BIRLA VISHVAKARMA MAHAVIDYALAYA

(ENGINEERING COLLEGE)

(AN AUTONOMOUS INSTITUTION)

VALLABH VIDYANAGAR – 388120, GUJARAT

AFFILIATED TO GUJARAT TECHNOLOGICAL UNIVERSITY

ACADEMIC REGULATIONS

AND

COURSES OF STUDY

FOR

POST GRADUATE DEGREE PROGRAMME LEADING TO

MASTER OF TECHNOLOGY (M. TECH.)

IN

ELECTRICAL ENGINEERING

For the students admitted during Academic Year 2015-18

OCTOBER – 2018

Contents

Institute Vision

"Produce globally employable innovative engineers with core values."

Institute Mission

- Re-engineer curricula to meet global employment requirement
- Promote innovative practices at all levels.
- Imbibe core values
- Reform policies, systems and processes at all levels.
- Develop faculty and staff members to meet the challenges

Core Values

Quality, Creativity, Team Work, Lifelong Learning, Pro-activeness, Cost Consciousness, Sharing, Transparency

Academic Regulations

FOR POST GRADUATE PROGRRAMMES

AR(PG) 1 ADMISSION

AR(PG) 1.1 A candidate for admission to the two year degree programme for Master of Technology must have eligibility as per the Gujarat Government/ACPC/GTU/CVM rules.

AR(PG) 1.2 Admission granted to an applicant is to be considered provisional until all the fees are paid and all the prescribed documents are in order. BVM Engineering College **DISCLAIMS ALL RESPONSIBILITIES** if any of the documents required as per ACPC/ Gujarat Technological University requirements are not submitted or found unacceptable by it. The college will not accept responsibility for students who do not submit the expected examination/ registration forms in time.

AR(PG) 2 PROGRAMMES OF STUDY

AR(PG) 2.1 A student shall follow the prescribed courses as given in the programme of study to which he/she is admitted. These courses for various programmes are listed in Annexure – I.

The syllabi for these courses are given in Annexure – II.

AR(PG) 3 COURSES LEVELS

AR(PG) 3.1 At the commencement of each semester a student shall register for the set of courses he/she intends to pursue during the semester. For the registration process, refer AR (PG) 8.

AR(PG) 3.2 All courses offered are divided into two levels: Level 1 and 2. The levels correspond to successive years of study of a typical M. Tech. student. In other words, a regular student will complete his Level-1 courses during his first year and Level-2 courses during his second year.

AR(PG) 3.3 The list of courses offered in semester will be announced by the college at the beginning of the semester.

AR(PG) 4 PROGRAMME ELECTIVE COURSES

AR(PG) 4.1 Each programme of studies contains a certain number of programme elective courses. Programme elective courses will be offered under each discipline at corresponding level from which a student may choose course(s).

AR(PG) 5 OPEN ELECTIVE COURSES

AR(PG) 5.1 Open elective courses are courses offer by a discipline for students other than the corresponding discipline.

AR(PG) 6 COURSE CREDITS

AR(PG) 6.1 Each course offered has **L-T-P** structure. Whereas, **L** means number of theory lecture hours per week, **T** means number of tutorial hours per week and **P** means number of practical/laboratory hours per week.

AR(PG) 6.2 Total course credits for a course are obtained by adding the hours of theory lectures, tutorials and practical together. E.g. 4-0-2 means a course has 6 credits, 3-2-0 means a course has 5 credits, 2-2-2 means a course has 6 credits.

AR(PG) 7 FACULTY COUNSELOR

AR(PG) 7.1 Each student is assigned to a Faculty Counselor who will advise and counsel him regarding the selection of courses to be registered in a given semester as well as monitor his/ her holistic growth. The final selection of courses made by the student must be approved by his Faculty Counselor.

AR(PG) 8 REGISTRATION

AR(PG) 8.1 To earn course credits in a semester a student must register for the courses at the commencement of the semester.

AR(PG) 8.2 At the commencement of each semester a period of two working days is designated as the registration period. A student must complete his registration formalities within this period as per the procedure laid down.

AR(PG) 8.3 A further period of 12 working days is designated as late registration period. During this period a student shall require to pay late registration fee, as decided by the Institute from time to time, to complete his registration. Late registration will only be permitted on genuine reasons (like medical and other unavoidable circumstances) to be approved by the concerned Head of Department and Principal

AR(PG) 8.4 Student shall not be permitted to attend classes without registration.

AR(PG) 8.5 The registration must be completed by the student in person.

AR(PG) 8.6 A student who has completed all the requirements for his degree will not be allowed to register in any further courses.

AR(PG) 8.7 All registrations in every semester must be duly approved by the concerned Head and Principal of the college.

AR(PG) 9 REQUIREMENTS FOR REGISTRARTION

AR(PG) 9.1 A student can register for a course provided that the following conditions are satisfied:

i) The course is included for the student's assigned programme of studies, or the student has been permitted to take the course as an open elective.
ii) The course is being offered in the semester.

AR(PG) 9.2 The courses selected by the student must be approved by his Faculty Counselor.

AR(PG) 10 MINIMUM ENROLLMENT

AR(PG) 10.1 Under normal circumstances an elective course will be conducted in a semester only if a stipulated minimum number of students have registered for the course as decided by the Board of Studies.

AR(PG) 10.2 An elective course in which the number of student registered is less than the stipulated minimum may be withdrawn from the elective course offering of that semester. The student registered in such a course will be permitted to amend their registration.

AR(PG) 11 ASSESSMENT OF STUDENT PERFORMANCE IN COURSE

AR(PG) 11.1 The performance of a student in a course is judged through (i) continuous assessment of theory, tutorial and practical work and (ii) end-semester theory, tutorial and practical examinations.

AR(PG) 11.2 The end- semester theory examination in a course has a weightage of 70 percent of theory marks. The remaining 30 percent of theory marks will be awarded through continuous assessment carried out during the semester.

AR(PG) 11.3 The end-semester tutorial/practical examination in a course has a weightage of 60 percent of total tutorial/practical marks and continuous assessment of the same carries the remaining 40 percent of total tutorial/practical marks. Tutorial/practical work (both end-semester and continuous) shall be evaluated on the basis of several of the following instruments of assessment: observation of experimental skills, reports, oral examination, quizzes, end-semester practical examination, attendance, etc.

Continuous assessment (tutorial/practical) scheme is given below:

Term work	20 percent (Equal weightage for every practical. At least 10 practical/ tutorial need to be performed or mini project)
Quiz / Assignment/ Viva/active learning component	20 percent
Total	40 percent

AR(PG) 11.4 The overall performance of student in the course is assessed on the principle of a "single head of passing", i.e., there will be a single grade for a course based upon the aggregate of marks obtained by the student in theory and practical components in continuous assessment as well as end semester examination. However, a student should score minimum 30% marks in end semester examination to make himself/ herself gradable.

Examiner(s) can grace up to 10% of total marks of end semester theory examination in marks of end semester theory examination to make a student gradable by making the resolution of the same in grade sheet. However, grace marks shall not be counted in the aggregate of marks obtained by the student for the grading.

AR(PG) 12 EXAMINATIONS

AR(PG) 12.1 The end-semester examination for all courses offered in each semester of an academic year will be conducted by the Institute.

AR(PG) 12.2 No student shall be allowed to the end semester examination unless he/she has attended minimum 75% of Theory Lectures/ Tutorials/ Practical classes of the course and will be awarded letter grade LA (Ref. AR (PG) 13) in all the subjects he/she has registered in the corresponding semester.

AR(PG) 12.3 The college will conduct two continuous assessment of theory (mid semester examination) in a semester for each subject. The average marks of two mid semester examinations shall be considered as the final marks for continuous assessment of theory.

A student who remains absent in any of the two mid semester examination for whatsoever reason(s) shall be awarded with zero marks in the respective mid semester examination.

However, a student remains absent due to any of the following unforeseen reasons, shall be permitted to appear along with remedial mid-semester examination. The marks of mid semester remedial examination of such students shall be considered as marks of mid semester examination in which he/she remained absent.

a) A student is critically ill or injured. (Student or his/her relative shall get prior approval)
b) Death of direct blood relation relative. (Student or his/her relative shall inform to Head/Principal immediately after the incident and permission will not be granted for more than 24 hours)
c) A student representing Gujarat state in national level events and/or India in international events organized by official boards.

AR(PG) 12.4 No student shall be allowed to appear in the end semester examination of a course unless he/ she scored at least 30% marks in mid semester examination and will be considered in "NOT PERMITTED TO APPEAR (NPTA)" status for the respective course. The NPTA status carries zero grade point in performance index calculation.

Remedial mid semester examination shall be conducted by the department for NPTA students before the beginning of the end semester examination. If a student gets 30% or more marks, he/she shall be "PERMITTED TO APPEAR" in the end semester examination. However, he/she will be awarded only 30% marks in continuous theory assessment. For genuine reasons, if a student remains absent in the mid semester examination and subsequently appear in the

remedial examination, the marks scored by the student will be considered as continuous theory assessment marks.

