DEPARTMENT OF ELECTRICAL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY SRINAGAR

HAZRATBAL, SRINAGAR, JAMMU & KASHMIR – 190 006

SEMESTER WISE COURSE STRUCTURE
AND
SUBJECT WISE COURSE CONTENT

FOR

M. Tech. PROGRAMME

ELECTRICAL POWER & ENERGY SYSTEMS (EPES)

1^{ST} to 4^{TH} Semester

IN

ELECTRICAL ENGINEERING

Applicable from **AUTUMN - 2020** batch onwards

Recommended by the Departmental Post Graduate Committee

On ___________________

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Department of Electrical Engineering,
National Institute of Technology Srinagar

Faculty Structure

S. No.	Name of Faculty	Designation	Qualification	Specialization
1.	Prof. M.D. Mufti	Professor	PhD	Power System Control, Dynamics & Stability
2.	Prof. Aijaz Ahmad	Professor	PhD	Power System Operation & Optimization
3.	Prof. S.A Lone	Professor	PhD	Stand-alone Power Systems
4.	Prof. A.H. Bhat	Professor	PhD	Power Electronics, Electric Drives and Power Quality
5.	Dr. S. Javed Iqbal	Associate Professor	PhD	Power System Dynamics & Control
6.	Dr. Obbu Chandra Sekhar	Associate Professor	PhD	Power Electronics and Drives
7.	Dr. M.A Bazaz	Associate Professor	PhD	Control & Automation
8.	Dr. Asadur Rahman	Assistant Professor	PhD	Power System Control & Optimization, Renewable Energy System
9.	Dr. Neeraj Gupta	Assistant Professor	PhD	Probabilistic Power Systems and Renewable Energy Systems
10.	Dr. Farhad Ilahi Bakhsh	Assistant Professor	PhD	Power Electronics and Drives, Renewable Energy Systems
11.	Dr. Kushal M Jagtap	Assistant Professor	PhD	Distributed Generation and Power Systems
12.	Dr. Ravi Bhushan	Assistant Professor	PhD	Power Stability and Control
13.	Dr. Chilaka Ranga	Assistant Professor	PhD	Electrical Machines and Di-Electrics
14.	Ms. Tabish Nazir Mir	Trainee Teacher	B. Tech, Pursuing PhD	Power Converters-Modulation and Control, Electric Drives

Requirements for Completion of
M. Tech - Electrical Power & Energy Systems (EPES):

(As per NIT Srinagar Academic Statutes)

1. A student has to complete a minimum of **60 credits** for the award of M. Tech Degree. The credit structure is as follows:

   Core : 32 credits

   Project : 16 credits

   Electives : 12 credits (Minimum)

2. Full time student has to take 12 to 18 credits in each semester.
3. Part time student has to take 9 to 12 credits in each semester.
4. In addition to above, a student can audit a total number of 3 courses during his/her entire programme of M. Tech, for which he/she will be awarded an AU grade, subject to following:
   a. In 1st year: 1st semester, full time student is not allowed to audit a course, whereas a part-time student can do so.
   b. A part time or full time student can audit only one course in one semester.

Eligibility Criteria for Admission to
M. Tech - Electrical Power & Energy Systems (EPES):

1. Any one of following B. E. / B. Tech 4 year Programme from Accredited/Recognized University/Institution:

   Electrical Engineering / Electrical and Electronics Engineering / Electrical & Instrumentation Engineering / Renewable Energy Engineering / Electrical and Computer Engineering / Power Plant Engineering
2. A valid GATE score in EE / IN.
3. Sponsored category students shall be admitted as per institute policy.

Seat Matrix

M. Tech - Electrical Engineering Department:

The Category wise seat matrix will be as follows:

Category	Intake capacity for M. Tech - **EPES**	Intake capacity for M. Tech - **PEED**
OC	10	10
OC-PWD	1	1
OC-EWS	2	2
OBC	7	7
SC	4	4
ST	2	2
Sponsored	5	5
Total	**31**	**31**

List of Abbreviations

Course Code are abbreviated as **EEM AXX**, where, **EEM** signifies M. Tech in Electrical Engineering	
EEM 1XX	**Theory Course**
EEM 2XX	**Practical Course**
EEM 3XX	**Dissertation**
L	**Lecture**
T	**Tutorial**
P	**Practical**
CW	**Class Work**
PR	**Practical Work**
MTE	**Mid Term Examination**
ETE	**End Term Examination**

Department of Electrical Engineering,
National Institute of Technology Srinagar

Course Structure for M. Tech - Electrical Power & Energy Systems (EPES)

Teaching Scheme				Contact Hrs. Per week			Exam. Duration		Relative Weightage (%)			
S. No.	Course Code	Course Title	No. of Credits	L	T	P	Th	Pr	CW	PR	MTE	ETE
1st YEAR		**1st SEMESTER (AUTUMN)**										
1	EEM 101	Advanced Power System Analysis	4	3	1	-	3	-	10	-	30	60
2	EEM 102	Power System Control	3	3	-	-	3	-	10	-	30	60
3	EEM 121	Power Quality Problems & Solutions	3	3	-	-	3	-	10	-	30	60
4	MTM 101	Optimization Techniques	3	3	-	-	3	-	10	-	30	60
5	- - - - - -	Elective – I	3	3	-	-	3	-	10	-	30	60
6	EEM 201	Power System Simulation Lab	2	-	-	4	--	1	-	25	25	50
Sub Total			**18**									
		2nd SEMESTER (SPRING)										
1	EEM 103	Power System Dynamics and Stability	3	3	-	-	3	-	10	-	30	60
2	EEM 104	Power System Optimization	3	3	-	-	3	-	10	-	30	60
3	EEM 105	Renewable Sources of Energy	3	3	-	-	3	-	10	-	30	60
4	EEM 125	HVDC Systems	3	3	-	-	3	-	10	-	30	60
5	- - - - - -	Elective – II	3	3	-	-	3	-	10	-	30	60
6	EEM 202	Advanced Power System Lab	2	-	-	4	-	1	-	25	25	50
Sub Total			**17**									
2nd YEAR		**3rd SEMESTER (AUTUMN)**										
1	EEM 106	Power System Restructuring & Deregulation	3	3	-	-	3	-	10	-	30	60
2	- - - - - -	Elective - III	3	3	-	-	3	-	10	-	30	60
3	- - - - - -	Elective - IV	3	3	-	-	3	-	10	-	30	60
4	EEM 301	Pre - Dissertation	4	-	-	-	-	-	-	-	-	-
Sub Total			**13**									
		4th SEMESTER (SPRING)										
1	EEM 302	Dissertation	12	-	-	-	-	-	-	-	-	-
Sub Total			**12**									

Total Credit points for all four (1st – 4th) semesters: 60

Electives for M. Tech in "Electrical Power & Energy Systems" in Semesters (1^{st} – 3^{rd})

