DELHI TECHNOLOGICAL UNIVERSITY

SCHEME OF TEACHING AND EVALUATION

MASTER OF TECHNOLOGY IN POWER SYSTEMS (PSY)

The following alphanumeric coding scheme has been adopted
Core Courses XXXYMN
Elective Courses XXXYCMN

XXX abbreviates a particular M. Tech. program, Y – (5 for M. Tech. 1 st year, 6 for M. Tech. 2 nd year),
C – credit of the course (4/3/2),
MN – Subject code (Odd number for odd semester and even number for even semester courses

Semester-I

	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group A	1	PSY501	Advanced Power System Analysis	Core	4	3	0	2	15	25	20	40	-	
	2	PSY503	Advanced Power Electronics	Core	4	3	0	2	15	25	20	40	-	
Group B	3	PSY5401/5403/……	Elective 1	Elective	4	3	0	2	15	25	20	40	-	**17**
	4	PSY5301/5303/……	Elective 2	Elective	3	3	0	0	20	-	30	50	-	
	5	PSY5201/5203/…… /UEC5201/5203/……	Elective 3/ University Elective I	Elective	2	2	0	0	20	-	30	50	-	

Semester-II

	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group C	1	PSY502	Advanced Power System Protection	Core	4	3	0	2	15	25	20	40	-	**17**

	2	PSY504	Power System Operation and Control	Core	4	3	0	2	15	25	20	40	-	
Group D	3	PSY5402/5404/…… ……	Elective 4	Elective	4	3	0	2	15	25	20	40	-	
	4	PSY5302/5304/…… ……	Elective 5	Elective	3	3	0	0	20	-	30	50	-	
	5	PSY5202/5204/…… ……/ UEC5202/5204/…… ……	Elective 6/ University Elective II	Elective	2	2	0	0	20	-	30	50	-	

Semester-III

	S.No.	**Course Code**	**Course Name**	**Type/ Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**	**Total Credits**
	Track 1													**12**
Group E	1	PSY651	Research Project	Core	12	0	0	12	0	-	0	100	0	
	Track 2													
	1	PSY601	Major Project I	Core	3						40	60		**12**
	2	PSY6401/6403/……	Elective 7	Elective	4	3	0	2	15	25	20	40	-	
	3	PSY6301/6303/……	Elective 8	Elective	3	3	0	0	20	-	30	50	-	
	4	PSY6201/6203/……	Elective 9	Elective	2	2	0	0	20	-	30	50	-	

Semester-IV

	S.No.	**Course Code**	**Course Name**	**Type/ Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**	**Total Credits**
ro u p	**Track 1**													

	1	PSY652	Research Project	Core	12	0		12	0	-	0	100	0	**12**
	Track 2													
	1	PSY602	Major Project II	Core	12	0		12	0	-	0	100	0	**12**

LIST OF ELECTIVES :													
	S.No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 1	1	PSY5401	Power System Dynamics and Stability	Elective	4	3	0	2	15	25	20	40	-
	2	PSY5403	Advanced Control Systems		4	3	0	2	15	25	20	40	-
	3	PSY5405	Modelling of Electrical Machines		4	3	0	2	15	25	20	40	-
	4	PSY5407	Soft Computing Techniques		4	3	0	2	15	25	20	40	-
	S.No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 2	1	PSY5301	Power System Instrumentation	Elective	3	3	0	0	20	-	30	50	-
	2	PSY5303	Flexible AC Transmission Systems		3	3	0	0	20	-	30	50	-
	3	PSY5305	Optimization Techniques for Power Systems		3	3	0	0	20	-	30	50	-
	4	PSY5307	Applied Mathematics		3	3	0	0	20	-	30	50	-
	S.No.	**Course Code**		**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
	1	PSY5201	SEMINAR		**2**	2	0	0	2	-	100	-	-
ec ti ve	2	PSY5203	Nuclear Energy and Power	Elective	2	2	0	0	20	-	30	50	-

	3	PSY5205	Forecasting Techniques in Power Systems		2	2	0	0	20	-	30	50	-
	4	PSY5207	Switched Mode Power Supplies		2	2	0	0	20	-	30	50	-
	5	PSY5209	Nuclear Energy and Power		2	2	0	0	20	-	30	50	-
	S.No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 4	1	PSY5402	Renewable Energy Systems	Elective	4	3	0	2	15	25	20	40	-
	2	PSY5404	High Voltage Engineering		4	3	0	2	15	25	20	40	-
	3	PSY5406	Power Quality		4	3	0	2	15	25	20	40	-
	4	PSY5408	Advanced Digital Signal Processing		4	3	0	2	15	25	20	40	-
	5	PSY5410	HVDC Transmission		4	3	0	2	15	25	20	40	-
	S.No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 5	1	PSY5302	Minor Project	Elective	3	0	0	-	-	40	-	-	60
	2	PSY5304	Intelligent Control Techniques		3	3	0	0	20	-	30	50	-
	3	PSY5306	Analog Filter Design		3	3	0	0	20	-	30	50	-
	4	PSY5308	Dynamics of Synchronous Machines		3	3	0	0	20	-	30	50	-
	5	PSY5310	Smart Grid		3	3	0	0	20		30	50	
	S.No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**

Elective 6	1	PSY5202	Restructured Power Systems	Elective	2	2	0	0	20	-	30	50	-
	2	PSY5204	Power System Planning		2	2	0	0	20	-	30	50	-
	3	PSY5206	Machine learning		2	2	0	0	20	-	30	50	-
	4	PSY5208	PMU and Advanced Metering		2	2	0	0	20	-	30	50	-
		PSY5210	EHV AC Transmission		2	2	0	0	20	-	30	50	
	S.No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 7	1	PSY6401	SCADA & Energy Management	Elective	4	3	0	2	15	25	20	40	-
	2	PSY6403	Computer Aided Power System Analysis		4	3	0	2	15	25	20	40	-
	3	PSY6405	Microcontroller & Embedded Systems		4	3	0	2	15	25	20	40	-
	4	PSY6407	Advanced Electric Drives		4	3	0	2	15	25	20	40	-
	S.No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective 8	1	PSY6301	Power System Reliability	Elective	3	3	0	0	20	-	30	50	-
	2	PSY 6303	Transients in Power Systems		3	3	0	0	20	-	30	50	-
	3	PSY6305	Advanced Distribution Systems		3	3	0	0	20	-	30	50	-
	4	PSY6307	Grid and Sub-Station Planning and Technologies		3	3	0	0	20	-	30	50	-
	5	PSY6309	Modern Electric Traction System		3	3	0	0	20	-	30	50	-

	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 9	1	PSY6201	Energy Auditing and Conservation	Elective	2	2	0	0	20	-	30	50	-
	2	PSY6203	Electricity Market and Regulations		2	2	0	0	20	-	30	50	-
	3	PSY6205	Digital Communication		2	2	0	0	20	-	30	50	-
	4	PSY6207	Energy, Ecology and Environment		2	2	0	0	20	-	30	50	-
	5	PSY6209	Artificial Intelligence		2	2	0	0	20	-	30	50	-

SEMESTER I

Courses

PSY501 Advanced Power System Analysis

Introduction and design considerations of EHV AC systems. Analysis of long transmission lines. Modelling of power system components. Formation of power network matrices. Power Flow studies. N-R method, decoupled and fast decoupled methods. Programming considerations for large systems – sparse matrix techniques. Economic Load Dispatch, Optimal Power Flow, Fault Studies - Symmetrical and unsymmetrical faults using matrix methods. Stability Studies – Transient and dynamic stability analysis of single machine connected to infinite bus and multi-machine systems.

Suggested Reading:

1. Stagg G. & El Abiad, A.H., Computer Methods in Power System Analysis, McGraw Hill.
2. Anderson P.M., Analysis of Faulted Power Systems, IEEE Press.
3. Arrillaga J., Arnold C.P., Computer Modelling of Electrical Power Systems, John Wiley.
4. Wood & Wollenberg, Power Generation, Operation and Control, John Wiley.
5. Elgerd, O.I., Electric Energy Systems Theory, TMH.