If a student still remains with NPTA status, he/she shall appear in mid semester remedial examination of the next semester.

AR(PG) 12.5 The End Semester tutorial/practical examination shall be rescheduled for a student who is not able to appear in the regular schedule due to following reason.

a) A student is critically ill or injured. (Student or his/her relative shall get prior approval)
b) Death of direct blood relation relative. (Student or his/her relative shall inform to Head/Principal immediately after the incident and permission will not be granted for more than 24 hours)
c) A student representing Gujarat state in national level events and/or India in international events organized by official boards.

However, such rescheduling should be confined within the Academic Calendar of the respective semester.

AR(PG) 12.6 The college will conduct only one continuous assessment of theory (mid semester examination) for all subjects of the semester in the following cases.

a) First Semester of M. Tech.
b) Corresponding semester of the year of transfer for transferred students or international students, if the admission of such students is five week later than commencement of academic calendar.

AR(PG) 13 LETTER GRADES

AR(PG) 13.1 The overall performance of a student in a course is represented by a letter grade from AA to **FF** and **LA** with the following meaning and equivalent grade points:

LETTER GRADE	EQUIVALENT GRADE POINTS	REMARK
AA	10	Outstanding
AB	9	Excellent
BB	8	Very Good
BC	7	Good
CC	6	Average
CD	5	Pass
FF	0	Fail
LA	0	Low Attendance (Fail)

AR(PG) 13.2 A course is completed successfully, i.e., credit is earned for a course, when a letter grade CD or better (in grade points) is obtained in the course.

AR(PG) 13.3 The scheme of awarding letter grades and the letter grades awarded in each course are subjected to scrutiny and approval by Academic Council.

AR(PG) 15 FAILURE IN A COURSE

AR(PG) 15.1 A student earns **zero** credit for a course when he gets letter grade **FF** or **LA** in the course.

AR(PG) 15.2 If letter grade **FF** or **LA** is obtained in an elective course, the student may change the elective.

AR(PG) 15.3 The letter grade **FF** or **LA** obtained in a course will be shown in the final transcript issued to the student (refer AR (PG) 22) whether or not he subsequently obtains another letter grade in a repeat attempt.

AR(PG) 15.4 A student with letter grade LA should repeat the course i.e. he/she should attend theory and practical classes as and when the course is offered.

AR(PG) 15.5 A student with letter grade **FF** should appear in end semester theory as well as practical/ viva exam and should obtain a letter grade **CD** or better (in grade points).

AR(PG) 15.6 A student with more than **four FF grade and/or NPTA status** in a level will not be allowed to move to the next level.

AR(PG) 16 SEMESTER PERFORMANCE INDEX (SPI)

AR(PG) 16.1 The performance of a student in a semester is expressed in terms of the semester Performance Index (SPI).

AR(PG) 16.2 The semester Performance Index is the weighted average of course grade points obtained by the student in the course taken in the semester. The weights assigned to course grade points are the credits carried by the respective courses.

That is,

$$SPI = \frac{\sum_{i=1}^{n} g_i c_i}{\sum_{i=1}^{n} c_i}$$

where, g_i is the equivalent grade point of i^{th} course,

c_i is the credit of the course

n is total number of courses registered by the student in a semester

AR(PG) 17 CUMULATIVE PERFORMANCE INDEX (CPI)

AR(PG) 17.1 The cumulative performance of student is expressed in terms of the Cumulative Performance Index (CPI). This index is defined as the weighted average of course grade points obtained by the student for all courses taken since entry to the programme, where the weights are defined in same way as in AR (PG) 16.

AR(PG) 17.2 If a student repeats a course, only the grade points obtained in the latest attempt are counted towards the Cumulative Performance Index (CPI).

AR(PG) 18 DISCONTINUINACE FROM THE PROGRAMME

AR(PG) 18.1 A Semester Performance Index (SPI) of less than 3.00 in two consecutive semesters shall disqualify a student from continuing his studies. Such a student will be referred to the Academic Council. After considering the extenuating circumstances, if any, the Academic Council shall decide whether the student should be allowed to continue his/ her studies. The Academic Council decision shall be final and binding.

AR(PG) 19 ADMISSION BY TRANSFER

AR(PG) 19.1 For a student admitted by transfer to the M. Tech. programme after completing part of his degree requirements elsewhere or under the previous regulations, the Board of Studies (BOS) shall decide the subjects which he/ she is deemed to have completed and shall be exempted from those subjects. In the grade sheet, the exempted subjects shall be specified as "EXEMPTED".

AR(PG) 19.2 The remaining requirements must be completed by the student in a proportionately smaller number of semesters which shall be prescribed for him at the time of his admission to the programme.

AR(PG) 19.3 The CPI of such a student will be calculated on the basis of only the courses taken at this Institute.

AR(PG) 20 REQUIREMNTS FOR THE AWARD OF M. Tech. DEGREE

AR(PG) 20.1 To be eligible for the award of the degree of Master of Technology a student must earn a total of at least **115** credits as prescribed under his programme of studies with

i) A minimum CPI of 5.00 and
ii) No course with letter grade FF or LA at any level.

AR(PG) 20.2 The total credits requirements for the degree of M. Tech must be completed in not more than 8 semesters from the date of admission.

AR(PG) 20.3 For a student admitted by transfer the maximum permissible duration shall be 50 percent more than the period prescribed for completion of his programme at the time of his admission.

AR(PG) 20.4 If the Academic Council is satisfied that there are extenuating circumstances, the student may be allowed a maximum of 2 additional semesters to complete his degree requirements.

AR(PG) 21 AWARD OF CLASS

AR(PG) 21.1 The class awarded to a student with his M. Tech. degree is decided by his final CPI as per the following table :

FIRST CLASS WITH DISTICTION - CPI not less than 7.25
FIRST CLASS - CPI less than 7.25 but not less than 6.50
SECOND CLASS - CPI less than 6.50 but not less than 5.75
PASS CLASS - CPI less than 5.75 but not less than 5.00
CPI less than 5.00 is not eligible for award of degree

A candidate who passes in all subjects and all heads of passing in the examination shall be given a gracing of the required CPI for getting second class/ first class/ first class with distinction, subject to a maximum of CPI 0.10, in concurrence with rules and guidelines of AICTE/ GTU.

AR(PG) 22 TRANSCRIPT

AR(PG) 22.1 The Transcript issued to the student at the time of leaving the University will contain a consolidated record of the entire course taken by him, grades obtained, SPI, CPI, etc.

AR(PG) 23 EXAMINERS

AR(PG) 23.1 The respective board of studies shall appoint at least two examiners for end semester theory as well as practical/viva examination. For each end semester theory examination, there shall be two paper setters. One paper setter out the two shall be from outside the institute (external examiner). The end semester theory and practical examination of each subject shall be conducted by an internal and an external examiner. The internal examiner shall be appointed as convener who shall co-ordinate the examination procedure for end semester examinations of the respective subject.

AR(PG) 24 RE-ASSESSMENT

AR(PG) 24.1 A student shall apply for re-assessment of his/ her answer books of end semester examination (theory) only within seven working days after the declaration of the results.

AR(PG) 24.2 The board of studies shall appoint **two examiners (one is Convener of original exam and other is new examiner)** for the reassessment of the end semester examination (theory) for both sections. **Both examiners shall jointly reassess both the sections.**

AR(PG) 24.3 The marks obtained by the candidate shall be considered for grading after re-assessment, only if, the change in mark is more than or equal to 10% of total mark of End Semester **(Theory)** Examination.

AR(PG) 25 GRADING

AR(PG) 25.1 The office of the Controller of Examination shall prepare the histogram of each subject for the purpose of grading after the completion of assessment of the subject. The histogram for dissertations shall not be prepared and each dissertation shall be graded individually as per the guidelines given from time to time.

AR(PG) 25.2 The convener of the respective subject shall grade the students based on the histogram provided by the Controller of Examination.

AR(PG) 26 GRADE REVIEW

AR(PG) 26.1 The Academic Council shall appoint Grade Review Committee for each semester. The Grade Review Committee shall constitute following members.

(a) Principal
(b) All Board of Studies Chairman
(c) University Nominee
(d) Dean, Academics
(e) Associate Dean, Academics
(f) Controller of Examination
(g) Member Secretary, Academic Council
(h) Office-in-charge of Credit System

AR(PG) 26.2 The Grade Review Committee shall meet immediately after results of all courses are completed and review the grades awarded by the convener of respective subject. The revision of the grade suggested by the Grade Review committee shall be considered as final grade and binding.

