TERCO

MADE IN SWEDEN BY TERCO

Electrical Machines Laboratory

- **Electrical Machines**
- **Drives**
- **Power Factor Control**
- **Wind Mill**

Content

Important Notice - Explanation of Suffix

Suffixes indicating voltage and/or frequency ensure that equipment corresponds with the various voltages in different countries.

For DC-machines, all having 220 V supply, the suffix indicates different to match synchronous speeds, speeds alternatively 50 or 60 Hz, when DC and AC machines are coupled together.

Examples of codes involved:

Torque Meter DC-Machines:

MV 1036-225 DC-machine Torque Meter (analogue), Voltage 220 V 50 Hz
Rated speed: Generator 1500 rpm, Motor 1400 rpm

MV 1036-226 DC-Machine Torque Meter (analogue), Voltage 220 V, 60 Hz
Rated speed: Generator 1800 rpm, Motor 1700 rpm

The same concerns Torque Meter DC-Machines with double ended shafts, with basic codes MV 1026 and Drive Machine MV 1028 as well as test machines DC MV 1006, to which one of the suffixes, -225 or -226, is added as necessary.

AC Test Machines
The suffix indicates in this case frequency and supply voltage as follows:

-405 supply voltage Star 400 V, Delta 230 V, Frequency 50 Hz
-406 same supply voltages, Frequency 60 Hz

Examples:

MV 1007-405: Induction Motor, slip-ring, Star 400 V, Delta 230 V, 50 Hz and 60 Hz
MV 1008-236: Synchronous Machine, Start 230 V, Delta 133 V, 60 Hz

Sometimes, when there is a '5' as last digit in the suffix, e. g. MV 1007-405, the product can be used both for 50 Hz and 60 Hz (see data in the catalogue).

Load Resistor MV 1100
Suffix -115 or -235 indicates only supply voltage for the cooling fan. The unit itself can be used as a load for all the voltages occuring in the electrical machine laboratories, within the admitted current limits.

Other Equipment
The same principles apply to all other items in the price list, coded with a basic number with a suffix. For other technical details, please check the catalogue.

PLEASE NOTE:
Equipment for other supply voltages can be supplied on request

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

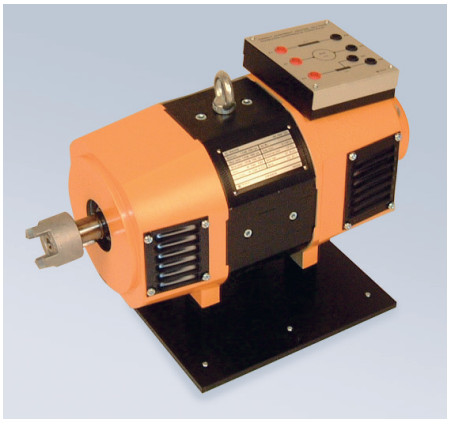
Small machines 1 kW with characteristics as large

MV1028 DC Machine (Motor and Brake Machine)

Complete with interpoles. This machine is used in test machine sets such as motors or generators, mounted on a 10 mm thick anodized aluminium plate to be placed on the machine bed MV 1004.

General Data	MV1028-225	MV1028-226
Generator	2.2 kW 1500 rpm	2.2 kW 1800 rpm
Motor	2.0 kW 1400 rpm	2.0 kW 1700 rpm
Excitation	220 V 0.8 A	220 V 0.8 A
Armature	220 V 12 A	220 V 12 A
Moment of inertia	J = 0.012 kgm^2	MV1028-226 and are
Dimensions	465 x 310 x 310 mm	designed for tests on
	Shaft height 162 mm	60 Hz networks.
Weight	50 kg	

MV1008-225 and -405 are designed for tests on 50 Hz networks.
MV1008-226 and -406 are designed for tests on 60 Hz networks.



MV1006 DC-Machine

The machine has a shunt and a series winding and can be connected as shunt motor, series motor, compound motor, shunt generator, series generator or compound generator. MV1006 has also commutating poles (interpoles) which improve the characteristics of the machine.

General Data	MV1006-225	MV1006-226
Generator	1.2 kW 1400 rpm	1.2 kW 1700 rpm
Shunt motor	1.0 kW 1400 rpm	1.0 kW 1700 rpm
Series motor	1.0 kW 1150 rpm	1.0 kW 1400 rpm
Rotor	220 V 5.5 A	220 V 5.5 A
Excitation	220 V 0.55 A	220 V 0.55 A

The series winding has an extra terminal at 2/3 of the winding.

Moment of inertia	J = 0.012 kgm^2 (approx.)
Dimensions	465 x 300 x 310 mm, Shaft height 162 mm
Weight	45 kg

MV1006-225 and -405 are designed for tests on 50 Hz networks.
MV1006-226 and -406 are designed for tests on 60 Hz networks.

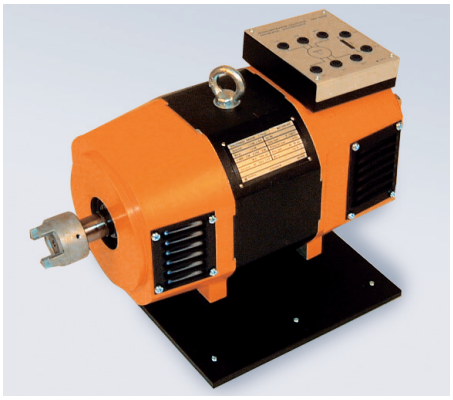
MV1007-405 Induction Motor Slip Ring

The machine is a 3-phase slip-ring asynchrous motor with means to connect a rotor starter to be used for starting.Terminals on anodized front panel with symbols and electrical data.

General Data	50 Hz	60 Hz
Power	1.1 kW,	1.1 kW,
Speed	1440 rpm, 50 Hz	1680 rpm, 60 Hz
Star connection	380-415 V, 3.2 A	380-415 V, 3.2 A
Delta connection	220-240 V, 5.5 A	220-240 V, 5.5 V
Secondary	260 V, 3.0 A	260 V, 3.0 A
Moment of inertia	J = 0.012 kgm^2 (approx.)	
Dimensions	465 x 300 x 310 mm, Shaft height 162 mm	
Weight :	42 kg	

MV1007-695 Induction Motor Slip Ring

As MV1007-405 but for 380-415 V 3-phase, Delta, 50-60 Hz



MV1008 Synchronous Machine

The machine has a DC excited cylindrical rotor, operating on voltages up to 220 V DC (maximum excitation).

General Data	MV1008-235	MV1008-236 (60 Hz)
Synch. Gen.	1.2 kVA x 0.8	1.2 kVA x 0.8
Synch. Motor	1.0 kW 1500 rpm	1.0 kW 1800 rpm
Star conn.	220-240 V 3.5 A	220-240 V 3.5 A
Delta conn.	127-140 V 6.1 A	127-140 V 6.1 A
Excitation DC	220 V 1.4 A	220 V 1.4 A
	MV1008-405	**MV1008-406 (60 Hz)**
Synch. Gen.	1.2 kVA x 0.8	1.2 kVA x 0.8
Synch. Motor	1.0 kW 1500 rpm	1.0 kW 1800 rpm
Star conn.	380-415 V 2.0 A	380-415 V 2.0 A
Delta conn.	220-240 V 3.5 A	220-240 V 3.5 A
Excitation DC	220 V 1.4 A	220 V 1.4 A
Moment of inertia	J = 0.012 kgm^2 (approx.)	
Dimensions	465 x 300 x 310 mm, Shaft height 162 mm	
Weight	39 kg	

MV1008-235 and -405 are designed for tests on 50 Hz networks.
MV1008-236 and -406 are designed for tests on 60 Hz networks.

MV1009-405 Induction Motor Squirrel Cage

General Data	50 Hz	60 Hz
4 pole machine	1.1 kW 1400 rpm	1.1 kW 1700 rpm
Star (Y)	380-415 V, 2.4 A	380-415 V, 2.4 A
Delta (D)	220-240 V, 4.1 A	220-240 V, 4.1 A
Moment of inertia	J = 0.0023 kgm^2 (approx.)	
Dimensions	355 x 300 x 310 mm Shaft height 162 mm	
Weight	19 kg	

MV1009-695 Induction Motor Squirrel Cage

As MV1009-405 but for 380-415 V 3-phase Delta. With this machine it is possible to do star/delta starts for 380-415 V lab voltage.

MV1009-385 Induction Motor Squirrel Cage

A 4-pole motor of 1.5 kW. Same design and electrical voltages as MV1009-405.

With Terco Classic Machines it is possible to produce characteristics which are typical for machines with 6-8 kW ratings, partly because Terco Electrical Machines have a robust construction with a higher than normal iron and copper content.

This makes it possible to overload the machines more before reaching saturation. If you compare the weight of corresponding machines from other manufacturer you will see the difference.

MV1054 Digital Torque-, Speed- and Shaft Power Meter

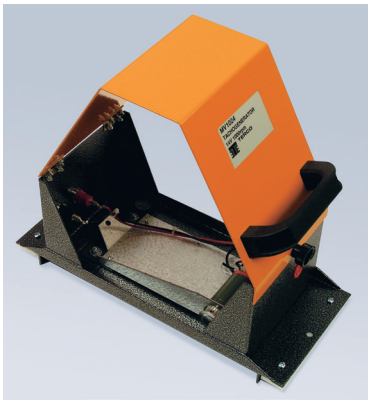
MV1054 is a modern torque meter based on the latest sensor technology. It comprises a magnetically based contactless torque sensor together with data acquisition and a display unit for torque, speed and shaft power. The sensor unit consists of a magnetically encoded torsion shaft with a magnetically based contactless sensor, together with a data acquisition unit with 15 bit resolution.

Torque measurement is performed/presented within the range -17.50Nm - +17.50Nm with exceptionally high accuracy including stand still torque as it is possible to lock the shaft with a specially attached bar.

Speed measurement is performed/presented within the range -3000- +3000rpm and the shaft power is calculated and presented within the range -5.50kW- +5.50kW.

Technical Specifications

Nominal torque		+/-17.50Nm
Max. mechanical torque		25Nm
Nominal shaft power		+/-5.50kW
Nominal speed		0 - 3000rpm
Data acquisition protocol		Modbus RTU 8N2
Baud Rate		9600kB/19200kB
Power supply		220-240VAC
1-phase, 50-60Hz		
Sensor Unit	Dimensions	200x190x146mm
	Weight	5kg
Display Unit	Dimensions	340x250x150mm
	Weight	5kg



Tachogenerators

The generator is mounted inside a protective guard. The cover is hinged and can be fixed by a locking screw.

MV1024 DC Generator 14 V at 1000 rpm (with trim potentiometer)

MV1025 DC Generator 14 V at 1000 rpm. (to be used with the MV1036 Electric Torque Meter System which has built-in trim potentiometer)

MV1029 Protective Cover (only)

Dimensions
Weight 2 kg

Please note : The protective guard can be fitted between the machines to
cover the rotating couplings, thus minimising the risk of accidents from rotating machinery.

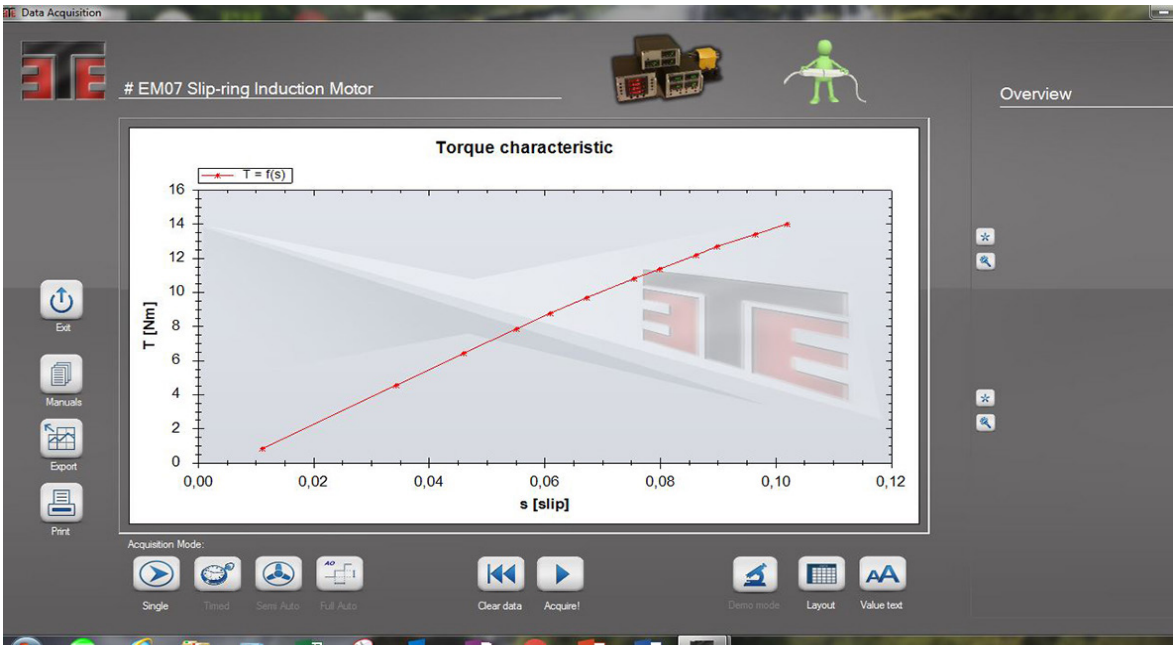
Measuring, Control and Data Acquisition for PC

Via the MV2658 PWM DC Control Module and the DC machine on the left, electric energy can be supplied or received for braking depending on which electric machine is being tested (right machine). Different lab setups can be selected via PC. All electrical and mechanical parameters can be logged for presentation in the PC.

