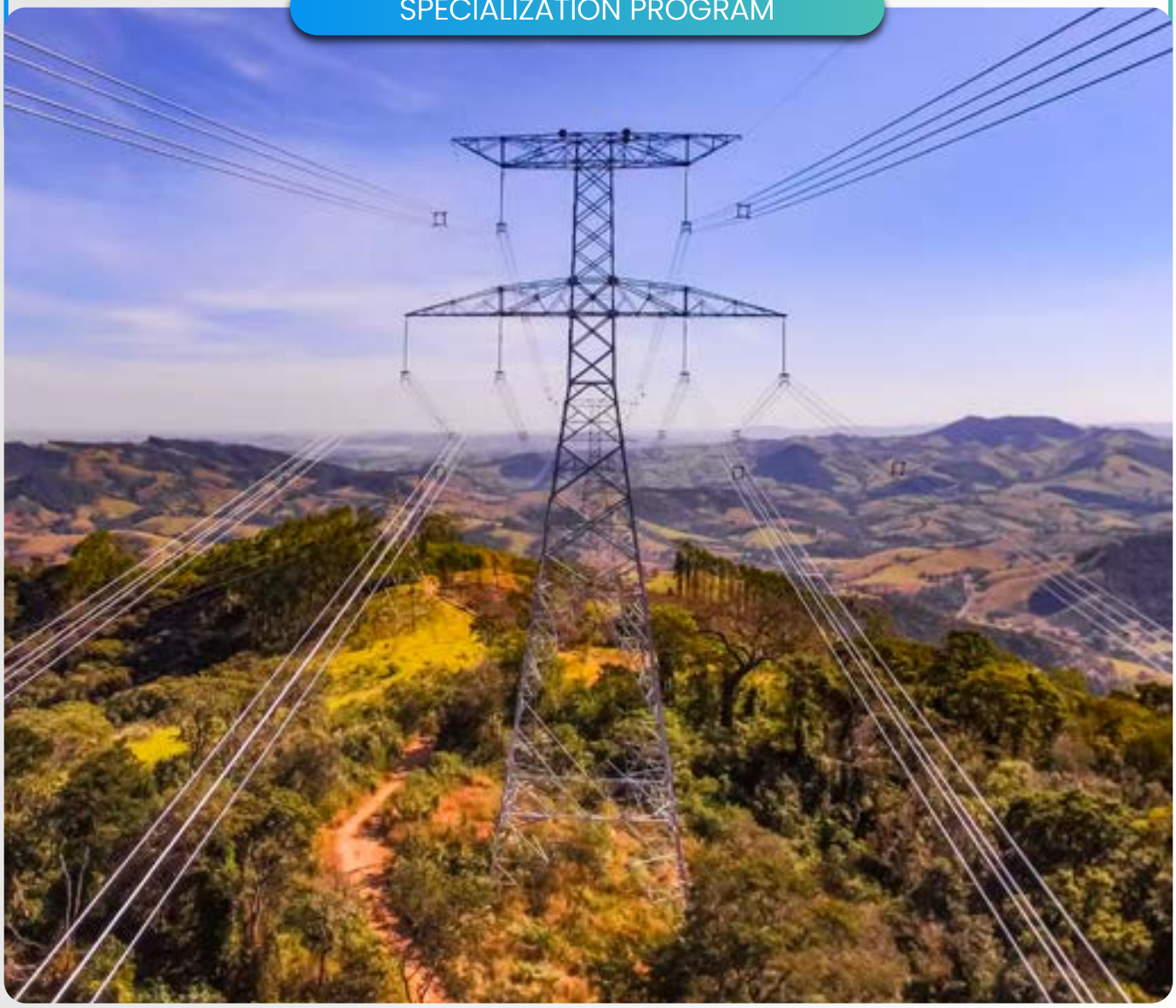
Escuela Técnica de Ingeniería

IEEE CREDENTIALING PROGRAM

HIGH VOLTAGE

# DIRECT CURRENT TRANSMISSION – HVDC

SPECIALIZATION PROGRAM



# ABOUT THE PROGRAM

**Did you know that Europe plans to add 64 GW of HVDC capacity by 2030 to support the transition to renewable energy (Source: HITACHI)?**

HVDC transmission offers advantages such as lower costs and minimized transmission losses, achieving efficiency over long distances. It can be used in a wide variety of applications such as interconnection of transmission networks, integration of renewable energy, submarine transmission, among others.