PSY503 Advanced Power Electronics

Solid-State Devices: Review of SCR, driving circuits and protection; Modern semiconductor devices and their operating characteristics; Heat sink design.

Phase Controlled Converters: Effect of load and source impedances, effect of free-wheeling diode; Three-phase, fully controlled and half controlled, twelve-pulse converters; Multi-pulse converters; Dual converters, Improved quality converters, power factor improvement techniques, PWM converter.

DC-DC Converters: Buck, Boost and Buck-Boost, Cuk, Fly-back converters; AC-AC Converters: Three-phase ac regulators, operation with resistive load; Single-phase and three-phase cyclo-converters; Matrix converters, output voltage control techniques, commutation methods.

Inverters: Review of three-phase voltage source inverters, voltage and frequency control; Harmonic reduction techniques, PWM inverters, Space Vector Modulation; Multi-level inverters, configurations: Diode clamped, flying capacitor and cascade multi-level inverters, applications; Current source inverter, commutation circuits, transient voltage suppressing techniques; DC link resonant converters, operation and control. Simulation Techniques: MATLAB simulation of power electronic converters.

Suggested Reading:

1. Dubey G. K., Doradla S. R., Joshi A. and Sinha R. M. K., “Thyristorised Power Controllers”, New Age

International Private Limited.
2. Mohan N., Underland T.M. and Robbins W.P., "Power Electronics – Converters, Applications and Design", 3rdEd., Wiley India.
3. Bose B.K., "Power Electronics and Variable Frequency Drives – Technology and Applications", IEEE Press, Standard Publisher Distributors
4. Lander C. W., "Power Electronics", 3rdEd., McGraw-Hill International Book Company
5. Rashid M., "Power Electronics- Circuits, Devices and Applications", 3rdEd., Pearson Education.

PSY5401 Power System Dynamics and Stability

Basis concepts of dynamical systems, Modelling of power system components for stability studies, generator, excitation systems, prime mover controller and associated systems, induction machines and composite loads, transmission lines. Analysis of single machine and multi machine systems. Small signal stability, low frequency oscillations, damping and synchronizing torque analysis, eigenvalue analysis. Power System Stabilizers. SSR and torsional oscillations-analysis and countermeasures.

Suggested Reading:

1. Power System Stability by Kimbark Vol. I&II, III – 1968, Dover Publication Inc, New York 1968.
2. Power System control and stability, P.M. Anderson & A.A. Fouad, Galgotia Publications New Delhi – 110060, 1981, 1st edition.
3. Power System Dynamics Stability and Control by K.R.Padiyar, Second edition B.S.Publications 2002.
4. Power System Analysis by John J.Graniger William D.Stevenson. JR. – Tata McGraw Hill Publications.
5. Kundur, P., "Power System Control and Stability", McGraw Hill.
6. Pai, M.A., and Sauer. P., "Power System Dynamics & Stability", Prentice Hall.

PSY5403 Advanced Control Systems

Modeling of dynamical system in continuous time state space and discrete time state space model, Solution of continuous time state equation, Solution of discrete time state equation. General concept of Controllability and Observability, Controllability test for continuous time and discrete time system, Observability test for continuous time and discrete time system, Stabilizabilty and Detectability definition and tests, loss of Controllability and Observability due to sampling, Controllable and Observable canonical forms. Nonlinear Models, Equilibrium points, Linearization of Nonlinear models, Separable Nonlinearities, Describing function analysis, Phase plane analysis of nonlinear systems, Bang-Bang control system, feedback linearization. Stability concept, stability definition in the sense of Lyapunov, Lyapunov stability theorem, Lyapunov instability theorem, direct method of Lyapunov for continuous time and discrete time systems, Lyapunov function for nonlinear systems. Pole placement technique, Ackerman's approach and Linear quadratic regulator for continuous time and discrete time systems, sliding mode control, H-infinity control, full order and reduced order observer design.

Suggested Reading:

1. J.P. Hespanha, " Linear Systems Theory", Second Edition, Princeton University Press, 2018.
2. Hostetter G. H., Savant, and Stefani, Design of Feedback Control Systems, Oxford University Press ,2001.
3. Kailath Thomas, Linear Systems, Prentice Hall ,1996.
4. Khalil, H., Nonlinear Systems, 3nd Ed., Macmillan, 2002
5. Slotine, J.J., and Li. W.P., Applied Nonlinear Control, Prentice-Hall, 1991.
6. Vidyasagar M., Nonlinear Systems Analysis, Prentice Hall, 2nd Edition ,1992
1.

PSY5405 Modelling of Electrical Machines

Generalized transformations, Physical model, Different reference frame, Primitive machine, dynamic variable, Formulation of dynamic equations of a generalized machine in arbitrary reference frame Analysis of induction machines, Space vector, induction motor modeling in arbitrary reference frame and in field oriented frame, Performance analysis Analysis of synchronous machine, Modeling, Operational impedances, Time constants, torque expression, Asynchronous damping, Steady state and transient performance, Phasor diagram and power angle characteristics, Symmetrical and asymmetrical short circuit analysis, Measurement of reactances and time constants

Suggested Reading:

1. Concordia, Charles, “Synchronous Machines- Theory and Performance”, Wiley, New York. 1989
2. Kimbark E.W., Power System Stability: Synchronous Machines”, Vol.3, Cover Publication, New York. 1976.
3. Adkins B., Harley R.G., “The Generalized Theory of Alternating Current Machines”, Chapman & Hall, London. 1979
4. Leonard W., “Control of Electrical Drives”, 3rd Edition. Springer 2002 Press, New York.
5. Murphy J.M.D., Turnbull F.G., “Power Electronics Control of AC Motors”, Pergamon Press, New York. 1988.

1.

PSY5407 Soft Computing Techniques

Introduction to crisp set and fuzzy sets, Operations on fuzzy sets. Fuzzy relations, fuzzy measures, fuzzy rules, membership functions, rule base, fuzzy models. Introduction to neural network, Learning schemes, supervised, unsupervised learning, incremental and batch training, backpropagation algorithm, the perceptron neural network, multilayer perceptron, radial basis function networks, self-organizing map, recurrent neural network, Elman networks, Jordan networks etc., Neuro-dynamics, applications of neural network. Basic concept of Genetic algorithm and detailed algorithmic steps. Solution of typical control problems using genetic algorithm. Concept of some other search techniques like tabu search and ant-colony search, biography based optimization techniques for solving optimization problems.

Suggested Readings:

1. Jacek M. Zuarda, “Introduction to Artificial Neural Systems, “Jaico Publishing House, 1997.
2. G.J. Klir & T.A. Folger, “Fuzzy sets, uncertainty and information”, First Edition, Prentice-Hall of India, 1988.
3. H.J. Zimmerman, “Fuzzy set theory-and its Applications”, Fourth Edition, Kluwer Academic Publishers, 2001.
4. Driankov, Hellendron, “Introduction to Fuzzy Control”, Second Edition, Narosa Publishers, 1996.

PSY5301 Power System Instrumentation

Measurement of Electrical Quantities: Measurement of voltage, current, phase angle, frequency, active power and reactive power in power plants; Energy meters and multipart tariff meters Voltage and Current Transformers: Voltage transformers for measurement and protection, errors, transient performance; capacitive voltage transformers and their transient behavior; Current transformers for measurement and protection, composite errors, transient response. Hydro Electric Power-Plant Instrumentation: Measurement of flow, level, pressure, temperature, hydraulic head and mechanical vibrations; Temperature scanners; Alarm annunciators. Thermal Power-Plant Instrumentation: Measurement of gas flow; Gas and feed-water analysis; Flame monitoring; Steam turbine instrumentation Nuclear Power-Plant Instrumentation: Reactor safety, neutron flux measurement; Reactor power level and coolant measurements Proactive Relays: Organization of protective relay; Single input, two-input and multi-input relays; Electromagnetic, electronic and digital relays.

