

Transmission Line, Transformer & Protection Laboratory



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Line Models

The following Line Models and Cable Model are designed for realistic conditions, such as overvoltage, overcurrent, and a certain magnetic coupling between the wires.

As linear behaviour for excess values is required, the line inductances must be represented by non-saturable induction coils. To withstand certain overvoltages, overdimensioning of wiring and capacitors is necessary.

One of the overhead models is representing a high voltage line of 220 kV, and the other a feeder at medium level 40 kV. All models are constructed as π -links, the HV model and the cable model as a double π -link.

Flexibility to simulate typical situations, such as compensating a long line at both ends and also in the middle, must also be available. Combination of the π -links make it possible to create other characteristic data, e.g. capacitors can be connected in Δ instead of Y.



Line Model



The network model can be used to complete a series of experiments with transmission lines. Those listed and described in detail in the instruction manual include:

- Characteristic data of the line
- Voltage drop on the lines
- Short circuit tests
- Earth fault

MV1420 Line Model

Technical Specifications

The model corresponds to a power transmission line of a length 136 km, voltage 77 kV, amperage 100 A, power rating 13 MW.

Voltage	220-240 V, three-phase (corresponding to 77 kV)
Amperage	5 A (corresponding to 100 A)
Line resistance	1.5 ohms
Line reactance	3.15 ohms

Line capacitance divided into capacitance to earth (4 μ F) and mutual line capacitance between phases (8 μ F).

Earth impedance	0.8 ohm
Fuses	5 A

Dimensions:	410 x 245 x 160 mm
Weight:	10 kg

The following studies can be made:

1. Measurements of characteristic data, resistance, reactance and capacitance of a line.
2. As transmission line:
Measurement of voltage drop and losses for different loads.
3. For two-phase and especially three-phase short circuit measurements with two three-phase transformers, one at each end.
4. For single-phase and two-phase earth fault measurements.

Optional Line Models equipment



MV1424 Line Model

Technical Specifications

Real line parameters

Nominal length:	40 km
Nominal voltage:	40 kV
Nominal current:	350 A

Positive sequence reactance X+:	15 ohm
Zero sequence reactance X0:	23 ohm
Positive sequence resistance R+:	8.4 ohm

Zero sequence resistance R0:	16.0 ohm
Positive sequence capacitance C+:	400 nF
Zero sequence capacitance Co:	265 nF

Line Model specifications

Represented length:	40 km
Nominal voltage:	400 V
Maximum voltage:	600 V

Nominal current:	10 A
Maximum current :	32 A (60 sec)

$R_1 = 4.7 \text{ ohm}$
$R_0 = 0.8 \text{ ohm}$
$X_1 = 2\pi\omega \times 5.45 \text{ mH}$
$X_0 = 2.62 \text{ ohm}$
$C_1 = 1.0 \text{ }\mu\text{F}$
$C_0 = 0.6 \text{ }\mu\text{F}$

Dimensions:	600 x 600 x 1720 mm
Weight:	190 kg

MV1425 Line Model

Real line parameters

Nominal length is 100 km (2 sections, each 50 km).

Data for one 50 km section

Nominal voltage:	220 kV
Nominal current:	775 A

Positive sequence reactance X+:	18 ohm
Zero sequence reactance X0:	24 ohm
Positive sequence resistance R+:	1.77 ohm

Zero sequence resistance R0:	8.0 ohm
Positive sequence capacitance C+:	475 nF
Zero sequence capacitance C0:	315 nF

Technical Specifications

Represented length 100 km with two π -links, each corresponding to a 50 km section.

Data for one π -link

Nominal voltage:	400 V
Maximum voltage:	600 V
Nominal current:	10 A
Maximum current (60 sec)	32 A

$R_1 = 0.5 \text{ ohm}$
$R_0 = 0.8 \text{ ohm}$
$X_1 = 2\pi\omega \times 3.77 \text{ mH}$
$X_0 = 1.57 \text{ ohm}$
$C_1 = 8.9 \text{ }\mu\text{F}$
$C_0 = 0.6 \text{ }\mu\text{F}$

Dimensions:	600 x 600 x 1720 mm
Weight:	220 kg



MV1438 Cable Model

MV 1438 consists of two cable sections with a nose section cable area of 150 square mm and 240 square mm respectively.

Real line parameters

PEX Cable 150 square mm Al	
Length	5 km
Nominal voltage	11 kV
Nominal current	260 A
Transmission ability	5.0 MVA
Positive sequence capacitance C+	0.45 μ F
Zero sequence capacitance C0	0.45 μ F
Inductance	1.8 mH
Resistance	1.1 ohm
Zero sequence reactance X ₀ (approx.)	2.3 ohm

Line Model Specifications

(one π -link)
corr. 5 km
400 V
6 A
2.4 kVA
0.28 μ F
0.28 μ F

Real line parameters

PEX Cable 240 square mm Al	
Length	5 km
Nominal voltage	11 kV
Nominal current	340 A
Transmission ability	6.5 MVA
Positive sequence capacitance C+	0.55 μ F
Zero sequence capacitance C0	0.55 μ F
Inductance	1.6 mH
Resistance	0.7 ohm
Zero sequence reactance X ₀ (approx.)	2.1 ohm

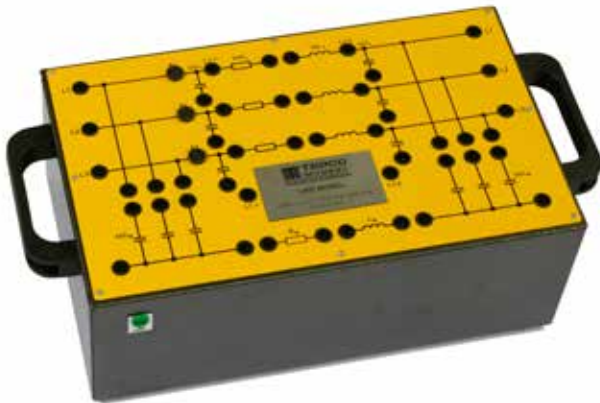
Line Model Specifications

(one π -link)
corr. 5 km
400 V
6 A
2.4 kVA
0.26 μ F
0.26 μ F
3.30 mH
1.5 ohm
4.3 ohm

Dimensions:
Weight:

600 x 600 x 1720mm
190 kg

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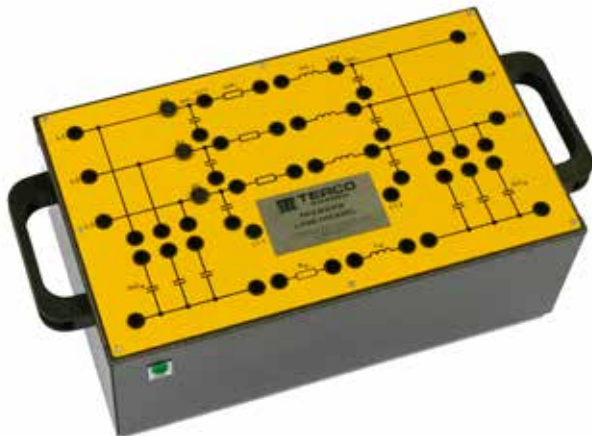
MV2221 Line Model

Line Model 230 kV, 100 km, 400 V 3-phase.
Three-phase model of an overhead power transmission line 100 km long, voltage 230 kV and ability 110 MVA.

Model value 400 V : R + 2.20 ohm, L 25 mH,
C + 4uF, Co 2.5 uF.

The network model can be used to complete a series of experiments with transmission lines. Those listed and described in detail in the instruction manual include characteristic data of the line. Voltage drop on the lines. Short circuit. Earth fault.

Dimensions: 410 x 245 x 160 mm
Weight: 10 kg



MV2222 Line Model

Line Model 11 kV, 5 km, 400 V 3-phase.
Three-phase model of an overhead power transmission line 5 km long, voltage 11 kV and ability 5 MVA.

