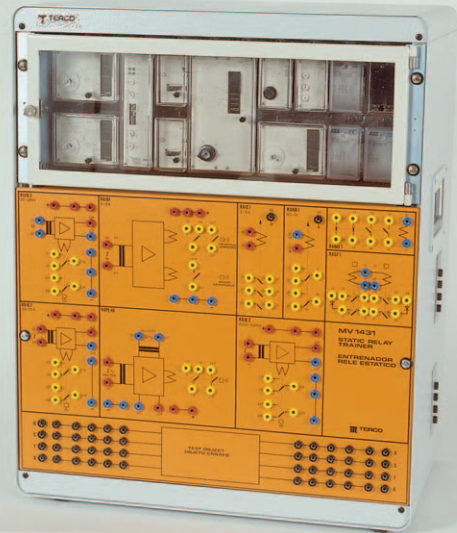
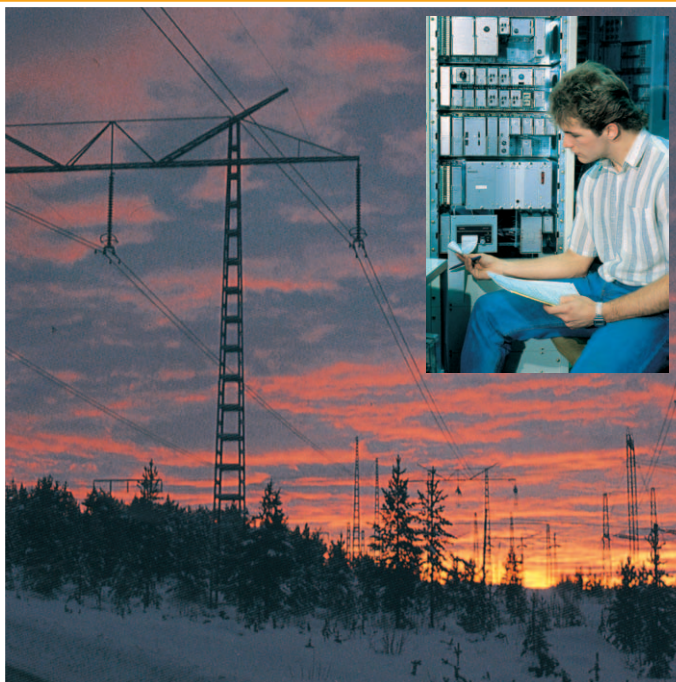




# Transmission Line, Transformer & Protection Laboratory



# Transmission Line, Transformer & Protection Laboratory

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 to be used at various levels for training in vocational schools, universities, organisations and industrial learning centres all over the world.

TERCO has delivered equipment to more than 65 countries throughout the world.

TERCO AB – one of the leading companies in technical education world-wide.

## Guarantee & Terms

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The guarantee is valid for 12 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.

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# Protective Relays

## MV 1431 Static Relay Trainer

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

The static relays used in the experiment unit belong to the well known ABB COMBIFLEX relay system. The unit is in form of a cubicle, made of a painted sheet metal enclosure with front panel, racks for relays and an auxiliary DC voltage supply.

Mimic diagrams of the relays with large clear symbols are printed on the front panel, and the connection and measuring points of the relays are led out to 4 mm banana plug safety sockets in various colours. Sockets are also provided for test objects.

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

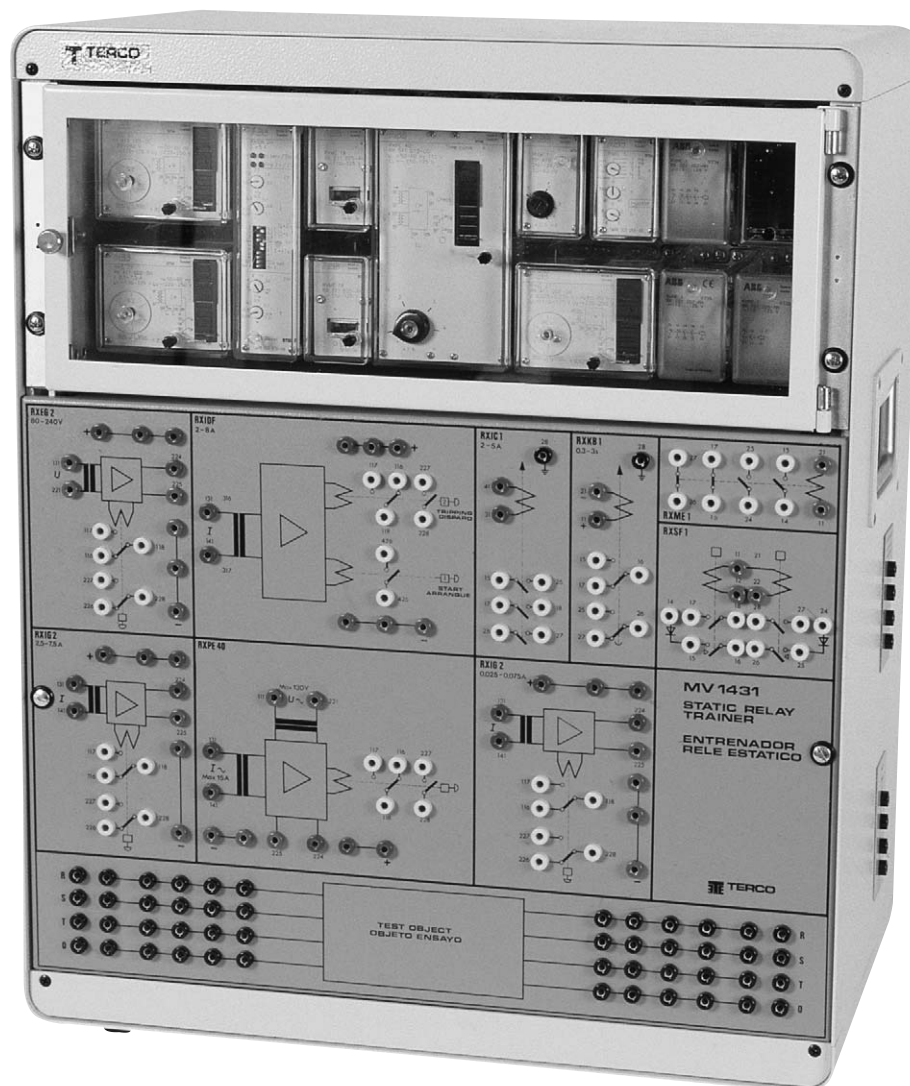
Following relays are provided:

1. Instantaneous voltage relay
2. Instantaneous low current relay
3. Time-lag overcurrent relay
4. Directional relay
5. Adjustable current relay
6. Time-lag relay
7. Instantaneous high current relay
8. Auxiliary relay
9. Signal relay

Supply voltage 220-240 V, 50-60 Hz

Dimensions 510 x 280 x 570 mm

Weight 30 kg





# Protective Relays

The laboratory manual for the Static Relay Trainer MV 1431 is divided into two parts:

Part A, dealing with construction and function of various types of protective relays.

Part B, which covers both medium level and advanced experiments on relay protection.

