COURSE OVERVIEW EE1046
Electricity and Electrical Equipment (E-Learning Module)

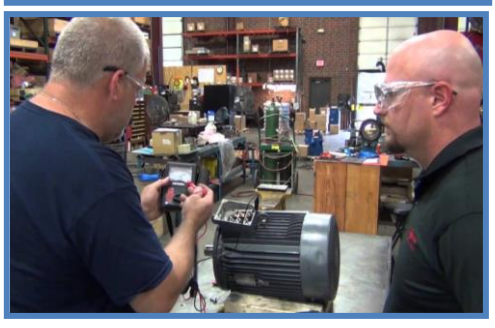
Course Title
Electricity and Electrical Equipment
(E-Learning Module)

Course Reference
EE1046

Course Format & Compatibility
SCORM 1.2. Compatible with IE11, MS-Edge, Google Chrome, Windows, Linux, Unix, Android, IOS, iPadOS, macOS, iPhone, iPad & HarmonyOS (Huawei)

Course Duration
30 online contact hours
(3.0 CEUs/30 PDHs)

Course Description



This E-Learning course is designed to provide participants with a detailed and up-to-date overview of electricity and electrical equipment. It covers the fundamentals of electric systems and the current carrying conductor produces magnetism; the direction of current in windings, the power factor (pf) - real power/ apparent power, relationships of the basic electrical quantities and induction experimental; the magnetic flux, Faraday's law of induction, Lenz's law, transient effects and AC circuit components; the circuits with multiple components, heat versus current in a resistor, magnetic hysteresis and balance three-phase voltages; and the eddy current, rectifiers and rectification, transformers, leakage flux, three phase system and 3-phase transformer connections.

Further, the course will also discuss the transformer efficiency, transformer losses, rating/specifications, cooling arrangement and components of a transformer; the condition monitoring, transformer testing, voltage ratio test, polarity check, diagnostic testing and the use of a commutator; and the basic principles of rotating machines, calculating horsepower, classifying motors and the characteristics of torque-speed.

During this course, participants will learn the AC motor starting methods, electrical variable speed drive methods, motor protection, insulation and troubleshooting and overload protection; the systematic operation of a thermal overcurrent relay during lock rotor condition; the effect of voltage variation; the insulation and testing, resistance readings, DC dielectric test set and harmonics filtering; the asymmetric and symmetric regular sampling, bipolar switching, unipolar switching and comparison of waveforms; the variable speed drive control loops system components of previous diagram, synchronous machines synchronous generators, power factor and conditions required for paralleling; the general procedure for paralleling generators, generator and generator protection, stator ground fault protection, differential protection, phase unbalance or negative phase sequence protection; the circuit breakers and switchboards, electric power reclosers improving network reliability with reclosers and basic components of a recloser; the typical radial circuit, basic application schemes fuse saving and fuse blowing and power station electrical systems.

Course Objectives

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

- Apply and gain a comprehensive knowledge on electricity and electrical equipment
- Discuss the fundamentals of electric systems and the current carrying conductor produces magnetism
- Describe the direction of current in windings, the power factor (pf) - real power/ apparent power, relationships of the basic electrical quantities and induction experimental
- Explain magnetic flux, Faraday's law of induction, Lenz's law, transient effects and AC circuit components
- Identify circuits with multiple components, heat versus current in a resistor, magnetic hysteresis and balance three-phase voltages
- Discuss eddy current, rectifiers and rectification, transformers, leakage flux, three phase system and 3-phase transformer connections
- Recognize transformer efficiency, transformer losses, rating/specifications, cooling arrangement and components of a transformer
- Employ condition monitoring, transformer testing, voltage ratio test, polarity check, diagnostic testing and the use of a commutator
- Explain the basic principles of rotating machines, calculate horsepower, classify motors and describe the characteristics of torque-speed
- Apply AC motor starting methods, electrical variable speed drive methods, motor protection, insulation and troubleshooting and overload protection
- Perform systematic operation of a thermal overcurrent relay during lock rotor condition as well as identify the effect of voltage variation

- Carryout insulation and testing, interpret resistance readings, use DC dielectric test set and apply harmonics filtering
- Illustrate asymmetric and symmetric regular sampling, bipolar switching, unipolar switching and comparison of waveforms
- Recognize variable speed drive control loops system components of previous diagram, synchronous machines synchronous generators, power factor and conditions required for paralleling
- Employ general procedure for paralleling generators, generator and generator protection, stator ground fault protection, differential protection, phase unbalance or negative phase sequence protection, etc
- Identify circuit breakers and switchboards, electric power reclosers improving network reliability with reclosers and basic components of a recloser
- Recognize the typical radial circuit, basic application schemes fuse saving and fuse blowing and power station electrical systems

Who Should Attend

This course provides an overview of all significant aspects and considerations of electricity and electrical equipment for engineers and other technical staff who are involved in the selection, installation, operation, testing, troubleshooting or maintenance of such electrical equipment.

