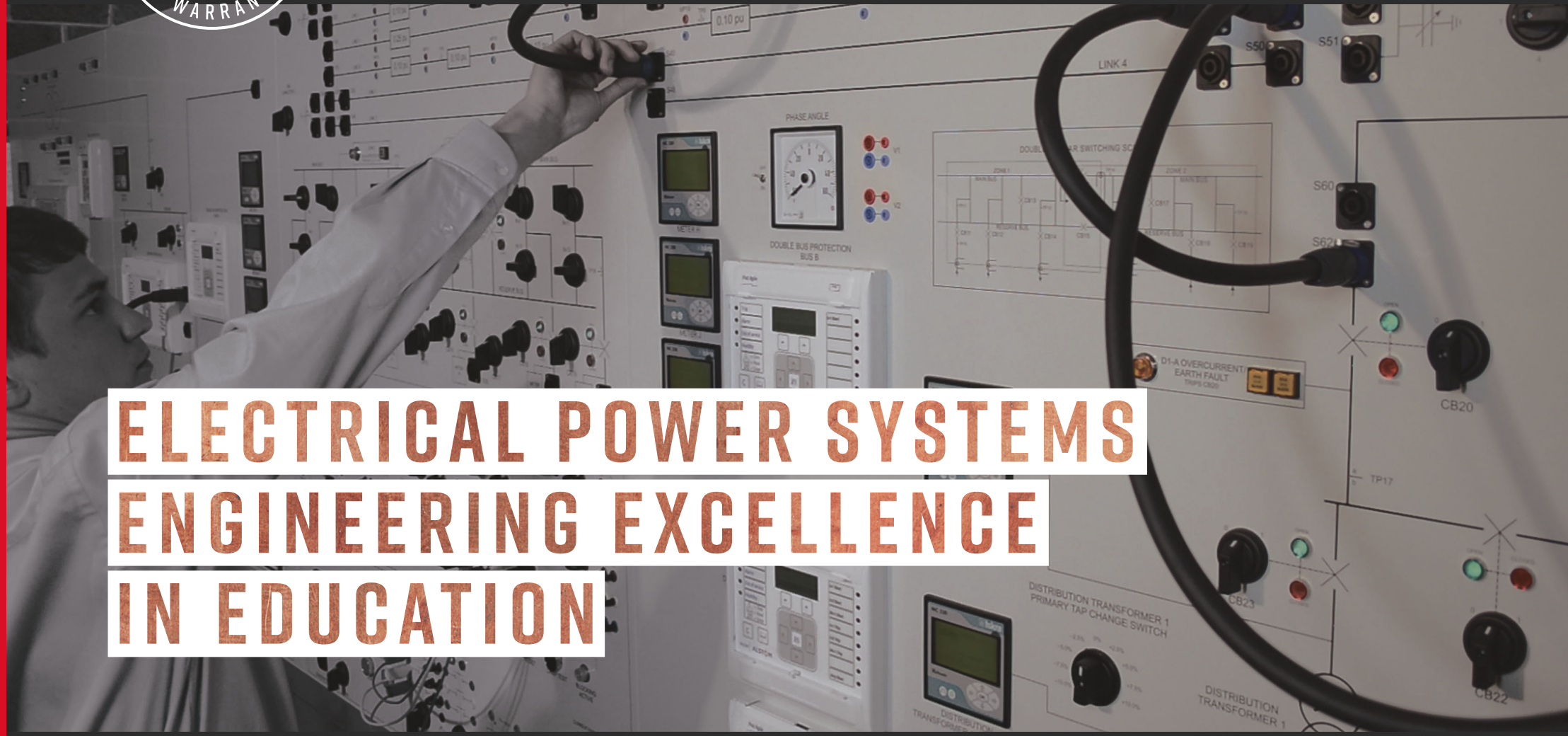
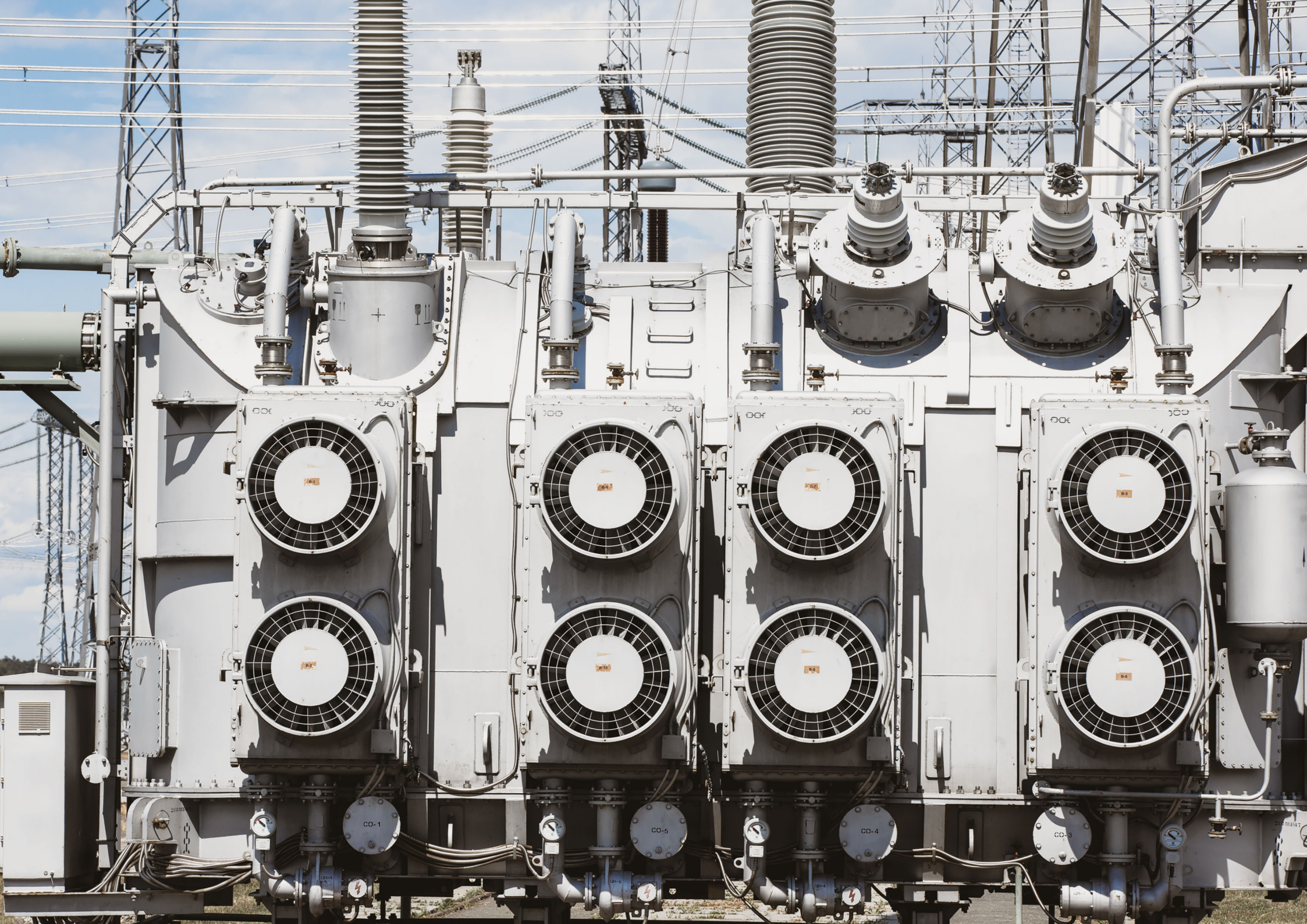
FIVE YEAR QUALITY TECQUIPMENT SINCE 1958 WARRANTY

TECQUIPMENT INDUSTRY



ELECTRICAL POWER SYSTEMS ENGINEERING EXCELLENCE IN EDUCATION


CO-1
CO-5
CO-4
CO-3

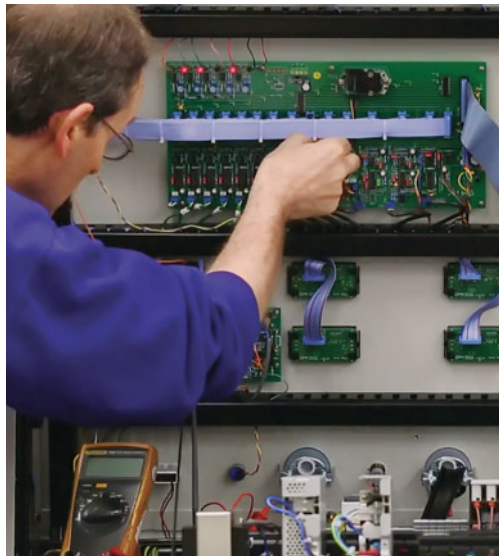
CONTENTS

ABOUT TECQUIPMENT

TecQuipment was founded in 1958 in Nottingham, UK and is dedicated to manufacturing the world's premium training equipment for engineers and technicians in electrical power systems.

The first TecQuipment Electrical Power System Simulator was manufactured over 20 years ago and has been supplied to institutions around the world, helping them to produce the finest engineers in their field.

In an industry that has developed rapidly, TecQuipment has continuously innovated over the years to ensure that our Electrical Power Systems range provides the capabilities and instrumentation that is used directly in the industry. This means the people in your facilities can go from trainee to engineer with maximum effectiveness and efficiency.

