COURSE OVERVIEW EE1200
Frequency Regulation & Ancillary Services

Course Title
Frequency Regulation & Ancillary Services

Course Date/Venue
December 07-11, 2026/Albatross Meeting Room, VOGO Abu Dhabi Golf Resort & Spa Formerly Westin Abu Dhabi Golf Resort & Spa, Abu Dhabi, UAE

Course Reference
EE1200

Course Duration/Credits
Five days/3.0 CEUs/30 PDHs

Course Description

This practical and highly-interactive course includes various practical sessions and exercises. Theory learnt will be applied using our state-of-the-art simulators.

This course is designed to provide participants with a detailed and up-to-date overview of Frequency Regulation & Ancillary Services. It covers the power system frequency, basics of power system dynamics, swing equation and frequency response; the types of frequency control, load-frequency control (LFC) and ancillary services; the governor control mechanisms, primary frequency control and secondary frequency control (AGC); the area control error (ACE), frequency control in multi-area systems and performance metrics for frequency control; and the ancillary services, spinning reserve and fast response.

During this interactive course, participants will learn the non-spinning and supplemental reserves, market-based ancillary services and frequency regulation markets; the role of system operators (ISO/TSO), impact of renewable energy on frequency and energy storage in frequency regulation; the demand response in frequency control, synthetic inertia, grid-forming inverters and wide-area monitoring for frequency stability; the advanced control techniques, implementation of ancillary services and performance evaluation and optimization; and the high renewable penetration grids, decentralized energy systems, AI-driven grid control and digital twin applications.

Course Objectives/Outcomes & Benefits for the Participants

Upon the successful completion of this course, each participant will be able to:-

- Apply and gain an in-depth knowledge on frequency regulation and ancillary services
- Discuss power system frequency, basics of power system dynamics and swing equation and frequency response
- Identify types of frequency control, load-frequency control (LFC) and ancillary services
- Recognize governor control mechanisms, primary frequency control and secondary frequency control (AGC)
- Discuss area control error (ACE), frequency control in multi-area systems and performance metrics for frequency control
- Classify ancillary services and apply spinning reserve and fast response
- Identify non-spinning and supplemental reserves, market-based ancillary services and frequency regulation markets
- Discuss the role of system operators (ISO/TSO), impact of renewable energy on frequency and energy storage in frequency regulation
- Apply demand response in frequency control, synthetic inertia and grid-forming inverters and wide-area monitoring for frequency stability
- Employ advanced control techniques, implementation of ancillary services and performance evaluation and optimization
- Discuss high renewable penetration grids, decentralized energy systems, AI-driven grid control and digital twin applications

Exclusive Smart Training Kit - H-STK®

*Participants of this course will receive the exclusive "Haward Smart Training Kit" (**H-STK®**). The **H-STK®** consists of a comprehensive set of technical content which includes **electronic version** of the course materials conveniently saved in a **Tablet PC**.*

Who Should Attend

This course provides an overview of all significant aspects and considerations of frequency regulation and ancillary services for grid operation and control engineers, transmission system operators (TSOS), independent system operator (ISO) personnel, load dispatch center operators, power system engineers, protection and control engineers, SCADA/EMS engineers, renewable energy integration engineers, energy storage and battery system engineers, smart grid and automation engineers, generation planning engineers, power market and ancillary service specialists, electrical utility professionals, consultants in energy and power infrastructure, regulatory and policy professionals in electricity markets, researchers and academics in power systems and other technical staff.

Course Certificate(s)

Internationally recognized certificates will be issued to all participants of the course who completed a minimum of 80% of the total tuition hours

Certificate Accreditations

Haward's certificates are accredited by the following international accreditation organizations:

- British Accreditation Council (BAC)

  Haward Technology is accredited by the **British Accreditation Council** for **Independent Further and Higher Education** as an **International Centre**. Haward's certificates are internationally recognized and accredited by the British Accreditation Council (BAC). BAC is the British accrediting body responsible for setting standards within independent further and higher education sector in the UK and overseas. As a BAC-accredited international centre, Haward Technology meets all of the international higher education criteria and standards set by BAC.

