

Electrical Machines & Power Systems Track

Comprehensive Understanding & Simulation Expertise for Modern Power Systems

Agnes

Phase 1: Foundational Electrical Machines

Months 1: Core Principles of Transformers & DC Machines



Week 1: Intro to Electrical Machines & Magnetic Circuits

- Introduction to electromechanical energy conversion and the foundational principles of motor and generator action.
- Exploring magnetic circuits, their analogies to electric circuits, B-H curves, hysteresis, and eddy currents.

Energy Conversion

Magnetic Circuits

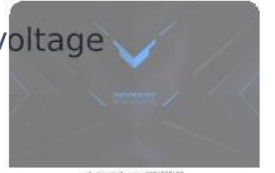


Week 2: Transformers - Construction & Testing

- Detailed study of transformer construction (core types, windings) and operation, including equivalent circuits and the per-unit system.
- Mastering OC/SC tests to determine parameters, voltage regulation, and efficiency.

Equivalent Circuit

OC & SC Tests



Week 3: DC Machines - Construction & Generators

- Understanding the physical construction of DC machines: field poles, armature, commutator, and brushes.
- Analyzing DC generator types (shunt, series, compound) and their no-load/load characteristics, including armature reaction.



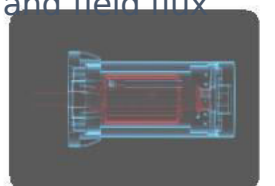
EMF Equation

DC Generators



Week 4: DC Machines - Motors & Control

- Studying various DC motor types and their essential speed-torque characteristics.
- Implementing speed control via armature voltage and field flux methods, plus starting and braking techniques.



Speed-Torque

Motor Control

Phase 1: AC Machines & Power Systems Basics

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Week 5



Induction Motors



Explore rotating magnetic fields, the principle of slip, and analyze torque-speed characteristics for industrial applications.

Rotating
Field

Slip
Theory

Torque
Curves

●
Week 6



Synchronous Machines



Understand alternator operations, voltage regulation, and the critical requirements for parallel grid operation and power factor correction.

Excitation

Power
Angle

Synchronization

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Week 7



Power Systems



Overview of generation sources, high-voltage transmission networks, substation functions, and low-voltage distribution systems.

Generation

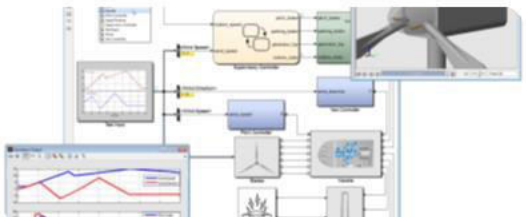
Transmission

Distribution

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Week 8



Fault Analysis & Protection



Differentiate fault types and learn the principles of protective relays and circuit breakers for maintaining system stability.

Short
Circuits

Protective
Relays

Resilience

Deep Dive: Fault Analysis & System Resilience

Importance of Simulation: Electrical machine simulations are necessary for design, control, analysis, and training of fault diagnostic

Benefits of Proactive Fault Simulation

Very High

Phase 2: Capstone Project Kick-off & Stability



Week 9: Foundation for Success

Welcome & Program Onboarding: Introduction to Phase 2 objectives, program structure, and expectations for the upcoming capstone journey.

Team Building & Collaboration: Facilitated sessions for group formation, understanding individual strengths, and establishing effective communication channels.

Team Synergy

Orientation

Collaboration



Advanced Power System Stability

System Dynamics & Stability Analysis: Deep dive into steady-state, transient, and dynamic stability, understanding factors affecting system equilibrium under disturbances.



Capstone Project: From Concept to Design



Project Selection Criteria: Overview of thematic areas including advanced machine control, smart grid solutions, and specialized fault analysis. Emphasis is placed on real-world relevance and innovative solutions.

Detailed Design Phase: Guidance on developing comprehensive project proposals, defining methodologies, outlining simulation setups, and planning the execution roadmap for a successful project outcome.

Leveraging Simulation Tools: Importance of utilizing advanced simulation tools (e.g., JMAG-RT, Simulink, ETAP) for design validation, performance prediction, and fault scenario testing.

Phase 2: Core Project Implementation



Option A: Motor Control Simulation



Modeling for Advanced Design

Focus on creating accurate digital twins of electrical machines for design, control, and fault analysis training. Explores dynamic models and FEM for detailed electromagnetic analysis.

Advanced Control Strategies

Delve into sophisticated algorithms like Field-Oriented Control (FOC) for precision, Direct Torque Control (DTC) for rapid response, and Model Predictive Control (MPC) for optimization.

Performance & Fault Analysis

Simulate motor behavior under various conditions to analyze efficiency, torque ripple, and response. Includes simulating breakdowns like phase loss and power supply loss.



Option B: Power Flow Analysis



Network Modeling & Representation

Build accurate models of power systems using bus-admittance/impedance matrices and single-line diagrams, essential for system engineers.

Load Flow Studies

Conduct simulations to determine steady-state conditions, analyzing voltage profiles, power flows, and losses using methods like Newton-Raphson.

Contingency & Security Analysis

Evaluate system resilience against disturbances (N-1 criterion) and simulate the impact of faults on voltage sag and stability using tools like Simulink.

Phase 2: Project Refinement & Advanced Scenarios



Week 11: Motor Control - Disturbance & Protection



Fault Simulation & Analysis:

Simulate motor breakdowns like phase loss and power supply loss. Analyze faults in IPM and induction motors using finite element techniques.