Suggested reading:

1. Modern Power Station Practice, Volume F: Control and Instrumentation”, British Electricity International, Peragmon Press,1990.
2. Elliott T. C., “Standard Hand Book of Power Plant Engineering”, McGraw-Hill International Book Company,1989
3. Van A. R. and Warrington C., “Protective Relays- Their Theory and Practice”, Vol. 1, Chapman and Hall Ltd,1968
4. Rao T. S. M., “Power System Protection – Static Relays with Microprocessor Applications”, 2nd Ed., Tata McGraw-Hill Publishing Company Limited, 2008
1.

PSY5303 Flexible AC Transmission Systems

Introduction, principles of reactive power control and transmission line compensation, series and shunt reactive power compensation, concept of Flexible AC Transmission systems (FACTS), Static Var Compensator (SVC), thyristor controlled reactor, thyristor switched capacitor, thyristor controlled series capacitor, static synchronous compensator, static synchronous series compensator, thyristor controlled phase angle regulator and unified power flow controller. Modeling and analysis of SVC, STATCOM, TCSC, SSSC, UPFC and IPFC, use of FACTS controllers in system control and protection. Harmonic and filters, simulation and study of FACTS Controllers under dynamic conditions.

Suggested reading:

1. Miller, T.J.E., “Reactive Power Control in Electric Systems”, John Wiley.
2. Hingorani, N.G., and Gyugyi, L., “Understanding FACTS”, IEEE Press.
3. E. Acha, V.G. Agelidis, “Power Electronic control in Electrical Systems”, Newnes, Butterworth, Elsevier.

PSY5305 Optimization Techniques for Power Systems

Introduction to power system optimization problems and linkages. Optimization basics and solution techniques for convex and nonconvex optimization problems. Static and dynamic optimization techniques. Basic Optimal power flow. Preventive and corrective security constrained optimal power flow, Unit commitment, hydrothermal scheduling, generation, transmission and reactive expansion planning. Optimization with uncertain data, Fuzzy and probabilistic techniques. Generation, transmission and reactive resources planning. Renewable generation integration optimization. Effect of markets and renewable generation in resources planning

Suggested reading:

1. Power generation operation and control, Wood and Woolenberg, WSE
2. Optimization on Power system Operation by Jizhong Zhu Wiley-IEEE Press.
3. S. S. Rao, “Optimization – Theory and Applications”, Wiley Eastern Limited, Second Edition, 1984.
4. Kalyanmoy Deb, “Optimization for Engineering Design – Algorithms and Examples”, Prentice Hall India
5. D.P. Kothari, “Power System Optimization”, TMH

PSY5307 Applied Mathematics

Review of sets, relations and mappings, Boolean algebra, and laws of probability. Bayes theorem. Random variable, Expectation, Moments and covariance. Probability as a set function. Second order random functions, Gaussian random functions. Poisson process, Markov Chain, Auto/cross correlation . Linear vector spaces over a field subspace, bases, dimension and linear transformations. Quadratic forms. Eigen,values using QR transformations, generalized Eigen vectors, canonical forms, singular value decomposition and applications, pseudo inverse. Solution of non linear differential equations. Finite differences and finite element. Calculus of variations. concept of variation and its properties, finite differences and finite elements methods. Euler’s equation, functional dependant on first and higher order derivatives, functional dependants on functions of several independent variables, variation problems with moving boundaries, isoperimetric problems, direct method, Ritz and Kantorovich methods

Suggested reading:

1. Bronson, R., Matrix Operations, Schaum’s outline series, McGraw Hill, New York.
2. Gupta, A.S., Calculus of Variations with Applications, Prentice Hall of India Pvt. Ltd., New Delhi.
3. Taha, H.A., Operations Research: An Introduction, Seventh Edition, Pearson Education Edition, Asia, New Delhi.
4. Ochi, M.K., Applied Probability and Stochastic Processes, John Wiley and sons.

PSY5201 SEMINAR

VlS5203 Nuclear Energy and Power

Introduction to Nuclear Physics, Basics atomic structure, mass energy equivalence, Interaction of radiation with matter, nuclear reactions fission and fusion, Energy released in reactions. Nuclear Power reactors: - Comparison of Nuclear and Fossil fuel. Heat generation and heat removal from the reactor, steam-cycles. Types of Thermal Reactors: Boiling Water, Pressurized water reactors, CANDU, High temperature gas cooled reactor, superheat in water reactor Fast Breeder Reactors. Nuclear power plant layout, Radiation Shielding, Nuclear power station operation, instrumentation and control: Irradiation effects, effects of temperature. Fuel cycles, instability, reactor control, start up and shunt down, reactor safety, reactor power level measurement, safety circuits.

Suggested reading:

1. Ken Kok, "Nuclear Engineering Hand book", Taylor and Francis.
2. N.Sharma, B.Banerjee "Nuclear power in India", Rupa (1 July 2008)
3. P.B. Myerscough, "Modern power Station Practice''
4. Ram, K.S. "Basic Nuclear Engineering", New Age International Pvt. Limited.

PSY5205 Forecasting Techniques in Power Systems

Principles of forecasting load, wind and price. Statistical and non-statistical based approaches. AI application for forecasting. Fundamentals of deregulated power market, Market time lines Forecast based decision time frames Principles of forecasting, Taxonomy of forecasting techniques, univariate/multivariate forecasting, forecasting performance measurement. Statistical forecasting Overview of regression, time series techniques AR, MA, ARMA, ARMAX, ARIMA.

Artificial Intelligence Techniques: fundamentals, mathematical modeling Neural Networks Fuzzy Neural Networks Support Vector Machines Hybrid Techniques Load Forecasting: Key issues and challenges. Data and feature selection, analysis and preprocessing, Price forecasting Key issues and challenges, price spikes and volatility analysis, Data selection, analysis and preprocessing, Feature selection, Modeling Model application and validation, Wind speed/power forecasting, ramp forecasting, Key issues and challenges, Uncertainty quantification of forecasts, Confidence/Prediction Intervals, Future Scope and new challenges in emerging smart grid environment.

Suggested reading:

1. Mohammed Shahidehpour, Hatim Yamin, Zui Li, Market Operations in in Electric Power System: forecasting, scheduling and risk mangement, John Wiley & Sons Ltd, 2002.
2. Rafal Weron, Modelling and Forecasting Electricity Loads and Prices: A statistical approach, John Wiley & Sons Ltd, 2006.

3. G.P. Box and G.M. Jenkins, Time Series Analysis: Forecasting and Control, Holden-Day Inc.
4. S. Makridakis, S.C. Wheelwright, R.J. Hyndman, Forecasting Methods and Applications, Wiley, 1998.
5. Gareth James, Daniela Witten, Trevor Hastie and Robert Tibshirani, "An Introduction to Statistical Learning with Applications in R", Springer, 2013.

PSY5207 Switched Mode Power Supplies

Introduction: Overview of linear voltage regulators, shunt and series regulators. Switching Concepts: Ideal switch, practical switch, switching functions. Switching Circuits: Introduction of switching circuits, harmonic concepts, power computations. Non-Isolated Switch-Mode DC-DC Converters: Buck, Boost, Buck-Boost converters. Isolated Switch-Mode DC-DC Converters: Introduction and types of switch mode dc-dc converters. Soft Switched DC-DC Converters: Series and Parallel resonant circuits, ZCS and ZVS switching topologies. Simulation of Switching Converters. Switching Converter Design: Choke and transformer design; driver circuits, snubber circuits; EMI suppression, Input rectifiers with unity input power factor; Reliability, few case Studies.

Suggested reading:

1. Rashid M. H., "Power Electronics Circuits Devices and Applications", 3rd ed Pearson Education 2008
2. Mohan N., Undeland T.M. and Robbins W.P., "Power Electronics-Converters, Applications and Design", 3rd ed Wiley India 2008
3. Whittington H.W., Aflynn B.W. and Macpherson D.E., "Switch Mode Power Supplies – Design and Construction", John Wiley and Songs. 1997
4. Hart Daniel W., "Introduction to Power Electronics", Prentice Hall International Edition. 1996
5. Luo Fang Lin and Ye Hong, "Advanced DC/DC Converters", CRC Press. 2003

SEMESTER II

PSY502 Advanced Power System Protection

Review of relay characteristics and operating equations with respect to static comparators. CTs, PTs and mixing transformers, effect of CT saturation on relay operation. Basic construction of static relays, input output devices, D.C. supplies and associated elements; time delay circuits. Static comparators: Different types of two input amplitude and phase comparators; theory and operation, effect of offset and remedy. Introduction of multi input comparators and characteristics. Transient over voltages and their suppression; Different type of relays: static, digital and computer aided relaying. Bus bar arrangements; High current bus bars and design consideration. Review of arc formation, properties and characteristics; interruption of current in circuit breakers; high resistance and low resistance theories of interruption; Effect on circuit breaker performance under different conditions in power system operation; Circuit breaker ratings. Study and operation of air blast, SF_6, vacuum and D.C. circuit breakers. Selection and design considerations, Circuit breaker testing methods as per standard.

