted to the programme after fulfilling all the requirements for the award of the degree.

1.1 Eligibility for Admissions

Admission to the above program shall be made subject to the eligibility and qualifications prescribed from time to time. Admissions shall be made on the basis of GATE Rank and merit rank obtained at an Entrance Test conducted by the TSSCHE or as decided by TSSCHE subject to reservations prescribed by the university/ State Government from time to time.

2. Programmes of study

The following two year M.Tech. degree programmes of study are offered by the departments at VNR VJIET.

Department	Specializations
ME	1. Advanced Manufacturing Systems 2. Automation 3. CAD/CAM
CE	1. Highway Engineering 2. Structural Engineering 3 Geotechnical Engineering
EEE	1. Power Electronics 2. Power Systems
CSE	1.Software Engineering 2 Computer Science and Engineering
ECE	1. VLSI System Design 2. Embedded Systems
EIE	Electronics and Instrumentation
IT	Computer Networks and Information Security

- **'ENGLISH'** language is used as the medium of instruction in all the above programmes.

3. Attendance requirements

Each academic year shall be divided into two semesters, each of 90 Instructions days, excluding examination, evaluation, declaration of results etc.

3.1 A student shall be eligible to appear for the semester end examinations in subject if he / she acquire a **minimum of 75% of attendance in that subject.**

3.2 Shortage of attendance up to 10% in any subject (i.e., attendance of 65% and above and below 75%) in a semester may be condoned by the Institute Academic Committee based on the rules prescribed by the Academic Council of the Institute from time to time.

3.3 A student shall get **minimum required attendance in at least three (03) theory subjects** in the present semester to get promoted to the next semester. In order to qualify for the award of the M.Tech. degree, the student shall complete all the academic requirements of the subjects, as per the course structure.

3.4 Shortage of **attendance below 65% shall in NO case be condoned**.

3.5 A stipulated fee shall be payable towards condonation of shortage of attendance.

3.6 In case the student secures less than the required attendance in any subject(s), he shall not be permitted to appear for the semester end examination in that subject(s). He shall re-register for the subject when offered next.

4. Evaluation

i. The performance of a student in each semester shall be evaluated subject–wise with a maximum of **100 marks for theory** and **100 marks for practical subjects**. In addition, **mini-project** and **comprehensive viva-voce** shall be evaluated for **100 marks** respectively.

ii. For theory subjects, the distribution shall be **40 marks for mid-term evaluation** and **60 marks for the semester end examination**.

❖ **Mid-Term Evaluation (40 M):**

Mid-term evaluation consists of **mid-term examination (30 M)** and **assignment/objective test/ case study/course project (10 M).**

➢ **Mid-term examination (30 M):**

- For theory subjects, two mid-term examinations shall be conducted in each semester as per the academic calendar. Each mid-term examination shall be evaluated for 30 marks.
- Pattern of Mid-term examination:
  3 X 10M = 30 M (three internal choice questions one from each UNIT shall be given, the student has to answer ONE question from each UNIT)
- There shall be TWO mid-term examinations for each subject and the average of two mid-term examinations shall be considered for calculating final mid-term examination marks in that subject.

➢ **Assignment/objective exam/ case study/course project (10 M):**

- Two assignment/objective exam/ case study/course project shall be given to the students covering the syllabus of first mid-term and second mid-term examinations respectively and evaluated for 10 marks each.
- The first assignment/objective exam/ case study/course project shall be submitted before first mid-term examination and the second one shall be submitted before second mid-term examination.
- The average of 2 assignments shall be taken as final assignment marks.

iii. For practical subjects, there shall be a **continuous evaluation during the semester for 40 marks and 60 marks for semester end examination**. Out of the 40 marks, **day-to-day work in the laboratory shall be evaluated for 10 marks**, and **15 marks for practical examination** and **15 marks for laboratory record.**

❖ **Semester End Examination (60 M):**

(a) Theory Courses

Question paper pattern for semester end examination (60 Marks)

- Paper shall consist of 05 questions of 10 marks each. (05X12M = 60 M)
- There shall be 01 question from each unit with internal choice.

(b) Practical Courses

Each laboratory course shall be evaluated for 60 marks. The semester end examination shall be conducted by two examiners, one Internal and other external concerned with the subject of the same / other department / Industry. The evaluation shall be as per the standard format.

4.1 Evaluation of Mini-Project: There shall be two presentations during the first year, one in each semester. For mini-project 1 and mini-project 2, a student under the supervision of a faculty member, shall collect the literature on a topic, critically review the literature, carry out the mini-project, submit it to the department in a report form and shall make an oral presentation before the departmental Project Review Committee (PRC). The Departmental PRC consists of Head of the Department, supervisor and one senior faculty member of the department. For each mini-project there shall be only internal evaluation of 100 marks. A student has to secure a minimum of 50% to be declared successful.

4.2 There shall be a comprehensive viva-voce in II year I semester. The comprehensive viva- Voce shall be conducted by a committee consisting of Head of the Department and two senior faculty members of the department. The comprehensive viva-voce is aimed to assess the students' understanding in various subjects studied during the M.Tech. programme of study. The comprehensive viva-voce shall be evaluated for 100 marks by the committee. There are no internal marks for the comprehensive viva-voce. A student must secure a minimum of 50% to be declared successful.

4.3 A student shall be deemed to have secured the minimum academic requirement in a subject if he secures a minimum of 40% of marks in the semester end examination and a minimum aggregate of 50% of the total marks in the semester end examination and mid-term evaluation taken together.

4.4 A student shall be given one chance to re-register, after completion of the course work, for each subject, provided the internal marks secured by a student are less than 50% and he has failed in the semester end examination. In such a case student may re-register for the subject(s) and secure required minimum attendance. Attendance in the re-registered subject(s) has to be calculated separately to become eligible to write the end examination in the re-registered subject(s). Re-registration for the subjects is allowed only if that particular re-registration subjects are the hindrance for the award of Degree. Re-registration is allowed in this case provided the student doesn't have any subject(s) yet to pass other than the re-registration subjects where the internal marks are less than 50% with prior permission.

4.5 Laboratory examination for M.Tech. courses must be conducted with two examiners, one of them being laboratory class teacher and second examiner shall be a teacher of same specialization either external or a teacher from the same department other than the teacher who conducted laboratory classes for that batch.

5. Evaluation of Project / Dissertation Work.

5.1 **Registration of Project Work:** A student shall be permitted to register for the project work after satisfying the attendance requirement of all the subjects (theory and practical subjects).

5.2 A Project Review Committee (PRC) shall be constituted with at least four members namely HOD, PG coordinator of the M.Tech. programme, project supervisor and one senior faculty member of same specialization.

5.3 After getting permission as per 5.1, a student has to submit, in consultation with the project supervisor, the title, objective and plan of action of his project work to the Departmental PRC for its approval. Only after obtaining the approval of PRC, the student can initiate the project work.

5.4 If a student wishes to change his supervisor or topic of the project he can do so with the approval of PRC. However, the committee shall examine whether the change of topic/supervisor leads to a major change of his initial plans of project proposal. If so, the date of registration for the project work shall be the date of change of supervisor or topic as the case may be.

5.5 Internal evaluation of the project shall be on the basis of the seminars (Project reviews) conducted during the second year by the PRC. A student shall submit draft report in a spiral bound copy form.

5.6 The work on the project shall be initiated in the beginning of the second year and the duration of project is for two semesters. A student is permitted to submit Project work only after successful completion of theory and practical course with the approval of PRC not earlier than 240 days from the date of registration of the project work. For the approval of PRC the student shall submit the draft copy of thesis to the Head of the Department (Through project supervisor and PG coordinator) and shall make an oral presentation before the PRC.
The student is eligible to submit project work if he has published at least one paper covering 70% of the project work and presented his project work in Show and Tell activity.

5.7 After approval of PRC, every student has to submit three copies of the project dissertation certified by the supervisor to the Department.

5.8 The dissertation shall be adjudicated by one examiner selected by the Chief Superintendent. For this, HOD shall submit a panel of 3/ 5 examiners, who are eminent in that field with the help of the concerned guide.

5.9 If the report of the examiner is not favourable, the student shall revise and resubmit the Dissertation, within the time frame as prescribed by PRC. If the report of the examiner is unfavourable again, the dissertation shall be summarily rejected.

5.10 If the report of the examiner is favorable, viva-voce examination shall be conducted by a board consisting of the project supervisor, Head of the Department and the external examiner who adjudicated the Thesis. The Board shall jointly report students work as:

A. **Excellent**
B. **Good**
C. **Satisfactory**
D. **Unsatisfactory**

Head of the Department shall coordinate and make arrangements for the conduct of viva-voce examination. The student has to secure any one of the grades as Excellent, Good or Satisfactory on his dissertation and viva-voce. If the report of the viva-voce is unsatisfactory, the student shall retake the viva-voce examination after three months, making modifications as suggested. If he fails to get a satisfactory report at the second viva-voce examination, he has to re-register for the project work as mentioned in clause 5.1. However, the student may select a new guide or new topic or both with the approval of the PRC and submit the project dissertation with a minimum of 240 days from the date of re-registration. Of course, this shall not prejudice the clause 6.1 below.

6. Award of Degree and Class

A student shall be declared eligible for the award of the M.Tech. degree, if he pursues a course of study and complete it successfully for **not less than two academic years** and **not more than four academic years**.

6.1 A student, who fails to fulfil all the academic requirements for the award of the degree within four academic years from the year of his admission, for any reason whatsoever, shall forfeit his seat in M.Tech. Course.

6.2 A student shall register and put up **minimum academic requirement in all 84 credits** and earn **84 credits.** Marks obtained in all 86 credits shall be considered for the calculation of Cumulative Grade Point Average (CGPA).

6.3 CGPA System:

Method of awarding absolute grades and grade points in two year M.Tech. degree programme is as follows:
Absolute Grading Method is followed, based on the total marks obtained in mid-term evaluation and semester end examinations.

- Grades and Grade points are assigned as given below.

Marks Obtained	Grade	Description of Grade	Grade Points(GP) Value Per Credit
>=90	O	Outstanding	10.00
>=80 and <89.99	A	Excellent	9.00
>=70 and <79.99	B	Very Good	8.00
>=60 and <69.99	C	Good	7.00
>=50 and <59.99	D	Pass	6.00
<50	F	Fail	
Not Appeared the Exam(s)	N	Absent	

The student is eligible for the award of the M.Tech degree with the class as mentioned in the following table.

