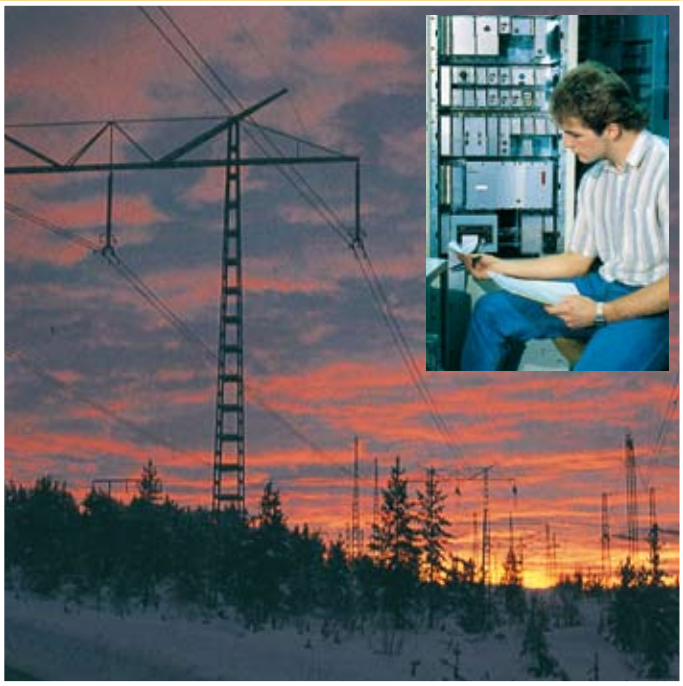
TERCO

Transmission Line, Transformer & Protection Laboratory



Contents

Protective Relays

MV 1431-1 Universal Relay Trainer

The equipment is intended for practical training in static relay and relay protection engineering for applications in power systems.

The Universal Relay Trainer MV 1431-1 is an integrated training system including different kinds of static relays, which are common in relay protection systems around the world.

The static relays used in the experiment unit belong to the well known ABB COMBIFLEX relay system.

The Universal Relay Trainer MV 1431-1 does not only include static relays, it also contains a current transformer, a voltage transformer and an internal power supply. These components are all fitted into a sturdy steel cabinet with a front panel on which all sub units can be connected using either 4 mm safety sockets or 2 mm signal plug terminals. The choice of 2 mm signal plug terminals makes the unit compact and suitable for experiments with the trainer standing on a table.

Mimic diagrams of the relays with large clear symbols are printed on the front panel. Sockets are also provided for test objects.

The rack carries a selection of the static relays used in modern electric power systems.

Following relays are provided:

1. Microprocessor operated double over- and undervoltage relay
2. Microprocessor operated double over current relay
3. Microprocessor operated multi-function directional / reverse power relay
4. Instantaneous over current relay
5. Two types of auxiliary output relays
6. Multirange time-lag relay
7. Flag / signal relay, double unit

Built-in are also :

- One current transformer
- One voltage transformer
- Internal power supply

Supply voltage	220-240 V, 50-60 Hz, 1-ph
Dimensions	510 x 280 x 570 mm
Weight	30 kg

Protective Relays

The laboratory manual for the Universal Relay Trainer MV 1431-1 covers from basic operation principles of each relay up to giving an introduction to the theory and the practical handling of typical situations where static relays are used to protect certain objects in for instance a power plant. The protected object may for example be a transformer, a generator, a bus bar or a feeder. The focus of the proposed experiments is not only the different measuring relays, but the surrounding auxiliary relays are also described and used to build a relay protection.

From the basic operation principles, which can be understood by the experiments, the students obtain knowledge about how relay protection systems are built and how they will work in different situations.

Experiment Manual

1. Introduction
2. Identifying the relays
3. Auxiliary Equipment
   - Auxiliary relay
   - Signal/flag relay
   - Current measuring relay, classic
   - Current measuring relay, double
   - Voltage measuring relay, double
   - Power measuring relay
   - Multifunction time relay
   - Tripping relay
4. Basic Experiments
   - Operating the tripping relay
   - Operating the signal relay
   - Operating the current relay
   - Time delay of the tripping relay
   - Time delay of the current relay
5. Modern Multifunctional Time Relay
   - Time relay at DC-operation
   - Time relay at AC-operation
   - Time relay together with measuring current relay
6. Double Overvoltage Relay
   - Get familiar with the relay
   - Define time over/under voltage function
   - Inverse time over voltage function
   - The instantaneous over voltage function
   - The influence of voltage transformers
7. Double Over Current Relay
   - Get familiar with the relay
   - Define time over current function
   - Inverse time over current function
   - The instantaneous over current function
   - The influence of current transformer
8. Operating the Reverse Power Relay
   - Background and principle diagram
   - The phase lag circuit
   - Reverse power caused by low current
   - Reverse power caused by low voltage
   - Reverse power caused by the angle between the current and the voltage
   - Reverse power setting
   - Reverse power in unstable system
9. Advanced Experiments
   - Earth-fault protection (95%)
   - Earth-fault protection using a current measuring relay
   - Differential protection
   - Reverse Power / Loss of Synchronization protection

Recommended peripheral equipment for MV 1431-1:

Qty	Description	Cat.Code
Basic and Medium Level		
1 pc	Variable transformer	MV 1103
1 pc	Terminal board	MV 1429
1 pc	Load switch	MV 1500
1 pc	Digital timer	MV 1918-1
1 pc	Rheostat 200 W / 5 Ohm	MV 1957
2 pcs	Rheostat 500 W / 2500 Ohm	MV 1963
2 pcs	Differential probe	MV 1971
1 set	Flex set, safety plugs	MV 1830-HF
3 pcs	Digital multimeter	
1 pc	Clip-on ammeter	
Extended Level In addition to the equipment above		
1 pc	Rheostat 200 W / 5 Ohm	MV 1957
1 pc	Push button panel	MV 1400
1 pc	Contactor	MV 1402
2 pcs	Current transformer	MV 1931
1 pc	Transformer, 1-phase	MV 1911
1 pc	Transformer, 3-phase	MV 1915
1 pc	Line model	MV 1420
1 pc	Load resistor 3-phase	MV 1100-235
1 pc	Digital multimeter	
1 pc	Clip-on ammeter	
Advanced Level In addition to the levels above		
1 pc	Mobile motor-generator unit	MV 1305-235

Protective Relays

MV 1434 Distance Protection Trainer

This unit is intended for advanced training in static relay technology and relay protection engineering for applications on middle- and high voltage OH-transmission lines, cables and network sections in power systems.

