edibon

Engineering and Technical Teaching Equipment

Advanced Mechanical, Electrical and Smart Grid Power Systems (Utilities)

APS12

Key Features:

- **8 of SCADA System Key Features** (Supervision, Control and Data Acquisition)
- **9 of National Grid Key Features**
- **3 of Black out and Recovery Energy System Key Features**
- **7 of Power Generation, Transmission, Distribution and Consumption Key Features**
- **7 of Protection Systems Key Features** (Industrial Relays)
- **6 of Power Generation, Transmission, Distribution and Consumption Key Features**
- **SCADA-NET Key Features** (30 students working simultaneously)
- **Custom made possibilities**

www.edibon.com
PRODUCTS
5.- ENERGY

See all Key Features in next page.

Certificate of Approval of the Quality Management System

European Union Certificate (total safety)

UL and CSA Regulations (All our products are manufactured according to current UL and CSA regulations)

Certificate of Approval of the Environmental Management System

Worlddidac Association Certificate of Membership

KEY FEATURES

Real industrial key features related with:

Advanced and Unique Key Features

8 of SCADA System Key Features

1. Two SCADA Systems (one SCADA for mechanical power plant + one SCADA for electrical power system).
2. Twelve mechanical power plants available. Any other available on request.
3. All hardware and software fully designed by the wide EDIBON, more than 20 engineers team (electrical, mechanical, telecommunications, software, etc.)
4. All electrical and mechanical changes done as real industrial system by using six touch screens and two panoramic screens.
5. To analyze the response at the electrical power system, after any action at the mechanical power plant.
6. To analyze the response at the mechanical power system, after any action at the electrical power plant.
7. Simulated values voltages up to 800 kV. Any other condition available on request.
8. Six touch screens and two panoramic screens for remote control as in real operations control room.

9 of National Grid Key Features

1. Full training in mechanical power plants linked to power generation, transmission, distribution and load consumption systems.
2. Real National Grid operation using mechanical power plant working together with electrical power system (hybrid system).
3. National Grid research by changing more than 486 variables.
4. Supervision and control of all elements of the National Grid.
5. Creating any grid possibility and working conditions.
6. National Grid operation using real values and industrial protection relays.
7. Study of National Grid stability (voltages, power flows, generation VS consumption, etc).
8. Analysis for effects of load characteristics on power systems.
9. Any industrial configuration possibilities.

3 of Black Out Key Features

1. Black out situations using hardware and real scenario.
2. Study of restoring the electrical power system, after a black out.
3. Several working conditions using more than 190 variables.

7 of Power Generation, Transmission and Distribution Key Features

1. Manual and automatic generation operations for a perfect understanding about mechanical and electrical power systems situations.
2. Synchronization system with two mechanical power plants + two electrical power systems.
3. Advanced automatic voltage regulator, allowing work with an unusual or special situations.
4. Manual and automatic control of generator current excitation.
5. Manual and automatic control of generator speed.
6. Four automatically configurable transmission lines. More transmission lines available on request.
7. Distribution systems with automatic voltage regulator to study drop voltages compensation.

7 of Protections Systems Key Features

1. Cutting-edge industrial protection relays of SEL from USA (differential, directional, distance, overcurrent and feeder management protection relays). Any other protection relays available on request.
2. More than 50 possible real fault conditions.
3. More than 200 variables to be set with the protection relays.
4. Study of grid conditions to set protection relays selectivity.
5. Faults loading and event reports to analyze short circuit transients and types.
6. Back-up protection relays for maximum safety requirements.
7. Automatic circuit breakers and lines wiring saving the workers and students time.

Other important Key Features

6 of Power Generation, Transmission and Distribution Key Features

1. Manual and automatic generators synchronization.
2. Advanced automatic voltage regulator, allowing work with an unusual or special situations.
3. Manual and automatic control of generator current excitation.
4. Manual and automatic control of generator speed.
5. Two 7 kVA three phase synchronous generators with brush excitation system working under different conditions: isolated operation, parallel operation with the national grid and parallel operation without national grid (load sharing).
6. Four transmission lines. More transmission lines available on request.

2 of Protections Systems Key Features

1. Advanced and complete protection relays system (SEL from USA): differential, directional, distance, overcurrent and feeder management protection relays.
2. Real logic operations with circuit breakers and disconnectors.

4 of Smart Grids Key Features

1. Real smart meters system with Smart Meter Trainer, Smart Energy Trainer, Net Metering Trainer and loads.
2. Home energy management systems.
3. Net-metering systems.
4. Remote control smart meter from the control panel.

SCADA-NET Key Features

30 students working simultaneously by using the EDIBON patent, SCADA-NET.

Potential Users

1. The APS12 can be used by power management staff, power plants operators, mechanical personal, training of teachers and students, and high level research.

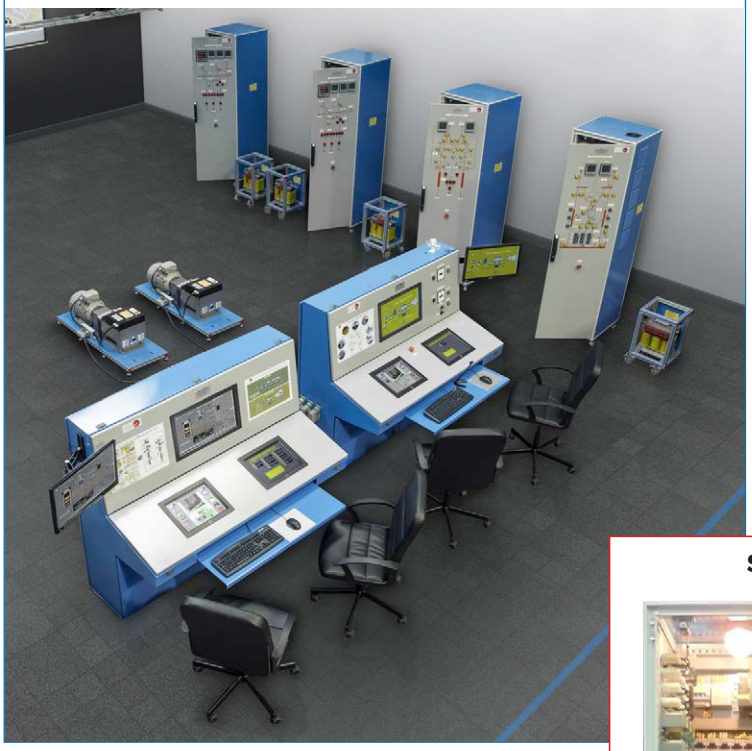
Custom made Key Features

2. Working as any real and particular electrical power system for a complete grid analysis and losses, electrical connections.
3. Any real generation systems as, big size steam turbine, gas turbine, fuel generator, etc., working with the complete APS12 available on request and custom made.
4. Up to twelve or more real generation possibilities.

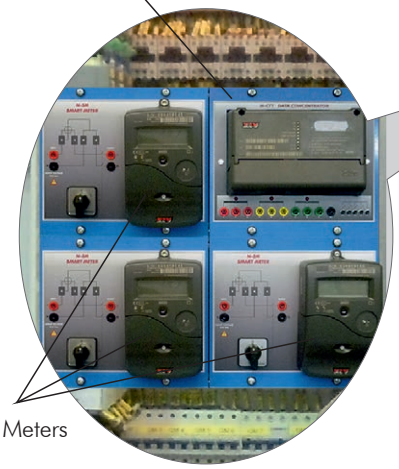
For details see Annex I: www.edibon.com/en/advanced-mechanical-electrical-and-smart-grid-power-systems-utilities/additional-info

THE APS12 WITH AUTHENTIC SMART METER MODULES

APS12



Data Concentrator



Smart Meters

SGDL1

APS12

Generation + Transmission + Distribution

Utilities

- Load Sharing.
- Automatic response of the turbine against load changes.
- Synchronization operations.
- Study of real faults.
- Different real National Grids circunstances.

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Bidirectional Communication

SGDL1

Smart Grid Distributed Loads I

Final User

- Bidirectional communication between Smart Meters and Utility.
- Industrial and Residential consumers.
- Automatic power factor compensation.
- Load curve profiles.
- Active powers, reactive powers, power factors and energy real time measurements.

EXAMPLE OF APS12 CONFIGURATION IN A LABORATORY

APS12-MES12

Complete Advanced 12 Mechanical Power Plants (M) + Smart Grid Electrical Power Systems (E) + Smart Grid Distributed Load I (S)

ELECTRICAL CONTROL BENCH:

- HUB I. **Electrical Power System with SCADA I.**

MECHANICAL CONTROL BENCH:

- HUB II. **Power Plant Energy System with SCADA II.**

GENERATION:

- G1. **Generator I with Complete Cabinet, including AVR (Automatic Voltage Regulator), with Synchronization System.**
- G2. **Generator II with Complete Cabinet, including AVR (Automatic Voltage Regulator), with Synchronization System.**

TRANSFORMATION:

- T-GR1. **Grid Transformer without voltage regulation.**
- T-GR2. **Grid Transformer with TAP CHANGER with voltage regulation.**
- T-G1. **Generator Group Transformer I.**
- T-G2. **Generator Group Transformer II.**

TRANSMISSION:

- LTS1. **Line I and II Cabinet with Transmission Substation with protection relays system.**

