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EE372:
Power System Simulation Using Generative AI

Training Description:

The **Power System Simulation Using Generative AI** training course provides electrical and power-system professionals with an updated understanding of how **Generative Artificial Intelligence (GenAI), machine learning, and data-driven techniques can complement conventional power-system modeling, simulation, analysis and decision-making**.

The training course combines established power-system simulation principles—load flow, short-circuit analysis, transient and dynamic stability, contingency assessment, renewable integration and grid operation—with emerging Generative AI applications. Participants will learn how Large Language Models (LLMs), AI assistants, synthetic data generation, retrieval-augmented generation (RAG) and AI-supported coding can accelerate model preparation, scenario development, simulation automation, troubleshooting, results interpretation and technical reporting.

Emphasis is placed on using GenAI as an **engineering copilot rather than a replacement for validated simulation tools and engineering judgment**. Participants will explore practical workflows integrating AI with tools and environments such as **Python and commonly used power-system simulation platforms**, while addressing hallucination risks, data quality, cybersecurity, governance, model validation and responsible AI use.

The training course is highly practical and includes hands-on exercises in which participants use laptops to develop AI-assisted simulation workflows and complete a final power-system case study.

Training Objectives:

By the end of the training, participants will be able to:

- ✓ Explain the fundamentals and latest applications of Generative AI within electrical power systems
- ✓ Review power-system modeling and simulation principles and their role in planning and operation
- ✓ Apply GenAI tools to support power-system model development and simulation workflows
- ✓ Use AI-assisted coding techniques to create and automate power-system analysis scripts
- ✓ Develop and evaluate load-flow, short-circuit, contingency, and stability simulation scenarios
- ✓ Use GenAI to generate realistic operating scenarios and synthetic power-system datasets
- ✓ Apply AI techniques to renewable-energy and distributed-energy-resource integration studies
- ✓ Explore AI-assisted forecasting of electrical demand and renewable generation
- ✓ Automate repetitive simulation, data-processing, visualization, and reporting activities
- ✓ Use GenAI to interpret simulation results while independently verifying engineering conclusions
- ✓ Identify anomalies, potential system vulnerabilities, and operational risks using AI-supported analysis
- ✓ Understand digital twins and their relationship with AI-enabled power-system simulation.
- ✓ Recognize cybersecurity, privacy, intellectual-property, and data-governance concerns associated with GenAI
- ✓ Evaluate AI outputs for hallucinations, technical errors, bias, and physically impossible recommendations
- ✓ Develop a practical roadmap for incorporating Generative AI into existing power-system engineering workflows

Training Designed for:

This training course is intended for Electrical Engineers, Power System Engineers, Transmission Engineers, Distribution Engineers, Power Generation Engineers, Grid Planning Engineers, System Studies Engineers, Protection and Control Engineers, SCADA/EMS Engineers, Renewable Energy Engineers, Smart Grid Engineers, Energy Management Engineers, Utility Operations Engineers, Electrical Design Engineers, Power System Analysts, Digital Transformation and AI Specialists working with power utilities, Technical Managers and Engineering Team Leaders and Professionals involved in power-system planning, operation, simulation, optimization and digitalization.

Recommended prerequisite: Participants should have a basic understanding of electrical power systems and engineering calculations. Previous experience with power-system simulation software or Python is beneficial but not mandatory.

Training Requirement:

"Hand's on practical sessions, equipment and software will be applied during the course if required and as per the client's request." Participants are encouraged to bring their **own laptops** for the practical exercises.

Contents can be adapted to your specific wishes. It is therefore possible to focus on specific modules of the training course as per client's learning needs and objectives. Further, it should be forwarded to us a month prior to the course dates.

Training Program:

DAY ONE:

POWER SYSTEM SIMULATION AND GENERATIVE AI FUNDAMENTALS

- **Power System Simulation Landscape**
  - Modern electric power-system architecture
  - Generation, transmission, distribution and loads
  - Conventional versus smart and AI-enabled grids
  - Why power-system simulation is critical
  - Planning versus operational simulation
  - Steady-state and dynamic studies
  - Understanding network models and electrical parameters
  - Bus, branch, generator, transformer and load modeling
  - Per-unit system review
  - Single-line diagrams and network representation
- **Introduction to Generative AI**
  - Artificial Intelligence, Machine Learning, Deep Learning and GenAI
  - How Generative AI differs from predictive AI
  - Large Language Models and foundation models
  - Transformers and contextual reasoning—practical overview
  - Multimodal AI and engineering applications
  - AI agents and emerging agentic workflows
  - Generative AI opportunities in the energy and utility sector
- **GenAI for Electrical Engineering**

- AI-assisted engineering calculations
- Generating Python and simulation scripts
- Explaining technical standards and equations
- AI-assisted troubleshooting
- Generating simulation scenarios
- Extracting information from engineering documents
- Summarizing simulation results
- Creating technical reports

