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5.5 M.Tech. in Power Electronics and Power System Courses

Academic Scheme and Course Content
Year 2016-17

DEPARTMENT OF ELECTRICAL ENGINEERING
SARDAR PATEL COLLEGE OF ENGINEERING
(An Autonomous Institute Affiliated to University of Mumbai)

SCHEME OF TEACHING AND EXAMINATION w.e.f. 2015-16

M. Tech. (Power Electronics and Power System)
(Semester – I)

Sr. No.	Course	Code	Course Plan for Each Week (Hrs)			Credits	Evaluation (Marks)						Total
			Lectures	Laboratory	Tutorial		Test I	Test II	End Semester	End Semester Weightage (%)	Termwork	Seminar	
1	Advanced Power Electronics	MTPX 111	3	-	02	04	20	20	100	60	25	--	125
2	Protection in Power System	MTPX 112	3	_	02	04	20	20	100	60	25	--	125
3	Modelling and Analysis of Electrical Machines	MTPX 113	3	--	02	04	20	20	100	60	25	--	125
4	Dynamics of Linear Systems	MTPX 114	3	--	02	04	20	20	100	60	25	--	125
5	Seminar-I*	MTPX 115	--	--	04	2	--	--	--	--	50	75	125
6	Elective – I	MTPX 116 to MTPX 119	3	--	02	04	20	20	100	60	25	--	125
Total			**15**	**--**	**14**	**22**	**100**	**100**	**---**	**300**	**175**	**75**	**750**

NOTE: (1) Test 1, Test 2 and end semester weightage marks will be added and shown as the theory marks in the mark sheet.
(2) For passing, student must secure minimum 50% marks in each course with all heads of passing taken together and minimum 50% marks in the end semester examination.

*Student has to present a seminar, on a topic selected in consultation with assigned Faculty member, in the allotted seminar slot as per the academic calendar. Seminar-I will be examined by the Faculties.

Evaluation process for Seminar –I

	Level of Topic selected	Reproduction of simulation results	Presentation	Suggested improvements in the presented work
Marks	**15**	**15**	**35**	**10**

Elective – I Courses

Sr. No.	**Code**	**Elective**
1.	MTPX 116	Digital Simulation of Power Electronics System
2.	MTPX 117	Power System Planning and Reliability
3.	MTPX 118	Artificial Intelligence for Power System
4.	MTPX 119	DSP Control in Power Electronics

Duration for Test I and Test II: **01 Hour**
Duration for End Semester : **04 Hour**

DEPARTMENT OF ELECTRICAL ENGINEERING
SARDAR PATEL COLLEGE OF ENGINEERING (AUTONOMOUS)
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SCHEME OF TEACHING AND EXAMINATION w.e.f. 2016-17

M. Tech. (Power Electronics and Power System)
(Semester – II)

Sr. No.	Course	Code	Course Plan for Each Week (Hrs)			Credits	Evaluation (Marks)						Total
			Lectures	Laboratory	Tutorial		Test I	Test II	End Semester	End Semester Weightage (%)	Term work	Seminar	
1	Flexible AC Transmission	MTPX 121	3	--	2	4	20	20	100	60	25	--	125
2	Advanced Control of Electrical Drives	MTPX 122	3	--	2	4	20	20	100	60	25	--	125
3	Power System Dynamics and Control	MTPX 123	3	--	2	4	20	20	100	60	25	--	125
4	Computer Application in Power System	MTPX 124	3	--	2	4	20	20	100	60	25	--	125
5	Seminar II*	MTPX 125	--	--	04	2	--	--	--	--	50	75	125
6	Elective II	MTPX 126 to MTPX 129	3	--	2	4	20	20	100	60	25	--	125
Total			**15**	**--**	**14**	**22**	**100**	**100**	**---**	**300**	**175**	**75**	**750**

NOTE: (1) Test I, Test II and end semester weightage marks will be added and shown as the theory marks in the mark sheet.

(2) For passing, student must secure minimum 50% marks in each course with all heads of passing taken together and minimum 50% marks in the end semester examination.

*Student has to present a seminar, on a topic selected in consultation withassigned Faculty member, in the allotted seminar slot. Seminar-II will be examined by the Faculties.

Evaluation process for Seminar –II

	Level of Topic selected	Reproduction of Simulation results	Presentation	Suggested improvements in the presented work
Marks	**15**	**15**	**35**	**10**

Elective – II Courses

Sr. No.	Code	Elective
1.	MTPX 126	Network Principles and Protocols
2.	MTPX 127	Optimization Techniques
3.	MTPX 128	Application of Power Electronics in Renewable Energy System
4.	MTPX 129	Applied Nonlinear Control

Duration for Test I and Test II**: 01 Hour**

Duration for End Semester**: 04 Hour**

DEPARTMENT OF ELECTRICAL ENGINEERING
SARDAR PATEL COLLEGE OF ENGINEERING (AUTONOMOUS)
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SCHEME OF TEACHING AND EXAMINATION w.e.f. 2016-17

M. Tech. (Power Electronics and Power System)
(Semester – III)

Sr. No.	Course	Code	Project Work Plan for Each Week	Credits	Evaluation (Marks)		Total
			Expected Hours to be Spent by Student		Report	Seminar	
1	Project Seminar Literature Review *	MTPX 231	40	15	50	50	100
2	Project Stage-I Seminar **	MTPX 232	40		50	50	100
Total			**--**	**15**	**100**	**100**	**200##**

Note: (1) Project seminars will be examined by the PGPECs (Post Graduate Project Evaluation Committees).
(2) ## Foreligibility to Semester –IV, student must secure 50% marks in Semester-III.

* Project area identification (in consultation with supervisor) and seminar on literature review is expected to be finished within first three months of semester as per academic calendar.
** Project stage-I is expected to begin immediately after seminar on literature review is over. Seminar on the same must be finished as per academic calendar.

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SCHEME OF TEACHING AND EXAMINATION w.e.f. 2016-17

M. Tech. (Power Electronics and Power System)
(Semester – IV)

Sr. No.	Course	Code	Project Work Plan for Each Week	Credits	Evaluation (Marks)		Total
			Expected Hours to be Spent by Student		Report	Seminar	
1	Project Stage-II Seminar (Pre-Synopsis)*	MTPX 241	40	10	50	50	100
2	Project Defence & Viva-Voce	MTPX 242	40	15	100	100	200
Total			**--**	**25**	**150**	**150**	**300**

*Project Stage-II Seminar (Pre-Synopsis) will be presented as per theacademic calendar.

Note: (1) Project seminar stage-II will be examined by the PGPECs (Post Graduate Project Evaluation Committees).
(2) Project defense& viva-voce will be examined by Supervisor and one approved External Examiner.

For passing, student must secure minimum 50% marks in each course with all heads of passing taken together.

