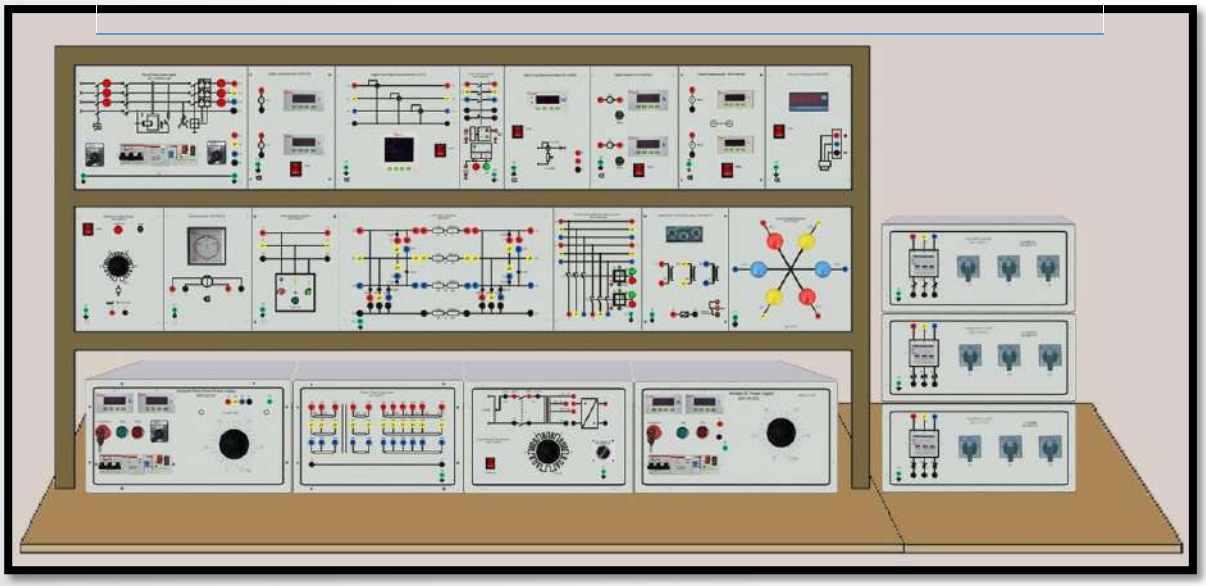
POWER ENGINEERING TRAINER
EDC-PE-1000

1. Power Generation, 2.Power Transmission & Distribution, 3.Power Protection Techniques, 4.Energy Utilization



POWER ENGINEERING TRAINER

This training system has been designed to provide the students with a fully comprehensive knowledge in Electrical Power Engineering systems. The trainer is composed of a set of modules for the simulation of the various subsystems forming a complete electrical power system, from power generation to energy utilization. High voltage components have been scaled down for obvious reasons: a real 380 kV power transmission line is represented by a 380 V line in the laboratory. However, the same low voltage industrial equipment which is normally used in real systems has been used also in this laboratory, whenever this was feasible.

ELECTRICAL POWER ENGINEERING

- This Training system contains high accuracy digital meters for accurate values without any human error.Full heat proof 4mm safety wires and pins.

- The trainer can be subdivided into four major study areas:
  - Power Generation
  - Power Transmission and Distribution
  - Protection Techniques
  - Energy Utilization

- In the Power Generation section a two-pole alternator is investigated. A dc shunt wound machine performs the drive function.To determine some of the characteristics of the synchronous machine, the so called isolated operation situation is reproduced.
- This is an operating mode in which the generator supplies only one single consumer.
- Then, various synchronization circuits are assembled and the response of the machine is investigated in a constant-voltage constant-frequency system. In this situation, voltage and frequency are predetermined by the system and have constant values.

- In the Power Transmission and Distribution section a three-winding transformer is investigated. Then, a model of an overhead high voltage power line is used to investigate its performance characteristics under various load conditions.
- Circuit configurations are connected for the demonstration of different neutral point connections in three-phase mains systems. Asymmetrical short-circuits are also simulated and reactive power compensation analyzed.

- In the Protection Techniques section instrument transformers, to reduce the high current and voltage values so that they can be measured safely and economically, are studied. Then, the procedures which are most commonly used in protective technology are introduced and the most frequently used relays (under/over voltage relays, definite and inverse time over-current relays, earth-fault relays, etc.) are investigated.
- Finally, over-voltage, under-voltage and earth fault monitoring and short-circuit protection of high voltage lines are analyzed.

- In the Energy Utilization section the problems related to reactive power compensation are discussed as well as the methods and the equipment relevant to measuring the electrical energy in ac current and in three-phase networks: active and reactive energy induction meters and maximum demand meters.