Model value 400 V : R + 2.4 ohm, L 17 mH,
C + 30 nF, Co 20 nF.

The network model can be used to complete a series of experiments with transmission lines. Those listed and described in detail in the instruction manual include characteristic data of the line. Voltage drop on the lines. Short circuit. Earth fault.

Dimensions: 410 x 245 x 160 mm
Weight: 10 kg



MV2225 Petersen Coil, Multi Terminal Unit

A Petersen coil is used together with OH-lines in the range of distribution voltage to medium voltage (MV).

The most common fault is line-to-earth where the current is limited by the phase voltage from the two healthy leads divided by the capacitive impedance added by the arc resistance and the remaining zero sequence impedance.

Since this current is mainly capacitive it could be balanced by an inductance between the neutral point of the transformer and ground. That is to say: when a line-to-earth fault occurs it will be extinguished automatically by the current in the Petersen coil and the re-closing device will connect power again in a fraction of a second.

Normally a HV-line has a firm ground. However, in this case we may also study a 230 kV model because of tutorial aspects.

Each inductance coil has three steps to optimize the reactance value for each line of "11 kV", "70 kV" and "230 kV".

The 3 coils have following values:
L = 0.63 H and +/- 30 % terminals (70 kV)
L = 1.00 H and +/- 30 % terminals (230 kV)
L = 100 H and +/- 30 % terminals (11 kV)
MV2225 is to be used together with the Line Models MV1420, MV2221 and MV2222.

Dimensions: 410 x 245 x 160 mm
Weight : 11 kg

MV1439 Power Factor Control Unit



MV1439-235 Power Factor Control unit
3 x 220-240 V 50-60 Hz

MV1439-405 Power Factor Control Unit
3 x 380-440 V 50-60 Hz

General

TERCO Power Factor Controller (PFC) is also a module within our Classical electrical Machine Program.

With the PFC you can minimise the currents caused by reactive losses of power and thereby optimising the transfer of energy between generation and loading.

This is becoming more and more important today when "Saving energy" is vital in a world with focus on pollution and shortage of energy.

Field of application

Inductive or mixed inductive and resistive networks in need of compensation, for example when starting and running induction motors.

Principles of operation

Depending on the power factor of the loading network a microprocessor will connect groups of capacitors. By measuring phase voltages and current the microprocessor will calculate how many capacitive groups that has to be connected and also in which combinations.

Electrical details

Number of 3-ph groups 6
 Power factor setting 0.7 inductive to 0.7 capacitive
 Nominal voltage 3 x 220-240 V 50 – 60 Hz
 Code no. MV 1439-235
 3 x 380-440 V 50-60 Hz
 Code no MV1439-405

Nominal power 0 – 2 kVAr cap.
 PF-Controller Automatic or manual
 Adjustable delay times, switching sequences and strategies.

Monitoring and Measurement on the controller:

Voltage, Current and Power factor

Switching modes: Linear and circular

Indication lamps: Indication lamps for the capacitor groups which are connected

Physical design

The Power Factor Control Unit is housed in a sturdy apparatus box with a clear mimic diagram explaining how to connect the supplying net from the left to the right side where the network in need for power factor compensation is connected.

Readings, parameters and sub parameters are indicated on the front of the controller. Other settings and programming than the defaults are simply performed from the keyboard and displayed on the controller front.

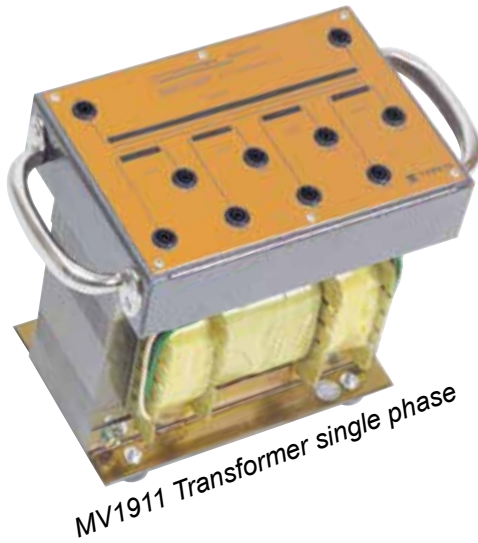
General data:

Power supply: 1-ph 220 - 240 V, 50 - 60 Hz
 Dimensions: 510 x 570 x 280 mm
 Weight: 24 kg

Typical Experiments with Terco PFC

- The concept of active power, apparent power and reactive power
- The concept of power factor and "cos"
- The concept of measuring methods
- Start current settings (C/k)
- Delay times
- Efficiency and losses
- Linear and circular switching modes
- PF-Controller design and schematics
- Programming the controller
- PF-Controller and resistive/inductive loads
- PF-Controller and induction motor loads
- Control range limits

ORDER DETAILS FOR TRANSMISSION LABORATORY			
Cat. Code	Description	pc	page
MV1420	Line Model 3-phase, 230V	1	4
Recommended peripheral equipment for MV1420			
MV1103	Variable Transformer, 3-phase	1	19
MV1429	Terminal Board	1	29
MV1100-235	Load Resistor 3-ph, 3.3kW	1	20
MV1107	Load Reactor, 3-ph, 3 kVAr	1	20
MV1102	Load Capacitor, 3-phase, 2.8 kVAr	1	21
MV1500	Load Switch, 3-pole 16A	2	29
MV1915	Transformer, 3-ph 2 kVA 50-60 Hz	2	10
MV1939	AC Power Energy Meter	2	26
MV1830-HF	Flex Set, 100 Safety Leads, Safety Plugs	1	31
MV1904	Flex Stand	1	31
Optional Line Models and equipment:			
MV1424	Line Model, 3-ph, 400V, one phi-link (40kV, 40km)	1	5
MV1425	Line Model, 3-ph, 400, double phi-link (220kV, 100km)	1	5
MV1438	Cable Line Model 400V, 3-phase (11kV, 5km)	1	6
MV2221	Line Model 400V 3-phase (230kV, 100km)	1	7
MV2222	Line Model 400V, 3-phase (11kV, 5km)	1	7
MV2225	Petersen Coil, Multi Terminal	1	7
MV1439-235	Power Factor Control Unit	1	8
Additional Equipment: Measuring and Data Acquisition for PC			
MV1943	Analog Output Module	1	27
MV2609	Data Acquisition and Control Software	1	28,28
Alternative instrument			
MV1922/23	Ammeter 0-10A, AC/DC	4	24
MV1926	Voltmeter 0-50-250-500V AC/DC	3	24
MV1937	Wattmeter 1-ph, 1-5A; 50-250-500V AC/DC	3	24
MV1929	Power Factor Meter 3-ph, 0-5A, 230V	1	25
MV1976	Power Factor Meter 3-ph, 0-5A, 400V	1	25



MV1911 Transformer Single-Phase

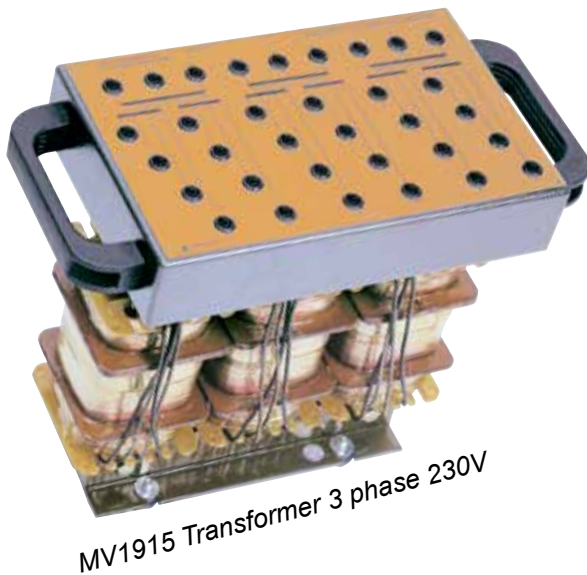
Ratings Single-phase 1 kVA, 50-60 Hz
 Primary: 230 V \pm 5 %
 Secondary: 4 x 57.5 V \pm 5 %

The secondary winding is divided into four windings for series or parallel connection.