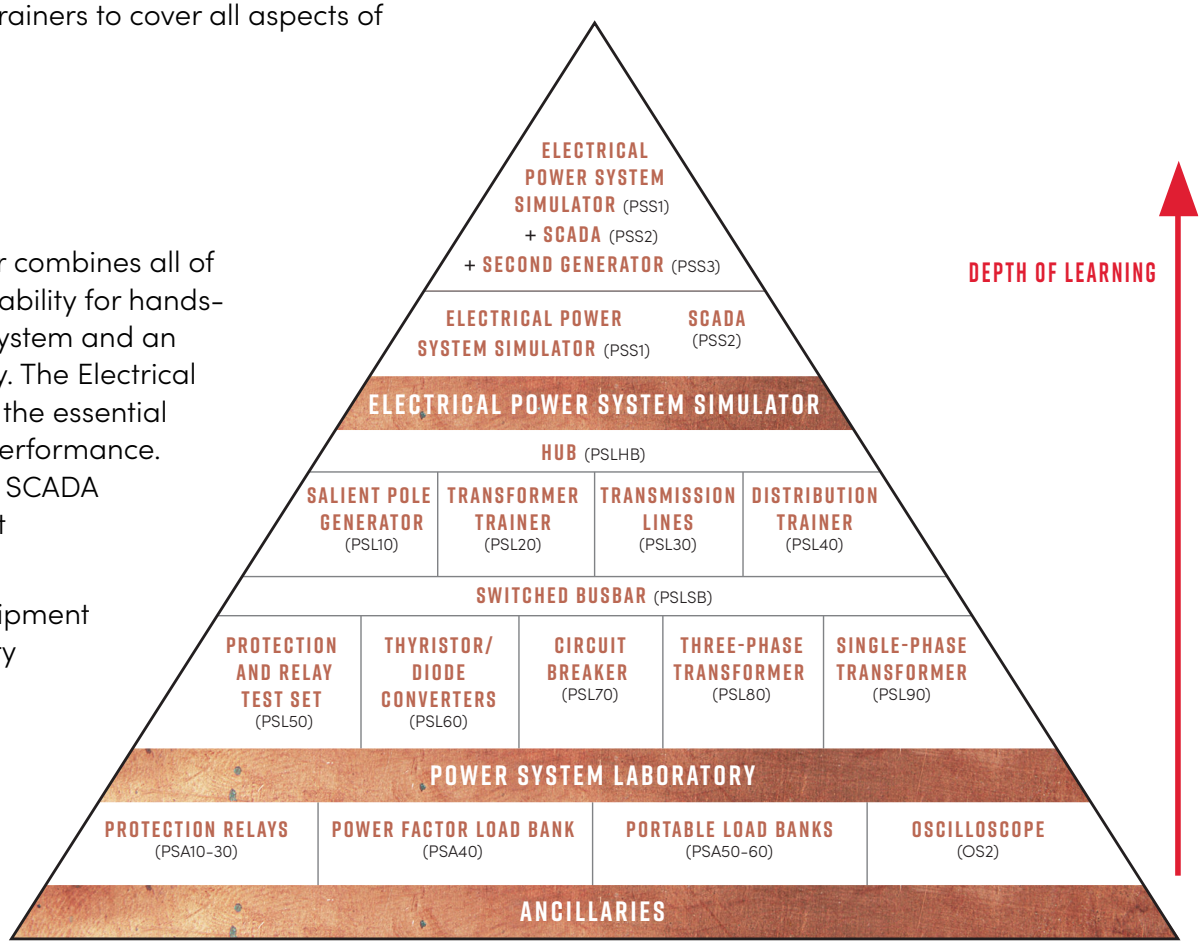


TecQuipment manufactures a comprehensive range of trainers to cover all aspects of an electrical power system, including:

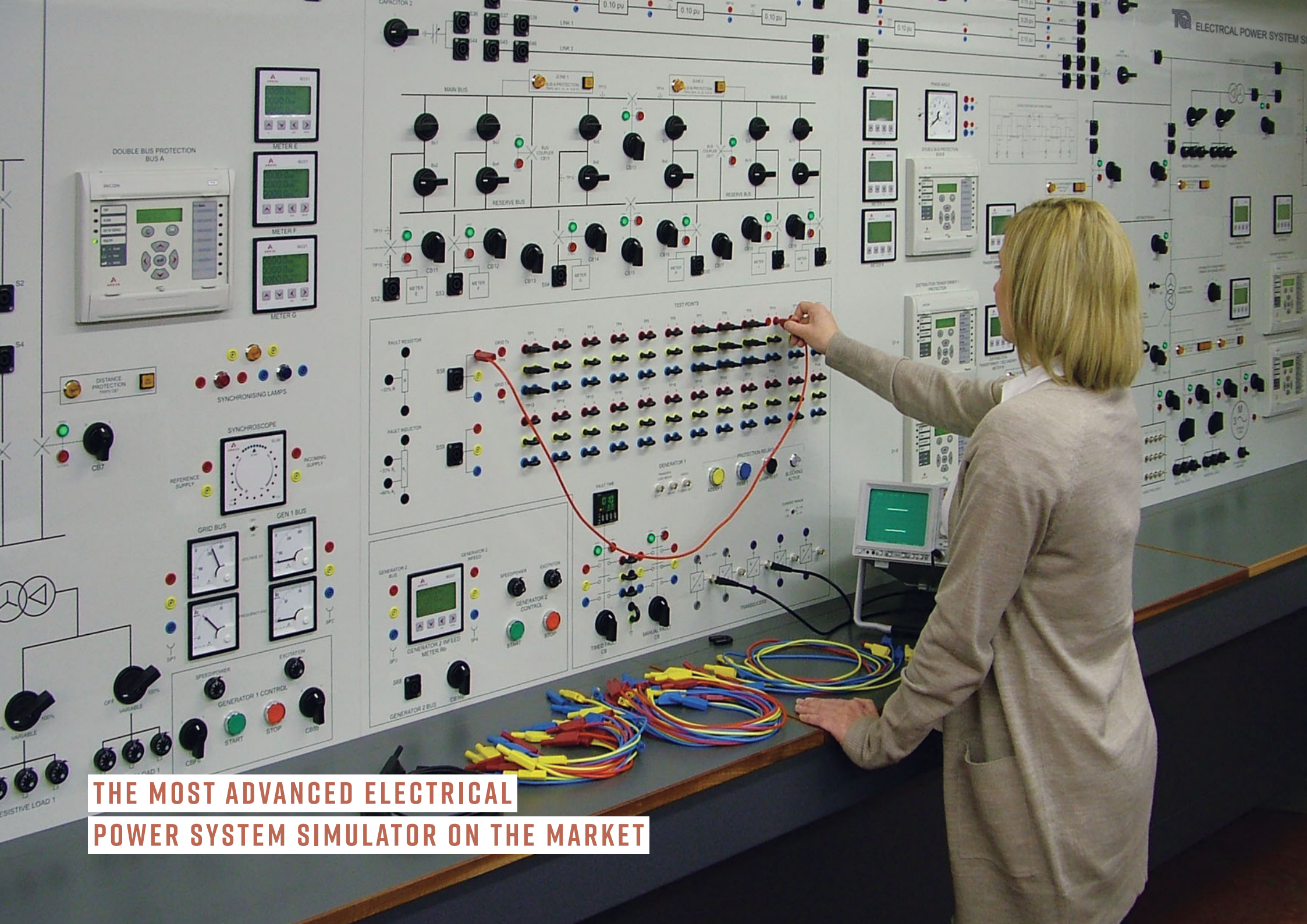
- GENERATION
- TRANSFORMATION
- TRANSMISSION
- DISTRIBUTION
- UTILISATION
- PROTECTION

The all-encompassing Electrical Power System Simulator combines all of the elements in one integrated grid unit. It offers the capability for hands-on experience on a laboratory-scaled electrical power system and an understanding of all the complexities needed for industry. The Electrical Power System Simulator enables trainees to understand the essential aspects of both component and system operation and performance. With the optional additions of a second generator and a SCADA system, the Electrical Power System Simulator is the most complete and advanced training unit on the market.

To support the Electrical Power System Simulator, TecQuipment provides a suite of stand-alone power systems laboratory trainers which allow trainees to study and understand fundamental principles of a power system, crucial for an individual in the power industry. The range covers all the relevant fields, from generation to utilisation. The power systems laboratory is supported by a range of separate relays and load banks for further experimentation.