SEMESTER-I	**CLASS: M. TECH. (Power Electronics and Power System)**		
CODE: MTPX 111	**COURSE: Advanced Power Electronics**		
Period per week (Each of 60 minutes)	Lecture	03	
	Laboratory	--	
	Tutorial	02	
Scheme of evaluation		Duration (Hrs)	Marks
	Test I	01	20
	Test II	01	20
	End Semester Exam*	04	100
	Termwork	--	25
	Seminar	--	--
	Total		**125**
	Credits		**04**

*60% weightage for end semester exam

Course Objectives:

- To understand the switching behavior of power electronics devices
- To study the different power electronics circuits such as rectifier, inverter and chopper.
- To demonstrate the design of power electronics circuit for different applications.
- Tounderstand the operation of inverter for grid connection

Course Outcomes:

- Able to understand and appreciate the switching behavior of the power electronic devices
- Able to design the power electronic circuit as per the application for small power range.
- Able to understand the operation of inverter from different perspectives

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Detailed Syllabus:

Sr.No.	Description	Hrs.
1	Review of line commutated converters, inverters, voltage control & power factor improvement. Power Devices: BJT, MOSFET, IGBT& GTOs - operating characteristics, gate drive requirements and circuits.	**06**
2	Switched - mode rectifier: various power circuit configurations & wave shaping techniques.	**04**
3	Multi level converters. Inverters : voltage source inverters:- single phase &six step inverters, voltage control & PWM strategies, space vector modulation	**04**
4	Implementation aspects, modification of power circuit for four quadrant operation of inverter.	**04**
5	Current source inverters: single phase and three phase power circuit configuration and analysis.	**04**
6	Load commutated inverters: principle of operation, modification of power circuit	**06**

	configuration for low frequency operation. Phase Controllers.	
7	DC- DC converters - principle of operation of buck, boost, buck-boost, Cuk, flyback, forward, push-pull. Converters	**08**

Term work:Contains 7-8 simulations/ tutorials based on the above syllabus.

Text Books / References

- N.Mohan,T.M. Undeland& W.P.Robbins, "Power Electronics: Converter, Applications & Design", John Wiley & Sons, 1989.
- M.H. Rashid, "Power Electronics: Circuits Devices and Applications", Prentice Hall of India, 1994.
- B.K.Bose, "Power Electronics & A.C. Drives", Prentice Hall, 1986.

Tentative syllabus for Examinations:

Sr. No.	Examination	Module
1	Test I	1 , 2 , 3
2	Test II	4 , 5, 6
3	Final Examination	1 to 7

SEMESTER-I	CLASS: M. TECH. (Power Electronics and Power System)		
CODE: MTPX 112	COURSE : Protection in Power System		
Period per week (Each of 60 minutes)	Lecture	03	
	Laboratory	--	
	Tutorial	02	
Scheme of evaluation		Duration (Hrs)	Marks
	Test I	01	20
	Test II	01	20
	End Semester Exam*	04	100
	Termwork	--	25
	Seminar	--	--
	Total		**125**
	Credits		**04**

*60% Weightage for end semester exam

Course Objectives:

- To understand the art and science of relaying technology.
- To study the different types of relays such as electromagnetic, static and digital and numeric relay.
- To demonstrate the hardware description of relaying system.
- To get Overview of protection of power electronics components such as lines, generators and transformers.

Course Outcomes:

- Able to appreciate the importance of unit protection and system protection with hands on practice
  Able to design the protection scheme for the given layout of power system

Detailed Syllabus:

Sr. No.	Description	Hrs
1	General philosophy of protection – Characteristic functions of protective relays – basic relayelements and relay terminology – Classification of Relays – Construction and operation ofElectro-magnetic relays – A review of conventional protection schemes for Transmission linesand station apparatus (Qualitative treatment only).	**02**
2	Static relays – Solid state devices used in static protection – Amplitude comparator and phasecomparator – Static Overcurrent relays.	**04**
3	Non-directional, Directional - Synthesis of Mho relay, Reactance relay, Impedance relay and Quadrilateral Distance relay using Static comparators,Differential relay. (Qualitative treatment only).	**06**

4	Hardware and software for the measurement of voltage, current, frequency, phase angle.	**04**
5	Microprocessor implementation of over current relays – Inverse time characteristics –Directional relay – Impedance relay– Mho relay, Differential relay – Numerical relay algorithms	**08**
6	Pilot relay protection: Wire pilot relaying, Carrier current pilot relaying, Microwave pilotrelaying – Fiber-optic based relaying – Apparatus Protection: Digital protection of generators,	**06**
7	Digital protection of Transformers – Protection of Long and short lines – Protection based onArtificial Intelligence – SCADA: Architecture, Use of SCADA in interconnected powersystems(Qualitative treatment only).	**06**

Term work: Contains 7-8 simulations/ tutorials based on the above syllabus

Text Books / References:

1. Y.G.Paithankar, S.R.Bhide, "Fundamentals of Power System Protection", Prentice – HallIndia, 2004
2. A.G.Phadke, J.S.Thorpe,"Numerical relaying for Power Systems", John-Wiley and Sons,1988
3. T.S.M.Rao, "Digital / Numerical Relays", Tata McGraw Hill,2005
4. Badri Ram and D. N.Vishwakarma, "Power system protection and Switchgear", Tata McGrawHill, NewDelhi, 2003.
5. Ravindar P. Singh, "Digital Power System Protection", PHI, NewDelhi, 2007.
6. L.P.Singh, "Digital protection, Protective Relaying from Electromechanical to Microprocessor", John Wiley & Sons, 1995
7. J.L. Blackburn, "Protective Relaying: Principles and Applications", MarcelDekker, New York, 1987

Tentative syllabus for Examinations:

Sr. No.	Examination	Module
1	Test I	1 , 2 , 3
2	Test II	4 , 5
3	Final Examination	1 to 7

SEMESTER-I	CLASS: M. TECH. (Power Electronics and Power System)		
CODE: MTPX 113	COURSE: Modeling and Analysis of Electrical Machines		
Period per week (Each of 60 minutes)	Lecture	03	
	Laboratory	--	
	Tutorial	02	
Scheme of evaluation		Duration (Hrs)	Marks
	Test I	01	20
	Test II	01	20
	End Semester Exam*	04	100
	Termwork	--	25
	Seminar	--	--
	Total		**125**
	Credits		**04**

* 60% weightage for end semester exam

Course Objectives:

- To understand the representation electrical machines by the set of mathematical equations
- To realize of the real behavior of electrical machines
- To study concepts of space phasors and frame transformation.