No load losses $P_o = 25$ W
 Impedance voltage $e_k = 8$ %
 Resistance voltage $e_k = 3$ %

MV 1911 can be used for determination of operating characteristics, losses and efficiency of a single-phase transformer by means of no load, short-circuit and load tests. The transformer has safety sockets mounted on the frontpanel with mimic diagrams.

Dimensions: 210 x 150 x 210 mm
 Weight: 22 kg



MV1915 Transformer 3-Phase

Ratings Three-phase, 2 kVA, 50-60 Hz,
 230/2 x 66.5 V per phase
 Primary 0-133-230 V \pm 5 % per phase
 Secondary Two 66.5 V windings per phase,
 each winding having tapplings for
 0-38.4-44-66.5 V (\pm 5 %)

The tapplings are so arranged that 230 V (star or delta connection) and 133 V (star, delta or zig-zag connection) can be obtained for all standard connections.

This transformer has safety sockets mounted on the frontpanel with mimic diagrams.

No load losses $P_o = 35$ W
 Impedance voltage $e_k = 8$ %
 Resistance voltage $e_k = 3$ %

With MV 1915, asymmetrical loading and parallel connection of three-phase transformers for different three-phase combinations on the primary and secondary side, can be studied. It can also be used for determination of operating characteristics, losses and efficiency.

Dimensions: 300 x 190 x 345 mm
 Weight: 33 kg

Experiment Transformers

These transformers are designed for studies of single and three-phase transformers, by the completion of a series of experiments, which are described in detail in the instruction manuals.

These include:

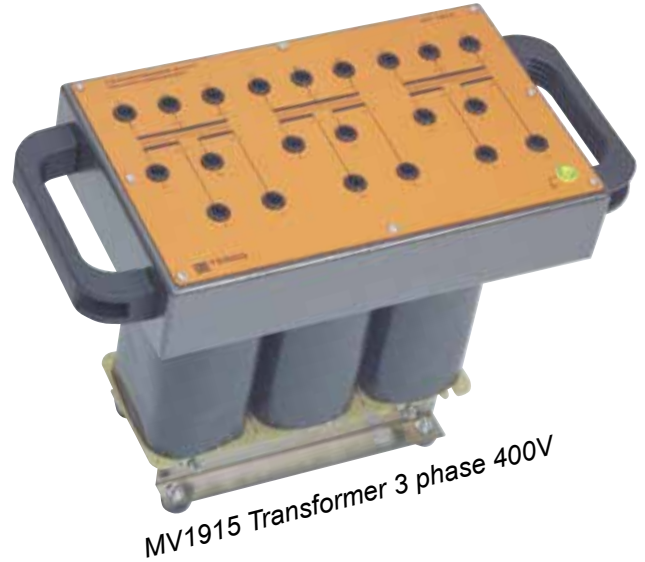
- Efficiency and short circuit impedance.
- Waveform of the no-load current.
- Inrush current.
- Three-phase connections.
- Unbalanced loading.

MV1972 Transformer 3-phase

This transformer has an E-type core and is suitable for setting up a variety of circuits for 3-phase transformers. MV 1972 has safety sockets mounted on a frontpanel with mimic diagrams.

General Data

Power rating	Three-phase 2 kVA, 50-60 Hz
Primary voltage	400 V \pm 5 % or 230 V \pm 5 % per phase
Secondary voltage	2 x 66.5 V \pm 5 % per phase
Test voltage	2.5 kV
Efficiency	92 %
Percentage impedance voltage	4 % approx.
Dimensions	350 x 165 x 260 mm
Weight	30 kg



ORDER DETAILS FOR TRANSFORMER LABORATORY				
Cat. Code	Description	pc	page	
MV1911	Transformer Single-Phase	1	10	
MV1915	Transformer 3-Phase 230V	1	10	
MV1972	Transformer 3-Phase 400V	1	11	
Recommended peripheral equipment for Transformer Laboratory				
MV1103	Variable Transformer, 3-phase	1	19	
MV1429	Terminal Board	1	29	
MV1100-235	Load Resistor	1	20	
MV1101	Load Reactor, 3-phase, 2.5 kVAr	1	20	
MV1102	Load Capacitor, 3-phase, 2.8 kVAr	1	21	
MV1500	Load Switch, 3-pole 16A	1	29	
MV1939	Power Energy Meter	1	26	
MV1830-HF	Flex Set, 100 Safety Leads, Safety Plugs	1	31	
MV1904	Flex Stand	1	31	
DMC9	Digital Multimeter. Equivalent instruments can be delivered and used.	1	23	
Optional:				
MV1915-C	Transformer 3-phase, sectioned	1	30	
MV1931	Current Transformer	1	30	
Alternative instruments instead of MV1939 above:				
MV1922/1923	Ammeter	4	24	
MV1926	Voltmeter	2	24	
MV1937	Wattmeter	3	24	

Protective Modules - Fully IEC 61850 compliant

MV1450 Line Multi Protection Module



The MV1450 Line Multi Protection Trainer module is intended for advanced training in modern line distance protection technology.

It is equipped with the fully IEC61850 compliant ABB protection REF630 which is one of the most modern and sophisticated protection units in the product family of Intelligent Electronic Devices (IEDs).

REF630 is designed for protection of transmission and distribution networks.

The use of a highly advanced IED enables great possibilities to perform a wide range of laboratory experiments.

The protective relay REF630 used in MV1455 enables the student to learn and explore how to protect a variety of different power line configurations from various fault conditions.

General Features

- Colour coded power inlet- and outlets for easy recognition of each phase.
 - Mimic diagrams of the circuit along with large clear symbols printed on the front panel
- Power bus circuit breaker switch:
- A two state switch (ON/OFF) with LED indication of CB (Circuit Breaker) status.
 - Internal circuitry prevents operation of the CB during an unacknowledged trip.

Trip reset button:

- Button for quick reset of LEDs and acknowledgement of a trip.
- Control, monitoring and protection integrated in one IED
- Fully IEC 61850 compliant.
- Four independent parameter setting groups.
- Large HMI with single line diagram.
- RJ-45 interface for communication with PC.
- Protection and Control IED Manager PCM600: Advanced software for configuration and parameter setting.

Technical Specification

- Power Supply: 1-ph 220 - 240 V, 50 - 60 Hz
Possible to supply a compatible device with power
- Power bus: 3ph, 400VAC, 2A
- Dimension: 483 x 356 x 422 mm.
Weight: 37 kg
- Protective earth: one 4mm safety connector for external components at the rear of the unit.

REF630 Important Protection functions

- Capable of a 5 zone full-scheme high-speed line distance protection with mho*), bullet and quadrilateral characteristics.
- Three stages of over-current protection (Low, high and instantaneous)
- Directional earth-fault protection
- Over-voltage protection
- Over-power protection (configurable direction)

**) In order to retain dependability and security in cases of close-in faults when the loop voltage is zero, mho distance elements use cross-phase and/or memory polarization.*

Full access to protections relays including parameter setting and Disturbance Records is possible via a standard web browser.

It is possible to view important analogue current and voltage sinus waveform vectors in a suitable diagram, together with protection's binary input and output status for in-depth fault analysis after such an event has occurred.