❖ Prompt Engineering for Power Engineers

- Structure of an effective engineering prompt
- Adding system context, constraints and assumptions
- Requesting equations and calculation steps
- Providing network data to an AI assistant
- Structured outputs for engineering applications
- Iterative prompting and refinement
- Prompt templates for power-system studies

❖ Practical Exercises

❖ Participants use GenAI to:

- Interpret a simplified electrical network
- Develop simulation assumptions
- Generate preliminary engineering calculations
- Create a basic simulation workflow
- Verify AI-generated answers against engineering principles

DAY TWO:

AI-ASSISTED LOAD FLOW, FAULT AND CONTINGENCY ANALYSIS

❖ Load Flow Analysis

- Purpose of load-flow studies
- Bus classifications: slack, PV, and PQ buses
- Active and reactive power balance
- Voltage magnitude and phase angle
- Newton-Raphson method
- Gauss-Seidel method
- Fast-decoupled load flow
- Convergence considerations

❖ AI-Assisted Load Flow Modeling

- Converting network information into simulation-ready data
- Using GenAI to generate bus and branch datasets
- AI-assisted creation of simulation scripts
- Automating repetitive model-building tasks
- Detecting missing or inconsistent input data
- Generating multiple loading scenarios

❖ Result Analysis

- Voltage-profile assessment
- Transmission-line and transformer loading

- Active and reactive power losses
- Identifying overloaded equipment
- Voltage-limit violations
- AI-assisted interpretation of load-flow results
- Engineering verification of AI conclusions

❖ Short-Circuit and Fault Studies
- Three-phase faults
- Single-line-to-ground faults
- Line-to-line faults
- Double-line-to-ground faults
- Fault-current fundamentals
- Using GenAI to support fault-study calculations
- Interpreting fault-analysis results

❖ Contingency Analysis
- N-1 security criteria
- Generator outages
- Transmission-line outages
- Transformer outages
- Ranking critical contingencies
- AI-assisted contingency generation
- Automated screening of large numbers of scenarios

❖ Hands-On Exercises

❖ AI-Assisted Load Flow and Contingency Study
- Build a test power network
- Execute base-case load flow
- Introduce operating constraints
- Generate contingencies using GenAI
- Run multiple simulation cases
- Identify voltage and thermal violations
- Ask the AI assistant to interpret results
- Validate recommendations using engineering judgment

DAY THREE:

DYNAMIC SIMULATION, STABILITY AND AI-BASED PREDICTION

❖ Power System Stability Fundamentals
- Rotor-angle stability
- Voltage stability
- Frequency stability
- Small-signal stability
- Transient stability
- Stability limits and operating margins

❖ Dynamic Power-System Modeling
- Generator dynamic models
- Excitation systems
- Automatic Voltage Regulators

- Turbine-governor models
- Power System Stabilizers
- Load dynamic behavior
- Protection and control interactions

❖ Transient Stability Simulation
- Fault initiation and clearing
- Generator response
- Rotor-angle behavior
- Critical clearing time
- Post-fault recovery
- Simulation of severe disturbances

❖ Generative AI for Dynamic Studies
- Creating disturbance scenarios with GenAI
- AI-generated simulation scripts
- Automating dynamic simulation cases
- Processing time-series simulation results
- AI-assisted identification of abnormal responses
- Summarizing complex stability studies

❖ AI-Assisted Load and Generation Forecasting
- Historical demand data
- Weather and calendar variables
- Peak-demand forecasting
- Renewable-generation forecasting
- Traditional forecasting versus AI approaches
- Using GenAI to support feature engineering
- Scenario-based demand generation

❖ Anomaly and Event Analysis
- Identifying unusual voltage behavior
- Frequency excursions
- Generator oscillations
- Abnormal power flows
- AI-supported event classification
- Importance of explainability and verification

❖ Practical Exercises

❖ AI-Assisted Dynamic Security Assessment
- Define a disturbance
- Generate simulation cases
- Run dynamic simulations
- Examine frequency and voltage response
- Analyze rotor-angle behavior
- Use GenAI to summarize the event
- Compare AI interpretation with engineering analysis

DAY FOUR:

RENEWABLE INTEGRATION, SMART GRIDS, SYNTHETIC DATA AND DIGITAL TWINS

- ❖ Changing Power-System Characteristics
  - Renewable-energy growth
  - Solar PV and wind integration
  - Distributed Energy Resources (DER)
  - Battery Energy Storage Systems (BESS)
  - Electric vehicles
  - Microgrids
  - Reduced system inertia
  - Bidirectional power flows
- ❖ Simulation of Renewable-Rich Networks
  - Modeling variable generation
  - Solar and wind profiles
  - Intermittency and uncertainty
  - Voltage impacts of distributed generation
  - Renewable curtailment
  - Storage dispatch
  - Grid-support functions
- ❖ GenAI for Renewable Integration Studies
  - Generating renewable operating scenarios
  - Creating synthetic solar and wind profiles
  - Simulating extreme operating conditions
  - AI-assisted renewable forecasting
  - Generating probabilistic scenarios
  - Assessing high-renewable penetration cases
- ❖ Synthetic Data Generation
  - Why synthetic data is useful
  - Limited and confidential utility datasets
  - Generating representative synthetic datasets
  - Preserving statistical and physical characteristics
  - Testing AI and simulation systems using synthetic data
  - Risks associated with unrealistic synthetic data
  - Validation against physical constraints
- ❖ Digital Twins and AI
  - Digital twin concepts
  - Physical versus virtual power-system models
  - Real-time and near-real-time simulation
  - SCADA/EMS data integration concepts
  - IoT and intelligent sensors
  - AI-supported digital twins
  - Predictive simulation and asset behavior
  - Potential applications in control centers
- ❖ AI for Grid Optimization
  - Voltage and reactive-power optimization
  - Generation dispatch

- Loss minimization
- Congestion management
- Storage scheduling
- Demand response
- Restoration scenario support

❖ Practical Exercises

❖ Renewable Integration Scenario

Participants develop an AI-assisted study involving:

- Variable renewable generation
- Changing system demand
- Battery storage
- Network constraints
- Multiple operating scenarios
- AI-generated recommendations
- Engineering validation of proposed actions

DAY FIVE:

GENAI AUTOMATION, GOVERNANCE, VALIDATION AND INTEGRATED SIMULATION PROJECT

❖ Automating Power-System Simulation

- AI-assisted Python development
- Connecting scripts with simulation workflows
- Batch simulation concepts
- Automated scenario creation
- Parameter sweeps
- Automated result extraction
- Data processing and visualization
- Generating engineering summaries

❖ Retrieval-Augmented Generation (RAG)

- Limitations of general-purpose LLM knowledge
- Connecting GenAI to approved engineering knowledge
- Using technical manuals and internal procedures
- Standards and controlled documentation
- RAG concepts for engineering organizations
- Reducing hallucination through grounded information

❖ AI Agents for Power-System Engineering

- From AI assistants to AI agents
- Multi-step simulation workflows
- Automated model preparation
- Simulation execution
- Result checking
- Report generation
- Human-in-the-loop approval
- Where autonomous AI should and should not be used

❖ GenAI Risks and Responsible Use

- AI hallucinations

- Incorrect electrical calculations
- False confidence in generated answers
- Data leakage and confidentiality
- Cybersecurity considerations
- Intellectual-property issues
- Model bias
- Regulatory and organizational requirements
- Responsible AI principles

❖ Verification and Validation Framework
- Never accepting AI output without verification
- Physics-based validation
- Cross-checking against simulation software
- Boundary and limit checking
- Comparing against historical results
- Sensitivity testing
- Documenting assumptions
- Human engineering approval

❖ Integrated Capstone Project – AI-Assisted Power System Simulation

❖ Participants work through an integrated power-system case study covering:
- Network-data preparation
- Base-case load flow
- Peak-load scenario
- Renewable-generation variation
- N-1 contingency
- Fault or disturbance scenario
- Voltage and loading assessment
- Dynamic-performance review
- AI-assisted scenario generation
- Automated analysis
- Identification of critical system conditions
- Development of mitigation recommendations
- AI-assisted technical report preparation
- Independent engineering verification

❖ Final Discussion: Implementing GenAI in Power Utilities
- Identifying high-value use cases
- Selecting appropriate GenAI tools
- Integration with existing simulation platforms
- Data-readiness assessment
- Building AI governance
- Training engineering teams
- Starting with controlled pilot projects
- Measuring productivity and engineering benefits
- Developing an organizational GenAI implementation roadmap

❖ Course Conclusion

- ❖ POST-ASSESSMENT and EVALUATION

Training Methodology:

This interactive training course includes the following training methodologies as a percentage of the total tuition hours:

- 30% Lectures, Concepts, Role Play
- 70% Workshops & Work Presentations, Techniques, Based on Case Studies & Practical Exercises, Gamification, Software & General Discussions
- Pre and Post Test

Training Certificate(s):

CMCT Internationally recognized certificate(s) will be issued to each participant who completed the course.

Training Fees:

AED 13, 000 per attendee, after discount (Abu Dhabi) - This rate includes participant's manual, hand-outs, buffet lunch, coffee/tea on arrival, morning & afternoon of each day.

Note: The 5% VAT (Value Added Tax), will be effective starting 01st of January 2018 as per the new regulation from the UAE Government. The VAT applies for all quotation both for local and abroad.

Training Timings:

Daily Timings:

07:45 - 08:00	Morning Coffee / Tea
08:00 - 10:00	First Session
10:00 - 10:20	Recess (Coffee/Tea/Snacks)
10:20 - 12:20	Second Session
12:20 - 13:00	Recess (Prayer Break & Lunch)
13:00 - 14:00	Last Session

For training registrations or in-house enquiries, please contact:
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