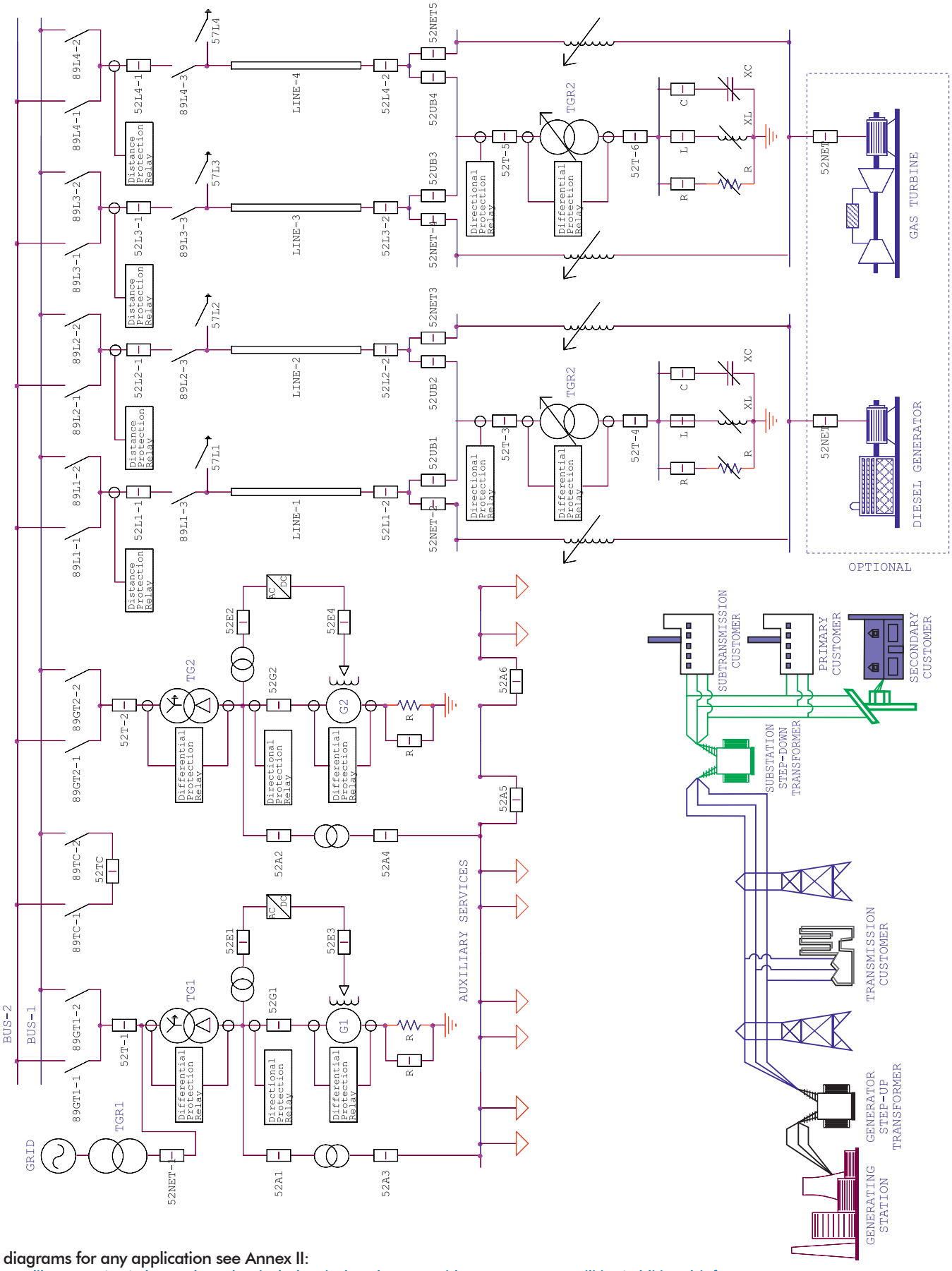
DISTRIBUTION AND CONSUMPTION:

- DSL1. **Distribution Substation I, Loads and Network Equivalents I with Protection Relays System.**
- SGDL1. **Smart Grid Distributed Loads I.**

APS12-MES12

Complete Advanced 12 Mechanical Power Plants (M) + Smart Grid Electrical Power Systems (E) + Smart Grid Distributed Load I (S)

MES12: Unifilar diagram



All diagrams for any application see Annex II:
www.edibon.com/en/advanced-mechanical-electrical-and-smart-grid-power-systems-utilities/additional-info

SOME CONTROL VARIABLES USED WITH APS12 ADVANCED SMART GRID POWER SYSTEM

The Advanced Mechanical, Electrical and Smart Grid Power Systems (Utilities) , "APS12", is one of the most advanced and complete power systems of the market. It is not a simulator but a real system. In the following pages are indicated the most important variables which allow control the system remote mode (manual and automatic) through the included SCADA.

The following are the most important 486 control variables that make the "APS12" a forefront system able to interact with the user thanks to the cutting-edge included devices.

The "APS12" is able to show any electric phenomenon that are present in real power systems, such as short circuits, over currents, over voltages, over frequencies, reverse power, generator runaway, black out, etc.

All power systems are formed by three fundamental parts:

1. Generation System.
2. Transmission/Distribution System.
3. Load System.

1. Generation System:

Power generation is the point where all power systems born, where transmission lines emerge up to distribution lines and finally, to give electrical service to the final consumer. It is necessary a great quantity of control variables for a power system reliable, safe and optimal because of these variables depend the electrical energy quality. This is the reason because the generation systems of the "APS12" are listed the most important **217 control variables** that will allow user to interact with a sophisticated, real and intelligent generation system, which is able to respond automatically against energy demand, it is able to protect automatically against short circuits, with light indicators and alarms that will allow us to understand at all time the generation system state.

See the 217 control variables in next page.

2. Transmission/Distribution System:

After power generation, transmission and distribution systems are required to give power to the final consumer. These systems are highways of aluminum and steel which transport great quantities of power up to strategic points of the country and even other countries. In the transmission systems is very important to know variables such as transported energy, length transmission lines, capacitive effect, energy losses produced along kilometers and kilometers, etc. Besides, in a transmission line system is not enough a conventional protection system. For these systems are required distance protection relays able to detect changes in the line impedances and to sense undetectable anomalies for other conventional protection relays.

Distribution substations adapt the transmission lines voltage levels up to lower voltage levels for energy distribution. On this point take importance the distribution transformer with voltage regulator, which are able to compensate the transmission liens drop voltages.

The transmission/distribution power system of "APS12" allows to study all these control variables and much more. In the following are listed the most important **111 control variables** that allow user to interact with the transmission/distribution system.

See the 111 control variables in next page.

3. Load System:

One the energy is transported; this has to be carried to the consumption points through distribution lines. Final consumer provokes changes in the power balance of the system from generation up to distribution. On this way, all machinery of the system (generation, transmission and distribution) works in real time in order to the electrical parameters remain constants in the consumption points.

In the consumption points is very important to ensure the electrical energy quality through reactive energy compensation devices. Besides, on this point are essential the feeders management protection relays, which are installed in strategic points of the distribution lines giving to the grid the required reliability, safety and efficiency. These protection relays monitor electrical variables such as frequency, voltage, current, power factor, etc. in order to protect the grid.

The load system of "APS12" allows to study all there control variables and much more. In the following are listed the most important **158 control variables** that allow user to interact with the load system.

See the 158 control variables in next page.

In the following are listed the most important 486 control variables which allow user to interact with the load system:

1. Generation System: the most important and used 217 physical variables in the National Grid power systems.

1.1. Some general control variables of the Turbine-Generator group:

- Manual start/stop control variable for starting/stopping of the turbine-generator group.
- Control variable to activate/deactivate the turbine I speed control.
- Control variable to activate/deactivate the synchronous generator I excitation control.
- Control variable to activate/deactivate the turbine II speed control.
- Control variable to activate/deactivate the synchronous generator II excitation control.
- Permission variable for generator I synchronization in automatic mode.
- Permission variable for generator II synchronization in automatic mode.
- Permission variable for generator I synchronization in manual mode.
- Permission variable for generator II synchronization in manual mode.

1.2. Remote Control (SCADA) of Turbine-Generator group:

1.2.1. Manual Remote Control (SCADA) of Turbine-Generator group:

- Island Mode:
  - Manual control variable for turbine frequency/speed control.
  - Manual control variable for synchronous generator excitation control.
  - Manual control variable for 52G breaker open/close.
- Load Sharing/Parallel Grid Mode:
  - Manual control variable for synchronization the generator and the grid.
  - Manual control variable for active power given to the grid.
  - Manual control variable for reactive power given to the grid.
  - Manual control variable for 52G breaker open/close.

1.2.2. Automatic Remote Control (SCADA) of Turbine-Generator group:

- Island Mode:
  - Automatic control variable for turbine frequency/speed control through AVR (Automatic Voltage Regulator).
  - Automatic control Variable for synchronous generator excitation/voltage control through AVR (Automatic Voltage Regulator).
  - Automatic control variable for line and phase voltages.
  - Automatic control variable for reactive power given to the grid.
  - Automatic control variable for maximum line current.
  - Automatic control variable for 52G breaker open/close.
- Load Sharing/Parallel Grid Mode:
  - Automatic control variable for synchronization the synchronous generator with the grid.
  - Automatic control variable for active power given to the grid.
  - Automatic control variable for active power maximum limit.
  - Automatic control variable for reactive power given to the grid.
  - Automatic control variable for reactive power maximum limit.
  - Automatic control variable for adjusting the synchronous generator optimum power factor.
  - Automatic control variable for 52g breaker open/close.
  - Automatic control variable for line and phase voltages.
  - Automatic control variable for maximum line current.

1.3. Control variables for protection system:

1.3.1. Over Current and Earth fault protection relay.

- Configuration variable for the current transformer relationship.
- Configuration variable for the voltage transformer relationship.
- Configuration variable for the removing fault time (TRIP duration).
- Configuration variable for level 1 instantaneous overcurrent 50P1P.
- Configuration variable for level 2 instantaneous overcurrent 50P2P.
- Configuration variable for level 3 instantaneous overcurrent 50P3P.
- Configuration variable for level 4 instantaneous overcurrent 50P4P.
- Configuration variable for level 5 instantaneous overcurrent 50P5P.
- Configuration variable for level 6 instantaneous overcurrent 50P6P.
- Configuration variable for the inverse time overcurrent parameter threshold.
- Configuration variable for inverse time curve type 51P1T: U1, U2, U3, U4, U5, C1, C2, C3, C4, C5.
- Configuration variable for the 51P1T Time-Dial of the inverse time overcurrent protection curve parameter.
- Configuration variable for the 51P2T inverse time curve threshold.
- Configuration variable for inverse time curve type 51P2T: U1, U2, U3, U4, U5, C1, C2, C3, C4, C5.
- Configuration variable for the 51P2P Time-Dial of the inverse time overcurrent protection curve parameter.
- Configuration variable for 50N1 neutral instantaneous overcurrent threshold.
- Configuration variable for 50N2 neutral instantaneous overcurrent threshold.
- Configuration variable for 51N1T inverse time neutral overcurrent parameter threshold.
- Configuration variable for inverse time curve type 51N1T: U1, U2, U3, U4, U5, C1, C2, C3, C4, C5.
- Configuration variable for the 51N1T Time-Dial of the inverse time overcurrent protection curve parameter.
- Configuration variable for 50G1 instantaneous residual overcurrent parameter threshold.
- Configuration variable for 50G2 instantaneous residual overcurrent parameter threshold.
- Configuration variable for 50G1T inverse time residual overcurrent parameter threshold.
- Configuration variable for inverse time curve type 51G1T: U1, U2, U3, U4, U5, C1, C2, C3, C4, C5.
- Configuration variable for the 51G1T Time-Dial of the inverse time overcurrent protection curve parameter.
- Configuration variable for 51Q1P negative sequence instantaneous overcurrent parameter threshold.
- Configuration variable for 51Q2P negative sequence instantaneous overcurrent parameter threshold.
- Configuration variable for 51Q1T inverse time overcurrent parameter threshold.
- Configuration variable for inverse time curve type 51Q1T: U1, U2, U3, U4, U5, C1, C2, C3, C4, C5.
- Configuration variable for the 51Q1T Time-Dial of the inverse time overcurrent protection curve parameter.
- Configuration variable for 51Q2T inverse time overcurrent parameter threshold.
- Configuration variable for inverse time curve type 51Q2T: U1, U2, U3, U4, U5, C1, C2, C3, C4, C5.
- Configuration variable for the 51Q2T Time-Dial of the inverse time overcurrent protection curve parameter.