The measuring technique used in the distance protection relay terminal is based on pure numerical methods.

Versatile local man machine communication (MMC) from the relay front panel, together with a general purpose communication port, brings distance protection relay close to the user, whether he will be located in a substation, control centre or in the students laboratory office.

Programming and readouts are performed from the MMC or from a standard PC, close-by or remote.

Features

The line distance protection terminal is based on an advanced version of the distance protection relay from ABB and includes:

- Five distance protection zones for multiphase faults with individual setting of the directionality and reach in both reactive and resistive direction, mixed forward and reverse.
- Separate and independent impedance measuring elements for the General Fault Criteria (GFC) with advanced characteristics.
- Event recorder.
- Disturbance recorder.
- Fault locator.

The trainer module contains, except for the protection relay, the following function modules:

- Internal DC-power supply
- Necessary current transformers
- Necessary voltage transformers
- Breaker simulator
- Digital inputs panel
- Output panel for communication, indications and tripping
- Auxiliary relays for AC and DC
- Software: Discs or CD for installation
  User´s manual and technical specifications
  Experiment manual

Examples of topics described in **Experiments Manual**:

- Electrical diagrams and identifying components
- Conditions for tripping
- Introduction to programming and calculation for a distance relay
- Calculating impedance ratio
- Calculating secondary impedances
- Setting parameters for impedance zones
- Setting of timers for the distance protection zones
- Selecting zone reach
- Setting instruction GFC (General Fault Criteria)
- Settings for trip functions
- How to set the terminal
- Creating radius network and calculating the impedance map
- Faults on a medium voltage line (MV 1424)
- Faults on a high voltage line (MV 1425)
- Faults on a cable line (MV 1438)

Recommended external laboratory equipment

2 pcs	Voltmeter 50-250-500 V	MV 1926
1 pc	A-meter 0-1-2 A	MV 1922
1 pc	A-meter 0-6-12 A	MV 1923
1 pc	3-ph power supply 0-230 V	MV 1103
1 pc	Terminal board	MV 1429
1 pc	1-ph load resistor 40 ohms, 2.25 A	MV 1966
1 pc	Line model OH line 40 kV	MV 1424
1 pc	Line model OH line 130 kV	MV 1425
1 pc	Cable model 5 kV	MV 1438
1 pc	3-ph load resistor 230 V, 5 A	MV 1100-235
1 pc	Capacitor load bank	MV 1102
1 pc	Inductive load bank	MV 1101
2 pcs	Load switch	MV 1500
1 set	Laboratory leads	MV 1830-HF
1 pc	Stand for lab. leads	MV 1904
1 pc	PC	

Supply Voltage	220-240 V, 50-60 Hz, 1-ph
Dimensions	510 x 280 x 570 mm
Weight	25 kg

Protective Relays

MV 1435 Differential Relay Trainer

This unit is intended for practical training in static relay and relay protection engineering regarding differential protections around transformers and busbars in power systems.

The static relays used are ABB COMBIFLEX type.

The differential relay consists of the following sub-modules: restraint- and differential circuitry unit, filter and measuring unit, trip- and alarm unit, signal- and indication unit together with a test block to which an external relay tester can be connected.

The trainer integrates the differential relay blocks, 12 current transformers, a circuit breaker simulator, input terminals, output terminals, transformer connection panel and operating power supplies of 230 V AC and 110 V DC.

Examples of experiments:

Electrical diagrams and identifying components
Conditions for tripping
Settings and indications of the differential relay
Characteristics of current transformers
Primary and secondary CT-currents at symmetrical- and nonsymmetrical loads
Protection of a single-phase transformer
Protection of a three-phase transformer in Yy-connection
Protection of a three-phase transformer in Yd-connection
Busbar protection

Recommended external laboratory equipment

1 pc	Experiment transformer, 1-ph	MV 1911
1 pc	Experiment transformer, 3-ph	MV 1915
2 pcs	Voltmeter 250 V	MV 1926
1 pc	A-meter 1A and 2A, or multimeters	MV 1922
4 pcs	A-meter 6A and 12A, or multimeters	MV 1923
1 pc	Variable transformer 3-ph	MV 1103 (or MV 1300)
1 pc	Terminal board	MV 1429
3 pcs	Rheostat 0-5 ohm, 6.3A	MV 1957
1 pc	3-ph load resistor 230 V, 5A	MV 1100-235
1 pc	Rheostat 0-50 ohm. 2.0A	MV 1959
1 pc	Pushbutton box for the breaker	MV 1400
1 pc	Switch	MV 1500
1 pc	Timer	MV 1918-1
1 pc	Capicator load bank	MV 1102
1 pc	Reactor load bank	MV 1101
1 set	Laboratory leads	MV 1830-HF
1 pc	Test handle	MV 1233
1 pc	Clip-on ammeter	
1 pc	Ohmmeter (Multimeter)	
1 pc	Oscilloscope	

Supply Voltage	220-240 V, 50-60 Hz, 1-ph
Dimensions	510 x 280 x 570 mm
Weight	32 kg

Protective Relays

MV 1437 Frequency Relay Trainer

The trainer consists of industrial protection relays from ABB which has been built into a suitable enclosure together with auxiliary relays, a contactor relay, external power supplies and a connection board with a mimic diagram.

The integrated protection from ABB is placed behind a glass door and each module in the integrated relay is covered by a plastic protection to protect from dust when not used for experiments.

The connections for experiments are to be connected by 4 mm safety plugs of the lab. flex cords but may also be connected by the earlier used contact type.

The trainer can be used together with most types of laboratory equipment working on a voltage level of 220-400 V.

Setting possibilities:

- Setting range for ± 10 Hz variant
  – Stage 1 (f 1) for 45-55 Hz or 55-65 Hz
  – Stage 2 (f 2) for 40-60 Hz or 50-70 Hz
  Stage 2 can also be used for rate-of-change of frequency (df/dt)
- Combines frequency, rate-of-change (df/dt) and time delay functions in one module
- Absolute value df/dt or negative df/dt only
- Measuring voltage range 20-320 V AC (input voltage transformer included)
- Time delay settable up to 20 s.