AR(PG) 27 DISSERTATION EVALUATION

AR(PG) 27.1 The student shall present his/her progress during the dissertation phase for at least two times in a semester as a part of continuous evaluation. The presentation shall be evaluated by the Dissertation Progress Committee (DPC). The DPC comprises at least two faculty members from the department of same area/field and the guide. The convener of the DPC shall be other than guide of the student.

AR(PG) 27.2 At the end of each semester, the dissertation shall be evaluated by the guide (internal examiner) and external examiner.

AR(PG) 27.3 Marks Distribution for a Dissertation in a semester shall be as follows.

Continuous Evaluation (CE)	**End Semester Examination (ESE)**
40 Marks	60 Marks
Evaluated in two presentations by DPC as per AR (PG) 27.1, each evaluator has equal weightage in assessment.	Evaluated in the presentation made by the student at the end of semester by internal examiner/s and external examiner/s. Internal examiner/s shall award 50% of ESE marks and external examiner/s shall award 50% of ESE mark.

AR(PG) 27.4 As partial fulfilment of the dissertation, the student shall present/publish at least one paper in conference/journal.

AR(PG) 27.5 The student shall submit the plagiarism report for his/her thesis. The thesis with less than 20% plagiarism shall be accepted for the End Semester Presentation. The plagiarism instruction shall be issued from time to time.

AR(PG) 27.6 No exemption/relaxation in the course work of 3rd and 4th semester shall be permitted during the dissertation period of the PG student.

Annexure – I: Programme of studies leading to the degree of the Master of Technology (Electrical Engineering)

Semester I

SR. No.	COURSE CODE	COURSE TITLE	L	T	P	C
1.	EE507	Advanced Power Electronics	4	0	2	6
2.	EE502	Power System Dynamics	4	0	2	6
3.	EE503	Power System Modeling and Simulation	4	0	2	6
4.	EE504	Advanced Power System Protection and Switchgear	4	0	2	6
5.	MA503	Optimization Techniques	3	2	0	5
		TOTAL	**19**	**2**	**8**	**29**

Semester II

SR. No.	COURSE CODE	COURSE TITLE	L	T	P	C
1.	EE505	Modern Control System	4	0	2	6
2.	EE506	HVDC and FACT System	4	0	2	6
3.	EE501	Electric Drives	4	0	2	6
4.	EE508	Power Quality Management	4	0	2	6
5.	EE541	Research Methodology in Electrical Engineering	1	2	0	3
		TOTAL	**17**	**2**	**8**	**27**

Semester III

SR. No.	COURSE CODE	COURSE TITLE	L	T	P	C
1.	EE601	Seminar	0	4	0	4
2.	EE611	Dissertation I	0	0	15	15
3.		**Open Elective**	3	2	0	5
4.		**Program Elective I**	4	2	0	6
		TOTAL	**7**	**8**	**15**	**30**
		Open Elective				
3A.	EE681	Renewable Energy Technology	3	2	0	5

Program Elective I, Semester III						
4A.	EE651	Artificial Intelligence and It's Applications in Power System	4	2	0	6
4B.	EE652	Power System Restructuring	4	2	0	6
4C.	EE653	Power System Planning and Reliability	4	2	0	6

Semester IV

SR. No.	COURSE CODE	COURSE TITLE	L	T	P	C
1.	EE612	Dissertation II	0	0	24	24
2.		**Program Elective II**	4	2	0	6
		TOTAL	**4**	**2**	**24**	**30**
Program Elective II, Semester IV						
2A.	EE654	Advanced Digital Signal Processing	4	2	0	6
2B.	EE655	Distributed Generation and Micro Grid	4	2	0	6
2C.	EE656	Smart Grid Technology	4	2	0	6

Annexure –II: Syllabi for the courses offered in programme of studies leading to the degree of Master of Technology (Electrical Engineering)

EE501: ELECTRICAL DRIVES
(CREDITS = 5 (L=3, T=0, P=2)

Teaching and Assessment Scheme:

Teaching Scheme			Credits	Assessment Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE	CE	ESE	CE	
3	0	2	5	70	30	30	20	150

Course Content:

Unit No.	Topic	Teaching Hrs.
1	**Fundamentals Of Electric Drives:** Introduction, Choice of Electrical Drives, Dynamics of Electrical Drives, Concept of Multi-quadrant operation, Components of load torques, Selection of motor power rating, Speed torque, speed control, Starting, Braking.	05
2	**DC Drives:** Modeling, Rectifier fed DC drive, Chopper controlled DC drives, Close loop control of DC drive. Ward Leonard Drives, Analysis of steady state and dynamic operation.	07
3	**Induction Motor Drives:** Introduction, Review of three phase I.M. analysis and performance, Analysis of I.M. fed from Non-sinusoidal supply voltage , Stator voltage control, V/f controlled induction motors, Various speed-torque control methods. Slip power recovery, CSI fed induction motor drives, Applications.	12
4	**Synchronous Motor Drives:** Introduction, Operation from Fixed Frequency Supply, Synchronous motor variable speed drive, Variable Frequency control of multiple synchronous motor, Self-controlled synchronous motor drive employing load commutated thyristor inverter, Self-controlled synchronous motor employing cycloconverter, Permanent magnet ac motor drives, Sinusoidal PMAC motor drives, Brush less dc motor drive.	12
5	**Machine Modeling And Analysis:** Basics of reference frame theory, voltage and torque equations in machine variables for induction motor and synchronous motor for different reference frames. Analysis of steady state and dynamic operation.	12
	Total	**48**

List of References:

1. G.K. Dubey, "*Power semiconductor controlled drives"*, Prentice Hall, New Jersey, 1989.
2. P. C. Krause, Oreg Wasynczuk, Scott D. Sudhoff and P.C.Krause, "*Analysis of Electric Machinery and drive systems"*, IEEE Press, 2002.
3. Bimal. K. Bose, "*Modern Power Electronics and AC Drives",* Pearson Education (Singapore) Pvt. Ltd., New Delhi, 2003.
4. P. S. Bhimbra,"*Generalized Theory of Electrical Machines",* Khanna Publications.
5. R. Krishnan, *"Electrical motor drives Modelling Analysis and Control*", PHI-India, 2005.

EE502: POWER SYSTEM DYNAMICS
(CREDITS = 5 (L=3, T=0, P=2)

Teaching and Assessment Scheme:

Teaching Scheme			Credits	Assessment Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE	CE	ESE	CE	
3	0	2	5	70	30	30	20	150

Course Contents:

Unit No.	Topics	Teaching Hrs.
1	**Power System Dynamics:** Introduction to power system stability, primitive definition of stability, Review of stability problems – stability of synchronous machines, tie line oscillations, method of simulation.	02
2	**Synchronous Machine Concepts, Theory and Modelling:** Introduction to modelling approach, Mathematical description of a synchronous machine, Derivation of stator self-inductance, rotor self-inductance, stator mutual inductances, Derivation of stator-rotor mutual inductance, need for transformation, Derivation of dqo transformation, Classification of synchronous machine modelling as per IEEE, Transient performance of synchronous machine, Magnetic saturation, Representation of saturation for stability study, Synchronous machine representation in stability studies, Reactive power capability curve.	10
3	**Analysis of Single Machine System:** Small Signal Analysis with Block Diagram Representation Characteristic Equation (CE) and Application of Routh-Hurwitz Criterion Synchronizing and Damping Torques Analysis Small Signal Model: State Equations.	05
4	**Analysis of Multimachine System:** A Simplified System Model, Detailed Models: Case I, II, Inclusion of Load and SVC Dynamics, Modal Analysis of Large Power Systems.	06

Unit No.	Topics	Teaching Hrs.
5	**Analysis of Subsynchronous Resonance and Transient Stability Controllers:** SSR in Series Compensated Systems, Modelling and analysis of Mechanical System, Computation of Ye(s) : Simplified and Detailed Machine Model, Analysis of Tensional Interaction - A Physical Reasoning, State Space Equations and Eigen value Analysis, Simulation of SSR, System resign for Transient Stability, Discrete Supplementary Controls, Dynamic Braking, Discrete control of Excitation Systems, Series Capacitor Insertion, Emergency Control Measures.	06
6	**Voltage Stability:** Introduction to voltage stability, voltage collapse according to IEEE/CIGRE, classification, voltage collapse incidents, Factors affecting voltage instability and collapse Comparison of Angle and Voltage Stability, Analysis of SMLB System, Dynamics of Load Restoration Analysis of Voltage Instability and Collapse, Derivation of critical voltage and critical power, P-V curves and Q-V curves, Integrated Analysis of Voltage and Angle Stability Overview on various types of bifurcations, saddle node bifurcation, Hopf bifurcation Continuation Power Flow (CPF), formulation of power flow equations, predictor corrector processes Sensitivity analysis for voltage stability, eigen-value sensitivity.	16
	Total	**45**

List of References:

1. P. S. Kundur ,"*Power System Stability and Control*", McGraw Hill Inc, New York.
2. K.R. Padiyar, "*Power System Dynamics, Stability and Control*" ,Interline Publishers, Bangalore.
3. P.Sauer and M.A.Pai," *Power System Dynamics and Stability*." Prentice Hall.
4. P.M. Anderson and A.A. Fouad, "*Power system control and stability".*
5. J. Machowski, J.W. Bialek and J.R. Bumby, "*Power System Dynamics, Stability and Control",* Wiley publishers.
6. V. Ajjarapu, "*Computational Techniques for Voltage Stability Assessment and Control"* Springer.