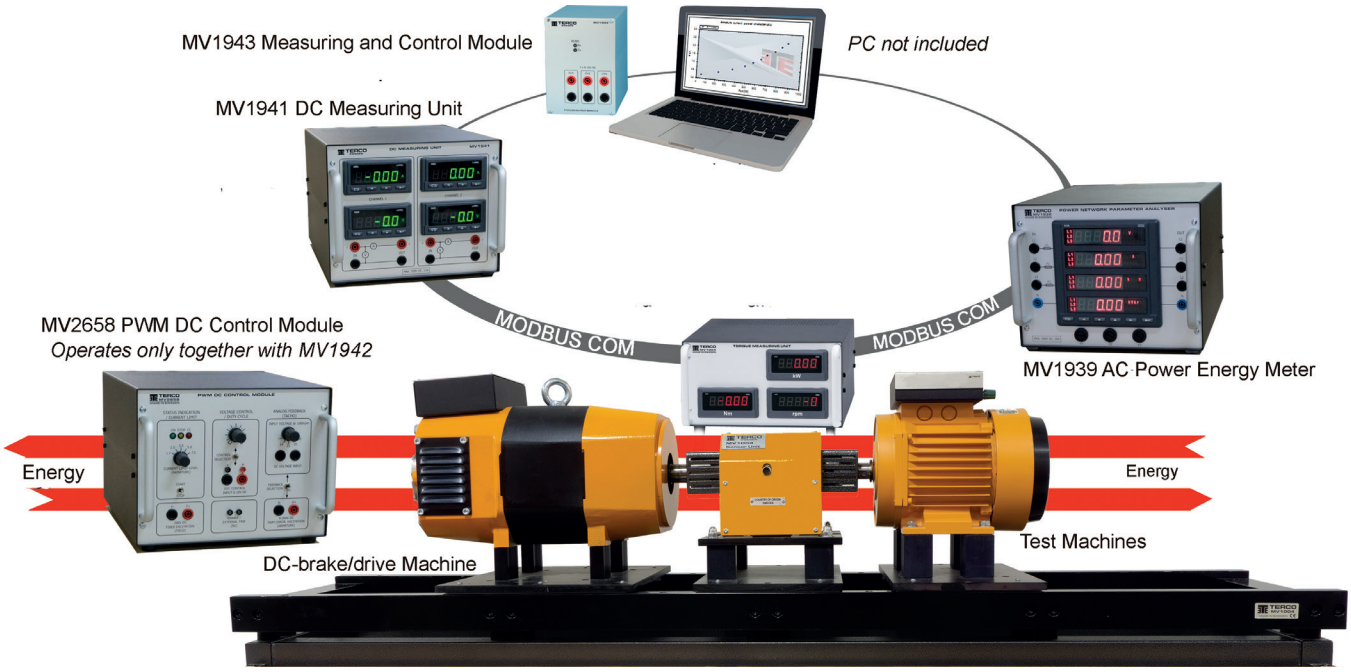
The system contains of an combination of Measuring units, Control Units, Data Interface Module and Data acquisition software, enabling the user to observe, control, record and investigate relevant electrical data.

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

Pre-configured experiment setups 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.



Graph presentation on PC



MV1943 Measuring and Control Module

The MV1943Measuring and Control Module integrates the communication interface functionalityof an 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 futures such as fully automatic data acquisition.

Technical Specifications

Power supply	220-240VAC, 50/60Hz
Communication:	
Interface	USB plug and play
Operating system	7/Vista/XP
Field interface	RS485
Maximum devices	32 devices
Power source	USB port

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 Soft-ware
Dimensions	105mm x 147mm x 167mm
Weight	300g

MV1942 Measuring Module

Technical Specifications

Communication:	
Interface	USB plug and play
Operating system	7/Vista/XP
Field interface	RS485
Maximum devices	32 devices
Power source	USB port

MV2609 Data Acquisition and Control Software

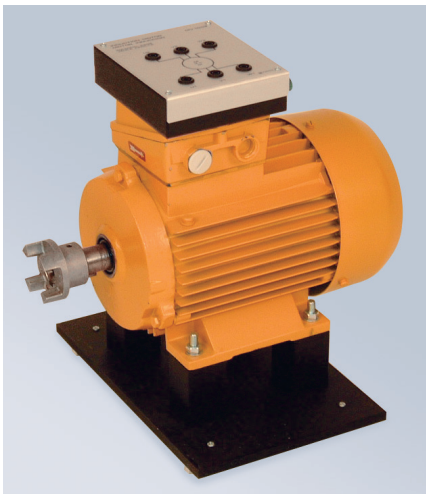
Acquisition functions
Data is read into the PC via Modbus to USB link and presented in real-time in both tabular and graph form.

Data may be acquired using one of 4 possible acquirement modes: Single, Timed, Semi-Automatic and Full Automatic. The saved data can then be exported in Excel format for further investigation.

Pre-configured experiment setups
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.

Additional Machines



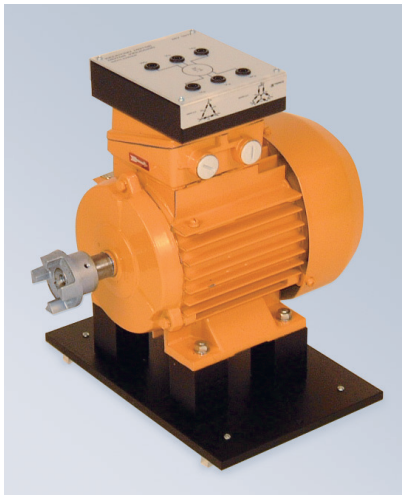
MV1015-405 Reluctance Motor

A reluctance motor starts as an induction motor, but operates normally as synchronous motor. A three-phase reluctance motor is self-starting when started as an induction motor. After starting, in order to pull it into step and then to run it as a synchronous motor, the reluctance motor has low rotor resistance. Some rotor teeth are removed to form a typical construction of a four-pole rotor.

General Data	50 Hz	60 Hz
Power	0.9 kW	0.9 kW
Speed	1500 rpm	1800 rpm
Delta Connection	220-240 V, 6.4 A	220-240 V, 6.4 A
Dimensions	360 x 300 x 310 mm Shaft height 162 mm	
Weight	25 kg	

MV1015-695 Reluctance Motor

Same as MV 1015-235 but for 380-415 V, 3-phase, Delta.



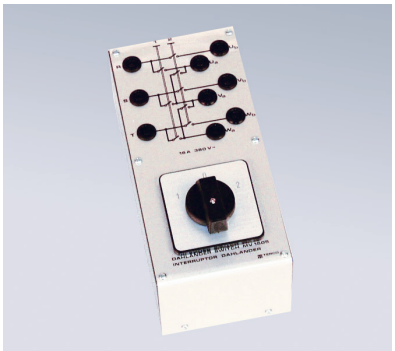
MV1017-235 Induction Dahlander Motor

The winding of the Dahlander motor is arranged in a way, that by connecting in different formations 2 speeds are available. Switching can be performed using a cam switch or using contactors.

General Data	50 Hz	60 Hz
Power	0.9 / 1.3 kW	0.9 / 1.3 kW
Speed	1400 / 2800 rpm	1680 / 3310 rpm
Voltage	D / YY 220-240 V 3-phase	D / YY 220-240 V 3-phase
Current	5.4 / 4.7 A	5.4 / 4.7 A
Dimensions	355 x 300 x 340 mm Shaft height 162 mm	
Weight	17 kg	

MV1017-405 Induction Dahlander Motor

As MV 1017-235 but for 380-415 V 3-phase



MV1505 Dahlander Switch

for Dahlander motor MV 1017, 16 A, 400 V, in metal case. Front panel showing symbols and technical data.

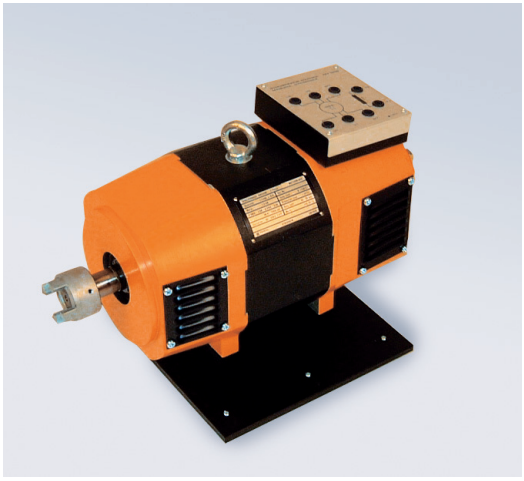
Marking of terminals	input	R, S, T
	output 1	Ua, Va, Wa
	output 2	Ub, Vb, Wb
Dimensions	95 x 200 x 80 mm	
Weight	1 kg	

MV1018 Universal Motor

This is a commonly used motor in domestic appliances. It can be run on DC or AC 1-phase. The rotor is connected in series with the field winding and supplied via the commutator and brushes.

General Data

Power	1 kW DC at 2600 rpm, 0.4 kW AC
Speed	3000 rpm at 50 Hz 3600 rpm at 60 Hz
Voltage	220-240 V AC / DC
Current	8 A AC, 7 A DC
Dimensions	465 x 300 x 310 mm Shaft height 162 mm
Weight	39 kg



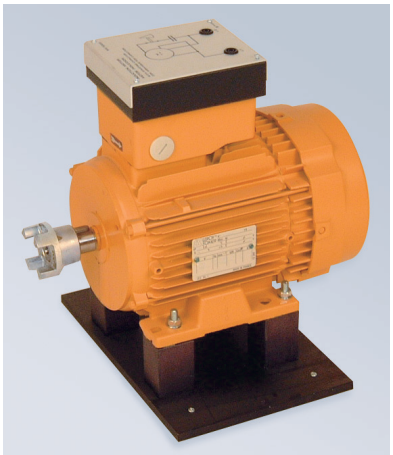
MV1027 Synchronous Machine

The machine has a DC excited rotor with salient poles, operating on voltages up to 220 V DC (maximum excitation) The advantages rising from this type of machine are measurements and characteristics corresponding to those of larger machines and the excitation voltage is readily available in most laboratories. An additional damping winding will counteract oscillations and also facilitate return to synchronism if the rotor falls out of phase.
The damping winding also allows the motor to be started as an asynchronous motor before energizing the field.

Suitable excitation rheostat : MV1905.

General Data	MV1027-235	MV1027-236	MV1027-405	MV1027-406
Synch. Gen.	1.2 kVA x 0.8	1.2 kVA x 0.8	1.2 kVA x 0.8	1.2 kVA x 0.8
Synch. Motor	1.0 kW 1500 rpm	1.0 kW 1800 rpm	1.0 kW 1500 rpm	1.0 kW 1800 rpm
Star conn.	220-240 V 3.5 A	220-240 V 3.5 A	380-415 V 2.0 A	380-415 V 2.0 A
Delta conn.	127-140 V 6.1 A	127-140 V 6.1 A	220-240 V 3.5 A	220-240 V 3.5 A
Excitation DC	220 V 1.4 A	220 V 1.4 A	220 V 1.4 A	220 V 1.4 A
Moment of inertia	J = 0.012 kgm^2 (approx.)			
Dimensions	465 x 300 x 310 mm, Shaft height 162 m			
Weight	39 kg			

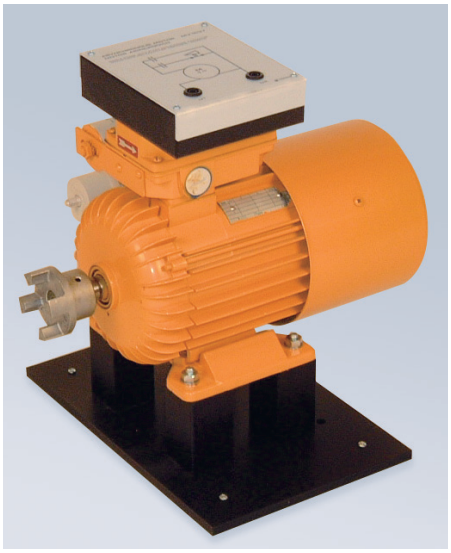
MV1027-235 and -405 are designed for tests on 50 Hz networks.
MV1027-236 and -406 are designed for tests on 60 Hz networks.



MV1020 Induction Motor Capacitor Start

The capacitor assisted starting winding is disconnected from the circuit when the motor has built up speed, by means of a relay.