Technical description of the protection:

The over/under frequency relay is a static microprocessor based relay with two delayed stages. The relay consists mainly of an input voltage transformer, filter circuits, microprocessor, MMI, LEDs for start, trip indications and three output units which provide separate change-over contacts for start indication of stages 1 and 2, trip of stage 1 and trip of stage 2

Operate values for both stage 1 and 2, are set with the potentiometers and programming switches. Both measuring stages can independently be programmed for over- or under frequency functions. Operation occurs for a frequency equal to or larger/lower than the set scale value and the selected scale constant.

Technical specifications:

Mains supply	220-240 V, 50-60 Hz
Fuses	glass tube 5 x 20 mm, 2 A F
Internal DC-supply	230 V DC
DC-supply for electronics	± 24 V
Frequency range over frequency f1	50 ± 5 Hz
Frequency range under frequency f2	50 ± 10 Hz
Rate of change of frequency (df/dt)	0,5-10 mHz/sec
Trip relay for power circuits	5 A/250 V
Contactor relay, three-phase for machine circuits	16 A/500 V

Dimensions	510 x 280 x 570 mm
Weight	appr. 25 kg

Recommended external equipment:

1 pc	Mobile motor-generator unit	MV 1305-405 (or MV 1305-235)
1 pc	Load resistor	MV 1100-235
1 set	Flex set	MV 1830-H

Protective Relays

MV 1427 Relay Tester

Range of application

Testing of current-, voltage-, time- and power-relays.

Start-up operations where variable current and voltage are required.

Testing of current transformers – ratio tests – plotting of magnetisation curves.

In electrical and measuring departments or in laboratories and technical schools.

Specifications

AC current 0-10 A (85 V), 0-40 A (25 V), 0-100 A (10 V)
Built-in ammeter, ranges 0-10 A, 0-100 A
Terminal for an external ammeter
AC voltage 0-250 V, 3 A
DC voltage 0-350 V, 2 A
110 V AC, 0.3 A terminal 20-220 V DC, 0.3 A terminal (independently adjustable)
Built-in capacitor for testing of reactive power relays
Terminal for synchronous start of an external device
Electronic timer, independent of mains frequency.
Measuring range 0-999.999 sec.
Accuracy 0.02 % of readouts +2 ms.
Terminal for external start and stop of timer
The tripping circuit is equipped with a signal lamp
Resistor set for voltage division etc.
Thermal protection of the output transformer

Mains supply	The Relay Tester can be delivered for 110, 220 or 240 V AC, 50-60 Hz. Please specify one
Dimensions	280 x 178 x 178 + 63 mm
Weight	15 kg

MV 1918-1 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	± 0.1 % of reading ± 1 digit
Resolution	1 msec
Height of digits	7 mm
Mains supply	220-240 V, 50-60 Hz
Dimensions	175 x 200 x 90 mm
Weight	1 kg

Transformers

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.

To complete all those experiments the following peripheral equipment is required:

Qty	Description	Cat.Code
1 pc	Variable 3-phase transformer	MV 1103
1 pc	Terminal board	MV 1429
1 pc	Load resistor	MV 1100-235
1 pc	Load reactor	MV 1101
1 pc	Load capacitor	MV 1102
2 pcs	Voltmeter 0-500 V	MV 1926
3 pcs	Ammeter 0-2 A	MV 1922
4 pcs	Ammeter 0-12 A	MV 1923
3 pcs	Wattmeter 1 A, 0-500 V	MV 1927
4 pcs	Wattmeter 5 A, 0-500 V	MV 1928
1 pc	Load switch	MV 1500
1 set	Laboratory leads, 4 lengths, 5 colours	MV 1830-HF
1 pc	Floor stand for laboratory leads	MV 1904
1 pc	Multimeter	
1 pc	Memory oscilloscope	

MV 1911 Transformer single-phase

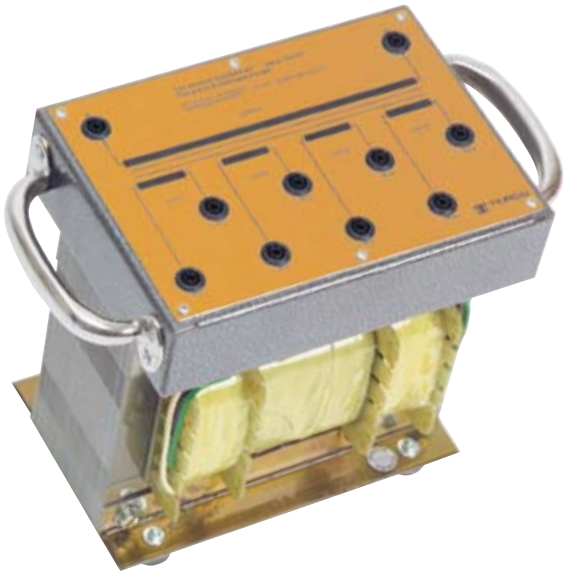
Ratings: Single-phase 1 kVA, 50-60 Hz
Primary: 230 V ± 5 %
Secondary: 4 x 57.5 V ± 5 %

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

No load losses Po = 25 W
Impedance voltage ek = 8 %
Resistance voltage ek = 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 a frontpanel with mimic diagrams.

Dimensions 210 x 150 x 210 mm
Weight 22 kg



MV 1500 Load Switch

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

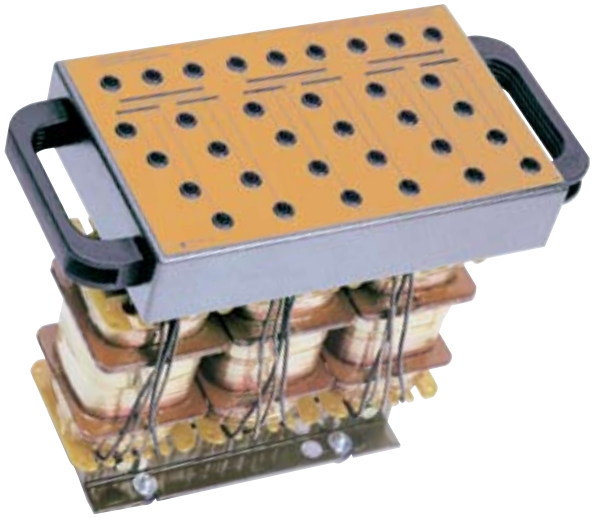
Marking of terminals: input R, S, T
output U, V, W

Dimensions 95 x 200 x 80 mm
Weight 1 kg

Transformers

MV 1915 Transformer 3-phase

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



The tappings 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 a frontpanel with mimic diagrams.