THE DIAGRAM SHOWS HOW THE DIFFERENT RANGES SUPPORT EACH OTHER TO CREATE A COMPLETE ELECTRICAL POWER SYSTEM COURSE


THE MOST ADVANCED ELECTRICAL
POWER SYSTEM SIMULATOR ON THE MARKET

COMPLETE SOLUTIONS FOR POWER SYSTEMS EDUCATION

REALISTIC, COMPREHENSIVE AND CONVENIENT

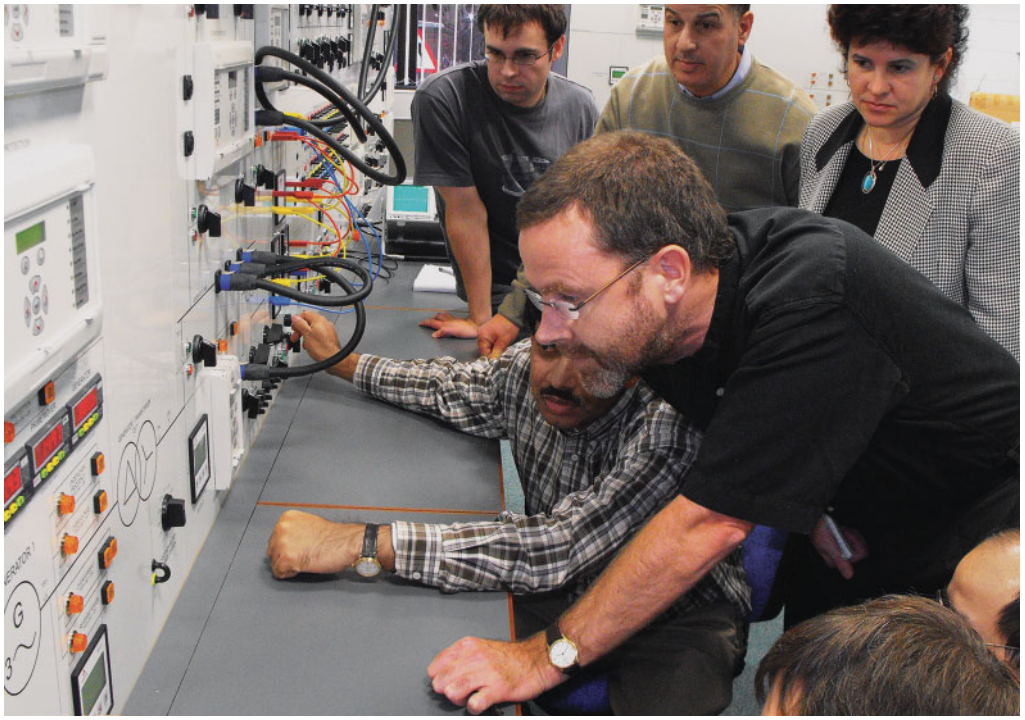
To maximise the educational value, laboratory equipment needs to reproduce real-life characteristics. The Electrical Power System Simulator (PSS1) offers a realistic, scenario-based learning platform, using industrial-standard equipment and software. The simulator can replicate a wide range of faults, and students can study an extensive variety of behaviour that a trainee will face in industry.

The design ensures that students get the highest quality practical experience possible. The Electrical Power System Simulator includes clear and detailed mimic diagrams on its connection panels, making it easy for trainees to connect and understand the circuits.

ADVANCED STUDY

The Electrical Power System Simulator is a natural progression from the modular Power Systems Laboratory as it has more complex features for further study. The optional SCADA – supervisory control and data acquisition (PSS2) and Second Generator (PSS3) extend its capabilities even further.

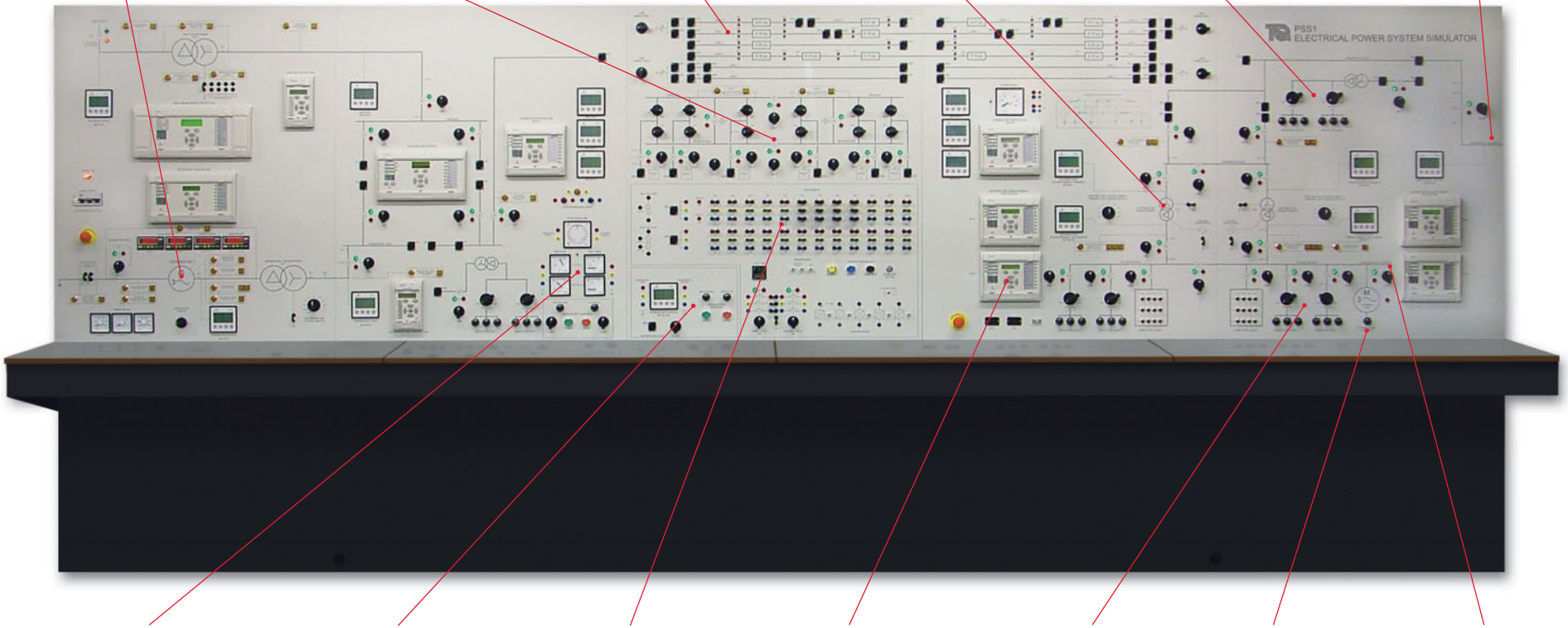
The Electrical Power System Simulator will help students to reach the highest level of training in power systems.



PSSI

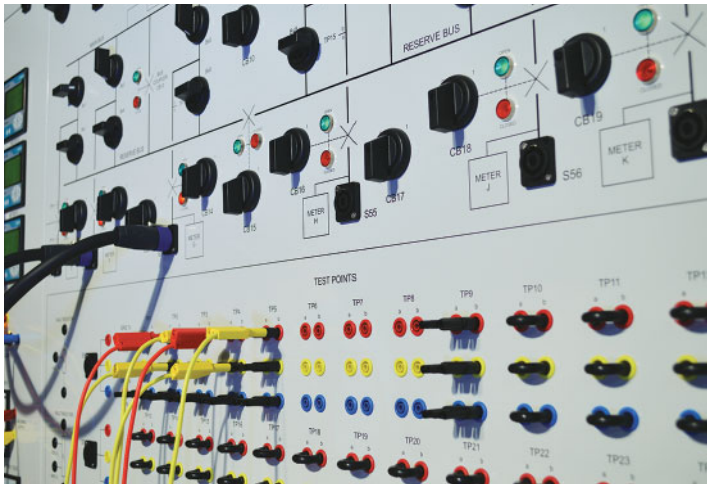
ELECTRICAL POWER SYSTEM SIMULATOR

A self-contained unit that simulates all parts of electrical power systems and their protection, from generation to utilisation.



TRAINING OUTCOMES

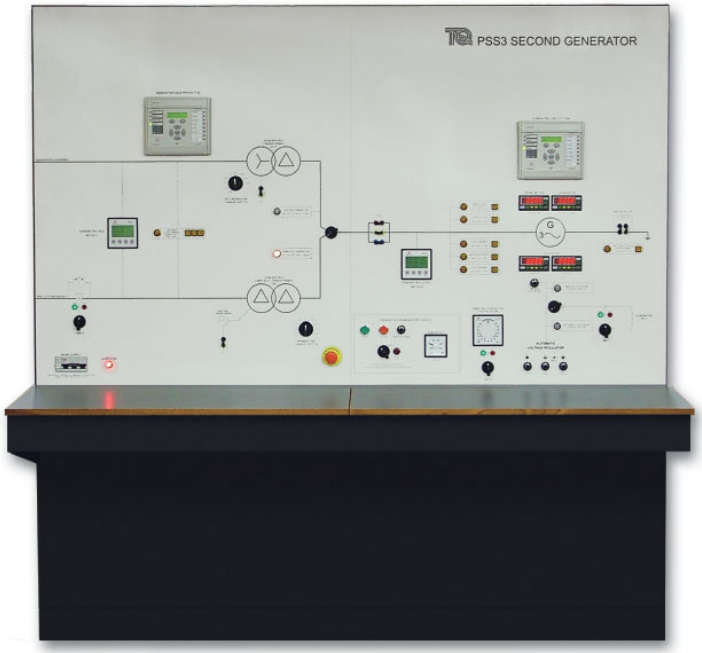
- Power transmission, distribution and utilisation
- Load flow, circuit interruption and differential protection
- Symmetrical, unsymmetrical and unbalanced faults and loads
- Generator synchronisation and performance, including stability and voltage regulation and control
- Using protection relays for overcurrent, distance protection, phase and earth faults
- Using protection relays for differential protection, under and overvoltage and frequency protection
- Transformer tappings and impedances
- Using relays for protection of a busbar, transformers and generators



PSS3

SECOND GENERATOR

The Second Generator is a self-contained motor and generator set that connects to the Electrical Power System Simulator for extra experiments in central and embedded generation power systems and their protection, from generation to utilisation.



