COURSE OVERVIEW EE0099
Harmonics in Equipment

Course Title
Harmonics in Equipment

Course Date/Venue
Session 1: July 20-24, 2025/Boardroom 1, Elite Byblos Hotel Al Barsha, Sheikh Zayed Road, Dubai, UAE
Session 2: December 22-26, 2025/Fujairah Meeting Room, Grand Millennium Al Wahda Hotel, Abu Dhabi, UAE

3.0 CEUs (30 PDHs) AWARD

Course Reference
EE0099

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

Course Description

This practical and highly-interactive course includes real-life case studies and exercises where participants will be engaged in a series of interactive small groups and class workshops.

Power system harmonics are defined as sinusoidal voltage and currents at frequencies that are integer multiples of the main generated (or fundamental) frequency. They constitute the major distorting components of the mains voltage and load current waveforms. However, the increasing content of power system inter-harmonics such as distorting components at frequencies that are not integer multiples of the fundamental has prompted a need to give them greater attention.

Most countries have in the past developed their own harmonic standards or recommendations to suit local conditions. However, with the growth of global trade, the need for equipment manufactured in one country to comply with standards in another has prompted concerted effort in formulating international standards on harmonics and inter-harmonics.

This course is designed to provide participants with a detailed and up-to-date knowledge of power system harmonics. It covers the factors influencing the development of standards; existing harmonic standards and general harmonic indices; harmonic analysis; discrete fourier transform (DFT); the nyquist frequency and aliasing; fast fourier transform (FFT); window function; efficiency of FFT algorithms; and alternative transforms.

At the completion of the course, participants will be able to identify the harmonics sources and the effects of harmonic distortion; illustrate harmonic monitoring and harmonic elimination; compute harmonic flows through direct harmonic analysis, derivation of network harmonic impedances from field tests, transmission line models, underground and submarine cables, three-phase transformer models, generator modeling, shunt and series elements, distribution system modeling, load models and computer implementation; and carryout advanced harmonic assessment covering transformer function model, iterative harmonic analysis (IHA), harmonic power flow, harmonic state estimation and the electromagnetic transients solution.

Course Objectives

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

- Apply and gain an in-depth knowledge on power system harmonics
- Discuss the mechanism of harmonic generation and define the factors influencing the development of standards, existing harmonic standards and general harmonic indices
- Recognize harmonic analysis covering fourier series and coefficients, simplifications resulting from waveform symmetry, complex form of the fourier series, convolution of harmonic phasors, the fourier transform and sampled time function
- Describe discrete fourier transform (DFT), the nyquist frequency and aliasing, fast fourier transform (FFT), window function, efficiency of FFT algorithms and alternative transforms
- Identify the harmonics sources and the effects of harmonic distortion
- Illustrate harmonic monitoring and harmonic elimination
- Compute harmonic flows through direct harmonic analysis, derivation of network harmonic impedances from field tests, transmission line models, underground and submarine cables, three-phase transformer models, generator modeling, shunt and series elements, distribution system modeling, load models and computer implementation
- Carryout advanced harmonic assessment covering transformer function model, iterative harmonic analysis (IHA), harmonic power flow, harmonic state estimation and the electromagnetic transients solution

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 a complete and up-to-date overview of power system harmonics for operations engineers, production engineers, standard engineers, instrumentation engineers, electrical engineers, utility specialists and senior electrical technical staff who wish to advise end-users on power quality concerns, those who service large end-users or who wish to understand the aspects of network design, construction and maintenance techniques for maximizing quality of supply. Personnel working in all areas of power system design who wish to know how the system interacts with the end-user will also gain from this course.

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.

Accommodation

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

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.

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
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**. 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)

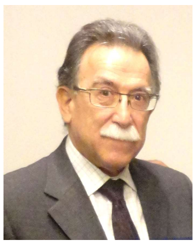
  Haward Technology is an Authorized Training Provider by the International Accreditors for Continuing Education and Training (IACET), 2201 Cooperative Way, Suite 600, Herndon, VA 20171, USA. In obtaining this authority, Haward Technology has demonstrated that it complies with the **ANSI/IACET 2018-1 Standard** 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 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:



Mr. Pan Marave, PE, MSc, BEng, is a **Senior Electrical & Instrumentation Engineer** with over **40 years** of extensive experience in **Oil**, **Gas**, **Petrochemical**, **Refinery** & **Power** industries. His expertise includes **Circuit Breaker**, **HV Switchgear Maintenance**, **HV/LV Electrical** Authorisation, Basic **Electricity**, **Electrical & Special Hazards**, **Personnel Protection**, **HV/LV Equipment**, **Motor Controllers**, **Electrical Switching** Practices, **Emergency Planning**, **Safety Management**, Safety Instrumented Systems (**SIS**), Safety Integrity Level (**SIL**), Emergency Shutdown (**ESD**); **DCS**, **SCADA** & **PLC**; **Measurement** (**Flow**, **Temperature**, **Pressure**); **Process Analyzers** & **Analytical Instrumentation**; **Process Control**, **Instrumentation** & **Safeguarding**; **Process Controller**, **Control Loop & Valve Tuning**; Industrial **Distribution Systems**; Industrial **Control & Control Systems**, Power Systems **Protection & Relaying**; **Earthing**, **Bonding**, **Grounding**, **Lightning & Surge Protection**; Electric Power **Substation** & **Systems**; Electrical Engineering Principles; **Motor Control Circuit**; **Electrical Fault Analysis**; Electrical Networks & Distribution **Cables**; **Circuit Breakers**, **Switchgears**, **Transformers**, **Hazardous Areas Classification** and **Detailed Engineering Drawings**, **Codes** & **Standards**. Furthermore, he is also well-versed in Microprocessors Structure, Lead Auditor (**ISO 9000:2000**), **ISO 9002**, Quality Assurance, and Projects & Contracts Management.