## Curriculum of experiments in Part A:

Preface

Description of relay unit

The static relay

Examples of symbols for operation and relay protection

Introductory exercise

Instantaneous measuring relays for ac

Operating and resetting values

Power consumption

Pick-up times

Static and electromechanical relay

Operating and resetting values

Power consumption

Effect of the dc component

Time-lag overcurrent relay

Operating resetting values for starting function without tripping function

Inverse time curves

Instantaneous operation

Directional relay for power or current with inverse time characteristic

Operating time curve

Effect of voltage

Effect of phase angle

## Curriculum of experiments in Part B

### Medium level:

Preface

Description of relay unit

The static relay

Examples of symbols for operation and relay protection

Directional overcurrent protection

Neutral point voltage sum current

Directional earth fault protection

Differential protection

### Advanced level:

Loss-of-sync and reverse power protection

## Recommended peripheral equipment:

Qty	Description	Cat. Code
	Part A	
	Power pack	MV 1300
	(alt MV 1103 Variable transformer 3-ph)	
3 pcs	Load switch	MV 1500
1 pc	Selector switch	MV 1501
1 pc	Digital timer	MV 1918
2 pcs	Rheostat 100 W/1000 $\Omega$	MV 1956
1 pc	Rheostat 200 W/5 $\Omega$	MV 1957
1 pc	Rheostat 200 W/50 $\Omega$	MV 1959
1 pc	Single phase transformer	MV 1911
1 pc	Diode 10 A	MV 1433
1 pc	Load capacitor	MV 1102
1 set	Laboratory leads	MV 1830
1 pc	Floor stand for laboratory leads	MV 1904
4 pcs	Digital multimeter	

### Medium level, Part B

#### In addition to the equipment above

1 pc	Selector switch	MV 1501
2 pcs	Rheostat 100 W/1 $\Omega$	MV 1953
1 pc	Rheostat 200 W/5 $\Omega$	MV 1957
1 pc	Rheostat 500 W/150 $\Omega$	MV 1961
1 pc	Rheostat 500 W/500 $\Omega$	MV 1962
1 pc	Rheostat 500 W/2500 $\Omega$	MV 1963
2 pcs	Push button panel	MV 1400
2 pcs	Contactors	MV 1402
3 pcs	Current transformer	MV 1931
1 pc	Three phase transformer	MV 1915
1 pc	Load resistor	MV 1100
1 pc	Load reactor	MV 1101
2 pcs	Line model	MV 1420
2 pcs	Digital multimeter	

### Additional equipment for advanced level, Part B

1 pc	Synchronizing unit	MV 1903
1 pc	Latch on contactor	MV 1430
1 pc	DC machine	MV 1006
1 pc	Synchronous machine	MV 1008
1 pc	Machine bed	MV 1004
1 pc	Shunt rheostat	MV 1905
1 pc	AC-tachometer gen.	MV 1025
1 pc	Revolution counter	MV 1925
1 pc	Powerpack	MV 1300
	(if not ordered in Part A)	

# 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 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 an optical fiber built-in serial port, brings distance protection relay close to the user, whether he 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

### Features

The line distance protection terminal is based on the basic 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
- Separate and independent impedance measuring elements for the General Fault Criteria (GFC) with advanced characteristics

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 or corresponding)
- Faults on a high voltage line (MV 1425 or corresponding)

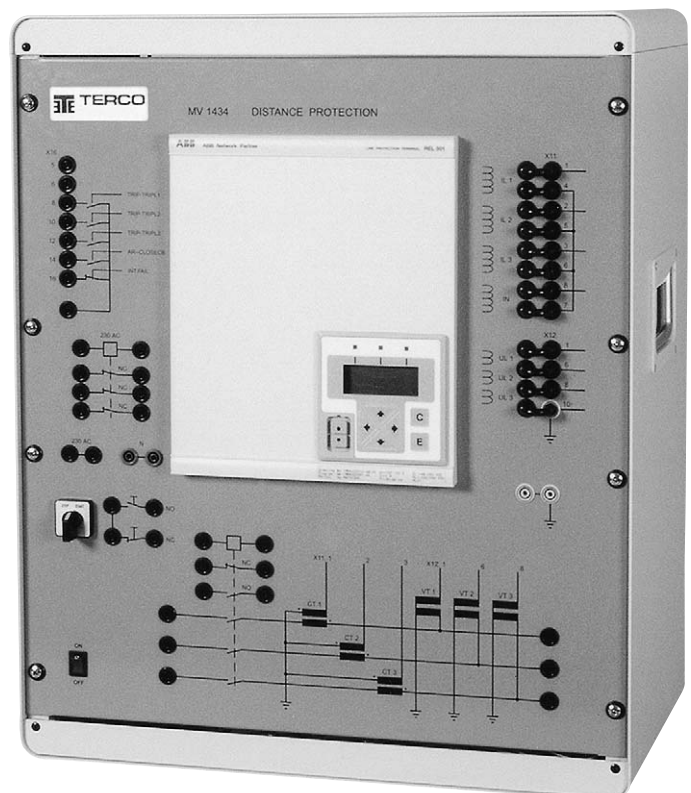
### Recommended external laboratory equipment

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	Three-phase power supply 0-230 V	MV 1103
1 pc	Terminal board	MV 1429
1 pc	Single-phase 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	Three-phase load resistor 230 V, 5 A	MV 1100
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
1 pc	Stand for lab. leads	MV 1904

Supply Voltage 220-240 V, 50-60 Hz

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

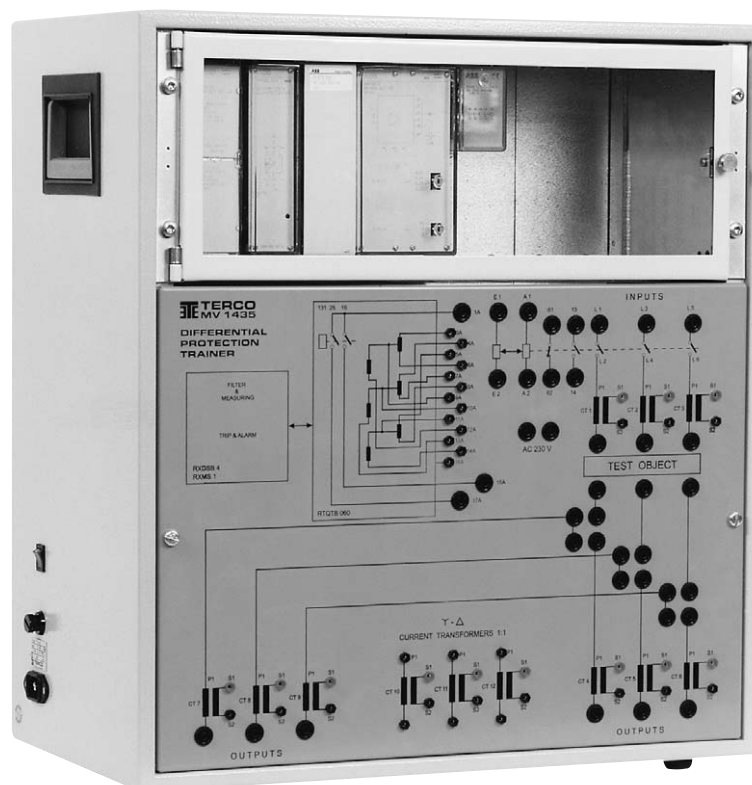
1 pc	Experiment transformer, single-phase	MV 1911
1 pc	Experiment transformer, three-phase	MV 1915
2 pcs	Voltmeter 250 V	MV 1926
1 pc	A-meter 1 A and 2 A, or multimeter	MV 1922
4 pcs	A-meter 6 A and 12 A, or multimeters	MV 1923
1 pc	Variable transformer three-phase	MV 1103
		(or MV 1300)
1 pc	Terminal Board	MV 1429
3 pcs	Rheostat 0-5 ohm, 6.3 A	MV 1957
1 pc	Three-phase load resistor 230 V, 5 A	MV 1100
1 pc	Rheostat 0-50 ohm. 2.0 A	MV 1959
1 pc	Pushbutton box for the breaker	MV 1400
1 pc	Switch	MV 1500
1 pc	Timer	MV 1918
1 pc	Capacitor load bank	MV 1102
1 pc	Reactor load bank	MV 1101
1 set	Laboratory leads	MV 1830
1 set	Clip-on ammeter or multimeter with a current probe (50 mA)	
1 pc	Ohmmeter (Multimeter)	
1 pc	Oscilloscope	