Suggested Reading:

1. R. van C. Warrington, “Protective Relays Their Theories and Practice”. Volume II, Third Edition, John Wiley & Sons, Inc, New Yark.
2. Ravindranath and M. Chander,“Power System Protection and Switchgear”, First Edition, New Age International (P) Limited
3. Ram And D. N. Vishwakarma, “Power System Protection And Switchgear”, Ninth Reprint, Tata McGraw-Hill Publishing Company
4. R. T. Lythall, “The J&P Switchgear Book”. Seventh Edition, Newnes-Butterworth.
5. Stan Stewart, “Distribution Switchgear”, The Institution of Electrical Engineers, London.
6. Power System Relaying, Stanley H Horowitz and A G Phadke, Willey, 2014.

PSY504 Low power VLSI Design

General characteristics of modern power systems, evolution, structure, power system control, operating states of a power system and control strategies, economic load dispatch, price based unit commitment problem. Concept of reactive power, reactive power flow analysis, active power and frequency control, real power balance and its effect on system frequency; Static VAR systems, types of SVC, fundamental frequency performance of SVC, application of SVC. Automatic generation control (AGC), generation control loops, load frequency control, AGC, AGC with economic dispatch performance measures, large signal, small signal, control and protective functions, ac and dc regulators, design of robust controllers in power systems. Division of power system into control areas, load-frequency control of single area and two area system - optimum control criterion, two area and multi-areas power system with and without integral control, SCADA systems and its applications in power networks, supervisory control, supervisory master stations, remote terminal units, communication links.

Suggested Reading:

1. Elgerd O.I, “Electric Energy System Theory – an Introduction”, Tata McGraw Hill, New Delhi.
2. Kundur. P., “Power System Stability and Control”, EPRI Publications, California
3. Allen J. Wood and Bruce. F. Wollenberg, “Power Generation Operation and Control’, John Wiley & sons, New York.
4. Mahalanabis A.K., Kothari. D.P. and Ahson. S.I., “Computer Aided Power System Analysis and Control”, Tata McGraw Hill publishing Ltd.
5. Vaibhav Donde, M.A. Pai & Ian A. Hiskens – “Simulation & Optimization in an AGC system after deregulation”, IEEE transactions on Power Systems
6. L.K.Kirchmeyer, “Economic Control of Interconnected systems”, Wiley
7. 7. R.N. Dhar, “Computer Aided power system operation and analysis”, TMH

PSY5402 Renweable Energy Systems

Basics of energy, conventional energy sources, renewable energy sources, global and Indian energy scenario, new technologies (hydrogen energy, fuel cells, bio fuels). Solar Energy: Theory of solar cells, solar cell materials, I-V characteristics of solar cell, PV module, PV array, MPPT, PV systems, Stand alone and grid connected PV systems, storage, PV based water pumping, solar

radiation and its measurement, flat plate collectors and their materials, applications and performance, solar thermal power plants, limitations. Wind Energy: site selection, power in the wind, impact of tower height, classification of wind turbine and rotors, wind energy extraction, betz'z limit, wind characteristics, performance and limitations of wind energy conversion systems. Biomass, Small Hydro and geothermal energy. Emerging technologies for power generation: Introduction to tidal energy, wave energy, OTEC, principle of working of various types of fuel cells and their working, performance and limitations, Emergence of hydrogen, cost analysis of hydrogen production, hydrogen storage.

Suggested reading:

1. Duffie and Beckmen, Solar Engineering of Thermal Processes, Wiley Publications, 1991.
2. S. P. Sukhatme, Solar Energy, TMH, India, 2008.
3. John Twiden and Tony Weir, Renewable Energy Resources, BSP Publications, 2006.
4. D. P. Kothari, Rakesh Ranjan, Renewable Energy Sources and Emerging Technologies, PHI, India, 2011.
5. C. S. Solanki, Renewable Energy Technologies, A Practical Guide for Beginners, PHI, India, 2012.
6 G. D. Rai, Non Conventional Energy Resources, Dhanpat Rai, India 2006

PSY5404 High Voltage Engineering

Breakdown in Gases, Breakdown in Uniform field, Townsend's mechanisms, Streamer Theory, Paschen's Law, breakdown in electronegative gases. Breakdown of gases in non-uniform field: effect of space charge, corona for positive and negative polarities. Breakdown phenomena under AC voltage and impulse voltage. Breakdown in Liquids: Classification of liquids, breakdown in pure liquids, breakdown in commercial liquids. Breakdown in Solids: Intrinsic breakdown, electromechanical breakdown, Thermal breakdown, Treeing and tracking, breakdown in Composite Insulators. Generation of high direct voltages: Rectifier circuits, voltage doubler and multiplier circuits, cascade circuits; Cascaded transformers, series resonant circuits; Characteristics of impulse and switching surge voltage, analysis of single stage impulse generator circuit, multi-stage impulse generators, constructional features of multi-stage impulse generators. Generation of Switching surges. High Voltage Testing of Power System Equipments. Over-voltages in Power Systems and Insulation Co-ordination.

Suggested reading:

1. Naidu, M.S. and Kamaraju, V. , "High Voltage Engineering", TMH
2. Wadhwa, C.L., "High Voltage Engineering", Wiley Eastern
3. Westinghouse Transmission & Distribution Reference Book, IBH
4. Kuffel & Zaengl, "High Voltage Engineering", Pergamon Press.

PSY5406 Power Quality

Classification of Power Quality issues, characterization, Power acceptability curves – Power quality problems: Poor load power factor, Non-linear and unbalanced loads, DC offset, Notching, Disturbance, flicker, transients, voltage fluctuations,

sags/swells/unbalance, Power Quality Indices, recommended practices, Influence of Non-Sinusoidal Conditions: Transmission and Distribution, Resonance, Shunt capacitors, Transformers, Inrush currents, Electric Machines, Ground systems. Voltage, Current, Power and Energy measurements, power factor measurement, Analysis in the periodic steady state, Time domain method, Frequency domain methods, IRPT, SRF Theory, instantaneous symmetrical components, Analysis of unbalanced systems, Analysis and reduction of voltage sag, Harmonics & Voltage Fluctuations: Sources and Effects, flicker, impulses, occurrence and causes of voltage unbalance, symmetrical components. Utility- Customer Interface-Harmonic filter, Load compensation and voltage regulation using DSTATCOM, Uninterruptible Power Sources, BESS, DVR, UPQC.

Suggested reading:

1. A. Ghosh and G. Ledwich, "Power Quality Enhancement Using Custom Power Devices", Kluwer Acadamic.
2. G.T. Heydt. "Electric Power Quality", Stars in a Circle Publications (2nd Edition).
3. J. Arrillaga, N.R. Watson, S. Chen, Power System Quality Assessment, John Wiley & sons, New York.
4. Math H.J. Bollen, Understanding Power quality problems, IEEE Press, New York.
5. E. Acha, Manuel Madrigal, Power system Harmonics, John Wiley & sons, New York.
6. Moreno – Murioz (Ed), Power Quality (Mitigation Technologies in Distribution Environment Springer, 07.
7. Bhim Singh, Ambrish Chandra, Kamal Al-Haddad,"Power Quality Problems and Mitigation Techniques", John Wiley & Sons Ltd. 2015.

