

**COURSE OVERVIEW EE1200**  
**Frequency Regulation & Ancillary Services**

**Course Title**

Frequency Regulation & Ancillary Services

**Course Date/Venue**

December 07-11, 2026/Al Hosn Suite, Le Royal Méridien Abu Dhabi, 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:

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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.

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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. Mike Tay**, PhD, MSc, BSc, is a **Senior Electrical, Instrumentation & Communications Engineer** with over **30 years** of extensive experience. His expertise widely covers **Power Management System (PMS)**, **Interruptible Power Systems (UPS)**, **Power System**, **Power Supply Design Management**, **Power System Faults**, **Current & Voltage Transformers**, **Power System Neutral Grounding**, **Protective Devices Troubleshooting**, **Protective Devices Testing & Maintenance**, **Power Flow Control**, **Frequency Regulation & Ancillary Services**, **Uninterruptible Power Supply (UPS) Design**, **Industrial UPS Systems & Battery Power Supplies Maintenance & Troubleshooting**, **UPS & Battery System**, **Battery & Battery Charger & UPS and Measurement Devices**, **UPS System & Battery Chargers Maintenance & Troubleshooting**, **UPS & Battery Design**, **Operation, Maintenance & Troubleshooting**, **UPS Operation & Alarm Panel Reading**, **Process Control & Instrumentation**, **Process Control Troubleshooting & Problem Solving**, **Process Control System**, **Advanced Process Control (APC) Technology**, **Process Control & Loop Tuning**, **Process Control & Automation**, **Data Accuracy & System Function**, **Control System Interface**, **Artificial Intelligence Application**, **Data Analytics and its Importance**, **AI is Used in Exploration and Production**, **AI for Reservoir Management**, **Distributed Control Systems (DCS)**, **Programmable Logic Controller (PLC)**, **Supervisory Control and Data Acquisition (SCADA)**, **Network Comprehensive**, **Systems Analysis**, **SCADA Security**, **ESD System Function**, **Analysis & Control**, **Modern Power Systems Protective Relaying**, **Custody Measurement & Loss Control**, **Fiber Optics Access Network Planning**, **Process Analyzer & Analytical Instrumentation**, **HV/MV Substation Design & Maintenance**, **Combined Cycle Power Generation**, **PLC & SCADA Automation**, **Advanced Online Analyzer**, **Protection Relay Maintenance**, **Feeder Overcurrent Protection**, **Electrical Protection Systems**, **Bus Protection**, **Motor Protection**, **Transformer Protection**, **Generator Protection**, **Numerical Relays**, **ESD System Analysis & Control**, **Custody Measurement**, **Safety Instrumented System (SIS)**, **Safety Integrity Level (SIL)**, **Diesel Generator**, **Electric Motors** and **Basic Electricity & Electrical Codes**. Further, he is also well-versed in **Communications**, **Telecommunications**, **Mobile Protocols**, **4G LTE**, **GSM/UMTS**, **CMDA2000**, **WIMAX Technology**, **HSPA+**, **Alarm Management System**, **Computer Architecture**, **Logic & Microprocessor Design**, **Embedded Systems Design** plus **Computer Networking with CISCO**, **Network Communication**, **Industrial Digital Communication**, **Designing Telecommunications Distribution System**, **Electrical Engineering**, **WIMAX Broadband Wireless System**, **TT Intranet & ADSL Network**, **TT Web & Voicemail**, **Off-site ATM Network**, **IT Maintenance**, **Say2000i**, **IP Phone**, **National Address & ID Automation**, **Electricity Distribution Network**, **Customs Network & Maintenance**, **LAN & WAN Network**, **UYAP Network**, **Network Routing Protocols**, **Multicast Protocols**, **Network Management Protocols**, **Mobile & Wireless Networks** and **Digital Signal Processing**.

During his career life, Dr. Tay worked with various universities and institutions such as the KOC Sistem, Meteksan Sistem, Altek BT, Yasar University, Dokuz Eylul University and METU and occupied significant positions being the **Aegean Region Manager**, **Group Leader**, **Technical Services Manager**, **Field Engineer**, **Instrumentation & Control Engineer**, **Research Assistant**, **Instructor**, **Instrumentation & Control Instructor**, **Technical Advisor**, **Technical Consultant** and **Senior Instructor/Lecturer**.