### Optional

1 pc	Test handle	MV 1233
------	-------------	---------

Supply Voltage      220-240 V, 50-60 Hz

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 safety 4 mm 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.

### 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

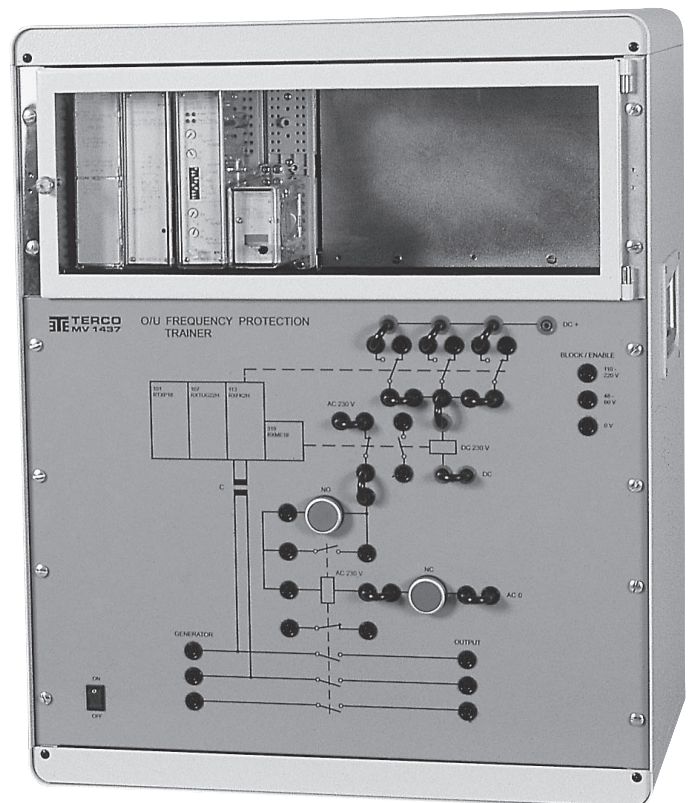
### Setting possibilities:

- 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.





## Protective Relays

### MV 1427 Relay Testing Unit

#### 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 readout +0, -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 Testing Unit 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 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.

The counter is working up to about 400 V.

#### General Data

Two measuring ranges	1-9999 ms 0.01-99.99 s
Accuracy	± 1 ms
Height of digits	7 mm
Mains supply	220-240 V, 50-60 Hz
Dimensions	130 x 135 x 65 mm
Weight	1 kg



# Protective Relays

## MV 1428 Protective Relays Installation Kit

### Design

The equipment is built up in modular system ABB-COMBIFLEX. This system provides a means of assembling complete equipment of modularised plug-in apparatus, terminal bases, connectors, branch connectors, cross connection terminals and accessories.

### Application

The installation kit is mainly intended for practicing diagram reading, installation, commissioning, operation and maintenance of equipment for control and protection. Together with the oil immersed transformer MV 1919, several different signal and protection schemes can be installed.

### The main components are:

1. Apparatus cubicle
2. Earth fault protection
3. Voltage relay
4. Low voltage relay
5. Current relay
6. Time lag relays
7. Test switch
8. Rectifier
9. Signal system

### Documentation

The comprehensive booklet contains a description of the equipment, applied theory, diagrams and wiring tables together with instructions for a number of exercises.

### Recommended peripheral equipment

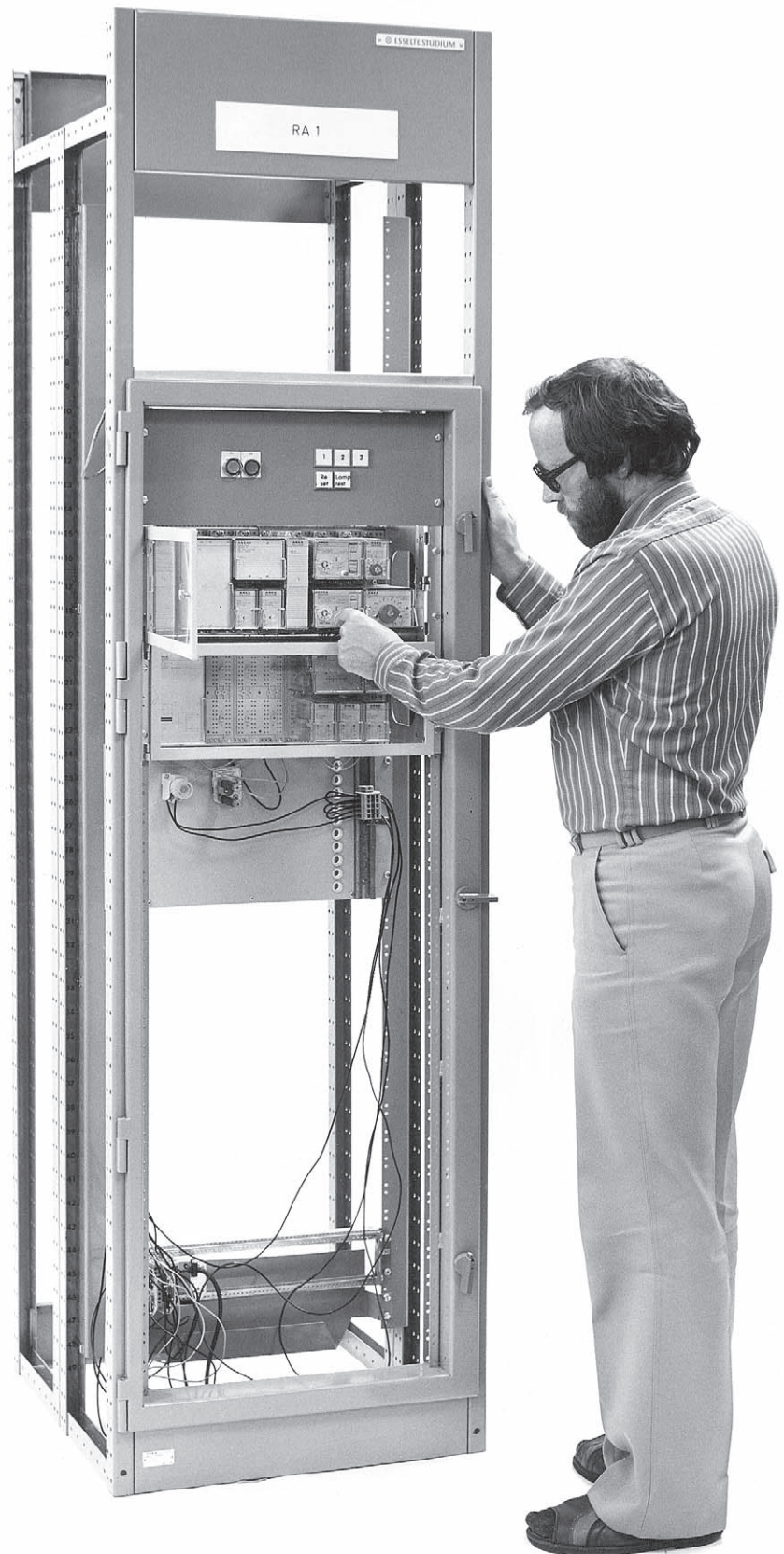
MV 1234	Tool set for installation, connection and testing
MV 1824	Set of cables and connection devices
MV 1427	Relay testing unit
MV 1430	Circuit breaker simulator
MV 1919	Oil immersed transformer
MV 1429	Terminal board
MV 1500	Load switch
MV 1105	Load resistor
MV 7003	Spare part set for MV 1428
	Multimeter