PSY5408 Digital Signal Processing

Discrete Time Signals and Systems: Representation of discrete time signals- classifications-Discrete time systems, Discrete Fourier transform properties. Fast Fourier transform- Z- transform, structure realization, direct form- lattice structure for FIR filter- Lattice structure for IIR Filter. Design of Filters: FIR Filter- windowing technique- optimum equiripple linear phase FIR filter- IIR filter- Bilinear transformation technique- impulse invariance method- Butterworth filter- Tchebyshev filter. Multistage representation: Sampling of band pass signal- antialiasing filter – Decimation by an integer factor- interpolation by an integer factor- sampling rate conversion – implementation of digital filter banks- sub-band coding- Quadrature mirror filter Digital Signal Processors, Fundamentals of fixed and floating point DSP architecture.

Suggested Readings:

1. John G.Proakis, Dimitris G. Manolakis, "Digital Signal Processing: Principles, Algorthms and Applications", PHI.
2. S. Salivahanan, A. Vallavaraj and C. Gnanapriya "Digital Signal Processing" TMH.
3. A.V. Oppenheim and R.W. Schafer, Englewood "Digital Signal Processing", Prentice-Hall, Inc.
4. Rabiner and Gold, "Theory and Application of Digital Signal Processing",

5. B. Venkatramani & M. Bhaskar, "Digital Signal Processors architecture, programming and applications", TMH.

PSY5410 High Voltage DC Transmission

DC power transmission technology introduction-comparison of ac and dc transmission –application of dc transmission-description of dc transmission system, planning for hvdc transmission-modern trends in dc transmission analysis of hvdc converter pulse number, choice of converter configuration-simplified analysis of graetz circuit-converter bridge characteristics, characteristics of twelve pulse converter –detailed analysis of converters.converter and hvdc system control.general principles of dc link control-converter control characteristics-system control hierarchy –firing angle control-current and extinction angle control-starting and stopping of dc link power control –higher level controllers-telecommunication requirements.harmonics and filters. introduction-generation of harmonics-design of ac filters-dc filters-carrier frequency and ri noise. simulations of hvdc systems introduction – system simulation: philosophy and tools-hvdc system simulation-modeling of hvdc systems for digital dynamic simulation.

Suggested reading:

1. Padiyar, K.R. "HVDC power transmission systems", Wiley Eastern Limited, New Delhi 1990. First edition.
2. Edward Wilson Kimbark, "Direct Current Transmission", Vol. I, Wiley Interscience, New York, London, Sydney,1971.
3. Rakosh Das Begamudre, Extra high Voltage AC transmission Engineering" New Age International (P) Ltd. New Delhi, 1990
4. Arrillaga, J., "High Voltage Direct Current Transmission", Peter Peregrinus, London,1983.

PSY 5302 Minor Project

PSY5304 Intelligent Control Techniques

Fuzzy Logic Systems: Fuzzy sets, operations on fuzzy sets, fuzzy relations, operations on fuzzy relation, linguistic variables, fuzzy if-then rules, compositional rule of inference, fuzzy reasoning. Fuzzy Logic Control: Basic concept of fuzzy logic control, reasoning with an FLC, relationship to PI, PD and PID control, design of FLC:determination of linguistic values, construction of knowledge base, inference engine, tuning, fuzzification and defuzzification, Mamdani type models, Takagi-Sugeno-Kang (TSK) fuzzy models Artificial Neural Networks: Perceptron, perceptron training rule, gradient descent rule, multilayer networks and backpropagation algorithm, convergence and local minima, regularization methods, radial basis function networks, alternative error minimization procedures, unsupervised networks. Neural Networks for feedback Control, Neural Network Reinforcement Learning Controller, Adaptive Reinforcement Learning Using Fuzzy Logic Critic, Optimal Control Using NN Hybrid algorithms, ANFIS and extreme- ANFIS, derivative free optimization methods, genetic algorithm, particle swarm optimization, Solution of typical control problems derivative free optimization.

Suggested reading:

1. Christopher M. Bishop, "Neural Networks for Pattern Recognition", Oxford University Press New York 1995
2. S. Haykin, "Neural Networks and Learning Machines" (3rd Edition), Prentice Hall 2009
3. Driankov, Hellendoorn, Reinfrank, "An Introduction to Fuzzy Control", Narosa Publishing House 1993
4. Timothy J. Ross., "Fuzzy Logic with Engineering Applications", 3rd edition John Wiley and Sons 2011
5. SR Jang, CT Sun, E Mizutani "Neuro-fuzzy and soft computing: a computational approach to learning and machine intelligence", Prentice-Hall of India 2004

PSY5306 Analog Filter Design

Introduction to modern active building blocks used in Analog Filters: Current Conveyors, Operational Transconductance Amplifiers, Current Feedback Amplifiers, OTRAS, CDBAS and other modern devices. First order filters: Realization with passive elements, realization with active elements, cascaded design Second order LP and BP filters: Design parameters, the 2nd order circuits, KHN, Biquads, S & K Biquads, SAB biquads and GIC circuits. LP filters with maximally flat and equal ripple response, inverse Chebyshev and Cauer filter. Frequency transformation: LP-HP, LP-BP, LP-BE, etc. LC, Ladder filters, Ladder Simulation by element replacement, GIC embedding technique, FDNR technique, creation of negative components, G_m-C & switched capacitor filters, sensitivity considerations.

Suggested Readings:

1. R. Schaumann & M.E. Vanvalkenburg, "Design of Analog Filters", First Edition, Oxford, 2001.

PSY5308 Dynamics of Synchronous Machines

Synchronous Machines Dynamics: Causes of Disturbances, Electromechanical equations, Operation as generator and motor, linearized analysis, Cyclic Variation of shaft torque, Large Angular oscillations, Equal area criterion, Hunting in Synchronous Machines Synchronous Machine Modelling: Mathematical Description of a Synchronous Machine: Basic equations of a Synchronous Machine: stator circuit equations, stator self, stator mutual and stator to rotor mutual inductances, dqo-Transformation: flux linkage and voltage equations for stator and rotor in dqo-coordinates, electrical power and torque, physical interpretation of dqo -transformation, Per Unit Representation: L_{ad} reciprocal per unit system and power – invariant form of Park's transformation; Equivalent circuit, computation of steady-state values, Swing equation, H- constant and D constant calculation, Representation in system studies, Synchronous Machine Representation in Stability studies; Simplified model and two-axis model with amortisseur windings neglected. Dynamic performance - three phase fault, transient stability limit, critical clearing time, computer simulation.

Suggested reading:

1. Paul C. Krause, Oleg Wasynczuk, Scott D. Sudhoff, "Analysis of Electric Machinery and Drive Systems", IEEE Press, Second Edition.
2. Samuel Seely, "Electromechanical Energy Conversion: Electric Machinery", TataMcGraw Hill, 5th Edition.
3. L.P. Singh, "Advanced power System Analysis and Dynamics", Wiley Eastern Limited

PSY5310 Smart Grid

Introduction: Structure and Fundamental Problems of Electrical Power Systems, Principles of Electrical Power Control, Power Flow Control, Distributed Generation and Energy Storage, Benefits to Grids, Damping of System Oscillations, Power Quality Control, Fully Integrated Power System-Smart Grid, Smart Electrical Energy Networks Concept-Microgrids & Picogrids. Microgrid configuration and interconnection, Technical advantages and challenges of Microgrid. Distribution system and operational issues

of Microgrid, power quality, Ride through, Grid synchronization. Network management needs of Microgrid, Microsource generation control, Domestic process control, Energy storage, Regulation and load shifting, Microsource controller, Decentralized Operation, Protection co-ordination, Grid Synchronization. PWM Rectifiers, Multilevel Converters, Neutral point Clamped VSC, space vector PWM, Z-source converters, Three level and Four wire inverters with z source, Grid-imposed Frequency VSC system control , D-STATCOM, SSSC, UPFC, Back to Back HVDC Conversion Systems, Bricks-Buses-Software (BBS). SCADA and control of DNO SCADA systems (Centralised & Distributed).

