DEPARTMENT OF ELECTRICAL ENGINEERING

Scheme of Instruction
and
Syllabi of

Ph.D. (ELECTRICAL ENGINEERING)

(Full Time & Part Time)

2025- 2026

UNIVERSITY COLLEGE OF ENGINEERING

(AUTONOMOUS)

OSMANIA UNIVERSITY

HYDERABAD – 500 007, TELANGANA

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SCHEME OF INSTRUCTION AND EVALUATION

Ph.D. ELECTRICAL ENGINEERING

S. No.	Course Code	Course Name
1	PHD5001EE	Research Methodology in Electrical Engineering
2	PHD5002EE	Power Electronic Converters for Renewable Energy
3	PHD5003EE	Advanced Computer Methods in Power Systems
4	PHD5004EE	Advanced Topics in Power Electronics
5	PHD5005EE	Hybrid Electric Vehicles
6	PHD5006EE	Power Electronic Applications to Power Systems
7	PHD5007EE	Real Time Applications in Power Systems
8	PHD5008EE	Smart Grid Technologies
9	PHD5009EE	Power System Stability

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Course Code	Course Title					
	RESEARCH METHODOLOGY IN ELECTRICAL ENGINEERING					
PHD5001EE			**L**	**T**	**P**	**C**
Pre-requisites			**3**	**-**	**-**	**3**
Evaluation	**SEE**	**100 Marks**	**CIE**		**-**	

Course Objectives

- To learn the research types, methodology and formulation.
- To know the sources of literature, survey, review and quality journals.
- To understand the research design for collection of research data.
- To understand the research data analysis, writing of research report and grant proposal.

Course Outcomes:

After the completion of this course, students shall be able to:

1. Know the importance of research, the method and the methodology adopted.
2. Do a proper research design for a given research topic.
3. Do the literature survey and the review.
4. Analyze and solve the statistical methods used for the research.
5. Write technical report, research proposals.

Course Articulation Matrix:

Course outcome	Programme outcome					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	-	-	-	2
CO2	3	3	-	-	-	2
CO3	3	3	-	-	-	2
CO4	3	3	-	-	-	2
CO5	3	3	-	-	-	2

UNIT - I

Research Methodology: Objectives and Motivation of Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Importance of Research Methodology, Research Process, Criteria of Good Research, Problems Encountered by Researchers in India, Benefits to the society in general.

Defining the Research Problem: Definition of Research Problem, Problem Formulation, Necessity of Defining the Problem, Techniques involved in Defining a Problem.

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UNIT - II

Literature Review: Importance of Literature Survey, Sources of Information, Assessment of Quality of Journals and Articles, Information through Internet, Need of Review, Guidelines for Review, Record of Research Review. A review of the smart grid concept for electrical power system, Multilevel Inverters for High Power Applications, Direct Torque Control of Induction Machine: A Review.

UNIT - III

Research Design: Meaning of Research Design, Need of Research Design, Feature of a Good Design, Important concepts related to Research Design, Different Research Designs, Basic Principles of Experimental Design, Developing a Research Plan, Design of Experimental Set-up, Use of Standards and Codes.

UNIT - IV

Data Collection and Analysis: Collection of primary data, Secondary data, Data organization, Methods of data grouping, Diagrammatic representation of data, Graphic representation of data. Sample Design, Need for sampling, some important sampling definitions, Estimation of population, Role of Statistics for Data Analysis, Parametric V/s Non-Parametric methods, Descriptive Statistics, Processing and Analysis of Data.

UNIT - V

Research Report Writing, Publishing: Format of the Research report, Style of writing report, References/Bibliography/Webliography, Preparing the List of Works, Cited, Technical paper writing/Journal report writing. Considerations when selecting a target journal, submitting a manuscript, how to respond to editors and referees, A process for preparing a manuscript. Plagiarism and Academic Integrity.

Research Proposal Preparation: Funding agencies in India and across the Globe, writing a Research Proposal and Research Report, Writing Research Grant Proposal: Minor and Major Research proposals (UGC and AICTE).