Elective – I, II, III, IV **3 Credits each**

Teaching Scheme				Contact Hrs. Per week			Exam. Duration		Relative Weightage (%)			
S. No.	Course Code	Course Title	No. of Credits	L	T	P	Th	Pr	CW	PR	MTE	ETE
1	EEM 107	Modeling & Simulation of Power System Components	3	3	-	-	3	-	10	-	30	60
2	EEM 108	Soft Computing	3	3	-	-	3	-	10	-	30	60
3	EEM 109	SCADA Systems	3	3	-	-	3	-	10	-	30	60
4	EEM 132	Smart Grid Technology	3	3	-	-	3	-	10	-	30	60
5	EEM 137	Optimal Control	3	3	-	-	3	-	10	-	30	60
6	EEM 110	Energy Management & Energy Audit	3	3	-	-	3	-	10	-	30	60
7	EEM 128	Flexible AC Transmission Systems	3	3	-	-	3	-	10	-	30	60
8	EEM 129	Hybrid Electric Vehicles	3	3	-	-	3	-	10	-	30	60
9	EEM 111	Selected Topics in Power & Energy Systems	3	3	-	-	3	-	10	-	30	60
10	EEM 112	Intelligent Control of Electrical Energy Systems	3	3	-	-	3	-	10	-	30	60
11	EEM 130	Non Linear Systems	3	3	-	-	3	-	10	-	30	60
12	EEM 113	Stand Alone Energy Systems	3	3	-	-	3	-	10	-	30	60
13	EEM 114	Advanced Power System Protection	3	3	-	-	3	-	10	-	30	60
14	EEM 115	Energy System Planning	3	3	-	-	3	-	10	-	30	60
15	EEM 116	Power System Reliability	3	3	-	-	3	-	10	-	30	60
16	EEM 117	Advanced Instrumentation Technology	3	3	-	-	3	-	10	-	30	60
17	EEM 118	Modeling and Analysis of Electric Machines	3	3	-	-	3	-	10	-	30	60
18	EEM 123	Linear Systems Theory	3	3	-	-	3	-	10	-	30	60
19	EEM 134	Modern Power Electronics	3	3	-	-	3	-	10	-	30	60
20	EEM 131	Power Electronics for Renewable Energy Systems	3	3	-	-	3	-	10	-	30	60
21	ECEM 159	Embedded Systems & Real Time Applications	3	3	-	-	3	-	10	-	30	60

Syllabi of Core Courses

In

Semester-I

ADVANCED POWER SYSTEM ANALYSIS

Credits: 4 **L T P**

Course code: EEM 101 **3 1 0**

Module 1

Network Modeling and Power Flow: System graph, loop, cutest and incidence matrices, y-bus formation, sparsity and optimal ordering , power flow analysis, Newton Raphson method, decoupled and fast decoupled method, formulation of three phase load flow, dc load flow, formulation of AC-DC load flow, sequential solution technique..

Module 2:

Fault Studies: Analysis of three phase symmetrical and unsymmetrical faults in phase and sequence domain, phase shift in sequence quantities due to transformer, open circuit faults.

Module 3

Stability Studies: Transient stability analysis, swing equation, stability of multimachine system using modified Euler method and Runge-Kutta method.

Module 4

Power System Security: Factors affecting security, State transition diagram, contingency analysis using network sensitivity method and AC power flow method. Introduction to power system monitoring, energy management system (EMS), SCADA, function of state estimator, maximum likelihood estimation.

Text Books:

1. D. P. Kothari and I. J. Nagrath, Modern Power System Analysis, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1994.
2. Hadi Saadat, Power System Analysis, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 2002.
3. George L. Kusic, Computer Aided Power System Analysis. Prentice Hall of India (P) Ltd., New Delhi, 1989.
4. J. Arrilaga, C. P. Arnold, B. J. Harker, Computer Modelling of Electric Power System, John Wiley & Sons.K. Mahailnaos, D. P. Kothari, S. I. Ahson, Computer Aided Power System Analysis & Control, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1988.

References:

1. G. T. Heydt, Computer Analysis Methods for Power Systems, Macmillan Publishing Company, New York.
2. L. P. Singh, Advanced Power System Analysis and Dynamics, New Age, International Publishers, New Delhi.
3. “Understanding FACTS Concepts and Technology of Flexible AC Transmission System”, N.G. Hingorani and L. Gyugyi

POWER SYSTEM CONTROL

Credits: 3 | **L T P**
Course code: EEM 102 | **3 0 0**

Module 1:

Power System - Introduction: Interconnection, Stability, Operating states, Control loops – AGC – AVR; System modeling – Governor – Turbines – Generator – Load – Tie-line.

Module 2:

Automatic Generation Control (AGC): Factors influencing and overriding economy; AGC implementation – AGC features – Participating factors; Static and Dynamic performance; Modes of control viz. Flat frequency – Tie-line control and Tie-line Bias control; Static and Dynamic response of controlled two-area system.

Module 3:

Automatic Voltage Regulator (AVR): Types of alternator exciters, AVR for generator excitation control, static and dynamic performance of AVR loop; MVAR control – Application of voltage regulator – synchronous condenser – transformer taps – static VAR compensators.

Module 4:

The Control Techniques: Classical, Optimal, Adaptive, and Intelligent (fuzzy & neural) control techniques; Energy storage devices and its application to power system control.

Text books:

1. Olle I Elgard, "Electric Energy systems Theory - An Introduction" Tata McGraw Hill, 2nd Edition.
2. Allen J.Wood and Wollenberg B.F, "Power Generation Operation and control", John Wiley & Sons, 2nd Edition, 1996.

References

1. Prabha Kundur, "Power System Stability and Control", McGraw Hill, 2006.
2. Kirchmayer L.K., "Economic Control of Interconnected Systems", John Wiley & Sons, 1959
3. Abhijit Chakrabarti and Sunita Halder, "Power System Analysis, Operation and Control" PHI.

POWER QUALITY PROBLEMS AND SOLUTIONS

	Credits: 3	**L T P**
Course code: EEM 121		**3 0 0**

Module-1

Introduction to Power Quality: Definition, Power Quality Problems, Causes and Consequences, voltage sags, swells, interruptions, flicker, reactive power and harmonics. Load Current Compensation, Reactive power compensation and zero voltage regulation. Compensation through passives, Active load compensation, D-STATCOM - Design, Control and Phasor Analysis.

Module-2

Source Voltage Compensation, Dynamics of sags and swells, Passive Series Compensation, Active Series Compensation- Dynamic Voltage Restorer (DVR) with and without energy support- Design, Control and Phasor Analysis.

Module-3

Combined Compensation - Unified Power Quality Conditioner (UPQC) , Right Shunt and Left Shunt Topologies, Phasor Analysis of UPQC-P,Q and S under various perturbations.

Module-4

Voltage and Current Harmonics- Causes and Consequences. Design of Passive Filters. Active Shunt Filters and Active Series Filters, Hybrid Filters, Improved Power Quality Converters.

Text Books:

1. Understanding Power Quality Problems: Voltage Sags and Interruptions by Math H. Bollen, Wiley-IEEE Press.
2. Power Quality Enhancement using Custom Power Devices by Arindham Ghosh, Gerard Ledwich, Springer.
3. Power Quality Problems and Mitigation Techniques by Bhim Singh and Ambrish Chandra, Wiley.

References

1. N. Mohan, T.M. Undeland & W.P. Robbins, Power Electronics: Converter, Applications & Design, John Wiley & Sons, 1989
2. Referred Journal/Conference publications

OPTIMIZATION TECHNIQUES
Credits: 3

Course Code: MTM 101	**L**	**T**	**P**
	3	**0**	**0**

Module 1
Mathematical formulation of optimization problems and their general methods of solution. Multiobjective and goal programming (solution using graphical methods and simplex based methods).

Module 2
Kuhn Tucker theory, quadratic programming, Direct search and gradient methods, Optimum of a unimodal function, Fibonacci method, Method of steepest descent.

Module 3
Newton-Raphson method, Hooke's and Jeeve's method, Conjugate gradient method. Bellman's principle of optimality and methods of recursive optimization (simple problems involving upto one constant).

Module 4
Introduction to recent optimization techniques for engineering applications (Genetic algorithms and Particle swarm technique).

Text books:

1. Engineering Optimization: Theory and Practice, 4th Edition by Singiresu S. Rao. (Wiley)

References:

1. Essentials of Metaheuristics by Sean Luke.

POWER SYSTEM SIMULATION LABORATORY

	Credits: 2	**L T P**
Course code: EEM 201		**0 0 4**

1. Study of DC load flow.
2. Study of AC load flow using Newton Raphson method.
3. Study of AC load flow using Gauss Seidel method.
4. Short circuit studies.
5. Automatic Generation Control of single-area power system.
6. Application of Swing equation and its solution to determine transient stability.

Software: MATLAB & Simulink / LabVIEW / ETAP / MiPower.