ORDER DETAILS FOR MV1450 LINE MULTI PROTECTION LABORATORY			
Cat. Code	Description	pc	page
MV1450	Line Multi Protection Trainer	1	12
Recommended peripheral equipment for MV1450			
MV1450-COMP	PC with installed & pre-programmed software for MV1450	1	12
MV1103	Variable Transformer, 3-phase	1	19
MV1429	Terminal Board	1	29
MV1100-235	Load Resistor 3-ph, 3.3kW	1	20
MV1101	Load Reactor, 3-phase, 2.5 kVAr	1	20
MV1102	Load Capacitor, 3-phase, 2.8 kVAr	1	21
MV1500	Load Switch, 3-pole 16A	2	29
MV1959	Rheostat 200W, 50 ohm., 2A	1	22
MV2221	Line Model 230kV, 100km, 400V, 3-phase	2	7
MV2222	Line Model 11kV, 5km, 400V 3-phase	2	7
MV1922/23	Ammeter 0-10A, AC/DC	2	24
MV1926	Voltmeter 0-50-250-500V AC/DC	2	24
MAT220349	Digital Clamp Meter AC / DC current	1	23
MV1830-HF	Flex Set, 100 Safety Leads, Safety Plugs	1	31
MV1904	Flex Stand	1	31

Power supply of modules



The modules Power Supply can be daisy-chained so that only one Power outlet is required

Every Module has two 1A fuse for Power Supply of the Module

Terco reserves the right to make changes in the design and modifications or improvements of the products at any time without incurring any obligations

MV1455 Differential Relay Module



General Features

- Colour coded power inlet- and outlets for easy recognition of each phase.
 - Mimic diagrams of the circuit along with large clear symbols printed on the front panel.
- Power bus circuit breaker switch:
- A two state switch (ON/OFF) with LED indication of CB (Circuit Breaker) status.
 - Internal circuitry prevents operation of the CB during an unacknowledged trip.
- Trip reset button:
- Button for quick reset of LEDs and acknowledgement of a trip.
 - Control, monitoring and protection integrated in one IED
 - Fully IEC 61850 compliant.
 - Four independent parameter setting groups.
 - Large HMI with single line diagram.
 - RJ-45 interface for communication with PC
 - Three power lines; 1 incoming power line and 2 outgoing. Each line contain three phases L1, L2, L3 and Neutral wire.
 - 12 Current Transformers which enables the student to study various CT-connections.
 - Protection and Control IED Manager PCM600: Advanced software for configuration and parameter setting.
 - Front panel switches that enable the student to test differential protection on a double-busbar.

The MV1455 Differential Relay Module module is intended for advanced training in modern differential protection technology.

It is equipped with the fully IEC61850 compliant ABB RET615 protective relay which is one of the most sophisticated protection unit in the product family of intelligent electronic devices (IEDs).

RET615 is designed for differential protection of transformers, generators, line sections and their combinations.

The use of a highly advanced IED enables great possibilities to perform a wide range of laboratory experiments.

The protective relay RET615 used in PTG1455 enables the student to learn and explore how to protect a variety of different power transformer connections with a differential protection scheme.

Technical Specification

Power Supply: 1-ph 220 - 240 V, 50 - 60 Hz

Possible to supply a compatible device with power

Power bus: (3-ph) 400V AC/ 2A with 4 mm safety connectors

Dimension: 357 x 483 x 420 mm

Weight: 37 kg

Protective earth: one 4mm safety connector for external components at the rear of the unit.

RET615 Important Protection Functions

- Differential Fault Protection
- Three-phase non-directional overcurrent protection, low, high and instantaneous stage
- Non-directional earth-fault protection, low and high stage
- Negative-sequence overcurrent protection
- Residual overvoltage protection

Full access to protections relays including parameter setting and Disturbance Records is possible via a standard web browser.

It is possible to view important analogue current and voltage sinus waveform vectors in a suitable diagram, together with protection's binary input and output status for in-depth fault analysis after such an event has occurred.

ORDER DETAILS FOR MV1455 DIFFERENTIAL RELAY LABORATORY			
Cat. Code	Description	pc	page
MV1455	Line Multi Protection Trainer	1	14
Recommended peripheral equipment for MV1450			
MV1455-COMP	PC with installed & preprogrammed software for MV1455	1	14
MV1103	Variable Transformer, 3-phase	1	19
MV1429	Terminal Board	1	29
MV1100-235	Load Resistor 3-ph, 3.3kW	1	20
MV1101	Load Reactor, 3-phase 2.5kVAr	1	20
MV1102	Load Capacitor, 3-phase, 2.8 kVAr	1	21
MV1500	Load Switch, 3-pole 16A	1	29
MV1957	Rhestat 200W, 5 ohm, 6.3A	3	22
MV1959	Rheostat 200W, 50 ohm,, 2A	1	22
MV1400	Push Button Panel	1	29
MV1911	Transformer 1-phase, 1kVA, 50-60 Hz	1	10
MV1915	Transformer 3-phase, 2kVA, 50-60 Hz	1	10
MV1922/23	Ammeter 0-10A, AC/DC	5	24
MV1926	Voltmeter 0-50-250-500V AC/DC	2	24
MAT220349	Digital Clamp Meter AC / DC current	1	23
DMC9	Digital Multimeter	1	23
MV1830-HF	Flex Set, 100 Safety Leads, Safety Plugs	1	31
MV1904	Flex Stand	1	31

Power supply of modules



The modules Power Supply can be daisy-chained so that only one Power outlet is required

Every Module has two 1A fuse for Power Supply of the Module

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MV1305-405 Mobile Motor / Generator Unit



A standard laboratory for power transmission normally consists of one or two generators, which are connected to one or more transmission links which finally reach transformers, distribution units and loads. This configuration may look like the very left line in figure 1.

However, a realistic network most likely looks like the complete network of figure 1. For example, here can be seen turbine/generators in parallel on the same busbar, a synchronous machine used as a synchronous compensator in the middle of a line, a single generator unit and a heavy group of generators.

Energy transfer, load shedding, static and dynamic stability at disturbances as well as sophisticated protection schemes can be studied under realistic forms. Not to forget compensation possibilities.

Power- and current- paths in grid networks are complicated. The TERCO system will give understanding for this problem.

The wide range flexibility will be given by the mobile generator station / synchronous alternator (compensator) MV 1305.

Two sets of MV 1305 can operate as described or work in parallel. In this case mechanical and electrical parameters might be changed by using e.g. flywheel (MV 1010) and different electrical connections.

Modes of Operation

- A. Control of active power (frequency): AC-machine and frequency converter drive ("turbine") + synchronous machine (generator) in closed loop connection regarding frequency.
- B. Control of active power (frequency) and reactive power (voltage): Two closed loops regarding frequency and voltage.
- C. Synchronous compensating: AC-machine and frequency converter drive ("turbine") idling, electrically disconnected or mechanically disconnected, synchronous machine in closed loop connection for voltage (=reactive power) control.

Technical Specification

	MV1305-405-235
Power Supply AC 3-ph	380-415 V
Frequency	50 Hz
Max current	16A

Turbine/AC-machine freq.drive:

Armature/stator Volt AC	323-528 V
Frequency	0-63 Hz
Armature/stator current	3.4 A
Input current	5.9 A
Rated output current	4.0 A
Rated output capacity	3.2 kVA
Speed	0-1800 rpm

Synchronous generator:

Armature volt AC 3-ph	0-140 / 240 V
Power	1.2 kVA
Cos ϕ	0.8
Field volt	0-230 V DC

Speed Control	0-1800 rpm
---------------	------------

Active power control	SCR-frequency converter, electronic current limit setting, start- and stop ramps.
----------------------	-----------------------------------------------------------------------------------

Feedback systems	Manual frequency setting. Automatic/Constant setting
------------------	---------------------------------------------------------

Field current supply	Integrated
----------------------	------------

Voltage control/ Reactive power control	PWM min. ripple-converter, electronic current limit setting
--------------------------------------------	-------------------------------------------------------------

Feedback systems	Manual voltage setting. Automatic/Constant setting. Separate voltage feedback
------------------	-------------------------------------------------------------------------------------

Instruments

AC-machine freq.drive: Parameters and indications (Turbine simulator) selected by 4-lines display in HMI-unit typically like:
 Frequency setpoint (F 50,00Hz)
 Stator Electric Frequency (H 51,00 Hz)
 Actual motor speed (from encoder 1500 rpm)
 Motor current (A 2,20 A)
 DC-interlink voltage (V 520 V)
 Speed control potentiometer (=frequency control)
 Control method selector

Synchronizing devices:
 Synchronizing instrument
 Double voltmeter
 Double frequency meter
 Synchronizing switch
 Automatic or manual synchronizing

Auxiliary:
 Machines mounted on machine bed with slirails.
 Control panel integrated with machines to one mobile unit. Laboratory connections by 4 mm banana plug of safety type. Possibilities of connecting different types of step-up transformers as well as other instruments and protections.