Course Outcomes:

- Able to develop the methodology for the modeling of electrical machines
- .Able to develop the ability to analyze the behavior of the electrical machines

Detailed Syllabus:

Sr.No.	Description	Hrs
1	General expression of stored magnetic energy, co-energy and force/torque, example using single and doubly excited system.	**04**
2	Calculation of air gap MMF and per phase machine inductance using physical machine data. Voltage and torque equation of dc machine, three phase symmetrical induction machine and salient pole synchronous machines in phase variable form.	**06**
3	(i) Static and rotating reference frames, transformation relationships, examples using static symmetrical three phase R, R-L, R-L-M and R-L-C circuits (ii) Application of reference frame theory to three phase symmetrical induction and synchronous machines, dynamic direct and quadrature axis model in arbitrarily rotating reference frames.	**08**
4	Voltage and torque equations, derivation of steady statephasor relationship from dynamic model, generalized theory of rotating electrical machine andKron's primitive machine	**06**

5	Induction machine equations in phase quantities assisted by space vectors-Sinusoidal distributedwinding; stator single-phase magnetizing and mutual inductance; per-phase magnetizinginductance; equivalent winding in a squirrel-cage rotor and rotor inductances; review of spacevectors; flux-linkage and voltage equations in terms of space vectors.	**04**
6	Dynamic analysis in terms ofdq windings-stator and rotor dq windings and inductance-flux linkage and voltage equations in dqcoordinates, electromagnetic torque; dq equivalent circuits; computer simulation	**04**
7	Permanent magnet synchronous machine: Surface permanent magnet (square and sinusoidalback emf type) and interior permanent magnet machines. Construction and operating principle,dynamic modeling and self controlled operation; Analysis of Switched Reluctance Motors.	**04**

TermworkContains 7-8 simulations/ tutorials based on the above syllabus

Text Books / References :

1. Charles Kingsley,Jr., A.E. Fitzgerald, Stephen D.Umans, “Electric Machinery”, Tata McGraw Hill, Fifth Edition, 1992.
2. R. Krishnan, “Electric Motor & Drives: Modeling, Analysis and Control”, Prentice Hall of India, 2001.
3. Ned Mohan, “Advanced electrical drives Analysis, Control and Modeling using Simulink”, MNPERE, Minneapolis, USA, 2001.
4. P. C. Krause, “Analysisof Electrical Machinery and Drive System,” IEEE Power Engineering Society
5. Anderson, P. M. and Fouad, A. A., “Power System Control and Stability”, John Wiley, second edition 2003.

Tentative syllabus for Examinations:

Sr. No.	Examination	Module
1	Test I	1 , 2, 3(i)
2	Test II	3(ii), 4, 5
3	Final Examination	1 to 7

SEMESTER-I	CLASS: M. TECH. (Power Electronics and Power System)		
CODE: MTPX 114	COURSE: Dynamics of Linear Systems		
Period per week (Each of 60 minutes)	Lecture	03	
	Laboratory	--	
	Tutorial	02	
Scheme of evaluation		Duration (Hrs)	Marks
	Test I	01	20
	Test II	01	20
	End Semester Exam*	04	100
	Termwork	--	25
	Seminar	--	--
	Total		**125**
	Credits		**04**

* 60% weightage for end semester exam

Course Objectives:

- To provide overview of the physical system and its representation in mathematical form
- To study linearization of the system for the analysis and understanding
- To understand the concept of stability of the system
- To discuss the need of compensator in the system
- To study design of the physical system for the desired response

Course Outcomes:

- Able to apply the concept of stability for the system
- Able to design the control system for the specific performance parameters

Detailed Syllabus:

Sr.No.	Description	Hrs
1	Background material on matrix algebra, differential equations, linear operators	**04**
2	Representation of dynamic systems, equilibrium points and linearization of nonlinear systems, Jordan form, functions of matrices, norms of vectors and matrices.	**06**
3	(i) Stability of systems, Lyapunov matrix equation (ii) Natural and forced response of state equations, state space descriptions, canonical realizations.	**06**
4	Observability and controllability, minimal realization, canonical decomposition, controllability and observability.	**04**
5	Indices in MIMO systems, Linear state variable feedback, stabilization, pole-placement, methods for obtaining feedback gains in MIMO systems.	**04**

6	Asymptotic observers, compensator design, and separation principle, reduced order observers, Considerations for system gains, Discretization of CT systems.	**06**
7	Design, and separation principle, reduced order observers, Considerations for system gains, Discretization of CT systems.	**06**

Text Books / References:

- Chi-Tsong Chen, “Linear Systems Theory and Design”, Oxford University PressNew York, 1999.
- T. Kailath, “Linear Systems”, Prentice-Hall, New Jersey, 1980, Science and Business Media 2008.
- Gilbert Strang, “ Linear Algebra and its Application”, Fourth Edition CENGAGE Learning

Tentative syllabus for Examinations:

Sr. No.	Examination	Module
1	Test I	1 , 2, 3(i)
2	Test II	3(ii), 4, 5
3	Final Examination	1 to 7

SEMESTER-I	CLASS: M. TECH. (Power Electronics and Power System)		
CODE: MTPX 116	COURSE: Elective – I : Digital Simulation of Power Electronics System		
Period per week (Each of 60 minutes)	Lecture	03	
	Laboratory	--	
	Tutorial	02	
Scheme of evaluation		Duration (Hrs)	Marks
	Test I	01	20
	Test II	01	20
	End Semester Exam*	04	100
	Term work	--	25
	Seminar	--	--
	Total		**125**
	Credits		**04**

*60% weightage for end semester exam

Course Objectives:

- To realize of the real world problem of power electronics systems.
- To study model of the power electronics systems.
- To understanding the techniques of voltage control using PWM techniques

Course Outcome

- Able to judge the results of the simulation study
- Able to simulate the given electrical system for the various operating conditions.

Detailed Syllabus:

Sr.No.	Description	Hrs
1	Review of numerical methods. Application of numerical methods to solve transients in D.C. switched R, L, R-L, R-C and R-L-C circuits. Extension to AC circuits.	**06**
2	Modeling of diode in simulation. Diode with R, R-L, R-C and R-L-C load with ac supply. Modeling of SCR, TRIAC, IGBT and Power Transistors in simulation. Application of numerical methods to R, L, C circuits with power electronic switches. Simulation of gate/base drive circuits, simulation of snubber circuits and control.	**06**
3	Simulation of inverter fed induction motor drives.	**06**
4	Simulation of single phase and three phase uncontrolled and controlled (SCR) rectifiers, converters with self commutated devices- simulation of power factor correction schemes.	**04**

5	Simulation of converter fed dc motor drives, Simulation of thyristor choppers with voltage, current and load commutation schemes, Simulation of chopper fed D.C. motor.	**04**
6	Simulation of single and three phase inverters with thyristors and self-commutated devices.	**06**
7	Space vector representation, pulse-width modulation methods for voltage control, waveforms.	**04**

Term work Contains 7-8 simulations/ tutorials based on the above syllabus

Text Books / References:

1. Simulink Reference Manual, Math works, USA.
2. Robert Ericson, "Fundamentals of Power Electronics", Chapman & Hall, 1997.
3. IssaBatarseh, "Power Electronic Circuits", John Wiley, 2004
4. M. H. Rashid, "Power Electronics: Circuits Devices and Applications", Prentice Hall of India, 1994.

