Electron S.R.L.

Design
Production &
Trading of
Educational
Equipment

A29 – ELECTRICAL POWER SYSTEM SIMULATOR TRAINER

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This Trainer simulates a real life generation, transmission and utilization system based on standard electrical machines, instruments and a transmission line simulator (ELECTRON Model A29 IDLE2). The simulator reproduces the conditions of a 30kV, 30Km long overhead line.

The architecture of this Trainer allows maximum flexibility in choosing the desired configuration from the suggested products (see table at the end) to which others can be added as required.

Following is a list of titles of typical experiences that can be executed on this trainer (all of them are described in the Manual supplied with the System) and that are meant to provide a base to be expanded by teachers and students who may wish to design new ones to cover additional training requirements. In a power generation, transmission and utilization system a very large number of different situations may be devised both in normal and abnormal/ failure conditions. They may anticipate what the students are likely to encounter in real life.

To take full advantage from these experiments, the students should already be familiar with the laboratory experiences on electrical machines (see our **ELECTRICAL MACHINE TRAINER, Model A4**): they provide the necessary theoretical background to better understand the practical aspects.

LINE EXPERIMENTS

VOLTAGE DROP ALONG THE LINE
- Single Phase Line
- Three Phase Line

POWER LOSS
- Single Phase Line
- Three Phase Line:
  - Symmetrical and Balanced System
  - Symmetrical and Unbalanced System
  - Three Phase four Wire Line

EFFICIENCY OF THE TRANSMISSION LINE
- Single Phase Line
- Three Phase Line

IMPROVEMENT OF POWER FACTOR
- Single Phase Line
- Three Phase Line

MEASUREMENTS OF CURRENTS ON THE PHASES
- Three Phase Line with one open Phase
- Three Phase Line, four Wires, with Balanced Load
- Three Phase Line, four Wires, with one Phase open

SYSTEM EXPERIMENTS

POWER GENERATION
- Voltage and frequency control of alternators
- Synchronization and parallel operation
- No-load operation
- Operation with R-L-C mixed load
- Active and reactive power control
- Unbalanced load

POWER TRANSMISSION
- Transmission Line R-L-C characteristics
- No-load line operation
- Line operation with R-L-C and mixed loads
- Unbalanced load

PROTECTIONS AND CONTROLS (may be set at the input or output of the transmission line)
- Phase to phase short-circuit
- Earth fault of one phase
- Phase failure
- Under-Over voltage
- Under/Over current