EE503: POWER SYSTEM MODELLING AND SIMULATION
(CREDITS = 6 (L=4, T=0, P=2)

Teaching and Assessment Scheme:

Teaching Scheme			Credits	Assessment Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE	CE	ESE	CE	
4	0	2	6	70	30	30	20	150

Course Content:

Unit No.	Topics	Teaching Hrs.
1	**Modelling & Simulation of system:** Graph Theory Network matrices, Bus admittance and Bus impedance matrices, Algorithm for Formation of Bus Impedance Matrix, Short Circuit Studies of a Large Power System Networks, Symmetrical Fault Analysis Using Bus Impedance Matrix.	06
2	**Power System Security:** Introduction, Factors Affecting Power System Security, Contingency Analysis: Detection of Network Problems, Overview of security analysis, Linear Sensitivity Factors, Contingency Selection, Concentric Relaxation, Bounding.	06
3	**Load Flow Studies:** Introduction, Different techniques such as Gauss Saidal method, Newton Raphson method, De-Coupled method, Fast Decoupled method, Modified Fast Decoupled, Concept of Optimal Power Flow, Linear Programming Methods for GS NR and FDLF method, DC load flow, Continuation Power flow.	06
4	**State Estimation:** Estimation of average, periodic, stochastic components of load, Power system state estimation, Maximum Likelihood Concept, Weighted Least Squares Estimation, Introduction, Matrix Formulation, State Estimation of an AC network, Development of Method, State Estimation by Orthogonal Decomposition, An Introduction to Advanced topics in state estimation, Detection and Identification of Bad measurements, Estimation of quantities not being measured, Network Observability and Pseudo measurements Application of Power Systems State Estimation.	12
5	**Computer Control of Power System:** Need of real time and computer control of power system, Operating states of power system, SCADA & Energy Management Centers, Smart Grid.	06
6	**Numerical Integration Techniques:** Numerical integration techniques: One step methods, Taylor series based methods, Forward -Euler's method, Runge-Kutte methods, Trapezoidal method, backward-Euler's method.	-
	Total	**36**

List of References:

1. A. J. Wood and B. F. Wollenberg, "*Power Generation Operation & Control"*, John Wiley & Sons, Inc, 1996.
2. L. P. Singh, "*Advanced Power System Analysis and Dynamics*" New Age International Ltd,New Delhi, 1992.
3. George Kusic, *"Computer-Aided Power Systems Analysis*" ,2nd Edition), , CRC Press – Indian Edition.

4. Stevenson and Grainger," *Power System Analysis",* TATA McGraw Hill.
5. Jos Arrillaga and Bruce Smith, "*AC-DC Power System Analysis*", IEE London UK, 1998.
6. Hadi Sadat, "*Power System Analysis",* Tata McGraw Hill, New Delhi, 1999.
7. Mariesa Crow, *"Computational methods for Electric Power Systems",* CRC press.
8. Glenn Stagg and El-abiad, *"Computer Methods in Power System Analysis*", McGraw-Hill.
9. J. Arrillaga, C.P. Amold and S. J. Harker "*Computer Modeling of Electrical Power Systems* John Wiley and Sons 1983.

EE504: ADVANCED POWER SYSTEM PROTECTION AND SWITCHGEAR
(CREDITS = 6 (L=4, T=0, P=2)

Teaching and Assessment Scheme:

Teaching Scheme			Credits	Assessment Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE	CE	ESE	CE	
4	0	2	6	70	30	30	20	150

Course Content:

Unit No.	Topics	Teaching Hrs.
1	**Static Relays:** Basic Block diagram, Advantages of Static Relays, Comparators, Phase and amplitude Comparators, General Equations of Comparators, Analysis of Amplitude and Phase Comparators, Operating principles, Static Overcurrent relays, Differential relays, and distance relays.	04
2	**Basic Elements of Digital Protection:** Basic Components of a Digital Relay, Signal Conditioning Subsystems, Transducers, Surge Protection Circuits, Analogue Filtering, Analogue Multiplexers, Conversion Subsystem, The Sampling Theorem, Signal Aliasing Error, Sample and Hold Circuit, Digital Multiplexing ,Digital-to-Analogue Conversion, Analogue-to-Digital Conversion, Digital Relay Subsystem, Benefits of digital relays. Mathematical basis for protective relaying algorithms: Fourier series, Other orthogonal expansions, Fourier transforms, Discrete Fourier transform Fourier algorithms, Fourier algorithms with shorter windows, Recursive forms, Walsh function algorithms, Differential-equation algorithms, Kalman filter algorithms, Removal of the DC offset.	08
3	**Load-Shedding and Frequency Relaying:** Introduction, Rate and Frequency Decline, Load-Shedding, Frequency Relays, Induction-Cylinder under frequency Relays, Digital Frequency Relays, microprocessor-Based Frequency Relay, Formulating a Load-Shedding Scheme, Maximum Anticipated Overload, Number of Load-	04

Unit No.	Topics	Teaching Hrs.
	Shedding Step, Size of the Load Shed at Each Step, Frequency Settings, Time Delay, Special Considerations for Industrial System.	
4	**Reclosing and Synchronizing:** Introduction, Reclosing Precautions, Reclosing System Consideration, One-Shot vs. Multiple-Shot Reclosing Relays, Selective Reclosing, Deionizing Times for Three-Pole Reclosing, Live-Line/Dead-Bus, Live-Bus/Dead-Line Control, Instantaneous-Trip Lockout, Intermediate Lockout, Factors Governing Application of Reclosing Considerations for Applications of Reclosing , Feeders with No-Fault-Power Back-Feed and Minimum Motor Load, Single Ties to Industrial Plants with Local Generation, Lines with Sources at Both Ends, Reclosing Relays and Their Operation, Review of Breaker Operation, Single-Shot Reclosing Relays, Multi shot Reclosing Relays, Synchronism Check, Phasing Voltage Synchronism Check Characteristic, Angular Synchronism Check Characteristic.	08
5	**Developments in New Relaying Principles** Introduction, Traveling Wave Based Protection of Transmission Lines, Frequency Based Relaying , Series Compensated Line Protection, Introduction, The Degree of compensation, Voltage Profile of Series Compensated Line, Faults with Unbypassed Series Capacitors, Relay Problems Due to compensation, Voltage and Current Inversion, Problems in reach measurement, Protection of Series compensated line, Concept of Adaptive Relaying , Fault Location Algorithms.	06
6	**Concept of Different Relay Algorithms** Introduction of different techniques, Least square based methods, Introduction, Integral LSQ fit, Power series LSQ fit, Differential equation based techniques, Basic principles, and Digital harmonic filtering by selected limits, Fourier analysis based techniques, Introduction, The full cycle window algorithm, The half cycle window algorithm.	06
	Total	**36**

List of References:

1. B.A Oza and R.P Mehta, "*Power System Protection*", TMH Publication, 2013.
2. Bhavesh Bhalja and R. P. Maheshwari, "*Protection and Switchgear"* Oxford University Press.
3. Badri Ram and D.N.Vishwakarma, *"Power system protection and Switch gear"*, TMH publication, New Delhi 1995.
4. T.S.Madhava Rao, "*Static relays"*, TMH publication, second edition 1989.
5. C. Christopoulos and A. Wright, "*Electrical Power System Protection"*, Springer International.
6. A. G. Phadke and J. S. Thorp, "*Computer Relaying for Power Systems*", John Wiley and sons.
7. J. L. Blackkburn, *"Protective Relaying (Principles and applications)*", Marcel Dekker,Inc.