TRAINING OUTCOMES

- Central and embedded generation
- Synchronising and paralleling with another three-phase source (mains or generator)
- Load sharing and stiff/ weak systems
- Circulating current monitoring
- Three-source systems: connecting the generator at the central generation or embedded generation level
- Automatic voltage regulator operation in constant reactive power and constant power factor modes

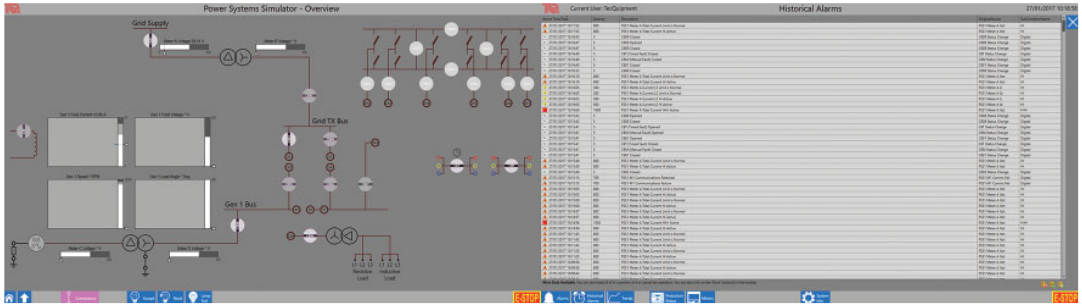
PSS2

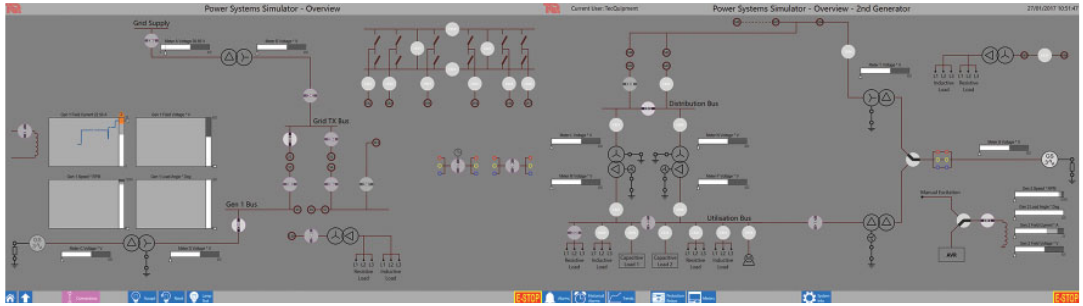
SCADA

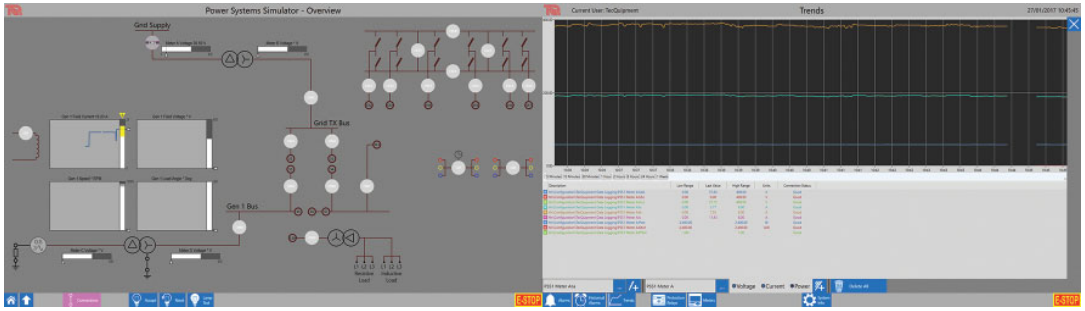
SCADA remotely controls and monitors the Electrical Power System Simulator and Second Generator to teach students how to control and supervise modern power systems.

KEY FEATURES:

- Uses an industry-standard SCADA backend
- Keeps a record of events, alarms and traces
- Remote monitoring and control of circuit breakers
- Remote triggering of controlled fault conditions
- Custom layouts for each experiment:
  - User connections highlighted to assist setup
  - Some experiments include a "schematic" view to further relate experiments to theory
  - Live traces and alarms integrated into experiment screens
- Dual full HD screen monitors with touch-screen capabilities





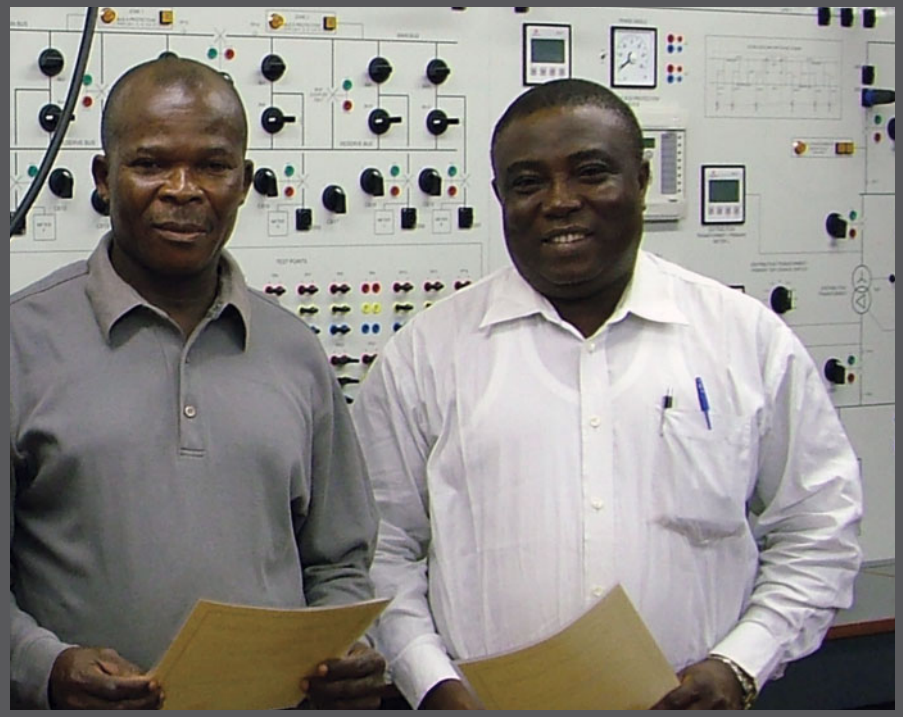


CASE STUDY

DELIVERING STATE-OF-THE-ART POWER SYSTEMS TRAINING TO FUTURE ENGINEERS IN THE CARIBBEAN

For power systems training, the University of Trinidad and Tobago (UTT) required a safe and cost-effective environment in which future engineers, technicians and control room operatives could gain both knowledge-based learning and skills-based training in all aspects of modern electrical power systems.

The UTT considered that TecQuipment's Electrical Power System Simulator (PSS) would provide the high functionality, relevance, flexibility and state-of-the-art design to address their power systems training and teaching needs. The PSS uses modern industrial instrumentation, control devices and techniques throughout, ensuring the operating characteristics are typical of full-scale electrical power systems. The UTT also ordered a Supervisory Control and Data Acquisition Unit (SCADA), a fully compatible optional ancillary which extends the scope of experimentation even further. The system is an actual industrial system which TecQuipment has specially adapted for education.



Before delivering the PSS, some key staff from UTT visited TecQuipment at our head office in the UK where they received full training on the effective implementation and use of the equipment.

The PSS was developed in close consultation with academia, including a leading, world-renowned expert in power systems who delivered some of the training. For their future reference, the PSS was supplied with fully comprehensive teaching, technical and support material written specifically to ensure users at all levels get the very best from the equipment.

When the PSS reached UTT, TecQuipment staff fully installed and commissioned it, ensuring it was running to UTT's complete satisfaction. Lecturers and qualified technicians were familiarised with the equipment to ensure they could use and maintain it in the years to come.

> "After using TecQuipment's Electrical Power System Simulator for some time, we are exceptionally pleased with its quality, operation and functionality. It really does embody all elements of a full electrical power system with a high concentration on educational value throughout the product design. This is a very effective teaching aid for power engineers."
>
> JOHN JOSEPH, LECTURER IN ELECTRICAL ENGINEERING, UTT

IN FOCUS

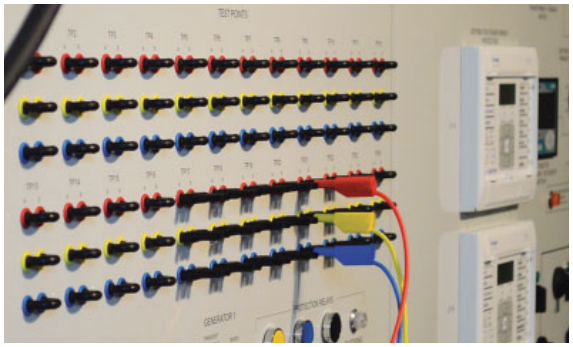
ALL THE COMPONENTS OF A STANDARD POWER SYSTEM

GRID SUPPLY: Mains power input via fully monitored and protected grid supply transformer. Numerous protective functions can be explored including biased differential and multiple earth fault detection methods.

