ELECTRICAL DISTRIBUTION SYSTEM ANALYSIS

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INTENDED AUDIENCE : UG and PG Students, Research Scholars, Distribution Utility Engineers, College Teachers, and Industry Professionals.

PRE-REQUISITES : Power System Analysis

INDUSTRIES APPLICABLE TO : 1. Power distribution utilities.
2. Load dispatch centers.
3. Distribution system equipment manufacturers.

ABOUT THE COURSE:

This course offers a comprehensive study of electrical distribution systems, emphasizing the fundamental differences from transmission systems in terms of structure and load patterns. With the rapid transition from passive to active networks, driven by the integration of distributed generation, energy storage, and smart-grid technologies, traditional transmission system analysis tools have proven to be insufficient. This course addresses these emerging challenges by introducing specialized modeling and analysis techniques tailored specifically for distribution systems.

The curriculum encompasses the modeling of essential components, including feeders, distribution transformers, voltage regulators, capacitors, loads and distributed generation. It covers advanced analysis methods, such as load flow and short-circuit analysis, which are crucial for the effective design, planning, and operation of contemporary distribution networks. A particular focus is placed on voltage and reactive power (volt-var) control (VVC), utilizing both traditional and advanced technologies. The course also includes a case study on a practical distribution system, such as the distribution network at IIT Roorkee, providing real-world insights into the operation of distribution systems.

ABOUT INSTRUCTOR :

Prof. Narayana Prasad Padhy holds the position of Professor (HAG) at IIT Roorkee. Currently, he is on lien from IIT Roorkee and is serving as the Chairman of BoG and Director at MNIT Jaipur, and Director (I/C) at IIIT Kota in India. He holds specialization in the area of Power System Engineering and AC-DC Smart Grid. Prior to his joining as director, he was Ravi Mohan Mangal Institute Chair Professor, and, joint faculty and founder Head of the Mehta Family School of Data Science and Artificial Intelligence, IIT Roorkee, India. He has served as Dean of Academic Affairs, Professor In-Charge Training and Placement, NEEPCO, and Institute Chair Professor at IIT Roorkee professors and currently holds the IIT Palakkad Technology I-Hub Foundation Chair Professorship.

After receiving his Ph.D. in 1997, he joined the Department of Electrical Engineering, BITS Pilani, as an Assistant Professor and worked till July 1998. Then he joined the Department of Electrical Engineering, University (IIT) of Roorkee India, as a Lecturer in 1998 and was promoted to Professor in 2008. He worked as a Visiting Professor/fellow at Ryerson University, Toronto Canada, and at the University of Bath, Bath, UK.

Prof Padhy has authored six popular textbooks of Power Systems and has delivered hundreds of talks in the area of Smart Grid on various national and international forums. Currently guiding 23 out of 43 research scholars in fulfilling their research objectives. He has authored more than 250 publications in international journals including 42 IEEE Transactions, 140 International Conferences, and 1 IEEE Magazine with an overall google scholar citation of 9482. He has tutored 3 NPTEL online courses and owns three patents in his name.

Prof Padhy has completed 6 International/National Project and currently serving as Principal Investigator for 6 International Projects in the field of Smart Grid with the funding of more than 16.5 Cr INR. He played a pioneer role in development of first smart distribution network management system (SDNMS) campus at IIT Roorkee and also to set-up AC-DC Hybrid Microgrid (ADMIRE) Lab which encompasses cutting-edge technologies to address research challenges of the smart grid. Involved in Mission Innovation (MI) 2.0- Green powered future mission activities which includes 22 international counties and head responsibilities of Mission Innovation Resource Center (MIRC) at IIT Roorkee.

He also served as technical consultant to various consultancy projects like Design and Deployment of Smart Distribution and Lighting System for Noida and UPSIDA and providing technology support for execution of Saharanpur smart city. For his work he has received SKOCH Silver AWARD as an Honorary from SKOCH group in 2020. Received Eminent Engineer Award,2019 from the Institution of Engineers Uttarakhand State Centre, Dehradun. Selected for Samanta Chanra Sekhar Award 2021 from the Government of Odisha for outstanding contributions in the field of Science and Technology. Elected for IEEE PES Chapter Outstanding Engineer Award from IEEE Power & Energy Society,2018. Felicitated for bringing laurels to the institute an honorary recognition from IIT Roorkee, 2017.