Protection Scheme Design:

Design protective relays and circuit breakers to ensure operational continuity and prevent damage during electrical or mechanical overloads.

Fault Detection

Motor Protection

Finite Element

JMAG-RT



Week 11: Power Flow - Short-Circuit & Stability



Advanced Fault Current Calculation:

Conduct detailed single-phase and three-phase fault simulations to determine fault current magnitudes and voltage sag characteristics.

Transient Stability Assessment:

Analyze the power system's ability to maintain synchronism after large disturbances, studying critical clearing time and power angle curves.

Short-Circuit

Voltage Sag

Grid Resilience

Dynamic Stability



Data Analysis & Visualization

Leverage MATLAB scripting to process large simulation datasets and generate high-quality visualizations for clear interpretation.

MATLAB

Data Interpretation



Optimization Techniques

Apply algorithms to enhance energy efficiency, improve stability margins, and maximize system reliability under varying conditions.

Efficiency

Reliability

Performance

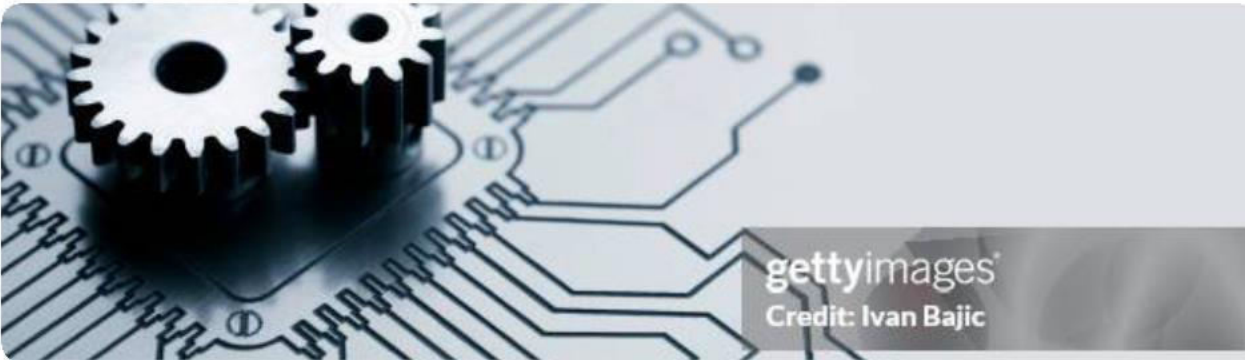
Strategic Impact of Advanced Scenario Capabilities

These capabilities directly contribute to addressing complex real-world engineering challenges.

Phase 2: Project Showcase & Career Launchpad



Week 12: Final Project Presentation & Documentation



Program Culmination: This week marks the pinnacle of the program. Participants present their capstone projects, showcasing mastery of electrical machines, power systems, and innovative problem-solving.

Effective Communication: Develop clear, compelling presentation skills to articulate complex technical solutions and structure your project narrative for maximum impact, from detailed documentation to engaging visuals.

Real-World Relevance: Emphasize the practical applications and potential industry contributions of your solutions, demonstrating your readiness for professional engineering roles.

Capstone Showcase

Technical Documentation

Professional Presentation

Innovation Display



Resume & Portfolio Building

Craft impactful resumes and portfolios that highlight your simulation expertise and analytical skills, providing tangible proof of your capabilities.

Professional Resumes

Project Showcase



LinkedIn & Networking

Optimize your LinkedIn profile and learn strategies to connect with industry professionals, enhancing your visibility and uncovering job opportunities.

Online Professionalism

Industry Connections



Mock Interviews

Participate in realistic technical and behavioral interviews with industry experts to receive personalized feedback and build confidence.

Interview Preparedness

Expert Feedback

Program Completion & Certification



Equipping You for Success

Your program emphasized hands-on simulation and analysis, preparing you for immediate contribution. You've gained experience with realistic, scenario-based learning platforms using industrial-standard software, mirroring real-world engineering environments.

The program has provided you with skills in "design, control, analysis, and training of fault diagnostic algorithms," making you a versatile and valuable asset.

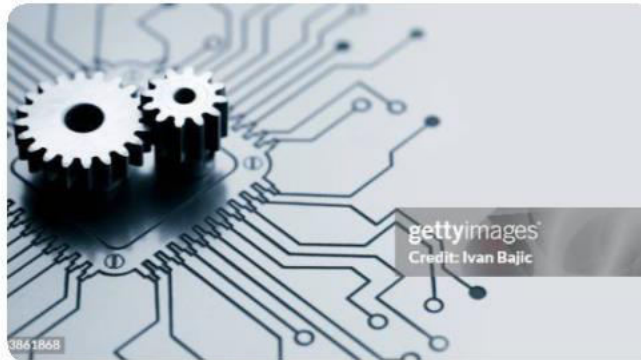
Practical Application

Industry Alignment

Problem Solvers



Graduation & Certification



This marks the culmination of your intensive journey. You've mastered critical simulation techniques and applied theory to real-world challenges.

Receive your official certification, a testament to your acquired skills. This credential validates your expertise and serves as a significant asset for your professional career.

Formal Recognition

Expertise Validation

Industry Ready



Your Future in Power Systems



Your comprehensive understanding spans from power flow analysis to system dynamics. The global energy transition means a growing demand for skilled engineers like you.

You are ready to contribute to grid modernization, renewable energy integration, and ensuring the reliability of our electrical infrastructure.

Energy Transition

Grid Modernization

Reliability Focus