1.3.2. Differential Protection Relay of Step-Up power transformer

- Configuration variable for the current transformer relationship.
- Configuration variable for the voltage transformer relationship.
- Configuration variable for the removing fault time (TRIP duration).
- Configuration variable for power transformer connection type.
- Configuration variable for measurement transformer connection type.
- Configuration variable for 87P differential protection element.
- Configuration variable for SLP1 restriction percentage of 87P differential element.
- Configuration variable for SLP2 restriction percentage of 87P differential element.
- Configuration variable for 2º harmonic restriction percentage.
- Configuration variable for 4º harmonic restriction percentage.
- Configuration variable for 5º harmonic restriction percentage.
- Configuration variable for 50P1P instantaneous overcurrent level of the primary winding power transformer.
- Configuration variable for 51P1D definite time instantaneous overcurrent level of the primary winding power transformer.
- Configuration variable for 51P1P inverse time overcurrent threshold of the power transformer primary winding.
- Configuration variable for inverse time curve type 51P1P: U1, U2, U3, U4, U5, C1, C2, C3, C4, C5.
- Configuration variable for the 51P1P Time-Dial of the inverse time overcurrent protection curve parameter.
- Configuration variable for 50Q1P negative sequence instantaneous overcurrent threshold of the power transformer primary winding.
- Configuration variable for 51Q1P negative sequence inverse time overcurrent threshold of the power transformer primary winding.
- Configuration variable for inverse time curve type 51Q1P: U1, U2, U3, U4, U5, C1, C2, C3, C4, C5.
- Configuration variable for 51Q1P Time-Dial of the inverse time overcurrent protection curve parameter.
- Configuration variable for 50N1P instantaneous residual overcurrent threshold of the power transformer primary winding.
- Configuration variable for 50N1P inverse time residual overcurrent threshold of the power transformer primary winding.
- Configuration variable for inverse time curve type 51N1P: U1, U2, U3, U4, U5, C1, C2, C3, C4, C5.
- Configuration variable for 51N1P Time-Dial of the inverse time overcurrent protection curve parameter.
- Configuration variable for 50P2P instantaneous overcurrent level of the power transformer secondary winding.
- Configuration variable for 50P2D definite time instantaneous overcurrent level of the power transformer secondary winding.
- Configuration variable 51P2P inverse time overcurrent threshold of the power transformer secondary winding.
- Configuration variable for inverse time curve type 51P2P: U1, U2, U3, U4, U5, C1, C2, C3, C4, C5.
- Configuration variable for 51P2P Time-Dial of the inverse time overcurrent protection curve parameter.
- Configuration variable for 50Q2P negative sequence instantaneous overcurrent threshold of the power transformer secondary winding.
- Configuration variable for 51Q2P negative sequence inverse time overcurrent threshold of the power transformer secondary winding.
- Configuration variable for inverse time curve type 51Q2P: U1, U2, U3, U4, U5, C1, C2, C3, C4, C5.
- Configuration variable for 51Q2P Time-Dial of the inverse time overcurrent protection curve parameter.
- Configuration variable for 50N2P instantaneous residual overcurrent threshold of the power transformer secondary winding.
- Configuration variable for 50N2P inverse time residual overcurrent threshold of the power transformer primary winding.
- Configuration variable for inverse time curve type 51N2P: U1, U2, U3, U4, U5, C1, C2, C3, C4, C5.
- Configuration variable for 51N2P Time-Dial of the inverse time overcurrent protection curve parameter.

1.3.3. Directional/Non Directional Protection Relay.

- Configuration variable for power transformer windings connection.
- Configuration variable to control the circuit breaker operations, limit 1.
- Configuration variable to control the circuit breaker operations, limit 2.
- Configuration variable to control the circuit breaker operations, limit 3.
- Configuration variable for current transformer relationship.
- Configuration variable for voltage transformer relationship.
- Configuration variable for Z1MAG positive sequence line impedance.
- Configuration variable for Z0MAG zero sequence line impedance.
- Configuration variable for 50P1P phase instantaneous overcurrent element 1.
- Configuration variable for 50P2P phase instantaneous overcurrent element 2.
- Configuration variable for 50P3P phase instantaneous overcurrent element 3.
- Configuration variable for 50P4P phase instantaneous overcurrent element 4.
- Configuration variable for 50P5P phase instantaneous overcurrent element 5.
- Configuration variable for 50P6P phase instantaneous overcurrent element 6.
- Configuration variable for 67P1D phase definite time overcurrent element 1.
- Configuration variable for 67P2D phase definite time overcurrent element 2.
- Configuration variable for 67P3D phase definite time overcurrent element 3.
- Configuration variable for 67P4D phase definite time overcurrent element 4.
- Configuration variable for 50N1P neutral ground instantaneous overcurrent element 1.
- Configuration variable for 50N2P neutral ground instantaneous overcurrent element 2.
- Configuration variable for 50N3P neutral ground instantaneous overcurrent element 3.
- Configuration variable for 50N4P neutral ground instantaneous overcurrent element 4.
- Configuration variable for 50N5P neutral ground instantaneous overcurrent element 5.
- Configuration variable for 50N6P neutral ground instantaneous overcurrent element 6.
- Configuration variable for 67N1D neutral ground definite time overcurrent element 1.
- Configuration variable for 67N2D neutral ground definite time overcurrent element 2.
- Configuration variable for 67N3D neutral ground definite time overcurrent element 3.
- Configuration variable for 67N4D neutral ground definite time overcurrent element 4.
- Configuration variable for 50G1P residual ground instantaneous overcurrent element 1.
- Configuration variable for 50G2P residual ground instantaneous overcurrent element 2.

1.3.3. Directional/Non Directional Protection Relay. (continuation)

- Configuration variable for 50G3P residual ground instantaneous overcurrent element 3.
- Configuration variable for 50G4P residual ground instantaneous overcurrent element 4.
- Configuration variable for 50G5P residual ground instantaneous overcurrent element 5.
- Configuration variable for 50G6P residual ground instantaneous overcurrent element 6.
- Configuration variable for 67G1D residual ground definite time overcurrent element 1.
- Configuration variable for 67G2D residual ground definite time overcurrent element 2.
- Configuration variable for 67G3D residual ground definite time overcurrent element 3.
- Configuration variable for 67G4D residual ground definite time overcurrent element 4.
- Configuration variable for 50Q1P negative sequence instantaneous overcurrent element 1.
- Configuration variable for 50Q2P negative sequence instantaneous overcurrent element 2.
- Configuration variable for 50Q3P negative sequence instantaneous overcurrent element 3.
- Configuration variable for 50Q4P negative sequence instantaneous overcurrent element 4.
- Configuration variable for 50Q5P negative sequence instantaneous overcurrent element 5.
- Configuration variable for 50Q6P negative sequence instantaneous overcurrent element 6.
- Configuration variable for 67Q1D negative sequence definite time overcurrent element 1.
- Configuration variable for 67Q2D negative sequence definite time overcurrent element 2.
- Configuration variable for 67Q3D negative sequence definite time overcurrent element 3.
- Configuration variable for 67Q4D negative sequence definite time overcurrent element 4.
- Configuration variable for 51PP inverse time overcurrent element 1.
- Configuration variable for 51PC curve: U1-U5, C1-C5.
- Configuration variable for 51PTD Time Dial.
- Configuration variable for 51NP ground time overcurrent element 1.
- Configuration variable for 51NC curve: U1-U5, C1-C5.
- Configuration variable for 51NTD Time Dial.
- Configuration variable for 51GP residual ground time overcurrent element 1.
- Configuration variable for 51GC curve: U1-U5, C1-C5.
- Configuration variable for 51GTD Time Dial.
- Configuration variable for 51G2P residual ground time overcurrent element 2.
- Configuration variable for 51G2C curve: U1-U5, C1-C5.
- Configuration variable for 51G2TD Time Dial.
- Configuration variable for 51QP negative sequence time overcurrent element.
- Configuration variable for 51QC curve: U1-U5, C1-C5.
- Configuration variable for 51QTD Time Dial.
- Configuration variable for ZLF forward load impedance.
- Configuration variable for ZLR reverse load impedance.
- Configuration variable for PLAF positive forward load angle.
- Configuration variable for NLAF negative forward load angle.
- Configuration variable for NLAR negative reverse load angle.
- Configuration variable for DIR1 Level 1 directional element.
- Configuration variable for DIR2 Level 2 directional element.
- Configuration variable for DIR3 Level 3 directional element.
- Configuration variable for DIR4 Level 4 directional element.
- Configuration variable for 27P1P phase undervoltage pickup.
- Configuration variable for 27P2P phase undervoltage pickup.
- Configuration variable for 59P1P phase overvoltage pickup.
- Configuration variable for 59P2P phase overvoltage pickup.
- Configuration variable for 59N1P zero sequence overvoltage element.
- Configuration variable for 89D1P frequency element 1.
- Configuration variable for 89D2P frequency element 2.
- Configuration variable for 89D3P frequency element 3.
- Configuration variable for 89D4P frequency element 4.
- Configuration variable for 89D5P frequency element 5.
- Configuration variable for 89D6P frequency element 6.

1.3.4. Protection Relay of Turbine-Generator Group.

- Configuration variable of synchronous generator nominal power.
- Configuration variable of synchronous generator poles number.
- Configuration variable of instantaneous overcurrent protection threshold.
- Configuration variable of inverse time overcurrent protection threshold.
- Configuration variable of overvoltage protection threshold.
- Configuration variable of undervoltage protection threshold.
- Configuration variable of overfrequency protection threshold.
- Configuration variable of subfrequency protection threshold.
- Configuration variable of reverse power level.
- Configuration variable of Proportional, Integral and Derivative (PID) for Turbine-Generator group control and regulation.

1.4. Control variables of double bus bar generation I substation switchgear. Local and remote control possibility (SCADA).

- Control variable of open/close 89TC-1 coupling disconnector.
- Control variable of open/close 89TC-2 coupling disconnector.
- Control variable of open/close 52TC coupling breaker.
- Control variable of open/close 89GT1-1 transformer disconnector.
- Control variable of open/close 89GT1-2 transformer disconnector.
- Control variable of open/close 52T-1 transformer breaker.
- Control variable of open/close 52E1 excitation breaker.
- Control variable of open/close 52NET-1 grid breaker.
- Control variable of open/close 52G1 generation breaker.

1.5. Control variables of double bus bar generation II substation switchgear. Local and remote control possibility (SCADA).