No load losses	Po = 35 W
Impedance voltage	ek = 8%
Resistance voltage	ek = 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

MV 1972 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 ± 5 % or 230 V ± 5 % per phase
Secondary voltage	2 x 66.5 V ± 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

Transformers

MV 1919 Oil Immersed Transformer

MV 1919 is designed and equipped as a normal, industrial transformer and suitable for practicing installation, commissioning, operation and maintenance.

A small size tank is included for compressed air. The tank is provided with a filling valve and a connection to test the Buchholz relay (gas detector).

Necessary peripheral equipment

Qty	Description	Cat.Code
1 pc	Load switch 440 V, 16 A	MV 1500
1 pc	Terminal board	MV 1429
3 pcs	Wattmeter 1-phase 1 A, 0-500 V	MV 1927
3 pcs	Voltmeter 0-500 V	MV 1926
3 pcs	Current transformer	MV 1931
1 pc	Variable three-phase transformer	MV 1103
1 set	Lab leads, 4 lengths, 5 colours	MV 1830
1 pc	Floor stand for laboratory leads	MV 1904
1 set	Spare parts for oil immersed transformer	MV 7002
3 pcs	Multimeter	
1 pc	LCR-meter	

Standard accessories:

1. Expansion vessel with oil level indicator, oil filler hole and test tap
2. Drying unit with oil seal (Dehydrating breather)
3. Gas detector relay with signalling and tripping contacts
4. Signal thermometer with signalling and tripping contacts
5. Porcelain bushings for 1 kV
6. Off-circuit tap changer with three positions
7. Rating plate
8. Control cubicle with terminal blocks, a protector (flashover protection with a non-linear resistor for connection to the transformer neutral point) and a voltage transformer, $\frac{400}{\sqrt{3}}$/110 V
9. Drain tray and drain valve
10. Earthing terminal
11. Lifting lugs
12. Testing equipment (tank) for gas detector relay
13. Open core current transformer, 200/1 A

Documentation

A comprehensive manual contains a description of the equipment, applied theory and instructions for a number of experiments. The exercises include tests stipulated in IEC recommendations.

Technical Data

Oil immersed 3-phase transformer	
Rated power	10 kVA
Rated frequency	50/60 Hz
Rated voltage	
Primary voltage	400 V, terminals for ± 5%
Secondary voltage	230/400 V
Cooling designation	ONAN
Connection designation	Dyn 11/Dzn 10
Impedance voltage	3.8 %
No-load losses	120 W
Load losses	320 W
Dimensions	700 x 460 x 1260 mm
Weight	220 kg

Current and Voltage Transformers

MV 1931 Current Transformer

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

Safety sockets

Accuracy class	1.0
Dimensions	95 x 200 x 80 mm
Weight	6 kg

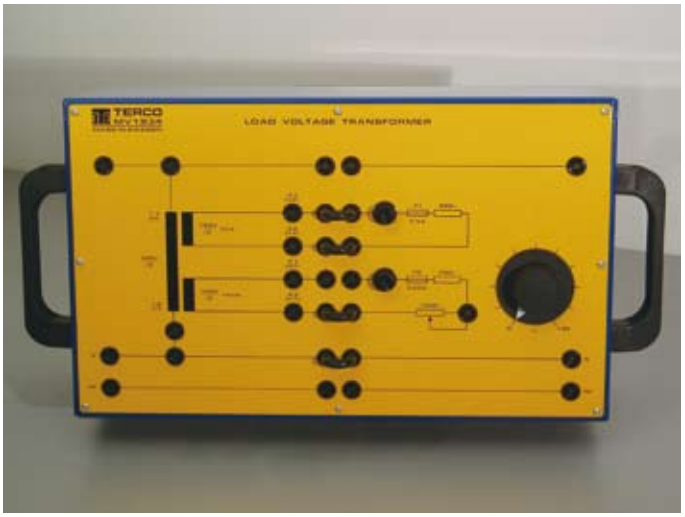
MV 1933 Current Transformer with load combinations

Current Transformer with load combinations

a. Load for the single-phase current transformer consisting of two isolated ohmic resistors.
b. Fixed resistor: about 0.5 ohm, load capacity about 7 A
c. Variable resistor: about 0 - 60 ohm, load capacity about 7 A
d. The variable resistor is protected with a fuse.
e. Scale: 0 - 100 %

Dimensions	410 x 245 x 175 mm
Weight	12 kg

MV 1934 Voltage Transformer with load combinations



a. Load for the single-phase voltage transformer consisting of two isolated ohmic resistors.
b. Fixed resistor: about 220 ohm, load capacity 0.5 A (0.5 A fuse)
c. Variable resistor: range from 300 - 1930 ohm, load capacity 0.25 A (0.25 A fuse)

Dimensions	410 x 245 x 175 mm
Weight	12 kg

Transmission

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.

MV 1420 Line Model

The model corresponds to a power transmission line of a length 136 km, voltage 77 kV, amperage 100 A, power rating 13 MW.
To complete all the experiments the following peripheral equipment (or similar) is required to MV 1420.

Qty	Description	Cat.Code
1 pc	Variable transformer	MV 1103
1 pc	Terminal board	MV 1429
1 pc	Load resistor	MV 1100-235
1 pc	Load reactor	MV 1107
1 pc	Load capacitor	MV 1102
3 pcs	Voltmeter 0-500 V	MV 1926
3 pcs	Ammeter 0-2 A	MV 1922
3 pcs	Ammeter 0-12 A	MV 1923
3 pcs	Wattmeter 5 A, 0-500 V	MV 1928
1 pc	Load switch	MV 1500
1 pc	Power factor meter	MV 1929
1 pcs	Three-phase transformer	MV 1915
1 set	Laboratory leads	MV 1830-HF
1 pc	Floor stand for lab. leads	MV 1904

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.