CGPA	Class
>= 8.0	First Class with Distinction
>= 7.0 and <8.0	First Class
>= 6.0 and < 7.0	Second Class

- **Calculation of Semester Grade Points Average (SGPA):**

- The performance of each student at the end of the each semester shall be indicated in terms of SGPA. The SGPA shall be calculated as below:

$$\mathrm{SGPA} = \frac{\text{Total earned weighted grade points in a semester}}{\text{Total credits in a semester}}$$

$$\mathrm{SGPA} = \frac{\sum_{i=1}^{p} C_i * G_i}{\sum_{i=1}^{p} C_i}$$

Where C_i = Number of credits allotted to a particular subject 'i'

G_i = Grade point corresponding to the letter grade awarded to the subject 'i'

i = 1,2,…..p represent the number of subjects in a particular semester

Note: SGPA is calculated and awarded for the students who pass all the courses in a semester.

- **Calculation of Cumulative Grade Point Average (CGPA):**

The CGPA of a student for the entire programme shall be calculated as given below:

- Assessment of the overall performance of a student shall be obtained by calculating Cumulative Grade Point Average (CGPA), which is weighted average of the grade points obtained in all subjects during the course of study.

$$\mathrm{CGPA} = \frac{\text{Total earned weighted grade points for the entire programme}}{\text{Total credits for the entire programme}}$$

$$\mathrm{CGPA} = \frac{\sum_{j=1}^{m} C_j * G_j}{\sum_{j=1}^{m} C_j}$$

Where C_j = Number of credits allotted to a particular subject 'j'

G_j = Grade Point corresponding to the letter grade awarded to that subject 'j'

j = 1,2,….m represent the number of subjects of the entire program.

- Grade lower than D in any subject shall not be considered for CGPA calculation. The CGPA shall be awarded only when the student acquires the required number of credits prescribed for the program.

- **Grade Card**

The grade card issued shall contain the following:

a) The credits for each subject offered in that semester

b) The letter grade and grade point awarded in each subject

c) The SGPA/CGPA

d) Total number of credits earned by the student up to the end of that semester.

7. Withholding of Results

If the student has not paid dues to the Institute, or if any case of indiscipline is pending against him, the result of the student may be withheld and he shall not be allowed into the next higher semester. The award or issue of the provisional certificate and the degree may also be withheld in such cases. This delay shall not prejudice clauses Nos.6.0 and 6.1.

8. Transitory Regulations

Students who have discontinued or have been detained for want of attendance or any other academic requirements, may be considered for readmission as and when they become eligible. They have to take up Equivalent subjects, as substitute subjects in place of repeated subjects as decided by the Chairman of the BoS of the respective departments. He/She shall be admitted under the regulation of the batch in which he/she is readmitted.

9. Minimum Instruction Days

The minimum instruction days for each semester shall be **90 instruction days.**

10. General

10.1 The academic regulations should be read as a whole for purpose of any interpretation.

10.2 In case of any doubt or ambiguity in the interpretation of the above rules, the decision of the Principal is final.

10.3 The Institute may change or amend the academic regulations and syllabi at any time and the changes and amendments made shall be applicable to all the students with effect from the date notified by the Institute.

10.4 Wherever the words he, him or his occur, they shall also include she, her and hers.

11. Supplementary Examination

Supplementary examinations shall be conducted along with regular semester end examinations. (During even semester regular examinations, supplementary examinations of odd Semester and during odd semester regular examinations, supplementary examinations of even semester shall be conducted).

VNR Vignana Jyothi Institute of Engineering & Technology

M. TECH - POWER SYSTEMS (PS)

Vision of the Institute

To be a World Class University providing value based education, conducting interdisciplinary research in cutting edge technologies leading to sustainable socio economic development of the nation.

Mission of the Institute

- To produce technically competent and socially responsible engineers, managers and entrepreneurs who will be future ready.
- To involve students and faculty in innovative research projects linked with industry, academic and research institutions in India and abroad.
- To use modern pedagogy for improving the teaching learning process.

Vision of the Department

To excel in Education, Technology and Research in Electrical and Electronics Engineering leading to sustainable socioeconomic development of the nation.

Mission of the Department

- Excellent teaching learning environment imbibed with professional ethics and social responsibility in promoting quality education.
- Promoting research through industry collaborations and innovative projects.

Program Educational Objectives (PEO) for M.Tech Power Systems (PS) Program:

The Post Graduates of Power Systems program will

I. Be eminent power engineers capable of playing significant role in the private and public power sectors or carrying out related research activities at academic and research institutions.
II. Apply their knowledge and skills of power system engineering with an understanding of realistic constraints for the overall benefit of the society.
III. Work and communicate effectively in inter-disciplinary environment, either independently or in a team and demonstrate leadership qualities.
IV. Engage in life - long learning and professional development through self-study, continuing education or professional and doctoral level studies.

Program Outcomes for M.Tech Power Systems (PS) Program:

Upon completion of the M.Tech. Power System (PS) programme, students will be able to

a. Apply advanced level knowledge, techniques, skills and modern tools of power system engineering.
b. Design advanced level power system, components, or processes to meet identified needs within economic, environmental and social constraints.
c. Function on multidisciplinary teams, working cooperatively, respectfully, creatively and responsibly as a member of a team.
d. Identify, formulate and solve power system related problems using advanced level computing techniques.
e. Communicate effectively by oral, written, computing and graphical means.
f. Acquire and demonstrate the professional, social, moral and ethical responsibility
g. Understand the impact of power engineering solutions in a global, economic, environmental and societal context.
h. Recognize the needs to engage in lifelong learning through continuing education and research.
i. Demonstrate knowledge of contemporary issues in the area of power system engineering.
j. Manage projects related to power systems in multidisciplinary environments.
k. Propose, plan and execute projects subjected to financial, personnel and time constraints in allied fields assimilating power systems advancements.

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING & TECHNOLOGY, HYDERABAD

M. Tech. (POWER SYSTEMS)

(R15 Regulation)

I YEAR I SEMESTER **COURSE STRUCTURE**

Subject code	Group	Subject Name	L	P	Credits
PSS01	**Core**	Advanced Power System Analysis	3	1	4
PSS02		Advanced Power System Protection	3	1	4
PSS03		Power System Operation and Deregulation	3	1	4
PES11	**Elective – I & Elective – II Basket**	HVDC Transmission	3	0	3 + 3
PSS11		Economic Operation of Power System	3	0	
PSS12		Gas Insulated Systems (GIS)	3	0	
PSS13		AI Techniques in Electrical Engineering	3	0	
PSS14		Distribution System Planning and Automation	3	0	
PSS15		Power System Transients	3	0	
PES31	**Open Elective I**	Microcontrollers and Applications	3	0	3
PSS31		Energy Auditing, Conservation and Management	3	0	
PES32		Advanced Digital Signal Processing	3	0	
PSS51	**Lab -1**	Power Systems Lab-I	0	3	2
PSS61		Mini Project -I	0	0	4
		Total	**18**	**6**	**27**

I YEAR II SEMESTER **COURSE STRUCTURE**

Subject code	Group	Subject Name	L	P	Credits
PSS04	**Core**	Power System Dynamics	3	1	4
PSS05		Flexible AC Transmission Systems	3	1	4
PES06		Modern Control Theory	3	1	4
PSS21	**Elective – III & Elective – IV Basket**	Power Quality	3	0	3 + 3
PSS22		Electric Smart Grid	3	0	
PSS23		EHV AC Transmission	3	0	
PSS24		Reactive Power Compensation and Management	3	0	
PSS25		Voltage Stability	3	0	
PSS26		Power System Reliability	3	0	
PES41	**Open Elective II**	Renewable Power Generation Technologies	3	0	3
PES42		Programmable Logic Controllers and their Applications	3	0	
PSS41		Optimization Techniques	3	0	
PSS52	**Lab -2**	Power Systems Lab-II	0	3	2
PSS62		Mini Project -II	0	0	4
		Total	**18**	**6**	**27**

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING & TECHNOLOGY, HYDERABAD

M. Tech. (POWER SYSTEMS)

(R15 Regulation)

II YEAR I SEMESTER **COURSE STRUCTURE**

Subject code	Group	Subject Name	L	P	Credits
PSS63		Comprehensive Viva-Voce	0	0	4
PSS71		Internship/Dissertation Phase – I	0	0	8
Total			**0**	**0**	**12**

II YEAR II SEMESTER **COURSE STRUCTURE**

Subject code	Group	Subject Name	L	P	Credits
PSS72		Dissertation Phase – II	0	0	18
Total			**0**	**0**	**18**

VNR Vignana Jyothi Institute of Engineering & Technology, Hyderabad

I Year – I Sem M.Tech (Power Systems)	L	T/P/D	C
	3	1	4

(PSS01) ADVANCED POWER SYSTEM ANALYSIS

Prerequisites: Fundamentals in power Systems, Power System Analysis.

Course Objectives:

- To record the graph theory of the Power System Network
- To interpret the formation of Network matrices.
- To construct the necessity of load flow studies and various methods of Analysis.
- To examine short circuit analysis using Z_{Bus}.

Course Outcomes:

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

- Remember proper mathematical models for analysis.
- Conclude methodologies of load flow studies for the power network.
- Apply contingency Analysis.
- Analyze power system studies.

UNIT I:

Admittance Model and Network Calculations: Admittance Model and Network Calculations, Branch and Node Admittances, Mutually Coupled Branches in Y_{BUS} , An Equivalent Admittance Network, Modification of Y_{BUS} , Network Incidence Matrix and Y_{BUS} , Method of Successive Elimination, Node Elimination, Triangular Factorization, Sparsity and Near Optimal Ordering.

UNIT II:

Impedance Model and Network Calculations: Impedance Model and Network Calculations, the BUS Admittance and Impedance Matrices, Thevenin's Theorem and Z_{BUS} ,Algorithms for building Z_{BUS} Modification of existing Z_{BUS}, Calculation of Z_{BUS} elements from Y_{BUS}, Power Invariant Transformations, Mutually Coupled Branches in Z_{BUS}.

UNIT III:

AC and DC Load Flows: Gauss Seidel method, N-R Method, Decoupled method, fast decoupled method, comparison between power flow solutions. DC load flow.

UNIT IV:

Contingency Analysis: Z_{BUS} Method in Contingency Analysis, Adding and Removing Multiple Lines, Piecewise Solution of Interconnected Systems, Analysis of Single Contingencies, Analysis of Multiple Contingencies, Contingency Analysis of DC Model, System Reduction for Contingency and Fault Studies.

UNIT V:

Fault Analysis: Fault Analysis: Symmetrical faults-Fault calculations using Z_{BUS}- Fault calculations using Z_{BUS} equivalent circuits –Selection of circuit breakers- Unsymmetrical faults- Problems on various types of faults.

Text Books:

1. John J.Grainger and W.D. Stevenson, “Power System Analysis”- T.M.H.Edition.
2. Modern Power System Analysis – by I.J.Nagrath & D.P.Kothari Tata M Graw – Hill Publishing Company Ltd, 2nd edition.