Training Methodology

This Trainee-centered course includes the following training methodologies:-

- Talking presentation Slides (ppt with audio)
- Simulation & Animation
- Exercises
- Videos
- Case Studies
- Gamification (learning through games)
- Quizzes, Pre-test & Post-test

Every section/module of the course ends up with a Quiz which must be passed by the trainee in order to move to the next section/module. A Post-test at the end of the course must be passed in order to get the online accredited certificate.

Course Fee

As per proposal

Course Certificate(s)

Internationally recognized certificates will be issued to all participants of the course.

Certificate Accreditations

Certificates are accredited by the following international accreditation organizations: -

- USA International Association for Continuing Education and Training (IACET)

  Haward Technology is an Authorized Training Provider by the International Association 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 1-2013 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 1-2013 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 Association 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.

- 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.

Course Contents

- Fundamentals of Electric Systems: Introduction to Machinery Principles
- Current (I, Amps)
- Potential (V, Volts)
- Resistance (R, Ohms)
- Ohm's Law
- Capacitance (C, Farads)
- Current Carrying Conductor Produces Magnetism
- Magnetic Lines w.r.t. Current Flow Direction
- Direction of Current in Windings Establish N & S Poles
- Inductance (L, Henrys)
- Frequency (f, Hertz)
- Reactance (X, Ohms)
- Impedance (Z, Ohms)
- Active Power (P Watts)
- Reactive Power (Q, Vars)
- Apparent Power (A, Volt-Amps, VA)
- Power Factor (PF) - Real Power/ Apparent Power
- Relationships of the Basic Electrical Quantities
- Induction Experimental
- Magnetic Flux
- Faraday's Law of Induction
- Generator
- Lenz's Law: Against the change
- Lenz's Law: Example
- Flux Density (B) & Flux (Φ)
- Summary: Electromagnetic Induction & Faraday's Law
- Faraday's Law
- Extra Facts 1: Fleming's Right Hand Rule
- Extra Facts 2: Non- Perpendicular B-Fields
- Extra Facts 3 – Coils
- What does it all mean?

- Transient Effects
- Phasors
- AC Circuit Components
- Circuits with Multiple Components
- Heat vs. Current in a Resistor
- Magnetic Hysteresis
- Balance Three-Phase Voltages
- Three Phase Circuit
- Balance Three-Phase Voltages
- Eddy Current
- Rectifiers and Rectification
- Half Wave Rectifier
- Full Wave Rectifier
- Course Recap
- Review Questions
- Transformers
- Transformer Action
- Principle of Operation
- Components of a Transformer
- Core Characteristics
- Laminated Cores
- Hollow Core Transformers
- Shell Core Transformers
- Transformer Windings
- Schematic Symbols for Transformer
- How A Transformer Works
- Exciting Current
- Effect of a Load
- Coefficient of Coupling
- Leakage Flux
- Primary and Secondary Phase Relationship
- Turns and Voltage Ratios
- Power Relationship between Primary and Secondary Windings

- Ideal Transformers
- Transformer Tests
- Open-circuit Test
- Short-circuit Test
- Transformer Losses
- Transformer Efficiency
- All Day Efficiency
- Transformer Ratings
- Types of Transformers
- Other Uses of a Transformer
- Effects of Current on the Body
- Cut View of Transformer
- Transformer with Conservator and Breather
- Apparent Power Rating of a Transformer
- Inrush Current
- Three Phase System
- 3 phase Transformer connections
- Star- Star connection
- Delta - Delta Connection
- Star- Delta Connection
- Delta - Star connection
- Classification of Transformer
- Classification on the Basis of Cooling Employed
- Transformer Efficiency
- Transformer Losses
- Eddy Currents
- Hysteresis Loss
- Types of Transformers
- Rating/Specifications
- Vector Group
- Cooling Arrangement
- Name Plate Details
- Components of a Transformer

- Oil filled Transformer
- Dry Type Transformer
- Core
- Oil
- Bushing
- OTI
- WTI
- Buchholz relay
- Overloading Capacity
- Condition Monitoring
- DGA- Key gases
- DGA
- DGA (Rogers Ratio Method)
- DGA (IEC 60599)
- Moisture Content in Cellulose Insulation
- Water Heat Run Test
- Relative saturation (RS) of water in oil
- Transformer Testing
- Voltage Ratio Test
- 1Φ Excitation Current at 415V
- Polarity Check
- Winding Resistance
- IR of Winding & Core
- Capacitance & Tan Delta of Winding & Bushing
- Diagnostic Testing
- SFRA
- DP Index
- Current Transformers & Potential Transformers CT and PT
- Oil Type Transformer
- Indicative Drawing
- Dry Type Transformers
- Course Recap
- Review Questions