1. ELECTRICAL POWER GENERATION

- The three-phase current has emerged as the simplest form of power, in terms of both transmission and universal application, in the area of public power supply.
- In fact, three-phase currents can be transmitted to a voltage level which is suitable for the distances the power has to be transmitted and, furthermore, it is ideal for being used by the consumers.
- The major problem is that electrical power cannot be stored in large quantities and, consequently, it has to be generated at the same time the consumer needs it.
- Then, if the synchronous generator must be connected in parallel with a constant- voltage constant-frequency system, it has to reach its nominal speed, and the excitation voltage has to be increased from zero until the stator voltage is brought up to the same level as that of the network. To obtain this situation, the magnitude, the phase relation and the rotational direction of the two voltages must be in agreement.
- This procedure is termed synchronisation. In this section a two-pole alternator is investigated.

2. POWER TRANSMISSION AND DISTRIBUTION

- The major advantage of ac and three-phase technology over dc technology is that the electrical power is generated economically in large power stations relatively far from the end users, transported at high voltage over long distances with very little power loss and finally made available to the consumers the way they need it.
- This is possible only by using transformers.
- In this laboratory a three-winding transformer is investigated. It consists of three individual poles with different connection possibilities on the primary side and variable secondary voltage. The third winding (tertiary winding) is designed as the delta stabilizing winding needed for asymmetrical loads.
- Overhead power lines are mainly used to transmit electrical energy from the power stations to the consumers. However, in densely populated areas the power can only be supplied via cables.
- Also busbars, disconnectors, power circuit breakers, voltage and current transformers are studied; these, in fact, are among the most important components of a switching station.