EE505: MODERN CONTROL SYSTEM
(CREDITS = 6 (L=4, T=0, P=2)

Teaching and Assessment Scheme:

Teaching Scheme			Credits	Assessment Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE	CE	ESE	CE	
4	0	2	6	70	30	30	20	150

Course Content:

Unit No.	Topics	Teaching Hrs.
1	**Digital Control:** Introduction - Advantages of Digital control systems, Practical aspects of the choice of sampling rate and multi-rate sampling, Basic discrete time signals, Quantization, Sampling theorem, Data conversion and Quantization - Sampling process, Mathematical modeling - Data reconstruction and filtering of sampled signals, zero - order hold.	03
2	**Z-Transforms:** Discrete-time Systems, Transform Methods, Theorems of Z transform, Solution of Difference Equations, Inverse z Transforms.	04
3	**Stability Analysis:** z transform analysis of open loop, closed loop systems - Modified z Transform - transfer function - Stability of linear digital control systems -Stability tests.	04
4	**Time Response:** System Time Response, Characteristic Equation, Analog s-plane/Digital z-plane Mapping, Steady-State Accuracy, Pulse transfer functions of the zero - order Hold and relationship between G(s) and G(z).	03
5	**Frequency Response:** Frequency domain analysis - Bode plots - Gain margin and phase margin, Nyquist stability criterion in the z- plane.	03
6	**Digital Controllers using Classical Methods:** PI, PD & PID Controllers, Lag, lead and lag-lead compensators, Design of lag compensator and lead compensator based on root locus and Bode plot approaches, Bilinear transformation.	09
7	**State Space analysis of digital control systems:** State equations of discrete data systems, solution of discrete state equations, State transition Matrix: z-transform method. Relation between state equations and transfer functions. Design of Dead beat Controller.	06

Unit No.	Topics	Teaching Hrs.
8	**Modern Digital Controller Design:** Pole Placement Design, State Estimation, Design of the full order and reduced order state observer, Controllability and Observability.	08
	Total	**40**

List of References:

1. M.Gopal,"*Digital Control and State Variable Methods*",Tata McGraw Hill, India, 1997.
2. K.Ogata,"*Discrete Time Control Systems*",PHI/Addison - Wesley Longman Pte. Ltd., India, Delhi, 1995.
3. B.C Kuo*," Digital Control Systems*", Oxford University Press, 2nd Edition,Inc., 1992.
4. Dorsay," *Continuous and Discrete Control Systems*", McGraw - Hill.
5. C. H. Houpis and G.B. Lamont*," Digital Control Systems*", McGraw Hill, 1985.

EE506: HVDC AND FACT SYSTEM
(CREDITS = 6 (L=4, T=0, P=2)

Teaching and Assessment Scheme:

Teaching Scheme			Credits	Assessment Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE	CE	ESE	CE	
4	0	2	6	70	30	30	20	150

Course Content:

Unit No.	Topics	Teaching Hrs.
1	**HVDC Transmission-Development :** Introduction, Historical Development, Equipment required for HVDC System, Comparison of AC and DC transmission, Limitation of HVDC Transmission Lines, Reliability of HVDC Systems, Standard Rated Voltages of HVDC and EHV AC systems, Choice of EHV AC and UHV AC lines and substation, Comparison of HVDC link with EHV AC link, HVDC-VSC Transmission System.	05
2	**HVDC Convertors:** Introduction, Insulated Gate Bipolar Transistor (IGBT), HVDC Converter Valve and Valve Assembly, HVDC –VSC Operation and Principles, Three Phase Six Pulse Converter using SCRs, Twelve Pulse Bridge Converters.	05
3	**Control of HVDC converter and system:** Introduction, Mechanism of AC power Transmission, Principles of Control, Necessity of Control in case of DC link, Rectifier Control Compounding Of	05

Unit No.	Topics	Teaching Hrs.
	Rectifier, Power Reversal in DC link, Voltage Dependent Current Order Limit- Characteristics of Converter, System Control Hierarchy and Basic Philosophy, Inverter Extinction Angle Control (EAG).	
4	**Converter Faults & Protection:** Introduction, Converter Faults, Protection against over currents, over voltages in a converter station, Surge arrester, protection against overvoltage's.	04
5	**Transient Stability Analysis:** Introduction, converter model, converter controller models, DC network models, solution methodology, direct methods for stability evaluation, transient stability improvement using DC link control.	04
6	**Harmonics in HVDC Systems:** Introduction, Importance of Harmonic Study, Generation of Harmonics by Converters, Characteristics Harmonics on the DC Side, Characteristics Current Harmonics.	05
7	**Reactive-Power Control in Electrical Power Transmission Systems:** Reactive Power, Uncompensated Transmission Lines, Compensation : Shunt Compensation, Series Compensation, Series-Shunt Compensation, Series-series Compensation and Effect of compensation on power-Transfer Capacity.	04
8	**Principles of Conventional Reactive-Power Compensators:** Introduction, The Saturated Reactor (SR), The Thyristor-Controlled Reactor (TCR), The Thyristor-Controlled Transformer (TCT), the Fixed Capacitor-Thyristor-Controlled Reactor (FC-TCR), The Thyristor-Switched capacitor and Reactor, The Thyristor-Switched capacitor-Thyristor-Controlled Reactor (TSC-TCR),Thyristor controlled series capacitor (TCSC), Static synchronous series compensator (SSSC), A Comparison of Different SVCs, STATCOM, Basic operation of UPFC & IPFC, Summary.	08
	Total	**40**

List of References:

1. R. Mohan Mathur and R K Verma,"*Thyristor-based FACTS controllers for Electrical Transmission Systems",* Wiley IEEE Press
2. N.G.Hingorani and L.Gyugyi, "*Understanding FACTS*", Standard Publishers, Delhi, 2001
3. T J E Miller, *"Reactive Power Control in Electric Systems",* John Willey.
4. Padiyar K R," *FACTS Controllers in Power Transmission & Distribution"*, New Age International.
5. Kalyan K. Sen and Mey Ling Sen," *Introduction to FACTS Controllers, Theory, Modeling and Applications",* 1st edition, IEEE Press, John Wiley & Sons, New Jercy.

EE507: ELECTRIC DRIVES
(CREDITS = 6 (L=4, T=0, P=2)

Teaching and Assessment Scheme:

Teaching Scheme			Credits	Assessment Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE	CE	ESE	CE	
4	0	2	6	70	30	30	20	150

Course Content:

Unit No.	Topics	Teaching Hrs.
1	**Fundamentals Of Electric Drives** Introduction, Choice of Electrical Drives, Dynamics of Electrical Drives, Concept of Multi-quadrant operation, Components of load torques, Selection of motor power rating, Speed torque, speed control, Starting, Braking.	05
2	**DC Drives** Modeling, Rectifier fed DC drive, Chopper controlled DC drives, Close loop control of DC drive. Ward Leonard Drives, Analysis of steady state and dynamic operation.	07
3	**Induction Motor Drives** Introduction, Review of three phase I.M. analysis and performance, Analysis of I.M. fed from Non-sinusoidal supply voltage , Stator voltage control, V/f controlled induction motors, Various speed-torque control methods. Slip power recovery, CSI fed induction motor drives, Applications.	10
4	**Synchronous Motor Drives** Introduction, Operation from Fixed Frequency Supply, Synchronous motor variable speed drive, Variable Frequency control of multiple synchronous motor, Self controlled synchronous motor drive employing load commutated thyristor inverter, Self-controlled synchronous motor employing cycloconverter, Permanent magnet ac motor drives, Sinusoidal PMAC motor drives, Brush less dc motor drive.	10
5	**Machine Modeling And Analysis** Basics of reference frame theory, voltage and torque equations in machine variables for induction motor and synchronous motor for different reference frames. Analysis of steady state and dynamic operation.	08
	Total	**40**

List of References:

1. G.K. Dubey, "*Power semiconductor controlled drives*", Prentice Hall, New Jersey, 1989.
2. P. C. Krause, Oreg Wasynczuk, Scott D. Sudhoff, P.C.Krause, "*Analysis of Electric Machinery and drive systems*", IEEE Press, 2002.
3. Bimal. K. Bose, "*Modern Power Electronics and AC Drives*", Pearson Education (Singapore) Pte. Ltd., New Delhi, 2003
4. P. S. Bhimbra,"*Generalized Theory of Electrical Machines*", Khanna Publications.
5. R. Krishnan, "*Electrical motor drives Modelling Analysis and Control*", PHI-India, 2005.