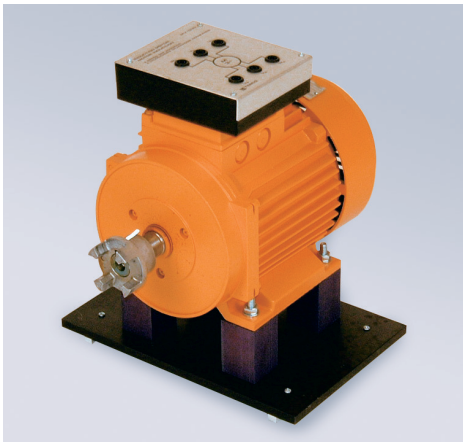
General Data	50 Hz	60 Hz
Power	0.75 kW	0.75 kW
Speed	1425 rpm	1710 rpm
Voltage	220-240 V 1-phase	220-240 V 1-phase
Current	6.8 A	6.8 A
Capacitors	310 uF	310 uF
Dimensions	350 x 300 x 350 mm Shaft height 162 mm	
Weight	24 kg	



MV1037 Induction Motor
Cap. Start and Run

To obtain a higher starting torque, the starting winding has a capacitor connected in series. Continuous rating of start winding allows the circuit to remain the same during starting and running.

General Data	50 Hz	60 Hz
Power	0.75 kW	0.75 kW
Speed	1430 rpm	1715 rpm
Voltage	220-240 V 1-phase	220-240 V 1-phase
Current	5.4 A 5.4 A	
Capacitors	25uF & 100 uF	25 uF & 100 uF
Dimensions	320 x 300 x 350 mm Shaft height 162 mm	
Weight	20 kg	



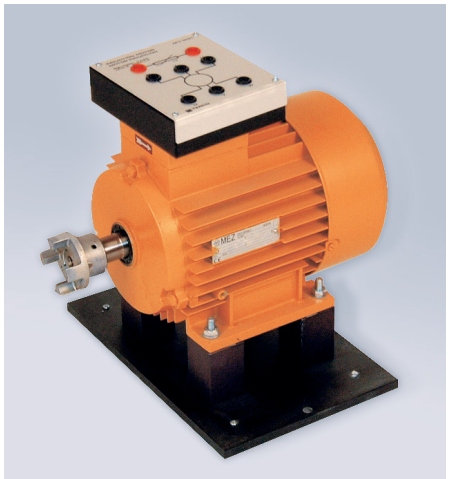
MV1030-235 Induction Motor
2 Speed 2 Windings

This motor unlike MV 1017 which has only one set of windings, has 2 separate sets of windings for high and low speed.

General Data	50 Hz	60 Hz
Power	0.8 / 1.0 kW	0.8 / 1.0kW
Speed	930 / 1440 rpm	1120 / 1730 rpm
Voltage	220-240 V 3-phase	220-240 V 3-phase
Current	4.7 / 6.0 A	4.7 / 6.0 A
Dimensions	450 x 300 x 340 mm Shaft height 162 mm	
Weight	24 kg	

MV1030-405 Induction Motor
2 Speed 2 Windings

As MV1030-235 but for 380-415 V, 3-phase.



MV1031 Induction Motor
Thermistor Protected

This squirrel cage motor has a thermistor built into the windings for temperature control of the motor. Thermal relay MV 1032 is used in conjunction with this motor.

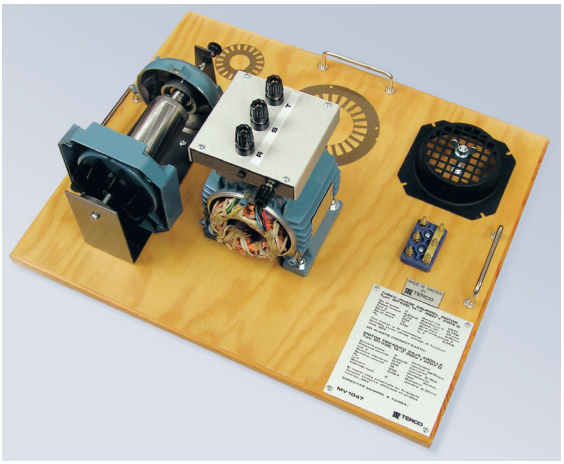
General Data	50 Hz	60 Hz
Power	1.1 kW	1.1 kW
Speed	1400 rpm	1700 rpm
Voltage	380-415/220-240 V 3-phase	380-415/220-240 V 3-phase
Current	3.0 / 5.2 A	3.0 / 5.2 A
Dimensions	340 x 300 x 310 mm, Shaft height 162 mm	
Weight	22 kg	

MV1032 Thermal Relay

This is a control unit against overheating of motor

MV1031. Most electrical machines withstand today 140ºC or more. However, it takes a long time to reach this temperature and the lab time is limited in the laboratory. Therefore we have chosen a cut off temperature at 60ºC for the experiments.

Dimensions	130 x 245 x 95 mm
Weight	1 kg

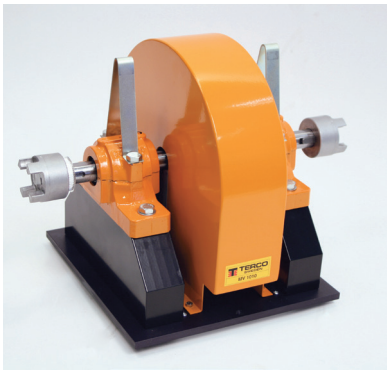


MV1047 Asynchronous Motor, 3-Phase Demonstration Set

The components of a type MT 63 induction motor are mounted on a wooden board. Only a screwdriver is needed to assemble the motor, and to permit repeated assembly and dismantling.

A 40 V, 3-phase, 50/60 Hz supply is recommended for testing the operation of the motor.

Dimensions	480 x 400 x 150 mm
Weight	7 kg



MV1010 Flywheel

The flywheel is stably journalled in 2 spherical bearings and secured to an aluminium foundation. This ensures correct shaft height and lateral alignment.

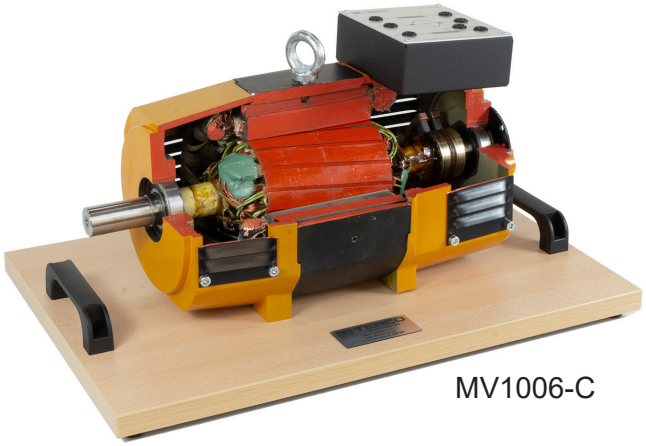
The flywheel is dynamically balanced and has a protective casing with 2 couplings. It is used in retardation tests for determining total friction losses, iron losses and short circuit losses at different excitation levels.

MV1010 is also suitable to use for tests with heavy load start.

Moment of inertia	J = 0.406 kgm^2.
Dimensions	400 x 300 x 300 mm
Weight	56 kg

Sectioned Motors and Transformer

The machines are sectioned about 90˚ allowing all the main components to be demonstrated clearly and in an educational way. Please note : It is not possible to do any practical experiments with the machines.

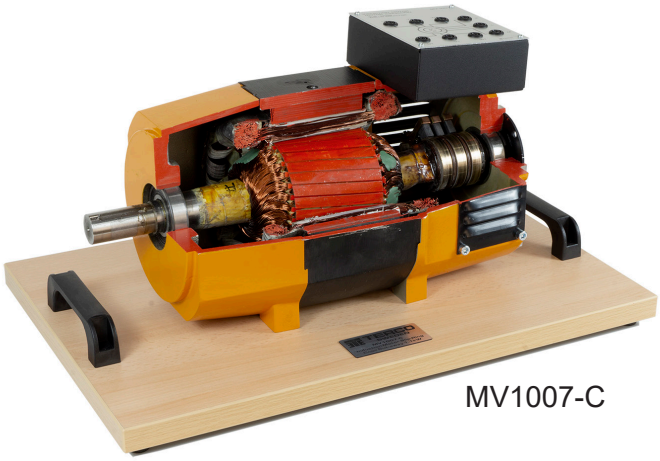


MV1006-C

MV1006-C DC Machine

This machine is cut-away to show commutator, brushes, rotor, stator, windings, ball-bearings.

Rated power	1.0 kW
Dimensions	465 x 300 x 310 mm
Shaft height	162 mm
Weight	40 kg



MV1007-C

MV1007-C Induction Motor Slip-Ring

This motor is cut-away to show slip-rings, brushes, rotor, stator, windings, poles, fan, ball-bearings, etc.

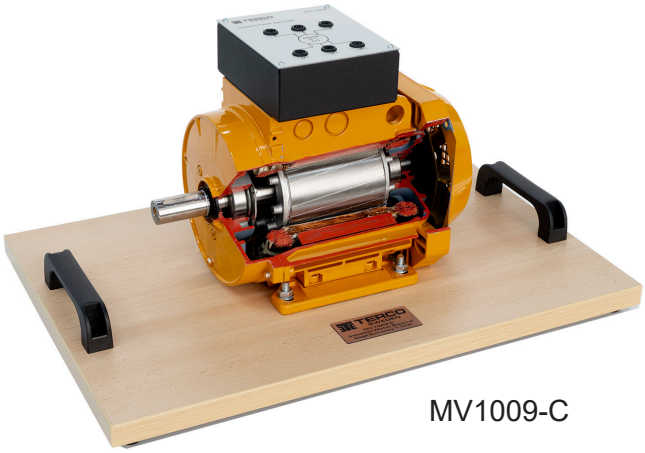
Rated power	1.1 kW
Dimensions	440 x 300 x 350 mm
Shaft height	162 mm
Weight	37 kg

MV1008-C

MV1008-C Synchronous Machine

This machine is cut-away to show slip-rings, brushes, rotor, stator, windings, poles, ball-bearings etc.

Rated power	1.0 kW
Dimensions	465 x 300 x 310 mm
Shaft height	162 mm
Weight	35 kg

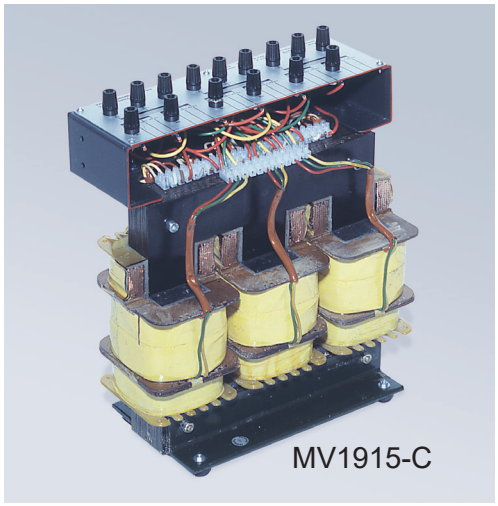


MV1009-C

MV1009-C Induction Motor Squirrel Cage

This motor is cut-away to show rotor, stator, windings, poles, fan,
ball-bearings, etc.

Rated power	1.1 kW
Dimensions	355 x 300 x 310 mm
Shaft height	162 mm
Weight	15 kg



MV1915-C

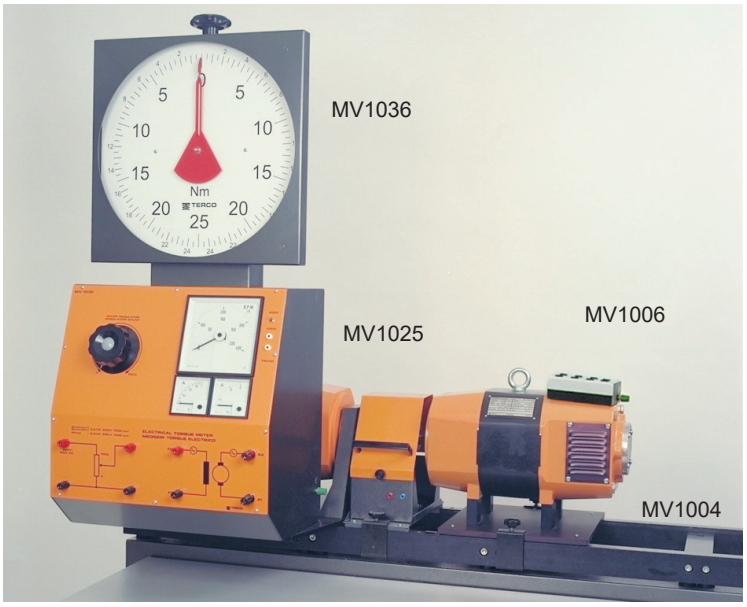
MV1915-C Three-phase Transformer

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

Please note : It is not possible to do any practical experiments with the transformer.

Electric Torque Meter System, Analogue Dial incl. DC-brake / DC-drive Machine



The picture shows MV1036 mounted on the machine bed MV1004 together with the tachometer generator MV1025 and the DC- test machine MV1006

A DC pendulum machine is freely suspended on plumber blocks and placed on an aluminium foundation plate. The front panel is fitted with the necessary meters, controls and connection terminals. The torque is read on an analogue dial. The DC-machine has interpoles.
This analogue torque measuring system is very pedagogical and easy to handle. It is a reliable product which has been sold to many technical schools worldwide.