GENERATION: Salient-pole generator and fully controllable prime mover to mimic source of rotational mechanical power, such as steam or hydroelectric turbines. There are eight different generator protective functions and digital and analogue feedback instruments for detailed investigation into generation behaviour.

TRANSMISSION LINES: Seven lines provide the ability to understand power transmission over long, over-head lines (125 km). There are also four cables to mimic shorter distance (10 km) power transmission. High-resolution line facilitates convenient distance protection experimentation.

DISTRIBUTION TRANSFORMERS AND UTILISATION LOADS: Two identical parallel distribution transformers model substation level of the power system. Tap changing switches and variable loads allow extensive modelling of substation behaviour. Protective functions, such as back tripping and multi-shot auto-reclose, can be explored in this section of the power system.



TEST AND MEASUREMENT POINTS

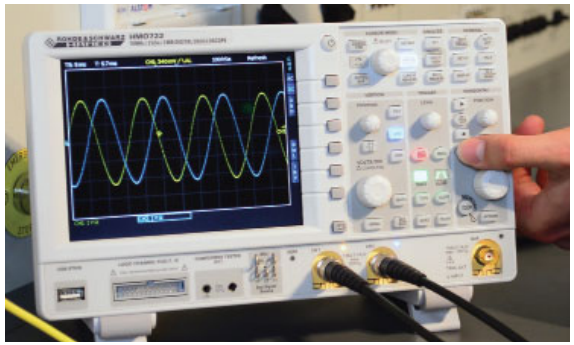
There are 24 test points over three phases providing the user with 72 different test points to customise the architecture of the circuit to meet your training requirements. These test points are located in one ergonomic position for efficient investigation.

Measurement points along the transmission lines provide trainees with the capabilities to measure the phase angle between two points on a line.

SYNCHRONISATION

Synchronisation of the internal generator allows experiments into power flow between the generator and the wider grid system, through the use of the manual three-lamp method, or through the synchroscope.

The addition of the second generator (PSS3), enhances the experimental capabilities of the power system. Comparison studies into synchronising the power system to either the grid supply or the second generator are possible. Trainees discover how the difference of electrical inertia affects a weak or stiff system in a fault condition.



INPUT FOR/REMOTE CONTROL OF SECOND GENERATOR

The Second Generator (PSS3) has the potential to input power at two levels of the Electrical Power System Simulator, simulating power from embedded or centralised sources.

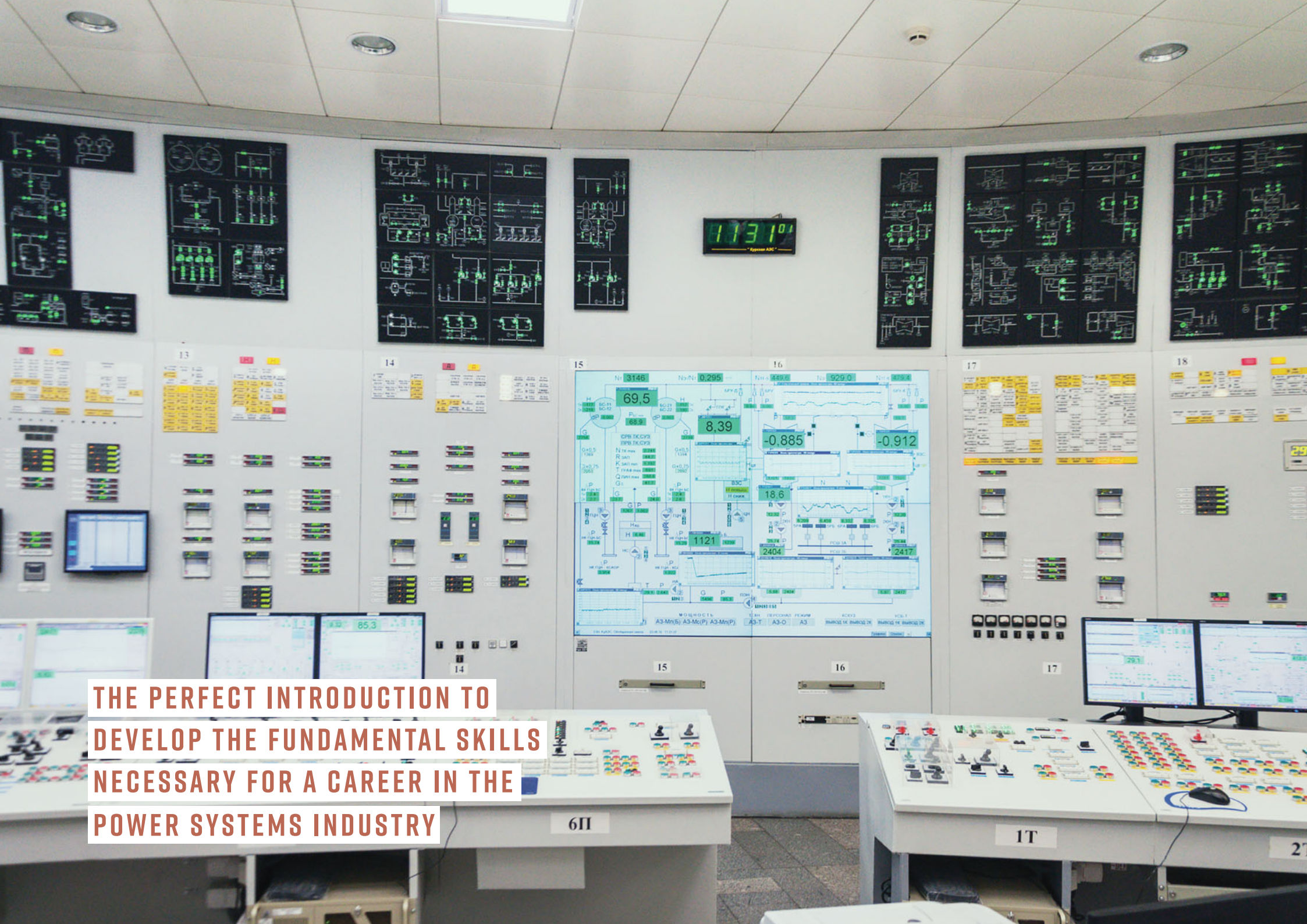
PROTECTION RELAYS

Industrial-standard numerical protection relays are utilised throughout the power system to protect the components in a variety of methods. The protection relays cover simple techniques such as over-current protection, to more complex concepts including 100 per cent stator earth fault generator protection.

BUSBAR

The Electrical Power System Simulator includes a switched busbar section, comprising of a main bus and stand-by "reserve" bus. This allows for the training of zonal protection and contingency planning in the event of a system fault.

The measurement centres provide the option for custom circuits to be created and investigated utilising sections of the bus matrix.


THE PERFECT INTRODUCTION TO
DEVELOP THE FUNDAMENTAL SKILLS
NECESSARY FOR A CAREER IN THE
POWER SYSTEMS INDUSTRY

POWER SYSTEMS LABORATORY

INTERCONNECTED SYSTEM

You can purchase one or more individual pieces of equipment from the Power Systems Laboratory (PSL) range as you require. The units are completely autonomous, with full experimental capabilities to understand the fundamental principles of each element of an electrical power system.

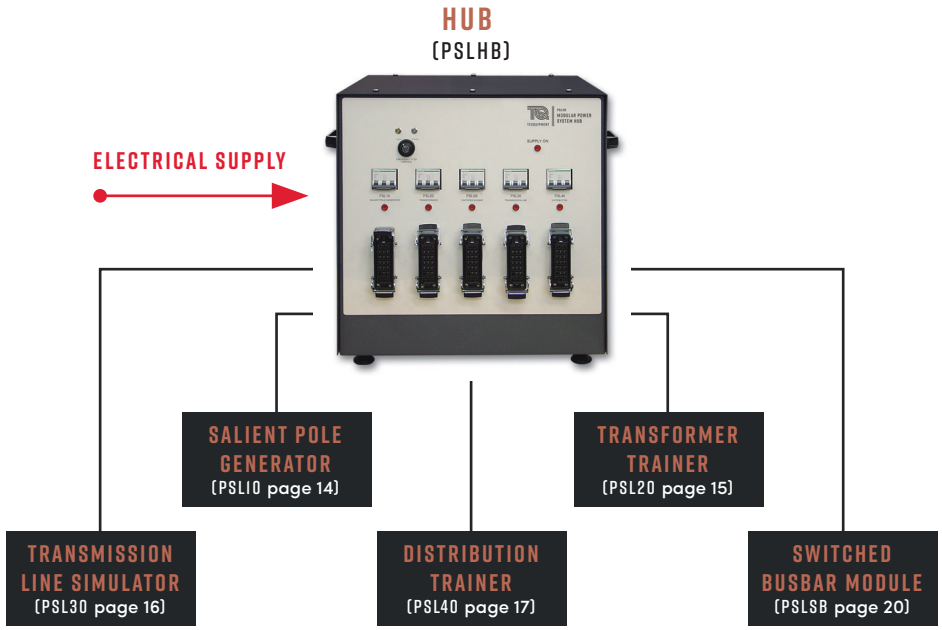
Users can connect the different Power Systems Laboratory trainers with the use of the Hub (PSLHB), so trainees can understand the transfer of the experimental power from one component of a power system to the next (i.e. generation to transformation). This allows the user to develop the knowledge needed to progress to the "systems thinking" provided by the Electrical Power System Simulator (PSS1).

