COURSE OVERVIEW EE1089
Switchgear Transient Recovery Voltage (TRV) Techniques & Result Analysis

H-STK© INCLUDED

3.0 CEUs (30 PDHs) AWARD

Course Title
Switchgear Transient Recovery Voltage (TRV): Techniques & Result Analysis

Course Date/Venue
Session 1: January 11-15, 2026/Crowne Meeting Room, Crowne Plaza Al Khobar, Al Khobar, KSA
Session 2: July 26-30, 2026/Tamra Meeting Room, Al Bandar Rotana Creek, Dubai, UAE

Course Reference
EE1089

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 switchgear transient recovery voltage (TRV) techniques and result analysis. It covers the general considerations and importance of TRV, the recent TRV studies in international bodies, main reference, standards and guides; the capacitive current switching TRV and recovery voltage comprising of "1-cos" waveshape, voltage jump and current breaking conditions; the various types of faults covering reminder, overdamped TRV, reflected waves, underdamped TRV and triangular wave-shape; the TRV modification for current asymmetry, circuit breaker influence on TRV; and the terminal fault TRV, short line fault TRV and initial transient recovery voltage (ITRV).

During this interactive course participants will learn the out-of-phase TRV, three-phase (long) line fault and shunt reactor switching TRV; the transformer limited fault TRV and options for specification; the transformer limited fault TRV for EHV and UHV circuit breakers; the TLF TRV peak calculation and TLF RRRV calculation; the series reactor limited fault TRV and the influence of series capacitor on TRV; and the harmonization of TRVs in IEC and IEEE standards for high-voltage circuit breakers.

Course Objectives

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

- Apply and gain an in-depth knowledge on switchgear transient recovery voltage (TRV) techniques and result analysis
- Discuss the general considerations and importance of TRV, the recent TRV studies in international bodies, main reference, standards and guides
- Explain the capacitive current switching TRV and recovery voltage comprising of "1-cos" waveshape, voltage jump and current breaking conditions
- Identify the various types of faults covering reminder, overdamped TRV, reflected waves, underdamped TRV and triangular wave-shape
- Perform TRV modification for current asymmetry and circuit breaker influence on TRV
- Describe the terminal fault TRV, short line fault TRV and initial transient recovery voltage (ITRV)
- Recognize out-of-phase TRV, three-phase (long) line fault and shunt reactor switching TRV
- Discuss transformer limited fault TRV and options for specification
- Identify transformer limited fault TRV for EHV and UHV circuit breakers and apply TLF TRV peak calculation and TLF RRRV calculation
- Recognize series reactor limited fault TRV and the influence of series capacitor on TRV
- Describe the harmonization of TRVs in IEC and IEEE standards for high-voltage circuit breakers

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 is designed for those who are involved in the selection, commissioning, operation, maintenance, testing or troubleshooting of the generator excitation systems and AVR including engineers, supervisors 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