MV1036-225 Electric Torque Meter System

Speed	0-4000 rpm
Ammeter	0-1 A (Field)
Ammeter	0-15 A (Arm.)
Shunt Control	Potentiometer
Torque	Grad. 0 – ± 25 Nm
Scale diam.	390 mm
Termination	4 mm terminals
Generator	2.2 kW 1500 rpm
Motor	2.0 kW 1400 rpm
Excitation	220 V 0.8 A
Armature	220 V 12 A
Dimensions	600 x 540 x 960 mm
Weight	90 kg

MV1036-226 Electric Torque Meter System

As MV1036-225 but following ratings.

Generator	2.2 kW 1800 rpm
Motor	2.0 kW 1700 rpm
Excitation	220 V 0.8 A
Armature	220 V 12 A
Weight	90 kg
Dim:	600 x 540 x 960 mm

DC machine MV 1036-226 is designed for tests on electrical machines with 60 Hz ratings.

DC Machine MV1036-225 is designed for tests on electrical machines with 50 Hz ratings but can be used for 60Hz (higher speed but less torque)

MV1026-225 Electric Torque Meter System

Same as MV1036-225, but the drive motor has a double ended shaft, enabling to couple two machines at the same time for experiments and studying 4Q drives with one AC- and one DC drive/motor, Ward-Leonard system, cascade, etc. For central mounting on the machine bed. Designed for tests on electrical machines with 50 Hz ratings.

MV1026-226 Electric Torque Meter System

Same as MV1036-226 except that the drive motor has a double ended drive shaft, making it possible to couple two machines at the same time for experiments and studying 4Q drives with one AC- and one DC drive/motor, Ward-Leonard system, cascade, etc. For central mounting on the machine bed. Designed for tests on electrical machines with 60 Hz ratings.

ORDER INFORMATION ELECTRICAL MACHINES LABORATORY			
Item	**Description**	**Pc**	**Page**
Electrical Machines Laboratory. Experiment Voltage 3 x 400V or 3 x 230V (MV1300 is changeable)			
MV1028-225	DC-Machine, 2.2 kW complete with interpoles 220V	1	5
MV1006-225	DC-Machine 1 kW 220 V 50 Hz	1	5
MV1007-405	Induction Motor slip-ring 1.1kW 400/230V 50-60Hz 1.1kW	1	5
MV1008-235	Synchronous Machine, 230 V Y 50 Hz 1.2 kVA x 0.8	1	6
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MV2658	MOSFET - PWM Module	1	34
Optional - Additional Machines and Torque Measuring,			
See page 11-16			
Electrical Torque Meter System, Analogue Dial. incl. DC-brake / DC-Drive Machine			
See page 17			

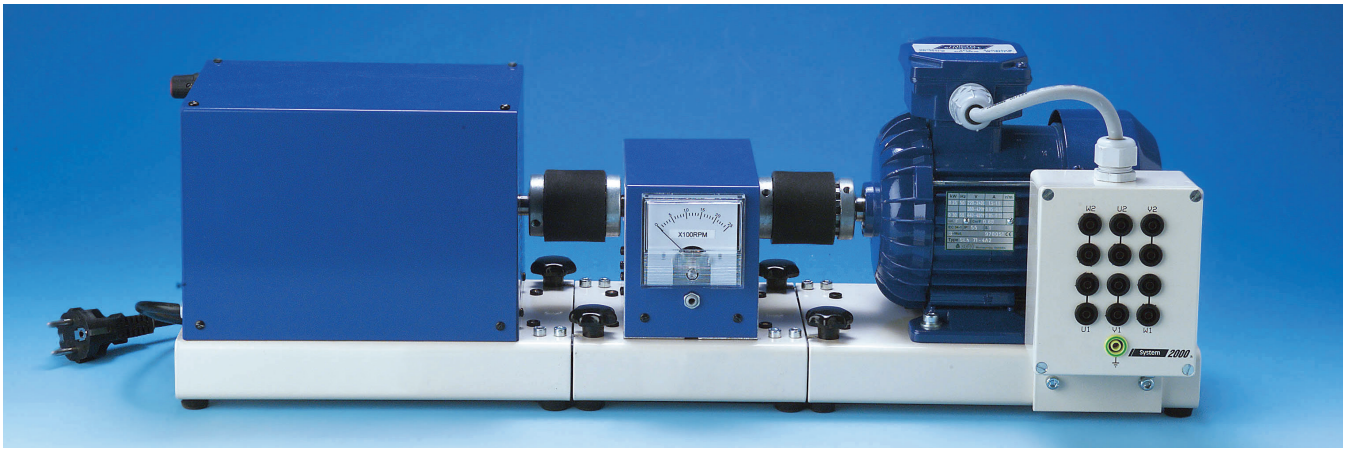
Ref. 200

Motor Control System

A Motor Control package including the DC-motor and the AC-motor, controlled in different, modern ways. The AC- and the DC-drives are the main subjects to be studied in this package. Other types of drives can be studied in connection with motor control in industry.

The package also covers combinations with control techniques and electricity. The experiments are performed with AC- and DC-motors, which can easily be mechanically connected together. They can be loaded steplessly, with a magnetic powder brake. Experiments are made with different control equipment used to drive and to control motors. Examples of control equipment are contactors, frequency converters, DC-drives and PLC. This equipment may be fixed in different units or on a module card to be connected to the Base Unit 2000.

Connection is done on terminals in an apparatus housing covering contactors, frequency converters, DC-drives, PLC and other applications.
The experiment book is mainly built on connections with laboratory leads of safety design with 4 mm terminals.



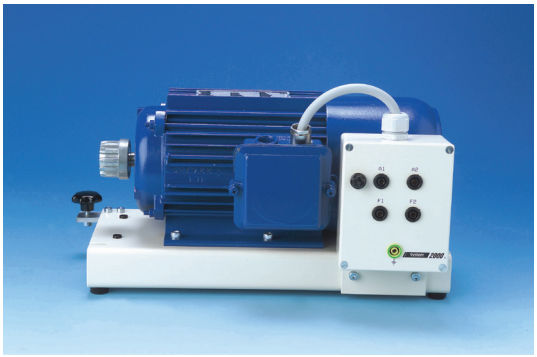
The picture above shows the AC-Motor together with the Brake Unit and rpm-Meter.

ELK102240 Squirrel-cage 3-phase asynchronous motor

The motor is mounted on a steel base to be connected to a magnetic powder brake or to other electrical machines with a quick shaft coupling.
The AC-motor can be switched between Y and D. The supply to the main current circuit of the AC-motor leads through a 3-phase terminal connected to a 3-phase net.
The AC-motor can also be supplied via a frequency converter.

General data

Voltage:	230/400 V 3-ph, 50 - 60 Hz
Current:	1.55 / 0.9 A
Power:	0.25 kW, 1380 rpm, at 50 Hz
Power factor	0.68
Dimensions:	280 x 220 x 225 mm
Weight:	8 kg



ELK102250 DC-Motor

The motor is mounted on a steel base to be connected to a magnetic powder brake or to other electrical machines with a quick shaft coupling. The DC-Motor has open shunt winding to make it possible to connect it as shunt or separate excitated DC - Motor.

General data

Shunt wound	DC-motor.
Armature voltage:	160 V
Field voltage:	190 V
Armature current:	2.1 A
Power:	0.25 kW
Speed:	1500 rpm.
Dimensions:	380 x 220 x 250 mm
Weight:	13 kg

ELK102242 Magnetic Powder Brake

To be used together with the AC-motor ELK102240 and DC-motor ELK102250.
Brake 0-10 Nm adjustable with a 10-turn potentiometer.

General data

Power supply:	230 V, 50 - 60 Hz.
Effect consumption max:	25 W.
Dimensions:	300 x 160 x 200 mm
Weight:	7 kg

ELK102244 Tachometer

To measure the rpm of a motor, the tachometer is connected to the motor shaft. The tachometer shows an analogue signal output in form of voltage which is in proportion to the rpm of the rotating shaft. It works like a DC generator. The measuring instrument has a scale of 0-2500 rpm.
Voltage output DC 0-20 V, may be used for voltage feedback to the DC or AC - Drive.

General data

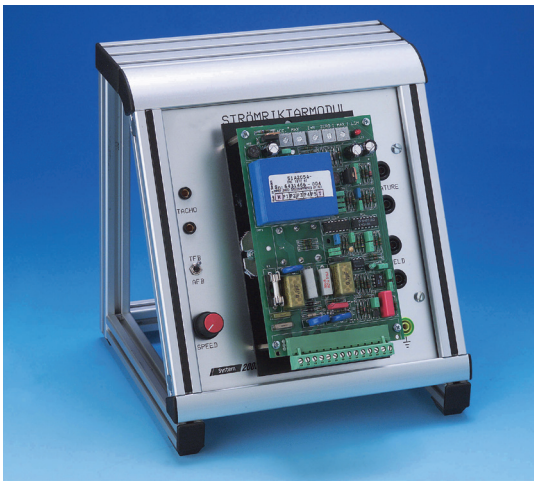
Output:	20 V DC at 2500 rpm
Dimensions:	210 x 160 x 150 mm
Weight:	3 kg

ELK102246 AC - Drive

The AC-Drive is suitable to control the speed of an AC motor. It is perfect in many industrial applications e.g. pumps, fans, drilling machines etc. The AC - Drive can be set with 100 different parameters e.g. acceleration & retardation times, current limit, over load, alarm, speed ranges.
It has also a built -in PID regulator. Here we focus the use of soft start and soft stop, rpm control and study the electronic overload protection.

General data

Max motor power:	0.4 kW
Input voltage:	230 V 1-ph, 50 - 60 Hz
Output voltage:	0-230 V 3-ph
Current.	2.5 A
Output frequency:	0.5-120 Hz
Dimensions:	230 x 250 x 245 mm
Weight:	2.6 kg

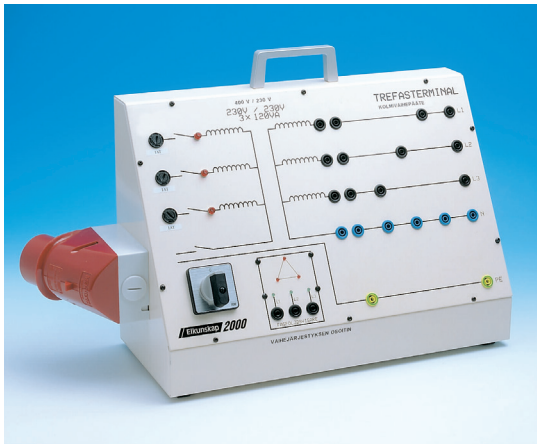


ELK102248 DC - Drive

The DC-Drive is used to run the DC motor. Here the parameters are set, as rpm, current limits, acceleration, ramps and others.

General data

Current max:	12 A
Armature voltage:	0-180 V DC.
Field voltage:	200 V DC.
Field current max:	1 A
Acceleration period:	0.2-5 s.
Feedback with armature current or tacho.	
Supply voltage:	230 V 1-ph, 50 - 60 Hz.
Dimensions:	230 x 250 x 245 mm
Weight:	2.6 kg



ELE102232 Three Phase Terminal

The AC-motor can be connected to a 3-phase net by a 3-phase terminal with a 5-pole 16 A electrical output as to standard CEE17. Inside the terminal panel there is a control device for the 3-phases and the neutral line. The different phases are fused and in the terminal box is an insulation transformer (1:1) as well.

The terminal panel is equipped for current- and voltage measuring on all phases and includes a phase sequence display where LED indicate the phase sequence. The connection from the 3-phase terminal panel to the AC-motor is done with lab leads, directly or via the Contactor Unit. Only 4 mm safety lab sockets are used.

General data

Supply voltage:	Prim. 5-pol. 400/230 V 3-ph, 50 - 60 Hz, 2,5A
	Sec. 5-pol 400/230 V 3-ph, 50-60 Hz, 2,5 A
Dimensions:	510 x 190 x 320 mm
Weight:	8.3 kg

ELE102000 Base Unit 2000

Base Unit 2000 is the base for the Lab System 2000. It is a Control Box comprising power supply, circuit box and PCB-holder. Into the Base Unit laboratory cards can be fitted. The cards have been carefully designed to suit each particular area of study. The lab cards when fitted are automatically powered via D-sub connector.
Base Unit 2000 is a common unit to be connected to different equipment. The Base Unit is connected to 230 V AC and feeds voltage to the connected modules which are inserted between a pair of short guides and there connected to a 64-pole housing.

General data

Supply voltage 230 V , 50 - 60 Hz 1-phase
The unit has 6 outputs with following data:

Output 1 - 3:	DC 12V / 3 A with LED indication and fuses
Output 4 - 6:	AC 12V / 3 A with LED indication and fuses
Dimensions:	370 x 180 x 75 mm
Weight:	4 kg

AUT302011 Control Module

The AC-motor is started and stopped by push button controlled electrical switches, located in the Control Module. They are specified with indication as normally closed (NC) or normally open (NO) contacts and there are two of each. In the Control Module you also find a number of indicating lamps. Two of them are red and two of them are green. To control the motor 24 V AC is used which is supplied from the Base Unit 2000, where the Control Module is to be connected. The Base Unit may be loaded up to 50 VA. The Control Module holds also 24 V DC for other experiments.