### General Data

#### Relays

Rated frequency	50-60 Hz
Auxiliary voltage	220-240 V AC

Dimensions	600 x 650 x 2250 mm
Weight	50 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.

Together with the Protective Relay Kit MV 1428, it is possible to practice also diagram and connection chart reading, as well as installation, wiring and testing protective relays.

### 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
	Spare parts for oil immersed transformer	MV 7002
3 pcs	Multimeter	
1 pc	LCR-meter	

### Specifications

#### Standard accessories:

- Expansion vessel with oil level indicator, oil filler hole and test tap
- Drying unit with oil seal (Dehydrating breather)
- Gas detector relay with signalling and tripping contacts
- Signal thermometer with signalling and tripping contacts
- Porcelain bushings for 1 kV
- Off-circuit tap changer with three positions
- Rating plate
- 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
- Drain tray and drain valve
- Earthing terminal
- Lifting lugs
- Testing equipment for gas detector relay
- 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	220-400 V, terminals for $\pm 5\%$
Secondary voltage	220-400 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





# 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 three-phase transformer	MV 1103
1 pc	Load resistor	MV 1100
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 pc	Laboratory leads, 4 lengths, 5 colours	MV 1830
1 pc	Floor stand for laboratory leads	MV 1904
1 pc	Memory oscilloscope	
1 pc	Multimeter	

### MV 1911 Transformer single-phase

Ratings                      Single-phase 1 kVA, 50-60 Hz,  
                                     Primary: 220 V  $\pm$  5 %  
                                     Secondary: 4 x 55 V  $\pm$  5 %

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

No load losses         $P_0 = 25$  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.

Dimensions              210 x 150 x 210 mm  
 Weight                    22 kg



### 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





## Transformers

### MV 1915 Transformer 3-phase

Ratings	Three-phase, 2 kVA, 50-60 Hz, 220/2 x 63.5 V per phase
Primary	0-127-220 V $\pm$ 5 % per phase
Secondary	Two 63.5 V windings per phase, each winding having tapings for 0-36.7-42-63.5 V ( $\pm$ 5 %)

The tapings are so arranged that 220 V (star or delta connection) and 127 V (star, delta or zig-zag connection) can be obtained for all standard connections.

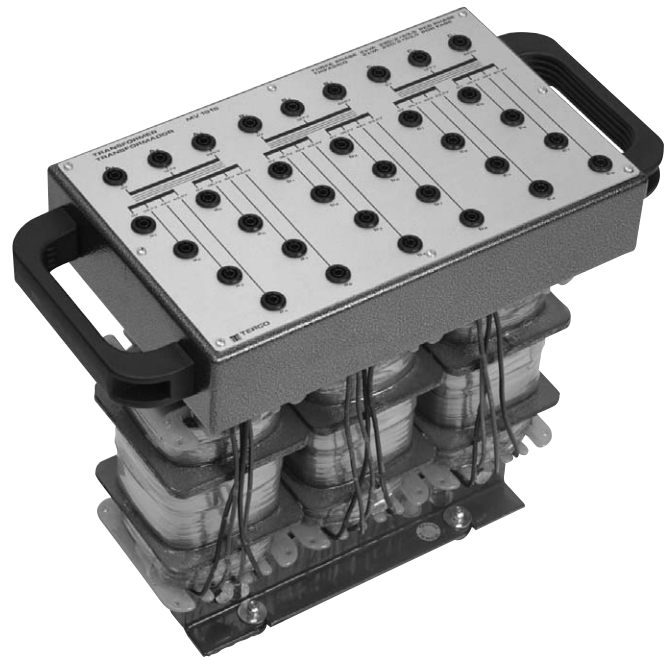
This transformer has safety sockets.

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

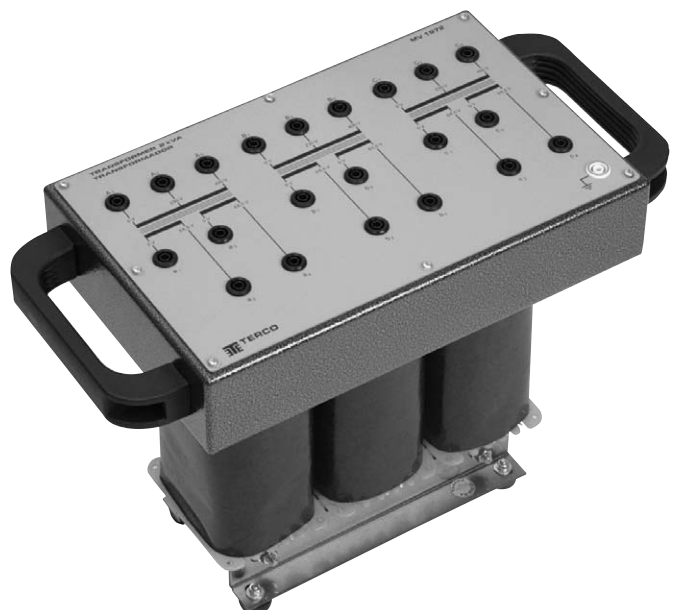


### MV 1972 Transformer 3-phase

This transformer has an E-type core and is suitable for setting up a variety of circuits for 3-phase transformers. Made with 2 x 2 scarf joints. MV 1972 has safety sockets.