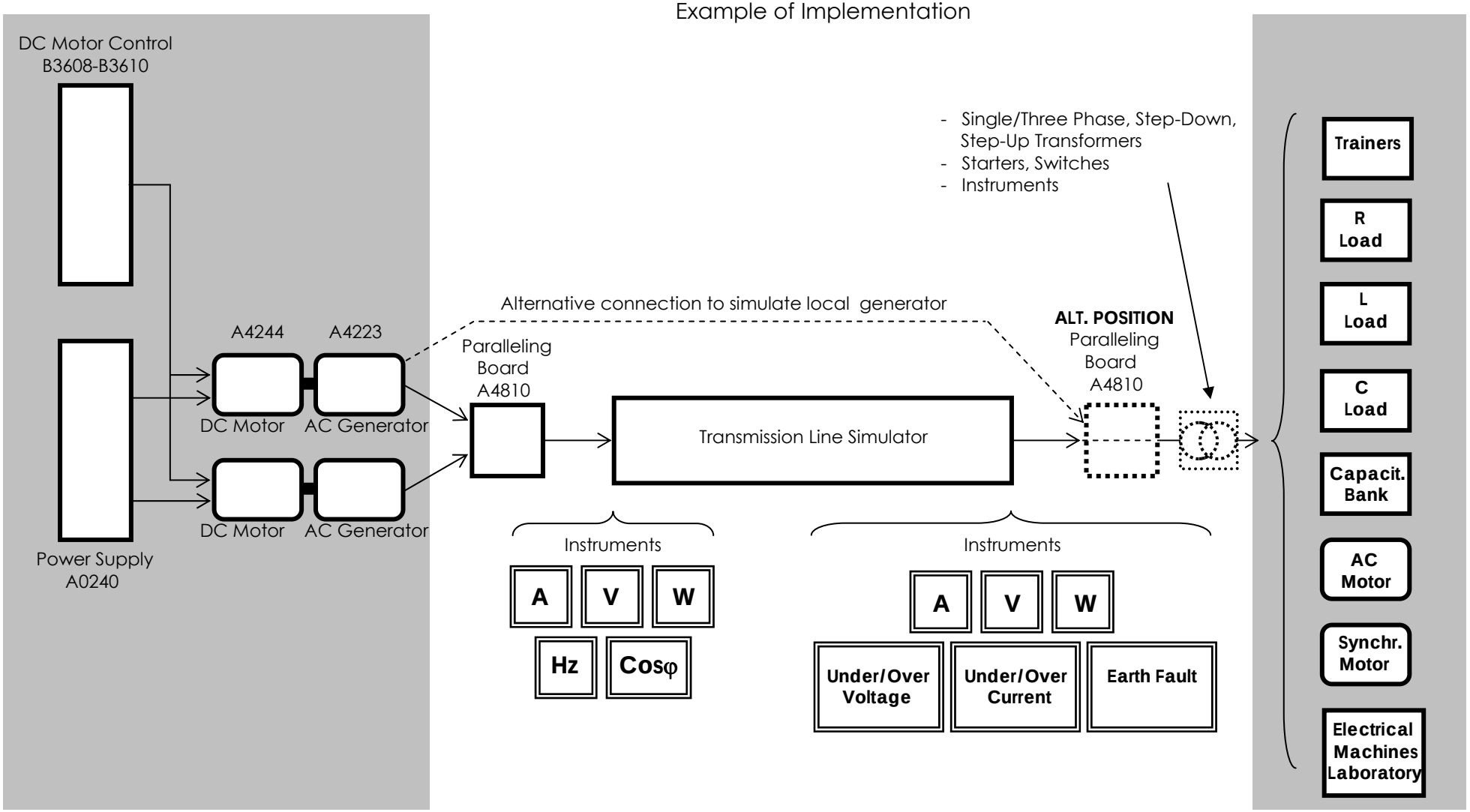
POWER UTILIZATION
- R-L-C loads
- Power measurement
- Unbalanced loads
- Power factor correction

Note: The table in the following pages suggests the most suitable products and quantities for implementing the System.

Ordering Information: Quotations will be provided based on the requested configurations.

ELECTRICAL POWER SYSTEM SIMULATOR

Example of Implementation



ELECTRICAL POWER SYSTEM SIMULATOR
COMPONENTS SELECTION TABLE

Description	Code	Essential/ Recomm.	Purpose	Q.ty
Universal Power Supply	A0240	E/R	Provides power to driving motors and excitation DC power to DC machines and AC generators	1/2
DC Motor Control	B3608	R	Provides power and speed control to driving motor	1
DC Motor Control	B3610	R	Provides power and speed control to driving motor	1
Shunt Excitation DC Machine	A4244	E/R	Driver for AC generator	1/2
Series Excitation DC Machine	A4242	E/R	Driver for AC generator	1/2
Synchronous Machine	A4223	E/R	AC synchronous machine as AC generator, and motor as load and power factor correction	1/2
Paralleling Board	A4810	E	For paralleling 2 AC generators or 1 generator and a distribution line	1
Line Simulator	A29 IDLE2	E	For simulating the transmission line	1
Resistive Load	A4510	E	For resistance loading the system	1
Capacitive Load	A4520	E	For capacitive loading the system and for additional power factor correction capability to that provided by the Line Simulator internal capacitors	1
Inductive Load	A4530	E	For inductive loading the system	1
Single Phase Transformer	A4110	R	For step-up-down voltage to single phase loads	1
Three Phase Transformer	A4115	R	For step-up-down voltage to three phase loads	1
Three Phase Variable Auto-transformer	A4121	R	For stepping up and down voltages in a continuous mode	1
Squirrel Cage 3 Ph. Motor	A4220	E	Provides an inductive load and driving power for miscellaneous experiments	1
Slip Ring 3 Phase Motor	A4222	E	Provides an inductive load and driving power for miscellaneous experiments	1
Single Phase Motor	A4232	E	Provides an inductive load and driving power for miscellaneous experiments	1
3 Phase Switch	A21-M021	E	For connecting power to the loads	3
STAR/DELTA Starter	A4820	E	For starting three phase AC motors	1
Ammeter	SL 150 RS 3362	E	To measure current on the three phases at the generators and at the loads	6
Milliammeter	SL 150 RS 3350	E	To measure small leakage currents	1