- Control variable of open/close 89GT2-1 transformer disconnector.
- Control variable of open/close 89GT2-2 transformer disconnector.
- Control variable of open/close 52T-2 transformer breaker.
- Control variable of open/close 52E2 excitation breaker.
- Control variable of open/close 52G2 generation breaker.

1.6. Control variables for faults selection.

- Control variable for direct single phase short preselection.
- Control variable for single phase short circuit with fault impedance.
- Control variable for direct two phases to ground short circuit preselection.
- Control variable for two phases to ground short circuit preselection with fault impedance.
- Control variable for direct two phase short circuit preselection.
- Control variable for two phase short circuit preselection with fault impedance.
- Control variable for direct three-phase phase short circuit preselection.
- Control variable for three-phase phase short circuit preselection with fault impedance.
- Control variable for fault injection.

2. Transmission System: the most important and used 111 physical variables in the National Grid power systems.

2.1. Control variables of double bus bar emitter/receptor transmission substation switchgear for line I:

- Control variable of open/close 89L1-1 disconnector.
- Control variable of open/close 89L1-2 disconnector.
- Control variable of open/close 89L1-3 disconnector.
- Control variable of open/close 52L1-1 breaker.
- Control variable of open/close 57L1 ground disconnector.
- Control variable of open/close 52L1-2 breaker.
- Control variable of open/close 52NET-2 breaker.
- Control variable of open/close 52UB1 breaker.

2.2. Control variables of double bus bar emitter transmission substation switchgear for line II:

- Control variable of open/close 89L2-1 disconnector.
- Control variable of open/close 89L2-2 disconnector.
- Control variable of open/close 89L2-3 disconnector.
- Control variable of open/close 52L2-1 breaker.
- Control variable of open/close 57L2 ground disconnector.
- Control variable of open/close 52L2-2 breaker.
- Control variable of open/close 52NET-3 breaker.
- Control variable of open/close 52UB2 breaker.

2.3.Control variables of double bus bar emitter/receptor transmission substation switchgear for line III:

- Control variable of open/close 89L3-1 disconnector.
- Control variable of open/close 89L3-2 disconnector.
- Control variable of open/close 89L3-3 disconnector.
- Control variable of open/close 52L3-1 breaker.
- Control variable of open/close 57L3 ground disconnector.
- Control variable of open/close 52L3-2 breaker.
- Control variable of open/close 52NET-4 breaker.
- Control variable of open/close 52UB3 breaker.

2.4. Control variables of double bus bar emitter transmission substation switchgear for line IV:

- Control variable of open/close 89L4-1 disconnector.
- Control variable of open/close 89L4-2 disconnector.
- Control variable of open/close 89L4-3 disconnector.
- Control variable of open/close 52L4-1 breaker.
- Control variable of open/close 57L4 ground disconnector.
- Control variable of open/close 52L4-2 breaker.
- Control variable of open/close 52NET-5 breaker.
- Control variable of open/close 52UB4 breaker.

2.5. Control variables of transmission lines I, II, III and IV parameters:

- Control variable to choice the capacitive effect I of line I.
- Control variable to choice the capacitive effect II of line I.
- Control variable to choice the capacitive effect III of line I.
- Control variable to choice the capacitive effect IV of line I.
- Control variable to choice the inductive effect I of line I.
- Control variable to choice the inductive effect II of line I.
- Control variable to choice the capacitive effect I of line II.
- Control variable to choice the capacitive effect II of line II.
- Control variable to choice the capacitive effect III of line II.
- Control variable to choice the capacitive effect IV of line II.
- Control variable to choice the inductive effect I of line II.
- Control variable to choice the inductive effect II of line II.
- Control variable to choice the capacitive effect I of line III.
- Control variable to choice the capacitive effect II of line III.
- Control variable to choice the capacitive effect III of line III.
- Control variable to choice the capacitive effect IV of line III.
- Control variable to choice the inductive effect I of line III.
- Control variable to choice the inductive effect II of line III.
- Control variable to choice the capacitive effect I of line IV.
- Control variable to choice the capacitive effect II of line IV.
- Control variable to choice the capacitive effect III of line IV.
- Control variable to choice the capacitive effect IV of line IV.
- Control variable to choice the inductive effect I of line IV.
- Control variable to choice the inductive effect II of line IV.

2.6. Control variables of distance protection relay:

- Configuration variable for current transformer relationship.
- Configuration variable for voltage transformer relationship.
- Configuration variable for remove fault duration.
- Configuration variable for line impedance.
- Configuration variable for length line.
- Configuration variables for Mho distance elements:
  - Configuration variable for Z1P instantaneous distance element of zone 1.
  - Configuration variable for Z2P instantaneous distance element of zone 2.
  - Configuration variable for Z3P instantaneous distance element of zone 3.
  - Configuration variable for Z4P instantaneous distance element of zone 4.
  - Configuration variable for 50PP1 instantaneous overcurrent element of zone 1.
  - Configuration variable for 50PP2 instantaneous overcurrent element of zone 2.
  - Configuration variable for 50PP3 instantaneous overcurrent element of zone 3.
  - Configuration variable for 50PP4 instantaneous overcurrent element of zone 4.
  - Configuration variable for Z1MG ground impedance element of zone 1.
  - Configuration variable for Z2MG ground impedance element of zone 2.
  - Configuration variable for Z3MG ground impedance element of zone 3.
  - Configuration variable for Z4MG ground impedance element of zone 4.
  - Configuration variable for Z1D time distance element of zone 1.
  - Configuration variable for Z2D time distance element of zone 2.
  - Configuration variable for Z3D time distance element of zone 3.
  - Configuration variable for Z4D time distance element of zone 4.
- Configuration variable for 50P1P instantaneous overcurrent element of level 1.
- Configuration variable for 50P2P instantaneous overcurrent element of level 2.
- Configuration variable for 50P3P instantaneous overcurrent element of level 3.
- Configuration variable for 50P4P instantaneous overcurrent element of level 4.
- Configuration variable for 67P1D definite time overcurrent element of level 1.
- Configuration variable for 67P2D definite time overcurrent element of level 2.
- Configuration variable for 67P3D definite time overcurrent element of level 3.

2.6. Control variables of distance protection relay: (continuation)

- Configuration variable for 67P4D definite time overcurrent element of level 4.
- Configuration variable for 50G1P residual instantaneous overcurrent element of level 1.
- Configuration variable for 50G2P residual instantaneous overcurrent element of level 2.
- Configuration variable for 50G3P residual instantaneous overcurrent element of level 3.
- Configuration variable for 50G4P residual instantaneous overcurrent element of level 4.
- Configuration variable for 67G1P residual definite time overcurrent element of level 1.
- Configuration variable for 67G2P residual definite time overcurrent element of level 2.
- Configuration variable for 67G3P residual definite time overcurrent element of level 3.
- Configuration variable for 67G4P residual definite time overcurrent element of level 4.
- Configuration variable for 50Q1P negative sequence instantaneous overcurrent element of level 1.
- Configuration variable for 50Q2P negative sequence instantaneous overcurrent element of level 2.
- Configuration variable for 50Q3P negative sequence instantaneous overcurrent element of level 3.
- Configuration variable for 50Q4P negative sequence instantaneous overcurrent element of level 4.
- Configuration variable for 67Q1D negative sequence definite time overcurrent element of level 1.
- Configuration variable for 67Q2D negative sequence definite time overcurrent element of level 2.
- Configuration variable for 67Q3D negative sequence definite time overcurrent element of level 3.
- Configuration variable for 67Q4D negative sequence definite time overcurrent element of level 4.
- Configuration variable for 51PP inverse time overcurrent element of level 1.
- Configuration variable for 51PP inverse time overcurrent element type: U1-U5, C1-C5.
- Configuration variable for 51PP “Time Dial”.
- Configuration variable for 51GP inverse time residual overcurrent element.
- Configuration variable for 51GP inverse time overcurrent element type: U1-U5, C1-C5.
- Configuration variable for 51GP “Time Dial”.
- Configuration variable for 51QP inverse time negative sequence overcurrent element.
- Configuration variable for 51QP inverse time overcurrent element type: U1-U5, C1-C5.
- Configuration variable for 51QP “Time Dial”.
- Configuration variable for directional element.

3. Distribution and Load Systems: the most important and used 158 physical variables in the National Grid power systems.

3.1. Control variables of distribution transformer voltage regulator:
- Control variable for voltage regulation at 0 %.
- Control variable for voltage regulation at 2, 5 %.
- Control variable for voltage regulation at 5 %.
- Control variable for voltage regulation at 7, 5 %.
- Control variable for voltage regulation at -2, 5 %.
- Control variable for voltage regulation at -5 %.
- Control variable for voltage regulation at -7,5 %.
- Control variable of open/close 52T-3 distribution transformer breaker.
- Control variable of open/close 52T-4 distribution transformer breaker.

3.2. Control variables of load system:
- Control variable for balance/unbalance three-phase resistor load.
- Control variable for balance/unbalance three-phase inductance load.
- Control variable for balance/unbalance three-phase capacitance load.
- Control variable for minimum load resistor.
- Control variable for medium load resistor.
- Control variable for maximum load resistor.
- Control variable for minimum load inductance.
- Control variable for medium load inductance.
- Control variable for maximum load inductance.
- Control variable for minimum load capacitance.
- Control variable for medium load capacitance.
- Control variable for maximum load capacitance.

3.3. Control variables of double bus bar emitter distribution substation switchgear. Local and remote control possibility (SCADA):
- Control variable of open/close 89T2-1 disconnector.
- Control variable of open/close 89T2-2 disconnector.
- Control variable of open/close 89T2-3 disconnector.
- Control variable of open/close 52T2-1 breaker.
- Control variable of open/close 89T1-1 disconnector.
- Control variable of open/close 89T1-2 disconnector.
- Control variable of open/close 89T1-3 disconnector.
- Control variable of open/close 52T1-1 breaker.

3.4. Control variables for the connected type load. Possibility to control both local and remote modes (SCADA):
- Control variable for minimum resistive load.
- Control variable for medium resistive load.
- Control variable for maximum resistive load.
- Control variable for minimum inductive load.
- Control variable for medium inductive load.
- Control variable for maximum inductive load.
- Control variable for minimum capacitive load.
- Control variable for medium capacitive load.
- Control variable for maximum capacitive load.

3.5. Control variables for load power factor compensation. Possibility to control both local and remote modes (SCADA):
The load system has an automatic power factor controller able to remain constant the load power factor according to the set point previously adjusted by the user. Six capacitor steps give more or less reactive power in function of the connected load.