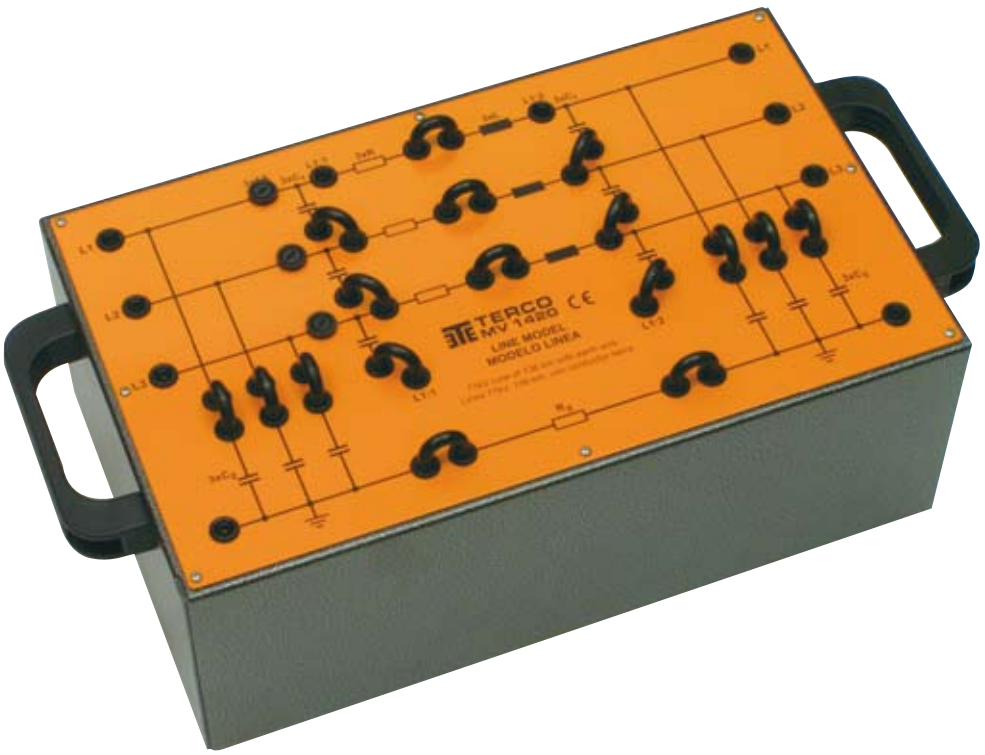
General Data

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 µF) and mutual line capacitance between phases (8 µF).

Earth impedance	0.8 ohm
Fuses	5 A
Dimensions	410 x 245 x 160 mm
Weight	10 kg

Many different line models are available in the Terco programme:
MV 1420 Line Model 77 kV, experiment voltage 220-240 V 3-ph.
MV 2221 Line Model 230 kV, experiment voltage 380-415 V 3-ph.
MV 2222 Line Model 11 kV, experiment voltage 380-415 V 3-ph.
MV 1424 Line Model 40 kV, experiment voltage 380-415 V 3-ph.
MV 1425 Line Model 130 kV, experiment voltage 380-415 V 3-ph.
MV 1438 Line Model 11 kV, experiment voltage 380-415 V 3-ph.

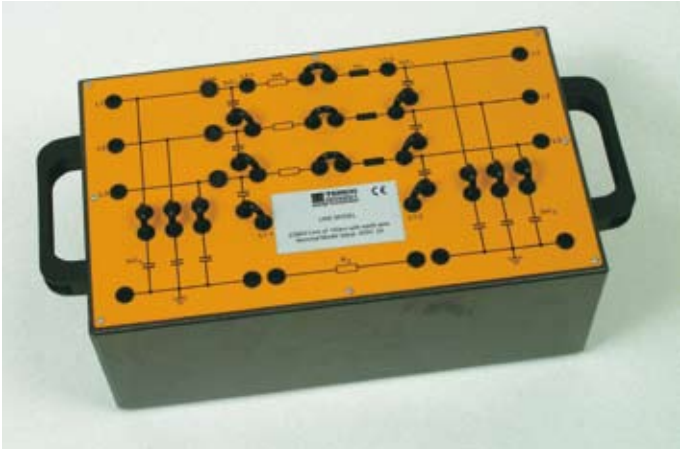


MV 2221 Line Model

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



MV 2222 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

To complete all the experiment,
the follwing peripheral equipment (or similar) is required for MV 2221 and MV 2222.

Qty	Description	Cat. Code
1 pc	Variable transformer	MV 1103
1 pc	Terminal board	MV 1429
1 pc	Load resistor	MV 1100-235
1 pc	Load reactor	MV 1107
1 pc	Load capacitor	MV 1102
3 pcs	Voltmeter 0-500 V	MV 1926
3 pcs	Ammeter 0-2 A	MV 1922
3 pc	Ammeter 0-12 A	MV 1923
3 pcs	Wattmeter 5 A, 0-500 V	MV 1928
1 pc	Load switch	MV 1500
1 pc	Power factor meter	MV 1976
1 pc	Three-phase transformer	MV 1915
1 set	Laboratory leads	MV 1830-HF
1 pc	Floor stand for laboratory leads	MV 1904

MV 2225 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)

MV 2225 is to be used together with the Line Models MV 1420, MV 2221 and MV 2222.

Dimensions	410 x 245 x 160 mm
Weight	11 kg

Transmission

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.

MV 1424 Line Model

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 capitance 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 ohm
R_0 = 0.8 ohm
X_1 = 2ϖω x 5.45 mH
X_0 = 2.62 ohm
C_1 = 1.0 µF
C_0 = 0.6 µF

Dimensions	600 x 600 x 1720 mm
Weight	190 kg

Transmission

MV 1425 Line Model

Real line parameters

Nominal length	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 sequense 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

Line Model 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 ohm
R_0 = 0.8 ohm
X_1 = 2ϖω x 3.77 mH
X_0 = 1.57 ohm
C_1 = 8.9 µF
C_0 = 0.6 µF

Dimensions	600 x 600 x 1720 mm
Weight	220 kg

Transmission

MV 1438 Cable Model

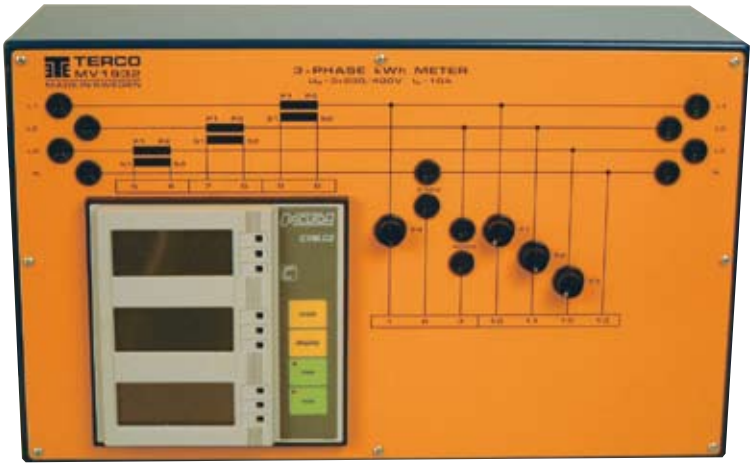
MV 1438 consists of two cable sections with a nose section cable area of 150 square mm and 240 square mm respectively.