Voltmeter	SL 150 RS 3431	E	To measure voltage at the generator and at the load	1
Voltmeter	SL 150 RS 3435	E	To measure voltage at the generator and at the load	1
Wattmeter	SL 150 RS 2826	E	To measure power at generator and at load	3
Frequency meter	A4750 AF	E	To measure frequency of the generated AC power	1
Power Factor Meter	A4750 AC	E	To measure power factor at various load conditions	1
Digital Three Phase Power Analyzer	A4750D	E	To monitor continuously all working parameters of the line	1
Phase Sequence indicator	SFT 3546	R	To indicate the sequence of the 3 phases	1
Single Tapping key	ST/1	R	Switch for instant closing/opening of a circuit	1
Reversing Switch	CI/2B	R	To reverse polarities	1
Reactive Power Controller	A2680	E	To automatically correct the power factor	1
Capacitor Bank	A2685	E	To correct the line power factor	1
Analogue Under / Over Current Fault Relay	A2651	E	To detect simulated overloads – single phase	3
Analogue Under / Over Voltage Relay	A2652	E	To detect simulated under and over voltage situations – single phase	3
Analogue Earth Fault Relay	A2653	E	To detect simulated earth failures – single phase	3
Digital Under / Over Current Relay	A2661	R	To detect simulated overloads – three phase	1
Digital Under / Over Voltage Relay	A2662	R	To detect simulated under and over voltage situations – three phase	1
Digital Earth Fault Relay	A2663	R	To detect simulated earth failures – three phase	1
Programmable Over Current Relay	A2671	R	To detect simulated overloads – three phase	1
Programmable Over Voltage Relay	A2672	R	To detect simulated under and over voltage situations – three phase	1
Programmable Directional Over Current / Earth Fault Relay	A2673	R	To detect simulated overloads and phase failures	1
Set of cables	A4890	R	Safety cables for connecting the components	1
Cable support	A4890S	R	Support for orderly storing the cables	1
Coupling base	A4840	E	Base for coupling coaxially two machines	2

NOTES

Code:	Model Code - For power range consult the ELECTRON Catalogue; power of machines, accessories and loads should be matched
E/R:	Essential/Recommended component. Essential components are required to perform the basic experiments. Recommended components provide additional and higher level training capabilities
Q.ty:	Essential/Recommended quantities for an effective and comprehensive training system.

A29 EEP- ELECTRIC ENERGY PROCESS SIMULATION SYSTEM

The system is composed by three independent units that are designed to work stand-alone or connected in series as shown in the picture:

1. **A29 CE-PE**, simulates production of electrical energy
2. **A29 SLE/2**, simulates transmission of electrical energy
3. **A29 IDLE/3**, simulates distribution of electrical energy

They actually implement a complete electrical energy process whose working parameters may be read and translated on tables and graphs to study and understand all aspects of the three steps of the energy process.

All simulator, when used alone, require 2 Energy Process Power Analyzers A29 APR-FR, one to be connected on its input and one on its output.

When they are used all together, in series, either 2 instruments can be used (one on the input of the production simulator and one on the output of the distribution simulator) or 6 when, for measurement purposes, it is necessary to control input and output of each one of them.