#### 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 70 V $\pm$ 5 % per phase
Number of turns	70 V winding, 105 turns 2.27 mm diam.
Number of turns	400 V winding, 586 turns, 1.33 mm diam.
Test voltage	2.5 kV
Efficiency	92 %
Percentage impedance voltage	4 % approx.
Dimensions	350 x 165 x 260 mm
Weight	30 kg



# Transmission

## MV 1420 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.  
Earth fault.

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	Load resistor	MV 1100
1 pc	Load reactor	MV 1101
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 1 A, 0-500 V	MV 1927
3 pcs	Wattmeter 5 A, 0-500 V	MV 1928
1 pc	Load switch	MV 1500
1 pc	Power factor meter	MV 1929
2 pcs	Three-phase transformer	MV 1915
1 set	Laboratory leads	MV 1830
1 pc	Floor stand for laboratory leads	MV 1904

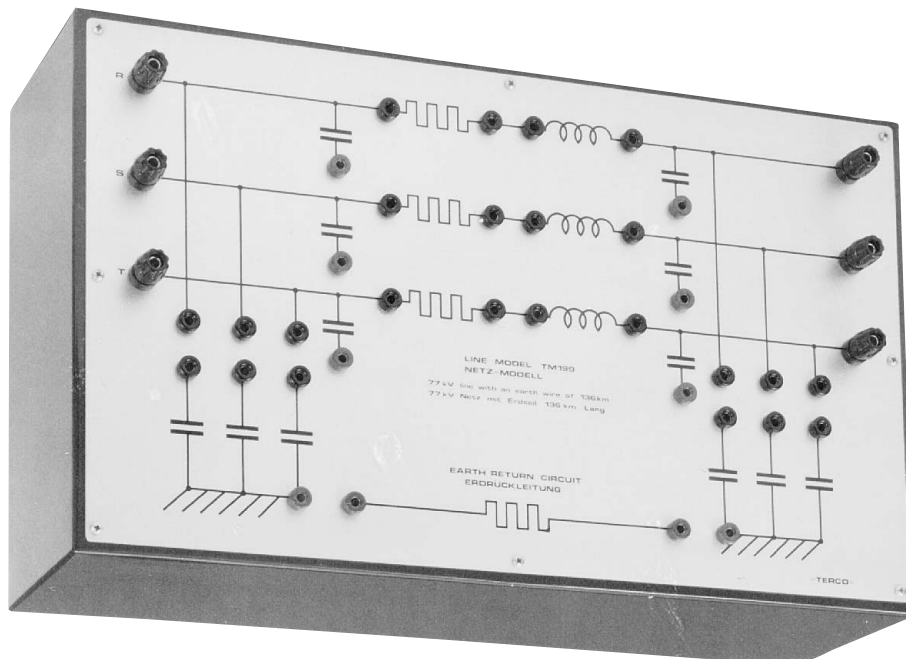
The model corresponds to a power transmission line of a length 136 km, voltage 77 kV, amperage 100 A, power rating 13 MW.

### 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 $\mu$ F) and mutual line capacitance between phases (8 $\mu$ F).	
Earth impedance	0.8 ohm
Fuses	5 A
Dimensions	410 x 245 x 160 mm
Weight	10 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 models is representing a high voltage line – 130 kV or higher, and the other a feeder at medium level 40 kV.

All models are constructed as  $\pi$ -links, the HV model and the cable model as a double  $\pi$ -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  $\pi$ -links make it possible to create other characteristic data, e.g. capacitors can be connected in  $\Delta$  instead of Y.

## MV 1424 Line Model

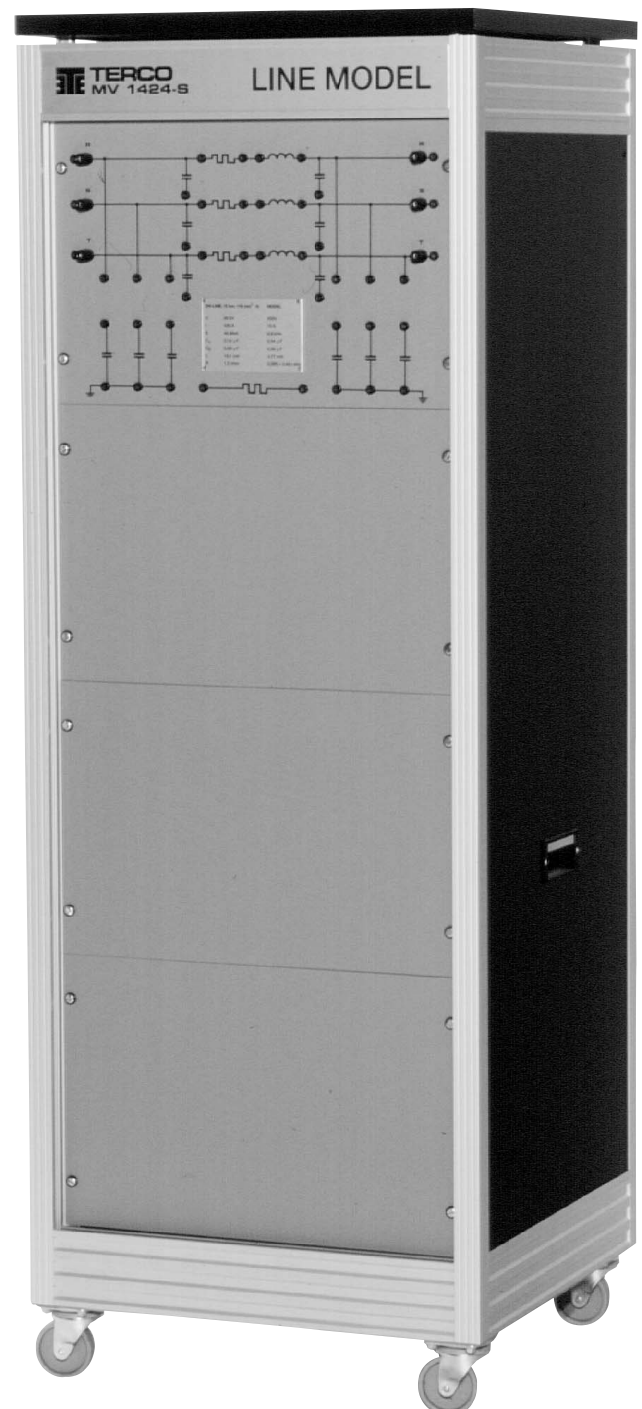
Real line parameters

Nominal length	40 km
Nominal voltage	40 kV
Nominal current	350 A
Positive sequence reactance $X_+$	15 ohm
Zero sequence reactance $X_0$	23 ohm
Positive sequence resistance $R_+$	8.4 ohm
Zero sequence resistance $R_0$	16.0 ohm
Positive sequence capacitance $C_+$	400 nF
Zero sequence capacitance $C_0$	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
$X_1 = 2\pi\omega \times 5.45$ mH	
$C_1$	1.0 $\mu$ F
$C_0$	0.6 $\mu$ F