Dr. Tay has **PhD**, **Master** and **Bachelor** degrees in **Electrical & Electronics Engineering** from the **Dokuz Eylul University** and the **Middle East Technical University (METU)** respectively. Further, he is a **Certified Instructor/Trainer**, a **Certified Internal Verifier/Assessor/Trainer** by the **Institute of Leadership & Management (ILM)**, a **Certified CISCO (CCSP, CCDA, CCNP, CCNA, CCNP) Specialist**, a **Certified CISCO IP Telephony Design Specialist**, **CISCO Rich Media Communications Specialist**, **CISCO Security Solutions & Design Specialist** and **Information Systems Security (INFOSEC) Professional**. He has further hold certification in **Fundamentals of Process Control** and **Understanding Process Control: An Overview** and delivered and presented innumerable trainings, courses, workshops, seminars and conferences worldwide.

**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. Howard 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, 07<sup>th</sup> of December 2026**

0730 – 0800	Registration & Coffee
0800 – 0815	Welcome & Introduction
0815 – 0830	<b>PRE-TEST</b>
0830 – 0930	<b>Introduction to Power System Frequency</b> 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	<b>Basics of Power System Dynamics</b> Inertia and Kinetic Energy in Generators • Role of Synchronous Machines • Frequency Response Characteristics • Impact of Disturbances
1030 – 1130	<b>Swing Equation &amp; Frequency Response</b> Relationship Between Power Imbalance and Frequency Change • Inertia Constant and System Response • Frequency Nadir Concept • Time-Domain Response
1130 – 1215	<b>Types of Frequency Control</b> Primary Frequency Control (Governor Response) • Secondary Control (AGC) • Tertiary Control (Economic Dispatch) • Time Scales of Control Actions

1215 – 1230	Break
1230 – 1330	<b>Load-Frequency Control (LFC)</b> Single-Area LFC • Multi-Area LFC • Area Control Error (ACE) • Tie-Line Power Control
1330 – 1420	<b>Ancillary Services</b> Definition and Purpose • Types of Ancillary Services • Role in Grid Reliability • Market versus Regulated Environments
1420 – 1430	<b>Recap</b> 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, 08<sup>th</sup> of December 2026**

0730 – 0830	<b>Governor Control Mechanisms</b> Speed Governor Operation • Droop Characteristics • Frequency-Power Relationship • Governor Response Curves
0830 – 0930	<b>Primary Frequency Control</b> Automatic Response to Disturbances • Droop Settings and Tuning • Contribution from Different Generators • Limitations of Primary Control
0930 – 0945	Break
0945 – 1100	<b>Secondary Frequency Control (AGC)</b> Automatic Generation Control (AGC) Principles • Frequency Restoration • Tie-Line Bias Control • Centralized versus Decentralized AGC
1100 – 1215	<b>Area Control Error (ACE)</b> Definition and Calculation • Components of ACE • Role in System Balancing • Minimizing ACE
1215 – 1230	Break
1230 – 1330	<b>Frequency Control in Multi-Area Systems</b> Interconnected Grid Operation • Power Exchange Between Areas • Coordinated Control Strategies • Stability Considerations
1330 – 1420	<b>Performance Metrics for Frequency Control</b> Frequency Deviation Limits • Control Performance Standards (CPS1, CPS2) • Response Time Metrics • Reliability Indicators
1420 – 1430	<b>Recap</b> 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, 09<sup>th</sup> of December 2026**

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



1100 – 1215	<b>Market-Based Ancillary Services</b> Electricity Market Structures • Bidding and Pricing Mechanisms • Capacity versus Energy Markets • Settlement Processes
1215 – 1230	Break
1230 – 1330	<b>Frequency Regulation Markets</b> Regulation Up and Down Services • Pay-for-Performance Mechanisms • Market Participation • Incentives and Penalties
1330 – 1420	<b>Role of System Operators (ISO/TSO)</b> Grid Balancing Responsibilities • Scheduling and Dispatch • Market Clearing • Reliability Enforcement
1420 – 1430	<b>Recap</b> 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, 10<sup>th</sup> of December 2026**