AC-machine M/G: Armature voltage
 Voltage selector switch
 Armature current
 Voltage control potentiometer
 Control method selector
 Field current ammeter

Dimensions: 1550 x 800 x 1200 mm
 Weight: 200 kg (approx.)

Item	Power Supply	Synchronous Generator
MV1305-405-235	380-415V 3-ph, 50Hz	220-240V 3-ph, 50Hz
MV1305-405-236	380-415V 3-ph, 60Hz	220-240V 3-ph, 60Hz
MV1305-405-405	380-415V 3-ph, 50Hz	220-240V 3-ph, 50Hz
MV1305-405-406	380-415V 3-ph, 60Hz	220-240V 3-ph, 60Hz



MV1300 Power Pack

This power supply unit is especially adapted for laboratory experiments on electric machines and power systems.

It can be used where variable or fixed AC or DC is required and is particularly suited to the laboratory experiments with Terco's torque meters and test machines. It is designed to slide under the lab table so that controls and connections are in a comfortable working position.

The contactor for variable voltages has a safety limit switch which eliminates switching on high voltages by mistake, thus protecting students and equipment especially when working on electrical machines. All outputs are fused by MCB's and have load switches.

The Power Pack has also Earth Leakages Circuit Breaker (ELCB).

MV1302 Power Pack

Same as MV 1300-405 but with the following data

Output voltage	DC fixed	220 V 3.5 A
	DC variable	0-220 V 16 A
	AC fixed	400 / 230 V 10 A 3-ph
	AC variable	3 x 0-400 V 8 A 3-ph

Supply voltage 380-400 / 220-230 V 50 / 60 Hz 3-ph

General Data

Supply Voltage

MV1300-235 220-240 / 127-140 V 50 / 60 Hz 3-ph.

MV1300-405 380-400 / 220-230 V 50 / 60 Hz 3-ph.

MV1300-415 415 / 240 V 50 / 60 Hz 3-ph.

Output voltage	DC fixed	220 V 3.5 A
	DC variable	0-220 V 16 A
	AC fixed	230/133 V 10 A 3-ph
	AC variable	3 x 0-230 V 10 A 3-ph
Standard	Fixed AC	230 V 10 A

Dimensions 660 x 435 x 790 mm

Weight 103 kg

MV1304 Power Pack

As MV1300-415 but with the following data

Output voltage	DC fixed	220 V 3.5 A
	DC variable	0-220 V 16 A
	AC fixed	415 / 240 V 10 A 3-ph
	AC variable	3 x 0-415 V 10 A 3-ph

Supply voltage 415 / 240 V 50-60 Hz 3-ph



MV1103 Variable Transformer 3-phase

Supplied with a scale showing output voltage. Thermal overload protection for three output phases are placed on the front panel. A common shaft rotates all output voltage sliders in parallel. The unit is mobile on 4 wheels.

Input: 3 x 400 V, 8 A, 50-60 Hz
Output: 3 x 0-450 V, 8 A

Dimensions: 280 x 290 x 560 mm
Weight: 34 kg



MV1104 Variable Transformer Single Phase

The annular core of this variable transformer is of high alloy transformer sheet with small losses.

The contact point on the winding, which is wound for a constant current obtained throughout the entire range, is provided by a sliding carbon contact. Thermal overload protector.

Switch with pilot lamp. Rubber pedestals at the bottom and rear for convenient placing in the most suitable position at any time.

Input: 230 V, 50-60Hz
Output-max: 0-260 V, 8 A, 50-60 Hz, 4mm outlets
Dimensions: 200 x 190 x 205 mm
Weight: 9 kg



MV1100 Load Resistor

MV1100 Load resistor contains three ganged resistors with continuous spindle regulation. The resistors are connected to terminals for 3-ph, single-phase or DC-voltage.

The current in the resistor is limited by tubular wire fuses in each phase. The unit has handles and wheels for simple and quick movement and is enclosed in a perforated metal cabinet. MV1100 is supplied with safety sockets and a load switch.

A cooling fan is placed at the bottom of the resistor.
 MV1100-235 Cooling fan supply 230 V AC 50 - 60 Hz
 MV1100-116 Cooling fan supply 110 V AC 60 Hz

General Data

3-phase 3.3 kW, continuously adjustable.

Star connection 400 / 230 V 0.8-5 A

Star connection 230 / 133 V 0.5-5 A

Delta connection 400 / 230 V 2.4-8.7 A

Delta connection 230 / 133 V 1.3-8.7 A

DC parallel connection 220 V 2.3-15 A

Overload capacity, brief duration, approx. 20 %.

Dimensions): 630 x 250 x 890 mm

Weight: 46 kg



MV1101 Load Reactor

Enclosed in a strong metal cabinet. The front panel has mimic diagram, terminals, fuses and electrical data. The unit can be used on 1- and 3-phase systems. 12 step regulation.

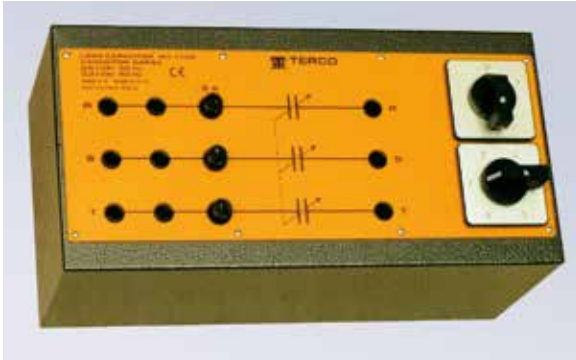
General Data

2.5 kVAr, 50-60 Hz

V	Connection	Hz	A
230	star	50	0.2-2.2
230	delta	50	0.6-6.6
400	star	50	0.4-3.8
230	star	60	0.2-1.9
230	delta	60	0.5-5.6
400	star	60	0.3-3.3

Dimensions: 510 x 220 x 320 mm

Weight: 40 kg



MV1102 Load Capacitor

Housed in a metal cabinet. Electrical data and symbols on the front panel with terminals and fuses. This unit can be used on 1- and 3-phase systems. 6 step regulation.

General Data

2.8 kVAr at 50 Hz, 3.3 kVAr at 60 Hz.

V	Connection	Hz	A
230	star	50	0.4-2.4
230	delta	50	1.2-7.2
400	star	50	0.7-4.2
230	III (parallel)	50	2.1-12.6
230	star	60	0.5-2.8
230	delta	60	1.4-8.6
400	star	60	0.8-5.0
230	III (parallel)	60	2.5-15

Dimensions: 185 x 370 x 170 mm

Weight: 7 kg



MV1106 Load Capacitor

The bank is made of metallized paper capacitors. The capacitors are fitted with discharging resistors. The capacitance of the bank can be varied in seven steps by means of rotary switches. It can be used in single-phase or three-phase circuits.