Suggested reading:

1. Mini S. Thomas, John Douglas McDonald, "Power System SCADA and Smart Grids", CRC Press 2015.
2. S. Chowdhary, S. P. Chowdhury and P. Crossley, "Microgrids and Active Distribution Network", IET, 2009
3. R. Strzelecki, G. Benesek, "Power Electronics in Smart Electrical Energy Networks", Springer, 2008
4. Amirnaser Yazdani & Reza Iravani, "Voltage Sourced Converters in Power Systems: Modeling, Control, and Applications", IEEE Press, 2010.
5. Nick Jenkins et al., "Embedded Generation", IET, 2000.

PSY5202 Restructured Power Systems

Market Models, Key issues in regulated and deregulated power markets; Market equilibrium- Market clearing price- Electricity markets around the world. Perceptrons Operational and planning activities of a Genco - Electricity Pricing and Forecasting -Price Based Unit Commitment Design - Security Constrained Unit Commitment design. - Ancillary Services for Restructuring- Automatic Generation Control (AGC). Introduction-Components of restructured system-Transmission pricing in Open-access system-Open transmission system operation; Congestion management in Open-access transmission systems- FACTS in congestion management – Open-access Coordination Strategies; Power Wheeling-Transmission Cost Allocation Methods Open Access Distribution - Changes in Distribution Operations- The Development of Competition –Maintaining Distribution Planning Power Market Development – Electricity Act, 2003, Developing power exchanges suited to the Indian market – use of IT in power- Competition- Indian power market- Indian energy exchange- Indian power exchange- Infrastructure model for power exchanges- Congestion Management-Day Ahead Market- Online power trading.

Suggested reading:

1. Loi Lei Lai, 'Power System Restructuring and Deregulation', John Wiley & Sons Ltd., 2001.
2. Mohammad Shahidehpour, Hatim Yamin, "Market operations in Electric power systems", John Wiley & son ltd., 2002
3. Lorrin Philipson, H. Lee Willis, 'Understanding Electric Utilities and Deregulation' Taylor & Francis, 2006.
4. Mohammad Shahidehpour, Muwaffaq Alomoush, 'Restructured Electrical Power Systems', Marcel Dekker, Inc., 2001.

PSY5204 Power System Planning

Introduction-Power system planning, power system development and growth, power sources, planning tools. Electricity regulations. Electricity Forecasting. Generation Planning. Transmission and distribution network planning. New operation and planning policies. Allocation of reserve. Demand side bidding. Pricing schemes. Competitive electricity markets. Environment effects. Technology and Innovation (Modern Trends).

Suggested reading:

1. Sullivan-"Power System Planning"., McGraw Hill.
2. Pabla, A.S., "Electric Power System Planning", Macmillan, India.

PSY5206 Machine Learning

Introduction to Machine Learning, Unsupervised, Supervised, Reinforcement, Hybrid models. Decision Boundaries: crisp, and non-crisp, optimisation problems. Unsupervised Learning: K-Means, Gaussian Mixture Models, EM. ML-Estimation: the simple case of one 1-D Gaussian, to the general case of K D-dimensional Gaussians. Eigen Analysis: PCA, LDA and Subspaces. Linear Models for Regression, Classification. The basic SVM optimisation: the primal and the dual problems

Suggested reading:

1. C. M. Bishop. "Pattern Recognition and Machine Learning". First Edition. Springer, 2006. (Second Indian Reprint, 2015).
2. P. Flach. "Machine Learning: The Art and Science of Algorithms that Make Sense of Data". First Edition, Cambridge University Press, 2012.
3. S. J. Russell, P. Norvig." Artificial Intelligence: A Modern Approach." Third Edition, Prentice-Hall, 2010.
4. Y. S. Abu-Mostafa, M. Magdon-Ismail, H.-T. Lin. "Learning from Data: A Short Course." First Edition, 2012.

PSY5208 PMU and Advanced Metering

Synchrophasor technology; Time-synchronized concepts and measurements, synchrophasor application in power system; Global Positioning System (GPS); PMU and it's principle of operation; PMU specifications, selection of locations; Phasor Data Concentrator (PDC); Wide Area Measurement system(WAMS) and monitoring concepts; State estimation (SE) and visulization of state estimators; PMUs for rotor angle stability, voltage stability, fault assessments and oscillation monitoring. Advanced metering infrastructure (AMI) and benefits, AMI System requirements and key components; Automated meter reading (AMR) network topology; TOD metering, Net Metering, Head-end-system; Differences between AMI and AMR; Wireless and wired communications (viz.PLCC,RF, WiFi, Optical fibre communication); Walk-by, drive-by and fixed network methods for data collection, communication flows; communication latency; advanced SCADA.

Suggested Readings:

1. Synchronized Phasor Measurements and Their Applications by Arun G Phadke, James S Thorp, Springer, 2017.
2. Power System Grid Operation Using Synchrophasor Technology, Edited by Nuthalapati, Sarma, Springer, 2019
3. Phasor Measurement Units and Wide Area Monitoring Systems by Antonello Monti , Carlo Muscas, Ferdinanda Ponci , Kindle Edition.
4. PMU Placement in Power System Network: A case Study by Ashish Mishra, Publisher: Lambert, May 2017
5. Power System Stability and Control by P. Kundur, McGraw-Hill, New York, 1994.
6. Application of Time-Synchronized Measurements in Power System Transmission Networks by Mladen Kezunovic, Sakis Meliopoulos, Vaiyhianatham Venkatsubramanian,Vijay Mittal, Springer, 2014.
7. Advanced Metering Infrastructure (AMI) by Gerardus Blokdyk , Third Edition, Nov 2018, Publisher: 5starcooks.
8. The 2018-2023 World Outlook for Advanced Metering Infrastructure (AMI) by Icon Group International, Publisher: ICON Group International, Inc.,December, 2017.

PSY5210 EHV AC Power Transmission

INTRODUCTION Standard transmission Voltages- average values of line parameters- Power handling capacity and line loss, Costs of transmission lines and equipment, Mechanical consideration in line performances. CORONA EFFECTS- Power losses and audible noise, I^2R losses and corona loss, Attenuation of travelling waves due to corona loss, Audible noise generation and characteristics, limits of audible noise, Day Night equivalent noise level, Radio Interference, corona pulse generation and properties, Limits for Radio Interference Fields, CIGRE formula, RI excitation function, Measurement of RI, RIV and excitation function, Design of Filter. ELECTROSTATIC FIELD OF EHV LINES – Capacitance of long object, calculations of electrostatic field of AC lines, effect of high electrostatic field on humans, animals and plants, Measurement of electrostatic field, electrostatic induction in unenergised circuit of DC line, Induced voltages in Insulated ground wires, electromagnetic interference. COMPENSATION OF EHV LINES- Series and shunt compensation, problems due to series compensation, Sub-synchronous resonance and remedial measures.

Suggested reading:

1. Begamudre, R.D., EHVAC Transmission Engineering, New Age .
2. Padiyar, K.R., HVDC Power Transmission Systems, Wiley Eastern Ltd.
3. Kimbark, E.W., Direct Current Transmission, John Wiley, U.S.A.
4. Power Engineer's Handbook, Revised and Enlarged 6th Edition TNEB Engineer's Association, October 2002.

SEMESTER III

PSY6401 SCADA and Energy Management Systems

Concept of Supervisory control & Data Acquisition System, Component and types of SCADA systems, CT, PT, Voltage to current, current to voltage converters, RTUs etc. Supervisory and control functions, man-machine communication, operator console, VDU display and its use, operator dialogues, mimic diagram functions, printing facilities etc. SCADA system structures, system classes, system interactions, performance criteria, software and hardware considerations, data bases, reliability and simulations, technical realizations, local system, communication system, central system, control system supervision & system maintenance. Application functions-real time network modeling, security management, production control and training simulators.

Introduction to communication systems, Hotline, PLCC, Mobile, Satellite, Microwave & Optical fibre communications. Transputerised SCADA system, SCADA on embedded FPGA.

Suggested Reading:

1. Krishana Kant, "Computer-based Industrial Control", PHI Publication.
2. Liptak, "Process Control", CRC Publication.
3. Madiseth & Williams, "Digital Signal Processing", CRC Press, IEEE Press.
4. Kissel, "Industrial Electronics", PHI Publication.
5. Mini S. Thomas, John Douglas McDonald, "Power System SCADA and Smart Grids", CRC Press 2015.