HVDC systems improve grid stability and security by allowing a rapid and flexible response to disturbances and faults. Finally, it reduces the environmental and social impact of transmission infrastructure due to its need for less land, materials, and maintenance than AC transmission.

Inel is proud to present this meticulously designed program, which covers not only the best engineering practices and studies in HVDC, but also the use of specialized software and other tools. We are convinced that this program will be a key investment with which you will join the select group of HVDC experts.

*There are no requirements to take this program, although basic knowledge of electrical systems is recommended.*

*The training will be carried out using PSCAD Version 5 PRO software. The student must enter with his or her own license.*

**START** | **October, 26th**

**SCHEDULE** | Saturdays and Sundays: 16:30– 18:40 (UK time)

**DURATION** | 44 chronological hours

**MODALITY**
100% Online
Synchronous

# VALUE PROPOSAL

# OBJETIVES

**Upon completion of the program, the student will be trained to:**

1. Interpret grid codes, international HVDC regulations
2. Learn about HVDC cables and transmission lines
3. Design HVDC stations, select and define technical specifications of components
4. Perform HVDC system modeling in PSCAD software
5. Study the control and protection systems in HVDC
6. Analize specialized applications and integration studies for HVDC

# WHO IS IT FOR?

**The specialization program is aimed at the following professionals:**

Connection study engineers, protection engineers, power system engineers in senior and junior positions responsible for conducting and coordinating electrical studies for their company.

Transmission engineers, independent consultants, project engineers.

Technical profiles who wish to acquire solid knowledge in the fundamentals and applications of high voltage direct current (HVDC).

# CURRICULAR STRUCTURE

## Module I: Fundamentals of power systems
(2 chronological hours)

*Learn the basic principles about electrical power systems*

### Session 1

- Introduction
  - *Structure of a power system*
- Generation
- Transmission
- Stability Criteria
- Representation of power systems
- Load flow
- Reactive power and voltage control

## Module II: Introduction to HVDC systems
(4 chronological hours)

*Understand the evolution of HVDC, its components, configurations, and different topologies*

### Session 2

- Introduction and general concepts
- Converters and Power electronics
- HVDC Technologies
  - *History and Evolution*
  - *Key drivers*
  - *Challenges*
- Main DC circuit LCC
- Main DC circuit VSC

### Session 3

- Comparison of HVDC LCC vs. HVDC VSC
- HVDC Configurations
  - *Monopolar*
  - *Bipolar*
  - *Others*
- Description of main equipment in HVDC LCC/MMC station
  - *Single-line arrangements*
  - *Converter description*
  - *Transformer and reactor arrangement*
  - *AC/DC filters*
- HVDC applications

## Module III: HVDC technologies and applications
(2 chronological hours)

*Know the diverse applications of HVDC technology in various geographical contexts*

### Session 4

- Projects in Asia
- Projects in Europe
- Projects in North America
- Projects in South America
  - *HVDC Itaipu Line (Brazil – Paraguay)*
  - *HVDC Xingu - Estreito Line (Brazil)*
  - *HVDC Kimal – Lo Aguirre Line (Chile)*
  - *HVDC Colombia – Panama Interconnection*
  - *HVDC Rio Madeira Line (Brazil)*

## Module IV: HVDC converter stations design
(4 chronological hours)

*Design HVDC converter stations, select and define technical specifications of components*

### Session 5

- Description of main equipment in HVDC LCC/ MMC station
  - *Converter description*
  - *Transformer arrangement*
  - *AC/DC filters*
  - *Others*
- Typical converter station arrangements
- Busbar and switch arrangement
- Main circuit selection

### Session 6

- Design studies for HVDC
  - *Static load flow and short circuit studies*
  - *Reactive compensation study*
  - *Insulation coordination studies*
  - *Harmonics and filter design*
  - *Others*
- Selection and design of converter station components
- Technical specifications
- Software applications

## Module V: HDVC cables and transmission lines
(2 chronological hours)

*Learn about HVDC cables and transmission lines*

### Session 7

- Introduction to high voltage cables technology
- Properties of cables used in HVDC
- Selection criteria and design of cables for HVDC
- Thermal load and overload considerations
- Introduction to high voltage overhead lines technology
- Electric fields, magnetic fields, electromagnetic interference
- Technical specifications

## Module VI: HVDC systems modelling
(8 chronological hours)

*Perform HVDC system modeling in PSCAD software*

### Session 8

- Introduction to systems modeling
- Analytical Tools and Techniques
- Introduction to HVDC system modeling
- Electrical network modeling