Syllabi of Core Courses

In

Semester-II

POWER SYSTEM DYNAMICS & STABILITY

Credits: 3 | **L T P**
Course code: EEM 103 | **3 0 0**

Module 1

Power system dynamics, Power system stability and its problems, Types of stability, Synchronous machine modeling, dq0-transformation, Per unit representation, Equivalent circuits for direct and quadrature axes.

Module 2

Excitation system and its modeling, Excitation system requirements and the types of excitation systems. Modeling of turbines, governors, loads.

Module 3

Fundamental concepts of small signal stability, State-space representation, Linearization, Eigenvalue and eigen properties of the state matrix, Small signal stability of single machine infinite bus (SMIB) system.

Module 4

Transient instability, Analysis using digital simulation and energy function method, Transient stability controllers. Mitigation using power system stabilizer (PSS) design and supplementary modulation control of FACTS devices.

Text Books:

1. Kundur P, "Power System Stability and Control", TMH.
2. Anderson and Fouad, "Power System Control and Stability", Galgotia Publications, Compensation 1981.
3. Ramanujam R, "Power System Dynamics- Analysis & Simulation", PHI learning Private Limited
4. Padiyar K R, "Power System Dynamics", 2nd Edition, B.S. Publishers, 2003.
5. Sauer P W & Pai M A," Power System Dynamics and Stability", Pearson, 2003.

References:

1. Olle I Elgerd, "Electric Energy Systems Theory an Introduction", 2nd Edition, McGraw-Hill, 1983.
2. Kimbark E W, "Power System Stability", McGraw-Hill Inc., 1994, Wiley & IEEE Press, 1995.
3. Yao-Nan-Yu, "Electric Power Systems Dynamics", Academic Press, 1983.

POWER SYSTEM OPTIMIZATION

Credits: 3 | **L T P**
Course code: EEM 104 | **3 0 0**

Module 1:

Economic operation: Economic load dispatch problem of thermal units without and with losses – Gradient method- Newton's method –Base point and participation factor method.

Module 2:

Unit Commitment: Introduction to unit commitment, methods of unit commitment; Priority-List Methods, Dynamic- Programming Solution, Forward DP Approach, Lagrange relaxation solution.

Module 3:

Hydro-thermal coordination: Hydroelectric plant models- short term hydrothermal scheduling problem - gradient approach, Cascaded and pump storage plant scheduling.

Module 4:

Optimal Power Flow: Solution of OPF - Gradient method - Newton's method - Linear programming method with only real power variables - Linear programming with AC power flow variables, Security-constrained optimal power flow, AC power flow methods – Contingency selection – Concentric relaxation – Bounding-security constrained OPF.

Text books

1. Allen J.Wood and Wollenberg B.F., 'Power Generation Operation and control', John Wiley & Sons, 2nd Edition, 1996.
2. Electric Energy systems Theory - An Introduction' Olle I Elgard, TMH, 2nd Edition.

References

1. Kirchmayer L.K., 'Economic Control of Interconnected Systems', John Wiley & Sons, 1959.
2. Nagrath, I.J. and Kothari D.P., 'Modern Power System Analysis', TMH, New Delhi, 2006.

RENEWABLE SOURCES OF ENERGY

Credits: 3 **L T P**

Course code: EEM 105 **3 0 0**

Module 1

Review of different energy resources, Energy problem, Energy and Environment, Need for Renewables, Rural Energy.

Module 2

Introduction to Solar Energy - Solar radiation and its measurement – Solar energy collectors – Energy Balance Equation and Collector Efficiency – Solar Cell Principles – Conversion Efficiency and Power Output – Photovoltaic system and Solar-Thermal system for Power Generation – Solar Cell Modules - Solar Energy Storage - Applications of Solar Energy.

Module 3

Wind Energy Conversion (WEC) - Basic Principles - Wind Energy Estimation – WEC System - Basic Components - Wind Energy Collectors - Rotor Types – Wind Turbine Types - Forces Developed by Blades – Aerodynamic Force – Braking systems – Tower - Control and Monitoring System – Performance of Wind Machines.

Module 4

Electric Power Generation from Tidal, Ocean Thermal and Geothermal energy. Simple power plant based on Tidal / OTEC / Geothermal. Concept of Hybrid Energy Systems.

Text Books

1. B. H. Khan, “Non-Conventional Energy Resources”, Tata McGraw-Hill, 2006.
2. John F. Walker & Jenkins. N, “Wind Energy Technology”, John Wiley and Sons, 1997.

Reference

1. G.D. Rai, “Non-Conventional Energy Sources”, First Edition, Khanna Publishers, Delhi, 1999.
2. Agarwal M.P., “Future Sources of Electrical Power”, S. Chand Co. Ltd., New Delhi, 1999.
3. Van Overstraeton and Mertens R.P., “Physics, Technology and Use of Photovoltaics”, Adam Hilger, Bristol,1996.

HIGH VOLTAGE DIRECT CURRENT SYSTEMS (HVDC SYSTEMS)

	Credits: 3	**L T P**
Course code: EEM 125		**3 0 0**

Module 1

Evolution of HVDC Transmission, Comparison of HVAC and HVDC system, Types of HVDC Transmission system, Components of HVDC Transmission system, Analysis of simple rectifier circuits, Required features of rectification circuits for HVDC Transmission.

Module 2

Analysis of HVDC converter: Different modes of valve operation, output voltage waveforms and DC voltage in rectification operation, output voltage waveforms and DC voltage in inverter operation, valve voltages, Equivalent electrical circuits, converter chart.

Module 3

Converter mal-operation, commutation failure, converter protection, DC reactor and damper circuits, HVDC system control features, Control modes, Control schemes and control comparisons, Energization and De-energization of bridges, Starting and stopping of HVDC link.

Module 4

Harmonic Analysis, Filter design, Grounding and DC lines, Reactive power requirements, Multi-terminal HVDC system (MTDC), HVDC Light, HVDC system in wind power generation.

Text Books

1. E. Kimbark, “Direct Current Transmission”, Wiley publishers.

References

1. K.R. Padiyar, “HVDC Power Transmission Systems”, New Age International Publishers.
2. Dragan Jovcic, Khaled Ahmed, “High voltage direct current transmission”.
3. NPTEL Lecture series on HVDC Systems.

ADVANCED POWER SYSTEM LABORATORY

Credits: 2

Course Code: EEM 202	**L**	**T**	**P**
	0	**0**	**4**

1. Load forecasting.
2. Transient stability studies.
3. Unit commitment problems.
4. Economic Load Dispatch with thermal power plants.
5. Economic Load Dispatch with Hydro thermal power plants.
6. Automatic Generation Control of multi-area power system.
7. Simulation of Hybrid Energy Systems using MATLAB.
8. Analysis of Power System Options for remote area using software packages.
9. Development of mathematical model and analysis of hybrid energy systems.

Syllabi of Core Courses

In

Semester-III

POWER SYSTEM RESTRUCTURING & DEREGULATION

	Credits: 3	L T P
Course code: EEM 106		**3 0 0**

Module 1

Introduction: Basic concept and definitions, privatization, restructuring, transmission open access, wheeling, deregulation, components of deregulated system, advantages of competitive system.

Module 2:

Power System Restructuring: An overview of the restructured power system, Difference between integrated power system and restructured power system. Explanation with suitable practical examples.

Congestion management in normal operation, explanation with suitable example, total transfer capability (TTC), Available transfer capability (ATC), Transmission Reliability Margin (TRM), Capacity Benefit Margin (CBM), Existing Transmission Commitments (ETC).

Module 3

Deregulation of Power Sector: Separation of ownership and operation, Deregulated models, pool model, pool and bilateral trades model, Multilateral trade model.

Competitive electricity market: Independent System Operator activities in pool market, Wholesale electricity market characteristics, central auction, single auction power pool, double auction power pool, market clearing and pricing, Market Power and its Mitigation Techniques, Bilateral trading, Ancillary services, Transmission Pricing.

Module 4

Open Access Same Time Information System (OASIS): Introduction, structure, functionality, implementation, posting of information, uses. Different Experiences in deregulation: U.S.A, Canada, U.K, Japan, Switzerland, Australia, Sweden, Germany and Indian power system.