References:

1. Power System Analysis and Design by J.Duncan Glover and M.S.Sarma., cengage 3rd Edition.
2. Olle. L.Elgard, “Electrical Energy Systems Theory”-T.M.H.Edition.
3. Power systems stability and control, Prabha Kundur, The Mc Graw – Hill companies**.**
4. Power System Operation and Control, Dr. K. Uma Rao, Wiley India Pvt. Ltd.
5. Operation and Control in Power Systems, PSR Murthy, Bs Publications.
6. Power System Operation, Robert H. Miller, Jamesh H. Malinowski, The Mc Graw – Hill companies**.**
7. Power Systems Analysis, operation and control by Abhijit Chakrabarti, Sunitha Halder, PHI 3/e , 2010

VNR Vignana Jyothi Institute of Engineering & Technology, Hyderabad

I Year – I Sem M.Tech (Power Systems)	**L**	**T/P/D**	**C**
	3	**1**	**4**

(PSS02) ADVANCED POWER SYSTEM PROTECTION

Prerequisites: Power System Protection, Switch gear Protection

Course Objectives:

- To distinguish all kinds of circuit breakers and relays for protection of Generators, Transformers and feeder bus bars from Over voltages and other hazards.
- To generalize neutral grounding for overall protection.
- To illustrate the phenomenon of Over Voltages and its classification.

Course Outcomes:

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

- Understand the basic function of a circuit breaker, all kinds of circuit breakers and differentiate fuse and circuit breakers under fault condition.
- Describe the necessity for the protection of alternators, transformers and feeder bus bars from over voltages and other hazards
- Illustrate neutral grounding, and how over voltages can be generated and how system can be protected against lightning and switching transient over voltages with various protective means
- Identify operation and control of microprocessor based relays.

UNIT I:

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.

UNIT II:

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.

Static Over Current Relays: Instantaneous over-current relay-Time over-current relays-basic principles –definite time and Inverse definite time over-current relays.

UNIT III:

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

Static Distance Relays: Static impedance-reactance–MHO and angle impedance relay-sampling comparator –realization of reactance and MHO relay using sampling comparator.

UNIT IV:

Multi-Input Comparators: Conic section characteristics-Three input amplitude comparator –Hybrid comparator-switched distance schemes –Poly phase distance schemes- phase fault scheme –three phase scheme – combined and ground fault scheme.

Power Swings: Effect of power swings on the performance of distance relays –Power swing analysis-Principle of out of step tripping and blocking relays-effect of line and length and source impedance on distance relays.

UNIT V:

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

Text Books:

1. Badri Ram and D.N.Vishwakarma, "Power system protection and Switch gear ", TMH publication New Delhi 1995.
2. T.S.Madhava Rao , "Static relays", TMH publication, second edition 1989.

References:

1. Protection and Switchgear, Bhavesh Bhalja, R. P. Mahesheari, Nilesh G. Chothani, Oxford University Press.
2. Electrical Power System Protection, C. Christopoulos and A. Wright, Springer International.

I Year – I Sem M.Tech (Power Systems)	**L**	**T/P/D**	**C**
	3	**1**	**4**

(PSS03) POWER SYSTEM OPERATION AND DEREGULATION

Prerequisites: Power System Operation and Control, Power System Analysis

Course Objectives:

- To find OPF with security constraints.
- To analyze the Linear sensitivity of the system
- To Calculate the State Estimation
- To apply the concept of deregulation and ATC.

Course Outcomes:

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

- Understand the optimal scheduling of power generation
- Analyze the System security and Contingency
- Detect and Identify the Bad measurements
- Calculate the ATC and the transmission pricing

UNIT I:

Optimal Power Flow: Introduction- Solution to the optimal power flow-gradient method-Newton's method-Linear sensitivity analysis- Linear programming methods- Security constrained OPF-Interior point algorithm- Bus incremental costs

UNIT II:

Power System Security: Introduction –Factors affecting power system security-Contingency analysis-Detection of network problems-Linear sensitivity analysis-AC power flow methods-contingency selection-concentric relaxation-Bounding area method

UNIT III:

State Estimation In Power Systems: Introduction- Power system state estimation- Maximum likelihood Weighted Least squares estimation-Matrix formulation- State estimation of AC network- State estimation by orthogonal decomposition- detection and identification of Bad measurements- Estimation of quantities not being measured- Network observability and pseudo measurements

UNIT IV:

Power System Deregulation: Introduction- motivation for restructuring of power systems-Electricity market entities model-benefits of deregulation- terminology-deregulation in Indian power sector-Operations in power markets-power pools-transmission networks and electricity markets.

UNIT V:

Available Transfer Capability: Introduction methods: of determination of ATC - ATC calculation considering the effect of contingency analysis- Transmission open access and pricing-cost components of transmission system- transmission pricing methods-Incremental cost based transmission pricing.

Text Books:

1. A.J.Wood & B.F.Woollenberg- John Wiley Power Generation, “Operation and Control”- 2^{nd} edition.
2. P.Venkatesh. B.V.Manikandan, S.Charles Raja- A.Srinivasan, “Electrical power systems: Analysis, security, Deregulation”– PHI 2012

References:

1. Bhattacharya, Kankar, Bollen, Math, Daalder, Jaap E. “Operation of Restructured Power System”, 2001, Springer.
2. Venkatesh P. , Manikandan B. V., Raja S. Charles , Srinivasan A. Electrical Power Systems: Analysis, Security And Deregulation, Phi Learning Pvt Ltd

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I Year – I Sem M.Tech (Power Systems)	**L**	**T/P/D**	**C**
	3	**0**	**3**

Elective – I and II

(PES11) H.V.D.C. TRANSMISSION

Prerequisites: Power Electronics, Power Systems

Course Objectives:

- To Comprehend the conversion principles of HVDC Transmission
- Analysis of 3,6 , 12 pulse converters, rectifier and inverter operations of HVDC converters
- To identify the different types of Harmonics and reduction by using Filters
- To Comprehend Interaction between HVAC and DC systems in various aspects
- To appreciate the reliable MTDC systems and protection of HVDC system

Course Outcomes:

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

- Find the applications of HVDC transmission in the power system with the acquired knowledge.
- Analyze different converter topologies viz. 3,6 and 12 Pulse converters and understand it's control aspects.
- Understand the filter configuration for Harmonics in HVDC systems.
- Appreciate the reliable Multi terminal HVDC system.
- Have knowledge on the Protection of HVDC systems against transient over voltages and over currents.

UNIT I:

Introduction: General consideration, Power Handling Capabilities of HVDC Lines Basic Conversion principles, static converter configuration.

UNIT II:

Static Power Converters: 3-pulse, 6-pulse, and 12-pulse converters, converter station and Terminal equipment, commutation process, Rectifier and inverter operation, equivalent circuit for converter – Analysis of VSC based HVDC system, special features of converter transformers. Harmonics in HVDC Systems, Harmonic elimination, AC and DC filters.

UNIT III:

Control of HVDC Converters and Systems: Constant current, constant extinction angle and constant ignition angle control Individual phase control and equidistant firing angle control DC power flow control. Control of VSC based HVDC system- Direct Control and Vector Control. Interaction between HV AC and DC systems – Voltage interaction Harmonic instability problems and DC power modulation.

UNIT IV:

MTDC Systems & Over Voltages: Series parallel and series parallel systems their operation and control.

Over voltages due to disturbances on DC side, over voltages due to DC and AC side line faults.

UNIT V:

Converter Faults & Protection: Converter faults, over current protection – valve group, and DC line protection over voltage protection of converters, surge arresters.

Text Books:

1. E.W. Kimbark: Direct current Transmission, Wiely Inter Science – New York
2. KR Padiyar : High Voltage Direct current Transmission Wiely Esatern Ltd New Delhi – 1992.

References:

1. J. Arillaga “HVDC Transmission”, Peter Peregrinus ltd. London UK 1983
2. E. Uhlman “Power Transmission by Direct Current”, Springer Verlag, Berlin Helberg. 1985.
3. S. Rao “EHVAC and HVDC Transmission Engg. Practice” Khanna publishers.

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I Year – I Sem M.Tech (Power Systems)	**L**	**T/P/D**	**C**
	3	**0**	**3**

Elective – I and II

(PSS11) ECONOMIC OPERATION OF POWER SYSTEMS

Prerequisites: Power System Analysis, Fundamentals in Power systems

Course Objectives:

- To acquaint with the economic operation of power system
- To provide students the knowledge of optimization techniques used in the power system
- To provide the knowledge of Hydrothermal scheduling, reactive power control.
- To provide exposure to the methods of conducting a research work

Course Outcomes:

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

- Analyze Thermal and Hydro generator characteristics and their economic operation.
- Solve the Unit Commitment problem with various constraints using conventional optimization techniques.
- Solve ELD, UC and AGC problems using Heuristic techniques.

UNIT I:

Introduction: Economic dispatch problem and methods of solutions – Economic importance – Characteristics of steam units. Economic dispatch of Thermal Units and methods of solutions – problem considering and neglecting transmission losses.

UNIT II:

Unit Commitment: Iterative and non–iterative methods of solutions – economic dispatch using dynamic programming. Unit Commitment – Definition – Constraints in Unit Commitment–Unit Commitment solution methods – Priority–List Methods – Dynamic Programming Solution. Economic dispatch versus Unit Commitment – constraints in thermal and hydro–units – hydro thermal coordination.

UNIT III:

Hydro – Thermal Scheduling: Long range and short–range hydro–scheduling – dynamic programming solution to hydro– thermal scheduling.

UNIT IV:

Automatic Generation Control: Control of generation – models of power system elements – single area and multi area block diagrams – generation control with PID controllers – implementation of Automatic Generation control (AGC) – AGC features.

UNIT V:

Different Approaches for Economic Dispatch: Economic dispatch by ANN and GA approaches.

Text Books:

1. Allen J. Wood & B.F. Woolen berg “Power Generation, Operation and Control”, Wiley India Pvt. Ltd., 2nd edition, 2006.

2. John J. Grainger and William D Stevenson “Power System Analysis”, McGraw Hill ISE, 1st edition 2003.

Reference:

1. PSR Murthy “Operation & Control in Power System”, BS Publications, 2nd edition, 2009.

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	L	T/P/D	C
I Year – I Sem M.Tech (Power Systems)	**3**	**0**	**3**

Elective – I and II

(PSS12) GAS INSULATED SYSTEMS

Prerequisites: Power Systems-I and Power Systems-II

Course Objectives:

- To know the GIS concepts and principles
- To choose Air Insulated Substation and GIS
- To demonstrate the design and constructional aspects of GIS
- To analyze transient phenomenon, problems and diagnostic methods in GIS

Course Outcomes:

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

- Know the advantages of GIS systems over air insulated systems
- Observe constructional design features of GIS design
- Discriminate the Problems and design 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- Disconnect or 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

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I Year – I Sem M.Tech (Power Systems)	**L**	**T/P/D**	**C**
	3	**0**	**3**

Elective – I and II

(PSS13) AI TECHNIQUES IN ELECTRICAL ENGINEERING

Prerequisites: Control systems, Power systems, Electrical Drives

Course Objectives:

- To locate soft commanding methodologies, such as artificial neural networks, Fuzzy logic and genetic Algorithms.
- To observe the concepts of feed forward neural networks and about feedback neural networks.
- To practice the concept of fuzziness involved in various systems and comprehensive knowledge of fuzzy logic control and to design the fuzzy control
- To analyze genetic algorithm, genetic operations and genetic mutations.