References

1. C. R. Kothari, *Research Methodology: Methods & Techniques*. New Delhi, India: New Age International Publishers, 2004.
2. R. Ganesan, *Research Methodology for Engineers*. Chennai, India: MJP Publishers, 2011.
3. V. Upagade and A. Shende, *Research Methodology*. New Delhi, India: S. Chand & Company Ltd., 2009.
4. P. Ramdass and W. Aruni, *Research and Writing Across the Disciplines*. Chennai, India: MJP Publishers, 2009.
5. M. Cargill and P. O'Connor, *Writing Scientific Research Articles: Strategy and Steps*. Hoboken, NJ, USA: John Wiley & Sons, Ltd., 2009.
6. *MLA Handbook for Writers of Research Papers*. New York, NY, USA: Modern Language Association of America, 2009.
7. C. H. Siva Kumar and G. Mallesham, *Engineering Research Methodology: Principles and Practices*. Amazon Kindle, Feb. 1, 2025.

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Course Code	Course Title					
	POWER ELECTRONIC CONVERTERS FOR RENEWABLE ENERGY					
PHD5002EE			**L**	**T**	**P**	**C**
Pre-requisites			**3**	**-**	**-**	**3**
Evaluation	**SEE**	**100 Marks**	**CIE**		**-**	

Course Objectives

- To learn the types of renewable sources such as Wind, solar, hydro and geothermal sources.
- To understand the principle and operation of various DC-DC converters.
- To understand the concepts of grid connected inverters and grid connected issues.
- To understand the principle of operation of doubly fed induction generator with rotor side converter topologies.

Course Outcomes

After the completion of this course, students will be able to:

1. Understand P-V & I-V characteristics of solar PV and different MPPT Techniques.
2. Understands the maximum power point tracking for different Converters.
3. Analyze the grid connection issues and different types of transformer less topologies.
4. Understand the P-V and I-V characteristics and power extraction of wind energy systems.
5. Analyze the different types of wind generators for wind power applications.

Course Articulation Matrix:

Course outcome	Programme outcome					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	-	3	2	3	2
CO2	3	-	3	2	3	2
CO3	3	-	3	2	3	2
CO4	3	-	3	2	3	2
CO5	3	-	3	2	3	2

UNIT I

Introduction to renewable sources: world energy scenario, Wind, solar, hydro, geothermal, availability and power extraction. Introduction to solar energy: Photovoltaic effect, basics of power generation, P-V &IV characteristics, effect of insolation, temperature, diurnal variation, shading, Modules, connections, ratings, Power extraction (MPP) tracking and MPPT schemes; standalone systems, grid interface, storage, AC-DC loads.

UNIT II

DC-DC converters for solar PV: buck/boost/buck-boost /flyback /forward/cuk, bidirectional converters, Interleaved and multi-input converters.

UNIT III

Grid connected Inverters: 1ph, 3ph inverters with & without transformers, Heric, H6, Multilevel Neutral point clamp, Modular multilevel, CSI; Control schemes: unipolar, bipolar, PLL and synchronization, power balancing / bypass, Parallel power processing; Grid connection issues: leakage current, Islanding, harmonics, active/reactive power feeding, unbalance.

UNIT IV

Introduction to wind energy: P-V, I-V characteristic, wind power system: turbine generator-inverter, mechanical control, ratings; Power extraction (MPP) and MPPT schemes. Generators for wind: DC generator with DC to AC converters; Induction generator with & w/o converter.

UNIT V

Synchronous generator with back-to-back controlled/ uncontrolled converter; Doubly fed induction generator with rotor side converter topologies; permanent magnet-based generators. Battery: Types, charging discharging. Introduction to AC and DC micro grids.

References

1. S. Chakraborty, M. G. Simões, and W. E. Kramer, *Power Electronics for Renewable and Distributed Energy Systems: A Sourcebook of Topologies, Control and Integration*. New York, NY, USA: Springer Science & Business Media, 2013.
2. N. Femia, G. Petrone, G. Spagnuolo, and M. Vitelli, *Power Electronics and Control for Maximum Energy Harvesting in Photovoltaic Systems*. Boca Raton, FL, USA: CRC Press, 2013.
3. C. S. Solanki, *Solar Photovoltaics: Fundamentals, Technologies and Applications*. New Delhi, India: Prentice Hall of India, 2011.
4. N. Mohan, T. M. Undeland, and W. P. Robbins, *Power Electronics: Converters, Applications, and Design*. Hoboken, NJ, USA: John Wiley & Sons, 1989.
5. M. H. Rashid, *Power Electronics: Circuits, Devices, and Applications*. New Delhi, India: Pearson Education India, 2004.
6. E. Gubía, P. Sanchis, A. Ursúa, J. López, and L. Marroyo, "Ground currents in single-phase transformerless photovoltaic systems," *Progress in Photovoltaics: Research and Applications*, vol. 15, no. 7, pp. –, 2007.
7. R. Teodorescu, M. Liserre, and P. Rodríguez, *Grid Converters for Photovoltaic and Wind Power Systems*. Hoboken, NJ, USA: John Wiley & Sons, Ltd., 2011.