All units are provided with 4mm safety connectors

See the following pages for detailed descriptions.

Ordering Codes

A29EEP Energy Process Simulator System (specify the types of simulators required)

A29 APR-FR Energy Process Power Analyzer

An optional kit, to be quoted separately, is available to measure the environmental electric and magnetic fields.

Production *Transmission* *Distribution*

PRODUCTION SIMULATOR – A29 CE-PE

The unit simulates a power station in all respects without rotating machines.

Features

- A variable transformer
- Start/Stop pushbuttons
- Typical Power Station protections
- A step-up transformer that can be connected STAR or DELTA
- Line paralleling devices

- Digital voltmeter on the Power Station side
- Zero digital voltmeter on the line side
- Three synchronizing lamps
- Paralleling Circuit Breaker
- Paralleling switch

- Line Simulator

- Insulation transformer
- Line Resistance and Inductance

Dimensions: 1,000 x 400 x 350 mm

Weight: 40 Kg approx.

Examples of Experiences

- Simulation the transformer configurations Yy0, Yy6, Dy5, Dy11
- Calibration of protections and measurement devices; 2 A2960 units are required in this case.

An Instruction Manual describes:

- Parallel operation with the main line
- Calibration of protections
- Connections to the Transmission Simulator

TRANSMISSION SIMULATOR – A29 SLE/2

This unit simulates two 3-phase overhead transmission lines, line 1 at 120kV or line 2 at 220kV, 70Km long, whose characteristics can be studied in detail by changing the working parameters.

Features

- Internal load
- Power factor correction capacitors
- Protections
- Self contained Power Supply
- Hubs for connecting the generation/ distribution simulators and external loads.

Lines

- π Model with concentrated parameters (line resistance, inductance and capacitance)
- Line 1: simulated transmitted power 16 MVA
- Line 2: simulated transmitted power 20 MVA

Dimensions 1,000 x 400 x 350 mm

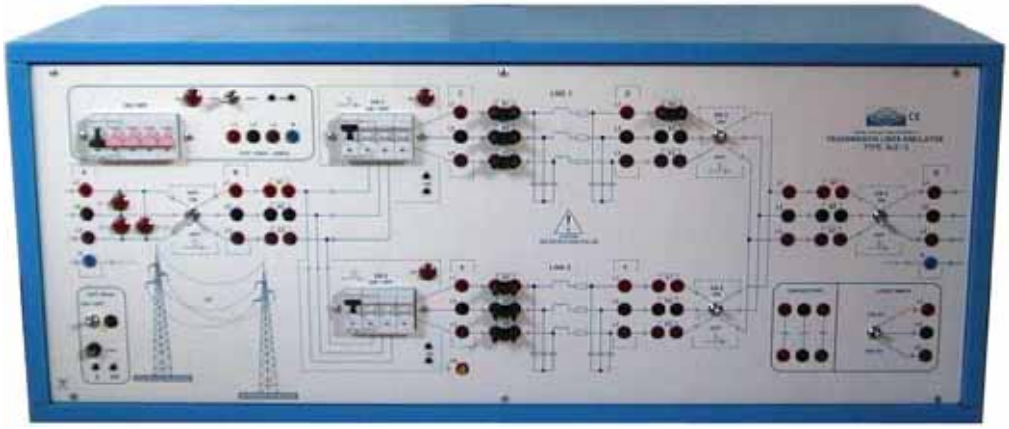
Weight: 45 Kg approx.

Examples of Experiences

- Study of unloaded and open lines
- Loaded lines at different voltages
- Line losses and efficiency
- Short circuited lines
- Lines in parallel
- Phasing
- Improvement of Power Factor
- Benefits of transporting energy at high voltage
- Voltage increase caused by capacitive load
- Protection for maximum current, power and energy inversion

An Instruction Manual describes the operation of:

- No load line
- 120 kV loaded line
- 120 kV loaded line with phasing
- 220kV line without phasing
- 220 kV line with phasing
- Paralleled lines
- Overvoltage caused by capacitive load
- Protections
- Connection to the Distribution Simulator



DISTRIBUTION SIMULATOR – A29 IDLE/3

This unit simulates an electrical sub-station and a medium voltage distribution line.