Real line parameters		Line Model specs
PEX Cable 150 square mm Al		(one ϖ-link)
Length	5 km	corr. 5 km
Nominal voltage	11 kV	400 V
Nominal current	260 A	6 A
Transmission ability	5.0 MVA	2.4 kVA
Positive sequence capitance C+	0.45 µF	0.28 µF
Zero sequence capitance C0	0.45 µF	0.28 µF
Inductance	1.8 mH	2.84 mH
Resistance	1.1 ohm	1.8 ohm
Zero sequence reactance X_0 (approx.)	2.3 ohm	3.7 ohm

Real line parameters		Line Model specs
PEX Cable 240 square mm Al		(one ϖ-link)
Length	5 km	corr. 5 km
Nominal voltage	11 kV	400 V
Nominal current	340 A	6 A
Transmission ability	6.5 MVA	2.4 kVA
Positive sequence capitance C+	0.55 µF	0.26 µF
Zero sequence capitance C0	0.55 µF	0.26 µF
Inductance	1.6 mH	3.30 mH
Resistance	0.7 ohm	1.5 ohm
Zero sequence reactance X_0 (approx.)	2.1 ohm	4.3 ohm

Dimensions	600 x 600 x 1720 mm
Weight	190 kg

Three-phase Universal Energy Meter / Analyser



MV 1932-1 Three-phase Universal Energy Meter / Analyser

This unit is a microprocessor controlled three-phase energy meter / analyser with three or four wire unbalanced load

MV 1932-1 is an universal energy meter for measuring kWh, kVAr and Maximum Demand.

The following will be applied for all three instrument functions.

1. Use a power supply which can give a 3-phase voltage and a corresponding current according to what is written on the front of the instrument.

2. It is not necessary to keep a constant voltage exactly according to what is given as nominal voltage. If, for example, you use an instrument designed for 3 x 230 V, it is recommended to connect a supply voltage around this value like 200-250 V.

3. It is not necessary to keep a constant current exactly according to what is given as nominal current. If, for example, you use an instrument designed for 10 A, it is recommended to run a current around 1-6 A because of practical reasons regarding the load configurations.

All experiments follow about the same set-up which consist of:

1. A power supply
2. The power meter
3. Three loads – resistive, inductive and capacitive
4. An ammeter or rather a clamp-on ammeter
5. A voltmeter
6. A timer or a wrist-watch with a timer function.

General data :

Programming	From the front
Main functions	kWh, kVArh (cap/ind), Max demand
Secondary read-outs	cosφ, W, VAr (cap/ind), voltages, values of power
Voltage input	3 x 230 V and 3 x 400 V
Current input	10A nominal, 20 A max
Operation frequency possible	50-60 Hz nominal, 20 – 800 Hz
Number of scales	3 x 4 digits
Scale response	1.5 sec
Power supply	From test circuit
Dimensions	410 x 245 x 175 mm
Weight	17 kg

Load Units

MV 1100 Load Resistor

Load resistor MV 1100 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. A cooling fan is placed in the bottom of the resistor.

MV 1100-235 Cooling fan supply 230 V AC 50 - 60 Hz
MV 1100-116 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

MV 1101 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

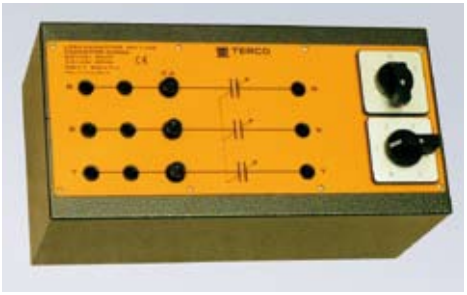
2.5 kVAr, 50-60 Hz

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

MV 1102 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.



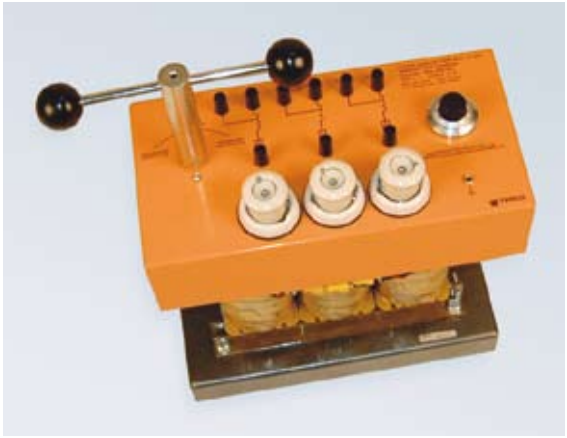
General Data

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	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	60	2.5-15

Dimensions	185 x 370 x 170 mm
Weight	7 kg

MV 1107 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.

General Data

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	

Rheostats

Rheostats 100-500 W

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 agains 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.

Standard Types

Order No.	Power W	Re-sistance Ohm	Max. current A	Dimen-sions
MV 1953	100	1	10.00	
MV 1954	100	10	3.20	
MV 1955	100	100	1.00	
MV 1956	100	1000	0.30	140x130 x 145
MV 1957	200	5	6.30	
MV 1958	200	15	3.70	
MV 1959	200	50	2.00	
MV 1960	200	300	0.80	
MV 1966	200	40	2.25	
MV 1961	500	150	1.80	
MV 1962	500	500	1.00	
MV 1963	500	2500	0.45	215x195
MV 1964	500	5000	0.30	x 230
MV 1965	500	10000	0.20	

Power Distribution System increases Safety in School Laboratories

Terco´s Power Distribution System consists of a distribution board which is installed near the classroom. Each circuit is protected by a MCB, making energising and isolating a simple process for the teacher. There is also a protection device which breaks the voltage in the event of accidental disturbance in any phase. An emergency stop is placed in a prominent position in the classroom and will break all supplies when operated.