Text / Reference Books:

1. "Power System Restructuring and Deregulation" Edited by Loi Lei Lai, John Wiley & Sons Ltd.
2. "Understanding Electric Utilities and Deregulation", Lorrin Philipson and H. Lee Willis, Marcel Dekker Inc, New York, CRC Press, 2005.
3. Power System Restructuring Engineering & Economics by Marija llic, Francisco Galiana and Lestor Fink, Kulwer Academic Publisher, USA-2000.

PRE - DISSERTATION

Credits: 4

Course code: EEM 301

A student needs to present/demonstrate the basic literature survey, motivation behind the selection of research topic, plan of work and preliminary implementation

Syllabi of Core Courses

In

Semester-IV

DISSERTATION

Credits: 12

Course code: EEM 302

A complete project report on the selected research topic needs to be submitted, besides detailed presentation/demonstration of the work done. Students are encouraged to stress on novelty and prospective publication.

Syllabi of Elective – I, II, III, IV

In Semester (1 – 3)

"Electrical Power & Energy Systems"

Electives for M. Tech in "Electrical Power & Energy Systems" in Semesters (1^{st} – 3^{rd})

Elective – I, II, III, IV **3 Credits each**

Teaching Scheme				Contact Hrs. Per week			Exam. Duration		Relative Weightage (%)			
S. No.	Course Code	Course Title	No. of Credits	L	T	P	Th	Pr	CW	PR	MTE	ETE
1	EEM 107	Modeling & Simulation of Power System Components	3	3	-	-	3	-	10	-	30	60
2	EEM 108	Soft Computing	3	3	-	-	3	-	10	-	30	60
3	EEM 109	SCADA Systems	3	3	-	-	3	-	10	-	30	60
4	EEM 132	Smart Grid Technology	3	3	-	-	3	-	10	-	30	60
5	EEM 137	Optimal Control	3	3	-	-	3	-	10	-	30	60
6	EEM 110	Energy Management & Energy Audit	3	3	-	-	3	-	10	-	30	60
7	EEM 128	Flexible AC Transmission Systems	3	3	-	-	3	-	10	-	30	60
8	EEM 129	Hybrid Electric Vehicles	3	3	-	-	3	-	10	-	30	60
9	EEM 111	Selected Topics in Power & Energy Systems	3	3	-	-	3	-	10	-	30	60
10	EEM 112	Intelligent Control of Electrical Energy Systems	3	3	-	-	3	-	10	-	30	60
11	EEM 130	Non Linear Systems	3	3	-	-	3	-	10	-	30	60
12	EEM 113	Stand Alone Energy Systems	3	3	-	-	3	-	10	-	30	60
13	EEM 114	Advanced Power System Protection	3	3	-	-	3	-	10	-	30	60
14	EEM 115	Energy System Planning	3	3	-	-	3	-	10	-	30	60
15	EEM 116	Power System Reliability	3	3	-	-	3	-	10	-	30	60
16	EEM 117	Advanced Instrumentation Technology	3	3	-	-	3	-	10	-	30	60
17	EEM 118	Modeling and Analysis of Electric Machines	3	3	-	-	3	-	10	-	30	60
18	EEM 123	Linear Systems Theory	3	3	-	-	3	-	10	-	30	60
19	EEM 134	Modern Power Electronics	3	3	-	-	3	-	10	-	30	60
20	EEM 131	Power Electronics for Renewable Energy Systems	3	3	-	-	3	-	10	-	30	60
21	ECEM 159	Embedded Systems & Real Time Applications	3	3	-	-	3	-	10	-	30	60

MODELING & SIMULATIONS OF POWER SYSTEM COMPONENTS

Credits: 3

Course Code: EEM 107

L	T	P
3	0	0

Module 1:

Synchronous Machine Theory and Modeling: Physical description –Mathematical description of a synchronous Machine – dqo transformation – Per Unit representation-Steady state analysis of Synchronous Machine- Equivalent circuit.

Module 2:

Induction Machine Modeling: Mathematical descriptions of Induction machine – dqo transformation - steady state characteristics-equivalent circuit- Torque -slip characteristics – per unit representation.

Module 3:

Excitation System Modeling: Excitation system requirements - Elements of an Excitation system –Types of Excitation systems-DC , AC and Static excitation systems- Self Excited DC exciter – Stabilizing Circuit-Modeling of power System stabilizer (PSS)

Module 4:

Transmission Line and Transformer Modeling: Pie Model of Transmission line- In phase Transformer – Phase shifting Transformer-Three winding transformer-modeling of Tap Changing transformer-Modeling of load-Modeling of power network-Inter phase power controller.

Hydraulic Turbine Modeling: Turbine Modeling-Governor Modeling -Transfer Function – Electrical Analogue – Non Ideal Turbine

Text books

1. Power System Dynamics and Simulation by Abhijit Chakrabarti - PHI Publishers, 2015
2. P.S.Bhimra, "Generalized theory of electrical machinery", Khanna publications
3. P.kundur , " Power System Stability and Control", Mc Graw-Hill Publications
4. S Krishna " An Introduction to Modeling of power Systems Components-Springer-2013

SOFT COMPUTING

Credits: 3 | **L T P**

Course code: EEM 108 | **3 0 0**

Module 1

Introduction to Soft Computing: Concept of computing systems, soft vs. hard computing, various types of soft computing techniques, Fuzzy Computing, Neural Computing, Genetic Algorithms, Adaptive Resonance Theory, Classification, Some applications of soft computing techniques.

Module 2

Evolutionary Algorithm: Fundamentals of Genetic Algorithms, basic concepts of "Genetics" and "Evolution", working principle, encoding, fitness function, reproduction, genetic modeling. Basic GA framework and different GA architectures, GA operators: Crossover, Selection, Mutation, Solving single-objective optimization problems using GAs.

Module 3

Fuzzy Set Theory & Fuzzy Systems: Fuzzy set theory, Fuzzy set versus crisp set, Crisp relation & fuzzy relations, introduction & features of membership functions, Extension Principle, Fuzzy If-Then Rules, Fuzzy Inference Systems, Sugeno Fuzzy Models, Fuzzification, Defuzzification, Applications.

Module 4

Fundamentals of Artificial Neural Network (ANN): Introduction, model of artificial neuron, Architectures, Learning methods, Deep learning, Taxonomy of ANN Systems, Single layer ANN system, Supervised learning neural networks, Perceptron, Adeline, Back propagation, Multilayer perceptron, Applications of ANN in research.

Text Books

1. Timothy J.Ross, "Fuzzy Logic with Engineering Applications", McGraw-Hill, 1997.
2. Davis E.Goldberg, "Genetic Algorithms: Search, Optimization and Machine Learning", Addison Wesley, N.Y., 1989.

References

1. Dan W. Patterson, "Introduction to AI and Expert System", PHI, 2009.
2. J.S.R.Jang, C.T.Sun and E.Mizutani, "Neuro-Fuzzy and Soft Computing", PHI, 2004, Pearson Education 2004.
3. Online NPTEL Lecture series on Soft Computing.

SCADA SYSTEMS

Credits: 3 **L T P**

Course code: EEM 109 **3 0 0**

Module 1:

General Theory: Purpose and necessity, general structure, data acquisition, transmission and monitoring, general power system hierarchical structure, overview of the methods of data acquisition systems, commonly acquired data, transducers, RTUs, data concentrators, various communication channels, cables, telephone lines, power line carrier, microwaves, fiber- optical channels and satellites.

Module 2:

Supervisory and Control Functions: Data acquisitions, status indications, measured values, energy values, monitoring alarm and event application processing. Control function: ON/OFF control of lines, transformers, capacitors and applications in process industry, valve, opening, closing etc. Regulatory functions: set points and feed-back loops, time tagged data, disturbance data collection and analysis, calculation and report preparation.

Module 3:

Man-Machine Communication: Operator consoles and VDUs, displays, operator dialogues, alarm and event loggers, mimic diagrams, report and printing facilities.