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Course Code	Course Title					
	ADVANCED COMPUTER METHODS IN POWER SYSTEMS					
PHD5003EE			**L**	**T**	**P**	**C**
Pre-requisites			**3**	**-**	**-**	**3**
Evaluation	**SEE**	**100 Marks**	**CIE**		**-**	

Course Objectives

- To understand various incidence matrices and formulation of network matrices.
- To be familiar with various methods of triangularization and significance of optimal ordering.
- To familiarize with bus impedance matrix preparation for a given network.
- To understand load flow techniques and solution methods.
- To familiarize short circuit studies and its importance.

Course Outcomes

After the completion of this course, the students shall be able to:

1. Able to obtain network matrices using graph theory.
2. Utilize optimal ordering and Factorization for efficient computations
3. Build ZBUS for single phase and three phase networks
4. Choose a suitable load flow technique for a particular application.
5. Analyze various types of faults.

Course Articulation Matrix

Course outcome	Programme outcome					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	-	3	-	-	2
CO2	3	-	3	-	-	2
CO3	3	-	3	-	-	2
CO4	3	-	3	-	-	2
CO5	3	-	3	-	-	2

UNIT I

Graph Theory: Network graph – Incidence matrices – Element node incidence matrix – Bus incidence matrix –Branch path incidence matrix – Basic and Augmented cut set incidence matrices – Basic and augmented branch incidence matrices – Basic and Augmented loop incidence matrices – Primitive network – Formation of Y Bus, YBR & Z loop by singular transformation.

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UNIT II

Z Bus formation: Matrix representation of power systems, Triangularization, Gaussian elimination method, LU, LDU factorization, Table of factors, Optimal ordering. Algorithm for formation of Z Bus matrix. Concept of branch and link addition – modification of bus impedance matrix for changes in the network, Z bus – sparse vector method.

UNIT III

Load flow studies: Concepts of load flow – classification of buses, Representation of fixed tap setting and on load tap changing transformers, Power System Loads-Basic Load Modeling concepts, Modeling of induction and synchronous motors. Load flow solution using Gauss-Seidel, Newton-Raphson methods – Treatment of voltage-controlled buses – Acceleration factors, Decoupled and Fast decoupled method, Flow chart and comparison of different methods.

UNIT IV

Modifications in Z bus matrix: Representation and performance equation of 3phase network elements – Three phase network elements with balanced and unbalanced excitation – Transformation matrices –Symmetrical and Clarke's components – Algorithm for formation of three phase bus impedance matrix –Modification of three phase Z bus changes in network.

UNIT V

Short circuit studies: Basic assumption in short circuit studies – System representation – General equations for short circuit study in phase variables and Symmetrical components for fault current and node voltage – Short circuit calculations for balanced three phase network using Z bus – Fault impedance and admittance matrices – Analysis of 3 phase, line to ground and double line to ground faults – Flow chart for short circuit study. Short circuit studies using Table of Factors

References

1. G. W. Stagg and A. H. El-Abiad, *Computer Methods in Power System Analysis*. New York, NY, USA: McGraw-Hill, 1968.
2. G. L. Kusic, *Computer-Aided Power System Analysis*. Englewood Cliffs, NJ, USA: Prentice Hall, 1986.
3. M. A. Pai, *Computer Techniques in Power System Analysis*. New Delhi, India: Tata McGraw-Hill, 2006.
4. P. Kundur, *Power System Stability and Control*. New Delhi, India: Tata McGraw-Hill, 2006.