Elected for Alexander von Humboldt Experienced Research Fellow Award from Alexander von Humboldt Foundation, Germany,2009. Elected as BOYSCAST Research Fellow Award for Young Scientist Elected from Department of Science and Technology, Govt. of India,2005. Recently received Global Lifetime Achievement Award for outstanding contribution to the Academics, Research, and the Society at Maldives National University, and IEEE Smart Cities Jury Award 2022 as Principal Investigator of the International Project D-SIDES IIT Roorkee Campus Pilot Project Work Based on Renewable Technology for Smart City Developments

Prof. Ganesh B. Kumbhar received the B.E. Degree in electrical engineering from Government College of Engineering, Karad in 1999, the M. Tech. Degree from the IIT-Madras in 2002, and the Ph.D. degree from the IIT Bombay in 2007. Currently, he is working as Assistant Professor at Department of Electrical Engineering, IIT-Roorkee. Previously, he has worked with Eaton Corporation Ltd., Tata Consultancy Services Ltd., and Crompton Greaves Ltd. in the areas of design and analysis of power system equipment. He has also worked as a Postdoctoral Research Scholar at the Centre for Energy System Research at Tennessee Tech. University, Cookeville, Tennessee, USA. His research interests include distribution system analysis, distributed generation planning and analysis, smart grid technologies and applications, power and distribution transformers, modeling and simulation, design and analysis.

COURSE OUTLINE:

Week 1 :

Module 1: Introduction to Electrical distribution system
Module 2: Components of distribution system substation and busbar layouts
Module 3: Components of distribution system and feeder configurations
Module 4: Nature of loads in a distribution system
Module 5: Load allocation in a distribution system

Week 2 :

Module 1: 'K' Factors and Their Applications
Module 2: Analysis of Uniformly Distributed Loads
Module 3: Lumping Loads in Geometric Configurations: Rectangular
Module 4: Lumping Loads in Geometric Configurations: Triangular
Module 5: Series Impedance of Distribution Lines and Feeders-Part I

Week 3 :

Module 1: Series Impedance of Distribution Lines and Feeders-Part II
Module 2: Models of Distribution Lines and Cables
Module 3: Modeling of Single-Phase and Three-Phase Transformers
Module 4: Modeling of Three-Phase Transformers-Part I
Module 5: Modeling of Three-Phase Transformers –Part II

Week 4 :

Module 1: Modeling of Three-Phase Transformers –Part III
Module 2: Modeling of Three-Phase Transformers –Part IV
Module 3: Modeling of Step Voltage Regulators-Part I
Module 4: Modeling of Step Voltage Regulators-Part II
Module 5: Modeling of Step Voltage Regulators -Part III

Week 5 :

Module 1: Modeling of Step Voltage Regulators -Part IV
Module 2: Load Models in Distribution System-Part I
Module 3: Load Models in Distribution System-Part II
Module 4: Modeling of Distributed Generation
Module 5: Applications and modeling of Capacitor Banks

Week 6 :

Module 1: Summary of Modeling of distribution system components
Module 2: Backward/Forward Sweep Load Flow Analysis Part I
Module 3: Backward/Forward Sweep Load Flow Analysis Part II
Module 4: Direct Approach Based Load Flow Analysis Part I
Module 5: Direct Approach Based Load Flow Analysis Part II

Week 7 :
Module 1: Direct Approach Based Load Flow Analysis Part III
Module 2: Direct Approach Based Load Flow Analysis: Weakly meshed system
Module 3: Gauss Implicit Z-matrix Method
Module 4: Sequence component based Short Circuit Analysis
Module 5: Thevenin's equivalent and phase variable based Short Circuit Analysis

Week 8 :
Module 1: Direct Approach for short-circuit analysis: Introuction and LG Fault
Module 2: Direct Approach for short-circuit analysis: LLG and LLLG Fault
Module 3: Direct Approach for short-circuit analysis: LL Fault and Examples
Module 4: Direct Approach for short-circuit analysis: Weakly meshed system
Module 5: Applications of distribution system analysis

Week 9 :
Module 1: Distributed generation integration issues in distribution system
Module 2: Distribution system protection issues
Module 3: Power quality, reliability, and availability
Module 4: Design and Operation Part-I
Module 5: Design and Operation Part-II

Week 10 :
Module 1: Definition and objective of Volt-var control (VVC)
Module 2: Traditional approaches of VVC
Module 3: Distribution Automation
Module 4: SCADA-Based VVC and Integrated VVC
Module 5: Advanced technologies for VVC Part-I

Week 11 :
Module 1: Advanced technologies for VVC Part-II
Module 2: System Planning-Part-I
Module 3: System Planning-Part-II
Module 4: Electricity Forecasting
Module 5: Case study: IIT Roorkee distribution system

Week 12 :
Module 1: Optimization techniques
Module 2: Optimal location and sizing battery energy storage system (BESS)
Module 3: Practical Insights into Electrical Distribution Systems
Module 4: Field deployment of BESS
Module 5: Emerging Technologies and Future Trends