Course Outcomes:

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

- Quote feed forward neural networks and learning and understanding of feedback neural networks.
- Generalize fuzziness involved in various systems and fuzzy set theory.
- Select fuzzy logic control and design
- Examine genetic algorithm and applications in electrical engineering.

UNIT I:

Artificial Neural Networks: Introduction to AI, classification of AI techniques - Knowledge representation -Models of Neural Network - Architectures –Learning process - Learning Rules and Algorithms – Error correction learning – Hebbian learning –Competitive learning — Supervised learning – Unsupervised learning– Reinforcement learning- learning tasks.

UNIT II:

Single & Multilayer Feed Forward Neural Networks: Introduction, Perceptron Models: Training Algorithms: Importance of Perception Convergence theorem, Limitations of the Perceptron Model, Applications.

Generalized Delta Rule, Derivation of Backpropagation (BP) Training, Summary of Backpropagation Algorithm, Learning Difficulties and Improvements, Applications.

UNIT III:

Fuzzy Logic: Introduction – Fuzzy versus crisp – Fuzzy sets - Membership function – Basic Fuzzy set operations – Properties of Fuzzy sets –Operations on Fuzzy relations – Min Max operations - Fuzzification, Membership value assignment, development of rule base and decision making system, Defuzzification to crisp sets, Defuzzification methods.

UNIT IV:

Genetic Algorithms: Introduction-Encoding –Fitness Function-Reproduction operators-Genetic Modeling –Genetic operators-Crossover-Single – site crossover-Two point crossover –Multi point crossover-Uniform crossover – Matrix crossover-Crossover Rate-Inversion & Deletion – Mutation operator – Mutation –Mutation Rate-Bit-wise operators-Generational cycle-convergence of Genetic - Problems on optimization-Algorithm

UNIT V:

Applications of AI Techniques: Control and Process Monitoring, fault diagnosis and load forecasting, Function Approximation, – Load flow studies – Economic load dispatch – Load frequency control –Single area system and two area system – Position and speed control of DC and AC Motors.

Text Books:

1. S.Rajasekaran and G.A.V.Pai, "Neural Networks, Fuzzy Logic & Genetic Algorithms"-PHI, New Delhi, 2003.
2. Bart Kosko,"Neural Network & Fuzzy System" Prentice Hall, 1992.

References:

1. P.D.Wasserman,Van Nostrand Reinhold,"Neural Computing Theory & Practice" New York,1989.
2. G.J.Klir and T.A.Folger,"Fuzzy sets,Uncertainty and Information"-PHI, Pvt.Ltd,1994.
3. D.E.Goldberg," Genetic Algorithms"- Addison Wesley 1999.

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	3	**0**	**3**

Elective – I and II

(PSS14) DISTRIBUTION SYSTEM PLANNING AND AUTOMATION

Prerequisites: Electrical Distribution Systems

Course Objectives:

- To understand the Distribution system planning and Load Management
- To calculate voltage drop and Power loss
- To identify the substation Location
- To analyze the Distribution Automation

Course Outcomes:

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

- Understand and distinguish characteristics of distribution systems from transmission systems
- Design, analyze and evaluate distribution system design based on forecasted data
- Identify and select appropriate sub–station location
- Design and evaluate a distribution system for a given geographical service area from alternate design alternatives

UNIT I:

Distribution System Planning: Planning and forecasting techniques – Present and future – Role of computers.

Load Characteristics: Definitions – Load forecasting – methods of forecast – regression analysis – correlation analysis and time series analysis – Load management – tariffs and metering of energy.

UNIT II:

Distribution Transformers: Types – Three phase and single phase transformers – connections – Dry type and self protected type transformers – regulation and efficiency.

Sub Transmission Lines and Distribution Sub–Stations: Distribution substations –Bus schemes –description and comparison of switching schemes Substation location and rating.

UNIT III:

Primary Distribution Systems: Types of feeders – voltage levels – radial type feeders.

Voltage Drop and Power Loss Calculations: Three phase primary lines – Copper loss – Distribution feeder costs – Loss reduction and Voltage improvement in rural networks.

UNIT IV:

Distribution Systems Protection: Capacitors in Distribution Systems: Effects of series and shunt capacitors – justification for capacitors – Procedure to determine optimum capacitor size and location.

Distribution System Protection: Basic definitions – types of over current protection devices. Objective of distribution system protection.

UNIT V:

Distribution System Automation: Reforms in power sector – Methods of improvement – Reconfiguration – Reinforcement – Automation – Communication systems – Sensors – Automation systems – Basic architecture of Distribution automation system – software and open architecture – RTU and Data communication – SCADA requirement and application functions – GIS/GPS based mapping of Distribution networks–Communication protocols for Distribution systems – Integrated sub– station metering system – Revenue improvement – issues in multi–year tariff and availability based tariff.

Grounding: Grounding system – earth and safety – nature and sizes of earth electrodes – design – earthing schemes.

Text Books:

1. Turan Gonen, "Electric Power Distribution Engg." Mc-Graw Hill,1986.
2. A. S. PABLA, "Electric Power Distribution", TMH,2000.

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I Year – I Sem M.Tech (Power Systems)	**L**	**T/P/D**	**C**
	3	**0**	**3**

Elective – I and II

(PSS15) POWER SYSTEM TRANSIENTS

Prerequisites: Power Systems, High Voltage Engineering, Power System Protection

Course Objectives:
- To gain knowledge in the sources and effects of lightning, switching and temporary over voltages.
- Ability to model and estimate the over voltages in power system
- To coordinate the insulation of power system and protective devices.
- Ability to model and analyze power system and equipment for transient over voltages using Electromagnetic Transient Program (EMTP).

Course Outcomes:
Upon the completion of the subject, the student will be able to
- Understand the insulation co-ordination
- Calculate the parameters of lightning flash and footing resistance
- Identify the line faults
- Model Power apparatus for transient studies

UNIT I:
Lightning Overvoltages: Mechanism and parameters of lightning flash, protective shadow, striking distance, electro geometric model for lightning strike, Grounding for protection against lightning – Steady-state and dynamic tower-footing resistance, substation grounding Grid, Direct lightning strokes to overhead lines, without and with shield Wires.

UNIT II:
Switching and Temporary Overvoltages: Switching transients – concept – phenomenon – system performance under switching surges, Temporary over voltages – load rejection – line faults – Ferro resonance, VFTO.

UNIT III:
Travelling Waves on Transmission Line: Circuits and distributed constants, wave equation, reflection and refraction – behavior of travelling waves at the line terminations – Lattice Diagrams – attenuation and distortion – multi-conductor system and multi velocity waves.

UNIT IV:
Insulation Co-ordination: Classification of over voltages and insulations for insulation co-ordination–Characteristics of protective devices, applications, location of arresters – insulation co-ordination in AIS and GIS.

UNIT V:
Computation of Power System Transients: Modeling of power apparatus for transient studies – principles of digital computation – transmission lines, cables, transformer and rotating machines – Electromagnetic Transient program – case studies: line with short and open end, line terminated with R, L, C, transformer, and typical power system case study: simulation of possible over voltages in a high voltage substation.

Text Books:

1. Pritindra Chowdhari, “Electromagnetic transients in Power System”, John Wiley and Sons Inc., Second Edition, 2009.
2. Allan Greenwood, “Electrical Transients in Power System”, Wiley & Sons Inc. New York, 2012.

References:

1. Klaus Ragaller, “Surges in High Voltage Networks”, Plenum Press, New York, 1980.
2. Rakosh Das Begamudre, “Extra High Voltage AC Transmission Engineering”, (Second edition) Newage International (P) Ltd., New Delhi, 2006.
3. Naidu M S and Kamaraju V, “High Voltage Engineering”, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.

I Year – I Sem M.Tech (Power System)	**L**	**T/P/D**	**C**
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Open Elective I

(PES31) MICROCONTROLLERS AND APPLICATIONS

Course Objectives:

- To relate the basic architecture and addressing modes of a stored-program computer.
- To summarize the principles of top down design to microcontroller software development
- To demonstrate assembly language programs for the advanced Microcontroller , assembly language code for high-level language structures such as IF-THEN-ELSE and DO-WHILE
- To analyze a typical I/O interface and to discuss timing issues
- To identify different types of memory used in microcontroller systems

Course Outcomes:

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

- Distinguish Types of computers & microcontrollers
- Construct Real time Applications of Microcontrollers.
- Demonstrate RTOS for Microcontrollers.
- Translate Hardware applications using Microcontrollers.

UNIT I:

Overview and Architecture of 8051 Resources: Architecture of a microcontroller – Microcontroller resources – 8051 microcontroller – Internal and External memories – Counters and Timers – Synchronous serial-cum asynchronous serial communication

UNIT II:

8051- Microcontrollers Instruction Set: Basic assembly language programming – Data transfer instructions – Data and Bit-manipulation instructions – Arithmetic instructions – Instructions for Logical operations on the test among the Registers, Internal RAM, and SFRs – Program flow control instructions – Interrupt control flow.

UNIT III:

8051 Real Time Control: Interrupt handling structure of an MCU – Interrupt Latency and Interrupt deadline– Multiple sources of the interrupts – Non-mask able interrupt sources – Enabling or disabling of the sources – Polling to determine the interrupt source and assignment of the priorities among them – Interrupt structure in Intel 8051.

UNIT IV:

Systems Design Digital and Analog Interfacing Methods: Switch, Keypad and Keyboard interfacings – LED and Array of LEDs, ADC and DAC Interfacing to 8051 – Programmable instruments interface using IEEE 488 Bus – Interfacing with the Flash Memory – Optical motor shaft encoders – Industrial control – Industrial process control system – Prototype MCU based Measuring instruments – Robotics and Embedded control

UNIT V:

Real Time Operating System & ARM7: Real Time operating system – RTOS of Keil (RTX51) – Use of RTOS in Design – Software development tools for Microcontrollers.