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. Ehab Mohamed, BSc, CompEX, ETAP, is a **Senior Electromechanical Engineer** with **30 years** of extensive industrial experience within the **Oil & Gas**, **Refinery**, **Petrochemical** and **Power** industries. He specializes in **Maintenance Management** Best Practices, **Rotating Equipment** Reliability Optimization, Practical **Machinery Vibration**, **Vibration** Techniques, Effective **Reliability Maintenance**, Excellence in **Maintenance & Reliability** Management, **Preventive & Predictive Maintenance**, Machinery Failure Analysis (**RCFA**), **Reliability** Optimization & Continuous Improvement, **Maintenance** Planning, Scheduling & Work Control, **Maintenance Management** Strategy, **Mechanical & Rotating Equipment** Troubleshooting, Preventive Maintenance, Predictive Maintenance, Reliability Cantered Maintenance (**RCM**), Condition Based Monitoring (**CBM**), **FMEA**, **Machinery and Rotating Equipment Troubleshooting**, **Turbines, Bearings, Compressors** and **Pumps**. Further he is also well-versed in **Power System Blackouts**, **Power System During Emergency** and **Blackouts**, **Electric Power System** Operation, Electrical Transient Analysis Program (**ETAP**), **Electrical** Installation & Maintenance, **Electrical** Inspection & Testing, **HV/LV** Equipment, **High Voltage Electrical Safety**, **LV & HV Electrical** System, **HV** Equipment Inspection & Maintenance, **HV Switchgear** Operation & Maintenance, **LV Distribution Switchgear & Equipment**, **Substation** Design & Commissioning, **Substation** Maintenance Techniques, **Switchgear** Operation & Maintenance, **Circuit Breakers & Switchgears** Inspection, **Power System** Control & Stability, Industrial **UPS** Systems & **Battery** Power Supplies, **Power Generation & Transmission**, **Power System Protection & Relaying**, **Electric Power** Calculation, **Power Systems Protection**, Distributed Control System (**DCS**) Applications & Troubleshooting, **SCADA & Industrial Communication**, Process Logic Controller (**PLC**), **Load Flow** Calculation, **Cable** Installation, **Transformer** Maintenance, Short Circuit & Protection Coordination, **Harmonic** Analysis Studies, **Earthing & Grounding**, **Power Factor Correction**, **Power System Protection & Relaying**, **Electric Motors & Variable Speed Drives**, **Power Generation**, **Electrical Fault** Detection & Remedies, Electrical **Control Circuits** & Equipment, **Hazardous Area** Classification, **Electrical Hazards**, **Explosion Proof Ex Equipment**, **Hazardous Area Classification & Intrinsic Safety**, **Motor** Testing & Maintenance, Modern **Power System Protective Relaying**, **Generators**, **Transformer**, Office 365, Outlook 365, Visio, ETAP, AutoCAD, RAMS, HRMS, Microsoft BI for Dashboard and Online Reports, Siemens TIA, ABB Drive, Wizard, Window, Composer Suite, SharePoint, NOV Rig Sense all versions, Cond Master Ruby for Condition Monitoring and OSIsoft Data Analytics. He is currently the **Engineering Manager** (Electrical & Controls) in **Weatherford Drilling International**.

During his career life, Mr. Ehab has gained his expertise and thorough practical experience and handling challenging positions such as being the **Engineering Manager**, **Product Manager**, **Acting Project Manager**, **Lead Operation Engineer**, **Plant Engineer**, **Maintenance Engineer**, **Electrical Project Engineer**, **Project Engineer**, **Field Support Engineer**, **Lead Electrical & Automation Engineer**, **Lead Electrical Engineer**, **Field Support Engineer**, **Application Engineer**, **Allen Bradley Rockwell Engineer**, **Lead Technical Assessor**, **Team Leader**, **Principal Teacher**, **Global Field Support Technician**, **Foreman**, **Technical Consultant**, **Technical Trainer** and **Staff Lecturer** for various companies such as the **Weatherford** Drilling International Inc., Daleel Petroleum Company (**DAPECO**), NDSC Drilling Contractor, NOKHBA Energy, Abraj Drilling, American Standard Polymer and Acrylic Plant, Future Technologies Ltd, Industrial Technical College, Ministry of Higher Education and El-Masria Trading & Technical Services.

Mr. Ehab has a **Bachelor's** degree in **Electrical Engineering**. Further, he is a **Certified Instructor/Trainer**, a **Certified Internal Verifier/Assessor/Trainer** by the **Institute of Leadership of Management** (**ILM**), a **Certified CompEx Inspector & Installer**, a **Certified Allen Bradley Rockwell Engineer** and a member of the Institution of Engineering & Technology (**IET**). Moreover, he holds a certification in Electrical Power Calculation (**ETAP**) and has delivered numerous trainings, courses, workshops, seminars and conferences internationally.

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 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.