5.3 kVAr at 50 Hz, 6.3 kVAr at 60 Hz

V	Connection	Hz	A
230	delta	50	1.9-13.4
400	star	50	1.1-7.7
230	III	50	3.3-23.2
230	delta	60	2.3-16.1
400	star	60	1.3-9.2
230	III	60	3.9-27.8

Dimensions: 520 x 225 x 360 mm

Weight: 13 kg



MV1107 Load Reactor

The reactor is continuously variable within the range 0.5-3.0 kVAr. When the reactor is connected to a system with 230 V between lines, the setting range can be increased to 0.15-3.0 kVAr by using Y-connection.

The required reactive power is set by means of a crank. For easier setting, the load reactor has a ten-turn scale with 100 scale divisions for each turn. Each winding is fitted with a fuse.

3-phase 0.5-3.0 kVAr, 400 V Y, 230 V Y, 50-60 Hz

V	Connection	Hz	A
230	star / delta	50	0.4-7.8
400	star	50	0.7-4.5
230	star / delta	60	0.3-7.6
400	star	60	0.6-3.7

Dimensions: 340 x 170 x 380 mm

Weight: 30 kg



MV1957, MV1959, MV1963 Rheostats

Each rheostat is enclosed in a robust metal case. The back, bottom and top of the case are perforated to provide optimum cooling. 2 glass fuses protect the resistor against excessive current and incorrect connection.

A scale with 100 scale divisions shows the resistance setting.

A front panel of yellow painted steel with black screen painted symbols simplifies series and potentiometer connection.

Constructional features

The insulation is of high class ceramic material. The resistance wire used is of highest quality with very good linearity.

Large flat brush with a sliding contact of copper graphite with specially balanced mounting guarantees perfect

contact with negligible wear on the resistance.

Cat. no.	W	Ω	I (A)	Dimension HxWxD mm	Weight
MV1957	200	5	6.3	140 x 130 x 145	1.5
MV1959	200	50	2.0		
MV1963	500	2500	0.45	215 x 195 x 230	3.5



DMC9 Digital Multimeter

High-resolution, 3-3/4 digit LCD, 4000-count autoranging

- 7 functions / 23 ranges
- Battery Test function with Go/NoGo LED indicator
- Industry standard test leads, safety rated
- Protective holster included

Voltage

- DC Voltage 400 mV, 4V, 40V, 400V, 600V
- AC Voltage 400 mV, 40V, 400V, 600V

Current

- DC Current 40 mA, 400 mA, 8 A, (10A for 10 min)
- AC Current 40 mA, 400 mA, 8 A, (10A for 10 min)

Resistance

- 400 Ohm, 4 kOhm, 40 kOhm, 400 kOhm, 4 MOhm, 40 MOhm.

Buzzer Sounds

Diode Test

Overload Protection

Included accessories: Protective holster, test leads, battery and users manual.

Dimensions: 140 x 78 x 50 mm

Weight: 0.22 kg



MAT220349 Digital Clampmeter AC/DC current

MAT229349 is a small and pliable clamp meter for AC and DC current up to 200 A.

A clear and easy-to-read 3.5 digit LCD display with max reading of 1999.

The slim jaws have an inner diameter of 30 mm and is easy to fit in narrow places.

The data-hold function freezes the value, and is useful when working in the dark or hard to get areas where you cannot see the LCD.

The measuring values are updated 2 times / sec.

MAT220349 is delivered with manual, battery and soft case.

Conforms with IEC safety requirements.

Specifications:

- Current (AC): 0-20 A, 0-150 A, 150-199, 9A
- Current (DC): 0 - 20 A, 0 - 150 A, 150 - 199, 9A
- Low battery indication: "B" mark on LCD
- Power supply (battery): 2 pcs RS-44 or 2 pcs LR-44

Dimensions: 20 x 44 x 146 mm

Weight: 0.1 kg



MV1922/1923 Ammeter

A sturdy amperèmeter with high accuracy and reliability. Extremely safe with safety sockets and dual insulation. Moulded, water-resistant casing.

Range	AC 10mA - 10A (7 steps) DC 100µA -10A (7 steps)
Accuracy	1,5% (DC), 2% (AC)
Operating frequency	45 - 400Hz
Fuse	1A and 10

Dimensions:	170 x 110 x 60 mm
Weight:	0.4 kg



MV1926 Voltmeter

A sturdy voltmeter with high accuracy and reliability. Extremely safety with safety sockets and dual insulation. Moulded, water-resistant casing.

Range	AC 3V - 1000V (6 steps) DC 100mV - 1000V (8 steps)
Accuracy	1,5% (DC), 2% (AC)
Operating frequency	20 - 400Hz
Fuse	Electronic Protection

Dimensions:	170 x 110 x 60 mm
Weight:	0.4 kg



MV1937 Wattmeter

MV 1937 is an Electronic Wattmeter with active power transducer. The instrument is panel-type 96 x 96 mm and mounted in durable varnished sheet metal enclosures having plastic feet. The instrument has a 90° scale and manages temperatures between -20° and +50°C. It complies with IEC recommendations.

Technical Data

Voltage ranges:	50 – 250 – 500 V AC / DC
Current ranges:	5 – 10 A, AC / DC

The current ranges can be changed with a switch when measuring.

Voltage inputs:	max 600 V
Current inputs:	max 20 A

The current inputs and voltage inputs are insulated from each other : 1.5 kV

Accuracy:	2.5 %
Frequency range:	DC – 20 kHz
Input impedance:	> 100 kohm (voltage input) < 3 mohm (current input)

Power supply:	220 – 240 V 50 – 60 Hz
Dimensions:	220 x 117 x 125 mm
Weight:	2 kg

Note : This wattmeter has a lamp and a buzzer warning for both overvoltage and overcurrent.

MV1929 Power Factor Meter

Three-phase instrument, symmetric load.
 Measuring range cap. 0.5 ... 1 ... 0.5 ind.
 Current range 0-5 A
 Voltage range 220 V \pm 20 % 3-phase
 Frequency range 40-65 Hz
 Accuracy class 1.5
 Dimensions: 220 x 117 x 125 mm
 Weight: 2 kg



MV1976 Power Factor Meter

Three-phase instrument, symmetric load.
 Measuring range cap. 0.5 ... 1 ... 0.5 ind.
 Current range 0-5 A
 Voltage range 380 V \pm 20 % 3-phase
 Frequency range 40-65 Hz
 Accuracy class 1.5
 Dimensions: 220 x 117 x 125 mm
 Weight: 2 kg

MV1918-1 Digital Timer

Suitable for measuring the pick-up and drop-out times of relays and for physical experiments. The timer has two inputs that can be wired either to start or stop timing. Timing is started or stopped by every change at the inputs (make or break). It is also possible to connect the timer to one of the inputs only, in which case the closing of a make contact starts the timer, and the opening of the circuit stops it.

The inputs are protected for over-voltage, AC and DC.

General Data

Two measuring ranges Timer 1 msec - 60 sec
 Counter 1 - 65 000 counts
 230 V DC max.
 Accuracy \pm 0.1 % of reading \pm 1 digit
 Resolution 1 msec
 Height of digits 7 mm
 Mains supply 220-240 V, 50-60 Hz
 Dimensions: 175x200x90 mm
 Weight: 1 kg



MV1971 Differential Probe

Voltage up to 1200 V
 Frequency range: DC - 1 MHz
 Impedance in: approx. 1 Mohm
 Impedance out: approx. 500 ohm
 Dimensions (HxWxD): 40 x 120 x 65 mm
 Weight: 0.3 kg



MV1939 Power Energy Meter



MV1939 Power Energy Meter is a practical solution for the study of 3-Phase AC power systems.

A microprocessor-based energy meter provides the user with an instant overview of the relevant three or four-wire, 3-Phase network parameters in balanced or unbalanced networks.