Tentative syllabus for Examinations:

Sr. No.	Examination	Module
1	Test I	1 , 2
2	Test II	3, 4, 5
3	Final Examination	1 to 7

SEMESTER-I	**CLASS: M. TECH. (Power Electronics and Power System)**		
CODE: MTPX 117	**COURSE: Elective – I : Power System Planning and Reliability**		
Period per week (Each of 60 minutes)	Lecture	03	
	Laboratory	--	
	Tutorial	02	
Scheme of evaluation		Duration (Hrs)	Marks
	Test I	01	20
	Test II	01	20
	End Semester Exam*	04	100
	Termwork	--	25
	Seminar	--	--
	Total		**125**
	Credits		**04**

*60% weightage for end semester exam

Course Objectives:

- To know power system planning, operation and management issues as well as reliability in a deregulated environment.
- The course will give a comprehensive overview of power system reliability. Evaluation of generation, transmission and composite system reliability and their impacts on system planning will be covered.

Course outcomes:

- Able to apply some advanced concepts of power system reliability and planning that will be useful for engineering professional practice in the power sector operation and planning.

Detailed Syllabus:

Sr. No.	Description	Hrs
1	**Load Forecasting:** Introduction, Forecasting Methodology, Energy Forecasting, Peak Demand Forecasting, Non-weather-sensitive Forecast (NWSF), Weather-sensitive Forecast (WSF), Total Forecast, Annual & Monthly Peak Demand Forecast.	**4**
2	**System Planning:** Introduction, Objectives & Factors affecting to System Planning, Short, Medium and Long Term Planning,, Reactive Power Planning. **Generation and Transmission planning:** Objectives & Factors affecting Generation Planning, Sources of Generation. Objectives of transmission planning Network Reconfiguration, **Generation system reliability analysis:** Introduction, Probabilistic generating unit models, Probabilistic load models, Effective load, Reliability analysis for an Isolated system	**8**
3	**Power system Reliability:** Introduction, Basic reliability Concepts, Terms and Definitions, outage, failure rate, and outage rate availability, unavailability, Reliability function, Mean time to failure, Hazard Rate Function, Bathtub Curve.	**04**

4	**Reliability of Systems:**Serial Configuration, Parallel Configuration, Combined Series – Parallel Systems, System Structure Faction, Minimal Cuts and Minimal Paths. Reliability models, Markov process.	**05**
5	**Generating Capacity reliability Evaluation:** **Static Generating capacity:** Introduction, Basic probability methods and Frequency & Duration method, capacity outage probability table, recursive algorithm, Evaluation of: loss of load indices, Loss of load expectation & Loss of energy **Spinning Generating capacity:** Introduction, load forecast uncertainty Derated capacity levels.	**06**
6	**Transmission system reliability Evaluation:** Introduction, Average interruption method, Frequency and duration method.	**05**
7	**Composite generation and transmission system:** Introduction, **Data** requirement, system and load point indices, Impact of component outage on the system reliability, application to simple system.	**04**

Term Work:
The term work will consist of at least Six Simulations/Computer Programs/Assignments Based on the above syllabus.

Text Books / References

Text Books:

1. Roy Billinton and Ronald N. Allan, "Reliability Evaluation of Power System," Plenum, Press, 1984
2. R.L. Sullivan, "Power System Planning," - Tata McGraw Hill Publishing Company

Reference Book:

3. Roy Billinton and Ronald N Allan, "Reliability Assessment of Large Electric Power Systems", Kluwer academic publishers, 1988
4. X. Wang and J.R. McDonald, " Modern Power System Planning", McGraw Hill

Tentative syllabus for Examinations:

Sr. No.	Examination	Module
1	Test I	1 , 2
2	Test II	3, 4, 5
3	Final Examination	1 to 7

SEMESTER-I	**CLASS: M. TECH. (Power Electronics and Power System)**		
CODE: MTPX 118	**COURSE: Elective – I : Artificial Intelligence for Power System**		
Period per week (Each of 60 minutes)	Lecture	03	
	Laboratory	--	
	Tutorial	02	
Scheme of evaluation		Duration (Hrs)	Marks
	Test I	01	20
	Test II	01	20
	End Semester Exam*	04	100
	Termwork	--	25
	Seminar	--	--
	Total		**125**
	Credits		**04**

*60% weightage for end semester exam

Course Objectives:

- To give an overview of artificial intelligence and its use to power system monitoring, operation and control.
- To study Artificial Neural Network and Fuzzy logic theory.
- To introduction applications in fault diagnosis, power system estimators and controllers.

Course outcomes:

- Able to apply Artificial Intelligence in power system applications
- Able to use fuzzy logic, Neural network and Genetic algorithms for power system applications.

Detailed Syllabus:

Module	Contents	Hrs
1.	Introduction to Artificial Intelligence: Introduction to Artificial Neural Network (ANN), Fuzzy systems, Expert Systems, Genetic Algorithm, EvolutionaryProgramming.	**02**
2.	Use of expert systems in power system monitoring operation and control.	**02**
3.	Artificial Neural Network Basics: Biological neurons: Function of single biological neuron, function of artificial neuron, Basic terminology related toartificialneuron. Characteristics of ANN, Typical applications of ANN such as classification, pattern recognition, forecasting Properties, strength of ANN.	**04**

4.	Different Architectures of ANN and Learning Processes Types of activation function, Learning Tasks, Single Layer Network and Multi-layer Network, Learning curves, Learning Rate, Annealing techniques.Feed forward Neural Network, Back propagation algorithm. Limitation of Back propagationalgorithm.	**08**
5.	Fuzzy Mathematics : Basic concept of Fuzzy Logic, Fuzzy set, Basic definition, Membership function, Operations of fuzzy sets, Fuzzy relations - Fuzzy graphs - Fuzzy analysis Propositional logic , predictive logic, Fuzzy set theory.	**08**
6.	Expert systems in fault diagnosis. Applications of Neural network based power system estimators and controllers. Fuzzy logic based controllers. Alarm analysis and decision making processes. Applications of imaging and pattern recognition for system identification and control.	**06**
7.	Database management and computer graphics aided decision making processes. Artificial intelligence method of crisis control and restoration processes. Application of GA in power system problem solution	**06**

Term workcontains 7-8 simulations/ tutorials based on the above syllabus

Text Books / References:

1. Simon Haykin, “Neural Networks: A Comprehensive Foundation,” 2nd Edition, Pearson Education.
2. Zimmermann, H. J., “Fuzzy Set Theory and Its Applications,” 2nd Edition, Kluwer Academic Publishers.
3. El Hawaray, “Electrical Power Applications with Fuzzy systems AIEEE Press.
4. D. P. Kothari, J. S. Dhillon, “ Power System Optimisation,” PHI
5. M.Ganesh, “Introduction to fuzzy sets and fuzzy logic”, Prentice Hall India.
6. Kelvin Waruicke, ArthurEkwlle, Raj Agarwal, “AI Techniques in Power System,” IEELondon

Tentative syllabus for Examinations:

Sr. No.	Examination	Module
1	Test I	1, 2, 3
2	Test II	4, 5
3	Final Examination	1 to 7

SEMESTER-I	CLASS: M. TECH. (Power Electronics and Power System)		
CODE: MTPX 119	COURSE: Elective – I : DSP Control in Power Electronics		
Period per week (Each of 60 minutes)	Lecture	03	
	Laboratory	--	
	Tutorial	02	
Scheme of evaluation		Duration (Hrs)	Marks
	Test I	01	20
	Test II	01	20
	End Semester Exam*	04	100
	Termwork	--	25
	Seminar	--	--
	Total		**125**
	Credits		**04**

*60% Weightage for end semester

Course Objectives:

- To understand comparison of microcontrollers and digital signal processors
- To learn and implement DSP programming
- Tounderstand internal details of DSP architecture, peripheral, addressing modes, interrupt structure, hardware multiplier

Course Outcomes:

- Able to understand and use new /advanced DSP
- Able to implement the basic power electronics control algorithm such as PWM techniques using DSPs.