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Course Code	Course Title					
	ADVANCED TOPICS IN POWER ELECTRONICS					
PHD5004EE			**L**	**T**	**P**	**C**
Pre-requisites			**3**	**-**	**-**	**3**
Evaluation	**SEE**	**100 Marks**	**CIE**		**-**	

Course Objectives

- To develop knowledge about advanced power semiconductor devices
- To be familiarize with ideal rectifier, near ideal rectifiers, bifurcation and Chaos
- To be aware of. Various State space modeling DC-DC converters and Soft-switching
- Analyze the operation of multi-level inverters and accessing appropriate applications.
- Design of optimal controllers for Power Electronic Systems and its modeling

Course outcomes: After the completion of this course, the students shall be able to:

1. Select an appropriate power semiconductor device and design a power converter for the required application
2. Develop and understand the near ideal rectifier for single phase and three-phase converter systems
3. Determine the power circuit configurations to fulfill the required power conversion with applicable constraints
4. Design multi-level inverters and DC-DC converters, z-source converters
5. Design the control circuit and the power circuit for a given power converter

Course Articulation Matrix:

Course outcome	Programme outcome					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	3	1	3	2
CO2	2	2	2	1	2	2
CO3	2	2	2	2	2	2
CO4	3	2	3	2	3	3
CO5	2	2	3	3	2	2

UNIT I

Introduction to switches - Advanced Silicon devices - Silicon HV thyristors, MCT, BRT &EST. SiC devices - diodes, thyristors, JFETs & IGBTs. Gallium nitrate devices - Diodes, MOSFETs.

UNIT II

Pulse Width Modulated Rectifiers: Properties of ideal rectifier, realization of near ideal rectifier, control of the current waveform, single phase and three-phase converter systems incorporating ideal rectifiers and design examples. Non-linear phenomena in switched mode power converters: Bifurcation and Chaos.

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UNIT III

Control of DC-DC converters- State space modeling of Buck, Boost, Buck-Boost, Cuk Fly back, Forward, Push-Pull, Half & Full-bridge converters. Closed loop voltage regulations using state feedback controllers. Soft-switching DC - DC Converters: zero-voltage-switching converters, zero-current switching converters, Multi-resonant converters and Load resonant converters.

UNIT IV

Advance converter topologies - Multi level converters - Cascaded H-Bridge, Diode clamped, NPC, Flying capacitor. Modular Multi-level Converters (MMC), Multi-Input DC-DC Converters, Multi pulse PWM current source converters, Interleaved converters, Z-Source converters.

UNIT V

Control Design Techniques for Power Electronic Systems- Modeling of systems, Digital Controller Design, Optimal and Robust controller Design.

References

1. A. M. Trzynadlowski, *Introduction to Modern Power Electronics*. New York, NY, USA: John Wiley & Sons, Inc., 1998.
2. L. Umanand, *Power Electronics: Essentials and Applications*, 1st ed. Hoboken, NJ, USA: Wiley Publishing Company, 2014.
3. B. J. Baliga, *Advanced High Voltage Power Device Concepts*. New York, NY, USA: Springer, 2011, ISBN: 978-1-4614-0268-8.
4. B. Wu, *High-Power Converters and AC Drives*. Hoboken, NJ, USA: IEEE Press/Wiley-Interscience, 2006.

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Course Code	Course Title					
	HYBRID ELECTRICAL VEHICLES					
PHD5005EE			L	T	P	C
Pre-requisites			3	-	-	3
Evaluation	SEE	100 Marks	CIE		-	

Course Objectives

- To understand the basics of electric and hybrid electric vehicles and their working
- To understand the basics of batteries and their role for electric/hybrid vehicle applications
- To obtain the knowledge of various types of electric/hybrid vehicles
- To understand the real time challenges in the implementation of this technology

Course Outcomes

After the completion of this course, the students shall be able to:

1. Understand basics of electric and hybrid electric vehicles both conceptually and mathematically so that clear understanding from basics physics is achieved.
2. Have the knowledge of battery behavior for electric vehicle application.
3. Understand different types of Electric/Hybrid vehicles technologies available and their applications.
4. Analyze challenges in implementing electric/hybrid vehicle technology by looking into various charging topologies and their impact on distribution systems.
5. Analyze various electric drives suitable for hybrid electric vehicles.