ARM7: Introduction to 32 bit processors – ARM architecture and organization – ARM / Thumb programming model – ARM / Thumb instruction set – Development tools.

Text Books:

1. Raj Kamal,” Microcontrollers Architecture, Programming, Interfacing and System Design”– Pearson Education, 2005.
2. Mazidi and Mazidi, “The 8051 Microcontroller and Embedded Systems” – PHI, 2000.

References:

1. A.V. Deshmuk, “Microcontrollers (Theory & Applications)” – WTMH, 2005.
2. John B. Peatman, “Design with PIC Microcontrollers” – Pearson Education, 2005.
3. Microcontroller Programming, Julio Sanchez, Maria P. Canton, CRC Press.
4. The 8051 Microcontroller, Ayala, Cengage Learning.
5. Microprocessors and Microcontrollers, Architecture, Programming and System Design, Krishna Kant, PHI Learning PVT. Ltd.
6. Microprocessors, Nilesh B. Bahadure, PHI Learning PVT. Ltd.

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Open Elective-I

(PSS31) ENERGY AUDITING, CONSERVATION AND MANAGEMENT

Course Objectives:

- To know the necessity of conservation of energy
- To generalize the methods of energy management
- To illustrate the factors to increase the efficiency of electrical equipment
- To detect the benefits of carrying out energy audits.

Course Outcomes:

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

- Tell energy audit of industries
- Predict management of energy systems
- Sequence the methods of improving efficiency of electric motor
- Analyze the power factor and to design a good illumination system
- Determine pay back periods for energy saving equipment

UNIT I:

Basic Principles of Energy Audit: Energy audit- definitions, concept , types of audit, energy index, cost index ,pie charts, Sankey diagrams, load profiles, Energy conservation schemes- Energy audit of industries- energy saving potential, energy audit of process industry, thermal power station, building energy audit.

UNIT II:

Energy Management: Principles of energy management, organizing energy management program, initiating, planning, controlling, promoting, monitoring, reporting- Energy manager, Qualities and functions, language, Questionnaire – check list for top management.

UNIT III:

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:

Power Factor Improvement, Lighting and Energy Instruments: Power factor – methods of improvement, location of capacitors, Pf with non linear loads, effect of harmonics on power factor, power factor motor controllers - Good lighting system design and practice, lighting control, lighting energy audit - Energy Instruments- wattmeter, data loggers, thermocouples, pyrometers, Lux meters, tongue testers, application of PLC's.

UNIT V:

Economic Aspects and Analysis: Economics Analysis-Depreciation Methods, time value of money, rate of return , present worth method , replacement analysis, life cycle costing analysis- Energy efficient motors- calculation of simple payback method, net present worth method- Power factor correction, lighting - Applications of life cycle costing analysis, return on investment .

Text Books:

1. W.R. Murphy, G. Mckay Butter worth, “Energy management”, Heinemann publications.
2. Paul o’ Callaghan, “Energy management”, Mc-graw Hill Book company-1st edition, 1998

References:

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

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I Year – I Sem M.Tech (Power Systems)	**L**	**T/P/D**	**C**
	3	**0**	**3**

Open Elective-I

(PES32) ADVANCED DIGITAL SIGNAL PROCESSING

Course Objectives:

- To have an overview of signals and systems and DFT & FFT Transforms.
- To study the design of IIR & FIR filters.
- To study the applications of DSP techniques in processors.

Course Outcome:

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

- Understand types of digital signals and Transforms and its application to signals and systems.
- Design of IIR & FIR filters.
- Understand different DSP processors and basic programming skills.

UNIT I:

Review of Discrete Time Systems: Discrete time Signals-Sequences –Stability and Causality – Frequency domain Representation of Discrete time Systems and Signals –Two-dimensional Sequences and Systems –Z-Transform –Z Transform Theorems and Properties –Two-dimensional Z Transform. Structures for discrete time system – Direct, cascade and parallel forms –Lattice structure.

UNIT II:

Discrete Fourier Transform: Representation of Periodic Sequences-the Discrete Fourier Series –Properties of the discrete Fourier series –Sampling, Z-transform –discrete Fourier transform – properties of discrete Fourier Transform –Linear Convolution –Decimation –in- Time and Decimation in- Frequency –FFT Algorithms

UNIT III:

Digital Filter Design Techniques: Introduction – Design of IIR Digital Filters from Analog Filters –Analog –Digital Transformation –Properties of FIR Digital Filters –Design of FIR Filters Using Windows –A Comparison of IIR and FIR Digital Filters.

UNIT IV:

Finite Register Length Effects: Introduction - Effects of coefficient on Quantization – Quantization in Sampling -Analog Signals- Finite Register Length effects in realizations of Digital Filters – discrete Fourier Transform Computations.

UNIT V:

Advanced DSP Processors: Commercial DSP devices – TMS C240 processor, TMS320C, ADSP 2181 processor – Architecture – Addressing modes – Program control – Instruction and programming –Simple programs.

Text Books:

1. Emmanuel C. Ifeachor, Barrie W. Jervis, "Digital Signal Processing: A Practical Approach", Pearson Education India Series, New Delhi, 2nd Edition, 2004

2. Sanjit K Mitra, "Digital Signals Processing: A Computer Based Approach", Tata McGraw-Hill Publishing Company Limited, New Delhi 2nd Edition, 2004.

References:

1. Alan Oppenheim. V and Ronald W.Schafer, "Digital Signal Processing", Prentice Hall of India Private.Limited. New Delhi,2ndEdition 1989.
2. John G. Proakis and Manolakis. D.G, "Digital Signal Processing: Principles Algorithms and Applications," Prentice Hall of India, New Delhi, 2004.
3. Avatar Singh and Srinivasan. S , " Digital Signal Processing: Implementation using DSP Microprocessors with Examples from TMS 320C54XX, Thompson Brooks/Cole,Florence, USA 2004.

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	0	3	2

(PSS51) POWER SYSTEM LAB – I

Prerequisites: Power System Analysis, Power System Reliability, Voltage Stability

Course Objectives:

- Develop Programs for Power System Analysis.
- Design models for Power Systems and Power Electronics.
- Develop Programs of Power System Reliability and Power Electronics.

Course Outcomes:

Upon the completion of the lab, the student will be able to Understand/Simulate/Analyze

- Power System Analysis using Software.
- Models of Power Systems and Power Electronics.
- Programs of Power System Reliability and Power Electronics.

List of experiments:

The following experiments are to be conducted by using suitable software

1. Formation of Y_{BUS}.
2. Load Flow Analysis with GS Method.
3. N-R method Load Flow Analysis
4. FDLF Load Flow Analysis.
5. Fault Analysis of a power system
6. Short Circuit Analysis.
7. Transient Stability Analysis for Single Machine connected to Infinite Bus by Point by Point Method.
8. Evaluation of generating system Reliability.
9. Evaluation of distribution system Reliability.
10. Contingency Analysis of IEEE test System.
11. Simulation of Single Phase Full Converter with RLE Load
12. Closed Loop Speed Control of Separately Excited D.C Motor.
13. Sinusoidal Pulse Width Modulation.
14. Formation of Z_{BUS} using addition of branch and line algorithm.

Any Ten of the above experiments are to be conducted.

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	0	**0**	**4**

(PSS61) MINI PROJECT – I

Course Objectives:

- To improve the capability of surveying for required literature.
- To inculcate the design ability of electrical systems
- To enhance the skills of fabricating the hardware projects
- To correlate the experimental results with theoretical/designed data.

Course Outcomes:

Upon the completion of the Mini Project, the student will be able to

- Carry out Literature study and give problem statement
- Select Control Strategy, design methodology and develop a suitable model for the chosen problem
- Execute and validate the Model
- Communicate effectively
- Write a technical report

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I Year – II Sem M.Tech (Power Systems)	L	T/P/D	C
	3	1	4

(PSS04) POWER SYSTEM DYNAMICS

Prerequisites: Electrical Power Systems, Electrical machines, Power System Analysis

Course Objectives:

- To remember the dynamic characteristics of power system equipment,
- To recognize dynamic performance of power systems
- To illustrate the system stability and controls.

Course Outcomes:

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

- Choose the fundamental dynamic behavior and controls of power systems to perform basic stability analysis.
- Comprehend concepts in modeling and simulating the dynamic phenomena of power systems
- Interpret results of system stability studies
- Analyze theory and practice of modeling main power system components, such as synchronous machines, excitation systems and governors

UNIT I:

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:

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:

Excitation System: Excitation system modeling-excitation systems block Diagram - system representation by state equations- Dynamics of a synchronous generator connected to infinite bus - system model Synchronous machine model-stator equations rotor equations - Synchronous machine model with field circuit - one equivalent damper winding on q axis (model 1.1) - calculation of Initial conditions.

UNIT IV:

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:

Application of Power System Stabilizers: Basic concepts in applying PSS - Control signals - Structure and tuning of PSS - Washout circuit - Dynamic compensator analysis of single machine infinite bus system with and without PSS.

Text Books:

1. K.R. Padiyar," Power system dynamics "- B.S. Publications.
2. P.M. Anderson and A.A. Fouad, "Power system control and stability",IEEE Press

References:

1. R. Ramanujam, "Power Systems Dynamics"- PHI Publications.

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I Year – II Sem M.Tech (Power Systems)	L	T/P/D	C
	3	1	4

(PSS05) FLEXIBLE A.C. TRANSMISSION SYSTEMS

Prerequisites: Power Electronics, Power Systems, Reactive power control

Course Objectives:

- Students should Comprehend the fundamentals of FACTS Controllers, Importance of controllable parameters and types of FACTS controllers & their benefits
- To outline Objectives of Shunt and Series compensation
- To relate to the Control of STATCOM and SVC and their comparison And the regulation of STATCOM
- To explain Functioning and control of GCSC, TSSC and TCSC

Course Outcomes:

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

- Analyze the Power and control circuits of Series Controllers GCSC, TSSC and TCSC.
- Select proper controller for the specific application based on the system requirements.
- Comprehend various systems thoroughly and their requirements
- Understand the control circuits of Shunt Controllers SVC & STATCOM for various functions viz. Transient stability
- Enhancement, voltage instability prevention and power oscillation damping.

UNIT I:

Facts Concepts: Transmission interconnections power flow in an AC system- loading capability limits- Dynamic stability considerations- importance of controllable parameters basic types of FACTS controllers- benefits from FACTS controllers.

UNIT II:

Voltage Source Converters: Single phase three phase full wave bridge converters transformer connections for 12 pulse 24 and 48 pulse operation- Three level voltage source converter-pulse width modulation converter, basic concept of current source Converters- comparison of current source converters with voltage source converters.