EE508: POWER QUALITY MANAGEMENT
(CREDITS = 6 (L=4, T=0, P=2)

Teaching and Assessment Scheme:

Teaching Scheme			Credits	Assessment Distirbution				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE	CE	ESE	CE	
4	0	2	6	70	30	30	20	150

Course Content:

Unit No.	Topics	Teaching Hrs.
1	**Power Quality:** Swell, Surges, Harmonics, over voltages, spikes, Voltage fluctuations, Transients, Interruption, overview of power quality phenomenon. 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. Three phase faults- single phase, phase to phase, phase to ground faults; phase angle jumps- theoretical calculations; magnitude and phase angle jumps- phase to phase, single phase, two phase to ground; for three phase unbalanced sags, load influence on voltage sags. Voltage tolerance criteria, (ITI/CBEMA).	07
2	**Harmonics:** Definition, causes of voltage and current harmonics, individual and total harmonic distortion, effect of harmonics on power system devices, guidelines for harmonic voltage and current limitation, harmonic current mitigation.	07
3	**PQ considerations in Industrial Power Systems:** Voltage sag effects, 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 drive and its operation, mitigation methods of DC drives.	07

Unit No.	Topics	Teaching Hrs.
4	**Passive Power Filter:** Types, Ac network impedance, Design of filters – single tuned, double tuned & damped filter, filter component ratings	05
5	**Active Power filters:** Advantages, Types – shunt, series & hybrid, current control techniques – instantaneous reactive power theory, synchronous reference frame theory, current controllers for active power filters – hysteresis, space vector pulse width modulation (SVPWM) Introduction to custom power devices and their applications in power system.	05
6	**Voltage quality controllers:** Shunt controllers: D-SVC, D-STATCOM – operation & control Series controllers: DVR – operation & control.	04
7	**Power Quality Standards and Power Quality Measurement:** ITI, CBEMA, EMC, IEEE Power Quality Standards. Power quality survey, measurement, use of various power quality instruments (Power quality Analyzer), and Power quality audit in industrial plants.	05
	Total	**40**

List of References:

1. Math H J Bollen, "*Understanding Power Quality Problems*", IEEE Press.
2. R C Dugan, M.F,M Granghar, H.W.Beaty , *"Electrical power quality",* TMH.
3. Moreno-Munoz, *"Power Quality: Mitigation techniques in a distributed environment"*.
4. Roger C. Dugan , *"Electrical Power Systems Quality"* , 2nd Edition, Tata McGraw Hill Publication.
5. Hirofumi Akagi, Edson Hirokazu Watanabe, Mauricio Aredes, *"Instantaneous Power Theory and Applications to Power Conditioning",* John Wiley & Sons, 2007.
6. C. Sankaran, *"Power quality"* , CRC Press, 2002.
7. M. H. J. Bollen, *"Understanding Power Quality Problems: Voltage sags and Interruptions"*, Wiley-IEEE Press, 1999.
8. Francisco C. De La Rosa Taylor& Francis group," *Harmonics and Power systems",* CRC Press.
9. J. Arrillaga, N.R. Watson, *"Power System Harmonics"*, Second Edition, John Wiley & Sons,Ltd ISBN: 0-470-85129-5.

EE541: RESEARCH METHODOLOGY IN ELECTRICAL ENGINEERING
(CREDITS = 3 (L=1, T=2, P=0)

Teaching and Assessment Scheme:

Teaching Scheme			Credits	Assessment Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE	CE	ESE	CE	
1	2	0	3	70	30	30	20	150

Course Content:

Unit No.	Topics	Teaching Hrs.
1	**How to Start Research:** Find what is expected of the you: Identify specific requirements for evaluation/review and what constitutes completion of your work Decide which sources you will need: Differentiate between journals, conferences, books, magazines and their Quality ,Understand how to establish their quality and authenticity Finding Information: How to conduct effective searches, How to find relevant papers related to your area of research, How to capture critical information Identify main ideas in scholarly literature: Understand and identify the bias, theoretical position and evidence produced Write notes to organize your ideas: Compare ideas and concepts from different papers Ethical Issues related to Research: Plagiarism, Intellectual Property rights, Copyrights, Patent References: Understand the importance of distinguishing your work from others work and acknowledging such references, Learn international standards of referencing.	04
2	**Focus to Problem & Understand the Direction of Research:** Identify Problem and Methods to Solve it: Analyze the question, Identify key areas in your field, Determine the nature and extension of papers that you should read Identify the gaps: Learn to Critique existing knowledge and how to find the gap Formulate the Problem Statement: Understand what should be the key aspects of your problem statement Examples of effective and ineffective Titles Validation:	06

Unit No.	Topics	Teaching Hrs.
	Identify problem and experimental/theoretical data for comparison with your model, earn how to extrapolate/scale data for validation, Find what is acceptable level of error and justification thereof.	
3	**Publishing Research:** Writing your Assignment: Identify the key features of any written work, Structure your assignment, Build your argument: Recognize the importance of emphasizing your point ,Distinguish between your point and the evidence available, Acknowledge the evidence Review and finalize your work: Know and follow the Process of reviewing and proof reading your work Writing your Assignment: Identify the key features of any written work, Structure your assignment, Build your argument: Recognize the importance of emphasizing your point ,Distinguish between your point and the evidence available, Acknowledge the evidence Review and finalize your work: Know and follow the Process of reviewing and proof reading your work Use feedback to improve your work.	04
4	**Showcasing the Research:** Delivering Your Presentation Check the logistics of your presentation: Identify the key message of your presentation, Understand the expectations and what will be the key review points Develop the structure of your presentation: Understand the key components of an oral presentation, Know the usual structure of a good presentation Putting together the support material: Identify all the material you need to carry as supporting material Get feedback on oral presentation: Prepare for delivery of your Oral presentation, Rehearse and time your presentation Find what is expected of the you: Identify specific requirements for evaluation/review and what constitutes completion of your work Decide which sources you will need: Differentiate between journals, conferences, books, magazines and their Quality ,Understand how to establish their quality and authenticity Finding Information: How to conduct effective searches, How to find relevant papers related to your area of research, How to capture critical information Identify main ideas in scholarly literature: Understand and identify the bias, theoretical position and evidence	02

Unit No.	Topics	Teaching Hrs.
	produced Write notes to organize your ideas: Compare ideas and concepts from different papers Ethical Issues related to Research: Plagiarism, Intellectual Property rights, Copyrights, Patent References: Understand the importance of distinguishing your work from others work and acknowledging such references, Learn international standards of referencing.	
	Total	**16**

List of References:

1. C.R. Kothari ,"*Research Methodology: Methods and Techniques*", New Age Publishers.
2. R.Paneerselvam ,"*Research Methodology*", PHI Learning Private Limited, Eight Printing 2010.

EE651: ARTIFICIAL INTELLIGENCE AND IT'S APPLICATIONS IN POWER SYSTEM

(CREDITS = 6 (L=4, T=2, P=0)

Teaching and Assessment Scheme:

Teaching Scheme			Credits	Assessment Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	CE	ESE	CE	
4	2	0	6	70	30	30	20	150

Course Content:

Unit No	Topics	Teaching Hours
1	**Introduction** Introduction, Intelligence, Artificial Intelligence: History, Early Works Techniques, Programming Methods.systems, expert systems brief histor of ANN, Fuzzy and GA, Intelligent System: History, Role of IS Comparison with conventional programs.	08
2	**Artificial Neural Network:** Fundamentals Of Neural Networks: Basic Concept, Neural Network Architectures, Characteristics, Learning Methods, early NN Architectures, Back propagation Networks: Architecture, Learning, Illustration,	08
3	**Fuzzy Logic:** Fuzzy Set theory, Crisp Set, Fuzzy set, Crisp relation, fuzzy relations. Fuzzy Systems: Crisp, predicate and fuzzy logic, Rule base system, Defuzzification	08

Unit No	Topics	Teaching Hours
	methods.	
4	**Genetic Algorithms:** Fundamentals, History, basics, working principal, encoding, fitness function, reproduction, Genetic Modeling, cross over, inversion, deletion, mutation, Bit wise operator, Application. 1. Roulette wheel selection 2. Stochastic remainder Roulette wheel selection , Rank selection, Tournament selection and stochastic universal sampling, different types of cross over methods in GA.	08
5	Applications of ANN, Fuzzy logic and GA in power systems operation and control for solving problems of load forecasting, voltage control, voltage stability, security assessment, feeder load balancing, AGC, Economic load dispatch, Unit commitment. Condition monitoring.	08
	Total	**40**

List of References:

1. S. Rajasekaran "*Neural Networks, Fuzzy Logic, and Genetic Algorithms Synthesis and Applications*", PHI Publication.
2. S. Rajasekaran, G. A. Vijayalakshmi Pai "*Neural Networks, Fuzzy logic and Genetic algorithms*", PHI publication.
3. Kalyanmoy Deb "*Optimization for Engineering Design*", PHI publication.
4. Kalyanmoy Deb "*Multi-objective Optimization using Evolutionary Algorithm*s", Willey Publication.
5. Kevin Warwick, Arthur Ekwue, Raj Agrawal "*Artificial intelligence techniques in power systems*".