Course Articulation Matrix

Course outcome	Programme outcome					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	3	-	-	2
CO2	3	-	3	-	-	2
CO3	3	-	3	2	-	2
CO4	3	-	3	2	-	2
CO5	3	-	3	2	-	2

UNIT I

Introduction to Electric Vehicles: Sustainable Transportation - EV System – EV - Advantages - Vehicle Mechanics - Performance of EVs - Electric Vehicle drivetrain - EV Transmission Configurations and components-Tractive Effort in Normal Driving - Energy Consumption - EV Market - Types of Electric Vehicle in Use Today – Electric Vehicles for the Future.

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UNIT II

Electric Vehicle Modelling - Consideration of Rolling Resistance – Transmission Efficiency - Consideration of Vehicle Mass - Tractive Effort - Modelling Vehicle Acceleration - Modelling Electric Vehicle Range -Aerodynamic Considerations - Ideal Gearbox Steady State Model - EV Motor Sizing - General Issues in Design.

UNIT III

Introduction to electric vehicle batteries - electric vehicle battery efficiency – electric vehicle battery capacity - electric vehicle battery charging - electric vehicle battery fast charging - electric vehicle battery discharging - electric vehicle battery performance – testing.

UNIT IV

Hybrid Electric Vehicles - HEV Fundamentals -Architectures of HEVs- Interdisciplinary Nature of HEVs - State of the Art of HEVs - Advantages and Disadvantages - Challenges and Key Technology of HEVs - Concept of Hybridization of the Automobile-Plug-in Hybrid Electric Vehicles - Design and Control Principles of Plug-In Hybrid Electric Vehicles - Fuel Cell Hybrid Electric Drive Train Design - HEV Applications for Military Vehicles.

UNIT V

Advanced Topics - Battery Charger Topologies, Charging Power Levels, and Infrastructure for Plug-In Electric and Hybrid Vehicles - The Impact of Plug-in Hybrid Electric Vehicles on Distribution Networks – Sizing Ultra capacitors for Hybrid Electric Vehicles.

References

1. M. Ehsani, Y. Gao, and A. Emadi, *Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory and Design*, 2nd ed. Boca Raton, FL, USA: CRC Press, 2010.
2. J. Larminie and J. Lowry, *Electric Vehicle Technology Explained.* Chichester, U.K.: John Wiley & Sons Ltd., 2003.
3. S. Dhameja, *Electric Vehicle Battery Systems*. Oxford, U.K.: Newnes, 2002.
4. C. Mi, M. A. Masrur, and D. W. Gao, *Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives.* Chichester, U.K.: John Wiley & Sons Ltd., 2011.
5. I. Hussain, *Electric and Hybrid Vehicles: Design Fundamentals*, 2nd ed. Boca Raton, FL, USA: CRC Press, 2011.

Research Papers:

6. R. C. Green II, L. Wang, and M. Alam, "The impact of plug-in hybrid electric vehicles on distribution networks: A review and outlook," in *Proc. IEEE*, 2010.
7. H. D. P. Pillay, "Sizing ultracapacitors for hybrid electric vehicles," in *Proc. IEEE*, 2005.
8. M. Yilmaz and P. T. Krein, "Review of battery charger topologies, charging power levels, and infrastructure for plug-in electric and hybrid vehicles," *IEEE Trans. Power Electron.*, vol. 28, no. 5, pp. –, May 2013.

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Course Code	Course Title					
	POWER ELECTRONIC APPLICATIONS TO POWER SYSTEMS					
PHD5006EE			**L**	**T**	**P**	**C**
Pre-requisites			**3**	**-**	**-**	**3**
Evaluation	**SEE**	**100 Marks**	**CIE**			**-**

Course Objectives

- To understand the issues involved in existing Power Transmission system
- To be familiar with the Techniques to overcome the problems associated with AC Power Transmission system
- To Understand the control of active and reactive power control using Power electronic converters

Course Outcomes

After the completion of this course, the students shall be able to:

1. Know the application of FACTS devices in Power Transmission system.
2. Study and apply the power transmission schemes – HVDC Transmission
3. Implement the control circuits based on the Controlling parameters of HVDC system
4. Select appropriate FACTS controllers depending on application.
5. Understand various types of HVDC systems and their advantages.