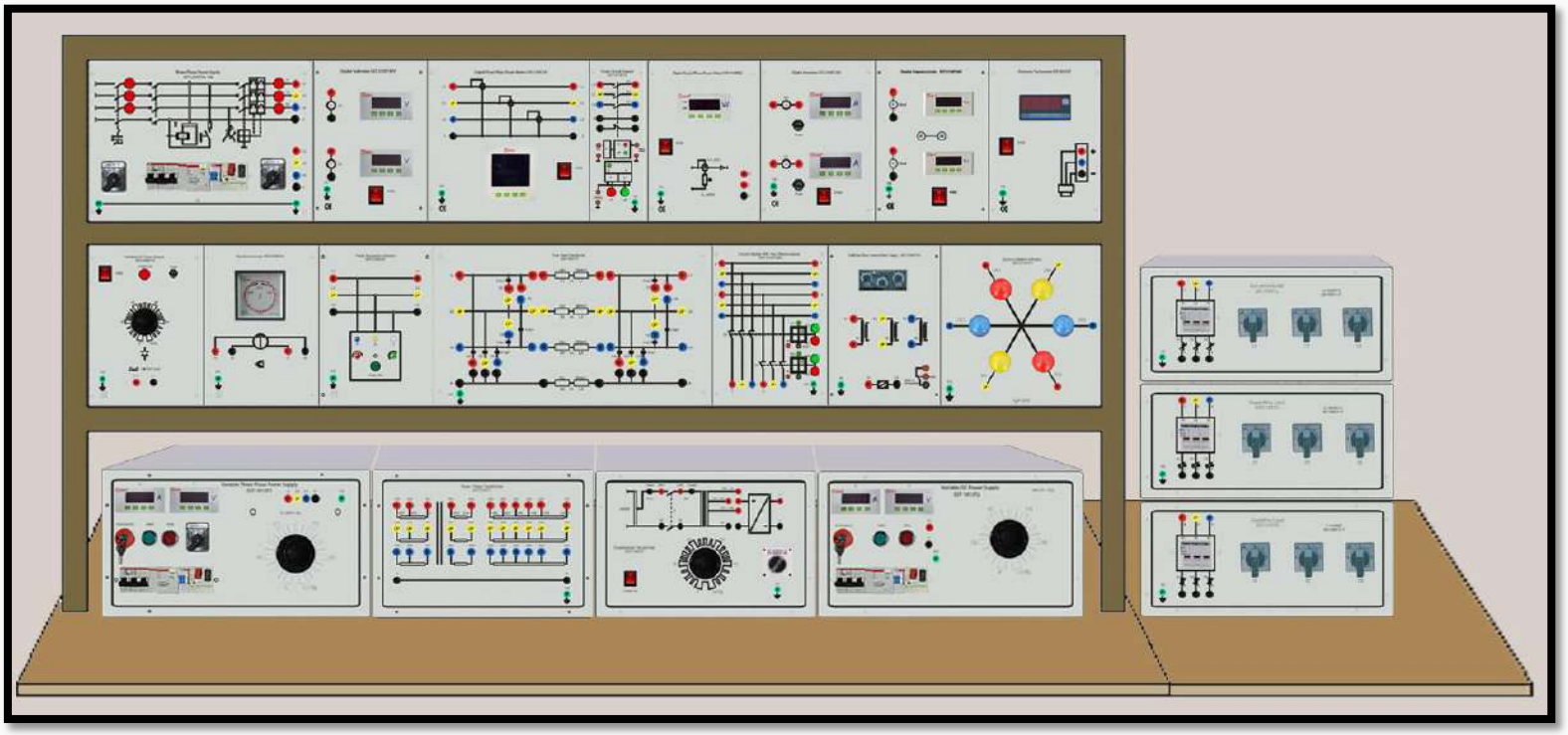
3. POWER PROTECTION TECHNIQUES

- In electrical power supply systems, currents and voltages are constantly measured and monitored to ensure that they remain within certain limits.
- In general, the current and voltage values are so high that they cannot be measured directly and special transformers have to be used to reduce these values to a level which can be measured safely and economically.
- In this laboratory single and three-phase current and voltage transformers are studied.
- In cases of short-circuit, for instance, the very high fault currents produced can destroy parts of the system and could often even endanger the lives of humans.
- For these reasons, special protection systems, which must react quickly and reliably in the event of faults, have been developed in the area of electrical power distribution.
- In this laboratory a number of protective relays are analyzed: under/over voltage time relays, definite time over-current relays, inverse time over-current relays, earth-fault relays, etc.).

4. ENERGY UTILIZATION

- Energy consumers, in particular the large ones like the industrial plants, are now obliged, either by contract or for reasons of economy, to provide reactive power compensation for their equipment.
- If the consumer refuses to set up a compensating facility, the power supply companies install reactive power meters and the reactive power which is consumed must be paid for.
- However, even modern and efficient compensating facilities often create difficulties in generating harmonic currents and generate harmonic-related problems in conjunction with other components of the network.
- In fact, the compensating capacitors and the feeding transformers or the supply network form a parallel oscillating circuit that can result in resonances which may cause damage to all the adjoining network installations.
- The subjects related to reactive power compensation and reactive power controllers are addressed in this laboratory.
- Finally, the laboratory deals also with the problem of the measurement of active and reactive power. Induction meters are usually employed for measuring electrical energy in ac current and in three-phase networks.
- These meters firstly provide the basis for calculating the cost of the power to be debited to the consumer and secondly are an important mean for the power supply companies to identify the need for an extension or a modification of the supply network.
- These topics are analyzed from the theoretical point of view and also by means of practical examples.

Summary of Modules Required			
Sr. No.	**Item Name**	**Model No.**	**Qty**
1	Motorized Variable three-phase power supply	EDC-PE-1001	1
2	Three-phase transformer	EDC-PE-1002	1
3	Three-phase power monitoring device	EDC-PE-1003	2
4	Resistive load	EDC-PE-1004	1
5	Inductive load	EDC-PE-1005	1
6	Capacitive load	EDC-PE-1006	1
7	Power circuit breaker	EDC-PE-1007	2
8	Single phase digital power meter	EDC-PE-1008	1
9	Overhead line model	EDC-PE-1009	2
10	110 km Overhead line model	EDC-PE-1010	1
11	Petersen coil	EDC-PE-1011	1
12	Line capacitor	EDC-PE-1012	2
13	MODBUD communication HUB	EDC-PE-1013	1
14	Three phase isolation transformer 3kVA	EDC-PE-1014	1
15	EDAQ SCADA Software	EDC-PE-1015	1
16	Holder for leads	EDC-PE-1016	2 Set
17	Connecting leads	EDC-PE-1017	2 Set
18	Multifunctional table base version with feet Frame with 3 levels version	EDC-PE-1018	2
19	Frame with 3 levels version	EDC-PE-1019	2
20	Analog Wattmeter	EDC-PE-1020	4



ELECTRICAL POWER ENGINEERING PANEL

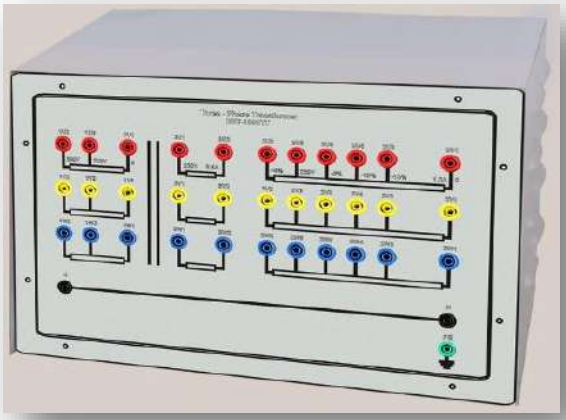
MODULES SPECIFICATIONS

Note: Every effort has been made to ensure that the information contained in this catalogue is accurate; however no labiality is accepted for errors. Should an error be discovered please inform the company in writing, giving full details. All modular images given are for guidance only and are not guaranteed as exact supplied they may have different shape components and parts according to the market availability.