POWER SYSTEMS LABORATORY HUB

When connected to a suitable mains supply, the Hub provides power for each part of the Power Systems Laboratory. It also links the electrical test circuits so students do not need to use long test leads between modules. The Hub links the emergency stop buttons of each connected module to give better safety in the laboratory.

POWER SYSTEMS LABORATORY ANCILLARIES

Relays – see page 23
Load banks – see page 24



PSL10

SALIENT POLE GENERATOR

Provides typical generator performance characteristics for experiments in generation, synchronising and paralleling, and load sharing.

- Four-pole, three-phase salient pole a.c. generator
- 50 Hz, 1500 rev.min^{-1} and 60 Hz, 1800 rev.min^{-1}
- Automatic voltage regulator (AVR) or manually excited

TRAINING OUTCOMES

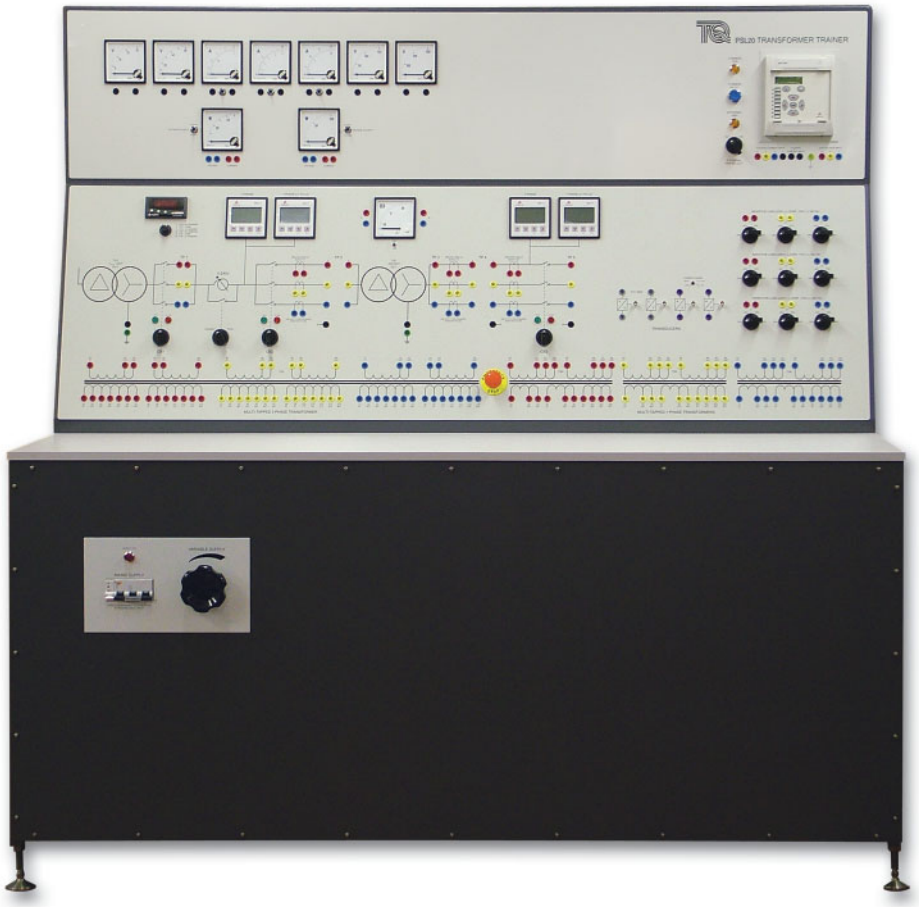
- Generator voltage and frequency control
- Voltage, speed and field current characteristics
- Generator open and short circuit tests
- Load tests
- Normal and sudden short-circuit tests
- Zero power factor test
- Synchronising and paralleling
- Control of real and reactive power
- Protection relays

PSL20

TRANSFORMER TRAINER

Investigates the principles and operating characteristics of single-phase and three-phase power and distribution transformers.

- **DELTA-STAR TRANSFORMER:** 5 kVA 220/220 VAC three-phase delta to star (Dy11)
- **SINGLE-PHASE EDUCATIONAL TRANSFORMERS:** Three x one volt per turn transformers rated at 1 kVA and 240 V with multi-tapped primary, secondary and tertiary windings. One transformer has thermocouples to its windings and core.
- **THREE-PHASE EDUCATIONAL TRANSFORMERS:** 3 kVA nominal three-limb, three-phase transformer with multi-tapped primary and secondary windings. One phase has thermocouples to its windings and core.



TRAINING OUTCOMES

- Voltage and turns ratios
- Parallel and series windings, delta, star and interstar
- Open and short circuit tests to find transformer properties, including losses and efficiency
- Balanced and unbalanced loads
- Phase differences in popular three-phase transformer connections
- Three to two-phase connections (Scott and Le Blanc)

PSL30

TRANSMISSION LINE SIMULATOR

Investigates short, medium and long transmission line performance in single-phase and three-phase systems.

LINE SIMULATION:

- Inductors, with three-phase line represented in per-unit values

THREE-PHASE LINES:

- Five sections, each at 0.15 p.u. value: 75 km of 132 kV line on a 100 MVA base
- One section at 0.25 p.u. value: 125 km of 132 kV line on a 100 MVA base

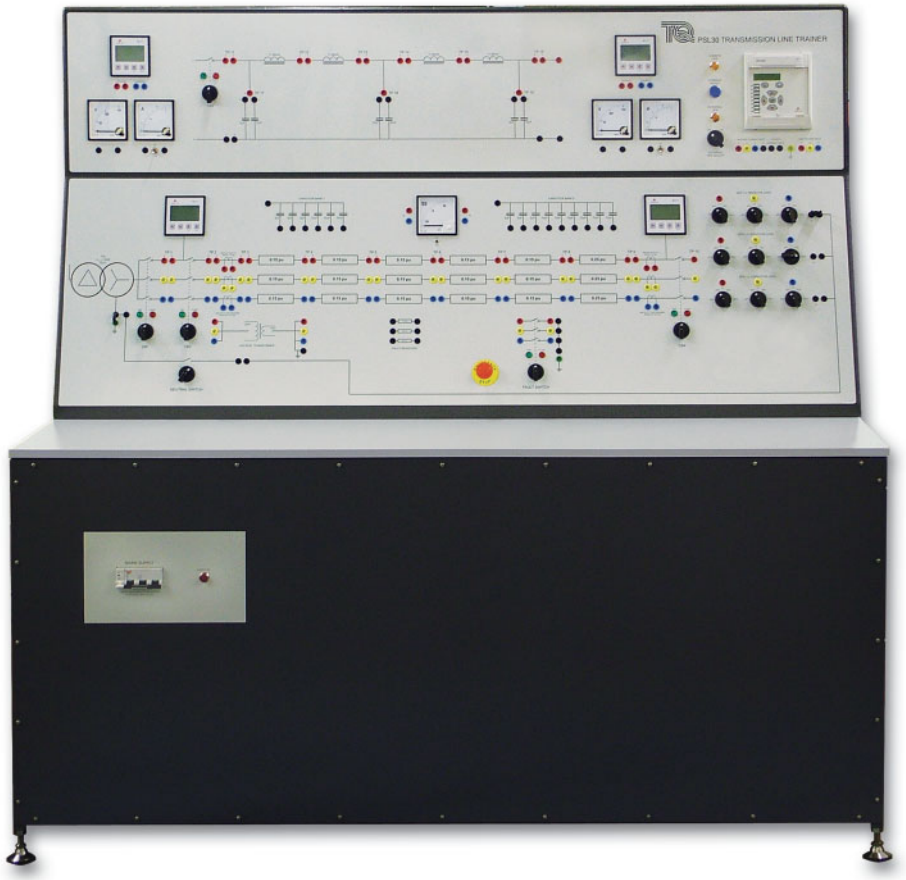
TRAINING OUTCOMES

SINGLE-PHASE LINE:

- Short-line investigation
- Medium or long-line investigation (nominal “Tee” and “Pi” methods)
- Effect of power and reactive power flow on voltage drop and transmission angle
- Medium/long-line investigation of a natural load of a line
- Voltage regulation at constant load and power factor

THREE-PHASE LINES:

- Per-unit values
- Unbalanced loads and the neutral connection
- Fault simulation and line protection studies
- Parallel feeders and multi-section lines



PSL40

DISTRIBUTION TRAINER

Shows how electricity is distributed and protected – investigates distribution through transformers, radial and ring-main circuits, and efficiency and regulation.