3.6. Differential Protection Relay of Step-Up power transformer:
- Configuration variable for the current transformer relationship.
- Configuration variable for the voltage transformer relationship.
- Configuration variable for the removing fault time (TRIP duration).
- Configuration variable for power transformer connection type.
- Configuration variable for measurement transformer connection type.
- Configuration variable for 87P differential protection element.
- Configuration variable for SLP1 restriction percentage of 87P differential element.
- Configuration variable for SLP2 restriction percentage of 87P differential element.
- Configuration variable for 2° harmonic restriction percentage.
- Configuration variable for 4° harmonic restriction percentage.
- Configuration variable for 5° harmonic restriction percentage.
- Configuration variable for 50P1P instantaneous overcurrent level of the primary winding power transformer.
- Configuration variable for 51P1D definite time instantaneous overcurrent level of the primary winding power transformer.
- Configuration variable for 51P1P inverse time overcurrent threshold of the power transformer primary winding.
- Configuration variable for inverse time curve type 51P1P: U1, U2, U3, U4, U5, C1, C2, C3, C4, C5.
- Configuration variable for the 51P1P Time-Dial of the inverse time overcurrent protection curve parameter.
- Configuration variable for 50Q1P negative sequence instantaneous overcurrent threshold of the power transformer primary winding.
- Configuration variable for 51Q1P negative sequence inverse time overcurrent threshold of the power transformer primary winding.
- Configuration variable for inverse time curve type 51Q1P: U1, U2, U3, U4, U5, C1, C2, C3, C4, C5.
- Configuration variable for 51Q1P Time-Dial of the inverse time overcurrent protection curve parameter.
- Configuration variable for 50N1P instantaneous residual overcurrent threshold of the power transformer primary winding.
- Configuration variable for 50N1P inverse time residual overcurrent threshold of the power transformer primary winding.
- Configuration variable for inverse time curve type 51N1P: U1, U2, U3, U4, U5, C1, C2, C3, C4, C5.
- Configuration variable for 51N1P Time-Dial of the inverse time overcurrent protection curve parameter.
- Configuration variable for 50P2P instantaneous overcurrent level of the power transformer secondary winding.
- Configuration variable for 50P2D definite time instantaneous overcurrent level of the power transformer secondary winding.
- Configuration variable 51P2P inverse time overcurrent threshold of the power transformer secondary winding.
- Configuration variable for inverse time curve type 51P2P: U1, U2, U3, U4, U5, C1, C2, C3, C4, C5.
- Configuration variable for 51P2P Time-Dial of the inverse time overcurrent protection curve parameter.
- Configuration variable for 50Q2P negative sequence instantaneous overcurrent threshold of the power transformer secondary winding.
- Configuration variable for 51Q2P negative sequence inverse time overcurrent threshold of the power transformer secondary winding.
- Configuration variable for inverse time curve type 51Q2P: U1, U2, U3, U4, U5, C1, C2, C3, C4, C5.
- Configuration variable for 51Q2P Time-Dial of the inverse time overcurrent protection curve parameter.
- Configuration variable for 50N2P instantaneous residual overcurrent threshold of the power transformer secondary winding.
- Configuration variable for 50N2P inverse time residual overcurrent threshold of the power transformer primary winding.
- Configuration variable for inverse time curve type 51N2P: U1, U2, U3, U4, U5, C1, C2, C3, C4, C5.
- Configuration variable for 51N2P Time-Dial of the inverse time overcurrent protection curve parameter.

3.7. Directional/Non Directional Protection Relay:

- Configuration variable for power transformer windings connection.
- Configuration variable to control the circuit breaker operations, limit 1.
- Configuration variable to control the circuit breaker operations, limit 2.
- Configuration variable to control the circuit breaker operations, limit 3.
- Configuration variable for current transformer relationship.
- Configuration variable for voltage transformer relationship.
- Configuration variable for Z1MAG positive sequence line impedance.
- Configuration variable for Z0MAG zero sequence line impedance.
- Configuration variable for 50P1P phase instantaneous overcurrent element 1.
- Configuration variable for 50P2P phase instantaneous overcurrent element 2.
- Configuration variable for 50P3P phase instantaneous overcurrent element 3.
- Configuration variable for 50P4P phase instantaneous overcurrent element 4.
- Configuration variable for 50P5P phase instantaneous overcurrent element 5.
- Configuration variable for 50P6P phase instantaneous overcurrent element 6.
- Configuration variable for 67P1D phase definite time overcurrent element 1.
- Configuration variable for 67P2D phase definite time overcurrent element 2.
- Configuration variable for 67P3D phase definite time overcurrent element 3.
- Configuration variable for 67P4D phase definite time overcurrent element 4.
- Configuration variable for 50N1P neutral ground instantaneous overcurrent element 1.
- Configuration variable for 50N2P neutral ground instantaneous overcurrent element 2.
- Configuration variable for 50N3P neutral ground instantaneous overcurrent element 3.
- Configuration variable for 50N4P neutral ground instantaneous overcurrent element 4.
- Configuration variable for 50N5P neutral ground instantaneous overcurrent element 5.
- Configuration variable for 50N6P neutral ground instantaneous overcurrent element 6.
- Configuration variable for 67N1D neutral ground definite time overcurrent element 1.
- Configuration variable for 67N2D neutral ground definite time overcurrent element 2.
- Configuration variable for 67N3D neutral ground definite time overcurrent element 3.
- Configuration variable for 67N4D neutral ground definite time overcurrent element 4.
- Configuration variable for 50G1P residual ground instantaneous overcurrent element 1.
- Configuration variable for 50G2P residual ground instantaneous overcurrent element 2.
- Configuration variable for 50G3P residual ground instantaneous overcurrent element 3.
- Configuration variable for 50G4P residual ground instantaneous overcurrent element 4.
- Configuration variable for 50G5P residual ground instantaneous overcurrent element 5.
- Configuration variable for 50G6P residual ground instantaneous overcurrent element 6.
- Configuration variable for 67G1D residual ground definite time overcurrent element 1.
- Configuration variable for 67G2D residual ground definite time overcurrent element 2.
- Configuration variable for 67G3D residual ground definite time overcurrent element 3.
- Configuration variable for 67G4D residual ground definite time overcurrent element 4.
- Configuration variable for 50Q1P negative sequence instantaneous overcurrent element 1.
- Configuration variable for 50Q2P negative sequence instantaneous overcurrent element 2.
- Configuration variable for 50Q3P negative sequence instantaneous overcurrent element 3.
- Configuration variable for 50Q4P negative sequence instantaneous overcurrent element 4.
- Configuration variable for 50Q5P negative sequence instantaneous overcurrent element 5.
- Configuration variable for 50Q6P negative sequence instantaneous overcurrent element 6.
- Configuration variable for 67Q1D negative sequence definite time overcurrent element 1.
- Configuration variable for 67Q2D negative sequence definite time overcurrent element 2.
- Configuration variable for 67Q3D negative sequence definite time overcurrent element 3.
- Configuration variable for 67Q4D negative sequence definite time overcurrent element 4.
- Configuration variable for 51PP inverse time overcurrent element 1.
- Configuration variable for 51PC curve: U1-U5, C1-C5.
- Configuration variable for 51PTD Time Dial.
- Configuration variable for 51NP ground time overcurrent element 1.
- Configuration variable for 51NC curve: U1-U5, C1-C5.
- Configuration variable for 51NTD Time Dial.
- Configuration variable for 51GP residual ground time overcurrent element 1.
- Configuration variable for 51GC curve: U1-U5, C1-C5.
- Configuration variable for 51GTD Time Dial.
- Configuration variable for 51G2P residual ground time overcurrent element 2.
- Configuration variable for 51G2C curve: U1-U5, C1-C5.
- Configuration variable for 51G2TD Time Dial.
- Configuration variable for 51QP negative sequence time overcurrent element.
- Configuration variable for 51QC curve: U1-U5, C1-C5.
- Configuration variable for 51QTD Time Dial.
- Configuration variable for ZLF forward load impedance.
- Configuration variable for ZLR reverse load impedance.
- Configuration variable for PLAF positive forward load angle.
- Configuration variable for NLAF negative forward load angle.
- Configuration variable for NLAR negative reverse load angle.
- Configuration variable for DIR1 Level 1 directional element.
- Configuration variable for DIR2 Level 2 directional element.
- Configuration variable for DIR3 Level 3 directional element.
- Configuration variable for DIR4 Level 4 directional element.
- Configuration variable for 27P1P phase undervoltage pickup.
- Configuration variable for 27P2P phase undervoltage pickup.
- Configuration variable for 59P1P phase overvoltage pickup.
- Configuration variable for 59P2P phase overvoltage pickup.
- Configuration variable for 59N1P zero sequence overvoltage element.
- Configuration variable for 89D1P frequency element 1.
- Configuration variable for 89D2P frequency element 2.
- Configuration variable for 89D3P frequency element 3.
- Configuration variable for 89D4P frequency element 4.
- Configuration variable for 89D5P frequency element 5.
- Configuration variable for 89D6P frequency element 6.

BRIEF INTRODUCTION

The Advanced Mechanical, Electrical and Smart Grid Power Systems (Utilities), "APS12", are ones of the most complete and advanced teaching power systems for the didactic and industrial world. For its flexible configuration, the utilization of real power system elements, the possibility to study mechanical power plants and electrical power systems parts working together and much more reasons, this power system is an authentic teaching mechanism for universities, vocational schools, future power systems operators, etc. With more than **486 control variables**, users can immerse in a world full of possibilities.

The mechanical and electrical power systems require an adequate management and control of the power flow to ensure a quality, safety and reliability from the power stations, where the energy is generated, up to the loads, where the energy is consumed.

A perfect coordination of Power Plants, Electrical Substations, Transmission and Distribution Lines, Protection Systems and Energy Utilization is very important to ensure a good operation of the electrical system. The Smart Grids play an important role on this great chain and are studied through the "APS12"optionally including the possibility to add Smart Meters Systems.

Nowadays, one of the problems that power systems face in many places of the world, are the black outs. The blackouts produce great economical and electrical damages in the countries and the grid, for this reason is very important to know the causes, the effects and the solutions for this problem. The "APS12" allows to analyze the causes and the effects of the black outs and shows how to solve this problem and how the electrical system is restored quickly.

The goal of the Advanced Mechanical, Electrical and Smart Grid Power Systems (Utilities), "APS12", is to study all these aspects and much more. The "APS12" allows the students to know how to get a perfect coordination, supervision and control in order to obtain the optimal performance of the system, so the generation and the consumption are in a perfect balance.

The "APS12" series can be acquired according to the customer requirements through the following available configurations:

a) APS12-MES. **Mechanical Power Plants (M) + Smart Grid Electrical Power Systems (E) + Smart Grid Distributed Loads I (S).**

b) APS12-ME. **Mechanical Power Plants (M) + Smart Grid Electrical Power Systems (E).**

c) APS12-ES. **Smart Grid Electrical Power System (E) + Smart Grid Distributed Loads I (S).**

d) APS12-E. **Smart Grid Electrical Power System (E).**

What are the Advanced Mechanical, Electrical and Smart Grid Power Systems (Utilities), "APS12"?