PSY6403 Computer Aided Power System Analysis

Sparsity Techniques: Storage of sparse matrix, Sparsity directed inversion methods and parallel inversions.

Load Flow with HVDC Link: Balanced AC load flow, DC system model, incorporation of control equations, inverter operation, unified and sequential solution techniques.

Three-phase Load Flow: load flow equations, solution techniques- Gauss-Seidal, Newton Raphson methods and fast decoupled method; Three-phase AC-DC load flow Short Circuit Studies for Unbalanced Network: Z-bus building algorithm; Derivation of fault admittance matrices, three-phase model of transmission lines- series and shunt impedance, mutually coupled three-phase lines, transformer modeling, sequence components, analysis of unbalance faults, open circuit fault, three-phase model of sysnchronous machine.

Sstate estimation and bad data processing: State estimation of linear and nonlinear systems, Pseudo-measurements, recursive and weighted least square estimation method, detection and identification of bad measurements, network observability.

Reactive power allocation and scheduling: sources of reactive power reactive power capability curve FACT devices modeling of reactive power allocation problem solution techniques.

Suggested reading:

1. Abur A. and Exposito A. G., Power System State Estimation: Theory & Implementation, Marcel Dekkar 2004.

2. Arrillaga J. and Watson N.R., " Computer Modelling of Electrical Power Systems, John Wiley & Sons 2003.
3. Wood A. J. and Wollenberg B.F., " Power Generation, Operation and Control, John Wiley & Sons.

PSY6405 Microcontroller and Embedded Systems

Organization of a microprocessor, register organization, C.P.U., Description of timing and control units, interfacing memory & I/O devices, Synchronous & Asynchronous data transfer, Interrupts, Polling, DMA, Introduction to Pentium and Pro-Pentium microprocessors. Basic organization of 8051, 8097, PIC, SLK-51 microcontrollers, instruction set - timing diagram, address modes, simple program and applications.

Embedded system and their components, categories of embedded systems. Stand alone, Real time Networked and Mobile etc., Requirements of embedded systems. Reliability, cost effectiveness, low power consumption, efficient use of processing power, efficient use of memory, approximate execution time, challenges and issues in embedded software development. Co design operating system, efficient I/O testing and debugging.

Hardware Architecture for embedded systems, Embedded Applications.

Suggested reading:

1. John B. Peatman, "Design with Microcontrollers", McGraw Hill International Ltd, Singapore, 1989.
2. Intel manual on 16 bit embedded controllers, Santa Clara, 1991.
3. Myko Predko. 'Programming and customizing the 8051 micro controller', Tata McGraw Hill, 1999.
4. Muhammad Ali Mazidi, Janice Gillispie Mazidi. 'The 8051 Microcontroller and Embedded systems', Pearson Education, 2004.
5. Michael Slater, "Microprocessor based design: A Comprehensive guide to effective hardware design", Prentice Hall, New Jersey, 1989
6. John B. Peatman, "Design with PIC Microcontrollers", Pearson Education Asia 2004

PSY6407 Advanced Electric Drives

Review: Power electronic converters for ac drive control, voltage source and current source inverters LCI-IM Drive: Drive configuration, commutation at different speeds, mathematical modeling, control structure, resonance problem and performance. FOC-IM Drive: Drive configuration, mathematical modeling, direct and indirect FOC, influence of parameters, VSI and CSI fed schemes, adaptive drive control Brushless DC Drive: Self control, CSI with load commutation, low speed commutation, inverter control strategies and performance Permanent Magnet SM Drive: Principle of operation, converter configuration, synchronization, trapezoidal and sinusoidal drive control structures and performance. Switched Reluctance Motor Drive: Principle of operation, converter circuits, sensors, speed control and performance. Resonant-Link Converter fed Drive: Principle of soft switching in inverters and converters utilizing resonant circuits, modulation strategies and application in IM drives Advanced Control Techniques: Application of modern and evolutionary techniques in drives such as fuzzy and ANN control.

Suggested reading:

1. Dubey G. K., “Fundamentals of Electric Drives”, 2nd Ed., Narosa 2007 Publishing House.
2. Pillai S. K., “A First Course in Electric Drives”, 2nd Ed., New Age 2008 International Private Limited.
3. Mohan N., Undeland T.M. and Robbins W.P., "Power ElectronicsConverters, Applications and Design", 3rd 2008 Ed., Wiley India
4. Dubey G. K., "Power Semiconductor Controlled Drives", PrenticeHall International Editions. 2001
5. Murphy J. M. D. and Turnbull F. G., “Power Electronics Control of AC Motors”, Pregamon Press. 1990
6. Bose B. K., "Power Electronics and Variable Frequency Drives", IEEE Press, Standard Publisher Distributors. 2001
7. Krishnan R., “Electric Motor Drives – Modeling, Analysis and Control”, Prentice Hall of India Private Limited. 2007

PSY6301 Power System Reliability

Basic probability theory, review of concepts, probability distributions. Markov processes, State Transition Matrix and state Transition Diagram. Definition of Reliability, general reliability function, evaluation of reliability using state enumeration. Tie set and cut set method. Reliability indices from state transition matrix and state transition diagrams. Models for generation system reliability evaluation, loss of load indices, loss of energy indices, frequency and duration methods. Reliability evaluation of two area interconnected system. Conditional probability approach for reliability evaluation of a generation-transmission system. Transmission system reliability evaluation using average interruption rate method and frequency and duration methods. Evaluation of interruption indices for radial distribution systems. Introduction to protective system reliability evaluation.

Suggested reading:

1. Billington, Ringley & Wood, “Power System Reliability Calculation”, MIT Press.
2. Endeerny, J, “Reliability Modelling in Power System”, John Wiley, NY.

PSY6303 Transients in Power System

Origin and nature of transients and surges. Fundamental concepts of RLC circuit analysis, application of Laplace transform, Simple switching transients, Effect of resistance on LC circuit transients, Abnormal switching transients, Transients in three-phase circuits, Travelling waves on transmission lines, Lightening, Insulation coordination, Overvoltage protection, substation equipment, Lumped and distributed circuit representations. Line energization and de-energization transients, current chopping, short-line faults, trapped charge effects, effect of source, control of transients, Lightening, effect of tower footing resistance, travelling waves, insulation coordination, circuit breakers duty, surge arresters, overvoltage limiting devices, Case studies.

Suggested reading:

1. Allan Greenwood, Electrical Transients in Power Systems, Wiley-Blackwell; 2nd Edition, 1991.
2. Pritindra Chowdhuri, Electromagnetic Transients in Power Systems (High-Voltage Power Transmission), 2nd edition, PHI Learning

PSY6305 Advanced Distribution Systems

Introduction to distribution systems. Nature of load and load modeling, 3 phase transformer modeling Distribution system load flow for balanced and unbalanced system radial and weakly meshed systems (with and without PV buses) Short circuit analysis of distribution systems

State estimation of distribution systems Basics of distribution system reliability Voltage regulation in distribution systems Distribution system protection issues Distributed generation integration issues in distribution system

Suggested reading:

1. Kersting W. H, "Distribution system modeling and analysis", CRC press,New York, 2002
2. Brown R. E., "Electric power distribution reliability (second edition)", CRC press, New York, 2009
3. Northcote-Green J. and Willson R., "Control and automation of electric power distribution systems", CRC press, New York, 2007
4. Chowdhury A. A. and Koval D. O., "Power distribution system reliability practical methods and applications", Wiley IEEE press, 2009

PSY6307 Grid and Sub-Station Planning and Technologies

Transmission Planning and security criteria; Load-generation balancing; Transmission network expansion and selection of EHVAC and HVDC Voltages; SIL, thermal loading and stability constraints; Overhead transmission line routes and Right of-ways; EHV cables and overhead conductor technologies; Series and shunt reactive power compensation/planning; Inter-area/region transmission planning; Grid connectivity planning for RESs; Transmission planning studies (Load flow ,short circuit, stability)

AIS, GIS, Hybrid sub-stations of medium to high AC Voltages, Generation Switchyard, HVDC switchyard, sub-station layouts, sub-stations capacity and design principle, Busbar topologies, CT, PT,CVT, Lightning Arrestor, Circuit Breakers, Bus bar protection, short-circuit levels and its limitations, Earth Mat, Bus splitting/sectionalization, Fault current limiters, Bay width and clearances, Static and dynamic reactive power compensation, Filters and land requirements.