UNIT III:

Static Shunt Compensation: Objectives of shunt compensation- midpoint voltage regulation voltage instability prevention- improvement of transient stability- Power oscillation damping- Methods of controllable var generation- variable impedance type static var generators switching converter type var generators hybrid var generators.

UNIT IV:

SVC and Statcom: The regulation and slope transfer function and dynamic performance- transient stability enhancement and power oscillation damping - operating point control - summary of compensator control.

UNIT V:

Static Series Compensators: Concept of series capacitive compensation- improvement of transient stability- power oscillation damping-Functional requirements- GTO thyristor controlled series capacitor (GSC)- thyristor switched series capacitor (TSSC)-Thyristor Controlled Series Capacitor(TCSC) - control schemes for GSC, TSSC and TCSC.

Text Books:

1. N.G. Hingorani and L. Guygi, "Understanding FACTS Devices" IEEE Press Publications 2000.
2. Padiyar, K. R. "FACTS Controllers in Power Transmission and Distribution" New Age International Publications, 2007.

References:

1. Enrique Acha, "FACTS: modelling and simulation in power networks", Wiley Publishers.
2. Hug song, "Flexible AC transmission system", Wiley and Interline Publishers.
3. Bikash Pal, "Flexible AC transmission system: Modelling and control", Springer Publishers.
4. Zhang, Xiao – Ping, Rehtanz, Christian, Pal, Bikash "FlexibleAC Transmission Systems: Modelling and Control", Springer, 2012.
5. Yong – Hua Sng, Allan Johns, "Flexible AC Transmission Systems", IET, 1999.

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I Year – II Sem M.Tech (Power Systems)	**L**	**T/P/D**	**C**
	3	**1**	**4**

(PES06) MODERN CONTROL THEORY

Prerequisites: Linear Control Systems, Digital Control Systems

Course Objectives:

- To remember basic and digital control system for the real time analysis and design of control systems.
- To define discrete systems in state variable analysis
- To practice stability analysis and design of discrete time systems.
- To analyze the stability, phase plane trajectories of non linear systems.

Course Outcomes:

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

- Define concept of Digital Control Systems.
- Explain discrete systems in state variable analysis.
- Apply the concepts of stability analysis and design of discrete time systems.
- Investigate optimal control.
- Evaluate the stability analysis of Non linear systems.

UNIT I:

Mathematical Preliminaries: Fields, Vectors and Vector Spaces – Linear combinations and Bases – Linear Transformations and Matrices – Scalar Product and Norms – Eigen-values, Eigen Vectors and a Canonical form representation of Linear operators – The concept of state – State Equations for Dynamic systems – Time invariance and Linearity – Non-uniqueness of state model – State diagrams for Continuous-Time State models.

UNIT II:

State Variable Analysis: Linear Continuous time models for Physical systems– Existence and Uniqueness of Solutions to Continuous-Time State Equations – Solutions of Linear Time Invariant Continuous-Time State Equations – State transition matrix and its properties. General concept of controllability – General concept of Observability – Controllability tests for Continuous-Time Invariant Systems – Observability tests for Continuous-Time Invariant Systems – Controllability and Observability of State Model in Jordan Canonical form – Controllability and Observability Canonical forms of State model.

UNIT III:

Non Linear 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 – Stability analysis of Non-Linear systems through describing functions. Introduction to phase-plane analysis, Method of Isoclines for Constructing Trajectories, singular points, phase-plane analysis of nonlinear control systems.

UNIT IV:

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 – Generation of Lyapunov functions – Variable gradient method – Krasooviski’s method. State feedback controller design through Pole Assignment – State observers: Full order and Reduced order.

UNIT V:

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

Text Books:

1. Modern Control System Theory by M.Gopal – New Age International -1984
2. Modern Control Engineering by Ogata.K – Prentice Hall - 1997

References:

1. Kirks D.E., 'Optimal Control Theory – An introduction', Prentice hall, N.J., 1970.
2. Digital Control Sysetms, Kuo, Oxford University Press, 2nd Edition, 2003
3. Applied non-linear control : J.E.Slotine &W.P.Li; Prentice Hall, USA,

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I Year – II Sem M.Tech (Power System)	**L**	**T/P/D**	**C**
	3	**0**	**3**

Elective – III and IV

(PSS21) POWER QUALITY

Prerequisites: Analysis of power electronic converters, Power systems

Course Objectives:

- Definition of power quality and different terms of power quality.
- Study of voltage power quality issue - short and long interruption
- Detail study of characterization of voltage sag magnitude and three phase unbalanced voltage sag.
- Know the behavior of power electronics loads; induction motors, synchronous motor etc by the power quality issues
- Overview of mitigation of power quality issues by the VSI converters.

Course Outcomes:

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

- Know the severity of power quality problems in distribution system;
- Understand the concept of voltage sag transformation from up-stream (higher voltages) to down-stream (lower voltage);
- Concept of improving the power quality to sensitive load by various mitigating custom power devices;

UNIT I:

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

UNIT II:

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

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

UNITIII:

Voltage Sag – Characterization – Single Phase: Voltage sag – definition, causes of voltage sag, voltage sag magnitude, monitoring, theoretical calculation of voltage sag magnitude, voltage sag calculation in non-radial systems, meshed systems- voltage sag duration.

Voltage sag – Characterization – Three Phase: Three phase faults, phase angle jumps, magnitude and phase angle jumps for three phase unbalanced sags, load influence on voltage sags.

UNIT IV:

PQ Considerations in Industrial Power Systems: Voltage sag – equipment behavior of Power electronic loads, induction motors, synchronous motors, computers, consumer electronics, adjustable speed AC drives and its operation. Mitigation of AC Drives, adjustable speed DC drives and its operation, mitigation methods of DC drives. Harmonics, Harmonics indices, Inter harmonics, Notching – Voltage vs Current distortion – Harmonics vs Transients – Sources and effects of harmonic distortion – System response characteristics – Principles of controlling harmonics – Standards and limitation – Mitigation and control techniques.

UNIT V:

Mitigation of Interruptions and Voltage Sags: Overview of mitigation methods – from fault to trip, reducing the number of faults, reducing the fault learning time changing the power system, installing mitigation equipment, improving equipment immunity, different events and mitigation methods. System equipment interface – voltage source converter, series voltage controller, shunt controller, combined shunt and series controller.

Power Quality and EMC Standards: Introduction to standardization, IEC Electromagnetic compatibility standards, European voltage characteristics standards, PQ surveys.

Text Books:

1. "Understanding Power Quality Problems" by Math H J Bollen. IEEE Press.
2. Roger C. Durgan, Mark F. McGranaghan and H.Wayne Beaty, "Electrical Power Systems Quality", Tata McGraw-Hill, 2nd Edition, New York, 2008

References:

1. Sankaran.C, "Power Quality", CRC Press, Washington D.C., 2002.
2. G.T. Heydt, 'Electric Power Quality', 2nd Edition. West Lafayette, IN, Stars in a Circle Publications, 1994.
3. Power Quality VAR Compensation in Power Systems, R. SastryVedamMulukutla S. Sarma,CRC Press.
4. A Ghosh, G. Ledwich, Power Quality Enhancement Using Custom Power Devices. Kluwer Academic, 2002

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I Year – II Sem M.Tech (Power Systems)

L	T/P/D	C
3	0	3

Elective – III and IV

(PSS22) ELECTRIC SMART GRID

Prerequisites: Electrical Distribution Systems, Power Systems

Course Objectives:

- To group various aspects of the smart grid
- To defend smart grid design to meet the needs of a utility
- To select issues and challenges that remain to be solved
- To analyze basics of electricity, electricity generation, economics of supply and demand, and the various aspects of electricity market operations in both regulated and deregulated environment.

Course Outcomes:

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

- Recite the structure of an electricity market in either regulated or deregulated market conditions.
- Understand the advantages of DC distribution and developing technologies in distribution
- Discriminate the trade-off between economics and reliability of an electric power system.
- Differentiate various investment options (e.g. generation capacities, transmission, renewable, demand-side resources, etc) in electricity markets.
- Analyze the development of smart and intelligent domestic systems.

UNIT I:

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:

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 Smart grid: Introduction- Launching intelligrid- Intelligrid today- Smart grid vision based on the intelligrid architecture-Barriers and enabling technologies. SCADA, synchro phasors (WAMS)

UNIT III:

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:

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:

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

Text Books:

1. Clark W Gellings, "The Smart Grid, Enabling Energy Efficiency and Demand Side Response"- CRC Press, 2009.
2. Jean Claude Sabonnadiere, NouredineHadjsaid, "Smart Grids", Wiley-ISTE, IEEE Press, May 2012

References:

1. JanakaEkanayake, KithsiriLiyanage,Jianzhong.Wu, Akihiko Yokoyama, Nick Jenkins, "Smart Grid: Technology and Applications"- Wiley, 2012.
2. James Momoh, "Smart Grid :Fundamentals of Design and Analysis"-Wiley, IEEE Press, 2012.

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	L	T/P/D	C
I Year – I sem M.Tech (Power System)	**3**	**0**	**3**

(PSS23) EHV AC TRANSMISSION
(Elective-I)

Prerequisites: High Voltage Engineering, Power Systems

Course Objectives:

- To identify the different aspects of Extra High Voltage A.C and D.C Transmission design and Analysis
- To understand the importance of modern developments of E.H.V and U.H.V transmission systems.
- To demonstrate EHV ac transmission system components, protection and insulation level for over voltages.

Course Outcomes:

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

- List the necessity of EHV AC transmission, choice of voltage for transmission, line losses and power handling capability.
- Estimate the Statistical procedures for line designs, scientific and engineering principles in power systems.
- Construct commercial transmission system.

UNIT I:

E.H.V.A.C. Transmission line trends and preliminary aspect standard transmission voltages – Estimation at line and ground parameters-Bundle conductor systems-Inductance and Capacitance of E.H.V. lines – positive, negative and zero sequence impedance – Line Parameters for Modes of Propagation.

UNIT II:

Electrostatic field and voltage gradients – calculations of electrostatic field of AC lines – effect of high electrostatic field on biological organisms and human beings - surface voltage gradients and maximum gradients of actual transmission lines – voltage gradients on sub conductor.

UNIT III:

Electrostatic induction in unenergized lines – measurement of field and voltage gradients for three phase single and double circuit lines – un energized lines. Power Frequency Voltage control and over-voltages in EHV lines: No load voltage – charging currents at power frequency-voltage control – shunt and series compensation – static VAR compensation.

UNIT IV:

Corona in E.H.V. lines – Corona loss formulae- attention of traveling waves due to Corona – Audio noise due to Corona, its generation, characteristic and limits. Measurements of audio noise radio interference due to Corona - properties of radio noise – frequency spectrum of RI fields – Measurements of RI and RIV.