Detailed Syllabus:

Sr. No.	Description	Hrs
1	Review of microcontrollers and digital signal processors, architecture, peripheral modules.	**04**
2	Typical processors for control implementation, memory organization, CPU details.	**04**
3	Addressing modes interrupt structure, hardware multiplier, pipelining, Fixed- and floating-point data representations, Assemblers, linkers and loaders.	**06**
4	Binary file formats for processor executable files. Typical structure of timer-interrupt driven programs. Implementing digital processor based control systems for power electronics.	**06**
5	Reference frame transformations, PLL implementations, machine models, harmonic and reactive power compensation, space vector PWM.	**06**

6	Numerical integration methods. Comparison in terms of time step, stability	**04**
7	Multitasking concepts for power electronics implementations, The need for multitasking, various multitasking method	**04**

Term work Contains 7-8 simulations/ tutorials based on the above syllabus

Text Books / References

Text/References

1. K. Ogata, "Discrete-Time Control Systems", second edition, Pearson Education Asia.
2. N. Mohan, "Power Electronics", third edition, John Wiley and Sons.

Tentative syllabus for Examinations:

Sr. No.	Examination	Module
1	Test I	1, 2, 3
2	Test II	4, 5
3	Final Examination	1 to 7

3.1 M.Tech. in Power Electronics and Power System Courses

Academic Scheme and Syllabus
Year 2015-16

SEM II

SEMESTER-II	CLASS: M. TECH. (Power Electronics and Power System)		
CODE: MTPX 121	COURSE: Flexible AC Transmission		
Period per week (Each of 60 minutes)	Lecture	03	
	Laboratory	--	
	Tutorial	02	
Scheme of evaluation		Duration (Hrs)	Marks
	Test I	01	20
	Test II	01	20
	End Semester Exam*	04	100
	Term work	--	25
	Seminar	--	--
	Total		**125**
	Credits		**04**

*60% weightage for end semester exam

Course Objectives:

- To understand the steady state and dynamic problems in AC systems
- To Study of series and shunt compensation
- To understand the control strategies to improve system performance and stability of the system
- To Study of harmonics and its mitigation, power quality concepts

Course Outcomes:

- Able to use ac power flow and its control
- Able to applythe effect of compensation of using different controllers in the practical systems.

Detailed Syllabus:

Sr.No.	Description	Hrs
1	Steady state and dynamic problems in AC systems. Flexible AC transmission systems (FACTS).	**04**
2	Principles of series and shunt compensation. Description of static VAR compensators (SVC), Thyristor Controlled series compensators (TCSC), Static phase shifters (SPS).	**06**
3	Static condenser (STATCON), Static synchronous series compensator (SSSC) and Unified power flow controller (UPFC).	**04**
4	Modelling and Analysis of FACTS controllers. Control strategies to improve	**06**

	system stability.	
5	Power Quality problems in distribution systems, harmonics, harmonics creating loads, modelling, harmonic propagation, Series and parallel resonances, harmonic power flow.	**06**
6	Mitigation of harmonics, filters, passive filters, Active filters, shunt, series hybrid filters, voltage sags & swells, voltage flicker.	**06**
7	Mitigation of power quality problems using power electronic conditioners, IEEE standards.	**04**

Term work Contains 7-8 simulations/ tutorials based on the above syllabus

Text Books /References

- G.T.Heydt, “Power Quality”, Stars in a Circle Publications, Indiana, 1991T.J.E. Miller, “Static Reactive Power Compensation,” John Wiley & Sons, New York, 1982.
- N. G. Hingorani, L. Gyugi, “ Understanding Understanding FACTS:Concepts and Technology of Flexible AC Transmission Systems”, Wiley, 2000
- Recent publications on Power Systems and Power Delivery.

Tentative syllabus for Examinations:

Sr. No.	**Examination**	**Module**
1	Test I	1 , 2, 3
2	Test II	4, 5
3	Final Examination	1 to 7

SEMESTER-II	CLASS: M. TECH. (Power Electronics and Power System)		
CODE: MTPX 122	COURSE: Advanced Control of Electrical Drives		
Period per week (Each of 60 minutes)	Lecture	03	
	Laboratory	--	
	Tutorial	02	
Scheme of evaluation		Duration (Hrs)	Marks
	Test I	01	20
	Test II	01	20
	End Semester Exam*	04	100
	Termwork	--	25
	Seminar	--	--
	Total		**125**
	Credits		**04**

*60% Weightage for end semester exam

Course Objectives:

- To study the torque-speed characteristics of AC and DC drives and different types of load
- To discuss modification of torque speed characteristics of AC and DC motors as per load requirements.
- To understand the power modulators and control strategies
- To study steady state stability of the motor load systemand higher level control of ac drives.

Course Outcomes:

- Able to apply the knowledge of electrical drives system for various applications such as flexible production systems, energy conservation, renewable energy, transportation etc., making Electric Drives an enabling technology.
- Able to understand the basic requirements placed by mechanical systems on electric drives.
- Able to apply the basic principles of power electronics in drives using switch-mode converters and pulse width modulation to synthesize the voltages in dc and ac motor drives.
- Able to understand the need of modification of the torque speed characteristics of machines. Describe the operation of induction machines in steady state and dynamic condition.
- Able to appreciate the speed control of induction motor drives in an energy efficient manner using power electronics with higher level control technique such as vector control.