- The International Accreditors for Continuing Education and Training (IACET - USA)

  Haward Technology is an Authorized Training Provider by the International Accreditors for Continuing Education and Training (IACET), 2201 Cooperative Way, Suite 600, Herndon, VA 20171, USA. In obtaining this authority, Haward Technology has demonstrated that it complies with the **ANSI/IACET 2018-1 Standard** which is widely recognized as the standard of good practice internationally. As a result of our Authorized Provider membership status, Haward Technology is authorized to offer IACET CEUs for its programs that qualify under the **ANSI/IACET 2018-1 Standard**.

  Haward Technology's courses meet the professional certification and continuing education requirements for participants seeking **Continuing Education Units** (CEUs) in accordance with the rules & regulations of the International Accreditors for Continuing Education & Training (IACET). IACET is an international authority that evaluates programs according to strict, research-based criteria and guidelines. The CEU is an internationally accepted uniform unit of measurement in qualified courses of continuing education.

  Haward Technology Middle East will award **3.0 CEUs** (Continuing Education Units) or **30 PDHs** (Professional Development Hours) for participants who completed the total tuition hours of this program. One CEU is equivalent to ten Professional Development Hours (PDHs) or ten contact hours of the participation in and completion of Haward Technology programs. A permanent record of a participant's involvement and awarding of CEU will be maintained by Haward Technology. Haward Technology will provide a copy of the participant's CEU and PDH Transcript of Records upon request.

Course Fee

US$ 5,500 per Delegate + **VAT**. This rate includes H-STK® (Haward Smart Training Kit), buffet lunch, coffee/tea on arrival, morning & afternoon of each day.

Course Instructor(s)

This course will be conducted by the following instructor(s). However, we have the right to change the course instructor(s) prior to the course date and inform participants accordingly:

Dr. Ahmed El-Sayed, PhD, MSc, BSc, is a **Senior Electrical & Instrumentation Engineer** with over **30 years** of extensive experience in the **Power**, **Petroleum**, **Petrochemical** and **Utilities**. He specializes in **Circuit Breaker**, **Breaker** Replacement Strategy, Digitalization & **Smart Breakers**, Advanced Arc Quenching Technology, **Circuit Breaker** in Petroleum Facilities, **Breaker** Failures & Protection, Electrical Testing of **Circuit Breaker, HV/LV Equipment**, **High Voltage Electrical Safety**, **LV & HV Electrical System**, **HV Equipment's Inspection & Maintenance**, **HV Switchgear Operation & Maintenance**, **LV Distribution Switchgear & Equipment**, **HV Switchgear Maintenance**, **HV/LV Electrical** Authorization, **Hazardous Area Classification, Power Quality**, **Disturbance Analysis**, **Blackout**, **Power Network**, **Power Distribution**, Power System **Frequency**, **Swing Equation & Frequency** Response, Load-Frequency Control (**LFC**), Primary & Secondary **Frequency Control**, Classification of **Ancillary Services**, **Power Systems Control**, **Power Systems Security**, Power System **Dynamics**, Power **Electronics**, **ETAP**, Electrical **Substations**, Tariff Design & Structure Analysis, **Engineering Drawings, Codes & Standards**, **P&ID Reading, Interpretation & Developing**, **PLC**, **SCADA**, **DCS**, **Process Control**, **Instrumentation**, **Automation**, Power **Generation**, **Process Control Instrumentation**, **SIS**, **SIL**, **ESD**, **Alarm Management Systems**, **Fieldbus Systems** and **Fiber Optics** as well as the service pricing of these. He is currently the **Systems Control Manager** of **Siemens** where he is in-charge of Security & Control of Power **Transmission Distribution** & **High Voltage** Systems and he further takes part in the Load Records Evaluation & Transmission Services Pricing.

During his career life, Dr. Ahmed has been actively involved in different Power System Activities including Roles in Power System Planning, Analysis, Engineering, **HV Substation** Design, Electrical Service Pricing, Evaluations & Tariffs, Project Management and also in Teaching and Consulting. His vast industrial experience was honed greatly when he joined many International and National Companies such as **Siemens**, **Electricity Authority** and **ACETO** industries where he focused more on dealing with Technology Transfer, System Integration Process and Improving Localization. He was further greatly involved in manufacturing some of **Power System** and **Control & Instrumentation Components** such as Series of Digital Protection **Relays**, MV **VFD**, **PLC** and **SCADA** System with intelligent features.