Motorized Variable three-phase power supply (EDC-PE-1001)

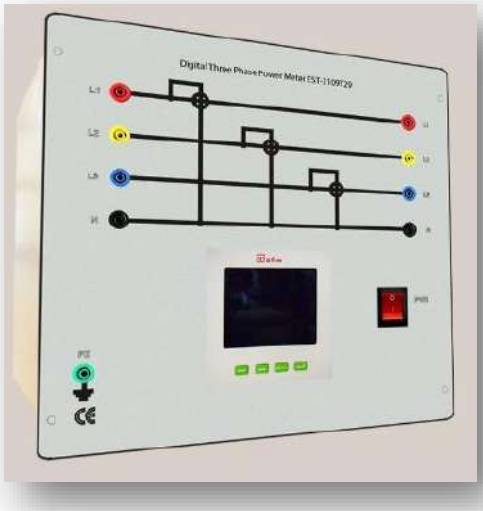
- Power supply unit for variable 3-phase voltage suitable for supplying AC machines.
  - key operated emergency push-button
  - start and stop push-buttons
  - Multifunctional digital instrument that supplies voltage, current and power
  - AC output: 3 x 0 ... 400 V, 2 A
  - Modbus interface connectors
  - Supply voltage: three-phase from mains.

Three-phase transformer (EDC-PE-1002)



- Primary: 3 x 380/415 V with tap at 220/230 V, star or delta connection.
- Secondary: 3 x 220/230 V windings with taps at +5%, -5%, -10%, -15%, star connection for 3 x 380/415 V, various star connections possible. Nominal power: 800 VA
- Tertiary: 3 x 220 V windings, delta connection for stabilizing the third harmonic voltage components, rated minimum power: 266VA. 4 mm. safety terminal will be included on the front panel for the electrical connection.

Three-phase power monitoring device (EDC-PE-1003)



- Microprocessor controlled three-phase energy analyzer.
- Type of display: LCD backlit
- Automatic backlit reduction off after 20 s that keyboard is not used.
- N° of reading points: 10000 4 digits (high digit 12 mm)
- Energy count: 8 digit counter (high digit 8 mm)
- Engineering units: automatic display according to the set VT and CT ratios
- Resolution: automatic, with the highest possible number of decimals
- Decimal point: automatic, with the highest possible resolution
- Reading update: 1.1 seconds
- Accuracy (of the reading)-

- Voltage: ± 0.2% ± 1 digit (80 ... 500V phase - phase)
- Current: ± 0.2% ± 1 digit (10 ... 120% In)
- Frequency: ± 0.15 Hz

- Energy count reference value 230 (400)V 5A 50Hz
  - Active energy: class 0.5s
  - Reactive energy: class 2

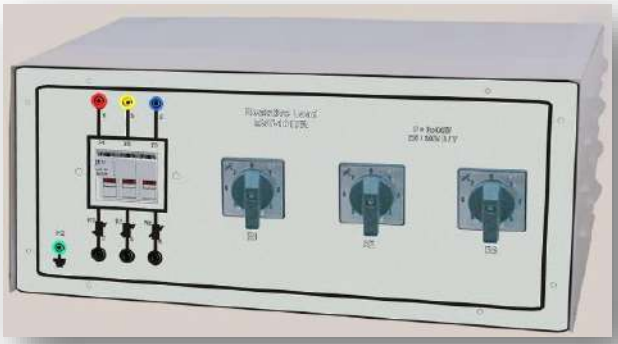
- PROGRAMMING
  - Parameters programming: front keyboard, 4 keys
  - Programming access: protected by password
  - Data and configuration parameters retention: non volatile memory (no battery)
- PROGRAMMABLE PARAMETERS
  INPUT
  - Connection: single-phase and three-phase network, 3 and 4-wire
  - Current rating: 1 - 5A
  - External VT ratio: 1 ... 10 (max. VT primary 1200V)
  - External CT ratio: 1 ... 9999 (max. CT primary 50kA/5A - 10kA/1A)
  - CURRENT DEMAND - POWER DEMAND
  - Average period: 5/8/10/15/20/30/60 min.
- DISPLAY
  - Contrast: 4 selectable values
  - Backlit: 0 - 30 - 70 - 100%
  - Customized page: content of default page
- RESETTABLE PARAMETERS
  - Min. and max. voltage value
  - Current demand
  - Current max. demand
  - Active, reactive, apparent power max. demand
  - Run hour
  - Partial active energy
  - Partial reactive energy

- INPUT
  - Single-phase network, three-phase network 3 and 4-wire
  - Three-phase voltage: 80 ... 500V (phase-phase
  - Single-phase voltage: 50 - 290V
  - Connection with external dedicated current transformers
  - Current rating In: 5A - 1A
  - Max. current Imax: 1.2 In
  - Instantaneous overload: 20 In/0.5 seconds
  - Frequency rating fn: 50Hz
  - Tolerance: 47 ... 63Hz
  - Type of measurement: true RMS value