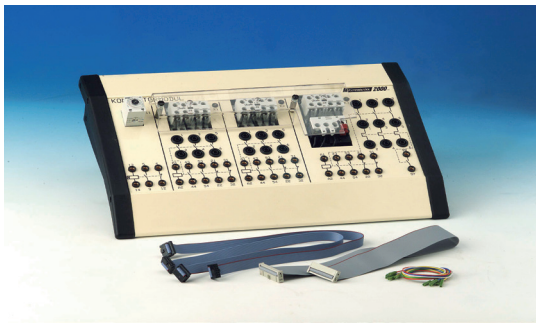
General data

The Control Module consists of:

- 2 push buttons, NC
- 2 lamps
- 2 push buttons, NO
- Output 24 V DC and 24 V AC

The Control Module has to be connected to the Base Unit 2000.

Dimensions:	240 x 140 x 55 mm
Weight:	0.7 kg

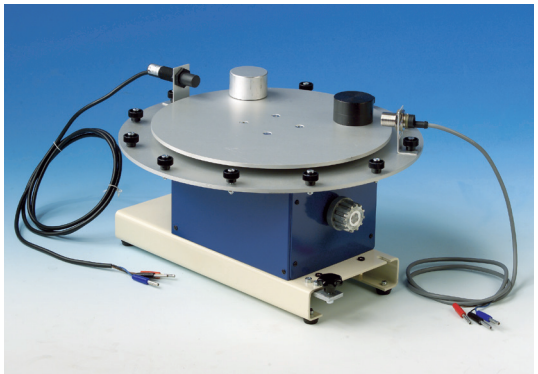


AUT302012 Contactor Unit

The Contactor Unit is used to control the motor. It connects the 3-phases from the 3-phase terminal to the AC-motor.
3 mini-contactors are placed in the Contactor Unit. If any of the contactors is in use, this is indicated by a LED. Two of the contactors have an auxiliary contact block and the third one has both, an auxiliary contact block and a thermal overload protection which is released at too high current output at any of the three phases meant for the motor drive. The time relay can be connected to one of the contactors.The auxiliary contact blocks are used together with the contacts in the Control Module when controlling the AC-motor. Mains supply terminals of safety design.

General data

Operating voltage:	24 V AC
Main voltage:	400 V 3-ph, 50 - 60 Hz
Max current:	10 A
Dimensions:	390 x 260 x 130 mm
Weight:	3.3 kg



ELK102252 Rotary Index Table

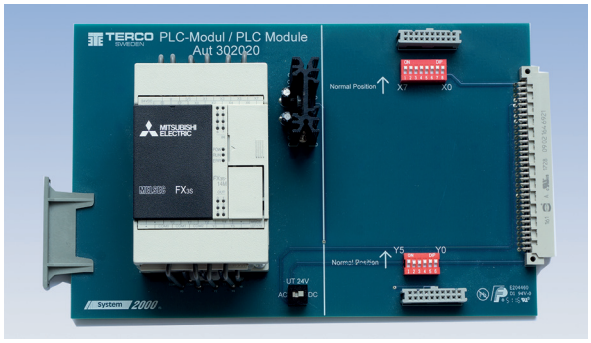
The Rotary index table is to be connected to a motor via a coupling. The rotary index table includes a worm gear where the outgoing vertical shaft drives a fixture plate. The worm gear reduces the speed 30:1.
The rotary index table shall be driven by an electrical motor by a ball bearing suspended shaft. The fixture plate with holders and sensors to recognize different materials.
Suitable to learn about different controls with frequency converters or current rectifiers and PLC.

General data

Dimensions:	400 x 380 x 190 mm
Weight:	7.4 kg

PLC - System

A PLC is a small Mini -Computer for industrial use comprising all necessary logic functions gathered in one housing. The input to our PLC is done from, for example, different sensors or electrical contacts. The output of the signals is done via contactors, pneumatic valves etc.



AUT302000 PLC Module

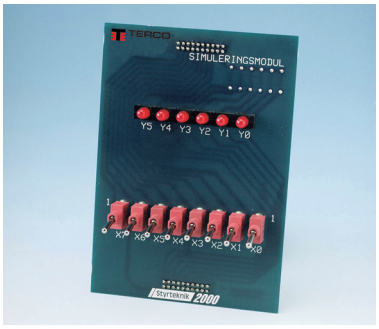
The PLC - Module has to be connected to the Base Unit 2000. To program a PLC a PC is connected to a programming port via a cable
Alternatively a PC software may be used for programming.
The PLC-module contains a PLC-system with sockets to connect any chosen module card. For the sockets there are several switches to simulate faults at the different in- and outputs.

General data

Mitsubishi Melsec FX0-14 MR PLC (24 V)
8 inputs and 6 outputs
Input and output of the PLC is connected to a 20 pin socket

Dimensions: 240 x 140 x 55 mm
Weight: 0.5 kg

USB Programming Cable for Mitsubishi Melsec FX Series PLCs,



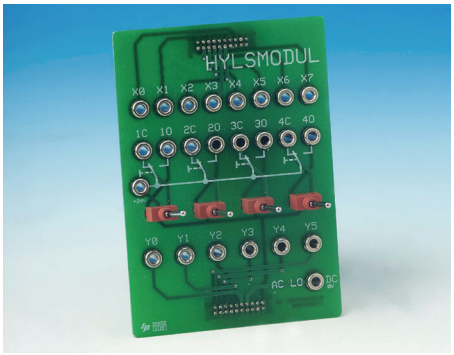
AUT302001 Simulation Module

The signal levels on the inputs can be altered through a simulation module, plugged into the sockets of the PLC module.

General data

Shows input status with 6 LED and has out-going signals simulated by 8 on/off switches.

Dimensions: 100 x 140 x 40 mm
Weight: 0.1 kg

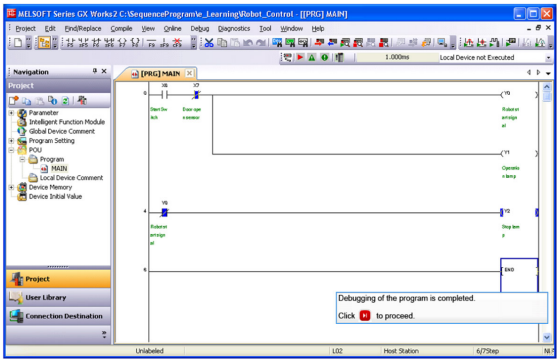


AUT302008 Socket Adapter

To connect the PLC module to an control object, a 4 mm socket adapter is used. It is plugged onto the sockets of the PLC module and thus all in- and outputs of the PLC-system are connected to the 4 mm socket adapter. Thereupon it is easy to connect the PLC system to another control object with 4 mm lab leads.
The socket adapter has also four electrical switches to be able to give in-signals to the PLC-system. The electrical switches can be turned to NC or NO.

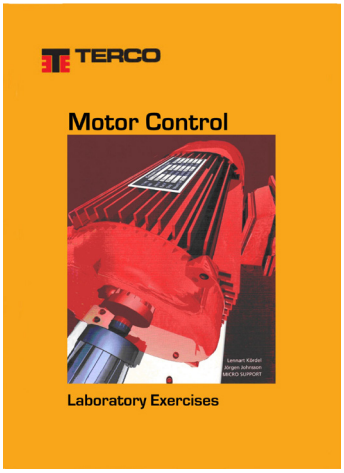
General data

Dimensions: 100 x 140 x 40 mm
Weight: 0.1 kg



AUT310712 Programming Software for PC

Programming software GX Works2 for programming of PLC from PC including USB cable.



BOK 103615 Experiments Book & Motor Control

Contents

- Ratings of a Motor
- Clockwise and Counter Clockwise Rotation of a Motor
- Overload Protection
- Control of a Motor
- Y / D Connection
- Faultfinding Control Circuit
- Motor Control of AC Drives
- Motor Control of DC Drives
- Motor Control with PLC Connected to Drives
- Faultfinding on PLC
- Sensors
- Control of a Rotary Index Table

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Ref. 419

DC-Drives

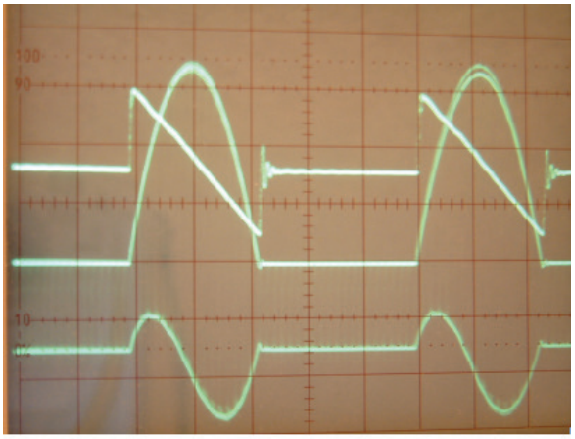
MV4207-1 DC-Motor Drive

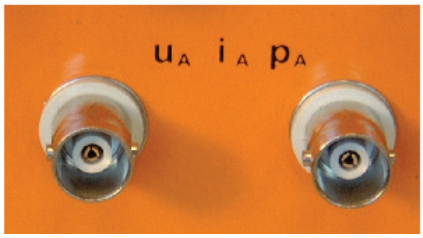
Single-phase 4-Quadrant Rectifier, Three-Phase supply

Covers the latest development in DC-motor operation with analogue control. The equipment is designed to work according to different industrial environments. The drive has signal in- and outputs for connections to slave and/or master drives.
To cover a wider range of machines regarding voltage and speed the primary supply is taken from a standard 3-phase outlet which will supply the inverter bridges by 2-phase 400 V.
The design will enhance the possibilities of learning the theory and practice of understanding the operation of 4Q-drives for both single drives and the basic understanding of three bridges and their commutation.
The 4-Q-DC-Drive can be used in the conception of speed/ torque control versus electro-machine theory.
When braking, the energy is transferred directly to the supplying network by operating in all four quadrants.

Technical Specification

Input voltage:	3-phase 3 x 400 V + N + PE, 50-60 Hz
Input max current:	16 A, rotor inductance is included
Output voltage:	0-250 V DC
Output current:	0 - 12 A (max 16 A)
Nom. output power:	2 kW
Design:	Tutorial where the 4Q industrial/ professional aspects are enhanced
Control:	Manually operated Digital / Analogue
Front control parameters: 12	
Feedback:	DC-tacho or armature voltage
Built-in unit for immediate:	
	U+I+P signals, isolated, including MUX for oscilloscope.
Built-in protections and contactor relays	
Dimensions	520 x 450 x 280 mm
Weight	23 kg





Standard Settings

12 Parameters are set manually:
Typically: Speed, Max Speed, Acc ram, Flux, Ret ramp, Ilim, Current/Speed proportional, Current demand in/out, etc.
Floating switches and potentiometers are used to study step response and stability. The results of the dynamic response regarding voltage, current and immediate power can be studied fully isolated on a standard oscilloscope via the built in isolation amplifier and multiplexer.

Manuals

consist of a theory section and an exercise section. The theory part explains for example general theory of the conditions for torque developed in an arbitrary machine, while the exercise section contains theory sections that are directly connected to the different experiments. The Manual consists of a complete binder together with an additional section , which will explain the UIP-unit (Voltage/Current/Power – unit) together with oscilloscope snap-shots showing different operation modes of the rectifier.

MV4207-3 DC-Motor Drive

Three-phase 4-Quadrant Rectifier, Three-Phase supply

Covers the latest development in DC-motor PC-controlled operation with 6 pulse 4Q rectifiers. The equipment is designed to work according to different function principles and it is possible to explain several different types of DC-drives depending on the purpose and industrial environment from traction to paper- and steel mills.

Output current/voltage can be chosen to optimize torque/ angular speed or to optimize other parameters by using a PC and the enclosed software. When braking, the energy is transferred directly to the supplying network by operating in all four quadrants. The field rectifier can be programmed manually or from a PC for optimized field control.

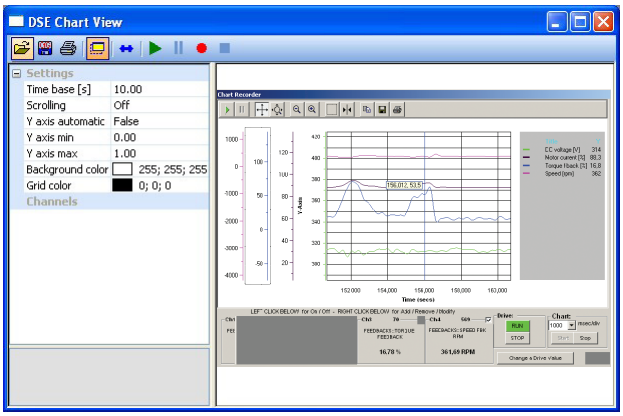
The 4Q DC Drive can be used in the conception of speed/torque control versus electro-machine theory. The equipment is also suitable for experiments and tests in industrial applications.