Suggested reading:

1. Power System Stability and Control by P. Kundur, McGraw-Hill, New York, 1994.
2. Understanding FACTS by Narain G. Hingorani and Laszlo Gyugyi, IEEE Press,Standard Publishers.
3. Power system voltage stability by Carson W. Taylor, McGRAW-HILL,Inc.
4. Modern Power system Analysis by D P Kothari and I J Nagrath.
5. An introduction to Reactive Power control and Voltage stability in Power Transmission System by
6. Fundamentals of Modern Electrical Substations (Kindle Edition) by Boris Shvartsberg
7. Short Circuit Currents in three-phase Systems by Richard Roeper,Wiley Eastern Ltd.
8. International Council on large Electric Systems (CIGRE) Study committee B3: Substations, CIGRE Green Book, Editors Terry Kreig & John Finn, Springer,2019.
9. Electric Power Substations Engineering,3rd Edition, Edited by John D. McDonald, CRC Press.

PSY6309 Modern Electric Traction System

Introduction to Railway Traction Systems Choice of traction system. General arrangement of D.C.traction system, A.C.single phase, 3phase systems, Composite systems Mechanics of Train Movement Analysis of speed time curves for main line, suburban and urban services, Simplified speed time curves., Traction Motors and Their Control Features of traction motors, Significance of D.C. series motor as traction motor, A. C. Traction motors-single phase, Three phase, Linear Induction Motor, Types of electric braking system. Important features of electric locomotives, Different types of locomotives, Current collecting equipment, Power conversion and transmission systems, Control and auxiliary equipment. Feeding and Distribution System. Distribution systems pertaining to traction (distributions and feeders), Traction sub-station requirements and selection, Method of feeding the traction sub- station Latest Trends in Traction system Present scenario– High speed traction, Metro, Latest trends in traction-Metro, monorail, Magnetic levitation Vehicle.

Suggested reading:

1. Modern Electric Traction, H. Partab, Dhanpat Rai and Sons, New Delhi
2. Electric Traction, A.T. Dover, Mac millan, Dhanpat Rai and Sons, New Delhi
3. Electric Traction Hand Book, R. B. Brooks Sir Isaac Pitman and sons ltd. London
4. Electromagnetic Compatibility in Railways Analysis and Management, Ogunsola

PSY6201 Energy Auditing and Conservation

Introduction to energy audit, energy management approach, understanding energy cost bench marking, energy performance matching energy usage to requirement maximizing system efficiency optimizing the input energy requirement fuel and energy substitution. Energy management and conservation in domestic sector. Energy management in small, medium and large HT

industries. Demand and Supply side management. Energy Audit, Energy Audit measuring tools. Distribution system and Transmission system planning with respect to loss reduction. Energy saving opportunities in electric motors benefits of power factor improvement and its techniques effect of harmonic on motors and remedies leading to energy conservation methods and techniques of energy conservation in ventilation and air conditioners electric furnace oven and boilers lighting welding and traction.

Suggested reading:

1. Steven R Patrick Dale R Patrick Stephen W Fardo " Energy conservation guidebook" The Fairmont Press, Inc 1993
2. S C Tripathy "Electric Energy Utilization and Conservation" Tata Mcgarw Hill india 1991.
3. IEEE Bronze book IEEE standard 739-1995-IEEE recommended practice for energy management in industrial and commercial facilities.1996
4. Books of energy management and auditors bureau of energy efficiency, http://beeindia.in/volume1,2,3& 4
5. Sunil S Rao " Utilization generation and conservation of electrical energy" Khanna publishers India 2011

PSY6203 Electricity Market and Regulation

Electricity Market Structure, Power Exchanges and its working principle for power trading, Power traders, electricity market clearing methodology, Power Purchase Agreements, Electricity pricing and trading, Demand side Management, Load frequency control, Long term- medium- short term open access in transmission, Grid connectivity, Bilateral contracts, Intraday, day ahead and spot market, Spot and day energy accounting, , Ancillary Services, Electricity Market Operators and Regulators, Regulations of electricity Utilities, T&D loss optimization, Integrating must run generation from RESs.

Suggested reading:

1. Fundamentals of Power System Economics by Daniel Kirschen & Goron Strbac, John Wiley & Sons, Ltd
2. Operation of Restructured Power Systems by Kankar Bhattaccharya, Math H. J.Bollen & Jaap E. Daalder, Kluwer Academic Publishers.
3. Compendium of Regulations, Central Electricity Regulatory Commission, New Delhi.

PSY6205 Digital Communication

Review of random variables and random process, signal space concepts, Common modulated signals and their power spectral densities, Optimum receivers for Gaussian channels, Coherent and non-coherent receivers and their performance (evaluating BER performance through software tools), Basics of Information theory, source and channel coding, capacity of channels, band-limited channels and ISI, multicarrier and spread spectrum signalling, multiple access techniques

Suggested reading:

1. John G Proakis and Salehi, Digital Communication, Fifth Edition, McGraw-Hill, 2007.
2. 2. John R. Barry, Edward A. Lee, David G. Messerschmitt, Digital Communications, Springer, third edition, 2004

PSY6207 Energy Ecology and Environment

Environment definition, Environmental Segments, Fundamentals of Ecology and Ecosystem, Components of ecosystem, Food chain, Food web, Trophic level, Energy flow. Introduction, types, characteristic features, structure and function of the following ecosystem: Forest, Grassland, Desert and Aquatic ecosystem. Effects of human activities on environment: Agriculture, Housing, Industry, Mining and Transportation activities, Basics of Environmental Impact Assessment & Sustainable Development.
Water Resources - Availability and Quality aspects. Mineral Resources, Soil, Material cycles- Carbon, Nitrogen and Sulphur Cycles. Energy - Different types of energy, Conventional and Non-Conventional Sources.
Gas Hydrates, Hydrogen as an alternative future source of Energy. Definition causes effects and control measures of: Air Pollution, Water pollution, Land pollution, Noise pollution. Climate Change and Global warming: Effects, Acid Rain, Ozone Layer depletion, Photochemical Smog, Solid waste management, Waste water treatment. Ambient air quality standards, Water quality parameters and standards.

Suggested Readings:

1. James Girard 'Principles of Environmental Chemistry', Jones & Bartlett Learning, 2005
2. Benny Joseph 'Environmental Studies', Tata McgrawHill, 2005.
3. A K De 'Environmental Chemistry' New Age International Publishers, 2005.
4. D.D. Mishra, S.S. Dara 'A Textbook of Environmental Chemistry and Pollution Control (With Energy, Ecology, Ethics and Society)', S. Chand and Co, 2004.
5. Samir K. Banerjee 'Environmental Chemistry' Prentice Hall of India, 2009.
6. P. Venugoplan Rao 'Principles of Environmental Science and Engineering' Prentice Hall of India, 2006.
7. D.L. Manjunath 'Environmental Studies' Pearson Education, 2006.

PSY6209 Artificial Intelligence

Introduction, philosophy of intelligent agents; uninformed search; heuristic search; local search; constraint satisfaction; logic and satisfiability; adversarial search; classical planning; decision theory; Markov decision processes; Bayesian networks representation, inference and learning; reinforcement learning; basics of supervised, semi-supervised and unsupervised learning; intro to NLP; intro to information retrieval; submodularity; current research trends.

Suggested Readings:

1. Stuart Russell & Peter Norvig, "Artificial Intelligence: A Modern Approach", Prentice-Hall, Third Edition (2009)
2. C. M. Bishop, "Neural Networks for Pattern Recognition" Oxford University Press 1995.
3. T . Dean, J. Allen, & Y. Aloimonos, "Artificial Intelligence theory and practice.", Benjamin Cummings, 1995.