Presently, Mr. Marave is the **Technical Advisor** of **Chamber of Industry & Commerce** in Greece. Prior to this, he gained his thorough practical experience through several positions as the **Technical Instructor**, **Engineering Manager**, **Electronics & Instruments Head**, **Electrical**, **Electronics & Instruments Maintenance Superintendent**, **Assistant General Technical Manager** and **Engineering Supervisor** of various international companies such as the **Alumil** Mylonas, **Athens Papermill**, **Astropol** and the **Science Technical Education**.

Mr. Marave is a **Registered Professional Engineer** and has **Master's** and **Bachelor's** degrees in **Electrical Engineering** from the **Polytechnic Institute of New York** and **Pratt Institute of New York** (**USA**) respectively. Further, he is a **Certified Instructor/Trainer**, a **Certified Internal Verifier/Assessor/Trainer** by the **Institute of Leadership & Management** (**ILM**) and an active member of the **Technical Chamber** and the Institute of Electrical and Electronics Engineer (**IEEE**) in Greece. He has presented and delivered **numerous international** courses, conferences, trainings and workshops worldwide.

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

Day 1

0730 – 0745	*Registration & Coffee*
0745 – 0800	*Welcome & Introduction*
0800 – 0815	***PRE-TEST***
0815 – 0930	***The Mechanism of Harmonic Generation***
0930 – 0945	*Break*
0945 – 1100	***Definitions & Standards*** *Factors Influencing the Development of Standards ● Existing Harmonic Standards ● General Harmonic Indices*
1100 – 1215	***Harmonic Analysis*** *Fourier Series & Coefficients ● Simplifications Resulting from Waveform Symmetry ● Complex Form of the Fourier Series ● Convolution of Harmonic Phasors ● The Fourier Transform ● Sampled Time Functions*
1215 – 1230	*Break*
1230 – 1420	***Harmonic Analysis (cont'd)*** *Discrete Fourier Transform (DFT) ● The Nyquist Frequency & Aliasing ● Fast Fourier Transform (FFT) ● Window Functions ● Efficiency of FFT Algorithms ● Alternative Transforms*
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

0730 – 0930	***Harmonic Sources*** *Transformer Magnetisation Nonlinearities ● Rotating Machine Harmonics ● Distortion Caused by Arcing Devices ● Single-Phase Rectification ● Three-Phase Current –Source Conversation*
0930 – 0945	*Break*
0945 – 1100	***Harmonic Sources (cont'd)*** *Three-Phase Voltage Source Conversation ●Inverted Fed A.C. Drives ● Thyristor Controlled Reactors ● Modulated Phase Control ● A.C Regulators*
1100 – 1215	***Effects of Harmonic Distortion*** *Resonances ● Effects of Harmonics on Rotating Machines ● Effect of Harmonics on Static Power Plant ● Power Assessment with Distorted Waveforms ● Harmonic Interference with Ripple Control Systems*
1215 – 1230	*Break*
1230 – 1420	***Effects of Harmonic Distortion (cont'd)*** *Harmonic Interference with Power System Protection ● Effect of Harmonics on Consumer Equipment ● Interference with Communications ● Audible Noise from Electric Motors*
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

0730 – 0930	***Harmonic Monitoring*** *Measurement Requirements ● Transducers ● Harmonic Instrumentation*
0930 – 0945	*Break*
0945 – 1100	***Harmonic Monitoring (cont'd)*** *Data Transmission ● Presentation of Harmonic Information ● Examples of Application*
1100 – 1215	***Harmonic Elimination*** *Filter Design Criteria ● Network Impedance for Performance Calculations ● Tuned Filters ● Damped Filters ● Conventional Filter Configurations ● Band-Pass Filtering for Twelve-Pulse Converters*
1215 – 1230	*Break*
1230 – 1420	***Harmonic Elimination (cont'd)*** *Distribution System Filter Planning ● Filter Component Properties ● Filter Costs ● D.C. Side Filters ● Active Filters*
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

0730 – 0930	***Computation of Harmonic Flows*** *Direct Harmonic Analysis ● Derivation of Network Harmonic Impedances from Field Tests ● Transmission Line Models*
0930 – 0945	*Break*
0945 – 1100	***Computation of Harmonic Flows (cont'd)*** *Underground and Submarine Cables ● Three-Phase Transformer Models ● Generator Modelling*
1100 – 1215	***Computation of Harmonic Flows (cont'd)*** *Shunt Elements ● Series Elements ● Distribution System Modeling*
1215 – 1230	*Break*
1230 – 1420	***Computation of Harmonic Flows (cont'd)*** *Load Models ● Computer Implementation ● Examples of Application of the Models ● Simulation Backed by Field Tests*
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

0730 – 0930	***Advanced Harmonic Assessment*** *Transfer Function Model*
0930 – 0945	*Break*
0945 – 1100	***Advanced Harmonic Assessment (cont'd)*** *Iterative Harmonic Analysis (IHA)*
1100 – 1215	***Advanced Harmonic Assessment (cont'd)*** *Harmonic Power Flow ● Harmonic State Estimation*
1215 – 1230	*Break*

1230 – 1345	***Advanced Harmonic Assessment (cont'd)*** *The Electromagnetic Transients Solution • Discussion on Advanced Harmonic Modelling*
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*

Practical Sessions

This practical and highly-interactive course includes real-life case studies and exercises:-

Course Coordinator

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