0730 – 0830	<b>Impact of Renewable Energy on Frequency</b> Reduced System Inertia • Variability and Uncertainty • Frequency Volatility • Need for Fast-Response Resources
0830 – 0930	<b>Energy Storage in Frequency Regulation</b> Battery Energy Storage Systems (BESS) • Fast Frequency Response (FFR) • Charging/Discharging Strategies • Market Participation
0930 – 0945	Break
0945 – 1100	<b>Demand Response in Frequency Control</b> Load Participation in Regulation • Demand-Side Management • Aggregated Loads • Incentive-Based Programs
1100 – 1215	<b>Synthetic Inertia &amp; Grid-Forming Inverters</b> Concept of Synthetic Inertia • Inverter-Based Resource Behavior • Grid-Forming versus Grid-Following • Control Strategies
1215 – 1230	Break
1230 – 1330	<b>Wide-Area Monitoring for Frequency Stability</b> PMU-Based Frequency Measurement • Real-Time Monitoring • Early Warning Systems • Integration with Control Systems
1330 – 1420	<b>Advanced Control Techniques</b> Model Predictive Control (MPC) • Adaptive Control Methods • AI-Based Frequency Control • Decentralized Control Approaches
1420 – 1430	<b>Recap</b> 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

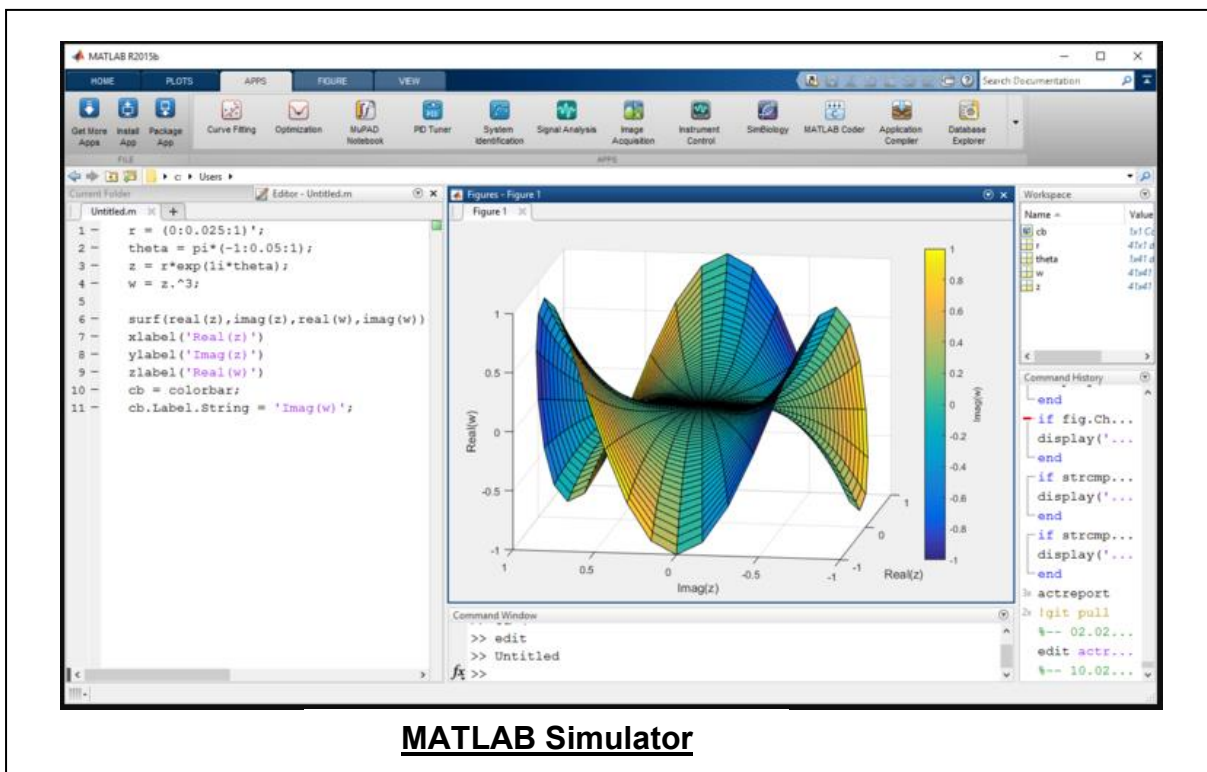
**Day 5: Friday, 11<sup>th</sup> of December 2026**

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

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



### **Course Coordinator**

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