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 – 0800	*Registration & Coffee*
0800 – 0815	*Welcome & Introduction*
0815 – 0830	***PRE-TEST***
0830 – 0930	***Introduction & General Considerations*** *Importance of TRV • Recent TRV Studies in International Bodies • Main Reference • Standards & Guides • Historical Perspective • General Considerations on Transient Recovery Voltages • Current Interruption Process in SF6 Circuit Breakers • TRV during Inductive Current Breaking • TRV & Recovery Voltage in Resistive, Inductive & Capacitive Circuits • Reflection from End of Lines*
0930 – 0945	*Break*
0945 – 1030	***Capacitive Current Switching TRV & Recovery Voltage*** *Capacitive Current Switching • "1-Cos" Waveshape • Capacitive Current Switching Voltage Jump • Three-Phase Capacitive Current Breaking Capacitor Bank with Isolated Neutral • Three-Phase Line-Charging Current Breaking • Three-Phase Cable-Charging Current Breaking • Three-Phase Capacitive Current Breaking: Single Phase Tests to Simulate Three-Phase Conditions*
1030 – 1230	***Types of Faults TRVs*** *Reminder • Overdamped TRV • Reflected Waves*
1230 – 1245	*Break*
1245 – 1420	***Types of Faults TRVs (cont'd)*** *Underdamped TRV • Triangular Wave-Shape*
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	***TRV Modification*** *Current Asymmetry & Circuit Breaker Influence on TRV • TRV Modification / Current Asymmetry • TRV Modification / Circuit Breaker Influence*
0930 – 0945	*Break*
0945 – 1100	***Terminal Fault TRV*** *First-pole-to-clear Factor • TRV Rating & Testing • TRV Application • TRV & Arcing Times • TRV for Generator Circuit Breakers • TRV Summary*
1100 – 1230	***Short Line Fault TRV*** *Evolution of Line Voltage • RRRV • Line Surge Impedance • Voltage at Current Zero • Line-side Contribution to TRV*
1230 – 1245	*Break*
1245 – 1420	***Short Line Fault TRV (cont'd)*** *Comparison of Test Duties • Line Characteristics • Influence of an Additional Capacitor • Influence of an Opening Resistor • Breaking with Opening Resistor • Summary*
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	***Initial Transient Recovery Voltage (ITRV)*** *ITRV & Terminal Fault TRV • Standard Values of ITRV*
0930 – 0945	*Break*
0945 – 1100	***Out-of-Phase TRV*** *Breaking in Out-of-Phase Condition • Voltages during Breaking in Out-of-Phase • Out-of-Phase Angle*
1100 – 1230	***Three-Phase (Long) Line Fault*** *Three-Phase Line Faults • Mutual Coupling Between Phases • Effective Surge Impedances for the First & Last Clearing Poles*
1230 – 1245	*Break*
1245 – 1420	***Three-Phase (Long) Line Fault (cont'd)*** *Typical Values of Surge Impedance in IEEE C37.011-2011 • Three-Phase Short-Line Faults*
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	***Shunt Reactor Switching TRV*** *Switching of Inductive Loads (Shunt Reactors) • Interruption of Small Inductive Currents • Current Chopping • Current Chopping: Current-Voltage Characteristics • Switching of Inductive Loads/Standards*
0930 – 0945	*Break*
0945 – 1100	***Transformer Limited Fault TRV*** *Transformer Limited Faults/Content • Introduction • Options for Specification*
1100 – 1230	***Transformer Limited Fault TRV for EHV & UHV Circuit Breakers*** *Introduction • TLF TRV Peak Calculation • TLF RRRV Calculation*