- AUXILIARY SUPPLY
  - Rated value Uaux ac: 80 ... 265V
  - Rated frequency: 50Hz
  - Working frequency: 47 ... 63Hz

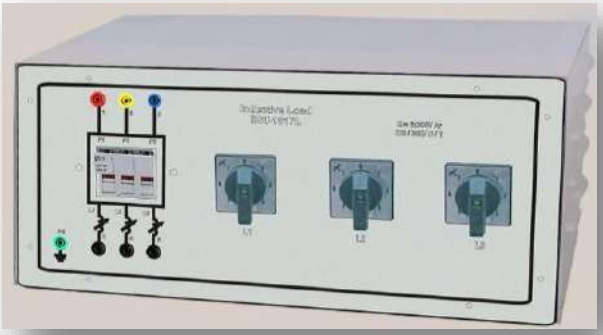
- RS485 COMMUNICATION
  - Galvanically insulated from input and aux. supply (Nemo 96HD/HD+)
  - Standard: RS485 - 3-wire
  - Transmission: serial asynchronous
  - Protocol: compatible JBUS/MODBUS
  - Bit number: 8
  - Stop bit: 1
  - Required response time to request: < =200ms
  - Meters that can be connected on the bus: 32 (up to 255 with RS485 repeater) Highest distance from supervisor: 1200m
- PROGRAMMABLE PARAMETERS
  - Address: 1 ... 255
  - Baud rate: 4800 - 9600 - 19200 – 38400
  - bit/s (38400 only for Nemo 96HD/HD+)
  - Parity bit: none - even – odd
- Three-phase network monitoring device. Measures three-phase rms, and peak values of voltages and currents (for 3 and 4 wire connections) as well as active, reactive and apparent power, active, reactive and apparent energy, power factor, THD and frequency.
- Input voltage: nominal 400Vac (Three-phase:80...690V, 50...400V per phase)
  Input current: up to 10A (5A with 10:5 current transformers).
- Operating frequency: 47...63 Hz
  Auxiliary supply: 80...265 Vac 50/60Hz single-phase from mains.

Resistive load (EDC-PE-1004)



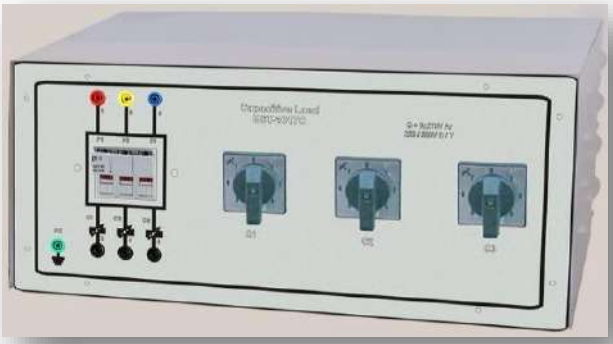
- It consists in a single or three-phase resistive step-variable load. Housed in a metallic box.
- MECHANICAL FEATURES
  - The load is composed of a rugged metal structure and of a front metal panel.
  - On the front panel all the controls, the protection, the output terminals and a clear synoptic diagram, will be collected.
- ELECTRIC FEATURES
  - The load is composed of resistances, with possibility of star, delta and parallel connection, controlled by three switches. This item will be provided also with fuses protection.
  - As a function of the switch positions, there will be the following phase values:
  - Position Max Resistance Max power per phase
    - 1: 1050 Ohm 46 W
    - 2: 750 Ohm 65 W
    - 3: 435 Ohm 110 W
    - 4: 300 Ohm 160 W
    - 5: 213 Ohm 230 W
    - 6: 150 Ohm 330 W
    - 7: 123 Ohm 400 W
  - Maximum power in single or three phase connection is 1200 W.
  - Rated voltage in star connection is 380V, in D connection is 220V, in single-phase is 220V.

Inductive load (EDC-PE-1005)



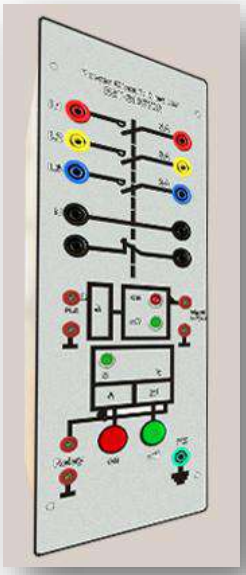
- It consists of a single or three-phase inductive step-variable load. Housed in a metallic box.
- MECHANICAL FEATURES
  - The load is composed of a rugged metal structure and of a front panel.
  - On the front panel all the controls, the protections, the output terminals and a clear synoptic diagram, will be collected.
- ELECTRICAL FEATURES
  - The load is composed of inductances, with possibility of star, delta and parallel connection, controlled by three switches.
  - This item will be provided also with fuses protection.
  - As a function of the switch position there will be the following phase values.
  - Position Inductance Max. Power per phase
    - 1: 4.46 H 34 VAr
    - 2: 3.19 H 48 VAr
    - 3: 1.84 H 83 VAr
    - 4: 1.27 H 121 VAr
    - 5: 0.90 H 171 VAr
    - 6: 0.64 H 242 VAr
    - 7: 0.52 H 297 VAr
  - Max reactive power 890 VAr in three-phase or single-phase connection.
  - Rated voltage in star connection is 380V, in D connection is 220V, in single-phase is 220V.
  - 4 mm. Safety terminal included on the front panel for the electrical connection.