Detailed Syllabus:

Sr.No.	Description	Hrs
1	Review: Basics of AC and DC Drives	**02**
2	Principle of phase control – Fundamental relations; Analysis of series and separately excitedDC motor with single-phase and three-phase converters – waveforms, performance parameters, Continuous and discontinuous armature current operations; Current ripple and its effect on performance; Operation with free wheeling diode; Implementation of braking schemes; Drive employing dual converter. Constant torque and constant horse power operations.	**06**
3	Modeling of DC drive elements – Equivalent circuit, transfer function of self, separately excited DCmotors; Linear Transfer function model of power converters; Sensing and feedback elements- Closed loop speed control – current and speed loops, P, PI and PID controllers – responsecomparison. Simulation of converter and chopper fed DC drive.	**06**
4	AC voltage controller fed induction machine operation – Energy conservation issues – V/f operation theory – requirement for slip and stator voltage compensation. CSI fed induction machine – Operation and characteristics.	**08**
5	Field oriented control of induction machines – Theory – DC drive analogy – Direct and Indirectmethods – Flux vector estimation.	**06**
6	Direct torque control of Induction Machines – Torque expression with stator and rotor fluxes, DTC control strategy.	**04**
7	Synchronous motor control - Brush and Brushless excitation – Load commutated inverter feddrive.	**04**

Term work Contains 7-8 simulations/ tutorials based on the above syllabus

Text Books / References :

1. G. K.Dubey, "Power Semiconductor controlled Drives", Prentice Hall Inc., New Jersey, 1989.
2. R.Krishnan, "Electric Motor Drives – Modeling, Analysis and Control", Prentice- Hall of IndiaPvt. Ltd., New Delhi, 2003.
1. G. K.Dubey, "Fundamentals of Electrical Drives", Narosal Publishing House, New Delhi, 2001.
2. B. K.Bose "Modern Power Electronics and AC Drives", Pearson Education (Singapore) Pte.Ltd., New Delhi, 2003.
3. VedamSubramanyam, "Electric Drives – Concepts and Applications", Tata McGraw-Hill Publishing company Ltd., New Delhi, 2002.

SEMESTER-II	CLASS: M. TECH. (Power Electronics and Power System)		
CODE: MTPX 123	Course: Power System Dynamics and Control		
Period per week (Each of 60 minutes)	Lecture	03	
	Laboratory	--	
	Tutorial	02	
Scheme of evaluation		Duration (Hrs)	Marks
	Test I	01	20
	Test II	01	20
	End Semester Exam*	04	100
	Termwork	--	25
	Seminar	--	--
	Total		125
	Credits		04

*60% Weightage for end semester exam

Course Objectives:

- (To study the stability considerations in power system.
- To understand the different stability of power system and multi-machine stability concept
- To study of voltage stability, PV, QV and PQ curves
- To utudy of improving the stability of power system

Course Outcomes:

- Able to understand and appreciate the stability concept in the power network.
- Able to apply the effects of various electrical parameter on stability

Detailed Syllabus:

Sr.No.	Description	Hrs
1	Power system stability considerations – definitions-classification of stability-rotor angle andvoltage stability-synchronous machine representation –classical model-load modeling concepts modeling of excitation systems-modeling of prime movers.	06
2	Transient stability-swing equation-equal area criterion-solution of swing equation-Numericalmethods-Euler method-Runge-Kutta method-critical clearing time and angle-effect of excitation system and governors	06
3	Multi machine stability –extended equal area criterion-transient energy function approach.	04
4	Small signal stability – state space representation – Eigen values- modal matrices-small signalstability of single machine infinite bus system –	04

5	Synchronous machine classical modelrepresentation-effect of field circuit dynamics-effect of excitation system-small signal stability of multi machine system.	**06**
6	Voltage stability – generation aspects - transmission system aspects – load aspects – PVcurve – QV curve – PQ curve – analysis with static loads – load ability limit – sensitivityanalysis-continuation power flow analysis - instability mechanisms-examples.	**06**
7	Methods of improving stability – transient stability enhancement – high speed fault clearing –steam turbine fast valving-high speed excitation systems- small signal stability enhancementpowersystem stabilizers – voltage stability enhancement – reactive power control.	**04**

Term work Contains 7-8 simulations/ tutorials based on the above syllabus

Text Books / References Books:

1. Kundur, P., "Power System Stability and Control", McGraw-Hill International Editions, 1994.
2. Anderson, P.M. and Fouad, A.A., "Power System Control and Stability", John Wiley, secondedition 2003.
3. Van Cutsem, T. and Vournas, C., "Voltage Stability of Electric Power Systems", Springer

Tentative syllabus for Examinations:

Sr. No.	Examination	Module
1	Test I	1, 2, 3
2	Test II	3, 4, 5
3	Final Examination	1 to 7

SEMESTER-II	CLASS: M.TECH. (Power Electronics and Power System)		
CODE: MTPX 124	COURSE: Computer Application in Power System		
Period per week (Each of 60 minutes)	Lecture	03	
	Laboratory	--	
	Tutorial	02	
Scheme of evaluation		Duration (Hrs)	Marks
	T1	01	20
	T2	01	20
	End Semester Exam*	04	100
	Term work	--	25
	Seminar	--	--
	Total		**125**
	Credits		**04**

*60% Weightage for end semester exam

Course Objectives:

- To study the representation of power system and its components.
- To understand the behavior of power system under healthy and faulty conditions
- To study the load flow analysis of power system.
- To understandthe advance techniques in the solution of power flow problem

Course outcomes:

- Able to appreciate the use of computational methods in the solution of power flow problem
- Able to use the behavior of power system under different operating conditions.

Detailed Syllabus:

Sr. No.	Description	Hrs
1	Review: Elementary linear graph theory – Incidence and Network matrices – Development of network matrices from Graph theoretic approach – Building algorithm for Bus impedance matrix – Modification of Z_{Bus} matrix due to changes in primitive network. Power system components and their representation – Synchronous machine, transmissionsystem, three phase power network.	**06**
2	Load Flow Studies – Overview of Gauss – Seidel and Newton – Raphson Methods – Decoupled Newton Load Flow – Fast Decoupled Flow – AC/DC load flow – Three phase Load Flow	**06**
3	Sparsity techniques – Triangular factorization – Optimal ordering – Optimal load flow in power systems.	**06**

4	Short Circuit Studies – Short Circuit calculations using Z bus – Short Circuit calculations forbalanced and unbalanced three phase network using Z_{bus} – Short Circuit studies using bus hybrid matrix.	**06**
5	Contingency Analysis – Contingencies using Z-bus in a superposition method – A second method of using Z bus for contingencies.	**06**
6	Unit Commitment. Load frequency control: Optimal hydro-thermal scheduling.	**04**
7	AI applications, case study.	**02**

Term work Contains 7-8 simulations/ tutorials based on the above syllabus

Text Books / References :

1. Stagg and El Abiad, “Computer methods in Power system Analysis,” McGraw Hill. 1968
2. Grainger, J.J. and Stevenson, W.D, “Power System Analysis,” McGraw Hill, New Delhi, 2003.
3. L. P. Singh, “Advanced Power Systems Analysis and Dynamics,” New Age Intl. Publishers, 1983
4. G. L. Kusic, “Computer Aided Power System Analysis,” Prentice Hall, 1986.
5. HadiSaadat, “Power System Analysis”, McGraw Hill, 1999.
6. J.Arrilaga and N.R.Watson, “Computer Modeling of Electrical Power Systems” Wiley, 2001.
7. I.J.Nagrath and D.P.Kothari, “Modern Power System Analysis”, Tata McGraw Hill, 1980.