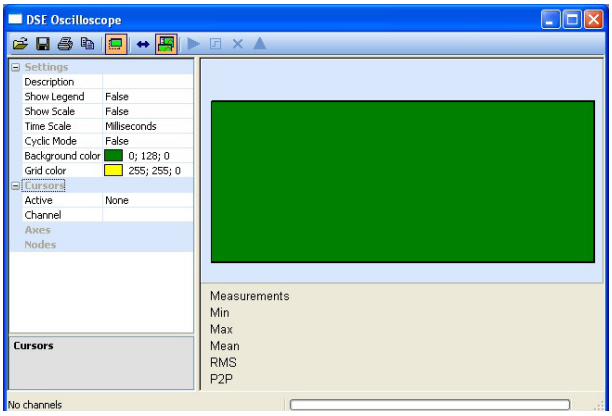
Technical Specification

Input voltage: 3-phase 3 x 400 V + N + PE, 50-60 Hz
Input max current: 16 A
Output voltage: 0 - 400 V DC
Output current: 0 - 12 A (max 16 A)
Nominal output power:
2 kW (max 3 kW)
Design: Tutorial but with the PC-controller industrial / professional aspects enhanced.
Control modes: Manually by front components, Manually by Operator Station, PC by RS 232 +"DELite"" + software

Front controls: Manually Digital > 20, Analogue > 4
Configuration: by PC or Operator Station
Self-tuning: by PC or Operator Station
Built-in protections and contactor relays

Dimensions 520 x 450 x 280 mm
Weight: 25 kg





Built-in Instruments and Oscilloscope Functions

The enclosed software will make it possible to configure the internal connections and operating principles by using a standard PC. On the screen it is possible to monitor 3 analogue instruments and edit a number of signals/ parameters in parallel, which can be saved and printed. The number of parameters/tags possible to study exceeds 200.

Standard Settings and Advanced Settings

Most parameters are set by default but settings can also be done manually from the front controls: Typically: Speed, Max Speed, Acc ram, Flux, Ret ramp, Ilim etc. Advanced settings, >200 parameters/tags, are performed by Operator Station on the unit, PC nearby the unit, connected to COM1 (COM2).

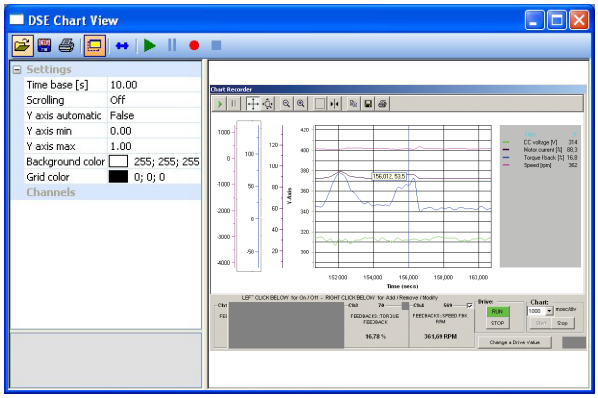
Manuals

Consists of a large quantity of experiments where related theoretical analyzes and explanations are performed in each experiment. Experiments furtheron covers basic operation and autotuning as well as more advanced operation directly from the drive keypad (operator station) or from PC where signal analysis also are possible by means of the chart recorder and the oscilliscope function.

AC-Drives

MV4206-1 AC-Motor Drive

Three-Phase supply, semi 4-Quadrant Drive frequency converter with MOS FET technique and a fixed intermediate DC-link.



Covers the latest development in AC-motor operation with frequency converters. The equipment is designed to work according to different function principles and it is possible to explain several different types of frequency converters existing today.
4-Q-Drive: The Frequency Converter can be used in the conception of speed/torque control and electro-machine theory. The equipment is also suitable for experiments and tests in industries i.e. far beyond the area that the experiments show.
When braking, the energy is transferred by the DC-link and a brake chopper to a built-in load resistor.
There is also an additional adjustable DC-injection brake.

Technical Specification

Input voltage: 3-phase 3 x 400 V + N + PE, 50-60 Hz
Input current: 16 A max
Output Power: 1.5 kW
Output voltage: 3 x 230 V
Max output current: 7 A
Max output frequency: 100 Hz
Choice of polygon: automatic
Breaking points: automatic
Internal switch frequency: 3 kHz max
Type of modulation: PWM sensorless vector
Intermediate DC-voltage: average value 300 V DC
Inverter bridge: MOSFET
Control voltage: +/- 10V DC analog, 0-24V DC Digital

Dimensions 520 x 450 x 280 mm
Weight 16 kg

Built-in Instruments Functions
The enclosed software will make it possible to configure the internal connections and operating principles by using a standard PC. On the screen it is possible to monitor 3 analogue instruments and scroll a number of signals/parameters in parallel, which can be saved and printed. The number of parameters/tags possible to study exceeds 200.

Standard Settings and Advanced Settings
Most parameters are set by default but settings can also be done manually from the front controls: Typically: Speed, Max Speed, Acc ram, Flux, Ret ramp, I-lim etc. Advanced settings: >200 parameters/tags, are performed by Operator Station on the unit, PC nearby the unit, connected via the comport.

Manuals
consist of a theory section and exercise section together with a software description. The theory part explains for example general theory of the conditions for torque developed in an arbitrary machine, while the exercise section contains theory that are directly connected to the different experiments.
The instruction manual is enclosed as a complete binder together with a corresponding CD.

MV2661 AC-CONTROL

The MV2661 is an AC drive primarily designed for speed control of a 3-phase squirrel cage induction motor.
Its purpose is to create a sinusoidal (or close to) 3-phase voltage that is connected to the stator of an AC-motor.

The AC-drive controls the pulse width and the frequency of the supplied voltage and can therefore keep the motor running at constant speed although the mechanical load applied at the rotor shaft varies.

The AC drive includes an autotune-function which automatically identifies the electrical and mechanical parameters of the connected induction motor.

The drive is capable of operating machines up to 1.5kW. It controls the output voltage 0-240V and frequency 0.1-600Hz. The maximum output current is 7.5A and the input current 15.7A (fuse size 15A).

It is mainly designed to operate together with Terco MV-machines, which are sized 1.1 – 1.5kW.

The AC CONTROL MV2661 is furtheron equipped with an internal brake chopper and an internal brake resistor which makes it possible to study short ramp time braking coarses.

All essential signals are connected to the front to make it possible not only to run typical experiments verifying the theory but also to make it possible to run the drive out of more advanced industrial aspects.

Technical specifications

Max. Applicable Motor Output	1.5kW
Rated Output Capacity	2.9kVA
Rated Output Current	7.5A
Maximum Output Voltage	3-ph prop. to input V.
Rated Input Current	15.7A (Fused 15A)
Power Supply	220-240VAC, 50/60Hz, 50/60Hz
Voltage Tolerance	+-10% (180-264V)
Frequency Tolerance	+-5% (46-63Hz)
Dimensions	340x250x150mm
Weight	6.2kg

ORDER INFORMATION AC- AND DC-MOTOR DRIVES			
Additional quotation to Electrical Machines Laboratory			
Item	**Description**	**Pc**	**Page**
DC-Drives			
MV4207-1	DC-Drive	1	25
MV4207-3	DC-Drive, Three-Phase supply	1	26
MV1024	DC-Tachogenerator incl. Cover, trim potentiometer incl.	1	34
MV2658	MOSFET - PWM Module	1	34
MV1055	Spacer Shaft	1	42
MV1974	Voltmeter, moving coil 0 - +/- 300 V	1	39
AC-Drives			
MV4206-1	AC Motor Drive	1	27
MV2661	AC-Control	1	28

Ref. 201

MV1439 Power Factor Control Unit

General

With the Power Factor Control Module (PFC) you can minimise the currents caused by reactive losses of power 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 as in industrial applications.

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 capacitive
Power factor setting	0 to 0.7
Nominal voltage	3 x 400 V 50 – 60 Hz
Nominal power	0 – 2 kVAr capacitive
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
Dimension:	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 φ
- 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 INFORMATION POWER FACTOR CONTROL SYSTEM SYSTEM 220-240 V			
Item	**Description**	**Pc**	**Page**
MV1439-235	Power Factor Control Unit	1	26
MV1100-235	Load Resistor 3-ph 3.3 kW	1	35
MV1101	Load Reactor, 3-phase, 2.5 kVAr	1	35
MV1102	Load Capacitor, three-phase 2.8 kVAr	1	35
MV1500	Load Switch, 3-pole 16A	3	42
MV1420	Line Model 3-phase, 230 V 3-phase	1	37
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ELC133A	LCR-meter	1	39
MV1830-HF	Flex Set, 100 Safety Leads, Safety Plugs	1	43
MV1904	Flex Stand	1	44
Optional			
MV1009-405	Induction Motor Squirrel Cage, 400/230V 50-60 Hz 1,1 kW	1	6
MV1028-225	DC-Machine, 2.2 kW complete with interpoles 220V	1	5
MV1905	Shunt Regulator	1	36
MV1004	Machine Bed	1	42
MV1029	Protective Cover	1	34

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ORDER INFORMATION POWER FACTOR CONTROL SYSTEM SYSTEM 380-440 V			
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MV1439-405	Power Factor Control Unit 3 x 400V 50-60 Hz	1	26
MV1100-235	Load Resistor 3-ph 3.3 kW	1	35
MV1101	Load Reactor, 3-phase, 2.5 kVAr	1	35
MV1102	Load Capacitor, three-phase 2.8 kVAr	1	35
MV1500	Load Switch, 3-pole 16A	3	42
MV2221	Line Model 230 kV, 100 km, 400 V 3-phase	1	37
MV1103	Variable Transformer, 3-phase	1	33
MV1429	Connection Box / Terminal Board	1	33
MV1939	AC Power Energy Meter	2	38
DT-2330	Digital Clamp Meter AC / DC current	2	39
MV1830-HF	Flex Set, 100 Safety Leads, Safety Plugs	1	43
MV1904	Flex Stand	1	44
Optional			
MV1009-405	Induction Motor Squirrel Cage, 400/230V 50-60 Hz 1,1 kW	1	6
MV1028-225	DC-Machine, 2.2 kW complete with interpoles 220V	1	5
MV1905	Shunt Regulator	1	36
MV1004	Machine Bed	1	42
MV1029	Protective Cover	1	34

Ref. 205

MV4250 Asynchronous Wind Mill System including HVDC Light Transmission Cable

The total system is integrated in one single unit:

- Controls for asynchronous machine
- Necessary instruments
- Magnetizing capacitors
- Compensating inductances
- Variable resistive load
- HVDC-light cable (two distances)
- Advanced 4Q 3-ph line inverter which is manually, MMI- or PC-operated.

Background

Depending on energy prices, negative influence on the environment, running on the edge of available power, transmission costs and the risk of local black-outs the need for alternative energy sources is obvious.

Wind power has been existing in a smaller scale for decades but are now used as an important power producer in parallel with the classic energy sources. The former drawbacks like expensive turbines, generators, gear-boxes and conventional transmission lines together with disturbances on the environment are now overcome to a great extent.

It is now possible to use a cheap turbine with firm blades designed for floating speed with an operating range from low to higher speeds. The turbine is connected mechanically to a conventional asynchronous machine (self exciting induction motor), which is the cheapest and most sturdy machine available in the market.

For bigger units synchronous generators equipped with permanent magnets are standard. In this case we will study a type of wind mill used up to some hundred kW. These windmills can be put out in the sea along the coastline and the power is transferred to the grid network by HVDC-light cables on a floating voltage level which by means of modern technology is transformed to conventional 3-ph 50 (60) Hz energy.

Description

The Wind Mill Control Unit (MV4250) is designed to be connected to an external standard type induction machine (optional) to simulate the wind turbine, which speed can be varied.

By means of the MV4250 the asynchronous motor/generator will be self excited and deliver a lower or higher 3-phase voltage of different frequencies.

There is a continuously controllable built-in resistive load bank to give the induction generator different working points or break-down points.

By the built-in capacitor bank the excitation can be increased gradually to buffer increasing load. A group of compensating inductances will keep the voltage level within reasonable limits.

A 3-phase rectifier bridge will supply the output side with a floating DC-voltage which can either be loaded by the internal resistive loads or connected to a HVDC-light line model which is feeding an advanced 3-ph 6-pulse 4Q converter.

The converter is operating against the infinite bus in a floating voltage current limitation mode turning the DC-energy to 3-ph 50 (60) AC.

There are instruments for AC- and DC voltages and ammeters for AC-input power, inductive current and capacitive current together with a DC-ammeter on the output to give a clear view of the generator operation.

The rather complex procedure of turning floating voltage DC-energy to 3-ph 50 (60) Hz AC is studied thoroughly since most types of windmills are using this method. Jumpers will give possibilities to connect other instruments like watt-meters (optional).

Principle diagrams are printed on the front plate (see below).