Data bases - SCADA, EMS and network data bases: SCADA system structure - local system, communication system and central system, Configuration- non-redundant single processor, redundant dual processor, multi control centers, system configuration. Performance considerations: real time operation system requirements, modularization of software programming languages.

Module 4:

Energy Management Center: Functions performed at a centralized management center, production control and load management, economic dispatch, distributed centers and power pool management.

Text books

1. Torsten Cegrell, Power System Control Technology, Prentice Hall International, 1986.
2. Stuart A. Boyer, SCADA: Supervisory Control and Data Acquisition, The Instrumentation, Systems and Automation Society, 4th edition, 2009.
3. Krishna Kant, Computer-Based Industrial Control, PHI Learning, 2nd edition, 2013.

References

1. Bela G. Liptak, Instrument Engineers Handbook, Volume 3: Process Software and Digital Networks, CRC Press, 4th edition, 2011.
2. Behrouz Forouzan, Data Communications and Networking, McGraw-Hill, 5th edition, 2012.

SMART GRID TECHNOLOGY

Credits: 3 **L T P**

Course code: EEM 132 **3 0 0**

Module 1

Introduction to AC and DC microgrids and their significance in the contemporary power scenario. Renewable integration, Standalone systems, grid interface, and energy storage in microgrids. Power converters for used in Micro-Grids: AC-DC, DC-DC, DC-AC, AC-AC topologies.

Module 2

Control of Microgrids: PLL and synchronization,Grid connection issues: leakage current, islanding, harmonics, active/reactive power feedin. Aspects of mechanical control, ratings; Power extraction (MPP) and MPPT schemes.

Module 3

Introduction to smart grid architecture, Advance Metering Infrastructure, Communication technologies, Cost benefit analysis and Business Model of smart grids – case study Data analytics. Forecasting techniques, Demand Response - mathematical formulation and solution.

Module 4

Electric vehicles Cyber security, Vehicle to Grid technology, Smart grid standards, Smart grid regulations, smart Cities, Smart grids and power markets Indian scenario, Pilot projects, and Road map with case studies Smart grid technology for Transmission system

Text books

1. Smart grid handbook, Vol. 1, 2, and 3 - By - Liu, Chen-Ching (Ed.) McArthur, Stephen(Ed.) Lee, Seung-Jae (Ed.) 2015.
2. Smart grid communications and networking by Hossain, Ekram (Ed.) Cambridge University Press 2012.
3. Ali Keyhani, Design of Smart Power Grid Renewable Energy Systems, Wiley-IEEE Press, 2011.ix
4. DC distribution systems and micro-grids by Tomislav Dragicevic and Pat Wheeler, IET.

Reference books:

1. Robert Ericson, ‘Fundamentals of Power Electronics’, Chapman & Hall, 1997.
2. N. Mohan, T.M. Undeland & W.P. Robbins, Power Electronics: Converter, Applications & Design, John Wiley & Sons, 1989
3. Muhammad H. Rashid, Power Electronics: Circuits, Devices, and Applications, Pearson Education India, 2004
4. Referred Journals/Conference Publications

OPTIMAL CONTROL

Credits: 3 | **L T P**

Course code: EEM 137 | **3 0 0**

Module 1:

Introduction: Classical and Modern Control, Concept of Optimization, Statement of the Optimal Control Problem, Performance Index, Constraints, Types of Constraints.

Module 2:

Calculus of Variations and Optimal Control: Basic Concepts: Function and Functional, Increment, Differential and Variation, Optimum of a function and a functional, basic variational problem, Fixed-end time and fixed-end state system, Discussion of Euler-Lagrange equation, Different cases for Euler-Lagrange equation, the second variation, Extrema of functions and functionals with conditions, Variational Approach to Optimal Control Systems, Optimal Control Systems with Hamiltonian formalism (Pontryagin principle), application to minimum time, energy and control effort problem.

Module 3:

Linear Control Optimal Control Systems: Finite Time Linear Quadratic Regulator, LQR System for general performance index, Analytical Solution to the Matrix differential Ricatti equation, Infinite Time Linear Quadratic Regulator, Finite-Time Linear Quadratic Tracking Problem

Module 4:

Dynamic Programming: Bellman's principle of optimality, Multistage decision processes, Optimal Control using Dynamic Programming, The HJB Equation

Books Recommended

1. D.S. Naidu, "Optimal Control Systems", CRC Press, 2003
2. D. E. Kirk, "Optimal Control Theory" Prentice Hall, 1970
3. Anderson and Moore, "Linear Optimal Control", Prentice Hall, 1971
4. Enid R Pinch, "Optimal Control and Calculus of Variations", Oxford University Press

ENERGY MANAGEMENT AND ENERGY AUDIT

Credits: 3

Course Code: EEM 110

L	T	P
3	0	0

Module 1

ENERGY SCENARIO - Energy needs of growing economy, Long term energy scenario, Energy pricing, Energy sector reforms, Energy and environment: Air pollution, Climate change, Energy security, Energy conservation and its importance, Energy strategy for the future, Energy conservation Act-2001 and its features.

Module 2

ENERGY MANAGEMENT AND AUDIT - Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit instruments, Facility as an energy system, Methods for preparing process flow, Material and energy balance diagrams.

Module 3

FINANCIAL MANAGEMENT - Investment-need, Appraisal and criteria, Financial analysis techniques- Simple payback period, Return on investment, Net present value, Internal rate of return, Cash flows, Risk and sensitivity analysis, Financing options, Energy performance contracts and role of ESCOs.

Module 4

ELECTRICAL SYSTEM - Electricity tariff, Load management and maximum demand control, Power factor improvement, Distribution and transformer losses. Losses in induction motors, Motor efficiency, Factors affecting motor performance, Rewinding and motor replacement issues, energy efficient motors. Light source, Choice of lighting, Luminance requirements, and Energy conservation avenues.

Text Books:

1. "Handbook on Energy Audit and Environment Management", Y. P. Abbi and S. Jain, Teri Press, 2006.
2. "Energy Conservation," P. Diwan and P. Dwivedi, Pentagon Press, 2008.
3. "Handbook of Energy Audits," A. Thumann, W. J. Younger, T. Niehus, CRC Press,8th Edition, 2008.

References:

1. "Energy Management Handbook," W. C. Turner, Seventh Edition, Fairmont Press Inc., 2007.
2. "Energy Cogeneration Handbook," George Polimeros, Industrial Press, Inc., New York, 1981.
3. Referred Journal/Conference Publications.

FLEXIBLE AC TRANSMISSION SYSTEMS (FACTS)

Credits: 3 **L T P**

Course code: EEM 128 **3 0 0**

Module 1

Introduction to FACTS Technology, Types of FACTS controllers, FACTS vs. HVDC, Benefits of FACTS Technology, Performance Equations and Parameters of Transmission Lines, Transfer of Active and Reactive Power over a Transmission Line, Uncompensated Transmission, Need for Compensation, Definition and Functions of compensation.

Module 2

Compensation Techniques: Ideal Shunt compensation, Ideal Series compensation, Phase-Angle control (Regulator), Advantages of Series compensation (voltage support, Transient stability improvement, Power oscillation damping), Advantages of shunt compensation, Thyristor-Controlled Reactor (TCR), Thyristor-Switched Capacitor (TSC).

Module 3

Analysis of various types of Static Var compensators (SVC), Static Synchronous Compensator (STATCOM): Analysis and comparison with SVC, STATCOM convertors (Multi-level VSIs for STATCOM applications), Series compensators: GTO-Controlled Series Capacitor (GCSC), Thyristor-Switched Series Capacitor (TSSC), Thyristor-Controlled Series Capacitor (TCSC), Static Synchronous Series Compensator (SSSC).

Module 4

Voltage & Phase-Angle Regulation, Thyristor-Controlled Voltage Regulator (TCVR), Thyristor-Controlled Phase-Angle Regulator (TCPAR), Series-Shunt compensator: Unified Power Flow Controller (UPFC), Series-Series compensator: Interline Power Flow Controller (IPFC), Thyristor Controlled Braking Resistor (TCBR), Modeling of some FACTS controllers.