Tentative syllabus for Examinations:

Sr. No.	Examination	Module
1	Test I	1 , 2
2	Test II	3 , 4
3	Final Examination	1 to 7

SEMESTER-II	CLASS: M.TECH. (Power Electronics and Power System)		
CODE: MTPX 126	**COURSE: Elective – II :Network Principles and Protocols**		
Period per week (Each of 60 minutes)	Lecture	03	
	Laboratory	--	
	Tutorial	02	
Scheme of evaluation		Duration (Hrs)	Marks
	Test I	01	20
	Test II	01	20
	End Semester Exam*	04	100
	Termwork	--	25
	Seminar	--	--
	Total		**125**
	Credits		**04**

*60% Weightage for end semester exam

Course Objectives:

- To understand of various network architecture, protocols and topologies
- To study of various routing algorithms and inter networking issues

Course Outcomes:

- Able learn and implement IP network routing algorithms
- Able to understand the network design issues

Detailed Syllabus:

Sr.No.	Description	Hrs
1	Networks-Architecture, ISO-ISO reference model-Topology-Switching-Transmissionmedia-Point to point protocols SLIP, PPP – LANS, ALOHA family of protocols, CSMA/CD, IEEE 802.3,802.4,802.5	**08**
2	Routing, Congestion control- Internetworking – Issues	**04**
3	Address Learning Bridges, Spanning Tree, Source routing, Bridges, Routers, Gateway.	**06**
4	IP datagram - hop by hop routing, ARP, RARP- subnets.	**06**
5	Subnet Addressing, Addressmasking, ICMP, RIP, RIPV2, OSPF, DNS, LAN and WAN Multicast.	**04**
6	Design Issues, Connection Management, Transmission Control Protocol (TCP) – UserData gram Protocol (UDP)	**04**
7	ApplicationLayer:Telnet - TETP-FTP-SMTP- Ping- Finger, Bootstrap – Network Time Protocol – SNMP	**04**

Term work Contains 7-8 simulations/ tutorials based on the above syllabus

Text Books / References:

1. Teanenbaum, A.S., “Computer Networks”, Third Edition, Prentice Hail of India, 1996.
2. W. Richard Stevens, “TCP/P Illustrated – Vol. I, the protocols, Addition – Wesley Professional Computing Series, 1994
3. Ulyess Black, “TCP/P and related Protocols”, II Edition, McGraw Hill International Edition, 1995.
4. D.E. Comer and D.L. Stevens, “Internetworking with TCP/IP Illustrated” – volume III, Prentice Hall of India 1997.
5. W.R. Stevens,“Unix Network Programming”, Prentice Hall of India, 1995

Tentative syllabus for Examinations:

Sr. No.	Examination	Module
1	Test I	1 , 2
2	Test II	3, 4, 5
3	Final Examination	1 to 7

<table>
<tr><td>SEMESTER-II</td><td colspan="3">CLASS: M.TECH. (Power Electronics and Power System)</td></tr>
<tr><td>CODE: MTPX 127</td><td colspan="3">COURSE:Elective- II : Optimization Techniques</td></tr>
<tr><td rowspan="3">Period per week
(Each of 60 minutes)</td><td>Lecture</td><td colspan="2">03</td></tr>
<tr><td>Laboratory</td><td colspan="2">--</td></tr>
<tr><td>Tutorial</td><td colspan="2">02</td></tr>
<tr><td rowspan="8">Scheme of evaluation</td><td></td><td>Duration (Hrs)</td><td>Marks</td></tr>
<tr><td>Test I</td><td>01</td><td>20</td></tr>
<tr><td>Test II</td><td>01</td><td>20</td></tr>
<tr><td>End Semester Exam*</td><td>04</td><td>100</td></tr>
<tr><td>Termwork</td><td>--</td><td>25</td></tr>
<tr><td>Seminar</td><td>--</td><td>--</td></tr>
<tr><td colspan="2">Total</td><td>125</td></tr>
<tr><td colspan="2">Credits</td><td>04</td></tr>
</table>

*60% Weightage for end semester exam

Course Objectives:

- To understand the basic principles of optimization techniques
- To study of different solution methodologies
- To understand the linear and nonlinear programming methods

Course Outcomes:

- Able to understand and apply the knowledge of optimization technique in solving the problem in different fields

Detailed Syllabus:

Sr.No.	Description	Hrs
1	Optimal problem formulation: Constraints, objective functions, variable bounds. Single variable optimization algorithm: optimality criteria – bracketing method; exhaustive search method & bounding phase method.	**06**
2	Region elimination methods – interval halving method, Fibonacci search method – Root finding using optimization technique.	**04**
3	Basic concepts – non-dominated solutions – preference structures, basic solution approach –Weighted sum approach; Distance method, concepts – calculation of distance measure – applications. Compromise approach and goal programming approach.	**04**
4	Steepest descent method for unconstrained optimization -Kuhn – Tucker conditions – transformation methods; penalty function method and multiplier method.	**06**
5	Sensitivity analysis direct search for constrained minimization; variable elimination method.	**04**

6	Integer linear programming – graphical representation – Gomory's cutting plane method – integer polynomial programming – integer nonlinear programming.	**06**
7	Derivative-free Optimization – Basics, Genetic Algorithms – Basics, Simulated Annealing – Downhill Simplex Search.	**06**

Term work Contains 7-8 simulations/ tutorials based on the above syllabus

Text Books / References:

1. Kalyanmoy Deb, "Optimization for Engineering Design – Algorithms and Examples", Prentice Hall India, Eighth printing, 2005.
2. Mitsuo Gen, Runwei Cheng, "Genetic Algorithms and Engineering Optimization", John Wiley & Sons Inc., 2000.
3. S. S. Rao, "Optimization – Theory and Applications", Wiley Eastern Limited, Second Edition, 1984.
4. Davis E Goldberg, "Genetic Algorithms: Search, Optimization and Machine Learning" Addison Wesly, N.Y., 1989.
5. R.Eberhart, P. Simpson and R.Dobbins," Computational Intelligence" PC Tools", AP Professional, Boston 1996
6. D. G. Leunberger, Yinyu Ye, "Linear and Nonlinear Programming", Third edition Springer 7. Mokhtar S. Bazaraa, Hanif D. Sherali and C. M. Shetty**, "**Nonlinear Programming: Theory and Algorithms**"** ***Wiley***, Third Edition

Tentative syllabus for Examinations:

Sr. No.	Examination	Module
1	Test I	1, 2, 3
2	Test II	4, 5, 6
3	Final Examination	1 to 7

SEMESTER-II	**CLASS: M.TECH. (Power Electronics and Power System)**		
CODE: MTPX 128	**COURSE: Elective – II : Application of Power Electronics in Renewable Energy System**		
Period per week (Each of 60 minutes)	Lecture	03	
	Laboratory	--	
	Tutorial	02	
Scheme of evaluation		Duration (Hrs)	Marks
	Test I	01	20
	Test II	01	20
	End Semester Exam*	04	100
	Termwork	--	25
	Seminar	--	--
	Total		**125**
	Credits		**04**

*60% Weightage for end semester exam

Course Objectives:

- To understand the impacts of renewable energy generation on environment
- To understand the selection of the electrical machines for energy conversion
- To study of power converters for PV and wind power generator
- To study of hybrid systems of renewable energy

Course outcomes:

- Learning Renewable Energy (RE) issues in the context of science, technology, economics, policy and society
- Nurturing the ability to develop RE systems considering sustainable development
- Developing the ability to relate RE to climate change and other global contemporary issues
- Understanding the professional ethics of RE
- Fostering the ability to function in a multi-disciplinary team that could consist of persons with varying backgrounds of policy, science, engineering, and business.