UNIT V:

Design of EHV lines based on steady state and transient limits - EHV cables and their characteristics.

Text Books:

1. R. D. Begamudre ,"EHVAC Transmission Engineering", New Age International (p) Ltd. 3rd Edition.
2. K.R. Padiyar, "HVDC Power Transmission Systems" New Age International (p) Ltd. 2nd revised Edition, 2012.

References:

1. S. Rao "EHVAC and HVDC Transmission Engg. Practice" Khanna publishers.
2. Arrillaga.J " High Voltage Direct Current Transmission" 2nd Edition (London) peter Peregrines, IEE, 1998.
3. Padiyar.K.R, " FACTS Controllers in Power Transmission and Distribution" New Age Int. Publishers, 2007.
4. Hingorani H G and Gyugyi. L " Understanding FACTS-Concepts and Technology of Flexible AC Transmission Systems" New York, IEEE Press, 2000.

I Year – II Sem M.Tech (Power Systems)

L	T/P/D	C
3	0	3

Elective – III and IV

(PSS24) REACTIVE POWER COMPENSATION AND MANAGEMENT

Prerequisites: Flexible AC Transmission Systems, Electrical Distribution Systems

Course Objectives:
- To identify the necessity of reactive power compensation
- To describe load compensation
- To select various types of reactive power compensation in transmission systems
- To contrast reactive power coordination system
- To characterize distribution side and utility side reactive power management.

Course Outcomes:
Upon the completion of the subject, the student will be able to
- Distinguish the importance of load compensation in symmetrical as well as un symmetrical loads
- Observe various compensation methods in transmission lines
- Construct model for reactive power coordination
- Distinguish demand side reactive power management & user side reactive power management

UNIT I:
Load Compensation: Objectives and specifications – reactive power characteristics – inductive and capacitive approximate biasing – Load compensator as a voltage regulator – phase balancing and power factor correction of unsymmetrical loads- examples.

UNIT II:
Steady – State Reactive Power Compensation In Transmission System: Uncompensated line – types of compensation – Passive shunt and series and dynamic shunt compensation –examples
Transient State Reactive Power Compensation in Transmission Systems:
Characteristic time periods – passive shunt compensation – static compensations- series capacitor compensation –compensation using synchronous condensers – examples

UNIT III:
Reactive Power Coordination: Objective – Mathematical modeling – Operation planning – transmission benefits – Basic concepts of quality of power supply – disturbances- steady –state variations – effects of under voltages – frequency –Harmonics, radio frequency and electromagnetic interferences

UNIT IV:
Demand Side Management: Load patterns – basic methods load shaping – power tariffs- kVar based tariffs penalties for voltage flickers and Harmonic voltage levels
Distribution side Reactive power Management: System losses –loss reduction methods – examples – Reactive power planning – objectives – Economics Planning capacitor placement – retrofitting of capacitor banks

UNIT V:

User Side Reactive Power Management: KVAR requirements for domestic appliances – Purpose of using capacitors – selection of capacitors – deciding factors – types of available capacitor, characteristics and Limitations

Reactive Power Management in Electric Traction Systems and Arc Furnaces:
Typical layout of traction systems – reactive power control requirements – distribution transformers- Electric Arc furnaces – basic operations- furnaces transformer –filter requirements – remedial measures –power factor of an Arc furnace

Text Books:

1. Reactive power control in Electric power systems by T.J.E.Miller, John Wiley and sons, 1982.
2. Reactive power Management by D.M.Tagare,Tata McGraw Hill,2004.

References:

1. Wolfgang Hofmann, Jurgen Schlabbach, Wolfgang Just “Reactive Power Compensation: A Practical Guide, April, 2012, Wiely publication.

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I Year – II Sem M.Tech (Power Systems)	L	T/P/D	C
	3	0	3

Elective – III and IV

(PSS25) VOLTAGE STABILITY

Prerequisites: Power System Analysis, Power System Operation

Course Objectives:

- To analyze the concepts of Power System Stability, Security and Assessment methods
- To understand the Reactive Power Control in Generation/Transmission Interconnected Networks
- To assess the methods for Voltage Stability Indices(L,VCPI) and Graphical Methods P-V Q-V Curves-Analysis
- To improve the Controlling and Compensation Methods of Voltage Stability

Course Outcomes:

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

- Understand the Issues related to Q-Control, PS load models, angle, voltage stability and control.
- Analyze Voltage Stability Indices (L,VCPI) and Graphical Methods P-V Q-V Curves
- Implement Prevention of Voltage Collapse, Power System Security and Compensation Methods.

UNIT I:

Introduction to Voltage Stability: Definitions: Voltage Stability, Voltage Collapse, Voltage Security; Physical relation indicating dependency of voltage on reactive power flow; Factors affecting Voltage collapse and instability; Previous cases of voltage collapse incidences.

UNIT II:

Graphical Analysis of Voltage Stability: Comparison of Voltage and angular stability of the system; Graphical Methods describing voltage collapse phenomenon: P-V and Q-V curves; detailed description of voltage collapse phenomenon with the help of Q-V curves.

UNIT III:

Analysis of Voltage Stability: Analysis of voltage stability on SMLB system: Analytical treatment and analysis.

Voltage Stability Indices: Voltage collapse proximity indicator - Determinant of Jacobin as proximity indicators- Voltage stability margin.

UNIT IV:

Power System Loads: Loads that influences voltage stability: Discharge lights, Induction Motor, Air-conditioning, heat pumps, electronic power supplies, OH lines and cables.

Reactive Power Compensation: Generation and Absorption of reactive power- Series and Shunt compensation- Synchronous condensers- SVCs- OLTCs - Booster Transformers.

UNIT V:

Voltage Stability Margin: Stability Margin: Compensated and un-compensated systems.

Voltage Security: Definition; Voltage security; Methods to improve voltage stability and its practical aspects.

Text Books:

1. "Performance, operation and control of EHV power transmission system"-A.Chakrabarthy, D.P. Kothari and A.K.Mukhopadyay, A.H.Wheeler Publishing, I Edition, 1995.
2. "Power System Dynamics: Stability and Control" – K.R.PADIYAR, II
3. Edition, B.S.Publications.

References:

1. "Power System Voltage Stability"- C.W.TAYLOR, Mc Graw Hill, 1994.

I Year – II Sem M.Tech (Power Systems)

L	T/P/D	C
3	0	3

Elective – III and IV

(PSS26) POWER SYSTEM RELIABILITY

Prerequisites: Mathematics, Power Systems-I & II, Distribution systems, Power System Protection.

Course Objectives:

- To identify the generation system model and recursive relation for capacitive model building
- To calculate the equivalent transitional rates, cumulative probability and cumulative frequency
- To classify the risk, system and load point reliability indices
- To evaluate the basic reliability indices

Course Outcomes:

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

- Find loss of load and energy indices for generation systems model
- Describe merging generation and load models
- Apply various indices for distribution systems

UNIT I:

Generating System Reliability Analysis – I: Generation system model – capacity outage probability tables – Recursive relation for capacitive model building – sequential addition method – unit removal – Evaluation of loss of load and energy indices – Examples.

UNIT II:

Generating System Reliability Analysis – II: Frequency of encountering a state – Evaluation of equivalent transitional rates, cumulative probability and cumulative frequency of identical generating units using two component repairable model – 2- level daily load representation - merging of generation and load models – Examples.

UNIT III:

Operating Reserve Evaluation: Basic concepts - risk indices – PJM methods –– Modeling of rapid start and hot reserve units using STPM approach - security function approach.

Bulk Power System Reliability Evaluation: Basic configuration – conditional probability approach – system and load point reliability indices – weather effects on transmission lines – Weighted average rate and Markov model – Common Mode Failures in two component repairable System

UNIT IV:

Inter Connected System Reliability Analysis: Probability array methods in two inter connected systems -Factors affecting the emergency assistance through the interconnections- Reliability evaluation in three interconnected systems.

Distribution System Reliability Analysis – I (Radial configuration): Basic evaluation Techniques of Radial networks – Evaluation of Basic reliability indices and additional interruption indices– Examples.

UNIT V:

Distribution System Reliability Analysis - II (Parallel Configuration): Basic evaluation techniques – inclusion of bus bar failures, scheduled maintenance – temporary and transient failures – weather effects - inclusion of breaker failures.

Substations and Switching Stations: Effects of short-circuits and breaker operation – Open and Short-circuit failures – Active and Passive failures

Text Books:

1. Reliability Evaluation of Power systems by R. Billinton, R.N.Allan, BS Publications, 2007.
2. Reliability Modeling in Electric Power Systems by J. Endrenyi, John Wiley and Sons, 1978

References:

1. Reliability Engineering: Theory and Practice by Alessandro Birolini, Springer Publications.
2. V. Sankar, System reliability concepts, Himalaya Publishing house, 2015.
3. An Introduction to Reliability and Maintainability Engineering by Charles Ebeling, TMH Publications.
4. Reliability Engineering by E. Balaguruswamy, TMH Publications.
5. Reliability Engineering by Elsayed A. Elsayed, Prentice Hall Publications.

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I Year –II Sem M.Tech (Power Systems)	**L**	**T/P/D**	**C**
	3	**0**	**3**

Open Elective-II

(PES41) RENEWABLE POWER GENERATION TECHNOLOGIES

Course Objectives:

- To recognize the awareness of energy conservation in students
- To identify the use of renewable energy sources for electrical power generation
- To collect different energy storage methods
- To detect about environmental effects of energy conversion

Course Outcomes:

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

- Find different renewable energy sources to produce electrical power
- estimate the use of conventional energy sources to produce electrical energy
- role-play the fact that the conventional energy resources are depleted
- arrange Store energy and to avoid the environmental pollution

UNIT I:

Photo Voltaic Power Generation: Photo voltaic power generation ,spectral distribution of energy in solar radiation, solar cell configurations, voltage developed by solar cell, photo current and load current, practical solar cell performance, commercial photo voltaic systems, test specifications for PV systems, applications of super conducting materials in electrical equipment systems.

UNIT II:

MHD Power Generation and Wind Energy: Principles of MHD power generation, ideal MHD generator performance, practical MHD generator, MHD technology.

Wind Energy conversion: Power from wind, properties of air and wind, types of wind Turbines, operating characteristics.

UNIT III:

Tidal Power and Wave Energy: Tides and tidal power stations, modes of operation, tidal project examples, turbines and generators for tidal power generation.

Wave Energy Conversion: properties of waves and power content, vertex motion of Waves, device applications. Types of ocean thermal energy conversion systems Application of OTEC systems examples,

UNIT IV:

Storage Systems: Energy Storage Parameters – Lead–Acid Batteries – Ultra capacitors – Flywheels – superconducting Magnetic Storage System – Pumped Hydroelectric Energy Storage – Compressed Air Energy Storage –Storage Heat –Energy Storage as an Economic Resource

UNIT V:

Fuel Cells: Types of fuel cells, H_2-O_2 Fuel cells, Application of fuel cells – Batteries, Description of batteries, Battery application for large power. Environmental effects of energy conversion systems, pollution from coal and preventive measures steam stations and pollution, pollution free energy systems.