Dimensions	550 x 550 x 1600 mm
Weight	90 kg



# Transmission

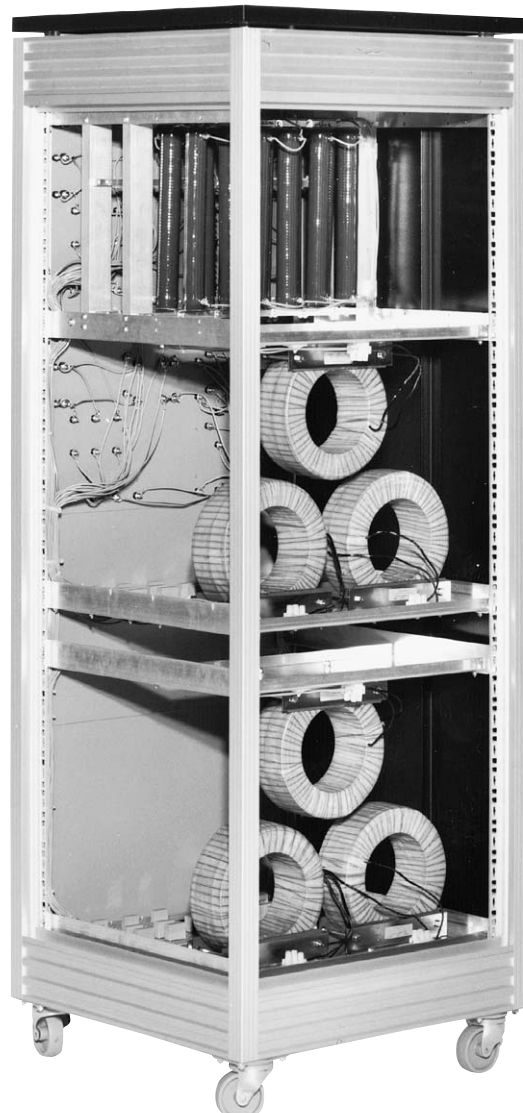
## MV 1425 Line Model

### Real line parameters

Nominal length	100 km (2 sections, each 50 km)
Data for one 50 km section:	
Nominal voltage	130 kV or higher
Nominal current	775 A
Positive sequence reactance $X_+$	18 ohm
Zero sequence reactance $X_0$	24 ohm
Positive sequence resistance $R_+$	1.77 ohm
Zero sequence resistance $R_0$	8.0 ohm
Positive sequence capacitance $C_+$	475 nF
Zero sequence capacitance $C_0$	315 nF

### Line Model specifications

Represented length	100 km with two $\pi$ -links, each corresponding to a 50 km section
Data for one $\pi$ -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
$X_1 = 2\pi\omega \times 3.77$ mH	
$C_1$	8.9 $\mu$ F
$C_0$	0.6 $\mu$ F
Dimensions	550 x 550 x 1600 mm
Weight	120 kg





# Transmission

## MV 1438 Cable Model

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

Real line parameters		Line Model specs
PEX Cable 150 square Al		(one $\pi$ -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 capacitance $C_+$	0.45 $\mu$ F	0.28 $\mu$ F
Zero sequence capacitance $C_0$	0.45 mF	0.28 mF
Inductance	1.8 mH	2.84 mH
Resistance	1.1 ohm	1.8 ohm

Real line parameters		Line Model specs
PEX Cable 240 square Al		(one $\pi$ -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 capacitance $C_+$	0.55 $\mu$ F	0.26 $\mu$ F
Zero sequence capacitance $C_0$	0.55 $\mu$ F	0.26 $\mu$ F
Inductance	1.6 mH	3.30 mH
Resistance	0.7 ohm	1.5 ohm

Dimensions	550 x 550 x 1600 mm
Weight	90 kg



## 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 mm <sup>2</sup> 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 mm<sup>2</sup>

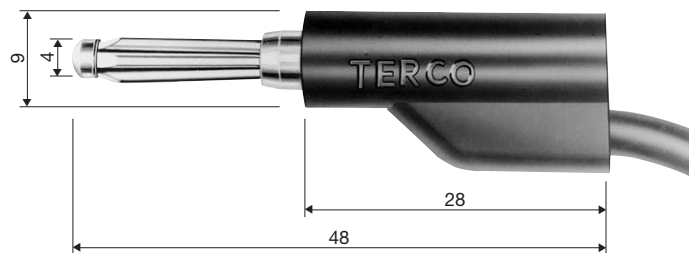
	25 cm	50 cm	100 cm	200 cm
Red	5	5	5	5
Yellow	5	5	5	5
Blue	5	5	5	5
Black	5	5	5	5
Yellow/green	5	5	5	5

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

### Separate Flexes

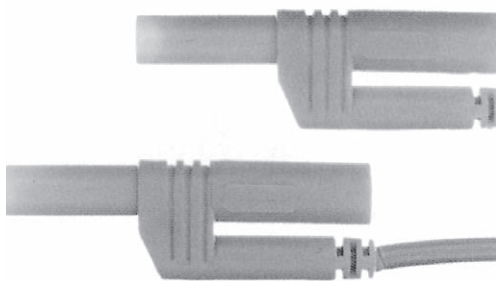
Area 2.5 mm<sup>2</sup>. Please note, each Ref. No. refers to a pack of 10 leads.

	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 mm<sup>2</sup> copper thread, PVC isolated, outer diameter 4 mm. Colours black, red, blue, yellow, green/yellow. Rated current 16 A.



### MV 1830-HF Flex Set

Area 1.5 mm<sup>2</sup>

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 mm<sup>2</sup>

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

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

## Rheostats and Flex Stand



### 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 against excessive current and incorrect connection.

A scale with 100 scale divisions shows the resistance setting.

A front panel of yellow painted aluminium 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.

### MV 1904 Flex Stand

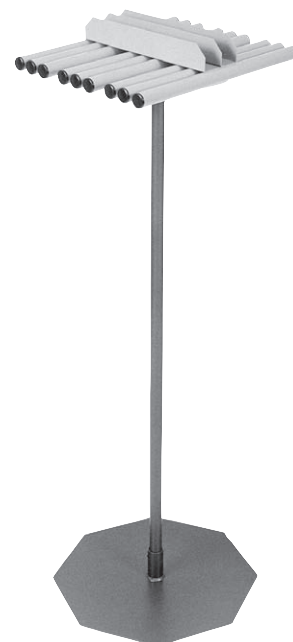
For suspension of laboratory flexes. The stand has 12 slots between parallel tubes with space for 10-15 laboratory flexes in each slot. Flexes of length 200 cm are suspended in a separate position above the stand. This rigid stand has a heavy steel plate pedestal.

### General Data

Height 1170 mm  
Weight 9 kg

### Standard Types

Order No.	Power W	Re- sistance Ohm	Max. current A	Dimen- sions
MV 1953	100	1	10.00	140x130 x 145
MV 1954	100	10	3.20	
MV 1955	100	100	1.00	
MV 1956	100	1000	0.30	
MV 1957	200	5	6.30	215x195 x 230
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	215x195 x 230
MV 1963	500	2500	0.45	
MV 1964	500	5000	0.30	
MV 1965	500	10000	0.20	



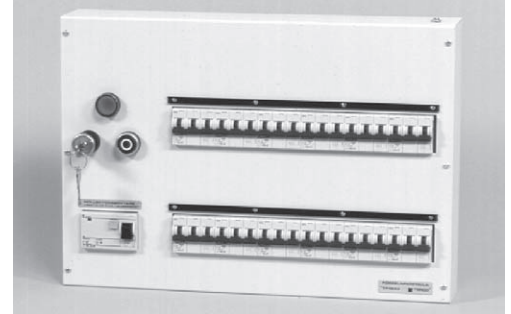
## Power Distribution System increases Safety in School Laboratories

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.