LINE SIMULATION:

- Inductors, with three-phase line represented in per-unit values

THREE-PHASE LINES:

- Five sections, each at 0.15 p.u. value: 75 km of 132 kV line on a 100 MVA base
- One section at 0.25 p.u. value: 125 km of 132 kV line on a 100 MVA base

TRAINING OUTCOMES

- a.c./d.c. transmission
- Radial and ring systems with different load types
- Distribution losses and efficiency
- Voltage control through reactive power compensation
- Use of a tapped distribution transformer for load voltage control
- Three-phase distribution system with balanced and unbalanced loads
- Effect of an open-circuited neutral conductor on voltage across a single-phase load
- Effect on line current of improved power factor
- Distribution system under faults
- Relay discrimination

PSL50

PROTECTION RELAY TEST SET

For comprehensive investigations into the theory and practice of electrical power system protection.

PROTECTION RELAYS INCLUDED:

- Overcurrent and Earth Fault Relay (PSA10)
- Differential Protection Relay (PSA15)
- Directional Overcurrent Relay (PSA20)
- Feeder Management Relay (PSA25)
- Distance Protection Relay (PSA30)

TRAINING OUTCOMES

- Overcurrent protection
- Relay discrimination using current and time settings
- Directional protection
- Differential protection
- Earth fault protection
- Distance protection
- Current Transformer (CT) polarity

PSL60

THYRISTOR AND DIODE TRAINER

A mobile unit that teaches the principles and applications of thyristors, diodes and converters in power circuits and regulation.

SEMICONDUCTORS:

- 6 x power diodes
- 6 x power thyristors

OTHER WOUND COMPONENTS:

- 10 mH inductor, tapped at 5 mH
- 52 mH interphase transformer, centre-tapped

TRANSDUCERS:

- 2 x voltage transducers 40 V in = 1 V out
- 3 x current transducers 2 A in = 1 V out

TRAINING OUTCOMES

- Single-phase and polyphase diode rectifier circuits
- Single and three-phase fully controlled thyristor bridge circuits
- Single-phase a.c. control using thyristors
- Rectifier harmonics, output smoothing methods and inverted operation
- Commutation effects in polyphase and single-phase rectifiers

PSLSB

SWITCHED BUSBAR MODULE

Connects other parts of TecQuipment's modular Power Systems Laboratory to allow investigations into more complex electrical power systems.

TRAINING OUTCOMES

WHEN USED WITH OTHER TECQUIPMENT POWER SYSTEMS PRODUCTS, THE SWITCHED BUSBAR MODULE ALLOWS INVESTIGATIONS INTO:

- Unit protection (high impedance differential protection)
- Faults inside a zone
- Faults outside a zone
- Through faults

PSL70

CIRCUIT BREAKER TRAINER

Compares different circuit protection devices and shows students how they perform.

CIRCUIT 1:

- Thermomagnetic Miniature Circuit Breaker (MCB) with C curve characteristics and an adjustable Residual Current Detector (RCD).

CIRCUIT 2:

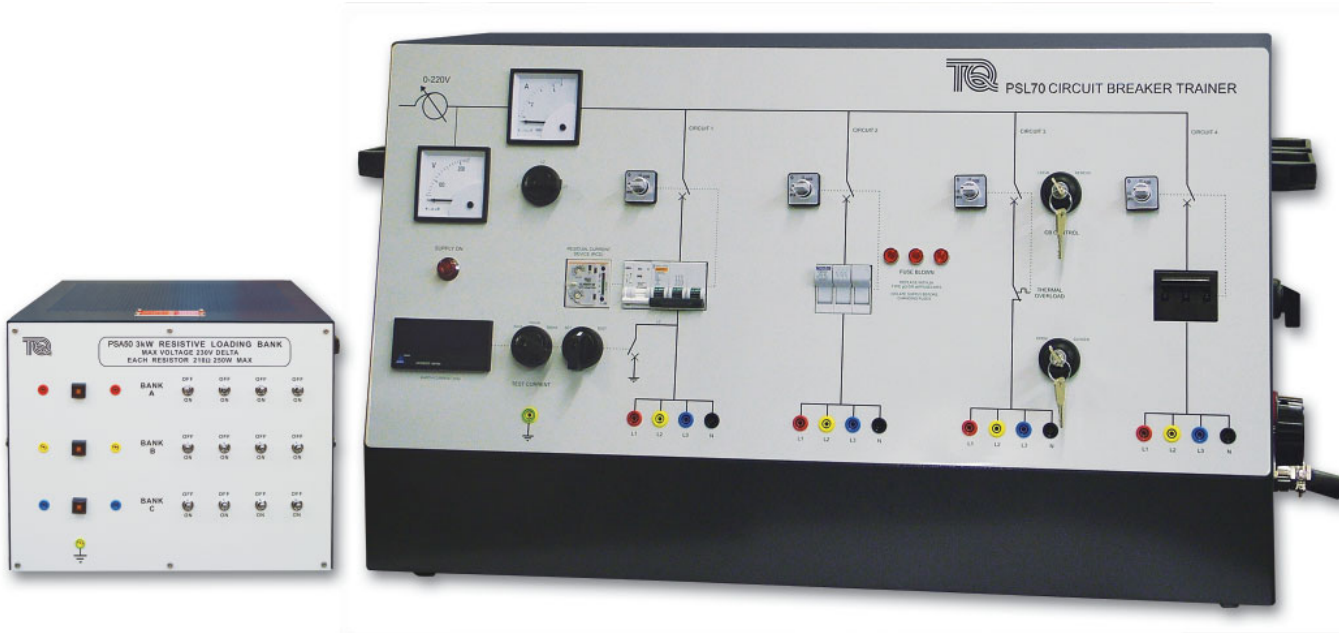
- Three type gG cartridge fuses in carriers. Includes a “fuse break” detector circuit.

CIRCUIT 3:

- Thermal overload and remote/local keyswitches.

TRAINING OUTCOMES

- Circuit overcurrent protection – using four different types of circuit protection
- Protection device rating and circuit current
- Local and remote control (of circuit breaking)
- Residual current detection (earth leakage) – with balanced and unbalanced loads



PSL80

THREE-PHASE MOBILE TRANSFORMER

A mobile 3 kVA three-phase, multi-tapped transformer for a wide range of single-phase or three-phase experiments.

TRANSFORMERS:

- 3 kVA nominal (1 kVA each phase)
- Three-limb, three-phase double-wound transformer
- Each primary has two sections: one with tappings at 18 V and 138 V; the other is mirrored at 120 V and 138 V.
- Each secondary has two sections: one with tappings at 40 V, 48 V, 50 V, 52 V, 60 V, and 69 V; the other is mirrored at 9 V, 17 V, 19 V, 21 V, 29 V and 69 V.

TRAINING OUTCOMES

- Single-phase and three-phase experiments
- Open and short-circuit tests to find iron and copper losses
- Harmonics and unbalanced loading
- Star-star, star-delta, delta-delta and delta-star connected transformers
- Interconnected star (interstar or zig-zag) connection

PSL90

SINGLE-PHASE TRANSFORMERS

A set of three single-phase, multi-tapped transformers for a wide range of single-phase or three-phase experiments.

TRANSFORMERS:

- 1 kVA nominal (each transformer)
- Single-phase, double-wound transformers. Each primary has two sections with tappings at 0 V, 104 V, 120 V and 138 V. Each secondary has two sections with tappings at 0 V, 52 V, and 60 V. Each transformer has different tertiary tappings:
  - one transformer has 0 V, 28 V, 50 V and 52 V
  - the second has 0 V, 47 V, 50 V and 52 V
  - the third has 0 V, 48 V, 50 V and 52 V

RELAYS

PSA10
OVERCURRENT AND EARTH FAULT RELAY

Supplied with TecQuipment's Protection and Relay Test Set (PSL50) to enable investigations into protection and monitoring of transformers, transmission lines and distribution schemes.

PSA15
DIFFERENTIAL PROTECTION RELAY

For investigations into protection of transformers, autotransformers, generators and other apparatus with two windings of transformers, transmission lines and distribution schemes.

PSA20
DIRECTIONAL OVERCURRENT RELAY

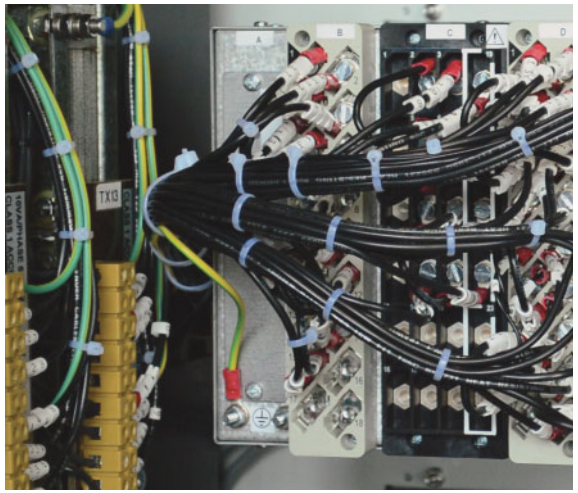
Supplied with TecQuipment's Protection and Relay Test Set (PSL50) to enable investigations into protection and monitoring of generator and transformer schemes, overhead lines, underground cables and backup on high-voltage systems.

PSA25
FEEDER MANAGEMENT RELAY

Supplied with TecQuipment's Protection and Relay Test Set (PSL50) to enable investigations into protection and monitoring of overhead lines and underground cables, transmission lines and distribution schemes.

PSA30
DISTANCE PROTECTION RELAY

Supplied with TecQuipment's Protection and Relay Test Set (PSL50) to enable investigations into protection and monitoring of overhead transmission lines.