Capacitive load (EDC-PE-1006)



- Single or three-phase capacitive step-variable load.
- MECHANICAL FEATURES: metallic box: on the front panel all the controls, the protections, the output terminals and a schematic diagram on PVC label will be shown.
- ELECTRICAL FEATURES
  - The load is be composed by three capacitors, with possibility of star, delta and parallel connection, controlled by a three switches.
  - As a function of the switch position, there will be the following phase a values (at 50Hz):
  - Position Capacitance Max power per phase
    - 1: 2 µF 30 VAR
    - 2: 3 µF 45 VAR
    - 3: 5 µF 76 VAR
    - 4: 8 µF 121 VAR
    - 5: 10 µF 152 VAR
    - 6: 13 µF 197 VAR
    - 7: 18 µF 275 VAR
  - Max reactive power in single-phase or three-phase connection 825 VAr.
  - Rated voltage in star connection 380V, in D connection is 220V, in single-phase 220V.

Power circuit breaker (EDC-PE-1007)

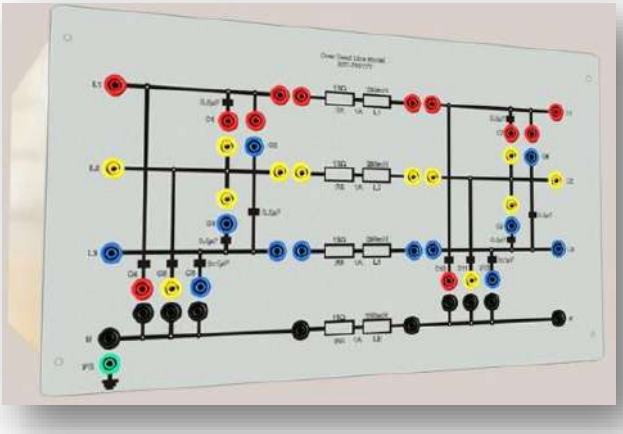


- Three-phase power circuit breaker with normally closed auxiliary contact.
- Contact load capability: 400 Vac, 3 A
- Supply voltage: single-phase from mains
- Insulation voltage: 750V
- Thermal current : 20A
- Insulation voltage: 750V
- Rated current: 3A
- Single-phase voltage 220/230V, 50-60Hz
- It is possible to control manually the power breaker switch using the push-buttons “on” and “off” or externally via the switching contact PLC or RELAY.
- This power contacts state will be indicated by leds:
  - Green led = open contacts.
  - Red led = closed contacts.
- While at SIGNAL OUTPUT terminals will be available a TTL level:
  - Low level (0V)= open contacts.
  - High level (5V)= closed contacts.
- The RS flip-flop state will be indicated by a led:
  - Yellow led = set flip-flop.
- 4 mm. safety terminal and 2 mm. terminals included on the front panel for the electrical connection.

Single phase digital power meter (EDC-PE-1008)

- Instrument used to measure the power (P, Q, S) on a single circuit branch in AC and DC.
- The RMS value of the voltage, current and active power (P) can be visualized on the LCD display along with the reactive (Q) and apparent power (S) values.
- A digital bar graph makes it easy to monitor the active power's intensity and a dedicated function button allows the adjustment of its scale.
- The user can communicate with the device through the RS485 serial port using Modbus protocol, to collect data using a supervision software such as SCADA or Labview.
- Technical features:
  - Automatic Scaling
  - Current range: 0-20 Iac/dc 50/60Hz
  - Voltage range: 0-750 Vac/dc 50/60Hz
  - Power range: 0-1000W, VAR and VA
  - Accuracy: ±0.5%
  - Resolution: 16bits
  - Refresh rate: 0.5s
  - Power supply: 90-260 Vac 50/60Hz
  - Power consumption: 3 VA
  - Communication: Modbus (RS485)

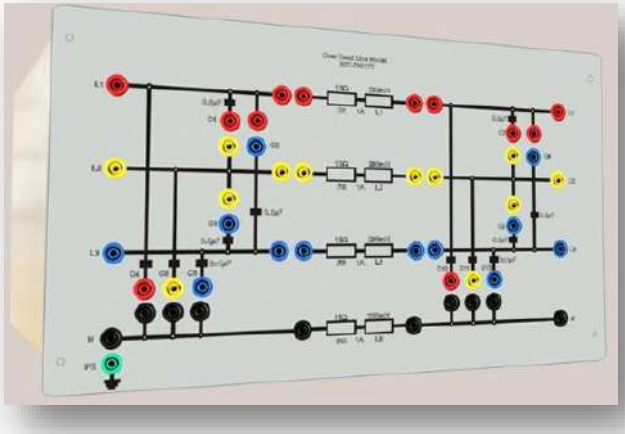
Overhead line model (EDC-PE-1009)