Detailed Syllabus:

Sr.No.	**Description**	**Hrs**
1	Introduction: Environmental aspects of electric energy conversion: impacts of renewableenergy generation on environment (cost-GHG Emission) - Qualitative study of different renewable energy resources: Solar, wind, ocean, Biomass, Fuel cell, Hydrogen energy systems and hybrid renewable energy systems.	**04**
2	Electrical Machines for Renewable Energy Conversion : Review of reference theory fundamentals-principle of operation and analysis: IG, PMSG, SCIG and DFIG.	**06**

3	Power Converters: Solar: Block diagram of solar photo voltaic system -Principle of operation: linecommutated converters (inversion-mode) - Boost and buck-boost converters-selection of inverter, battery sizing, array sizing.	**06**
4	Wind Power Application: Different power converter configurations: Three phase AC voltage controllers- AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters.	**06**
5	Grid Interactive Inverters, matrix converters, voltage and reactive power supportPower Point Tracking (MPPT).	**04**
6	Analysis and Wind Genaration Issues : Stand alone operation of fixed and variable speed wind energy conversion systems and solar system-Grid connection Issues -Grid integrated PMSG and SCIG Based WECS Grid Integrated solar system.	**06**
7	Hybrid Renewable Energy Systems: Need for Hybrid Systems- Range and type of Hybrid systems- Case studies of Wind-PV Maximum power point track.	**06**

Term work Contains 7-8 simulations/ tutorials based on the above syllabus

Text Books / References Books:

1. Rashid .M. H, “Power electronics Hand book”, AcademicPress, 2001.
2. Rai G.D, “Non conventional energy sources”, KhannaPublishers, 1993.
3. Rai G.D, “Solar energy utilization”, KhannaPublishers, 1993.
4. Gray, L. Johnson, “Wind energy system”, Prentice hall, 1995.
5. B. H. Khan, “Non-conventional Energy sources”, TataMcGraw-hillPublishing Company, New Delhi.

Tentative syllabus for Examinations:

Sr. No.	Examination	Module
1	Test I	1 , 2, 3(i)
2	Test II	3(ii), 4, 5
3	Final Examination	1 to 7

SEMESTER-II	**CLASS: M. TECH. (Power Electronics and Power System)**		
CODE: MTPX 129	**COURSE: Elective – II : Applied Nonlinear Control**		
Period per week (Each of 60 minutes)	Lecture	03	
	Laboratory	--	
	Tutorial	02	
Scheme of evaluation		Duration (Hrs)	Marks
	Test I	01	20
	Test II	01	20
	End Semester Exam*	04	100
	Termwork	--	25
	Seminar	--	--
	Total		**125**
	Credits		**04**

*60% Weightage for end semester exam

Course Objectives:

- To understand the need for nonlinear control system analysis and design.
- To understand Lyapunov's Stability concepts with some emphasis on mathematical development of stability criterion for different systems
- To understand Phase plane and Describing Function Method for analysis of nonlinear system.
- To understand feedback linearization method for designing nonlinear control system

Course outcomes:

- Able to understand the behavior of nonlinear system and to design the control system for the same.
- Able to apply the stability criterion for the given system.

Detailed Syllabus:

Sr. No.	Description	Hrs
1	Introduction, Nonlinear Models and Nonlinear Phenomenon, Mathematical Preliminaries, Induced Norms and Matrix Measures, Contraction Mapping Theorem	**03**
2	Nonlinear System Analysis: Phase Plane Analysis, Phase Portraits, Singular Points, Symmetry in Phase Portrait, Constructing Phase Portrait, Determining Time from phase portrait, phase plane analysis of linear and nonlinear system, limit cycles	**07**

3	Lyapunov Stability: Nonlinear systems and Equilibrium Points, Concepts of Stability, Linearization and Local Stability, Lyapunov's Direct Method, System Analysis based on Lyapunov's Direct Method, Control Design Based on Lyapunov's Direct Method.	**08**
4	Advanced Stability Theory: Concepts of Stability for Non-Autonomous System, Lyapunov's Analysis of Non-Autonomous System, Barbalat's Lemma, Lassalle's Invariance Principal, Instability Theorems, Indirect Method of Lyapunov, Domain of Attractions.	**08**
5	Describing Function Analysis: Fundamentals, Analysis of Nonlinear System Using Describing Function Method.	**02**
6	Nonlinear Control System Design: Feedback Linearization, Input State Linearization, Input-Output Linearization.	**04**
7	Design Examples Using Feedback Linearization.	**04**

Term work Contains 7-8 simulations/ tutorials based on the above syllabus

Text Books / References Books:

1. Jean-Jacques E Slotine, Weiping Li, "Applied Nonlinear Control", Prentice Hall
2. Hasan K. Khalil, "Nonlinear Systems", Prentice Hall
3. M. Vidyasagar, "Nonlinear Systems Analysis", SIAM, Classics in Applied Mathematics
4. Shankar Sastry, "Nonlinear Systems: Analysis, Stability and Control", Springer
5. Haracio Marquez, "Nonlinear Control Systems: Analysis and Design", Wiley
6. L.P.Singh, "Digital protection, Protective Relaying from Electromechanical to Microprocessor", John Wiley & Sons, 1995
7. J.L. Blackburn, "Protective Relaying: Principles and Applications", MarcelDekker, New York, 1987

Tentative syllabus for Examinations:

Sr. No.	Examination	Module
1	Test I	1 , 2 , 3
2	Test II	4 , 5, 6
3	Final Examination	1 to 7

SEM-III

MTPX 231 Seminar on Literature Review

The project work extends through the third and fourth semester. The project work is defined based on the interest of the students to specialize in a particular area. Students are expected to carry out independent research work on the chosen topic and submit a thesis for evaluation.The work at this stage may involve review of literature, laboratory experimental work, development of software, development of model, case study, field data collection and analysis etc. On completion of the work the student shall prepare a report and will give a Seminar on the report.

MTPX 232 Dissertation Seminars Stage I

Student shall finalize a theme, related to Power Electronics and Power system area for the dissertation work. Student shall prepare a report on the theme outlining importance of the theme of the study, objective, scope of work, methodology, and a review of literature published in the relevant area. The student shall present seminars on this report.

SEM – IV

MTPX 241 Dissertation Seminars Stage II

Student shall study the problem of dissertation in the light of outcome of Stage I and Stage II seminars. On completion of simulation, analysis, hardware implementation and inference the student shall prepare an interim report and shall present a seminar on the work done, before the submission of Synopsis to the Institute.

MTPX 242 Dissertation and Viva Voce

On finalization of the dissertation student shall submit the dissertation report to the Institute. The student shall have to appear for a Viva-voce examination for the dissertation.