Course Articulation Matrix:

Course outcome	Programme outcome					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	-	3	-	-	3
CO2	3	-	3	-	-	3
CO3	3	-	3	-	-	3
CO4	3	-	3	-	-	3
CO5	3	-	3	-	-	3

UNIT I

Facts concepts: Reactive power control in electrical power transmission, principles of conventional reactive power compensators. Introduction to FACTS, flow of power in AC parallel paths, meshed systems, basic types of FACTS controllers, definitions of FACTS controllers, brief description of FACTS controllers.

UNIT II

Static shunt and series compensators: Shunt compensation - objectives of shunt compensation, methods of controllable VAR generation, static VAR compensators - SVC, STATCOM, SVC and STATCOM comparison. Series compensation - objectives of series compensation, thyristor switched series capacitors (TCSC), static series synchronous compensator (SSSC), power angle characteristics, and basic operating control schemes.

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UNIT III

Combined Compensators: Unified power flow controller (UPFC) - Introduction, operating principle, independent real and reactive power flow controller and control structure. Interline power flow controller (IPFC), Introduction to Active power filtering, Concepts relating to Reactive power compensation and harmonic current compensation using Active power filters.

UNIT IV

HVDC transmission: HVDC Transmission system: Introduction, comparison of AC and DC systems, applications of DC transmission, types of DClinks, Layout of HVDC Converter station and various equipment. HVDC Converters, analysis of bridge converters with and without overlap, inverter operation, equivalent circuit
representation of rectifier and inverter configurations

UNIT V

Control of HVDC system: Principles of control, desired features of control, converter control characteristics, power reversal, Ignition angle control, current and extinction angle control. Harmonics-introduction, generation, ac filters and dc filters. Introduction to multiterminal DC systems and applications, comparison of series and parallel MTDC systems.

References

1. Y. H. Song and A. T. Johns, *Flexible AC Transmission Systems (FACTS)*. London, U.K.: Institution of Electrical Engineers Press, 1999.
2. N. G. Hingorani and L. Gyugyi, *Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems*. New York, NY, USA: IEEE Press, 2000, ISBN: 0-7803-3458-8.
3. K. R. Padiyar, *HVDC Transmission Systems*. New Delhi, India: Wiley Eastern Ltd., 2010.
4. R. Mohan Mathur and R. K. Varma, *Thyristor-Based FACTS Controllers for Electrical Transmission Systems*. Hoboken, NJ, USA: IEEE Press/Wiley-Interscience, 2002.
5. K. R. Padiyar, *FACTS Controllers in Power Transmission and Distribution*. New Delhi, India: New Age International Publishers, 1st ed., 2007.
6. E. Acha, C. R. Fuerte-Esquivel, H. Ambriz-Pérez, and C. Ángeles-Camacho, *FACTS: Modelling and Simulation in Power Networks*. Hoboken, NJ, USA: John Wiley & Sons, 2002.

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Course Code	Course Title					
	REAL TIME APPLICATIONS IN POWER SYSTEMS					
PHD5007EE			**L**	**T**	**P**	**C**
Pre-requisites			**3**	**-**	**-**	**3**
Evaluation	**SEE**	**100 Marks**	**CIE**		**-**	

Course Objectives

- To prepare the students to understand
- The concept of state estimation and also the solution techniques of the state estimation problem.
- The methodology for detection and identification of bad data from the available measurements in the Energy control centre.
- The concepts of power system security and methods for analyzing the system security.
- The need of computer control of power system and necessity of different softwares available in Energy control centre.

Course Outcomes

After the completion of this course, students will be able to:

1. Able to estimate the state of given power system using WLS method for the available measurements in the energy control centre.
2. Able to choose suitable state estimation solution technique for a given power system network.
3. Able to detect and identification of bad data for the set of measurements available in the energy control centre.
4. Able to analyze the security of a given power system using different methods.
5. Able to understand the need of the computer control of power system and also the significance of different software's available in the energy control centre.