The Advanced Mechanical, Electrical and Smart Grid Power Systems (Utilities), "APS12", are not a simple electrical power system simulator; the "APS12" really represents a whole electrical and mechanical power system with different optional configurations that allow us to construct different National Grids models.

The "APS12"consists of a series of cubicles and benches that are connected to form the Electrical Power System and the Mechanical Power Plant:

- The **Electrical Power System** consists of the following cubicles and electrical control bench (HUB I): the Power Station Cubicle with the synchronous generator and turbine, the Power Transmission Lines Cubicle, the Power Distribution Lines and the Energy Utilization Cubicle and the High Voltage Protection System integrated in all cubicles. Cubicles have diagrams in the front panel and indicator lamps that represent the unifilar scheme of the whole electrical system to indicate the circuit breakers and disconnectors state. In the front panel of the cubicles are located network analyzers to show the electrical parameters of the power generation, transmission and distribution lines and the loads consumption. The electrical control bench (HUB I) has three touch screens and one panoramic screen with which are controlled remotely the hardware of the cubicles: synchronous generator, circuit breakers and disconnectors, short circuit tests, protection relays, power flow, etc.

- The **Mechanical Power Plants** consists of a mechanical control bench (HUB II) with three touch screens and one panoramic screen. The HUB II is supplied with 12 optional mechanical power plants simulation software: Combined Cycle Power Plant, Nuclear Power Plant, Diesel Fuel Power Plant, Fossil Fuel Power Plant, Gas Power Plant, Hydroelectric Power Plant, Wind Powered Power Plant, Photovoltaic Power Plant, Heliothermic Power Plant, Biomass Power Plant, Fuel Cells Power Plant and Geothermal Power Plant.

The "APS12" has been designed to offer a variety of training possibilities available for:

Power management staff/Operators of power plants and substations/Maintenance personnel/Teaching of teachers and students/ Research of universities.

A configuration with all characteristics of a Real National Grid

The Advanced Mechanical, Electrical and Smart Grid Power Systems (Utilities), "APS12", are a real simulation of a power system due to it includes the same components used in real power systems: protection relays, power transformers, synchronous generator, synchronoscope, automatic voltage and frequency controllers, SCADA Control and Data Acquisition System, network analyzers, PLC´s, etc. The "APS12" has been developed in cooperation with professionals of the power systems industry.

With the "APS12" it is possible to train people to make correct decisions under different operation conditions, such as control of synchronous generator, parallel operations with two synchronous generator and the grid, short-circuit tests, black-outs. All these aspects and much more are carried out from the "operations room", as actually done.

In short, students, teachers, operators of power plants, maintenance personnel, etc. will take the control of an authentic Smart Grid Power System through the hardware and the SCADA I and SCADA II controlling widely the "APS12".

Simple to use, but advanced, robust and safe

The EDIBON Advanced Mechanical, Electrical and Smart Grid Power Systems (Utilities), "APS12", integrates more than one hundred configurations without physical external cables and connections. All system is prewired and configured with programmed PLC´s, which are located into the cabinets. From the SCADA unit, with six touch screens and two panoramic screens, the user sends commands to the PLC´s and, in a second, the system configuration changes. This avoids hours of wiring and the possibility of mistakes during experiments.

Cutting Edge Protection Relays System used by prestigious utilities

The "APS12" has two levels revolutionary protection systems.

In the level 1, students and teachers can configure and manage actual protection relays manufactured by SEL (Schweitzer Engineering Laboratories from USA). SEL revolutionized the protection industry by building the first microprocessor-based protective relays. These relays integrated, economized, and simplified the art of transmission line protection while introducing two powerful tools: fault locating and event reporting.

The types of protection relays that are included in "APS12" are: differential protection relay, overvoltage protection relay, inverse power protection relay, under voltage protection relay, over frequency protection relay, under frequency protection relay, distance protection relay, directional protection relay, overcurrent protection relay, etc. However, as the students can make configuration mistakes, the "APS12" has a second system protection or backup protection (level 2) in order to avoid damages in the system.

a) APS12-MES. **Mechanical Power Plants (M) + Smart Grid Electrical Power Systems (E) + Smart Grid Distributed Loads I (S).**

Options:

- APS12-MES12. Complete Advanced 12 Mechanical Power Plants (M) + Smart Grid Electrical Power Systems (E) + Smart Grid Distributed Loads I (S).
  (2 generators + 2 Transmission Lines + 2 Distribution Lines and Loads + 2 Smart Grid Distributed Loads I)

- APS12-MES2. 2 Mechanical Power Plants (M) + Smart Grid Electrical Power Systems (E) + Smart Grid Distributed Loads I (S).
  (2 generators + 2 Transmission Lines + 2 Distribution Lines and Loads + 2 Smart Grid Distributed Loads I)

- APS12-MES1. 1 Mechanical Power Plants (M) + Smart Grid Electrical Power Systems (E) + Smart Grid Distributed Loads I (S).
  (1 generator + 1 Transmission Line + 1 Distribution Line and Loads + 1 Smart Grid Distributed Loads)

- APS12-MESCE. Custom made configuration with EDIBON references adapted to customer needs.

- APS12-MESC. 1 Mechanical Power Plants (M) + Smart Grid Electrical Power Systems (E) + Smart Grid Distributed Loads I (S) + Additional Custom Made Configurations with customer industrial needs. For example:
  - Diesel Generator with particular technical characteristics.
  - Gas Turbine.
  - Possibility to study electricity theft.
  - Black-outs studies.
  - ……

b) APS12-ME. **Mechanical Power Plants (M) + Smart Grid Electrical Power Systems (E).**

Options:

- APS12-ME12. Complete Advanced 12 Mechanical Power Plants (M) + Smart Grid Electrical Power Systems (E).
  (2 generators + 2 Transmission Lines + 2 Distribution Lines and Loads)

- APS12-ME2. 2 Mechanical Power Plants (M) + Smart Grid Electrical Power Systems (E).
  (2 generators + 2 Transmission Lines + 2 Distribution Line and Loads)

- APS12-ME1. 1 Mechanical Power Plants (M) + Smart Grid Electrical Power Systems (E).
  (1 generator + 1 Transmission Line + 1 Distribution Line and Loads)

- APS12-MECE. Custom made configuration with EDIBON references adapted to customer needs.

- APS12-MEC. 1 Mechanical Power Plants (M) + Smart Grid Electrical Power Systems (E) + Additional Custom Made Configurations with customer industrial needs. For example:
  - Diesel Generator with particular technical characteristics.
  - Gas Turbine.
  - Possibility to study electricity theft.
  - Black-outs studies.
  - ……

c) APS12-ES. **Smart Grid Electrical Power System (E) + Smart Grid Distributed Loads I (S).**

Options:

- APS12-ES2. Smart Grid Electrical Power System (E) + Smart Grid Distributed Loads I (S).
  (2 generators + 2 Transmission Lines + 2 Distribution Lines and Loads + 2 Smart Grid Distributed Loads I)

- APS12-ES1. Smart Grid Electrical Power System (E) + Smart Grid Distributed Loads I (S).
  (1 generator + 1 Transmission Line + 1 Distribution Line and Loads + 1 Smart Grid Distributed Loads I)

- APS12-ESCE. Custom made configuration with EDIBON references adapted to customer needs.

- APS12-ESC. Smart Grid Electrical Power System (E) + Smart Grid Distributed Loads I (S) + Custom Made Configurations with customer industrial needs. For example:
  - Diesel Generator with particular technical characteristics.
  - Gas Turbine.
  - Possibility to study electricity theft.
  - Black-outs studies.
  - ……

d) APS12-E. **Smart Grid Electrical Power System (E).**

Options:

- APS12-E2. Smart Grid Electrical Power Systems (E).
  (2 generators + 2 Transmission Lines + 2 Distribution Lines and Loads)

- APS12-E1. Smart Grid Electrical Power Systems (E).
  (1 generator + 1 Transmission Line + 1 Distribution Line and Loads)

- APS12-ECE. Custom made configuration with EDIBON references adapted to customer needs.

- APS12-EC. Smart Grid Electrical Power Systems (E) + Custom Made Configuration with customer industrial needs. For example:
  - Diesel Generator with particular technical characteristics.
  - Gas Turbine.
  - Possibility to study electricity theft.
  - Black-outs studies.
  - ……

e) Other elements available on request:

Loads:

- C-DL. Dynamic Loads.

Visualization Systems:

- VS-PR. 30 Students visualization system with projector.
- SCADA-CRI. 30 Students visualization and remote control individually.
- ESN. EDIBON SCADA-Net.

For details see Annex III: www.edibon.com/en/advanced-mechanical-electrical-and-smart-grid-power-systems-utilities/additional-info

APS12-MES12.

Complete Advanced 12 Mechanical Power Plants (M) + Smart Grid Electrical Power Systems (E) + Smart Grid Distributed Load I (S)

MECHANICAL POWER PLANT GENERAL DESCRIPTION

The APS12-MES12 is the most advanced configuration of all APS12 series. With 12 different Power Plants, this system offers the possibility to study the most important operations, control process, situations and problems that may occur in real power plants of the world through complex numerical equations adapted to power plant particular conditions.

The mechanical part is totally engaged with the electrical side following one side to the other according the evolution of the system thanks to two included SCADAs: the SCADA I (for electrical power system) and SCADA II (for mechanical power plant). On this way, this configuration is one of the best options for all these teachers, students and sector professionals that require the maximum and complete teaching/training performance.

The SCADA I is installed in the mechanical control bench. This bench has three touch screens and one normal screen from which all mechanical power plants parameters can be monitored and controlled as in real control stations.

ELECTRICAL POWER SYSTEM GENERAL DESCRIPTION

From the Electrical Power Systems point of view, the APS12-MES12 configuration gives the possibility to study in depth a complete national grid with two power generators, two transmission lines, two distribution lines and two great commutable loads.

The Electrical Power System includes all elements of real power systems. Synchronous generators, step-up voltage transformers, distribution transformers with voltage regulator, cutting-edge protection relays, automatic voltage controllers for manual and automatic generation control, real logic operations with circuit breakers and disconnectors, signaling lamps to indicate their state, more than 30 alarms, commutators to change automatically the lines' length and the capacitive effect, network analyzers wired in strategic points to know in real time all power flows state and all power system electrical parameters. All these parameters and much more can be controlled from the SCADA I System.

The SCADA II is installed in the electrical control bench. This element has three touch screens and one normal screen from which all electrical system can be monitored and controlled.