Voltage system in the lab: 400/230 V 3-ph and 230 V 1-ph
Incoming voltage 400/230 V 3-ph

Other voltages available on request.

TF 1251 Distribution Panel

The distribution panel is manufactured in varnished sheet metal and used for separate distribution of power to each lab. group (student panel). It contains one main switch, eleven 3-pole 16 A MCB (miniature circuit breakers), one ELCB (earth leakage circuit breaker), one indicator lamp and lockable ON-key. The distribution panel breaks the supply voltage when a current > 30 mA flows in the protection lead.

TF 1251 is wired for connection of outgoing groups to each MCB. The incomming wires to be connected to the main switch.

Dimensions	480 x 330 x 60 mm
Weight	10 kg

TF 1252 Student Panel for table mounting

Comprising:
One 3-pole main switch 16 A
One MCB (Micro Circuit Breaker) 10 A
Three 2-pole, 2-way earthed wall sockets
One 3-ph socket CEE
One protective earth terminal
Junction line for distribution of any AC or DC voltage

Dimensions	600 x 120 x 75 mm
Weight	approx. 4 kg

TF 1253 Transformer

10 kVA intermittent
The transformer is air cooled and enclosed in sheet metal for placement on the floor.

Main voltage	3-ph 380-415 V +/-5% 50-60 Hz
Connection	D/Y-0
Secondary	3-ph 380-415 / 220-240 V 50-60 Hz
Dimensions	420 x 250 x 420 mm
Weight	85 kg

TF 1229 Contactor with Thermal Protection

Enclosed in a plastic cover
Current: 16-24 A

For transformer TF 1226 and TF 1253

Dimensions	142 x 115 x 112 mm
Weight	1 kg

TF 1211 Emergency Stop

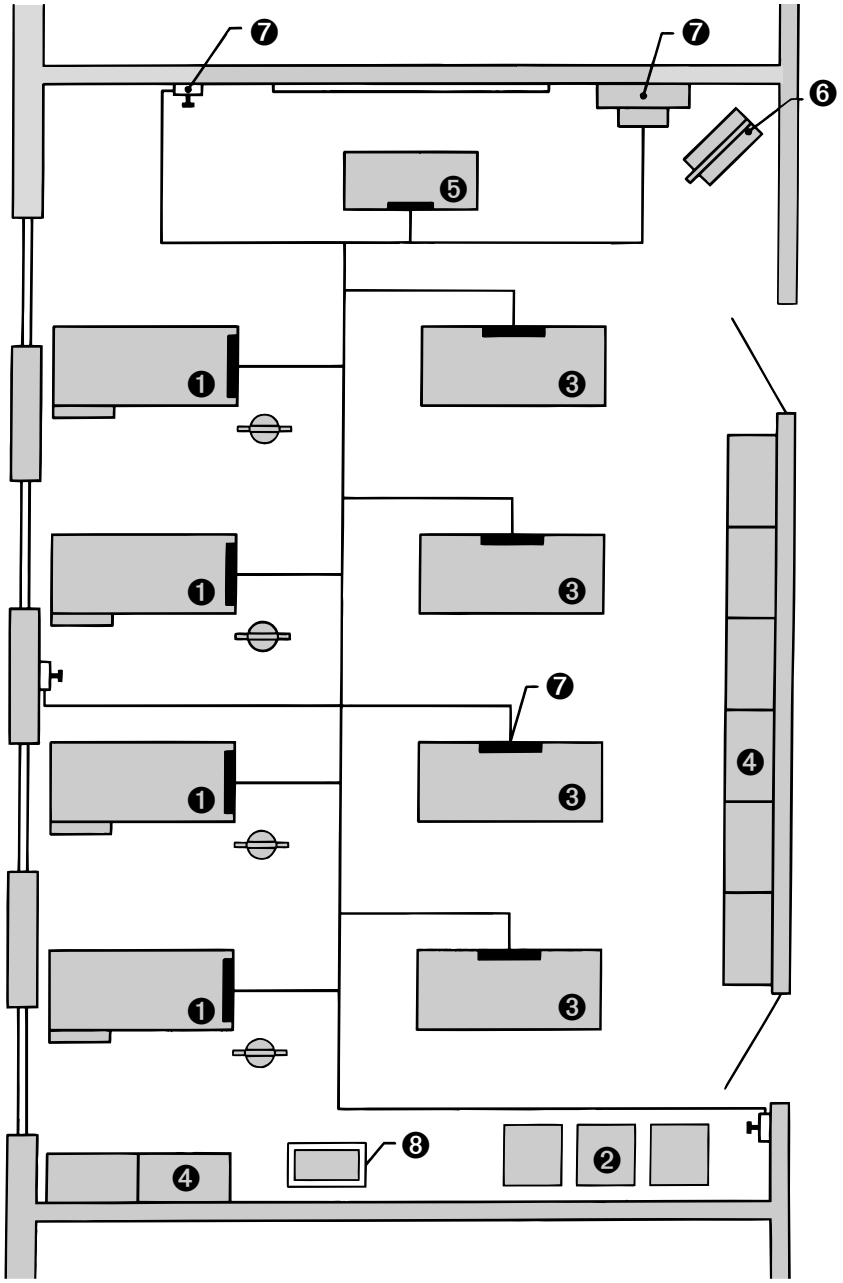
Dimensions excluding the sign:	70 x 70 x 70 mm
Weight	0.2 kg

Emergency sign in English enclosed

See also our brochure: *Power Distribution System and Furniture for Laboratories*

Laboratory Layout

The layout is most important when designing a functional laboratory. It is of great importance that equipment and furniture are taken into account early in the planning stage. A standard solution for planning a laboratory for 16 students can be seen below. If the space of the laboratory has been determined already, the standard solution may not be applicable. Our engineers will be pleased to advise on any individual requirements. See also our brochures for Power Distribution System and Furniture for Laboratories.



❶ Three-phase benches for accessories such as protective relays, loads, power supplies, switches, flex stands with flexes.

❷ Line models, floor standing.

❸ Four benches for experiments on transformers or for theoretical follow-up of the experiments.