Text Books:

1. "Energy conversion systems" by Rakosh das Begamudre, New age International publishers, New Delhi - 2000.
2. "Renewable Energy Resources" by John Twidell and Tony Weir, 2nd Edition, Fspon & Co.

References:

1. "Understanding Renewable Energy Systems" by Volker Quaschning, 2005, UK.
2. "Renewable Energy Systems-Advanced Conversion, Technologies & Applications" by Faner Lin Luo Honer Ye, CRC press, Taylor & Francies group.
3. Felix A. Farret, M. GodoySimoes,Integration of Alternative Sources of Energy, John Wiley & Sons, 2006.
4. Remus Teodorescu, Marco Liserre, Pedro Rodríguez,Grid Converters for Photovoltaic and Wind Power Systems,John Wiley & Sons, 2011.
5. Gilbert M. Masters, Renewable and Efficient Electric Power Systems, John Wiley & Sons

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I Year – II Sem M.Tech (Power Electronics)	L	T/P/D	C
	3	0	3

Open Elective-II

(PES42) PROGRAMMABLE LOGIC CONTROLLERS AND THEIR APPLICATIONS

Prerequisite: None

Course Objectives:

- It is to provide and ensure a comprehensive understanding of using advanced controllers in measurement and control instrumentation.
- To illustrate about data acquisition - process of collecting information from field instruments.
- To analyze Programmable Logic Controller (PLC), IO Modules and internal features.
- To Comprehend Programming in Ladder Logic, addressing of IO.
- To apply PID and its Tunning.

Course Outcomes:

- Describe the main functional units in a PLC and be able to explain how they interact.
- Know different bus types used in automation industries.
- Develop ladder logic programming for simple processes.

UNIT I:
PLC Basics: PLC system, I/O modules and interfacing, CPU processor, programming equipment, programming formats, construction of PLC ladder diagrams, devices connected to I/O modules.

UNIT II:
PLC Programming: Input instructions, outputs, operational procedures, programming examples using contacts and coils. Drill press operation.
Digital logic gates, programming in the Boolean algebra system, conversion examples. Ladder diagrams for process control: Ladder diagrams & sequence listings, ladder diagram construction and flow chart for spray process system.

UNIT III:
PLC Registers: Characteristics of Registers, module addressing, holding registers, input registers, output registers.
PLC Functions: Timer functions & Industrial applications, counters, counter function industrial applications, Arithmetic functions, Number comparison functions, number conversion functions.

UNIT IV:
Data Handling Functions: SKIP, Master control Relay, Jump, Move, FIFO, FAL, ONS, CLR & Sweep functions and their applications.
Bit Pattern and changing a bit shift register, sequence functions and applications, controlling of two axis & three axis Robots with PLC, Matrix functions.

UNIT V:
Analog PLC Operation: Analog modules & systems, Analog signal processing, multi bit data processing, analog output application examples, PID principles, position indicator with PID control, PID modules, PID tuning, PID functions.

Text Books:

1. Programmable Logic Controllers – Principle and Applications by John W. Webb & Ronald A. Reiss, Fifth Edition, PHI
2. Digital Design by Morris Mano, PHI, 3rd Edition 2006.

References:

1. Programmable logic Controllers, Frank D. Petruzella, 4th Edition, McGraw Hill Publishers.
2. Programmable Logic Controllers – Programming Method and Applications by JR. Hackworth & F.D Hackworth Jr. – Pearson, 2004.
3. Programmable logic controllers and their Engineering Applications, 2nd Edition, Alan J. Crispin.

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	L	T/P/D	C
I Year – II Sem M.Tech (Power Systems)	**3**	**0**	**3**

Open Elective-II

(PSS41) OPTIMIZATION TECHNIQUES

Course Objectives:

- To understand linear programming
- To understand optimization problem statement.
- To study single variable and multi variable optimization problems with equality and inequality constraints
- To understand various optimization techniques.

Course Outcomes:

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

- Formulate mathematical statement of optimization problem
- Understand various methods of optimization techniques
- Understand the concept of genetic algorithm

UNIT I:

Introduction and Classical Optimization Techniques: Statement of an Optimization problem – design vector – design constraints – constraint surface – objective function – objective function surfaces – classification of Optimization problems.

Classical Optimization Techniques: Single variable Optimization – multi variable Optimization without constraints – necessary and sufficient conditions for minimum/maximum – multivariable Optimization with equality constraints. Solution by method of Lagrange multipliers – multivariable Optimization with inequality constraints – Kuhn – Tucker conditions.

UNIT II:

Linear Programming: Standard form of a linear programming problem – geometry of linear programming problems – definitions and theorems – solution of a system of linear simultaneous equations – pivotal reduction of a general system of equations – motivation to the simplex method – simplex algorithm.

Transportation Problem: Finding initial basic feasible solution by north – west corner rule, least cost method and Vogel's approximation method – testing for optimality of balanced transportation problems.

UNIT III:

Unconstrained Nonlinear Programming: One – dimensional minimization methods: Classification, Fibonacci method and Quadratic interpolation method

Unconstrained Optimization Techniques: Univariate method, Powell's method and steepest descent method.

UNIT IV:

Constrained Nonlinear Programming: Characteristics of a constrained problem, Classification, Basic approach of Penalty Function method; Basic approaches of Interior and Exterior penalty function methods. Introduction to convex Programming Problem.

UNIT V:

Dynamic Programming: Dynamic programming multistage decision processes – types – concept of sub optimization and the principle of optimality – computational procedure in dynamic programming – examples illustrating the calculus method of solution - examples illustrating the tabular method of solution.

Text Books:

1. Engineering optimization: Theory and practice by S. S.Rao, New Age International (P) Limited, 3rd edition, 1998.
2. Introductory Operations Research by H.S. Kasene and K.D. Kumar, Springer (India), Pvt .Ltd.

References:

1. Optimization Methods in Operations Research and systems Analysis – by K.V. Mital and C. Mohan, New Age International (P) Limited, Publishers, 3rd edition, 1996.
2. Dr. S.D.Sharma, “Operations Research – theory and applications”, Macmillan publishers India Ltd, 4th edition.
3. Operations Research: An Introduction” by H.A. Taha, PHI Pvt. Ltd, 6th edition.
4. Linear Programming by G. Hadley, A. W. Pub.Company, 1962.

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I Year – II Sem M.Tech (Power Systems)	**L**	**T/P/D**	**C**
	0	**3**	**2**

(PSS52) POWER SYSTEM LAB – II

Prerequisites: Power System Analysis, Power System Protection

Course Objectives:

- To understand the Performance of Transformers and Synchronous Machines
- To select the Transmission Lines, UG Cables, String Insulators, CTs and PTs.
- To analyze the characteristics of OC, UV/OV, negative sequence relays.

Course Outcomes:

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

- Test and evaluate the performance of Power Transformers and Synchronous Machines.
- Test and evaluate the performance of Transmission lines, UG Cables, Insulators and other Auxiliary Power Systems Equipment
- Test, Evaluate/Choose the various types of Relays (Electromagnetic, Static and Microprocessor based relays)

List of Experiments:

1. Determination of Equivalent circuit of a 3-Winding Transformer.
2. Determination of Sequence Impedances of a Cylindrical Rotor Synchronous Machine.
3. Fault Analysis of Synchronous machine:
   i. Single Line to Ground fault (L-G).
   ii. Line to Line fault (L-L).
   iii. Double Line to Ground fault (L-L-G).
   iv. Triple Line to Ground fault (L-L-L-G).
4. Determination of Sub-transient reactance's of a Salient Pole Synchronous Machine.
5. Determination of Sequence Impedances of Three Phase Transformer
6. Characteristics of IDMT Electromagnetic Over Current Relay
7. Differential protection on Single Phase Transformer.
8. Characteristics of Static Percentage biased Differential Relay.
9. Characteristics of Micro processor based Over Voltage/ Under Voltage Relay.
10. Characteristics of Static Negative sequence Relay
11. Determination of string efficiency of a suspension string insulator.
12. Performance and Testing of Generator Protection System.
13. Performance and Testing of Transformer Protection System.
14. Performance and Testing of Transmission Line Model.

Any TEN of the above experiments are to be conducted

I Year – II Sem M.Tech (Power Systems)	L	T/P/D	C
	0	0	4

(PSS62) MINI PROJECT –II

Course Objectives:

- To improve the capability of surveying for required literature.
- To inculcate the design ability of electrical systems
- To enhance the skills of fabricating the hardware projects
- To correlate the experimental results with theoretical/designed data.

Course Outcomes:

- Carry out Literature study and give problem statement
- Select Control Strategy, design methodology and develop a suitable model for the chosen problem
- Execute and validate the Model
- Communicate effectively
- Write a technical report

II Year – I sem M.Tech (Power Systems)	**L**	**T/P/D**	**C**
	0	**0**	**4**

(PSS63) COMPREHENSIVE VIVA-VOCE

Course Objectives:

- To get a global and overall view on the subject.
- To refresh the technical content at finishing stage of the program.
- To enhance the communication and presentation skills.

Course Outcomes:

- Comprehend the fundamentals and technical knowledge in Power Systems and its allied fields.
- Apply and analyze Power Systems concepts in its allied fields
- Communicate effectively

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II Year – I Sem M.Tech (Power Systems)	**L**	**T/P/D**	**C**
	0	**0**	**8**

(PSS71) INTERNSHIP/DISSERTATION PHASE – I

Course Objectives:

- To improve the capability of surveying for required literature.
- To inculcate the design ability of electrical systems
- To enhance the skills of fabricating the hardware projects
- To correlate the experimental results with theoretical/designed data.

Course Outcomes:

- Carry out Literature study and give problem statement
- Select Control Strategy, design methodology and develop a suitable model for the chosen problem
- Execute and validate the Model
- Communicate effectively
- Write a technical report

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II Year – II Sem M.Tech (Power Systems)	**L**	**T/P/D**	**C**
	0	**0**	**18**

(PSS72) DISSERTATION PHASE – II

Course Objectives:

- To improve the capability of surveying for required literature.
- To inculcate the design ability of electrical systems
- To enhance the skills of fabricating the hardware projects
- To correlate the experimental results with theoretical/designed data.

Course Outcomes:

- Carry out Literature study and give problem statement
- Select Control Strategy, design methodology and develop a suitable model for the chosen problem
- Execute and validate the Model
- Communicate effectively
- Write a technical report