SMART GRID GENERAL DESCRIPTION

The Electrical Power System includes advanced smart grid technology with real and sophisticated Smart Meters and smart devices. Smart Meters are the last link of smart grid power systems. It allows the utilities to know in real time how many energy is consumed by each final customer, allowing utilities to take the best decisions about energy prices and what power plants will give more or less power in the national grid.

Home Energy Management Systems are studied on this part by means of smart devices which are programmed by the user. Through these elements users will know how to manage smart devices to optimize the energy consumption. For example, programming presence sensors to switch on/off lights according to certain conditions, temperature sensors to switch on/off the electric heating, light sensors to switch on/off automatically lights, etc.

Finally, through the included smart grid elements, the user can study the most important concepts of Net-Metering. Nowadays final customers can generate, consume or sell its own energy through small wind turbines and photovoltaic panels installed at homes. The APS12 allows study all these circumstances with real generators and network analyzers making possible to measure outgoing, ingoing and consuming power flows and to calculate energy balance.

TECHNICAL SPECIFICATIONS

HUB II. **Mechanical Power Plants and Energy System with SCADA II.**

- Energy Control Desk:
  - Three touch screens for monitoring and control the power plants.
  - Panoramic screen.
  - Computer + keyboard + mouse.
  - Power cables and communication cable.
  - Magneto-thermal switches.
  - SCADA II system with computer control electronics and the proper operation software package.
  - Communication interface with HUB I.
  - 230 VAC Single-Phase power supply.
  - Interrupted power supply to support black out.
  - Single-Phase residual circuit breaker 30mA / 230 VAC.

  Dimensions: 1600 x 840 x 1400 mm approx. (62.99 x 33.07 x 55.11 inches approx.)

Mechanical Control Bench

- Power Plants:
  - PPE/CC. Combined Cycle Power Plant.
  - PPE/NU. Nuclear Power Plant.
  - PPE/FD. Diesel Fuel Power Plant.
  - PPE/FF. Fossil Fuel (coals) Power Plant.
  - PPE/GA. Gas Power Plant.
  - PPE/HY. Hydroelectric Power Plant.
  - PPE/WP. Wind Powered Power Plant.
  - PPE/FV. Photovoltaic Power Plant.
  - PPE/HE. Heliothermic Power Plant.
  - PPE/BM. Biomass Power Plant.
  - PPE/FC. Fuel Cells Power Plant.
  - PPE/GT. Geothermal Power Plant.
  - Other power plants available on request.

HUB I. **Electrical Power System with SCADA I.**

- Electrical Control:
  - Three touch screens.
  - Panoramic screen.
  - Computer + keyboard + mouse.
  - Power cables and communication cable.
  - Magneto-thermal switches.
  - General emergency stop switch.
  - General emergency stop indicator.
  - Security key indicator.
  - Security key switch.
  - Generator manual synchronization push buttons.
  - Generator synchronizer devices.
  - Generator manual synchronization indicator.
  - Security keys for synchronization and fault insertion are included.
  - Programmable logic controller (PLC) with 42 I/O signals and RS-485 communication interface.
  - Magneto-thermal switches.
  - Connectors of 6 and 24 pins.
  - 4 ports RS232-RS485 converter.
  - SCADA I system with computer control electronics and the proper software package for controlling the units of the system and to exchange information with HUB II Power Plant Energy System and SCADA II.

  Dimensions: 1600 x 840 x 1400 mm approx. (62.99 x 33.07 x 55.11 inches approx.)

Electrical Control Bench

Technical specifications

G1. **Generator I with Complete Cabinet, including AVR (Automatic Voltage Regulator), with Synchronization System.**

Front panel diagram with signaling lamps to indicate the circuit breakers state.
Inductances for simulating the transient and sub-transient state of the generator.
400 VAC Three-Phase Power supply.
Current transformers.
Voltage transformers.
Vector inverter with automatic frequency load controller (AFLC).
Automatic/manual voltage regulator (AVR) and automatic/manual synchronization device.
Magneto-thermal switches.
Power connectors.
3 x Power energy analyzers with RS-485 communication interface:
- Voltage: Range 20-500 Vrms. Prec.: 0.5%. Phase to phase-Phase to neutral. Current: Range 0.02-5 Arms. Prec.: 0.5%.
- Frequency: Range 48 to 62 Hz. 0.1Hz.
- Power: Active, Reactive and Apparent. Range 0.01 to 9900 kW. Prec.: 1%.
- Power Factor: Power Factor for each phase and average. Range -0.1 to + 0.1. Prec.: 1%.

Digital protection relays with RS-485 communication interface.
- Differential protection relay.
- Overcurrent protection relay.
- Overvoltage/under voltage protection relay.
- Directional protection relay.

Generator Rotor to Ground protection relay.
Advanced Generator protection relay with AVR with the following protections:
- Overcurrent protection threshold.
- Over/under voltage protection threshold.
- Reverse power protection threshold.
- Over/under frequency protection threshold.
- Unbalance protection threshold.

Programmable logic controller (PLC) with 42 I/O signals and RS-485 interfaces for generation system topology configuration.
- S7-300 PLC.
- 1 slot with 16 24 VDC digital inputs.
- 2 slots with 32 230 VAC digital outputs.
- MPI communication cable.

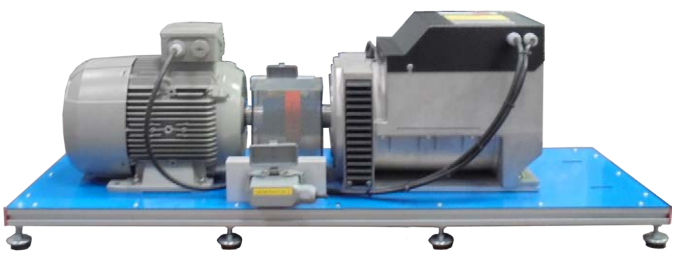
55 Circuit breakers for generation switchgear maneuvers.
Power switches and fault state indicators in the front panel.
Emergency stop included.
Back-up generation protection devices.
4 power connectors for energy distribution
2 62 pin signal connectors for communications.
Dimensions: 1200 x 900 x 2000 mm approx. (47.24 x 35.43 x 78.74 inches approx.)

G1. Generator I with Complete Cabinet, including AVR (Automatic Voltage Regulator), with Synchronization System

Generator-Motor Group:
Base plate in painted steel and anodized aluminum structure with wheels for an easy mobility.
Three-Phase synchronous generator with brush excitation:
- Nominal Power: 7 kVA.
- Nominal Output Voltage: 230/400 VAC D/Y.
- Nominal Speed: 1500 rpm.
- Nominal frequency: 50/60 Hz.
- Power factor: 0.8.

Motor prime mover:
- Three-Phase squirrel cage motor.
- Nominal Power: 7 kVA.
- Nominal Output Voltage: 400 VAC.
- Nominal Speed: 1500 rpm.
- Nominal frequency: 50/60 Hz.
- Driven by a vector controller multifunction inverter with RS-485.
- Semiflex coupling.

Dimensions: 1300 x 450 x 450 mm approx. (51.18 x 17.71 x 17.71 inches approx.)



Generator-Motor Group

Technical specifications

T-GR1. **Grid Transformer without Voltage Regulation.**

Three-phase power transformer.
Primary voltage:400 VAC. Star.
Secondary voltage: 400 VAC. Delta.
Nominal Power: 5kVA.
Connection group Dy11.
Two power connectors.
Anodized aluminum structure and panels in painted steel with wheels for mobility.
Dimensions: 400 x 360 x 600 mm approx. (15.74 x 14.17 x 23.62 inches approx.)

T-GR1. Grid Transformer without voltage regulation

T-G1. **Generator Group Transformer I.**

Three-phase power transformer.
Primary voltage:400 VAC. Star
Secondary voltage: 400 VAC. Delta
Nominal Power: 5kVA.
Connection group Dy11.
Two power connectors.
Anodized aluminum structure and panels in painted steel with wheels for mobility.
Dimensions: 400 x 360 x 600 mm approx. (15.74 x 14.17 x 23.62 inches approx.)

T-G1. Generator Group Transformer I

G2. **Generator II with Complete Cabinet, including AVR (Automatic Voltage Regulator), with Synchronization System.**

Front panel diagram with signaling lamps to indicate the circuit breakers state.
Inductances for simulating the transient and sub-transient state of the generator.
400 VAC Three-Phase Power supply.
Current transformers.
Voltage transformers.
Vector inverter with automatic frequency load controller (AFLC).
Automatic/manual voltage regulator (AVR) and automatic/manual synchronization device.
Magneto-thermal switches.
Power connectors.
3 x Power energy analyzers with RS-485 communication interface:
- Voltage: Range 20-500 Vrms. Prec.: 0.5%. Phase to phase-Phase to neutral Current: Range 0.02-5 Arms. Prec.: 0.5%.
- Frequency: Range 48 to 62 Hz. 0.1Hz.
- Power: Active, Reactive and Apparent. Range 0.01 to 9900 kW. Prec.: 1%.
- Power Factor: Power Factor for each phase and average. Range -0.1 to + 0.1. Prec.: 1%.

Digital protection relays with RS-485 communication interface.
- Differential protection relay.
- Overcurrent protection relay.
- Overvoltage/under voltage protection relay.
- Directional protection relay.

Generator Rotor to Ground protection relay.
Advanced Generator protection relay with AVR with the following protections:
- Overcurrent protection threshold.
- Over/under voltage protection threshold.
- Reverse power protection threshold.
- Over/under frequency protection threshold.
- Unbalance protection threshold.

Programmable logic controller (PLC) with 42 I/O signals and RS-485 interfaces for generation system topology configuration.
- S7-300 PLC.
- 1 slot with 16 24 VDC digital inputs.
- 2 slots with 32 230 VAC digital outputs.
- MPI communication cable.

55 Circuit breakers for generation switchgear maneuvers.
Power switches and fault state indicators in the front panel.
Emergency stop included.
Back-up generation protection devices.
4 power connectors for energy distribution
2 62 pin signal connectors for communications.
Dimensions: 1200 x 900 x 2000 mm approx. (47.24 x 35.43 x 78.74 inches approx.)

G2. Generator II with Complete Cabinet, including AVR (Automatic Voltage Regulator), with Synchronization System

Generator-Motor Group:
Base plate in painted steel and anodized aluminum structure with wheels for an easy movement.
Three-Phase synchronous generator with brush excitation:
Nominal Power: 7 kVA.
Nominal Output Voltage: 230/400 VAC D/Y.
Nominal Speed: 1500 rpm.
Nominal frequency: 50/60 Hz.
Power factor: 0,8
Motor prime mover:
Three-Phase squirrel cage motor.
Nominal Power: 7 kVA.
Nominal Output Voltage: 400 VAC.
Nominal Speed: 1500 rpm.
Nominal frequency: 50/60 Hz.
Driven by a vector controller multifunction inverter with RS-485.
Semiflex coupling.
Dimensions: 1300 x 450 x 450 mm approx. (51.18 x 17.71 x 17.71 inches approx.)