Text Books

1. Hingorani & Gyugyi, “Understanding FACTS – Concepts and Technology of Flexible AC Transmission Systems” Wiley publishers.
2. Mathur & Varma, “Thyristor–Based FACTS Controllers for Electrical Transmission Systems” IEEE Press Series on Power Engineering.

References

1. K.R. Padiyar, “FACTS Controllers in Power Transmission and Distribution” New Age International Publishers.
2. Journal & Conference publications.
3. Online NPTEL Lecture series on FACTS.

HYBRID ELECTRIC VEHICLES

Credits: 3 | **L T P**

Course code: EEM 129 | **3 0 0**

Module-1

Introduction: Conventional vehicle and its components, propulsion load, drive cycles, Concept of electric vehicles and hybrid electric vehicles (HEVs), architectures of HEVs, series and parallel HEVs, complex HEVs.

Module-2

HEVs Drive-train: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.

Module-3

Plug-in Hybrid Electric Vehicles: PHEVs Architectures, equivalent electric range of PHEVs; Fuel economy of PHEVs, power management of PHEVs, PHEVs battery charging, end-of-life battery for electric power grid support, vehicle to grid technology.

Module-4

Power Electronics in HEVs: Rectifiers used in HEVs, Buck converter used in HEVs, nonisolated bidirectional DC-DC converter, regenerative braking, voltage source inverter, current source inverter, isolated bidirectional DC-DC converter, PWM rectifier in HEVs, EV and PHEV battery chargers.

Text Books

1. Chris Mi and M. Abul Masrur, “Hybrid Electric Vehicle: Principles and Applications with Practical Perspectives” John Wiley & Sons.
2. Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, Ali Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory and Design” CRC Press.

References

1. Iqbal Husain, “Electric and Hybrid Vehicles: Design Fundamentals” CRC Press.
2. Ronald K. Jurgen, “Electric and Hybrid-electric Vehicles” SAE International.
3. Referred Journals/Conference Publications

SELECTED TOPICS IN POWER & ENERGY SYSTEMS

Credits: 3

Course Code: EEM 111	**L**	**T**	**P**
	3	**0**	**0**

Module 1

Conventional Energy Sources - Global & National Energy Scenarios, Environmental Aspects and Global Warming, Study of power sector reforms, various governmental and non-governmental agencies related to power sector, power sector rules and regulations.

Module 2

Introduction of wind and solar energy systems, Wind and solar hybrid stand-alone power systems, Control of hybrid power systems with and without grid connection. Introduction to smart grid, Power system state estimation.

Module 3

Energy storage systems: Basic concept and types of energy storage devices, different battery systems and battery charging, system planning, operating features and performance calculations.

Module 4

Overall structure of electrical systems, Supply and demand side, Economic operation, Input-output curves, Load sharing, Industrial Distribution, Load profiling, Electricity tariff types and calculation.

Text Books/Reference:

1. Non-Conventional Energy Sources by B.H. Khan, TMH, New Delhi.
2. Renewable Energy Sources Their Impact On Global Warming by T .Abbasi& S.A. Abbasi, PHI Learning Pvt. Ltd., 2011.
3. Electrical Estimating and Energy Management by K. R. Gangadhar Rao, Sapna book house, 2006.
4. Smart Grid: Fundamentals of Design and Analysis by James Momoh, Wiley-IEEE Press, 2012.
5. Wind & Solar Power Systems by M.R. Patel, Taylor & Francis, Boca Raton.
6. State estimation in electric power systems: a generalized approach by A. Monticelly, Springer.
7. Fundamentals of Energy Storage by Johannes Jensen Bent Squrensen, John Wiley, NY, 1984.

INTELLIGENT CONTROL OF ELECTRICAL ENERGY SYSTEMS

Credits: 3 | **L T P**

Course code: EEM 112 | **3 0 0**

Module 1

Introduction: General understanding of more advanced control design techniques e.g. cascade control, model based control, adaptive control.

Module 2

Expert systems: Fuzzy Logic, Neural Networks, Genetic algorithms applications in alarm processing, fault diagnosis in power systems, reactive power & voltage control, stability control for power systems.

Module 3

Intelligent control techniques: for wind diesel hybrid energy systems- modeling, simulation & case studies. Problems and solution techniques in the area of control of energy converting systems.

Module 4

Intelligent Energy Management System (EMS): Understanding how to minimize the power consumption without compromising the qualitative issue, multi-agent control system for energy and comfort management in the smart buildings. The energy management system - its control and case studies

Text books:

1. H. Bevrani, T. Hiyama, "Intelligent Automatic Generation Control", CRC Press; 1st edition, April 2017.
2. Tariq Samad, "Perspectives in Control Engineering Technologies, Applications, and New Directions", Wiley-Blackwell, September 2000.

References:

1. Ognjen Kuljaca, Frank Lewis, Krunoslav Horvat, "Intelligent control of industrial and power systems: Adaptive Neural Network and Fuzzy Systems", Lap Lambert Academic Publishing, May 2012.

NON-LINEAR SYSTEMS

	Credits: 3	L T P
Course code: EEM 130		**3 0 0**

Module 1:

Introduction To Non-Linear Systems: Why Non-Linear Control, Non-Linear System Behaviour, Multiple Equilibrium Points, Limit Cycles, Dependence of Non-linear system behaviour on initial conditions, Bifurcations and chaos, Commonly Occurring Non-linearities in Physical Systems: Saturation, On-Off Non-linearity, Dead Band Non-Linearity, Hysteresis/Backlash etc., Phase Plane Analysis of Non-linear systems

Module 2:

Linearization of Non-linear systems: Types of Non-linearities: Hard and Soft, Autonomous and Non-Autonomous Systems, Local Linearization of Non-linear systems with Soft Nonlinearities, concept of Jacobian, Applicability of linearized models, and Concept of local stability.

Module 3:

Describing Function Analysis: Describing Function Fundamentals, Application Domain, Basic Assumptions, Computing Describing Functions, Describing Functions of Common Nonlinearities, Describing Function Analysis of Non-Linear Systems, and Reliability of Describing Function Analysis.

Module 4:

Fundamentals of Lyapunov theory: Lyapunov's direct method, Positive Definite Functions and Lyapunov functions, Stability Analysis based on Lyapunov's direct method, Controller design based on Lyapunov's direct method, Concept of stability for Non-linear systems, Lyapunov Stability Analysis of Non-linear systems.

Books Recommended

1. Slotine and Li, " Applied Nonlinear Control" - Prentice-Hall Publication
2. H. K. Khalil, " Non-Linear Systems" Prentice Hall, 2001
3. M Vidyasagar, "Non-linear System Analysis", 2nd Edition, Prentice Hall, 1993
4. Alberto Isidori, "Nonlinear Control Systems",Vol I and II, Springer, 1999

STAND-ALONE ENERGY SYSTEMS

	Credits: 3	L T P
Course code: EEM 113		**3 0 0**

Module 1

Introduction to Stand-Alone Energy Systems: Solar, Wind, Micro-hydel and Diesel Power Generation Systems, Introduction to various energy storage devices.

Module 2

Solar based Stand-Alone Energy Systems: Connection of PV Module in Series and Parallel, I-V and P-V characteristics, Sizing of the PV array and battery, charge controller, Maximum Power Point Trackers, Power Electronics interface of SPV system with load and existing grid.

Module 3

Wind based Stand-Alone Energy Systems: Directly coupled Stand-Alone Wind System, Stand-Alone wind system with storage, Power Electronics interface of wind system with load and existing grid.

Module 4

Hybrid Stand-Alone Energy Systems: Modeling and Analysis of various combinations like PV-Wind, PV-Diesel and PV-Mains with examples.