Dr. Ahmed is well-versed in different electrical and instrumentation fields like Load Management Concepts, **PLC** Programming, Installation, Operation and Troubleshooting, **AC Drives** Theory, Application and Troubleshooting, Industrial Power Systems Analysis, AC & DC **Motors**, Electric Motor **Protection**, **DCS SCADA**, **Control** and Maintenance Techniques, Industrial Intelligent Control System, **Power Quality** Standards, Power Generators and Voltage Regulators, Circuit Breaker and Switchgear Application and Testing Techniques, **Transformer** and **Switchgear** Application, Grounding for Industrial and Commercial Assets, Power Quality and **Harmonics**, **Protective Relays** (O/C Protection, Line Differential, Bus Bar Protection and **Breaker Failure Relay**) and Project Management Basics (PMB).

Dr. Ahmed has **PhD**, **Master's** & **Bachelor's** degree in **Electrical** and **Instrumentation Engineering** from the **University of Wisconsin Madison**, **USA**. Further, he has numerous papers published internationally in the areas of Power Quality, Superconductive Magnetic Energy Storage, SMES role in Power Systems, Power System **Blackout** Analysis, and Intelligent Load Shedding Techniques for preventing Power System Blackouts, HV **Substation Automation** and Power System Stability.

Training Methodology

All our Courses are including **Hands-on Practical Sessions** using equipment, State-of-the-Art Simulators, Drawings, Case Studies, Videos and Exercises. The courses include the following training methodologies as a percentage of the total tuition hours:-

30% Lectures
20% Practical Workshops & Work Presentations
30% Hands-on Practical Exercises & Case Studies
20% Simulators (Hardware & Software) & Videos

In an unlikely event, the course instructor may modify the above training methodology before or during the course for technical reasons.

Learning Design & Customization

This course can be customized to the exact requirements of clients. Haward Technology is so proud of our huge capabilities in tailoring our courses to the training needs of our valued clients.

Accommodation

Accommodation is not included in the course fees. However, any accommodation required can be arranged at the time of booking.

Course Program

The following program is planned for this course. However, the course instructor(s) may modify this program before or during the workshop for technical reasons with no prior notice to participants. Nevertheless, the course objectives will always be met:

Day 1: ***Monday, 07th of December 2026***

0730 – 0800	*Registration & Coffee*
0800 – 0815	*Welcome & Introduction*
0815 – 0830	***PRE-TEST***
0830 – 0930	***Introduction to Power System Frequency*** *Definition and Significance of System Frequency • Relationship Between Generation and Load Balance • Frequency Standards (50 Hz / 60 Hz) • Consequences of Frequency Deviations*
0930 – 0945	*Break*
0945 – 1030	***Basics of Power System Dynamics*** *Inertia and Kinetic Energy in Generators • Role of Synchronous Machines • Frequency Response Characteristics • Impact of Disturbances*
1030 – 1130	***Swing Equation & Frequency Response*** *Relationship Between Power Imbalance and Frequency Change • Inertia Constant and System Response • Frequency Nadir Concept • Time-Domain Response*
1130 – 1215	***Types of Frequency Control*** *Primary Frequency Control (Governor Response) • Secondary Control (AGC) • Tertiary Control (Economic Dispatch) • Time Scales of Control Actions*

1215 – 1230	*Break*
1230 – 1330	***Load-Frequency Control (LFC)*** *Single-Area LFC • Multi-Area LFC • Area Control Error (ACE) • Tie-Line Power Control*
1330 – 1420	***Ancillary Services*** *Definition and Purpose • Types of Ancillary Services • Role in Grid Reliability • Market versus Regulated Environments*
1420 – 1430	***Recap*** *Using this Course Overview, the Instructor(s) will Brief Participants about the Topics that were Discussed Today and Advise Them of the Topics to be Discussed Tomorrow*
1430	*Lunch & End of Day One*