### TF 1251 Distribution Board

The distribution board is used for separate distribution of power to each lab. group (Student Panel). Contains 3-pole 16 A miniature circuit breakers, earth fault circuit breaker, indicator lamp and control keys. The distribution board breaks the supply voltage when a current  $\geq 4\text{mA}$  flows in the protection lead.

Order No.	Weight kg	Dim. mm
TF 1251 for 12 groups	10	480 x 330 x 60



### TF 1252 Student Panel

Student panel for mounting on wall or table.  
 One 3-pole switch 16 A.  
 Miniature circuit breaker.  
 Three 2-pole, 2-way earthed wall sockets.  
 One 3-phase socket.  
 One protective earth terminal.  
 Junction Line for distribution of any AC or DC voltage.  
 The 4 junction line terminals are marked from 1 to 4.  
 The intention is to connect all terminals marked "1" to each other, all "2" to each other etc. on respective student panel in the entire laboratory.  
 By doing the above installation you can e.g. supply 30 V between terminals 1 and 2 on one of the student panels and all other student panels in the lab will also have 30 V between terminals 1 and 2.

Order No.	Weight kg	Dim. mm
TF 1252	7	600 x 120 x 75

### TF 1253 Transformer

Connection voltage 3-phase 380-415 V + / - 5 % 50-60 Hz  
 Connection Delta/Star-0  
 Secondary 3-phase 380-415 / 220-240 V 50-60 Hz

Order No.	Power	Weight kg	Dim. mm
TF 1253	10 kVA	85	420 x 250 x 420



### TF 1229 Contactor with Thermal Protector (enclosed)

Intended for transformer above.

Order No.	For Transformer	Weight kg	Dim. mm
TF 1229	TF 1253	1	142 x 115 x 112



### TF 1211 Emergency Stop

Emergency stop including emergency sign (in English).

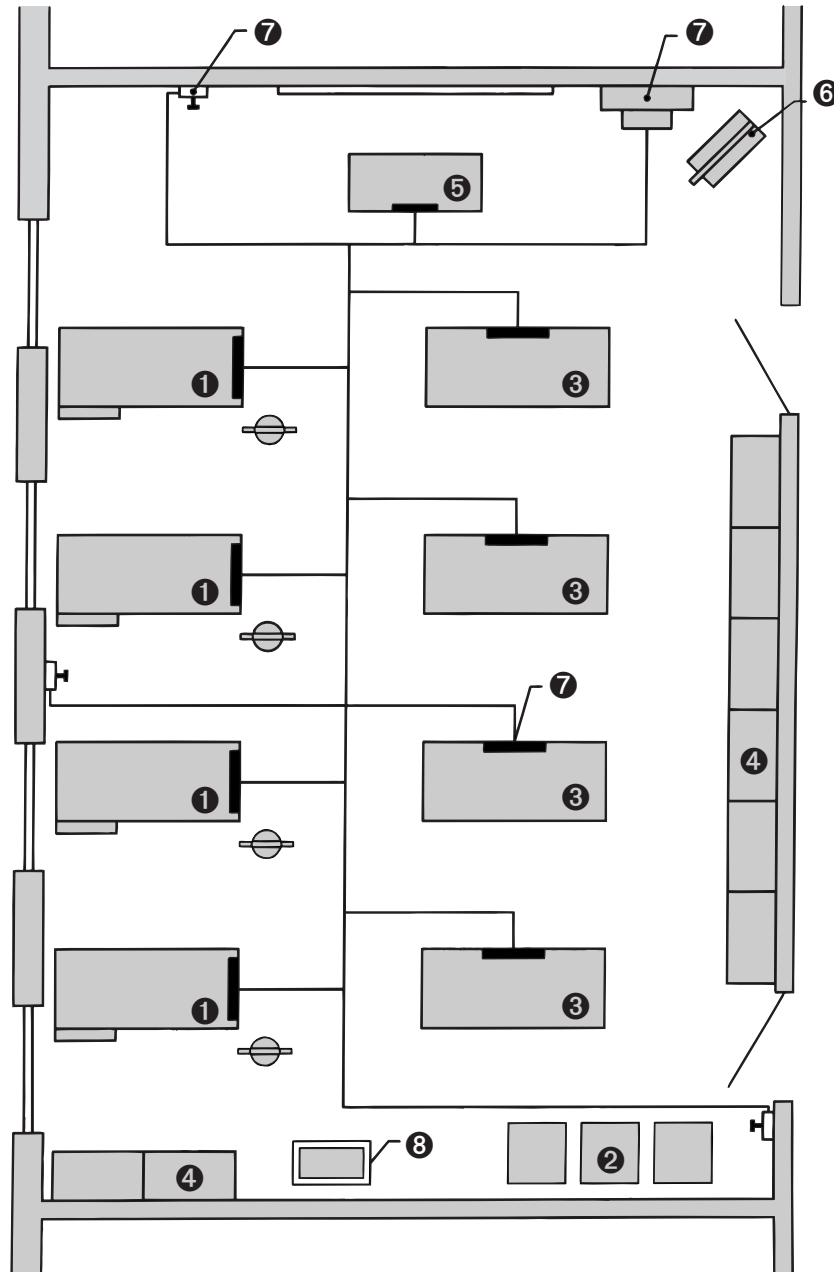
Order No.	Weight kg	Dim. mm
TF 1211 enclosed	0.4 kg	70 x 80 x 50
Surface mounting		





## 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 supplies and furniture.



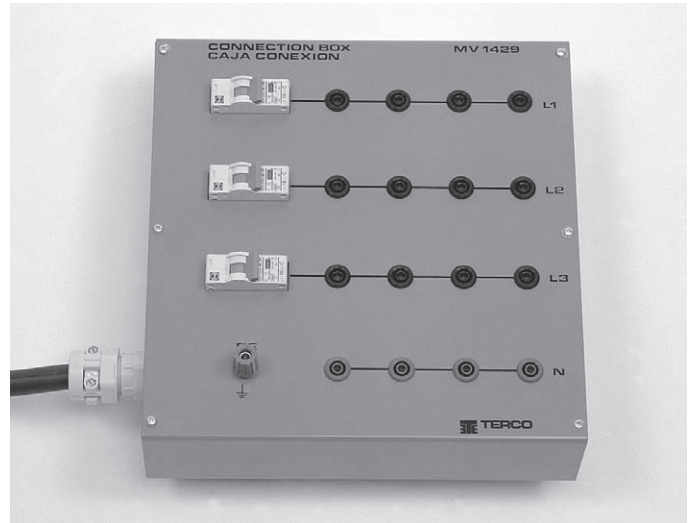
- ❶ Three-phase benches for accessories such as protective relays, loads, power supplies, switches, flex stands with flexes.
- ❷ Line models, floor standing.
- ❸ Four benches for experiments on transformers or for theoretical follow-up of the experiments.
- ❹ Cabinets for instruments, tools and accessories.
- 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.