1230 – 1245	Break
1245 – 1420	***Transformer Limited Fault TRV for EHV & UHV Circuit Breakers (cont'd)*** Application to EHV Circuit Breakers (Standardization in IEEE) • Application to UHV Circuit Breakers (Standardization in IEC) • Conclusion
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	***Series Reactor Limited Fault TRV***
0930 – 0945	Break
0945 – 1100	***Influence of Series Capacitors on TRV*** CIGRE Studies • Annex: Series Capacitor Bank Equipment
1100 – 1230	***Harmonization of TRVs in IEC & IEEE Standards for High-Voltage Circuit Breakers*** Harmonization of IEC & IEEE Standards • Harmonization of Capacitive Current Switching • Harmonization of TRVs for Circuit Breakers of Rated Voltages Higher than 1 kV & Less than 100 kV • Harmonization of TRVs for Circuit Breakers of Rated Voltages Equal or Higher than 100 kV
1230 – 1245	Break
1245 – 1345	***Annexes***
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 (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 simulators “GE Multilin Relay 469” , “GE Multilin Relay 750” and “Switchgear Simulator”.

GE Multilin Relay 469 Simulator

GE Multilin Relay 750 Simulator

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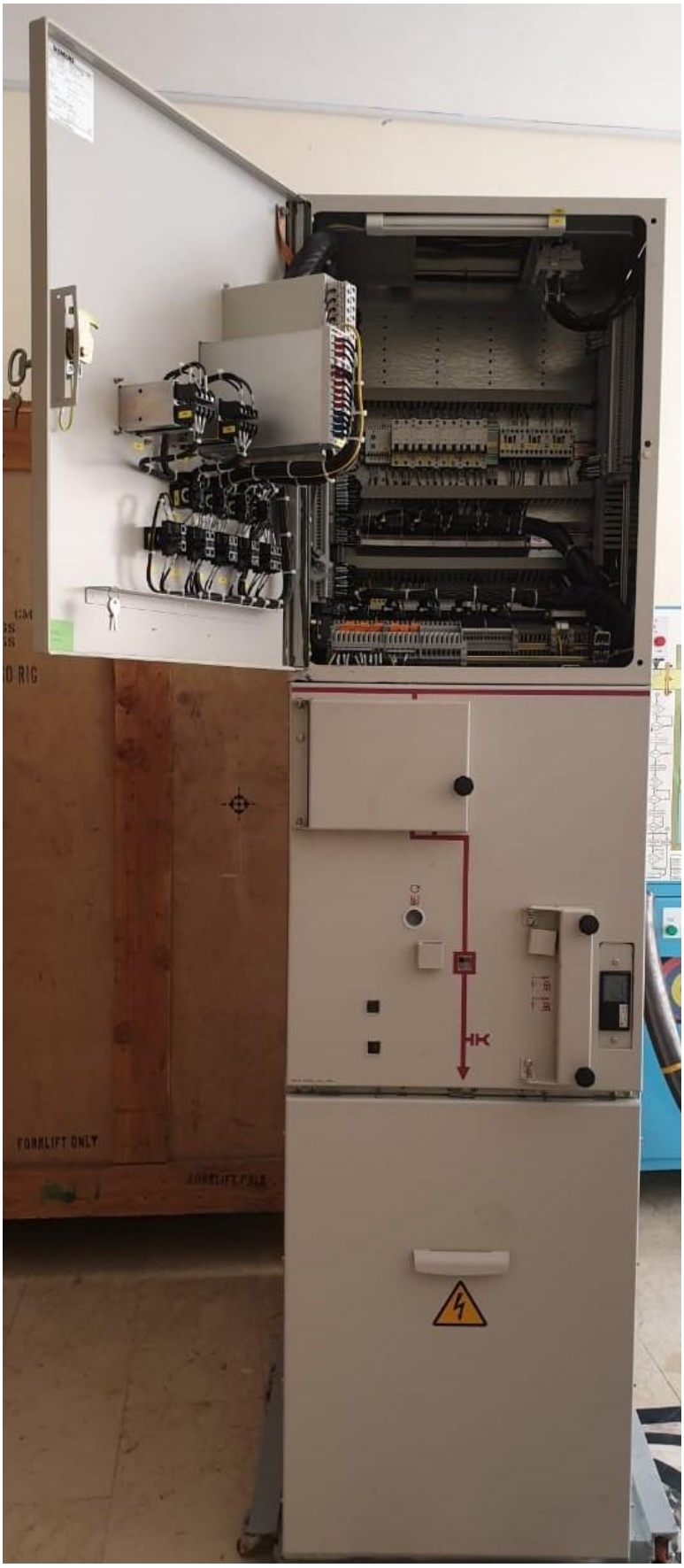
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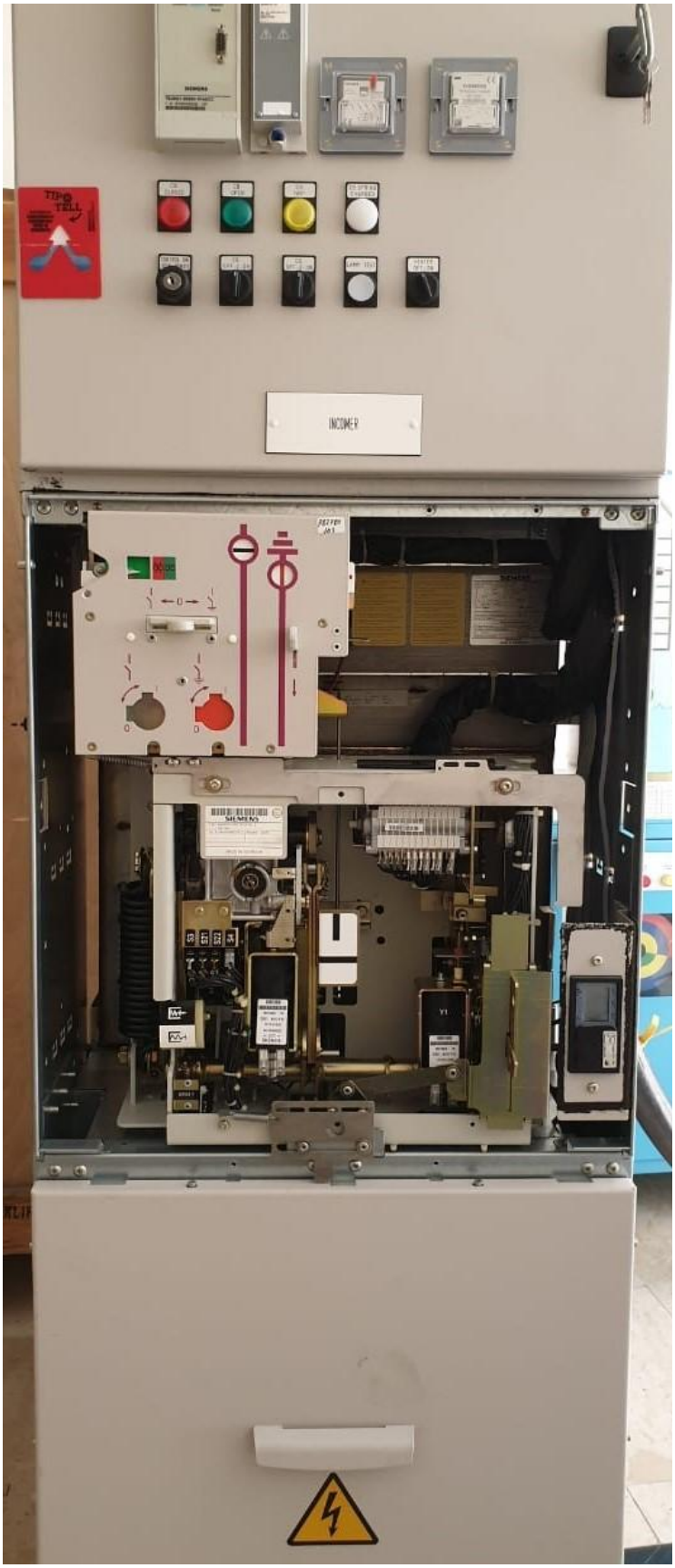
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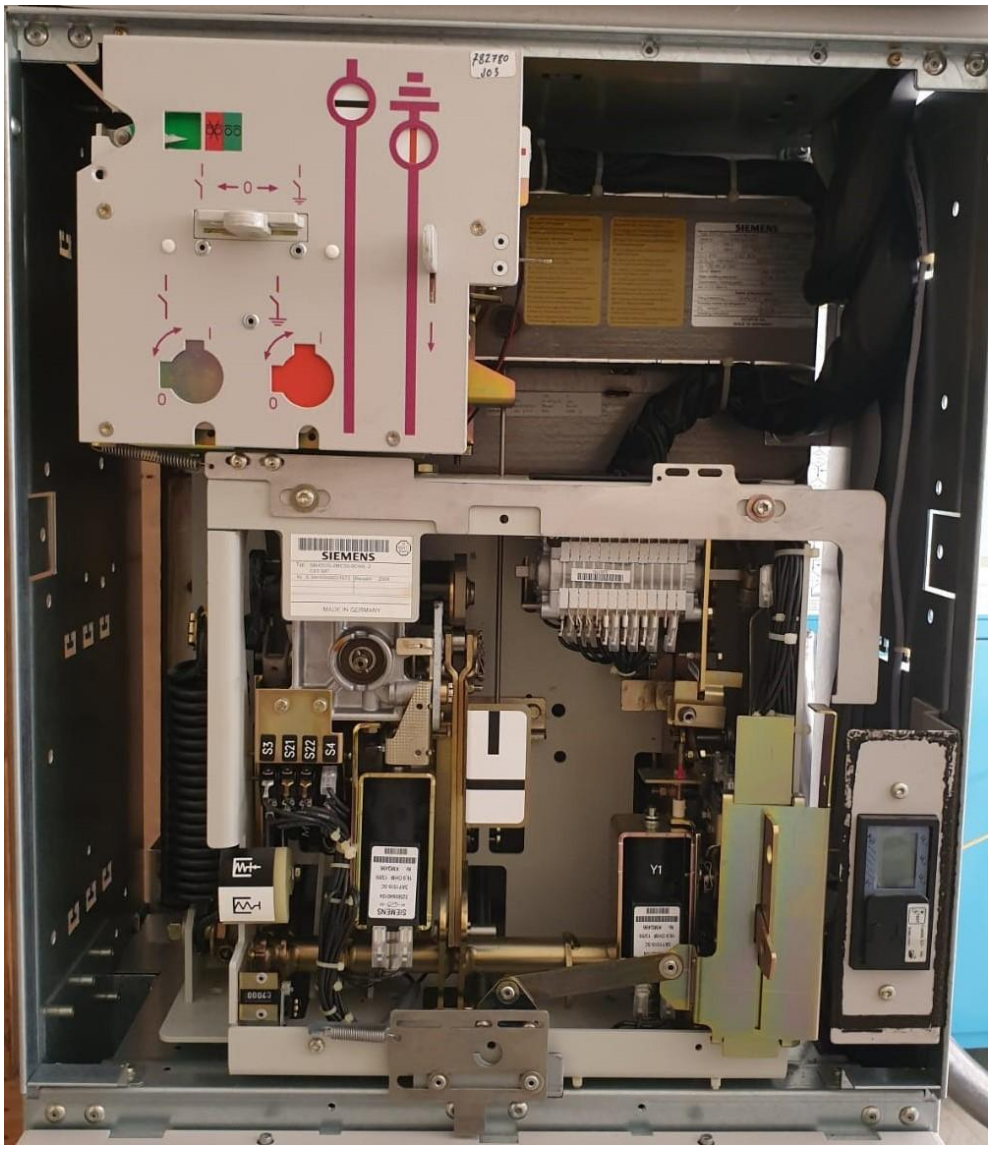

Course Coordinator
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