Day 2: ***Tuesday, 08th of December 2026***

0730 – 0830	***Governor Control Mechanisms*** *Speed Governor Operation • Droop Characteristics • Frequency-Power Relationship • Governor Response Curves*
0830 – 0930	***Primary Frequency Control*** *Automatic Response to Disturbances • Droop Settings and Tuning • Contribution from Different Generators • Limitations of Primary Control*
0930 – 0945	*Break*
0945 – 1100	***Secondary Frequency Control (AGC)*** *Automatic Generation Control (AGC) Principles • Frequency Restoration • Tie-Line Bias Control • Centralized versus Decentralized AGC*
1100 – 1215	***Area Control Error (ACE)*** *Definition and Calculation • Components of ACE • Role in System Balancing • Minimizing ACE*
1215 – 1230	*Break*
1230 – 1330	***Frequency Control in Multi-Area Systems*** *Interconnected Grid Operation • Power Exchange Between Areas • Coordinated Control Strategies • Stability Considerations*
1330 – 1420	***Performance Metrics for Frequency Control*** *Frequency Deviation Limits • Control Performance Standards (CPS1, CPS2) • Response Time Metrics • Reliability Indicators*
1420 – 1430	***Recap*** *Using this Course Overview, the Instructor(s) will Brief Participants about the Topics that were Discussed Today and Advise Them of the Topics to be Discussed Tomorrow*
1430	*Lunch & End of Day Two*

Day 3: ***Wednesday, 09th of December 2026***

0730 – 0830	***Classification of Ancillary Services*** *Frequency Regulation Services • Spinning and Non-Spinning Reserves • Voltage Support • Black Start Capability*
0830 – 0930	***Spinning Reserve & Fast Response*** *Definition and Requirements • Role in Contingency Handling • Activation Mechanisms • Response Time Criteria*
0930 – 0945	*Break*
0945 – 1100	***Non-Spinning & Supplemental Reserves*** *Characteristics and Applications • Deployment Strategies • Coordination with Spinning Reserves • Reliability Contributions*

1100 – 1215	***Market-Based Ancillary Services*** *Electricity Market Structures • Bidding and Pricing Mechanisms • Capacity versus Energy Markets • Settlement Processes*
1215 – 1230	*Break*
1230 – 1330	***Frequency Regulation Markets*** *Regulation Up and Down Services • Pay-for-Performance Mechanisms • Market Participation • Incentives and Penalties*
1330 – 1420	***Role of System Operators (ISO/TSO)*** *Grid Balancing Responsibilities • Scheduling and Dispatch • Market Clearing • Reliability Enforcement*
1420 – 1430	***Recap*** *Using this Course Overview, the Instructor(s) will Brief Participants about the Topics that were Discussed Today and Advise Them of the Topics to be Discussed Tomorrow*
1430	*Lunch & End of Day Three*

Day 4: Thursday, 10th of December 2026

0730 – 0830	***Impact of Renewable Energy on Frequency*** *Reduced System Inertia • Variability and Uncertainty • Frequency Volatility • Need for Fast-Response Resources*
0830 – 0930	***Energy Storage in Frequency Regulation*** *Battery Energy Storage Systems (BESS) • Fast Frequency Response (FFR) • Charging/Discharging Strategies • Market Participation*
0930 – 0945	*Break*
0945 – 1100	***Demand Response in Frequency Control*** *Load Participation in Regulation • Demand-Side Management • Aggregated Loads • Incentive-Based Programs*
1100 – 1215	***Synthetic Inertia & Grid-Forming Inverters*** *Concept of Synthetic Inertia • Inverter-Based Resource Behavior • Grid-Forming versus Grid-Following • Control Strategies*
1215 – 1230	*Break*
1230 – 1330	***Wide-Area Monitoring for Frequency Stability*** *PMU-Based Frequency Measurement • Real-Time Monitoring • Early Warning Systems • Integration with Control Systems*
1330 – 1420	***Advanced Control Techniques*** *Model Predictive Control (MPC) • Adaptive Control Methods • AI-Based Frequency Control • Decentralized Control Approaches*
1420 – 1430	***Recap*** *Using this Course Overview, the Instructor(s) will Brief Participants about the Topics that were Discussed Today and Advise Them of the Topics to be Discussed Tomorrow*
1430	*Lunch & End of Day Four*