- Three-phase model of an overhead power transmission line 360 km long, voltage 380 kV and current 1000 A.
  - Scale factor: 1:1000
  - Line resistance: 13 Ω, line inductance: 290 mH, mutual capacitance: 1 µF, earth capacitance: 2 µF, earth resistance: 11 Ω, earth inductance: 250 mH.

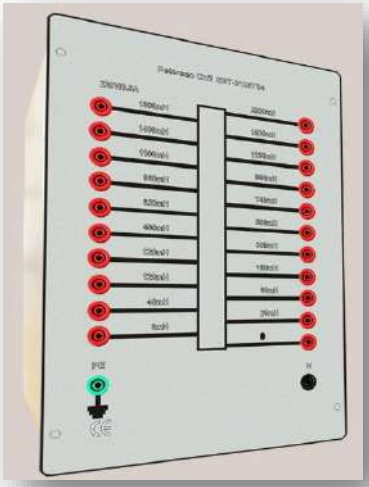
- Three-phase model of an overhead power transmission line of length 360 km, voltage 380 kV and current line 1000 A. Scale factor: voltage 380 V: 380 kV = 1:1000 current 1 A: 1000 A = 1:1000
  - Line parameters: resistance RL = 13
  - Inductance LL = 290 mH
  - Mutual capacitance CL = 0.5 µF
  - Earth capacitance CE = 1 µF
  - Earth return parameter: resistance RE = 11 Ω
  - Inductance LE = 250 mH

110 km Overhead line model (EDC-PE-1010)



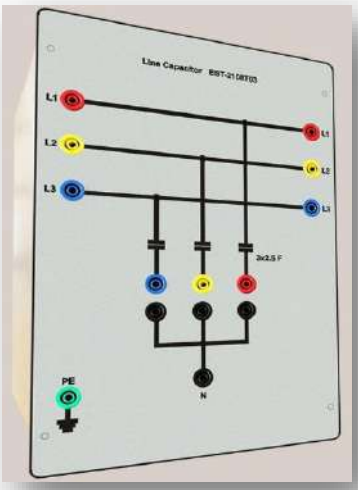
- Three-phase model of an overhead power transmission line 100 km long, voltage 380 kV and current 1000 A.
  - Scale factor: 1:1000.
  - Line resistance: 13 Ω, line inductance: 290 mH, mutual capacitance: 1 µF, earth capacitance: 2 µF, earth resistance: 11 Ω, earth inductance: 250 mH.
- Three-phase model of an overhead power transmission line of length 100 km, voltage 380 kV and current line 1000 A. Scale factor: voltage 380 V: 380 kV = 1:1000 current 1 A: 1000 A = 1:1000
- Line parameters:
  - resistance RL = 13 Ω
  - inductance LL = 290 mH
  - mutual capacitance CL = 0.5 µF
  - earth capacitance CE = 1 µF
- Earth return parameter: resistance RE = 11 Ω inductance LE = 250 mh

Petersen coil (EDC-PE-1011)

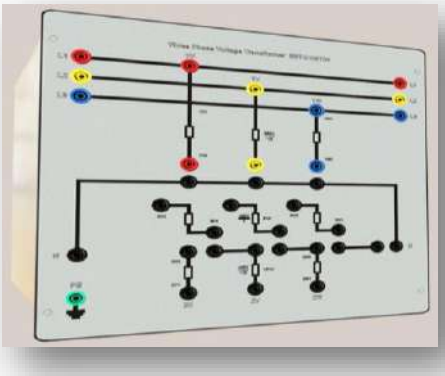


- Module with insulated panel, Petersen coil, inductance with 20 taps for earth fault compensation in transmission lines: 2000mH-1800mH-1600mH-1400mH-1250mH-1100mH-980mH-860mH-750mH-620mH-500mH-400mH-300mH-220mH-160mH-120mH-80mH-40mH-20mH-5mH-0.

- Inductance: 0.005 ... 2 H
- Rated voltage: 220 V
- Rated current: 0.5 A
- 4 mm. safety terminal included on the front panel for the electrical connection.