Features

- Line protections
- Over-voltage dischargers
- High Voltage to Medium Voltage step-down transformer
- Power factor correction capacitors
- Internal load
- External load connectors
- Self contained Power Supply
- Protections

Line

- 30 - 30√3 - 10 kV, 30Km long
- T Model with concentrated parameters (phase resistance, inductance and earth capacitance)

Dimensions: 1,000 x 400 x 350 mm

Weight: 40 Kg approx.

Examples of experiences

- Study of non-loaded lines
- Loaded lines at different voltages
- Losses and line efficiency
- Voltage drop as a function of load
- Line loss as a function of load
- Balanced and unbalanced 3-phase systems
- Short circuited lines
- Phasing
- Improvement of power factor
- Benefits of transporting energy at high voltage
- Voltage increase caused by capacitive load

An Instruction Manual describes the operation of:

- 3-phase no-load line
- 3-phase loaded line
- Loaded 3-phase line V / √3
- Earth fault protection of a 3-phase line with insulated Neutral

ENERGY PROCESS POWER ANALYZER – A29 APR-FR

The functional parameters of an Energy System can be read by this microprocessor controlled multifunction instrument.

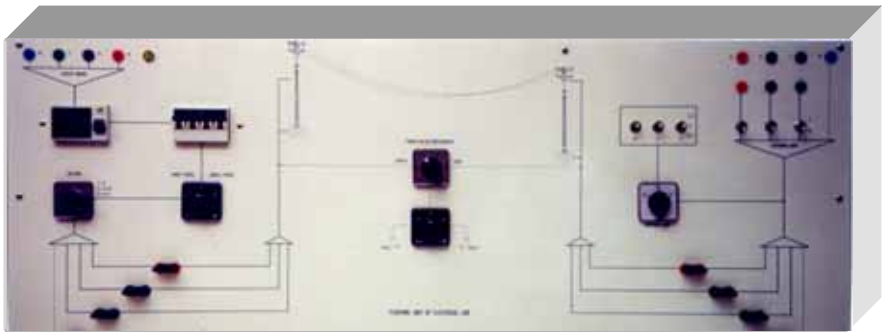
Features

- Graphic back-lighted display with 4 simultaneous readings
- Auto-range
- Manual or automatic scanning of:
- Active power W
- Active power average
- Apparent Power VA
- Apparent power average
- Power factor Cosφ
- Power factor Cosφ average
- Voltage V
- Current I
- Current Average
- Energy KWh, KVArh
- Frequency Hz
- 4 mm safety connectors

Ranges

- 400V max.
- 5A max, for higher range use current transformers

A29 IDLE2 - ELECTRICAL TRANSMISSION LINE SIMULATOR



This Trainer simulates a 3 Phase 30 kV, 30Km long overhead transmission line. The operating conditions are simulated by internal resistive-inductive loads that can be connected ON/OFF, full or half value and STAR/DELTA by means of single phase switches.

The unit also contains 10 and 20 µF capacitors that can be connected ON/OFF, STAR/DELTA, in parallel with the input or output lines for power factor correction by means of switches.

External loads can be connected to output terminals controlled by switches.

Terminals at both ends allow the connection of instruments for measuring and controlling the line.

A 3 position input switch allows various input line voltages (mains voltage, mains/√3, mains/3).

Supplied with exercise manual.

A great variety of subjects can be studied; the most common are:

. balanced and unbalanced three phase systems
. line drop as a function of load
. line loss as a function of load
. power factor correction
. protection and monitoring systems

Technical characteristics:
. phase resistance 6+6 Ohm approx.
. phase inductance 2.5+2.5 mH approx.
. earth capacitance 0.047µF
. max. input voltage 380 V
. max. line current 3 A
. max. transmitted power 3x600VA