### Session 9

- Converter modeling - Analytical
  - *LCC converter*
  - *VSC converter*
- Simulation tools
- Converter modeling - Numeric

- *LCC converter*
- *VSC converter*
- *Converter models in normal and abnormal operating regimes*

### Session 10

- Subsystem modeling
  - *Transformer and filter modeling*
  - *Control and protection system models*
  - *Insulation and grounding system models*

### Session 11

- Models for stability and electromagnetic transients
  - *Electromechanical stability models in HVDC lines*
  - *Transient models in HVDC systems*
  - *Stability analysis*
  - *Model order reduction and validation*
- Application with PSCAD software

## Module VII: Grid code for HVDC (2 chronological hours)

*Interpret grid codes and standards applicable to HVDC systems.*

### Session 12

- International standards and grid codes
- Frequency stability
- Reactive power and voltage
- Control requirements
- Protection requirements
- Power quality
- Other

## Module VIII: Control and protection of HVDC systems (4 chronological hours)

*Study the control and protection systems in HVDC*

### Session 13

- General description of LCC controls
- Specific LCC controls
  - *Firing Controls*
  - *PLL*
  - *Current Control*
  - *Inverter Controls*
  - *Active power Controls*
  - *Other controls*
- General description of VSC controls
- Specific VSC controls
  - *External control: active power, reactive power, DC voltage control, AC voltage control*
  - *Internal current control*
  - *Energy control*
  - *Grid forming control*
  - *Capacitor balancing control*
  - *Modulation strategies*

### Session 14

- Partial Feedback of the final Project

### Session 15

- HVDC behavior during AC fault events
- Analysis of DC-side transients for typical DC faults
- Protection methods for HVDC system
  - *DC fault analysis*
  - *DC fault detection and location algorithms*
  - *DC fault interruption methods*

## Module IX: Integration studies for HVDC (8 chronological hours)

*Analize integration studies for HVDC systems*

### Session 16

- General description of integration studies
  - *Need for integration studies*
- Load flow analysis study
- Short circuit and fault analysis study
- Transient Stability analysis study
- Simulation Demonstrations

### Session 17

- Overvoltage study and insulation coordination
- Protection coordination study
- Harmonic analysis study
  - *Model capability and usage*
  - *Harmonic impedance*
- Simulation Demonstrations

### Session 18

- Dynamic performance analysis study
  - *Control system*
  - *Protection systems*
  - *Faults*
  - *Performance Evaluation*
- HIL Testing
- Commissioning

### Session 19

- Software applications

## Module X: Operation strategies for HVDC systems
(2 chronological hours)

*Learn the strategies of real-time operation for HVDC systems*

### Session 20

- Fundamentals of HVDC operation
  - *Real-time control architecture*
  - *SCADA systems for HVDC*
  - *Latency and synchronization requirements*
- Real-time Operation
  - *Common Maneuveurs*
  - *Emergency Schemes and Higher order Controls*
  - *Dynamic dispatch*
  - *Real-time compensation of renewable energy fluctuations*
  - *Other topics*
- Perturbations and Contingency Analysis
- Reliability, Availability and Maintainability (RAM)

## Module XI: Advanced topics in HVDC
(2 chronological hours)

*Explore advanced concepts in HVDC systems*

### Session 21

- HVDC grid systems and multi-terminal HVDC
- Integration of HVDC with renewable energy sources
- HVDC system stability and dynamic performance

### Session 22

- Final Feedback of the final Project

# INSTRUCTORS

## Trevor Dobbin

*Specialist in High Voltage Direct Current Transmission - HVDC*

**Electronic and Computer Engineering** with a Master of Science in Electric Engineering in Federal University of Rio de Janeiro (UFRJ), Brazil.

**Specialist in HVDC** transmission controls, simulations, dynamic systems modelling, control systems, nonlinear systems stability analysis and control.

**Experience** in HVDC transmission proyects, focusing on HVDC transmission, specifically in Bipole 1 and 2 HVDC links, including their controls and protection replicas, and RTDS simulation and modeling.

**Currently instructor of Inel -** Escuela Técnica de Ingeniería and Brazilian Regular Member SC B4 and Cigre Brasil CE B4 Coordinator, CIGRE.

*NOTE: INEL reserves the right to modify the teaching staff for reasons of force majeure or availability of the speaker, ensuring that the quality of the program won´t be affected.*

# METHODOLOGY AND REQUIREMENTS

The participant will be accompanied throughout the program by teachers and support staff who will resolve all their doubts and queries.