The simplified connection process means your laboratory experiments can be set up and taken down in just minutes, leaving more time to investigate and understand the characteristics and ambiguities of 3-Phase power networks.

Each line is fused with a 500V, 10A slow fuse and together with 10:1A current transformers provide a good level of protection against incorrect connection, mishandling and carelessness.

Technical specifications

Power supply 220VAC, 50/60Hz

Measurement

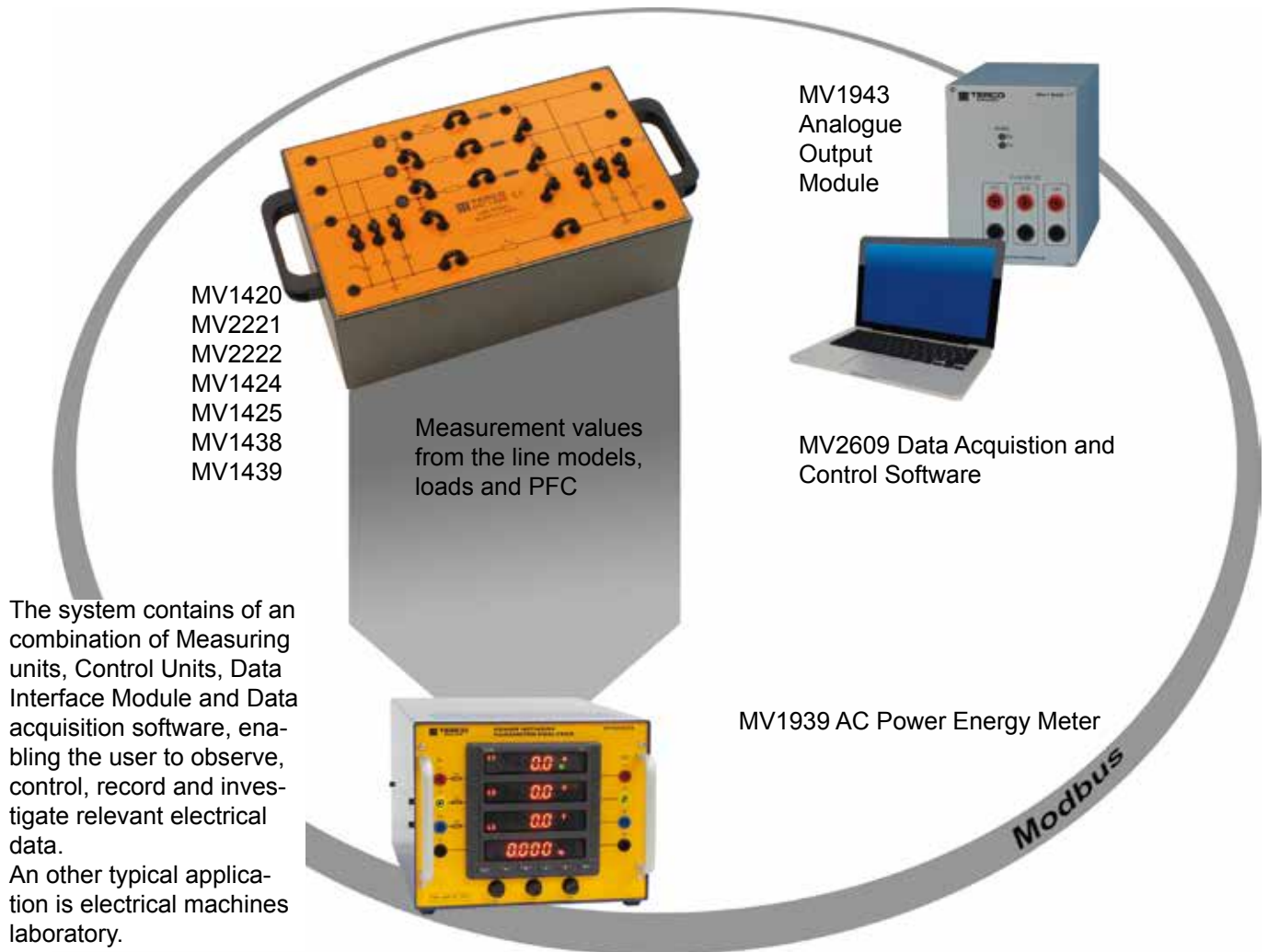
Voltage, V: 500VAC max
 VT ratio: Direct measurement
 Current, I: 10A max
 Active power, P: 0.0...(±)1999.9 W
 Apparent power, S: 0.0...(±)1999.9 VA
 Reactive power, Q: 0.0...(±)1999.9 VAR
 Active power factor, Pf: -1...cos φ...1
 Frequency, f: 15...500Hz

MV1939 Power Energy Meter enables the measurement and visualisation of 46 power energy quantities and 25 harmonics for each phase of current and voltage. The analyser can display parameters of interest in the study of symmetrical as well as non-symmetrical networks, such as: phase voltages, phase-to-phase voltages, line currents, phase active powers, phase reactive powers, phase apparent powers, phase active power factors, phase reactive/active power factors, mean three-phase voltage, mean phase-to-phase voltage, mean three-phase current, three-phase active, reactive and apparent powers, mean three-phase power factors.

The visualization of parameters is distributed over programmable pages (max 20 pages) where each page simultaneously displays four parameters.

Dimension: 255 x 195 x 335mm
 Weight: 10kg

Additional Equipment: Measuring and Data Acquisition for PC



MV1943 Analog Output Module



The MV1943 Analog Output Module integrates the communication interface functionality of a USB to RS-485 adapter, with a 3-channel Modbus controlled 0-10V DC source in one compact unit.

Coupled with the MV2658 PWM Control unit, the MV1943 provides both communication

between Terco measuring units and a PC, as well as simultaneous motor control. The 3-channel analog output is controlled via PC using the Terco Data Acquisition Software and enables additional features such as fully automatic data acquisition.

Technical Specifications

Communication Interface	USB plug and play
Operating system	virtual serial port driver 7/Vista/XP
Field interface	RS485
Maximum devices	32 devices
Power source	USB port
Consumption	<100 mA
Voltage output Channels	3
Channel output	0-10 V
Resolution	12 bit (2.5 mV)
Isolation	1500 Vac, Field to Logic
Control system	Terco MV2609 Data Acquisition Software
General	
Power supply:	220-240VAC, 50/60Hz
Dimensions:	105 x 147 x 167 mm
Weight:	0.3 kg

MV2609 Data Acquisition and Control Software

Acquisition functions

Data is read into the PC via Modbus to USB link and presented in real-time in both tabular and graph form.

Data may be acquired using one of 4 possible acquisition modes: Single, Timed, Semi-Automatic and Full Automatic*.

The saved data can then be exported in Excel format for further investigation.



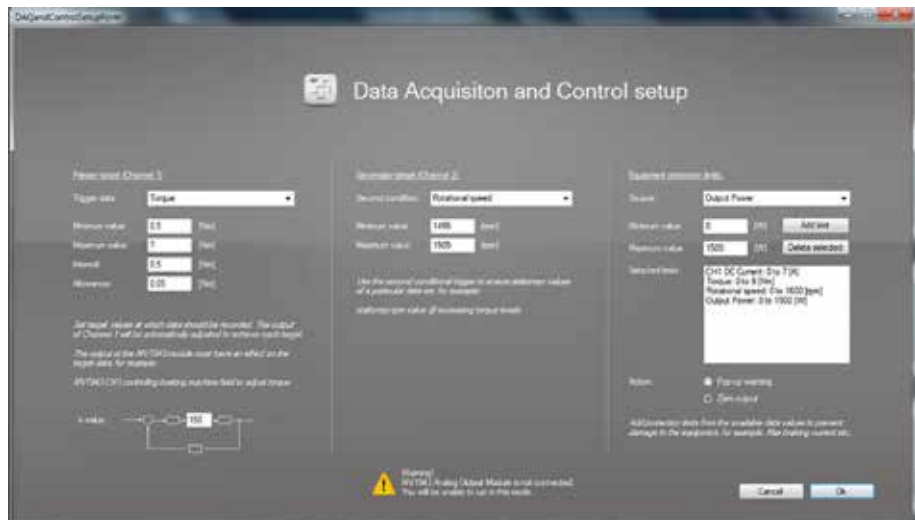
Pre-configured experiment set-ups are included but the experiment presentation window is fully customizable, allowing the user to select available hardware, define data columns and set up graph parameters such as data sources and titles.