LOAD BANKS

PSA50
PORTABLE RESISTIVE LOAD BANK

A portable resistive load bank for electrical power experiments and general laboratory use.

PSA55
PORTABLE CAPACITIVE LOAD BANK

A portable capacitive load bank for electrical power experiments and general laboratory use.

PSA60
PORTABLE INDUCTIVE LOAD BANK

A portable inductive load bank for electrical power experiments and general laboratory use.

PSA40
POWER FACTOR LOAD BANK

A fully adjustable three-phase load bank with selectable power factor compensation.

CASE STUDIES

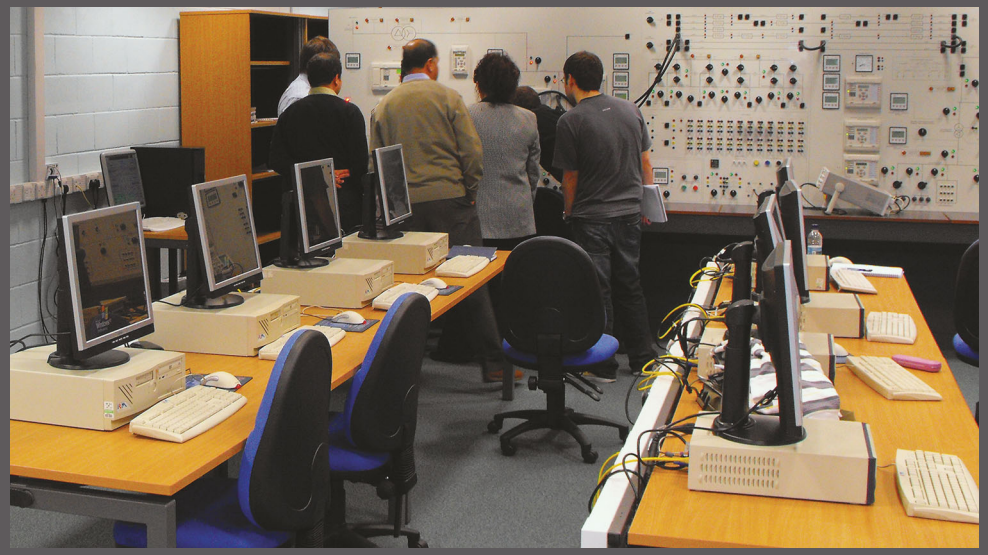
CARDIFF UNIVERSITY, UK

TecQuipment was very pleased to be associated with a world-leading laboratory for undergraduate teaching and post-graduate research following the installation, commissioning and training of our Electrical Power System Simulator at Cardiff University, Cardiff School of Engineering. The equipment includes the PSS1 Electrical Power System Simulator and the PSS3 Second Generator.

These will be used by some of the leading research groups in the UK including:

- The Institute of Advanced Materials and Energy Systems
- The High Voltage Research Centre of Excellence
- Electrical Energy Tech Research Group
- Centre for Integrated Renewable Energy Generation and Supply

Cardiff University is at the forefront of developing new and more efficient ways of utilising the electrical power generated by the National Grid and we take great pride in playing a part in the future development of our Electrical Power Generation Industry.



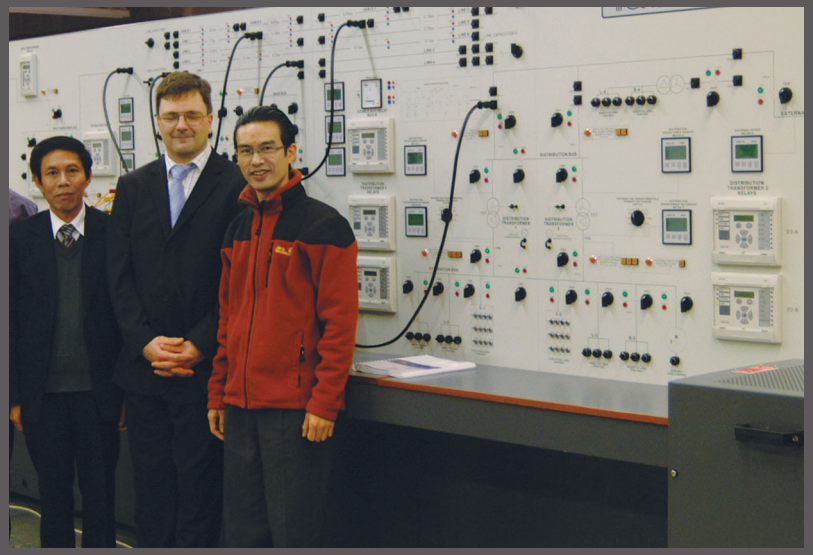
HANOI UNIVERSITY OF TECHNOLOGY, VIETNAM

Dr Viet and Professor Ut of the Electrical Department of the Hanoi University of Technology in Vietnam visited us at our Head Office to approve an upgrade to their Electrical Power System Simulator. The upgrade was necessary due to limitations in the original product that could not be resolved on site in Hanoi.

The PSS was brought back to us for the upgrade and electrical engineer Adrian Wint and electrical wireman Adrian Deere worked all hours to complete the upgrade before the Vietnamese academics arrived.

During their visit, Dr Viet and Professor Ut were shown the improvements to their PSS and taken through its whole range of recommended experiments.

Our visitors were happy that we had met all their needs and were now anxiously looking forward to using their fully modernised PSS to train their students.



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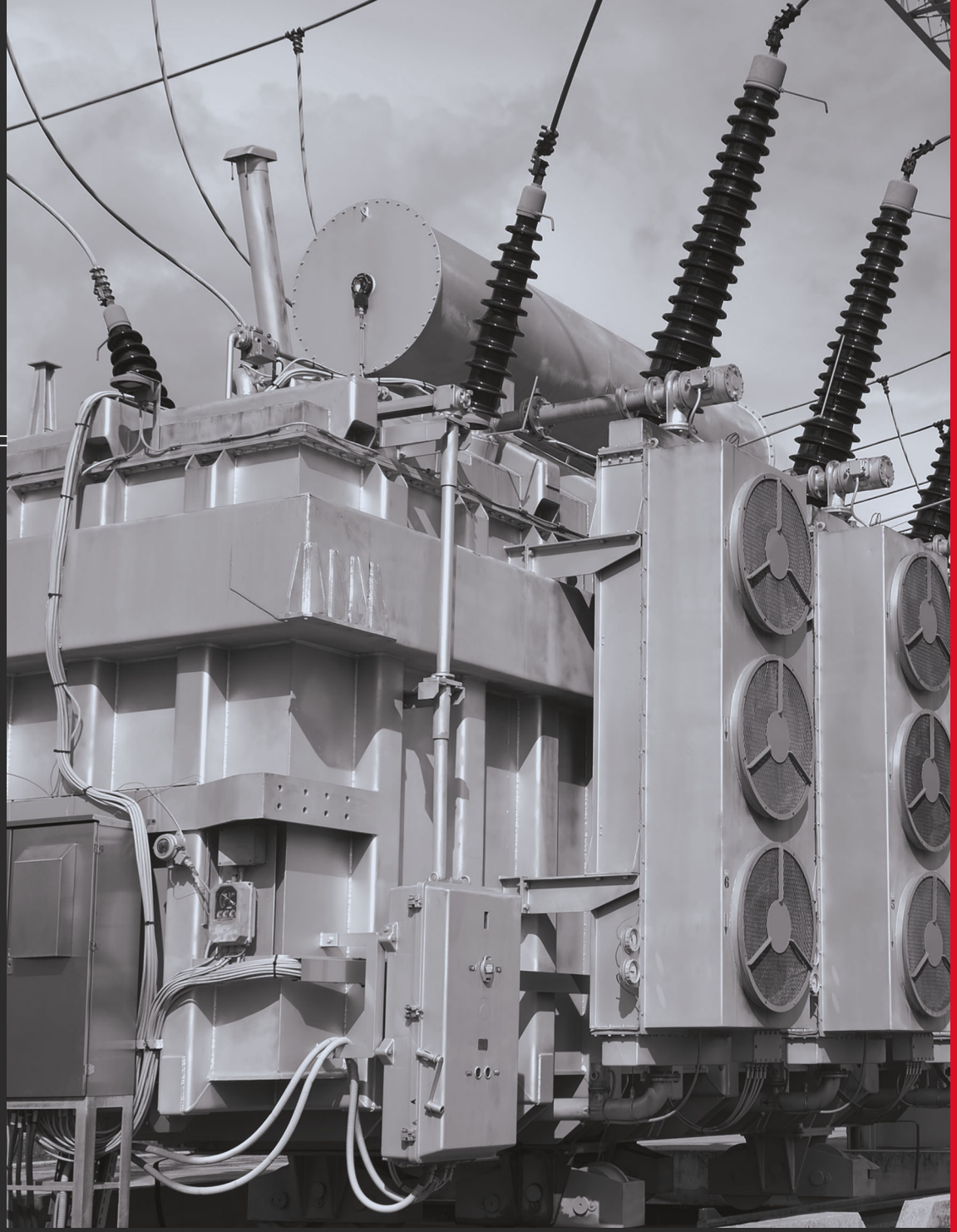

TecQuipment Ltd, Bonsall Street, Long Eaton, Nottingham NG10 2AN, UK