ELECTRICAL POWER ENGINEERING

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Introduction

This trainer has been designed to provide students with a fully comprehensive knowledge in Electrical Power Engineering systems.
The trainer is composed of a set of modules for the simulation of the various subsystems forming a complete electrical power system, from power generation to energy utilization.
High voltage components have been scaled down for obvious reasons: a real 380 kV power transmission line is represented by a 380 V line in the laboratory. However, the same low voltage industrial equipment which is normally used in real systems has been used also in this laboratory, whenever this was feasible.

The trainer can be subdivided into four major study areas:

- Power Generation
- Power Transmission and Distribution
- Protection Techniques
- Energy Utilization

In the Power Generation section a two-pole alternator is investigated. A dc shunt wound machine performs the drive function. To determine some of the characteristics of the synchronous machine, the so called isolated operation situation is reproduced.
This is an operating mode in which the generator supplies only one single consumer.
Then, various synchronization circuits are assembled and the response of the machine is investigated in a constant-voltage constant-frequency system. In this situation, voltage and frequency are predetermined by the system and have constant values. Problems related to the protection of the generation are also dealt with.

In the Power Transmission and Distribution section a three-winding transformer is investigated. Then, a model of an overhead high voltage power line is used to investigate its performance characteristics under various load conditions.
Circuit configurations are connected for the demonstration of different neutral point connections in three-phase mains systems. Asymmetrical short-circuits are also simulated and reactive power compensation analyzed.

In the Protection Techniques section instrument transformers, to reduce the high current and voltage values so that they can be measured safely and economically, are studied. Then, the procedures which are most commonly used in protective technology are introduced and the most frequently used relays (under/over voltage relays, definite and inverse time over-current relays, earth-fault relays, etc.) are investigated.
Finally, over-voltage, under-voltage and earth fault monitoring and short-circuit protection of high voltage lines are analyzed.
Special attention is given to the issue of protection of the generation, of the transmission and of transformers.

In the Energy Utilization section the problems related to reactive power compensation are discussed as well as the methods and the equipment relevant to measuring the electrical energy in ac current and in three-phase networks: active and reactive energy induction meters and maximum demand meters.

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Power Generation

The three-phase current has emerged as the simplest form of power, in terms of both transmission and universal application, in the area of public power supply.
In fact, three-phase currents can be transmitted to a voltage level which is suitable for the distances the power has to be transmitted and, furthermore, it is ideal for being used by the consumers.

The major problem is that electrical power cannot be stored in large quantities and, consequently, it has to be generated at the same time the consumer needs it. The generation of electrical energy is performed almost exclusively by means of high power synchronous machines, or alternators, whose construction design depends on the type of drive, which can normally be steam, gas or water.

Then, if the synchronous generator must be connected in parallel with a constant- voltage constant-frequency system, it has to reach its nominal speed, and the excitation voltage has to be increased from zero until the stator voltage is brought up to the same level as that of the network. To obtain this situation, the magnitude, the phase relation and the rotational direction of the two voltages must be in agreement.

This procedure is termed synchronisation. In this section a two-pole alternator is investigated.
A dc shunt wound machine performs the drive function (GTU 101.1).

To determine its characteristics the synchronous machine is operated in what is known as an isolated operation. In this configuration the generator supplies energy to one consumer only.
In this case, the alternator determines the voltage magnitude and the frequency.

Then, various synchronisation circuits are assembled and the response of the machine is investigated in a constant-voltage constant-frequency system. Here, voltage and frequency have constant values and are predetermined by the system.

Furthermore, problems related to the protection of the generation are also dealt with (GTU 101A).