- Introduction to Electrical Machines
- Electric Motors and Generators
- Introduction
- A Simple AC Generator
- Thus for the arrangement shown below
- A Simple DC Generator
- Use of a Commutator
- A Simple Generator with Two Coils
- DC Generators or Dynamos
- A four-pole DC Generator
- Field Coil Excitation
- DC Generator Characteristics
- AC Generators or Alternators
- A Four-Pole Alternator
- Example
- DC Motors
- DC Motor Characteristics
- AC Motors
- A Squirrel-Cage Induction Motor
- Universal Motors
- Electrical Machines – A Summary
- Key Points
- Meters Must have for Troubleshooting
- Review Questions
- Induction Motors
- Objectives of the Session
- Motors
- Magnetic Induction
- Basic Principles of Rotating Machines
- Motor Parts
- Enclosure
- Stator (Windings)
- Rotor

- Wound Rotor Motors
- Bearings
- Other Parts
- Motor Speed
- Synchronous Speed
- Rated Speed
- Motor Slip
- Torque
- Torque-Speed Curve
- Motor Power
- Calculating Horsepower
- Electrical = Input
- Example:1
- Example:2
- Nameplate – Examples
- Classification of Motors
- Synchronous vs Induction Motors
- Single Phase Induction Motors
- Split Phase Motor
- Capacitor Run Motor - (Permanent Split Capacitor or PSC)
- Capacitor Start Motor
- Capacitor Start-Capacitor Run
- Universal Motor
- Course Recap
- Review Questions
- Speed Control of Induction Motors
- Induction Motors
- Introduction
- Construction
- Rotating Magnetic Field
- Synchronous Speed
- Rotating Magnetic Field
- Principle of Operation

- Induction Motor Speed
- The Slip
- Frequency
- Torque
- Horse power
- Example
- Solution
- Equivalent Circuit of an Induction Motor
- Power Relations
- Example
- Solution
- Torque-speed Characteristics
- Comments
- Complete Speed-torque c/c
- Maximum Torque
- Determination of Motor Parameters
- NEMA 3 Phase Motors
- Rating of AC Induction Motors
- Cooling and Ventilation of Electric Motors (IC)
- Degree of Protection of Motor Enclosures (IP)
- Construction and Mounting of AC Induction Motors
- AC Motor Starting Methods
- Speed Control of Induction Motors
- Objectives of the Session
- The Need for Variable Speed Drives
- Fundamental Principles
- Torque-speed Curves for Variable Speed Drives
- Types of Variable Speed Drives
- Electrical Variable Speed Drive Methods
- Eddy Current Drive for Speed Control
- Types of Variable Speed Drives
- Eddy-Current Principles
- Electrical Variable Speed Drive Methods

- Review Questions
- Motor Protection, Insulation & Troubleshooting
- Motor Standards
- Causes of Motor Failures
- Why Motors Fail?
- Protection of Low Voltage Motors
- Overload Protection
- Medium Voltage Motor Protection
- Electrical Faults in Stator Windings
- Motor Differential Protection
- Overload and Locked Rotor (Stalling) Motor Protection
- Operation of a Thermal Overcurrent Relay During Lock Rotor Condition
- Unbalanced Phases
- Single Phasing Cause
- Loss of Phase or Single Phasing
- Under and Overvoltage Protection
- Effect of Voltage Variation
- Undervoltage Cause
- Undervoltage Effect
- Overvoltage Cause
- Overvoltage Effect
- Under and Overvoltage Protection
- Motor Winding Temperature
- Under and Overvoltage Protection
- Siemens Motor Protection Relays
- SIPROTEC Motor Protection
- Motor Protection Function provided by SIPROTEC
- Motor Protection of Small Motor 100-500kw
- Motor Protection of Small Motor 500kw (1-2MW)
- Motor Protection of Small Motor (>2MW)
- Insulation and Troubleshooting
- What Makes Insulation to Deteriorate?
- What Makes Insulation to Deteriorate?