## Accessories

### MV 1429 Terminal Board

The box has outlets for laboratory leads with 4 mm diameter plug pins. These outlets are connected to a 5 x 2.5 mm<sup>2</sup> 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 core of the 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 carbon contact.

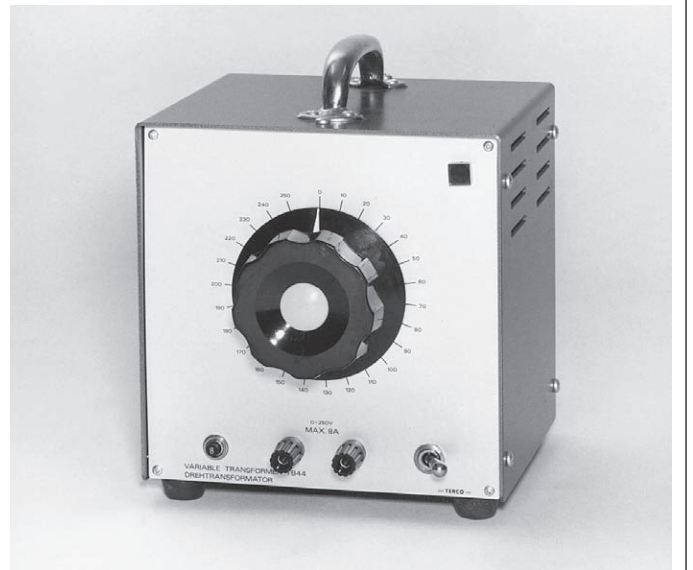
Thermal overload protector.

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

#### General Data

Input 220 V +/- 5 %  
Output-maximum 0-250 V, 8 A

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 the three output phases are placed on the front panel. Same technical data as MV 1104 above.

Input 3 x 400 V, 8 A  
Output 3 x 0-450 V, 8 A

Dimensions 280 x 300 x 470 mm  
Weight 32 kg

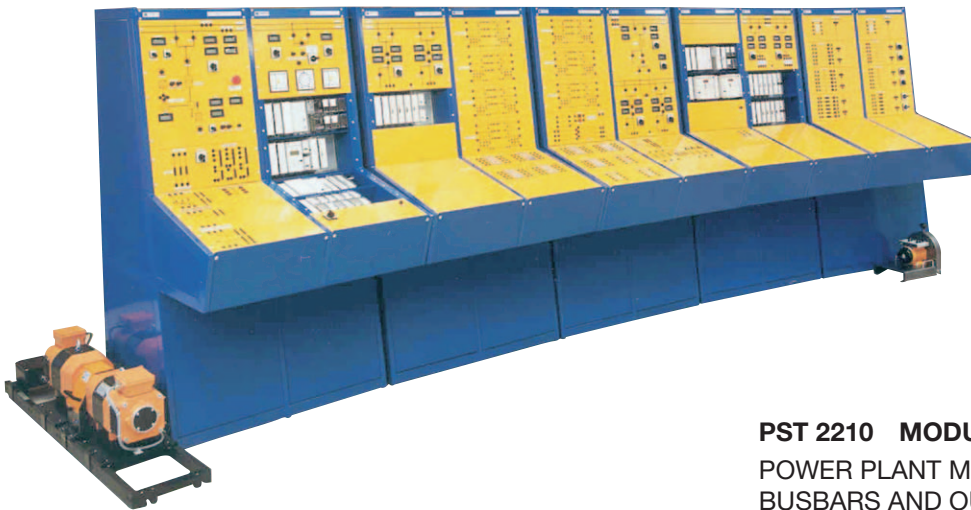
### MV 1103-415 Variable Transformer 3-phase

As MV 1103 above but with the following voltages and currents.

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



# Power System Simulators



## POWER SYSTEM SIMULATOR PST 2200

The picture shows a complete standard Power System Simulator level 3 with turbine-generator, power plant section, transmission lines, receiving substation and the load module incl. an induction motor with flywheel.

### The Power System Simulator PST 2200

is a simulated power station with three-phase artificial lines, simulated loads and a complete range of generator and system protection equipment.

The PST 2200 has close resemblance to actual field conditions but with the reduced power the risk of accidents is minimized as well as space requirements.

The system consists of four modules which can be operated individually and completed later with remaining modules.

This enhances the economical flexibility as well as it gives excellent opportunities to specialize on certain training items.

### PST 2210 MODULE NO. 1

POWER PLANT MODULE WITH HIGH VOLTAGE BUSBARS AND OUTGOING LINES

### PST 2220 MODULE NO. 2

TRANSMISSION LINES MODULE

### PST 2230 MODULE NO. 3

RECEIVING SUBSTATION MODULE WITH HIGH VOLTAGE SIDE AND MEDIUM VOLTAGE FEEDERS

### PST 2240 MODULE NO. 4

LOAD MODULE

For more information, ask for a detailed brochure

## POWER SYSTEM SIMULATOR PSS 1200

TERCO also manufactures another power system simulator, the PSS 1200.

This simulator has the same mimic structure but all components are built-in into industrial racks which are possible to open at the front.

This simulator has analogue instruments.

### High Voltage Power System Model

1. Power Station Simulator incl. Turbine-Generator
2. Basic Loads and Measurements
3. Advanced Loads and Measurements
4. Substation Simulator

### Industrial Power Distribution Model

5. Oil Immersed Transformer
6. Low Voltage Switchgear with Industrial Load Models.

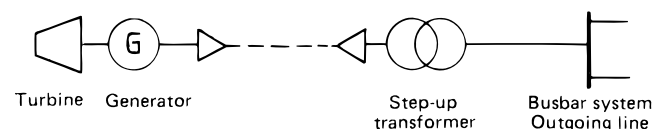
The modular system was chosen due to its flexibility and adaptability, both to the size of student groups and to available laboratory space.

TERCO has the possibility to offer training, in Sweden or at site, of technical people in POWER SYSTEMS, INDUSTRIAL ELECTRONICS, POWER ELECTRONICS, ELECTRICAL MACHINES, and MOTOR DRIVES.

Please ask for our special brochure and further information.



Power Station Simulator MV 1231





# Terco headoffice



Terco headoffice and factory outside Stockholm, Sweden.

**TRAINING FOR TOMORROWS WORLD**

EL. INSTALL. & CONTACTORS

INDUSTRIAL ELECTRONICS

CLASSIC ELECTRICAL MACHINES 1 kW

MATERIAL TESTING

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400 W SCAN LAB ELECTRICAL MACHINES

TECHNICAL EDUCATION WORLDWIDE  
**TERCO**

<p><b>POWER STATION SIMULATOR (PST)</b></p>	<p><b>PROTECTION RELAYS</b></p>	<p><b>POWER STATION SIMULATOR (PSS)</b></p>
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