Experiments GTU101.1

Alternator and parallel operation

- determination of the effective resistance of stator and exciter windings of the alternator
- determination of the mechanical and iron losses of the alternator
- recording the open-circuit curve at various speeds
- determination of the ohmic and stray losses of the alternator
- recording the short-circuit curve at various speeds
- calculating the synchronous reactance
- recording the response of the alternator operating with the excitation and speed kept constant under different types of load
- recording the regulation characteristics at different power factors
- determination of the conventional efficiency of the alternator using the open- and short-circuit test results
- becoming familiar with various lamp circuits used to connect an alternator
- in parallel to a constant-voltage constant-frequency system
- parallel operation using a synchronoscope
- response of the alternator on a constant-voltage constant-frequency system
- recording the V-curves (Mordey curves) of the synchronous motor

Experiments GTU101A

Generation protection

- no-load test
- short-circuit test
- load characteristics
- regulation performances characteristics
- manual synchronization procedure
- automatic synchronization procedure
- power factor characteristics
- overcurrent protection
- over-voltage or under-voltage protection
- over-frequency or under-frequency protection
- unbalance protection
- earth protection

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Configurations

		GTU101.1 Alternator and parallel operation	GTU101A Generation protection	TOTAL
Variable dc power supply	DL 1013T2	1		1
Resistive load	DL 1017R	1	1	1
Inductive load	DL 1017L	1	1	1
Capacitive load	DL 1017C	1		1
Shunt dc motor	DL 1023PS	1		1
Three-phase synchronous machine	DL 1026A	1	1	1
Motor driven power supply	DL 1067S		1	1
Optical transducer	DL 2031M	1		1
Universal base	DL 1013A	1	1	1
Electronic tachometer	DL 2025DT	1		1
Experiment transformer	DL 1055TT	1		1
Three-phase power supply	DL 2108TAL-SW	1	1	1
Variable dc power supply	DL 2108T01	1		1
Power circuit breaker	DL 2108T02	1	2	2
Switchable capacitor battery	DL 2108T20		1	1
Feeder manager relay	DL 2108T23		1	1
Generator synchronising relay	DL 2108T25		1	1
Brushless motor with controller	DL 2108T26		1	1
Communication ModBus hub	DL HUBRS485F		1	1
SCADA software	DL SCADA-WEB		1	1
Moving coil ammeter (100-500-1000mA)	DL 2109T1A	2		2
Moving coil ammeter (1.25-2.5A)	DL 2109T2A5	2	1	2
Moving iron voltmeter (600V)	DL 2109T1PV	1		1
Synchronization indicator	DL 2109T1T	1	1	1
Phase sequence indicator	DL 2109T2T	1		1
Double frequencymeter	DL 2109T16/2	1		1
Double voltmeter (250-500V)	DL 2109T17/2	1		1
Three-phase voltage transformer	DL 2109T24		1	1
Power meter	DL 2109T26	1		1
Power factor meter	DL 2109T27	1		1
Synchronoscope	DL 2109T32	1		1
Moving coil ammeter (100-1000mA)	DL 2109T1AB	1		1
Moving coil voltmeter (15-30V)	DL 2109T2VB	1		1
Connecting leads	DL 1155GTU	1	1	1
Table	DL 1001-1	1	1	1
Frame	DL 2100-3M	2	2	2
Accessory: Storage cabinet	DL 2100TA	1	1	1
For Countries with 3-phase mains different from 380V:				
Three-phase transformer	DL 2100TT	1	1	1

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Power Transmission and Distribution