- How Insulation Resistance is Measured
- Insulation and Testing
- How to Interpret Resistance Readings
- Types of Insulation Resistance Tests
- Test Voltage vs. Equipment Rating
- Use of DC Dielectric Test Set
- 11kV XLPE Aluminium Single Core 500mm² with Voids
- Insulation Resistance to Ground
- Introduction
- Polarization Index
- Course Recap
- Review Questions
- Power Electronics Rectifiers PWM Pulse Width Modulation Inverters
- Objectives of the Session
- Introduction & Definitions
- Power Diodes
- IDEAL
- Power Thyristors
- Power Electronic Rectifiers (AC/DC)
- Gate Controlled Power Electronic Devices
- DC to AC Conversion (INVERTER)
- Simple Square-wave Inverter
- AC Waveforms
- Harmonics Filtering
- Variable Voltage Variable Frequency Capability
- Output Voltage Harmonics/Distortion
- Total Harmonics Distortion (THD)
- Fourier Series
- Harmonics of Square-wave
- Spectra of Square-wave
- Single-phase, Full-bridge
- Three Phase Inverter Waveforms
- Pulse Width Modulation (PWM)

- Pulse Width Modulation (PWM)
- PWM types
- Modulation Index, Ratio
- Regular Sampling
- Asymmetric and Symmetric Regular Sampling
- Bipolar Switching
- Unipolar Switching
- Bipolar PWM Switching: Pulse-width Characterization
- Three-phase harmonics
- Effect of Odd and “Triplens”
- AC Drives and Harmonics
- Recommended Limits - IEEE 519
- Attenuation of Harmonics
- Comparison of Waveforms
- Review Questions
- Control Systems for AC Variable Speed Drives
- Objectives of the Session
- The Overall Control System
- Power Supply to the Control System
- The DC Bus Charging Control System For Low Voltage Converters 440V, 415V, 380V: 60 or 50 Hz
- The PWM Rectifier for AC Converters
- Variable Speed Drive Control Loops
- Variable Speed Drive Control Loops System Components of previous diagram
- Vector Control for AC Drives
- Current Feedback in AC Variable Speed Drives
- Speed Feedback from the Motor
- Course Recap
- Review Questions
- Synchronous Machines Synchronous Generators
- Synchronous Machines
- Basic AC Power Flow
- Losses
- Power Factor

- Basic Expressions
- Successively Smaller and Smaller Torque Angle
- Synchronous Machine Models
- Saturation and the Magnetization Curve
- Synchronous Generators
- Equivalent Circuit of a Synchronous Generator
- Phasor Diagram of a Synchronous Generator
- Power and Torque in Synchronous Generators
- The Synchronous Generator Operating Alone
- Terminal Characteristics of Synchronous Generators
- Parallel Operation of Synchronous Generators
- Conditions Required for Paralleling
- General Procedure for Paralleling Generators
- Operation of Generators in Parallel with Large Power Systems
- Defining Generator Capability
- Review Questions
- Generator and Generator Protection
- Generator Protection
- Stator Ground Fault Protection
- Differential Protection
- Phase Unbalance or Negative Phase Sequence Protection
- Interturn Protection
- Under-frequency and Over-frequency Protection
- Out-of-Step Protection
- Loss of Excitation Protection
- Overexcitation Protection
- Reverse Power Protection
- Phase Back-up Protection
- Generator Overcurrent Protection Voltage Controlled & Voltage Restrained
- Generator Short-Circuit Current
- Generator Current Decrement
- Course Recap
- Review Questions

- Circuit Breakers and Switchboards
- Objectives
- Introduction
- Switches and Circuit Breakers
- Air-Circuit Breakers
- High-Voltage Circuit Breakers
- Electric Power Reclosers Improving Network Reliability with Reclosers
- Improving Network Reliability with Reclosers
- Recloser
- Basic Components of a Recloser
- Interrupter Module Details
- Operation Options
- Module Configuration Options
- Mounting Options
- Major Manufacturers
- Relay / Controls
- Protection
- Recent Innovations
- Communication Hardwired
- What is reclosing and why do you do it?
- Reference Metric Definitions
- Reclosers vs. Switches
- Recloser vs. Breaker
- Line Segmenting Evolution
- Typical Radial Circuit
- Basic Application Schemes Fuse Saving
- Fuse Saving
- Basic Application Schemes Fuse Blowing
- Fuse Blowing
- Additional Reclosers
- Additional Recloser Placement
- Single Phase Reclosers
- Next Step – Looped Circuits

- Distributed Transfer
- Take Aways
- COURSE RECAP
- Review Questions
- Power Station Electrical Systems
- Introduction
- Generators
- Exciters
- Power Transformer
- 230KV Power Transformer in Gas Plant
- Voltage Regulators
- Bus-Bars
- Reactors
- Insulators
- Switchgear
- 230KV Switchgear
- Switches
- Protective Equipment
- Fuse
- Circuit Breakers
- Types of Circuit Breakers
- Relays
- Types of Relay
- Current Transformer
- Potential Transformer
- Batteries
- Control Rooms
- Control Room in Thermal Power Plant
- Review Questions