EE652: POWER SYSTEM RESTRUCTURING
(CREDITS = 6 (L=4, T=2, P=0)

Teaching and Assessment Scheme:

Teaching Scheme			Credits	Assessment Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	CE	ESE	CE	
4	2	0	6	70	30	30	20	150

Course Content:

Unit No.	Topics	Teaching Hrs.
1	**Introduction to restructuring of power industry:** Reasons for restructuring of power industry; Understanding the restructuring	04

Unit No.	Topics	Teaching Hrs.
	process, Entities involved, The levels of competition, The market place mechanisms, Sector-wise major changes required; Reasons and objectives of deregulation of various power systems across the world.	
2	**Fundamentals of Economics:** Consumer and suppliers behavior, Total utility and marginal utility, Law of diminishing marginal utility, Elasticity of demand and supply curve, Market equilibrium, Consumer and supplier surplus, Global welfare, Deadweight loss.	06
3	**The Philosophy of Market Models:** Monopoly model, Single buyer model, Wholesale competition model, Retail competition model, distinguishing features of electricity as a commodity, Four pillars of market design, Cournot, Bertrand and Stackelberg competition model.	06
4	**Transmission Congestion Management:** Transfer capability, Importance of congestion management, Effects of congestion, Classification of congestion management methods, ATC, TTC, TRM, CBM, ATC calculation using DC and AC model, Nodal pricing, Locational Marginal Prices (LMPs), Implications of nodal pricing, Price area congestion management	08
5	**Ancillary Service Management:** Type and Classification of ancillary services, Sources of reactive power, Black start capability service, Provisions of ancillary services, Markets for ancillary services, Co-optimization of energy and reserve services, Loss of opportunity cost, International practices of ancillary services.	04
6	**Pricing of transmission network usage and loss allocation:** Introduction to transmission pricing, Principles of transmission pricing, Classification of transmission pricing, Rolled-in transmission pricing paradigm, Marginal transmission pricing paradigm, Composite pricing paradigm, Merits and de-merits of different paradigms, Classification of loss allocation methods, Pro-rata methods, Incremental methods, Power flow tracing based allocation	06
7	**Market power and generators bidding:** Attributes of a perfectly competitive market, The firm's supply decision under perfect competition, Imperfect competition, Monopoly, Oligopoly, Electricity markets under imperfect competition Sources of market power, Effect of market power, Identifying market power, HHI Index, Entropy coefficient, Lerner index, Market power mitigation, Effects of contract for differences, Role of demand side bidding, Financial	06

Unit No.	Topics	Teaching Hrs.
	markets, Introduction to optimal bidding by a generator company.	
	Total	**40**

List of References:

1. A. R. Abhyankar, S. A. Khaparde, "*NPTEL Course-Restructured Power Systems*", Available: http://nptel.iitm.ac.in/courses/108101005.
2. Daniel Kirschen and Goran Strbac "*Fundamentals of Power System economics*", John Wiley & Sons Ltd, 2004.
3. Sally Hunt "*Making competition work in electricity*", John Wiley & Sons, Inc., 2002.
4. Loi Lei Lai "*Power system restructuring and deregulation*", Wiley India.

EE653: POWER SYSTEM PLANNING AND RELIABILITY
(CREDITS = 6 (L=4, T=2, P=0)

Teaching and Assessment Scheme:

Teaching Scheme			Credits	Assessment Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE	CE	ESE	CE	
4	2	0	6	70	30	30	20	150

Course Content:

Unit No.	Topics	Teaching Hrs.
1	**System Planning:** Introduction, Objectives & Factors affecting to System Planning , Short Term Planning, Medium Term Planning, Long Term Planning, Reactive Power Planning.	07
2	**Reliability:** Reliability, Failure, Concepts of Probability, Evaluation Techniques (i) Markov Process (ii) Recursive Technique, Stochastic Prediction of Frequency and Duration of Long & Short Interruption, Adequacy of Reliability, Reliability Cost.	08
3	**Generation Planning and Reliability:** Generation Sources, Integrated Resource Planning, Generation System Model, Loss of Load (Calculation and Approaches),Outage Rate, Capacity Expansion, Scheduled Outage, Loss of Energy, Evaluation Methods, Interconnected System, Factors Affecting Interconnection under Emergency Assistance.	08

Unit No.	Topics	Teaching Hrs.
4	**Transmission Planning and Reliability:** Introduction, Objectives of Transmission Planning, Network Reconfiguration, System and Load Point Indices, Data required for Composite System Reliability.	07
5	**Distribution Planning and Reliability:** Radial Networks, Network Reconfiguration, Evaluation Techniques, Interruption Indices, Effects of Lateral Distribution Protection, Effects of Disconnects, Effects of Protection Failure, Effects of Transferring Loads, Distribution Reliability Indices, Parallel & Meshed Networks, Bus Bar Failure, Scheduled Maintenance, Temporary and Transient Failure, Breaker Failure.	10
	Total	**40**

List of References:

1. R.L. Sullivan "*Power System Planning*", Tata McGraw Hill Publishing Company Ltd.
2. Roy Billinton & Ronald N. Allan "*Reliability Evaluation of Power System*", Springer Publication.
3. T. W. Berrie "*Electricity Economics & Planning*", Peter Peregrinus Ltd., London.

EE654: ADVANCED DIGITAL SIGNAL PROCESSING
(CREDITS = 6 (L=4, T=2, P=0)

Teaching and Assessment Scheme:

Teaching Scheme			Credits	Assessment Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE	CE	ESE	CE	
4	2	0	6	70	30	30	20	150

Course Content:

Unit No.	Topics	Teaching Hrs.
1	**Introduction:** Signals, systems and signal processing, classification of signals, concept of discrete time signals, sampling of analog signal and sampling theorem, anatomy of digital filter.	05
2	**Discrete Time Signals And Systems:** Discrete time signals, Classification, analysis of discrete time signals and systems, implementation of discrete time systems, Correlation of discrete time signals, LTI Systems, Properties of LTI Systems, linear convolution and	08

Unit No.	Topics	Teaching Hrs.
	its properties, Linear Constant Coefficient Difference equations, Frequency domain representation of Discrete-Time Signals & Systems, Representation of sequences by discrete time Fourier Transform, (DTFT), Properties of discrete time Fourier Transform, and correlation and Auto correlation of signals	
3	**Z- Transform And Analysis Of Linear Time Invariant System:** Z-Transform, Properties of ROC for Z-transform, the inverse Z- transform methods, Z- transforms properties, Analysis of LTI systems in time domain and stability considerations. Frequency response of LTI system.	06
4	**Discrete And Fast Fourier Transforms:** Frequency domain sampling, proportion of DFT, efficient computation of DFT : FFT algorithms, Quantization effects in the computation of the DFT.	04
5	**Digital Filters:** Digital filter design, design techniques for IIR and FIR filters, Analysis of finite word length effects, Structures of FIR and IIR filters, design of FIR filters using windows; Optimum approximations of FIR filters using Parks-McClellan algorithm, Design of IIR filters from analog filters by bilinear transformations; impulse invariance method.	08
6	**Applications of Dsp:** Introduction to TMS320LF240x DSP Controller: Introduction, Brief Introduction to Peripherals, Types of Physical Memory and Introduction to Software tools (For Practical Work). Applications of DSP to power system/power electronics/Instrumentation.	09
	Total	**40**

List of References:

1. Proakis-Manolakis, "*Digital signal Processing*", Pearson, 4th edition,
2. Oppenheim-Schetor, "*Discrete time signal processing*", Prentice Hall.
3. N. G. Palan, "*Digital Signal Processing*", Techmax Publications.
4. Rabiner-Gold, "*Theory & application of digital signal processing*", PHI, 1992.
5. Sanjit Mitra, "*Digital Signal processing*", McGraw-Hill Science/Engineering/Math; 3rd edition, 2005.
6. Andy Bateman and Iain Paterson-Stephens, "*The DSP Handbook: Algorithms, Applications and Design Techniques*", Prentice Hall PTR, 2002.
7. Datasheet of TMS320LF240x DSP Controller by Texas Instruments.

EE655: DISTRIBUTED GENERATION AND MICRO GRID
(CREDITS = 6 (L=4, T=2, P=0)

Teaching and Assessment Scheme:

Teaching Scheme			Credits	Assessment Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE	CE	ESE	CE	
4	2	0	6	70	30	30	20	150

Course Content:

Unit No.	Topics	Teaching Hrs.
1	**Introduction:** Conventional power generation: advantages and disadvantages, Energy crises, Non-conventional energy (NCE) resources: review of Solar PV, Wind Energy systems, Fuel Cells, micro-turbines, biomass, and tidal sources.	08
2	**Distributed Generations (DG):** Concept of distributed generations, topologies, selection of sources, regulatory standards/ framework, Standards for interconnecting Distributed resources to electric power systems: IEEE 1547. DG installation classes, security issues in DG implementations. Energy storage elements: Batteries, ultra-capacitors, flywheels. Captive power plants.	08
3	**Impact Of Grid Integration:** Requirements for grid interconnection, limits on operational parameters,: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues.	08
4	**Microgrids:** Concept and definition of microgrid, microgrid drivers and benefits, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids, communication infrastructure, modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques.	10
5	**Power Quality Issues In Microgrids:** Power quality issues in microgrids- Modelling and Stability analysis of Microgrid, regulatory standards, Microgrid economics, Introduction to smart microgrids.	06
	Total	**40**

List of References:

1. AmirnaserYezdani, and Reza Iravani, "*Voltage Source Converters in Power Systems: Modeling, Control and Applications*", IEEE John Wiley Publications, 2009.
2. DorinNeacsu, "*Power Switching Converters: Medium and High Power*", CRC Press, Taylor & Francis, 2006.
3. Chetan Singh Solanki, "*Solar Photo Voltaics*", PHI learning Pvt. Ltd., New Delhi, 2009.
4. J.F. Manwell, "*Wind Energy Explained, theory design and applications*," J.G. McGowan Wiley publication, 2002.
5. D. D. Hall and R. P. Grover, "*Biomass Regenerable Energy*", John Wiley, New York, 1987.
6. John Twidell and Tony Weir, "*Renewable Energy Resources*" Tyalor and Francis Publications, 2005.