Text Books

1. M. R. Patel, Wind and Solar Power Systems: Design, Analysis, and Operation, Second Edition, Taylor & Francis.
2. J. K. Kaldellis, “Stand-Alone and Hybrid Wind Energy Systems: Technology, Energy Storage and applications”, CRC Press.
3. B. Zohuri, “Hybrid Energy Systems: Driving Reliable Renewable Sources of Energy Storage”, Springer.

References

1. D. Rekioua, “Wind Power Electric Systems: Modeling, Simulation and Control”, Springer.
2. Referred Journals/Conference Publications

ADVANCED POWER SYSTEM PROTECTION

Credits: 3

Course Code: EEM 114	**L**	**T**	**P**
	3	**0**	**0**

Module 1

Protective Relaying: Relay terminology, Definitions, Classification, electromechanical, static and digital-numerical relays. Design-factors affecting performance of a protection scheme; faults-types and evaluation, Instrument transformers for protection.

Module 2:

Relay Schematics and Analysis: Over Current Relay- Instantaneous/Inverse Time –IDMT Characteristics; Directional Relays; Differential Relays- Restraining Characteristics; Distance Relays: Types- Characteristics.

Module 3

Protection of Power System Equipments: Generator, Transformer, Transmission Systems, Busbars, Motors; Pilotwire and Carrier Current Schemes.

Module 4

System grounding: Ground faults and protection; Load shedding and frequency relaying; Out of step relaying; Re-closing and synchronizing.

Module 5

Basic elements of digital protection: Digital signal processing – Digital filtering in protection relay – digital data transmission – Numeric relay hardware – relay algorithm – distance relays – direction comparison relays – differential relays – software considerations – numeric relay testing –concept of modern coordinated control system. Integrated and multifunction protection schemes: SCADA based protection systems, Testing of Relays.

Text Books:

1. A T John and A K Salman-Digital protection for power systems-IEE power series-15, Peter Peregrines Ltd, UK, 1997.
2. C.R. Mason, The art and science of protective relaying, John Wiley &sons, 2002.
3. Donald Reimert, Protective relaying for power generation systems, Taylor & Francis-CRC press 2006.
4. Gerhard Ziegler-Numerical distance protection, Siemens, 2nd ed, 2006.
5. A.R.Warrington, Protective Relays, Vol .1&2, Chapman and Hall, 1973.
6. T S.Madhav Rao, Power system protection static relays with microprocessor applications, Tata McGraw Hill Publication, 1994.

References:

1. Helmut Ungrad , Wilibald Winkler, Andrzej Wiszniewski, Protection techniques in electrical energy systems, Marcel Dekker, Inc. 1995.
2. Badri Ram , D.N. Vishwakarma, Power system protection and switch gear, Tata McGraw Hill, 2001.
3. Blackburn, J. Lewis ,Protective Relaying, Principles and Applications, Marcel Dekker, Inc., 1986. Anderson, P.M, Power System Protection,. McGraw-Hill, 1999.
4. Singh L.P ,Digital Protection, Protective Relaying from Electromechanical to Microprocessor, John Wiley & Sons, 1994.
5. Wright, A. and Christopoulos, C, Electrical Power System Protection,. Chapman & Hall, 1993.

ENERGY SYSTEM PLANNING
Credits: 3

Course Code: EEM 115

L	T	P
3	0	0

Module 1:

INTRODUCTION OF POWER PLANNING: National and regional planning, Structure of power system, Planning tools, Electricity regulation, Needs uses and current status of forecasting – Fundamentals of quantitative forecasting, Load forecasting, forecasting techniques, modeling. Explanatory and time serious forecasting, least square estimates, Peak load forecasting, Accuracy of forecasting methods- Regression methods, Box Jenkins time serious methods

Module 2

GENERATION PLANNING: Integrated power generation, co-generation / captive power, power pooling and power trading, transmission & distribution planning, power system economics, power sector finance, financial planning, private participation, rural electrification investment, concept of rational tariffs.

Module 3

LOAD FORECASTING: Load Forecasting Categories-Long term, Medium term, short term, very short term Applications of Load Forecasting, Factors Affecting Load Patterns Medium and long term load forecasting methods- end use models, econometric models, statistical model based learning.

Module 4

SHORT TERM LOAD FORECASTING (STLF): Applications of Load Forecasting, methods- similar day approach, regression methods, time series, ANN, Expert systems, Fuzzy logic based method, support vector machines ANN architecture for STLF, Seasonal ANN, Adaptive Weight, Multiple-Day Forecast, Training and Test Data, Stopping Criteria for Training Process, sensitivity analysis.

TEXT BOOK:

1. Dasari, S., Electric Power System Planning, IBT Publishers (1999).
2. Pabla, A.S., Electric Power Distribution, Tata McGraw Hill (2008).
3. A course in Electrical Power- Soni, Gupta and Bhatnagar, DhanpatRai& Sons
4. Electrical Power System Design – M. V. Deshpande, TMH publication

REFERENCES:

1. Markey operations in electric power systems Forecasting, Scheduling, and Risk Management, Shahidehpour M, Yamin H, Li z, John Wlley & sons.
2. L. L. Lie: Power System Restructuring and Deregulation, John Willey & Sons UK.
3. X. Wang, J. R. Mc Donald: Modern Power System Planning, MGH

POWER SYSTEM RELIABILITY

Credits: 3

Course Code: EEM 116

L	T	P
3	0	0

Module 1

Reliability concepts, Binomial distribution, Poisson distribution, Normal distribution, Exponential distributions, Meantime to failure, Meantime between failures, Series and parallel system. MARKOV process, Recursive technique.

Module 2

Generator system reliability analysis- Generation system model, State load model, Capacity outage probability tables, Recursive relation for capacitive model building, Evaluation of reliability indices, Frequency and duration methods.

Module 3

Reliability analysis of isolated and interconnected system, Two systems with tie line, Generator system cost analysis, Variable reserve and maximum peak load reserve, Multi connected systems.

Module 4

Transmission system reliability model analysis, average interruption rate-LOLP method, frequency and duration method. Distribution system reliability analysis- Basic techniques, Interruption indices, System performance, Risk prediction, Radial System, Effect of load transfer, Line failure, parallel and mesh networks, Industrial systems.

Books/ References:

1. "Power System Reliability Evaluation", Roy Billinton, Plenum Press, New York.
2. "Reliability Assessment of Large Electric Power Systems", Roy Billinton, Ronald N. Allan, IEEE Press.
3. "Reliability Engineering Fundamentals and Applications", R. Ramakumar, Prentice Hall.
4. "Applied Reliability Assessment in Electric Power Systems", Roy Billinton, Ronald W. Allan and Luigi Salvaderi, IEEE Press.
5. "Reliability Modeling in Electrical Power Systems", J. Endrenyi, John Willey, New York.

ADVANCED INSTRUMENTATION TECHNOLOGY

Credits: 3

Course Code: EEM 117	**L**	**T**	**P**
	3	**0**	**0**

Module 1

Chemical Sensors: Blood –Gas and Acid –base physiology Electrochemical sensors, Chemical Fibro sensors, Iron-Selective Field-Effect Transistor (ISFET), Immunologically Sensitive Field Effect Transistor (IMFET) , Integrated flow sensor and Blood Glucose sensors.

Optical Sensors: Fiber optic light propagation, Graded index fibers, Fiber optic communication driver circuits, Laser classifications, Driver circuits for solid–state laser diodes, Radiation sensors and Optical combinations.

Module 2

Biomedical Sensors: Sensors Terminology in human body, Introduction, Cell, Body Fluids Musculoskeletal system, Bioelectric Amplifiers, Bioelectric Amplifiers for Multiple input Circuits, Differentional Amplifiers, Physiological Pressure and other cardiovascular measurements and devices.

Module 3

Electrodes: Electrodes for Biophysical sensing, Electrode model circuits, Microelectrodes, ECG,EEG, electrodes ECG signals, waveforms, Standard lead system, Polarization Polarizable, Non polarizable electrodes and body surface recording electrodes. Ultrasonic Transducers for Measurement and therapy – radiation detectors – NIR spectroscopy.