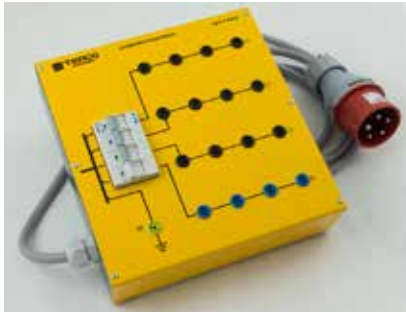
The software is designed to work with Terco Modbus instruments but may be set up to communicate with many Modbus devices.



Control functions*

When used together with the MV1943 Analog Output Module and the MV2658 PWM DC Control Module, the Data acquisition and Control software can be used to automatically control a DC machine which can be implemented, for example, as a mechanical brake.





MV1429 Terminal Board

The box has outlets (three phases, zero and earth) for laboratory leads with 4 mm diameter plug ins. These outlets are connected to a 5 x 2.5 mm² cable with a 3-phase CEE plug rated 16A. The connection box is equipped with miniature circuit breakers for 16 A.

Dimensions: 250 x 240 x 75 mm
 Weight: 2.0 kg



MV1500 Load Switch

Three-pole, 16 A, 250 V- DC / 440 V-AC, switch in metal case. Front panel showing symbols and technical data.

Marking of terminals input R, S, T
 output U, V, W

Dimensions (HxWxD): 95 x 200 x 80 mm
 Weight: 1 kg



MV1400 Push Button Panel

MV1400 is a suitable control device

It consists of :

- a signal lamp
- an OFF-button with one break and one make contact
- an ON-button with one break and one make contact.

The buttons are of non-locking type with instantaneous action so that contact operations are felt on depression of a button.

Dimensions (HxWxD): 75 x 175 x 130 mm
 Weight: 1 kg



MV1931 Current Transformer

Primary: 20-15-5 A/Sec. 1 A

Safety sockets

Accuracy class: 1.0

Dimensions (HxWxD): 95 x 200 x 80 mm
 Weight: 6 kg



MV1402 Contactor

The contactor is one of the most common components in automation. It is used, for instance, in remote control and automatic control systems.

General data

- 3 main contacts with thermal current rating 25 A at resistive load
- 5 auxiliary contacts (3 make and 2 break) with thermal current rating 10 A
- Operating coil, 50 Hz or 60 Hz, 230 V

Dimensions (HxWxD) 150 x 245 x 130 mm

Weight: 1.3 kg



MV1915-C Three-phase Transformer

This transformer is cut-away to show the windings, coils, terminals, insulation, iron core etc.

Rated power: 2 kVA

Dimensions: 300 x 190 x 345 mm

Weight: 27 kg

Note: It is not possible to do any practical experiments with this transformer.

Laboratory Flexes with Safety Plugs, Fixed Sleeve



MV1830-HF Flex Set Area 1.5 mm²

Set of 100 leads in 5 different colours, red, yellow, blue, black, yellow/green, and 4 different lengths, 25, 50, 100 and 200 cm, 5 of each.

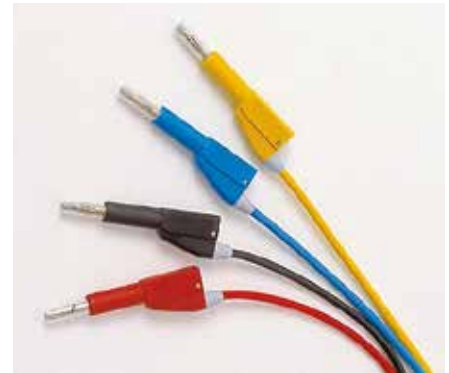
	25 cm	50 cm	100 cm	200 cm
Red	5	5	5	5
Yellow	5	5	5	5
Blue	5	5	5	5
Black	5	5	5	5
Yellow/green	5	5	5	5

Alternative Flexes: Laboratory Flexes with Safety Plugs, Retractable Shroud

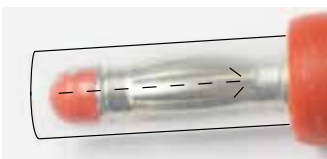
MV1830-H Flex Set Area 1.5 mm²

Set of 100 leads in 5 different colours, red, yellow, blue, black, yellow/green, and 4 different lengths, 25, 50, 100 and 200 cm, 5 of each.

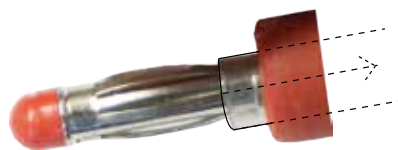
Length	25 cm	50 cm	100 cm	200 cm
Red	5	5	5	5
Yellow	5	5	5	5
Blue	5	5	5	5
Black	5	5	5	5
Yellow/green	5	5	5	5



Safety lead with 2 covered spring plugs of 4 mm diameter, with retractable shroud covering the plugs, and 4 mm diameter axial bushings moulded with Polypropylen, fixed to 1.5 mm² copper thread, PVC isolated, outer diameter 4 mm. Rated current 16 A.



The pin is protected by a plastic sleeve when the flex is not connected.



The plastic sleeve is pushed in to the flex when the plug is connected to the equipment.

MV1904 Flex Stand

For suspension of laboratory flexes. The stand has 12 slots between parallel tubes with space for 10-15 laboratory flexes in each slot. Flexes of length 200 cm are suspended in a separate position above the stand. This rigid stand has a heavy steel plate pedestal.

General Data

Height: 1170 mm
 Weight: 9 kg



Standard Colouring of safety connections

EU



ASIA, Middle East



Note the difference in colour marking of phases and neutral conductors according to International Standards



TERCO offers comprehensive manuals for each product upon delivery. On request we can also offer them in digital form.

Guarantee & Terms

All overseas deliveries are dispatched in special, made to order wooden crates, extremely sturdy and damage resistant.

The guarantee is valid for 24 months from delivery and covers repair or exchange of parts, defective due to faulty design or workmanship at our factory. Detailed conditions of guarantee are specified in our Terms of Guarantee.

Spare parts for 2-5 years of normal operation can be offered on request.

Regular after-sales service is performed by the worldwide network of Terco representatives, along with the advice and support of our engineers.

Commissioning and training is normally offered separately. Special training can be arranged on request either in Sweden or on site.

Terco is ISO 9001 certified

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TERCO HEADOFFICE



Terco headoffice and factory outside Stockholm, Sweden



TERCO AB was founded in 1963 with the aim of producing and supplying practically oriented equipment for technical education.

TERCO develops, manufactures and markets advanced equipment and systems for technical education. TERCO is today represented in more than 50 countries world wide.

TRAINING FOR TOMORROW'S WORLD



Power Systems



High Voltage



Electrical Machines & Drives



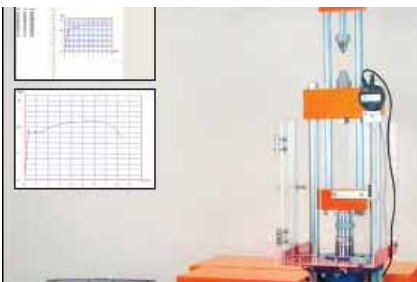
Mechatronics



Process Control



Energy



Material Testing



Furniture & Power Distribution



Training

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