EE656: SMART GRID TECHNOLOGY
(CREDITS = 6 (L=4, T=2, P=0)

Teaching and Assessment Scheme:

Teaching Scheme			Credits	Assessment Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE	CE	ESE	CE	
4	2	0	6	70	30	30	20	150

Course Content:

Unit No.	Topics	Teaching Hrs.
1	**Introduction to Smart Grid:** Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Functions of Smart Grid, Opportunities & Barriers of Smart Grid, Difference between conventional & smart grid, Concept of Resilient & Self-Healing Grid, Present development & International policies in Smart Grid. Case study of Smart Grid ,CDM opportunities in Smart Grid, What is a Smart Grid?, The Smart Grid Enables the ElectriNetSM, Local Energy Networks, Electric Transportation, Low-Carbon Central Generation, What Should Be the Attributes of the Smart Grid?, Why Do We Need a Smart Grid?, Is the Smart Grid a "Green Grid"?, Smart Grid Initiative for Power Distribution Utility in India (Term paper).	08
2	**Sensing, Measurement, Control and Automation Technologies:** Smart metering and demand-side integration, Introduction, Smart metering, Evolution of electricity metering, Key components of smart metering, Smart meters: An overview of the hardware used Signal acquisition, Signal conditioning, Analogue to digital conversion, Computation, Input/output, Communication, Communications infrastructure and protocols for smart metering, Home-area network, Neighborhood area network, Data	08

Unit No.	Topics	Teaching Hrs.
	concentrator, Meter data management system, Protocols for communications, Demand-side integration, Services provided by DSI, Implementations of DSI, Hardware support to DSI implementations, Flexibility delivered by prosumers from the demand side, System support from DSI. Smart Appliances, Automatic Meter Reading (AMR), Outage**.** Management System (OMS), Plug in Hybrid Electric Vehicles (PHEV), Vehicle to Grid, Grid to Vehicle, Coordination of PHEV charging and discharging cycle, Smart Sensors, Home & Building Automation, Phase Shifting Transformers.	
3	**Smart Substations:** Substation Automation equipment, Current transformers. Voltage transformers, Intelligent electronic devices, Bay controller, Remote terminal units, Faults in the distribution system, Components for fault isolation and restoration, Fault location, isolation and restoration, Voltage regulation. Feeder Automation, Geographic Information System(GIS), Intelligent Electronic Devices(IED) & their application for monitoring & protection, Smart storage like Battery, Pumped Hydro, SMES, Compressed Air Energy Storage, fuel cells, super capacitors and its case studies.	06
4	**Transmission System Operation:** Wide Area Measurement System (WAMS), Phase Measurement Unit (PMU), WAMPAC	06
5	**Micro Grids And Distributed Energy Resources:** Concept of micro grid, need & applications of micro grid, formation of micro grid, issues of interconnection, protection & control of micro grid. Islanding, need and benefits, different methods of islanding detection. Distributed Energy Resources: Small scale distributed generation, Distributed Generation Technology, Internal Combustion Engines, Gas Turbines, Combined Cycle Gas Turbines, Micro turbines, Fuel Cells, Solar Photovoltaic, Solar thermal, Wind power, Geothermal, - all sources as a DG. Advantages and disadvantages of DG.	06
6	**Power Quality Management In Smart Grid:** Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit. Information And Communication Technology For Smart Grid: Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN). Bluetooth, Zig-Bee, GPS, Wi-Fi, Wi-Max based communication, Wireless Mesh Network, Broadband over Power line (BPL).	06
	Total	**40**

List of References:

1. Ali K., M.N. Marwali, Min Dai, "*Integration of Green and Renewable Energy in Electric Power Systems*", Wiley.
2. Clark W. Gellings, "*The Smart Grid: Enabling Energy Efficiency and Demand Response*", CRC Press.
3. JanakaEkanayake, N. Jenkins, K. Liyanage, J. Wu, Akihiko Yokoyama, "*Smart Grid: Technology and Applications*", Wiley.
4. Jean Claude Sabonnadiere, NouredineHadjsaid, "*Smart Grids*", Wiley Blackwell.
5. Tony Flick and Justin Morehouse, "*Securing the Smart Grid*", Elsevier Inc.
6. Peter S. Fox-Penner, "*Smart Power: Climate Change, the Smart Grid, and the Future of Electric Utilities*", Island Press.
7. James Momoh "*SMART GRID Fundamentals of Design and Analysis*", IEEE press, A John Wiley & Sons, Inc., Publication.
8. Bhavesh Bhalja, R. P. Maheshwari and N. G. Chothani, "*Protection and Switchgear*", Oxford University Press, New Delhi, India, 2nd Edition, 2015.
9. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, "*Smart Grid: Technology and Applications*", wiley India.

EE681: RENEWABLE ENERGY TECHNOLOGY
(CREDITS = 5 (L=3, T=2, P=0)

Teaching and Assessment Scheme:

Teaching Scheme			Credits	Assessment Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE	CE	ESE	CE	
3	2	0	5	70	30	30	20	150

Course Content:

Unit No.	Topics	Teaching Hrs.
1	**Introduction:** Renewable Sources of Energy, Grid-Supplied Electricity, Distributed Generation-Renewable. Various no-conventional energy resources; Introduction, availability, classification, relative merits and demerits.	04
2	**Solar Energy:** 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	10
3	**Wind Energy conversion:** Wind power and its sources, site selection criterion, momentum theory, classification of rotors, wind characteristics, performance and limitations of energy conversion systems. Power from wind, properties of air and wind,	08

Unit No.	Topics	Teaching Hrs.
	types of wind Turbines, operating characteristics.	
4	**Geothermal Energy:** Resources of geothermal energy, thermodynamics of geothermal energy conversion-electrical conversion, non-electrical conversion, environmental, Tides and tidal power stations, modes of operation, tidal project examples, turbines and generators for tidal power generation.	06
5	**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,	08
	Total	**36**

List of References:

1. S.P. Sukhatme, "*Solar Energy - Principles of thermal collection and storage*", TMH, 2008.
2. Thomas Ackermann, "*Wind Power in Power System*", John Willey &Sons, 2005.
3. Felix A. Farret, M. Godoy Simoes, "*Integration of Alternative Sources of Energy*", John Wiley & Sons, 2006.
4. Remus Teodorescu, Marco Liserre and Pedro Rodríguez, "*Grid Converters For Photovoltaic and Wind Power Systems*", John Wiley & Sons, 2011.

MA503: OPTIMIZATION TECHNIQUES
(CREDITS = 5 (L=3, T=2, P=0)

Teaching and Assessment Scheme:

Teaching Scheme			Credits	Assessment Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE	CE	ESE	CE	
3	2	0	5	70	30	30	20	150

Course Content:

Unit No.	Topics	Teaching Hrs.
1	Definition, Classification of optimization problems, Classical Optimization Techniques, Single and Multiple Optimization with and without inequality constraints.	05
2	Linear programming –formulation-Graphical and simplex methods-Big-M method-Two phase method-Dual simplex method-Primal Dual problems.	08
3	Unconstrained one dimensional optimization techniques -Necessary and sufficient conditions –Unrestricted search methods-Fibonacci and golden section method-Quadratic Interpolation methods, cubic interpolation and direct root methods.	08

Unit No.	Topics	Teaching Hrs.
4	Unconstrained n dimensional optimization techniques – direct search methods –Random search –pattern search and Rosen brooch's hill claiming method- Descent methods-Steepest descent, conjugate gradient, quasi - Newton method.	08
5	Constrained optimization Techniques- Necessary and sufficient conditions –Equality and inequality constraints-Kuhn-Tucker conditions-Gradient projection method-cutting plane method- penalty function method.	08
6	Dynamic programming- Multistage decision processes, concept of sub-optimization and principle of optimality, Recursive relations, Integer Linear programming, Branch and bound algorithm.	08
	Total	**45**

List of References:

1. Rao S.S., "*Optimization: Theory and Application*", Wiley Eastern Press, 2nd edition 1984.
2. Stephen G. Nash and Aridla Sofer, "*Linear and nonlinear programming*", Mc Graw Hill.
3. K. Deb, "*Optimization for engineering design*", PHI.
4. Taha H.A., "*Operations Research –An Introduction*", Prentice Hall of India, 2003.
5. Fox, R.L., "*Optimization methods for Engineering Design*", Addition Welsey, 1971.