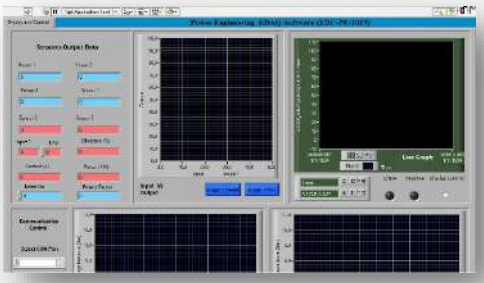
Line capacitor (EDC-PE-1012)	MODBUD communication HUB (EDC-PE-1013)
	
• Didactic equipment: ○ Module with insulated panel, three-phase transmission line capacitor with exactly half of the operating capacitance of the 380 kV transmission line model with a length of 360 km. ○ Capacitance: 3 x 2.5 uF, 450 Vac. ○ 4 mm. Safety terminal included on the front panel for the electrical connection.	• Didactic equipment. • Module with insulated front panel including: ○ two RS485 inputs and six RS485 outputs. ○ Analog output 1 0 to 10V ○ Analog output 2 0 to 10V ○ One switch for power on/off and a port for power supply connector. • HUB that allows communication and control via PC of all the modules that are provided with RS485 connectors. ○ The Analog Outputs are connected only with CH2 Input ○ AO1 = Analog output 1: 0 to 10V ○ AO2 = Analog output 2: 0 to 10V ○ Channel 1: RS485 - 4W ○ CH1 = RS485 INPUT ○ CH1 = RS485 OUTPUT ○ Channel 2: RS485 - 2W ○ CH2 = RS485 INPUT ○ CH2 = RS485 OUTPUT.

Three phase isolation transformer 3kVA (EDC-PE-1014)



- Isolation transformer to be placed between the three-phase mains and the laboratories providing a three-phase secondary voltage with isolated neutral suitable for the module's operation.
- Technical features:
  - Three-phase mains input with +10%/-10% adjustment.
  - Output: 400V with +5%/-5% adjustment.
    - 3 x three phase CEE sockets (3P+N+E)
    - 2 x single phase CEE sockets (2P+E)
    - 2 x single phase type F socket
    - 16 A, 30 mA differential magneto-thermal protection.
  - Motor-protection circuit-breaker: 6.3 to 10 A.
  - Mushroom emergency stops push-button
  - Maximum output power: 3 KVA.

EDAQ SCADA Software (EDC-PE-1015)



SCADA software for control and monitoring. With the possibility to show the application to different devices connected in the same network.

Holder for leads (EDC-PE-1016)

Material:

- High-quality insulating material (e.g., polycarbonate or ABS) resistant to heat, electrical conductivity, and physical impact.
- Compatibility: Designed to securely hold standard 4mm banana plugs, crocodile clips, and insulated test leads commonly used in power system labs.
- Compatible with the voltage and current ratings of this power system lab equipment.

Capacity:

Connecting leads (EDC-PE-1017)

• Holds a minimum of 10-20 leads of varying thickness (1-5 mm² cross-section). • Adjustable slots to accommodate different lead lengths. Design: • Wall-mountable or tabletop design with anti-slip base. • Compact and organized layout for easy access. • Includes separators or partitions for sorting by type or length. Electrical Safety: • Compliant with IEC 61010 standards for laboratory equipment. • Insulated surface to prevent accidental contact with conductive parts. Durability: • Resistant to corrosion, wear, and environmental factors such as humidity. • Long operational life for use in educational and industrial environments. Dimensions: • Approximate size: 300 mm x 150 mm x 100 mm (adjustable based on requirements). Weight: • Lightweight yet stable, approximately 1-1.5 kg.	
Multifunctional table base version with feet (EDC-PE-1018)	**Frame with 3 levels version (EDC-PE-1019)**

• Workbench with melamine flatbed. Two holes will be present on the flatbed to allow the assembly of a three-level frame.
• Technical features:
  • Dimensions: 80x120x90 (HxWxL)
  • Complete with locking wheels
  • Workbench will be supplied with 15 sockets protected by a thermal magnetic circuit breaker.
	
	• Levels:
	  • Three distinct levels for component placement, each with sufficient space for modules, devices, and wiring.
	  • Adjustable height for ergonomic convenience and optimal component arrangement.

	• Lighting Type: • Energy-efficient LED lamps integrated at each level. Daylight color temperature (~5000-6500K) for natural and strain-free illumination. • Power Supply: • 220-240V AC, 50/60 Hz, with low-power consumption LEDs. • Separate ON/OFF switch for each level's LED lamps. • Brightness: • Minimum illumination level: 500 lux at the work-space. Safety: • Overload protection and surge suppressors for LED lamps. • Heat-resistant and fire-retardant enclosures.

Analog Wattmeter (EDC-PE-1020)

- Principle: Electrodynamometer type
  - Accuracy: Class 0.5
  - Scale Length: 135mm (5-3/8'')
  - Scale Divisions: 120
  - Frequency Ranges:
- AC 25 to 1000Hz (COSØ=1.0) (suitable for DC)
- AC 25 to 500Hz (COSØ=0.2)
- Current: 2/10A
- Voltage: 120/240V
- Power factor: 1