The major advantage of ac and three-phase technology over dc technology is that the electrical power is generated economically in large power stations relatively far from the end users, transported at high voltage over long distances with very little power loss and finally made available to the consumers the way they need it.
This is possible only by using transformers. In fact, they are suitable for stepping up the voltage of the generator to values which are suitable for high voltage systems, for power exchanging between networks, for stepping down the voltages to the medium voltage level and then for feeding the power into the low voltage network.
In this laboratory a three-winding transformer is investigated. It consists of three individual poles with different connection possibilities on the primary side and variable secondary voltage. The third winding (tertiary winding) is designed as the delta stabilizing winding needed for asymmetrical loads.
Overhead power lines are mainly used to transmit electrical energy from the power stations to the consumers. However, in densely populated areas the power can only be supplied via cables.
Both means of transmission, overhead lines and cables, are included in the general term “line”.
Today, the public supply of power takes place almost exclusively by means of three-phase current with frequency of 50 or 60 Hz, depending upon the Country.
Due to the phase shift of the three currents in a three-phase system, a rotating field is created which is ideal for use by consumers. Furthermore, another advantage of three-phase systems is that they provide the consumers with two different levels of voltage, so that he can use his equipment in the best economical way.
In this laboratory a three-phase model of an overhead power transmission line (with a simulated length of 360 km long, a simulated voltage of 380 kV and a simulated current of 1000 A) is used, with a scale factor of 1:1000.
The performance characteristics of the line are investigated under various load conditions. Circuit configurations are then connected for the demonstration of various neutral point connections in three-phase mains systems. Asymmetrical short-circuits are also simulated.
Questions regarding reactive power compensation are finally addressed. But, transmission networks require a great number of lines and transformers as well as switchgears and substations.
Of course, because of the importance of electrical power, special attention is paid to guaranteeing the smooth operation of all the transmission devices.

Various voltage levels are used for transmitting power; the levels are determined by the amount of power and the distance; the higher the transmission voltages, the lower the currents as well as the transmission losses. However, it must also be considered that network investment costs increase with the voltage.

To evaluate the optimum network configuration heavy calculations have to be carried out. In this laboratory the basic circuits of power engineering, series and parallel connections of operating equipment (lines, transformers) as well as circuits involving the conversion of delta connections to star connections and vice versa, are analyzed.

Also busbars, disconnectors, power circuit breakers, voltage and current transformers are studied; these, in fact, are among the most important components of a switching station.

Three-phase transformer - GTU102.1

- determination of the vector group of the three-phase transformer
- determination of the voltage transformation ratio of the transformer operating at no-load
- determination of the current transformation ratio of the transformer operating with short-circuit
- determination of the equivalent circuit quantities based on the consumed active and reactive power
- measurement of the effect of the load type and magnitude on the performance of the secondary voltage
- determination of the efficiency of the transformer
- investigation of the zero-impedance of the three-phase transformer with various connection modes
- examination of the load capacity of the secondary side using a single-phase load with different connection modes on the primary side
- determination of the influence of a delta stabilizing winding
- demonstration of the possibility of utilizing a three-phase transformer in economy connection (autotransformer)

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Overhead line model - GTU102.2

- measurement of the voltages in no-load operation
- concept of operating capacitance
- line model with increased operating capacitance
- measurement of current and voltage relationship of an over-head line in matched-load operation; interpretation of the terms: characteristic wave impedance, lagging and leading operation, efficiency and transmission losses
- measurement and interpretation of the current and voltage ratios of a transmission line during a three-phase short-circuit
- measurement and interpretation of the current and voltage ratios of a transmission line with mixed ohmic-inductive and pure inductive loads
- measurement and interpretation of the current and voltage ratios of a transmission line with mixed ohmic-capacitive and pure capacitive loads
- investigation on the performance of a transmission line with isolated neutral point connection in the case of a fault to earth
- measurement of the earth-fault current and the voltage rise of the faulty phases
- determination of the inductance of an earth-fault neutralizer for the overhead line model
- investigation on the performance of a transmission line with a fault and comparison of the current values with those determined during earth-fault with isolated neutral point system
- measurement of the fault currents of asymmetrical short-circuits and comparison of the results with those for a three-phase fault
- investigation on the effect of parallel compensation on the voltage stability at the load and the transmission losses of the line
- investigation on the effect of series compensation on the voltage stability at the load
- use of measurement techniques to determine the zero-phase sequence impedance of the overhead line model and comparison of this value with the theoretical one

Series and parallel connection of HV lines - GTU102.3

- measurement of the voltage distribution in the series connection of two lines without operating capacitances
- measurement of the voltage distribution in the series connection of two lines with operating capacitances
- measurement of the voltage distribution in the parallel connection of two lines without operating capacitances
- measurement of the voltage distribution in the parallel connection of two lines with operating capacitances