Course Articulation Matrix

Course outcome	Programme outcome					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	-	3	-	-	3
CO2	3	-	3	-	-	3
CO3	3	-	3	-	-	3
CO4	3	-	3	-	-	3
CO5	3	-	3	-	3	3

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UNIT I

State Estimation: Introduction, Power system state estimation, Types of measurements, Linear weighted least square (WLS) estimation theory, DC Load flow based WLS state estimation, Linearised model of WLS state estimation of Non-linear AC power systems, sequential and non-sequential methods to process measurements, typical results of state estimation on an Ac network.

UNIT II

Types of State Estimation: State estimation by conventional WLS (normal equations), orthogonal decomposition and its algorithm, hybrid method. Tracking of state estimation. Dynamic state estimation.

UNIT III

Advanced Topics in State Estimation: Detection and identification of bad measurements, estimation of quantities not being measured, Network observability and pseudo-measurements, observability by graphical technique and triangularisation approach, Optimal meter placement, Application of power system state estimation.

UNIT IV

Power System Security Analysis: Concept of security, Security analysis and monitoring, factors affecting power system security, detection of network problems, an overview of security analysis, contingency analysis for generator and line outages by interactive linear power flow (ILPF) method, network sensitivity factors.
Contingency selection

UNIT V

***Computer control of Power Systems*:** Need for real-time and computer control of power systems, operating states of a power system, Supervisory control and Data acquisition system (SCADA), implementation considerations, energy control centers, software requirements for implementing the above functions.

References

1. A. J. Wood and B. F. Wollenberg, *Power System Generation, Operation and Control*. Hoboken, NJ, USA: John Wiley & Sons, 1996.
2. J. J. Grainger and W. D. Stevenson Jr., *Power System Analysis*. New York, NY, USA: McGraw-Hill, 1994.
3. E. Handschin, *Real-Time Control of Electrical Power Systems*. Amsterdam, Netherlands: Elsevier Publishing Co., 1988.
4. *Proceedings of the IEEE*, "Special issue on computer control of power systems," Jul. 1974.

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Course Code	Course Title					
	SMART GRID TECHNOLOGIES					
PHD5008EE			**L**	**T**	**P**	**C**
Pre-requisites			**3**	**-**	**-**	**3**
Evaluation	**SEE**	**100 Marks**	**CIE**		**-**	

Course Objectives

1. To understand the differences, motivations, and vision behind the transition to smart grids.
2. To identify explain the key enabling technologies and architectural components that constitute a smart grid system.
3. To evaluate communication infrastructure, architectures, and protocols in enabling smart grid functionalities and data exchange.
4. To analyze Microgrid dynamics, control strategies, and associated protection challenges.
5. To operational and management concepts and the functions of modern Energy and Distribution Management Systems.

Course Outcomes

After the completion of this course, students will be able to:

1. Analyze the conceptual architecture of a smart grid, identifying its key domains, layers, and enabling technologies.
2. Explain the Advanced Metering Infrastructure, Wide Area Measurement Systems in enhancing grid visibility and control.
3. Evaluate the functionality and application of key communication protocols relevant to smart grid.
4. Analyze the operational modes of microgrids and the implications of seamless transitions between them.
5. Formulate strategies for Demand Side Management (DSM) and explain the concepts related to outage management and system restoration (FLISR).

Course Articulation Matrix

Course Outcome	Program Outcome					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	2	2	1	1
CO2	2	-	3	2	1	2
CO3	2	-	3	2	1	2
CO4	3	-	3	3	2	3
CO5	3	-	3	3	2	3

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Course Code	Course Title					
	POWER SYSTEM STABILITY					
PHD5009EE			L	T	P	C
Pre-requisites			3	-	-	3
Evaluation	SEE	100 Marks	CIE		-	

Course Objectives

- To gain knowledge about the dynamic mechanisms behind angle and voltage stability problems in electric power systems, including physical phenomena and modeling issues.
- To understand the modelling of excitation and prime mover controllers for stability analysis.
- To model low frequency oscillation studies and develop supplementary damping methods.
- To know about sub synchronous oscillations and damping schemes
- To understand Voltage stability, means to improve it.

Course Outcomes

After the completion of this course, students will be able to:

1. Analyze the performance of single machine and multi machine systems under transient, steady state and dynamic conditions.
2. Model excitation and prime mover controllers for stability analysis.
3. Design supplementary excitation systems, stabilizers for improving stability
4. Analyze sub synchronous oscillations and understand various damping schemes to reduce these oscillations.
5. Understand voltage stability and methods of enhancing it.