Technical Specifications

Minimum/maximum power by design	0,5 – 2,0 kVA input
Magnetising capacitors	by 3-step selector switch
Compensating inductors	by 3-step selector switch

Resistive load bank on DC-side continuously controlled by PWM-unit 3-phase rectifier block

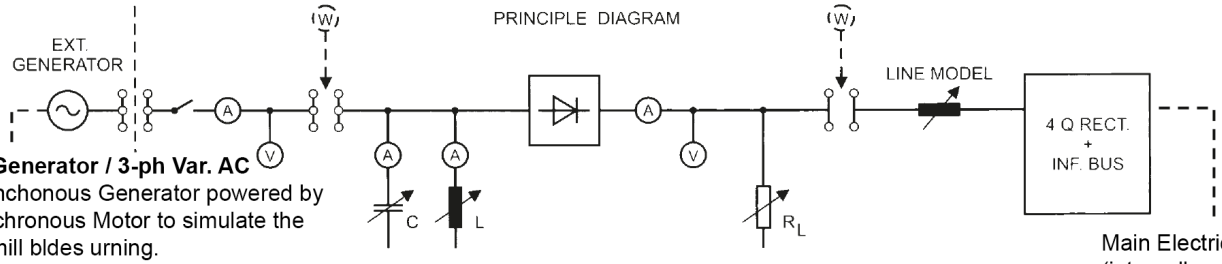
V-meter for AC-input	250 V AC
V-meter for DC-output	400 V DC
A-meter for AC-input	6 A AC
A-meter for capacitive current	6 A AC
A-meter for inductive current	4 A AC
A-meter for DC-output	6 A DC

Short- and long HVDC cable model

Suitable induction machine std (or optional)	0,75 – 1,5 kW
Advanced 4Q-converter including software	>1,5 kW
External alternative inputs from	3x230 V generator, ind. or synchr., 3x230 V power supply max 300 V DC
Power supply	3x400 VAC, 16A, 50–60 Hz
Dimensions	510x360x570 mm
Weight	45 kg

Examples of experiment setups

- Self exciting of an asynchronous motor/generator
- Working points depending on speed and capacitance
- Working characteristics depending on resistive loads
- The influence of compensating inductances
- Total efficiency depending on involved parameters
- Magnetising currents and risk for over-excitation
- Rotating currents
- Principles of floating speed and frequency
- HVDC-light cables
- Principles of DC energy transfer using a 4Q-converter operating in current limit mode at floating voltage
- Operating the main converter manually, via MMI or by PC



Ext. Generator / 3-ph Var. AC
- Asynchonous Generator powered by Asynchronous Motor to simulate the windmill bldes urning.
-3-ph Variable AC Voltage directly connected to simulate the windmill generator

Main Electric Net (internally connected

ORDER INFORMATION RENEABLE ENERGY - WIND MILL CONTROL			
Item	**Description**	**Pc**	Page
MV4250	Asynchronous Wind Mill System incl. HVDC Light Line	1	31
Optional 1			
MV1009-385	Induction Motor Squirrel Cage	2	6
MV1004	Machine Bed	1	42
MV1029	Protective Cover	1	34
MV4206-1	AC Motor Drive	1	27
Optional 2			
Mavowatt 4	Wattmeter	2	41
MetraHit Pro	Digital Multimeter	1	40
MV1830-HF	Flex Set, 100 Safety Leads, Safety Plugs	1	43
MV1904	Flex Stand	1	44

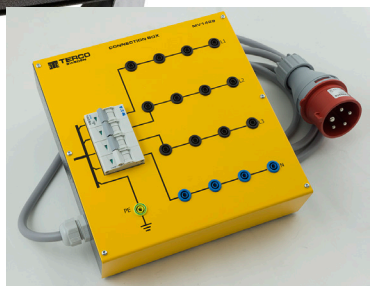
Ref. 203

Power Supply

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	



MV1300 Power Pack

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

General Data

MV1300-235 Supply voltage 220-240 / 127-140 V 50 / 60 Hz 3-ph.
MV1300-405 Supply voltage 380-400 / 220-230 V 50 / 60 Hz 3-ph.
MV1300-415 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

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	

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

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

MV2658 PWM DC Control Module

MV2658 is an indispensable equipment in the electrical machines laboratory as it can be used in several different types of applications.

It can be used as a DC-Machine Drive in the range up to 1.2kW, a Generator Field Controller (VAr controller), or a Machine Brake Controller suitable with Terco equipment in the range up to 3.3kW

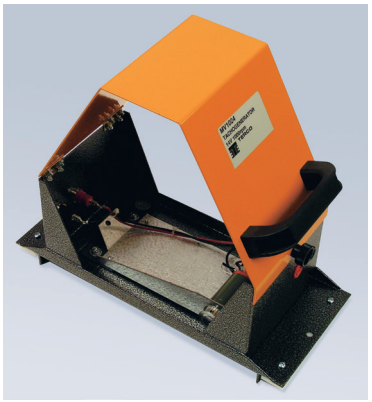
Technical Specifications

- PWM (16kHz) Based Excitation Voltage 0-260VDC.
- Selectable Current Limit Levels (front panel switch): 1.7ADC, 2.5ADC, 3.5ADC, 5.0ADC, 7.5ADC.
- Fixed Excitation Output 200VDC (for DC Drive application).
- PWM Controlled Excitation on the front panel control
- 0-100% Duty Cycle) or from the control input
- fully isolated, 0-10VDC = 0-100% Duty Cycle.

The control input can be used for instance in PC based control together with Terco DAQ software. (Optional analogue output interface unit necessary).

- Control Methods selectable between PWM Controlled Excitation Voltage Feedback and External Analog Voltage Feedback.
- Power Supply 220-240VAC, 50/60Hz

- Dimensions: 255 x 195 x 330mm
- Weight: 8kg (approximatly)



Tachogenerators

The generator is mounted inside a protective guard. The cover is hinged and can be fixed by a locking screw.

MV1024 DC Generator 14 V at 1000 rpm (with trim potentiometer)

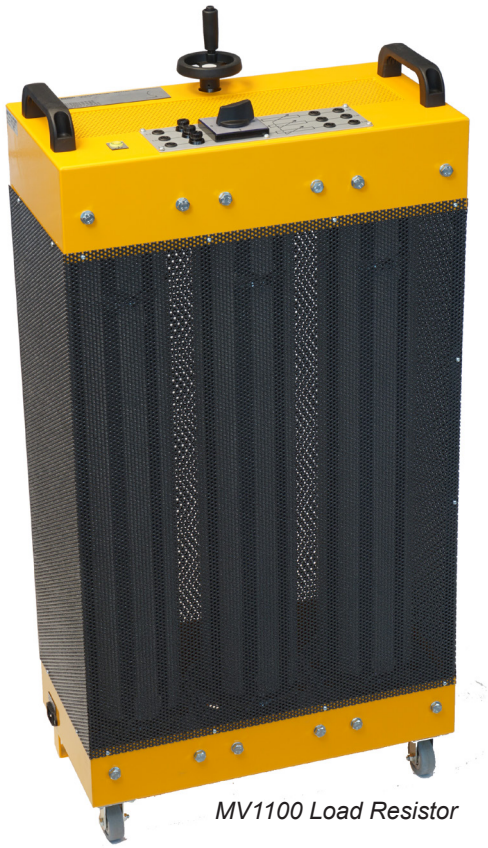
MV1025 DC Generator 14 V at 1000 rpm. (to be used with the MV1036 Electric Torque Meter System which has built-in trim potentiometer)

MV1029 Protective Cover (only)

Dimensions
Weight 2 kg

Please note : The protective guard can be fitted between the machines to
cover the rotating couplings, thus minimising the risk of accidents from rotating machinery.

Loads



MV1100 Load Resistor

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. 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 Reaktor

MV1101 Load Reactor

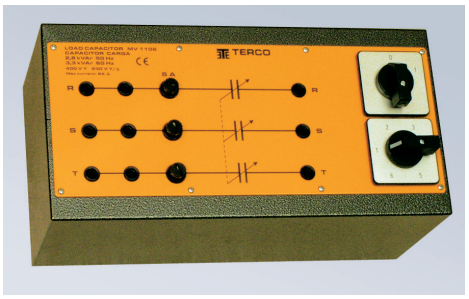
Enclosed in a strong metal cabinet. The front panel has mimic diagram, terminals, fuses and electrical data. The unit can be used on 1- and 3-phase systems. 12 step regulation.

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

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

On the back of the MV1905 is placed a cooling fan

MV1905 Shunt Regulator

Used for field regulation of DC-machines MV1006, MV1028, MV1034 and for synchronous machines MV1008 and MV1027.

General Data

Power Supply	230V AC
Potentiometer-connected	440 ohms
Supply voltage	220 V DC
Max current	2 A
Dimensions	215 x 190 x 230 mm
Weight	3 kg

MV2636 AC & DC Starter

This is an universal starter for both AC slip-ring induction motors like MV1007 and for DC-motors like MV1006, MV1028

Dimensions	350 x 260 x 150 mm
Weight	4 kg

Line Models

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

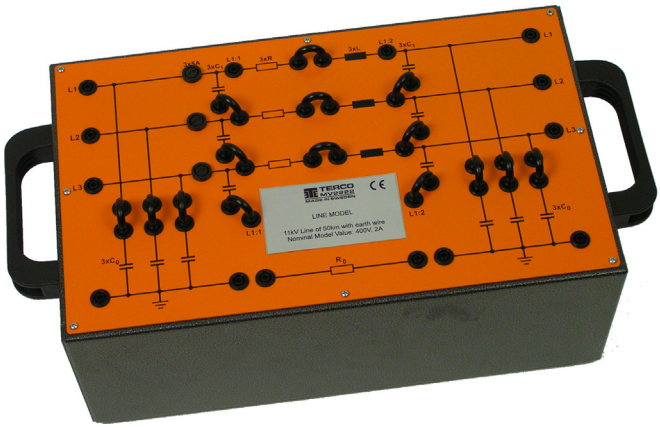
Line capacitance divided into capacitance to earth (4 µF) and mutual line capacitance between phases (8 µF).

Earth impedance	0.8 ohm
Fuses	5 A

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

The following studies can be made:

1. Measurements of characteristic data, resisance, 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.



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

For more Line Models see catalogue Transmission Line, Transformer and Protection Relays

Instruments

MV1939 AC Power Energy Meter

MV1939 AC Power Energy Meter is a practical solution for the study of 1, 2 and 3-Phase AC power systems up to 500VAC/10A.

The Power Energy Meter enables the measurement and visualization of a wide range of parameters in the study of symmetrical as well as non-symmetrical networks, such as: phase voltages, phase-to-phase voltages, line currents, mean three-phase current, mean three-phase voltage, mean phase-to-phase voltage, three-phase active, reactive and apparent powers, mean three-phase power factors.

The visualization of parameters is distributed over several pages (default preset to display five pages) where each page simultaneously displays four parameters.

Technical Specifications

Power supply	220-240VAC, 50/60Hz
Measurement ratings:	
Voltage / Current	500VAC max / 10AAC max
Reactive / Active Power	5 kVAr / 5 kW
Cos Phi	0-1-0
Communications:	
Serial interface	RS485
Transmission protocol	Modbus RTU8N2
Baud Rate	19200kB
Dimension	255 x 205 x 335mm
Weight	10kg

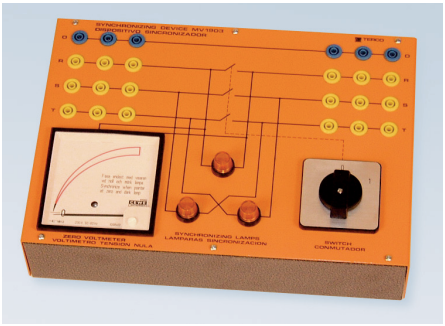
MV1941 DC Measuring Unit

for study of DC circuits up to 350VDC/12ADC.
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 the circuits being investigated.
Robust components provide a good level of protection against incorrect connection, mishandling and carelessness.

Technical Specifikations

Power supply	220-240VAC, 50/60Hz
Measurement ratings:	
Voltage / Current	350V DC max / 12A DC
Communications:	
Serial interface	RS485
Transmission protocol	Modbus RTU8N2
Baud Rate	19200kB
Dimension	255x205x335mm
Weight	7kg

Both MV1939 AC Power Meter and MV1941 DC Measuring Unit is equipped with a standardized industrial data acquisition protocol (Modbus) and is compatible with the MV2609 Terco DAQ software (MV1943 Computer Interface is necessary).



MV1903 Synchronizing Device

The equipment includes 1 zero voltmeter, 1 circuit breaker, 3 signal lamps and terminal bolts.

General Data	MV1903-235	MV1903-405
Zero Voltmeter	2 x 140 V	2 x 220 V
Circuit Breaker	16 A 500 V	16 A 500 V
Synch. Lamps	130 V with resistor	220 V with resistor
Supply Voltage	220-240/127-140V 50-60 Hz	380-415/220-240 V 50-60 Hz
Dimensions	315 x 240 x 90 mm	
Weight	3 kg	

Other voltages can be supplied on request.

MV1974 Voltmeter, moving coil

Test Voltage:	2 kV, AC
Measuring range:	AC 0 - +/- 300V
Safety sockets	
Accuracy class:	1.0
Dimensions (HxWxD):	95 x 200 x 80 mm
Weight:	2 kg

MAT220349 Digital Clampmeter AC/DC current

MAT229349 is a small and reliable 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 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

Dimension:	20x44x146 mm
Weight:	0.1 kg

ELC133A LCR-meter

Capacitance range	20nF to 10mF(@100/120Hz)
Inductance range	20mH to 1000H(@100/120Hz)
Resistance range	20Ω to 10MΩ(@100/120Hz)
Measurement	R,L,C,D,Q,θ
Power supply	9V
Dimension	87x184x41mm
Weight	330g

MAT220118 Digital multimeter

TRMS multimeter with a bandwidth up to 1 kHz. The instrument has built-in voltage indication, so-called ”phase function”.