## ONLINE MODE
Synchronous or in real time

**Methodology**
**Practical /** Theoretical

**Virtual classroom**
Recorded sessions and additional resources

**Final project** with advice from the instructor(s)

**Certification**
**for 44 hrs. chronological**
valid internationally

## REQUIREMENTS

Internet with Wi-Fi or cable (preferably) with a minimum speed of 8 Mbps download and 4 Mbps upload.

Operational headphones and microphone.

Use of webcam and dual screen optional, but recommended.

# DOUBLE CERTIFICATION

Upon successful completion of the specialization program, the student will receive double certification, one from Inel - Escuela Técnica de Ingeniería and another from IEEE (Institute of Electrical and Electronics Engineers).

## Requirements to access double certification:

- Minimum attendance of 70% to live classes.
- Final score of 14 or more.
- Presentation of the final project.


CERTIFICATE

This is to certified that:

ROBERT LUIS ROSAS ROMERO

Has successfully completed the:

"SPECIALIZATION PROGRAM IN HIGH VOLTAGE DIRECT CURRENT TRANSMISSION - HVDC"

Escuela Técnica de Ingeniería

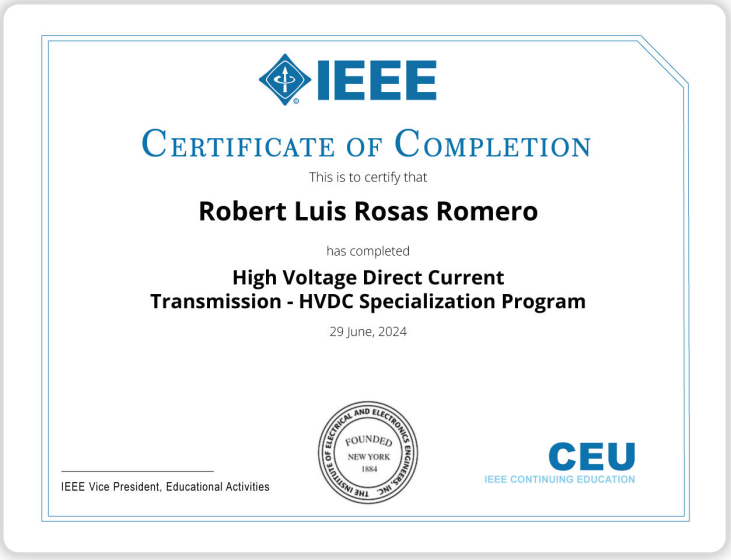
Verify the validity and authenticity of the certificate scanning the QR code

Certificate Code

Date

Huancayo, Perú

**Certification valid internationally** that accredits 44 chronological hours


IEEE

CERTIFICATE OF COMPLETION

This is to certify that

**Robert Luis Rosas Romero**

has completed

**High Voltage Direct Current Transmission - HVDC Specialization Program**

29 June, 2024

IEEE Vice President, Educational Activities

FOUNDED NEW YORK 1884

CEU

IEEE CONTINUING EDUCATION

**IEEE will provide a PDH/CEU certificate for this course.** IEEE awards 4.4 CEUs

# INVESTMENT

| Dollars | Euros |
| --- | --- |
| US$ | € |
| 1,950 | 1,750 |

***Discounts apply for cash payment***

## FINANCING IN PARTS

*WITHOUT DISCOUNT*

*Note: Consult for additional financing options.*

**CONTACT**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## INSCRIPTION

1. Send proof of payment to inel@inelinc.com when making the payment.

2. Enter your personal and billing information at **https://bit.ly/INEL_Inscripción_PE_EI_26_24_1**

3. You will receive instructions for accessing the virtual classroom, the content of the program will be available on the start day.

# CORPORATE TRAINING

Keeping top talent engaged is key to ensuring they don't quit or leave for a competitor. The #1 reason employees leave companies is lack of professional development.

For this reason, at Inel we are committed to companies. We are your long-term strategic partners in the continuous training of professionals, demanded by the current context.

## BENEFITS

**Online mode** synchronous, asynchronous or inhouse.

**Personalized training** in accordance with the requirements of the organization.

**Increase profitability** and opening new lines of business

**Improve and retain talent** of your company

**Increased productivity,** efficiency and quality of work.


**CONTACT**

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Escuela Técnica de Ingeniería

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