❹ Cabinets for instruments, tools and accessories.

❺ Teacher desk.

❻ Roller table.

❼ Terco Safety Power Distribution System with key-operated central, transformer, student-panels and emergency stops.

❽ Oil immersed transformer.

Flexes

Terco Flex

The Terco Flex complies with the safety requirement that connection shall not be made sideways, as well as with all reasonable demands on a laboratory flex.

Moulded soft PVC covering for high reliability cable anchorage.

General Data

Standard colours	blue, read, yellow, black, yellow/green
Standard area	2.5 mm² containing 650 wires of 0.07 mm diameter
Rated current	25 A

MV 1830 Flex Set

Set of 100 Leads in 5 colours. Area 2.5 mm²

	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

MV 1830 Flex set also exists with double quantities of flexes as code no MV 1801

Separate Flexes

Area 2.5 mm². Please note, each Ref. No. refers to a pack of 10 leads.

	25 cm	50 cm	100 cm	200 cm
Red	MV 1802	MV 1807	MV 1812	MV 1817
Yellow	MV 1803	MV 1808	MV 1813	MV 1818
Blue	MV 1804	MV 1809	MV 1814	MV 1819
Black	MV 1805	MV 1810	MV 1815	MV 1820
Yellow/green	MV 1806	MV 1811	MV 1816	MV 1821

Laboratory Flexes with Safety Plugs

Safety lead with 2 covered spring plugs of 4 mm diameter, with stiff protection sockets 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. Colours black, red, blue, yellow, green/yellow. Rated current 16 A.

MV 1830-HF Flex set also exists with double quantities of flexes as code no MV 1801-HF

MV 1830-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

Separate Flexes

Area 1.5 mm²
Please note, each Ref. No. refers to a pack of 10 leads.

	25 cm	50 cm	100 cm	200 cm
Red	MV 1802-HF	MV 1807-HF	MV 1812-HF	MV 1817-HF
Yellow	MV 1803-HF	MV 1808-HF	MV 1813-HF	MV 1818-HF
Blue	MV 1804-HF	MV 1809-HF	MV 1814-HF	MV 1819-HF
Black	MV 1805-HF	MV 1810-HF	MV 1815-HF	MV 1820-HF
Yellow/Green	MV 1806-HF	MV 1811-HF	MV 1816-HF	MV 1821-HF

Accessories

MV 1429 Terminal Board

The box has safety outlets for laboratory leads with 4 mm diameter plug pins. These outlets are connected to a 5 x 2.5 mm2 cable of 1.5 m length and cable connection for a diameter of 5.5 mm.

The connection box is equipped with miniature circuit breakers for 20 A.

Dimensions	250 x 240 x 75 mm
Weight	2.0 kg

MV 1104 Variable Transformer 1-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.
4 mm safety outlets.

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

MV 1103 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.
Same technical data as MV 1104 above.

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

MV 1103-415 Variable Transformer

Input 3 x 415 V, 8 A (maximum values), 50-60 Hz
Output 3 x 0-415 V, 8 A

Same technical data as MV 1103 above.

MV 1300 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. All outputs are fused by MCB´s and have load switches. The Power Pack has also Earth Leakages Circuit Breaker (ELCB).

General Data

MV 1300-235 Supply voltage 220-240 / 127-140 V 50 / 60 Hz 3-ph.
MV 1300-405 Supply voltage 380-400 / 220-230 V 50 / 60 Hz 3-ph.
MV 1300-415 Supply voltage 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	

MV 1305 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.

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.

This unit is also suitable to be used together with Terco´s Frequency Relay Trainer MV 1437

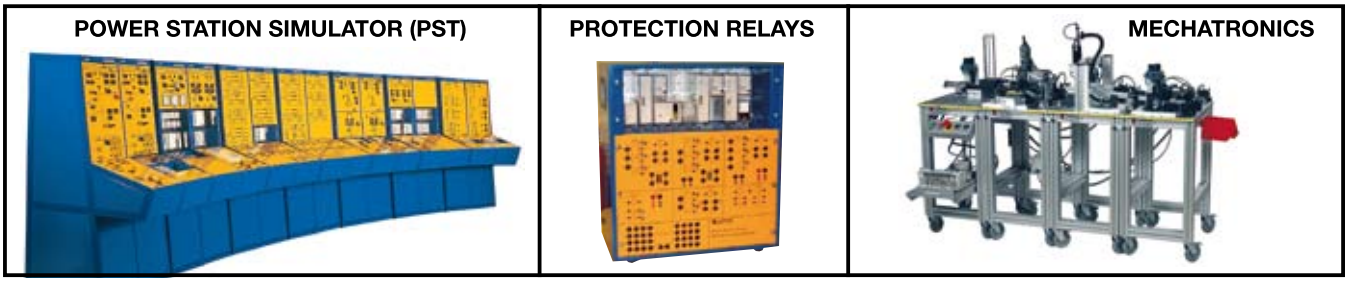
Technical Specification		**MV 1305-405**	**MV 1305-235**
Power Supply	Voltage	380-415 V AC 3-ph	380-415 V AC 3-ph
	Frequency	50-60 Hz	50-60 Hz
	Max current	16 A	16 A
Turbine/DC-machine	Armature volt	0-240 V DC	0-240 V DC
	Field volt	190 V DC	190 V DC
	Armature current	12 A	12 A
	Field current	0.8 A	0.8 A
	Power	2.0 kW	2.0 kW
	Speed	0-1800 rpm	0-1800 rpm
Synchronous generator	Armature volt	0-240 / 415 V AC	0-140 / 240 V AC
	Power	1.2 kVA	1.2 kVA
	Cos φ	0.8	0.8
	Field volt	0-230 V DC	0-230 V DC
	Speed	0-1800 rpm	0-1800 rpm
Speed control/ Active power control	SCR-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:

DC-machine (Turbine simulator)	Armature voltage Armature current Indication lamp for field voltage Speed control potentiometer (=frequency control) Control method selector
AC-machine	Armature voltage Voltage selector switch Armature current Voltage control potentiometer Control method selector Field current ammeter
Synchronizing devices	Synchronizing instrument Double voltmeter Double frequency meter Synchronizing switch
Dimensions	1550 x 800 x 1200 mm
Weight	200 kg (approx.)

Terco Headoffice

Terco headoffice and factory outside Stockholm, Sweden.



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