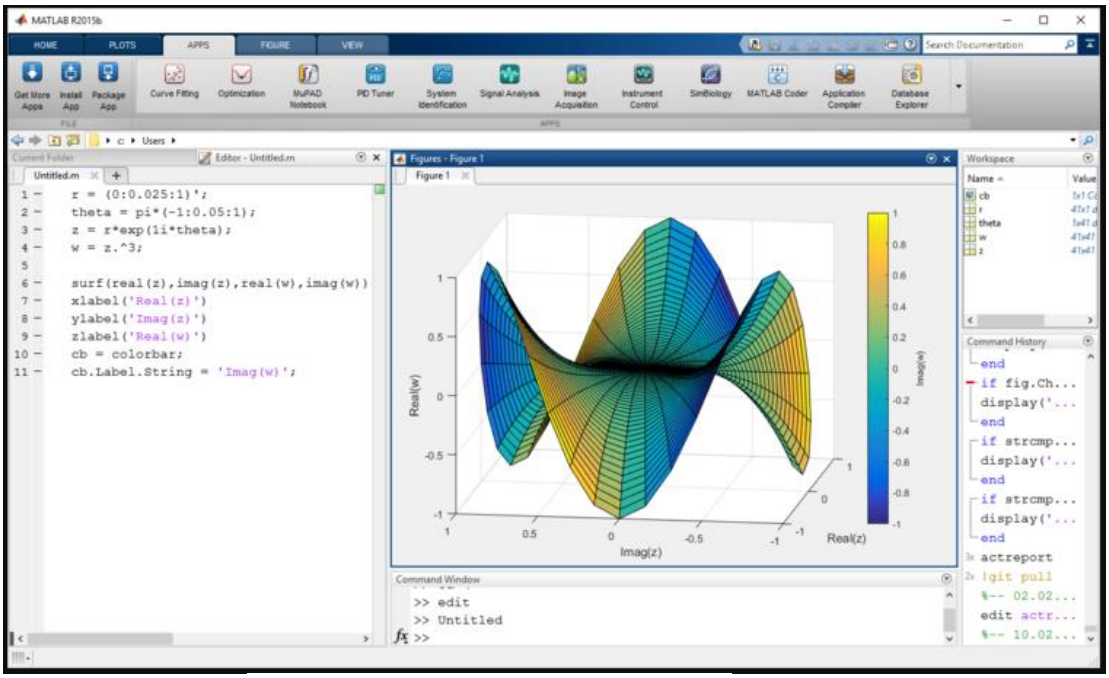
Day 5: Friday, 11th of December 2026

0730 – 0830	***Case Studies of Frequency Disturbances*** *Major Blackout Events • Frequency Collapse Scenarios • Root Cause Analysis • Lessons learned*
0830 – 0930	***Implementation of Ancillary Services*** *Utility-Scale Implementation • Coordination Among Generators • Integration with EMS/SCADA • Operational Challenges*

0930 – 0945	*Break*
0945 – 1100	***Software Tools & Simulation*** *MATLAB/Simulink • DIgSILENT PowerFactory • PSS/E • Modeling Frequency Response*
1100 – 1215	***Performance Evaluation & Optimization*** *Evaluating Frequency Response • Improving Control Strategies • Optimization Techniques • Continuous Monitoring*
1215 – 1230	*Break*
1230 – 1300	***Future Trends in Frequency Regulation*** *High Renewable Penetration Grids • Decentralized Energy Systems • AI-Driven Grid Control • Digital Twin Applications*
1300 - 1345	***Capstone Project & Evaluation*** *Modeling a Frequency Control System • Designing Ancillary Service Strategy • Analyzing System Response • Presenting Recommendations*
1345– 1400	***Course Conclusion*** *Using this Course Overview, the Instructor(s) will Brief Participants about the Course Topics that were Covered During the Course*
1400 – 1415	***POST-TEST***
1415 – 1430	*Presentation of Course Certificates*
1430	*Lunch & End of Course*

Simulator (Hands-on Practical Sessions)

Practical sessions will be organized during the course for delegates to practice the theory learnt. Delegates will be provided with an opportunity to carryout various exercises using our state-of-the-art simulator "MATLAB".



MATLAB Simulator

Course Coordinator

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