Course Articulation Matrix

Course outcome	Programme outcome					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	3	-	-	3
CO2	3	-	3	-	-	3
CO3	3	-	3	-	-	3
CO4	3	-	3	-	-	3
CO5	3	-	3	-	-	3

UNIT I

Stability Concepts: Basic concept of stability-Types of stability – Stability criteria for single and multi-machine systems –Synchronous machine representation for stability studies – Swing equation for single and multi-machine system – Basic assumptions– Different methods of solution of swing equation–Solution by indirect methods– Runge-Kutta method – Determination of critical time and critical angle.

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UNIT-I

Introduction to Smart Grid: Conventional Power Systems vs. Smart Grid, Smart Grid Architecture, Enablers of Smart Grid, Smart Grid Standards and Regulations, Global and Indian Smart Grid Initiatives

UNIT-II

Smart Grid Components: Advanced Metering Infrastructure (AMI)- Smart meters, Automatic Meter Reading (AMR), Meter Data Management Systems (MDMS), benefits and challenges. Phasor Measurement Units (PMUs) and Wide Area Measurement Systems (WAMS).

UNIT-III

Smart Grid Communications: Communication Architectures for Smart Grid: Two-way digital communications, network topologies, IP-based systems. Communication Protocols-Standards and protocols relevant to smart grid applications (e.g., Modbus, DNP3, IEC 61850). Power Line Communications (PLC): Technology and applications.

UNIT-IV

Microgrids: Definition, characteristics, and distinguishing features, benefits and challenges, architecture (AC, DC, Hybrid), operation modes (grid-connected, islanded), control strategies (hierarchical control), Major protection issues of stand-alone Microgrid.

UNIT-V

Smart Grid Operation, Control, and Management: Demand Side Management (DSM) and Demand Response (DR) Strategies. Self-Healing Grids - Concepts and technologies for automated outage management and system restoration. Energy Management Systems (EMS) and Distribution Management Systems (DMS) in Smart Grid Context.

References

1. J. Ekanayake, K. Liyanage, J. Wu, A. Yokoyama, and N. Jenkins, *Smart Grid: Technology and Applications*. Chichester, U.K.: John Wiley & Sons, 2012.
2. J. A. Momoh, *Smart Grid: Fundamentals of Design and Analysis*. Hoboken, NJ, USA: Wiley/IEEE Press, 2012.
3. N. Hatziargyriou, *Microgrids: Architecture and Control*. Hoboken, NJ, USA: Wiley/IEEE Press, 2014.
4. A. Keyhani and M. Marwali, *Smart Power Grids*. Hoboken, NJ, USA: Wiley/IEEE Press, 2011.

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UNIT II

Excitation models: Hydraulic power and governor models – IEEE standard models – Models for steam turbine – Various Excitation systems, Effect of Excitation systems on Stability.

UNIT III

Low frequency oscillation and supply controls: Transfer function of low frequency oscillation studies – Improving system damping with supplementary excitation – Design of supplementary excitation system – State equation for single machine system – Improving system model with governor control.

UNIT IV

Sub Synchronous oscillations: Turbine generator torsional characteristics, Torsional interaction with power system controls. Sub Synchronous resonance. Damping schemes.

UNIT V

Concept of voltage stability – Characteristics of network, generator and load for voltage stability – Methods of enhancing stability, Transient stability analysis using Transient Energy Function Analysis, Extended Equal Area Criterion – Basics.

References

1. Y. N. Yu, *Power System Dynamics*. Orlando, FL, USA: Academic Press, 1983.
2. P. Kundur, *Power System Stability and Control*. New Delhi, India: Tata McGraw-Hill, 2006.
3. K. R. Padiyar, *FACTS Controllers in Power Transmission and Distribution*. New Delhi, India: New Age International Publishers, 1st ed., 2007.
4. G. W. Stagg and A. H. El-Abiad, *Computer Methods in Power Systems*. New York, NY, USA: McGraw-Hill, 1968.
5. J. Machowski, J. Bialek, and J. Bumby, *Power System Dynamics: Stability and Control*. Chichester, U.K.: John Wiley & Sons, 2008.

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