Generator-Motor Group

T-G2. **Generator Group Transformer II.**
Three-phase power transformer.
Primary voltage:400 VAC. Star.
Secondary voltage: 400 VAC. Delta.
Nominal Power: 5kVA.
Connection group Dy11.
Two power connectors.
Anodized aluminum structure and panels in painted steel with wheels for mobility.
Dimensions: 400 x 360 x 600 mm approx. (15.74 x 14.17 x 23.62 inches approx.)

T-G2. Generator Group Transformer II

LTS1. **Line I and II Cabinet with Transmission Substation with Protection Relays System.**
Front panel diagram with signaling lamps to indicate the circuit breakers state.
Inductances, capacitors and resistors. It includes tapping points for changing the length of lines and the configuration of PI or T line loss profiling, and fault injection with the help of PLC control device.
400 VAC Three-Phase Power supply.
Current transformers.
Voltage transformers.
Magneto-thermal switches.
Power connectors.
2 x Power energy analyzers with RS-485 communication interface for Line 1 and Line 2:
Voltage: Range 20-500 Vrms. Prec.: 0.5%. Phase to phase-Phase to neutral. Current: Range 0.02-5 Arms. Prec.: 0.5%.
Frequency: Range 48 to 62 Hz. 0.1Hz.
Power: Active, Reactive and Apparent. Range 0.01 to 9900 kW. Prec.: 1%.
Power Factor: Power Factor for each phase and average. Range -0.1 to + 0.1. Prec.: 1%.
Digital protection relays with RS-485 communication interface.
Distance protection relay.
Overcurrent protection relay.
Overvoltage/under voltage protection relay.
Directional protection relay.
Programmable logic controller (PLC) with 42 I/O signals and RS-485 interfaces for generation system topology configuration.
S7-300 PLC.
1 slot with 16 24 VDC digital inputs.
2 slots with 32 230 VAC digital outputs.
MPI communication cable.
65 Circuit breakers for generation maneuvers.
Power switches and fault state indicators in the front panel.
Emergency stop included.
Back-up protection devices.
4 power connectors for energy distribution.
2 62 pin signal connectors for communications.
Dimensions: 1200 x 900 x 2000 mm approx. (47.24 x 35.43 x 78.74 inches approx.)

LTS1. Line I and II Cabinet with Transmission Substation with Protection Relays System

Technical specifications

LTS2. **Line III and IV Cabinet with Transmission Substation with Protection Relays System.**

Front panel diagram with signaling lamps to indicate the circuit breakers state.
Inductances, capacitors and resistors. It includes tapping points for changing the length of lines and the configuration of PI or T line loss profiling, and fault injection with the help of PLC control device.
400 VAC Three-Phase Power supply.
Current transformers.
Voltage transformers.
Magneto-thermal switches.
Power connectors.
2 x Power energy analyzers with RS-485 communication interface for Line 1 and Line 2:
- Voltage: Range 20-500 Vrms. Prec.: 0.5%. Phase to phase-Phase to neutral. Current: Range 0.02-5 Arms. Prec.: 0.5%.
- Frequency: Range 48 to 62 Hz. 0.1Hz.
- Power: Active, Reactive and Apparent. Range 0.01 to 9900 kW. Prec.: 1%.
- Power Factor: Power Factor for each phase and average. Range -0.1 to + 0.1. Prec.: 1%.

Digital protection relays with RS-485 communication interface.
- Distance protection relay.
- Overcurrent protection relay.
- Overvoltage/under voltage protection relay.
- Directional protection relay.

Programmable logic controller (PLC) with 42 I/O signals and RS-485 interfaces for generation system topology configuration.
- S7-300 PLC.
- 1 slot with 16 24 VDC digital inputs.
- 2 slots with 32 230 VAC digital outputs.
- MPI communication cable.

65 Circuit breakers for tansmission switchgear maneuvers.
Power switches and fault state indicators in the front panel.
Emergency stop included.
Back-up protection devices.
4 power connectors for energy distribution
2 62 pin signal connectors for communications.
Dimensions: 1200 x 900 x 2000 mm approx. (47.24 x 35.43 x 78.74 inches approx.)

LTS2. Line III and IV Cabinet with Transmission Substation with Protection Relays System

DSL1. **Distribution Substation I, Loads and Network Equivalents I with Protection Relays System.**

Front panel diagram with signaling lamps to indicate the circuit breakers state.
Inductances, capacitors and resistors for different energy consumption.
400 VAC Three-Phase Power supply.
Current transformers.
Voltage transformers.
Magneto-thermal switches.
Power connectors.
2 x Power energy analyzers with RS-485 communication interface for Line 1 and Line 2:
- Voltage: Range 20-500 Vrms. Prec.: 0.5%. Phase to phase-Phase to neutral. Current: Range 0.02-5 Arms. Prec.: 0.5%.
- Frequency: Range 48 to 62 Hz. 0.1Hz.
- Power: Active, Reactive and Apparent. Range 0.01 to 9900 kW. Prec.: 1%.
- Power Factor: Power Factor for each phase and average. Range -0.1 to + 0.1. Prec.:1%.

Digital protection relays with RS-485 communication interface.
- Differential protection relay.
- Overcurrent protection relay.
- Overvoltage/under voltage protection relay.
- Directional protection relay.

Programmable logic controller (PLC) with 42 I/O signals and RS-485 interfaces for generation system topology configuration.
- S7-300 PLC.
- 1 slot with 16 24 VDC digital inputs.
- 2 slots with 32 230 VAC digital outputs.
- MPI communication cable.

65 Circuit breakers for distribution and consumption switchgear maneuvers.
Power switches and fault state indicators in the front panel.
Emergency stop included.
Back-up protection devices.
4 power connectors for energy distribution.
2 62 pin signal connectors for communications.
Dimensions: 1200 x 900 x 2000 mm approx. (47.24 x 35.43 x 78.74 inches approx.)

DSL1. Distribution Substation I, Loads and Network Equivalents I with Protection Relays System

Technical specifications

T-GR2. **Grid Transformer with TAP CHANGER with Voltage Regulation.**

Three-phase power transformer.
Primary voltage:400 VAC. Delta
Secondary voltage: 400 VAC. Star
Nominal Power: 5kVA.
Connection group Dy11.
Two power connectors.
Automatic TAP voltage regulator: -7,5% /-2,5% / 0% /+2,5% /+5% /+7,5%.
Anodized aluminum structure and panels in painted steel with wheels for mobility.
Dimensions: 400 x 360 x 600 mm approx. (15.74 x 14.17 x 23.62 inches approx.)

T-GR2. Grid Transformer with TAP CHANGER with voltage regulation

DSL2. **Distribution Substation II, Loads and Network Equivalents II with Protection Relays System.**

Front panel diagram with signaling lamps to indicate the circuit breakers state.
Inductances, capacitors and resistors for different energy consumption.
400 VAC Three-Phase Power supply.
Current transformers.
Voltage transformers.
Magneto-thermal switches.
Power connectors.
2 x Power energy analyzers with RS-485 communication interface for Line 1 and Line 2:
- Voltage: Range 20-500 Vrms. Prec.: 0.5%. Phase to phase-Phase to neutral. Current: Range 0.02-5 Arms. Prec.: 0.5%.
- Frequency: Range 48 to 62 Hz. 0.1Hz.
- Power: Active, Reactive and Apparent. Range 0.01 to 9900 kW. Prec.: 1%.
- Power Factor: Power Factor for each phase and average. Range -0.1 to + 0.1. Prec.: 1%.

Digital protection relays with RS-485 communication interface.
- Differential protection relay.
- Overcurrent protection relay.
- Overvoltage/under voltage protection relay.
- Directional protection relay.

Programmable logic controller (PLC) with 42 I/O signals and RS-485 interfaces for generation system topology configuration.
- S7-300 PLC.
- 1 slot with 16 24 VDC digital inputs.
- 2 slots with 32 230 VAC digital outputs.
- MPI communication cable.

65 Circuit breakers for generation maneuvers.
Power switches and fault state indicators in the front panel.
Emergency stop included.
Back-up protection devices.
4 power connectors for energy distribution
2 62 pin signal connectors for communications.
Dimensions: 1200 x 900 x 2000 mm approx. (47.24 x 35.43 x 78.74 inches approx.)

DSL2. Distribution Substation II, Loads and Network Equivalents II with Protection Relays System

Technical specifications

SGDL1. **Smart Grid Distributed Load I.**

Front panel energy distribution diagram with signaling lamps to indicate the loads state.
Inductances and resistors for different final user energy consumption.
400 VAC Three-Phase Power supply.
Current transformers.
Magneto-thermal switches.
Power connectors.
3 x Power energy analyzers with RS-485 communication interface for Industrial Load, Residential Load 1 and Residential Load 2.
Voltage: Range 20-500 Vrms. Prec.: 0.5%. Phase to phase-Phase to neutral. Current: Range 0.02-5 Arms. Prec.: 0.5%.
Frequency: Range 48 to 62 Hz. 0.1Hz.
Power: Active, Reactive and Apparent. Range 0.01 to 9900 kW. Prec.: 1%.
Power Factor: Power Factor for each phase and average. Range -0.1 to + 0.1. Prec.: 1%.
Three-Phase Automatic Power Factor Compensator: six compensation steps / power set point.
3 x Three Phase Smart Meters.
1 x Three Phase Data Concentrator with power line communication.
Programmable logic controller (PLC) with 42 I/O signals and RS-485 interfaces for generation system topology configuration.
S7-300 PLC.
1 slot with 16 24 VDC digital inputs.
1 slots with 32 230 VAC digital outputs.
MPI communication cable.
Circuit breakers for load maneuvers.
Power switches and fault state indicators in the front panel.
Emergency stop included.
Back-up protection devices.
4 power connectors for energy distribution
2 62 pin signal connectors for communications.
Dimensions: 1200 x 900 x 2000 mm approx. (47.24 x 35.43 x 78.74 inches approx.)

SGDL1. Smart Grid Distributed Load I

T-D1. **Distribution Transformer I.**

Three-phase power transformer.
Primary voltage:400 VAC. Star.
Secondary voltage: 400 VAC. Delta.
Nominal Power: 5kVA.
Connection group Dy11.
Two power connectors.
Anodized aluminum structure and panels in painted steel with wheels for mobility.
Dimensions: 400 x 360 x 600 mm approx. (15.74 x 14.17 x 23.62 inches approx.)

T-D1. Distribution Transformer I

For details see Annex IV: www.edibon.com/en/advanced-mechanical-electrical-and-smart-grid-power-systems-utilities/additional-info

✱ Specifications subject to change without previous notice, due to the convenience of improvements of the product.

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