Module 4

Advanced Sensor Design: Fluoroscopic machines design, Nuclear medical systems, EMI to biomedical sensors, types and sources of EMI, Fields, EMI effects. Computer systems used in X-ray and Nuclear Medical equipments. Calibration, Typical faults, Trouble shooting, Maintenance procedure for medical equipments and Design of 2 & 4 wire transmitters with 4–20 mA output.

Aerospace Sensor: Laser Gyroscope and accelerometers, sensors used in space and environmental applications.

Text Book:

1. "Sensors Hand Book Sabaree Soloman - Sensors Hand Book," McGraw Hill, 1998.
2. "Principles of Holography," H. M. Smith, John Wiley & Sons, New York, 1975.
3. "Medical instrumentation Application and Design," J. G. Webster, Houghton Mifilin Co. 2004.

References

1. "Introduction to Medical Equipment Technology," Carr and Brown, Addison Wesley. 1999
2. "Optical Fibre Sensors," B. Culshaw and J. Dakin J (Eds), vol. 1 & 2 Artech House, Norwood. (1989).
3. "Guided Weapon Control Systems," P. Garnell, Pergamon Press. 1980.

MODELING AND ANALYSIS OF ELECTRIC MACHINES

Credits: 3

Course Code: EEM 118	**L**	**T**	**P**
	3	**0**	**0**

Module 1:

Basic concepts of Modeling: Basic Two-pole Machine representation of Commutator machines, 3-phase synchronous machine and 3-phase induction machine, Kron's primitive Machinevoltage, current and Torque equations.

Module 2:

Reference frame theory: Linear transformation-Phase transformation - three phase to two phase transformation (abc to αβ0) and two phase to three phase transformation.

DC Machine Modeling: Mathematical model of separately excited D.C motor, Mathematical model of D.C Series motor.

Module 3:

Modeling of three phase Induction Machine: Generalized model in arbitrary reference frame-Electromagnetic torque-Derivation of commonly used Induction machine models- Stator reference frame model-Rotor reference frame model-Synchronously rotating reference frame model

Module 4:

Modeling of Synchronous Machine: Synchronous machine inductances – Mathematical model transformation to the rotor's dq0 reference frame- Flux linkages in terms of winding currents referring rotor quantities to the stator- voltage equations in the rotor's dq0 reference frame electromagnetic torque-currents in terms of flux linkages. Modeling of PM Synchronous motor, BLDC motor and Switched Reluctance motor

Text books

1. R.Krishnan, "Electric Motor Drives - Modeling, Analysis& control" – Pearson Publications-1st edition -2002
2. D.Sudhoff, "Analysis of Electrical Machinery and Drive systems" – P.C.Krause, OlegWasynczuk, Scott – Second Edition-IEEE Press

References

1. Generalized Theory of Electrical Machines – P.S.Bimbra-Khanna publications-5th edition-1995
2. Dynamic simulation of Electric machinery using Matlab / Simulink –Chee Mun Ong-Prentice Hall edition (19 September 1997)
3. Referred Journal/Conference publications

LINEAR SYSTEMS THEORY

Credits: 3

Course Code: EEM 123	**L**	**T**	**P**
	3	**0**	**0**

Module 1:

Linear Algebra Fundamentals: Vector Spaces, Basic properties of vector spaces, subspaces and bases, dimensions, linear dependence and linear independence, orthogonal bases and orthogonal projections, basic matrix operations, matrix decompositions, Eigen values and Eigen Vectors.

Module 2:

State Space Modelling: State Variable Modelling of Linear Time-invariant systems, Equivalence between state-space models and transfer function models, Canonical Representations, Solution of state equations, Concept of state transition Matrix, Evaluation of state transition matrix, Numerical Solution of state equations, Concept of controllability and observability, Necessary and Sufficient conditions for controllability and observability, concept of Grammians.

Module 3:

Pole Placement Techniques: State Feedback Controller Design, Necessary and Sufficient conditions for arbitrary pole placement, State Regulator Problem Formulation and State regulator design, State Observer Design, Full Order and Reduced Order Observer, Observer based state feedback control, Separation Principle.

Module 4:

Modelling of Power Electronic Converters: Basic issues involved, Modelling of PE Circuits as linear switched systems, Model Order Reduction based algorithms for modelling, Multiresolution simulations.

Books Recommended

1. Chi Tsong Chen, "Linear System Theory and design", Oxford University Press
2. Thomas Kailath, "Linear Systems" Prentice Hall
3. Katsuhiko Ogata, "State Space Analysis of Control Systems", Prentice Hall
4. M Gopal, "Digital Control and State Variable Methods", Tata McGraw Hill.

MODERN POWER ELECTRONICS

Credits: 3

Course Code: EEM 134

L	T	P
3	0	0

Module 1

Three phase rectifier circuits- a review. Power quality problems associated with conventional rectifier circuits, conventional power factor corrective converters.

Module 2

Design of passives for power electronic converters, Resonant Converters, Soft switching techniques, Zero Voltage Switching and Zero Current switching.

Module 3

High Power Converters- Diode Clamped Multi-level converter, Flying capacitor type multi-level converter, Cascaded H-bridge multi-level converter, Capacitor voltage unbalancing in multi-level converters

Module 4

Matrix Converters, Modulation techniques of matrix converters, applications, Z-Source Converters.

Text Books

1. Robert Ericson, 'Fundamentals of Power Electronics', Chapman & Hall, 1997.
2. N. Mohan, T.M. Undeland & W.P. Robbins, Power Electronics: Converter, Applications & Design, John Wiley & Sons, 1989
3. High Power Converters and AC Drives by Bin Wu, Wiley.

References

1. Modern Power Electronics and AC motor Drives By Bimal K Bose- Pearson Publishers.
2. Three-phase AC-AC Power Converters Based on Matrix Converter Topology by Pawel Szczesniak, Springer.
3. Referred Journal/Conference publications**.**

POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS

Credits: 3

Course Code: EEM 131	**L**	**T**	**P**
	3	**0**	**0**

Module-1

Overview of conventional and renewable energy technologies, World and India's renewable energy scenario, Energy security, Energy growth, Energy demands, Qualitative study of different renewable energy resources: Solar, wind, ocean, Biomass, Fuel cell, Hydrogen energy systems.

Module-2

Solar photo voltaic (SPV) system, Array sizing, Battery sizing, MPPT, Power Electronic Interface of SPV system in isolated and grid connected mode.\

Module-3

Wind power generation, Wind energy conversion system (WECS), Power Electronic Interface of WECS, Stand alone operation of fixed and variable speed WECS, Grid integrated PMSG and SCIG based WECS.

Module-4

Need for hybrid energy systems, Type and range of hybrid energy systems, Case studies of SPV & Wind energy systems.

Text Books

1. B. H. Khan, "Non Conventional Energy Resources", Tata McGraw-Hill, New Delhi.
2. C. S. Solanki, "Solar Photovoltaics", PHI.
3. S. N. Bhadra, D. Kastha, S. Banerjee, "Wind Electrical Systems", Oxford.
4. Freris L. L., "Wind Energy Conversion Systems", PHI.

References

1. M. S. J. Asghar, "Power Electronics", PHI.
2. MNRE Manual.
3. Referred Journals/Conference Publications

EMBEDDED SYSTEMS AND REAL TIME APPLICATIONS
Credits: 3

Course Code: ECEM 159	**L**	**T**	**P**
	3	**0**	**0**

Module 1
Embedded system concepts, Hardware organization and architecture.

Module 2
Microcontrollers, ADC/DAC, Input/Output devices, Memory devices.

Module 3
Synchronous/Asynchronous data transfer, Serial/parallel communication ports.

Module 4
Programming embedded systems, Embedded board level design concepts, Introduction to MEMS.

Text books:
1. Introduction to Embedded Systems by McGraw Hill Education India Private Limited
2. Embedded System Design: A Unified Hardware / Software Introduction by Wiley

References:
1. Referred Journal/Conference Publications