Measurement of current up to 10 A and capacitance and temperature with thermocouple type K. Further available. Min / Max function and relativity measurement.

The instrument is rated for category IV 600V and has a large, backlit 6000-digit display with bargraph function.

Automatic voltage detection and automatic shutdown.

Built-in impact protection and high protection class.

Metrahit Pro Digital Multimeter

- True effective value change, TRMS 15Hz - 10kHz
- Measures on motor controls
- Accuracy +/- 0.05% (V DC)
- Scale 11999
- Backlit display with high contrast and large numbers
- Automatic range selection for current measurement from 1A to 10A (16A) (resolution 100µA) and with just one input
- Precision multimeter: V, A, Ω, Hz, ° C / ° F
- Safety according to IEC 61010-1, cat IV / 600V and cat III / 1000V
- All measuring ranges are overload protected up to 1000V
- Three inputs with automatic fault switching blocking, (ABS)
- Secured current inputsTraceable calibration certificate is included
- Automatic shutdown (10min)

Dimension:	200x 87 x 45 m
Weight:	0.35 kg

Phase Cop 2 Phase Sequence Indicator

Tester for determining the direction of rotation or phase sequence in 3-phase systems.

- 3 LEDs indicate whether or not the 3-phase conductors are live
- Very large voltage and frequency range
- Simple operation
- Rugged design
- Permanently connected cables with contact-protected connector plugs, three plug-on test probes and one plug-on alligator clip

Voltage range	90-660 V
Frequency	45-1000 Hz
Dimensions	70 x 105 x 40 mm
Weight	0.3 kg

Mavowatt 4 Network analyzer 1-pole, 3-pole

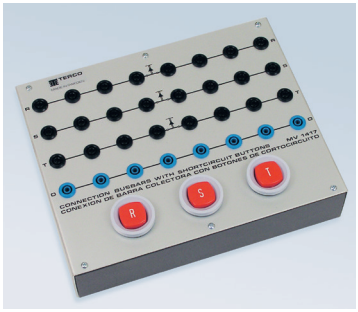
- Single-phase alternating current 12.5 kW (active)
- Triple phase three-phase current, equal to load current: 25 kW (active), 25 kVar x V3 (blind power)
- Rated current 0.25 A / 1 A / 5 A / 25 A
- Rated voltage 50/100/250/500 V
- Frequency range 10 - 400 Hz
- Voltage measurement AC / DC 50/100/250/500 V
- Current measurement AC / DC 0.25 A / 1 A / 5 A / 25 A
- Accuracy class 1.5 (2.5 P, U, I)

Dimension: 181 x 62 x 110 mm
Weight: 0.8 kg

MX24B Digital Multimeter

20A ac 750V ac 20A dc 1000V dc

Accessories

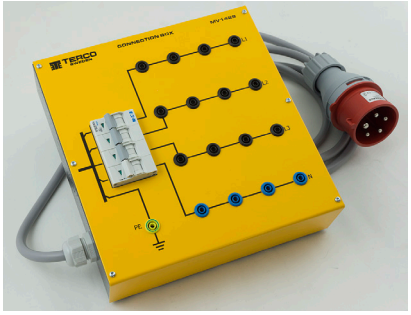


MV1417 Terminal Board with Short-Circuit Buttons

Combined terminal and protection board for instruments. Current coils of ammeters and wattmeters connected to the board through a normally short-circuited contact which is opened during measurement. Opening of the contacts for phase R, S, T is done with a robust push-button for each phase.

Reading of the instrument can be done only when the button is pressed, which is of great advantage in the event of wrongly terminated instruments.

Dimensions: 245 x 195 x 50 mm
Weight: 1.5 kg



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

MV1055 Shaft Spacer

To be used as an shaft extension between MV1054 torque/speed meter and either the test machine or the braking/driving machine to give space for the MV1024 tachometer generator when doing closed-loop experiments with DC-drives.
MV1055 is also suitable between the MV1010 flywheel and the MV1054 torque/speed meter.

MV1500 Load Switch

Three-pole:	16 A, 250 V- DC/440 V-AC
Dimensions:	95 x 200 x 80 mm
Weight:	1 kg

MV1502 Reversing Switch

Suitable for 3-phase machine, 16 A, 500 V

Dimensions:	95 x 200 x 80 mm
Weight:	1 kg

MV1503 Star / Delta Switch

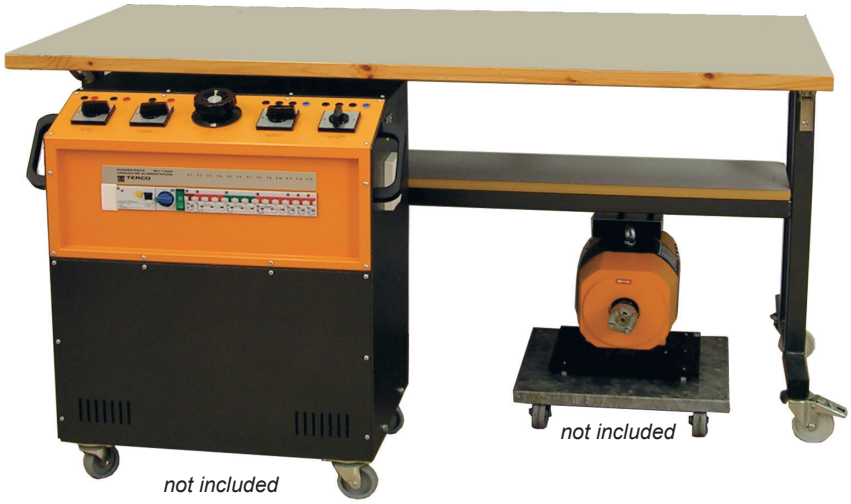
Suitable for 3-phase machine, 16 A, 500 V

Dimensions:	95 x 200 x 80 mm
Weight:	1 kg

MV1004 Machine Bed

This strong, stable machine bed of anodized aluminium
bars has rubber dampers on the underside to prevent transmission of vibration to the base. Clamps for mounting torque meter and machines are included

Dimensions:	1500 x 300 x 65 mm
Weight:	15 kg



MV1003 Mobile Test Bench

For mobile use, the torque meter or brake system and test machines with machine bed are placed on a mobile bench having one folding leaf, one fixed shelf and four wheels, of which 2 can be locked.

Dimensions of the folding leaf:
1490 x 400 x 30 mm

Dimensions:	1500 x 600 x 840 mm
Weight:	55 kg

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.

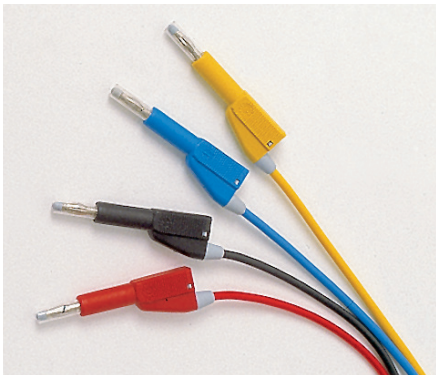
	25 cm	50 cm	100 cm	200 cm
Red	5	5	5	5
Yellow	5	5	5	5
Blue	5	5	5	5
Black	5	5	5	5
Yellow/green	5	5	5	5

Alternative Flexes: Laboratory Flexes with Safety Plugs, Retractable Shroud

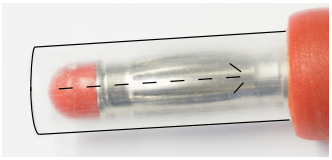
MV1830-H Flex Set Area 1.5 mm²

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.

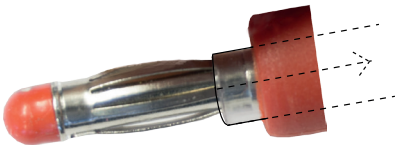
Length	25 cm	50 cm	100 cm	200 cm
Red	5	5	5	5
Yellow	5	5	5	5
Blue	5	5	5	5
Black	5	5	5	5
Yellow/green	5	5	5	5



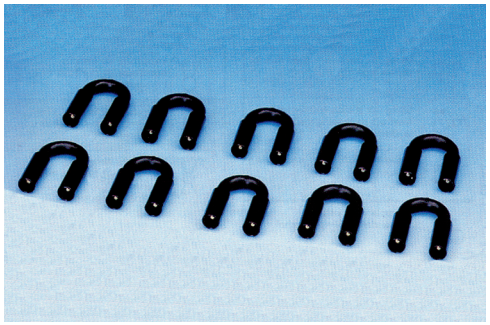
Safety lead with 2 covered spring plugs of 4 mm diameter, with retractable shroud covering the plugs, and 4 mm diameter axial bushings moulded with Polypropylen, fixed to 1.5 mm² copper thread, PVC isolated, outer diameter 4 mm. Rated current 16 A.



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.



LEY500590 Safety Jumpers

Short circuiting 4 mm black jumpers used for connecting motors etc

General data

Dimension:	38 x 26 x 8 mm
Weight:	0.05 kg.

ELE102002 IK Storage Rack

A system Storage Rack for lab modules. The Storage Rack will protect the Lab Cards against electrical and mechanical damage.

General data

Dimensions:	180 x 180 x 355 mm
Weight:	1.4 kg

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

Item Index

Alphabetical Index

Important Notice - Explanation of Suffix

Suffixes indicating voltage and/or frequency ensure that equipment corresponds with the various voltages in different countries.

For DC-machines, all having 220 V supply, the suffix indicates different to match synchronous speeds, speeds alternatively 50 or 60 Hz, when DC and AC machines are coupled together.

Examples of codes involved:

Torque Meter DC-Machines:

MV 1036-225 DC-machine Torque Meter (analogue), Voltage 220 V 50 Hz
Rated speed: Generator 1500 rpm, Motor 1400 rpm

MV 1036-226 DC-Machine Torque Meter (analogue), Voltage 220 V, 60 Hz
Rated speed: Generator 1800 rpm, Motor 1700 rpm

The same concerns Torque Meter DC-Machines with double ended shafts, with basic codes MV 1026 and Drive Machine MV 1028 as well as test machines DC MV 1006, to which one of the suffixes, -225 or -226, is added as necessary.

AC Test Machines
The suffix indicates in this case frequency and supply voltage as follows:

-405 supply voltage Star 400 V, Delta 230 V, Frequency 50 Hz
-406 same supply voltages, Frequency 60 Hz

Examples:

MV 1007-405: Induction Motor, slip-ring, Star 400 V, Delta 230 V, 50 Hz and 60 Hz
MV 1008-236: Synchronous Machine, Start 230 V, Delta 133 V, 60 Hz

Sometimes, when there is a '5' as last digit in the suffix, e. g. MV 1007-405, the product can be used both for 50 Hz and 60 Hz (see data in the catalogue).

Load Resistor MV 1100
Suffix -115 or -235 indicates only supply voltage for the cooling fan. The unit itself can be used as a load for all the voltages occuring in the electrical machine laboratories, within the admitted current limits.

Other Equipment
The same principles apply to all other items in the price list, coded with a basic number with a suffix. For other technical details, please check the catalogue.

PLEASE NOTE:
Equipment for other supply voltages can be supplied on request

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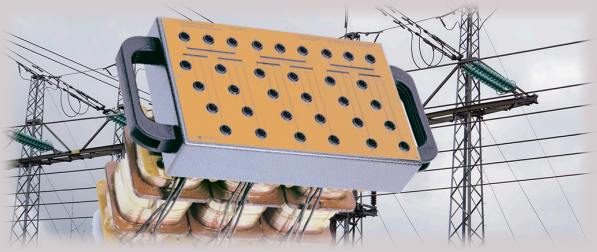
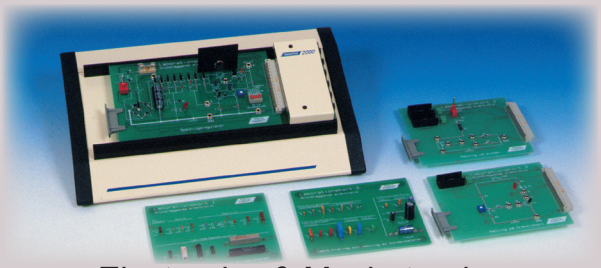
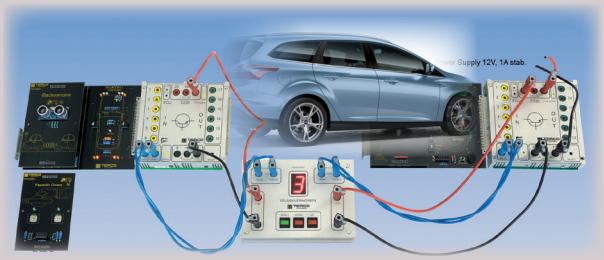


Transmission

Process, Control & Servo System



Electronics & Mechatronics



Automotive Electronics

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Power Distribution & Furniture for Lab

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