Busbar systems - GTU102.4

- operation of a switching station with two busbars and different voltages
- busbar transfer with interruption of the power supply to the consumer
- busbar coupling and bus transfer without interruption of the power supply to the consumer
- switching sequence for disconnectors and power circuit breakers

		GTU102.1	GTU102.2	GTU102.3	GTU102.4	TOTAL
Variable three-phase power supply	DL 1013T1	1	1	1		1
Line model	DL 7901TT		1	2	1	2
Three-phase transformer	DL 1080TT	1	1	1	1	1
Resistive load	DL 1017R	1	1	1	1	1
Inductive load	DL 1017L	1	1	1		1
Capacitive load	DL 1017C	1	1			1
Three-phase power supply	DL 2108TAL-SW		1		1	1
Power circuit breaker	DL 2108T02		1	1	4	4
Double busbar with two disconnectors	DL 2108T02/2				1	1
Double busbar with four disconnectors	DL 2108T02/4				1	1
Line capacitor	DL 2108T03		2			2
Petersen coil	DL 2108T04		1			1
Moving coil ammeter (100-500-1000mA)	DL 2109T1A	1	1			1
Moving coil ammeter (1.25-2.5A)	DL 2109T2A5	2	3	3	3	3
Moving iron voltmeter (600V)	DL 2109T1PV		2		2	2
Moving iron voltmeter (125-250-500V)	DL 2109T3PV	2		3		3
Power meter	DL 2109T26	2	1			2
Power factor meter	DL 2109T27		1			1
Connecting leads	DL 1155GTU	1	1	1	1	1
Table	DL 1001-1	1	1	1	1	1
Frame	DL 2100-3M	2	2	2	2	2
Accessory: Storage cabinet	DL 2100TA	1	1	1	1	1
For Countries with 3-phase mains different from 380V:						
Three-phase transformer	DL 2100TT	1	1	1	1	1

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Protection Techniques

In electrical power supply systems, currents and voltages are constantly measured and monitored to ensure that they remain within certain limits.
These values are needed in order to provide constant information on the state of the system, to calculate the amount of power supplied to a customer and to switch off rapidly faulty sections of a network in case of a fault.
In general, the current and voltage values are so high that they cannot be measured directly and special transformers have to be used to reduce these values to a level which can be measured safely and economically.
In this laboratory single and three-phase current and voltage transformers are studied.
But, a very important subject must also be considered, the one related to the protection of electrical power systems, in order to avoid that any fault could spread through the network and result in a collapse of the entire power supply system. In cases of short-circuit, for instance, the very high fault currents produced can destroy parts of the system and could often even endanger the lives of humans.
For these reasons, special protection systems, which must react quickly and reliably in the event of faults, have been developed in the area of electrical power distribution.
A fundamental task of a protective system is to recognize the damaged system component and, where possible, to disconnect only this component so that the remaining power distribution can be maintained.
In this laboratory a number of protective relays are analyzed: under/over voltage time relays, definite time over-current relays, inverse time over-current relays, earth-fault relays, etc.).
Then, special attention is paid to the problem of high voltage line protection, with discussions on the criteria about the most suitable protective system to be used. Experiments on over-voltage and under-voltage monitoring, short-circuit protection and earth-fault monitoring complete the analysis of this very important problem.

Protection of HV line - GTU103.3

- demonstration of how an under/over voltage time relay monitors the protection of a load against under- and over-voltage
- demonstration of the protection of a transmission line connected in a solid earthed network, when there is a three-phase, two-phase or single-phase short-circuit
- demonstration of how an earth-fault warning relay monitors the transmission line for an earth fault in a network with isolated neutral connection

Instrument transformers - GTU103.1

- determination of the transformation ratio of a current transformer for various primary currents and investigation on the influence of the load on the transformation ratio
- explanation of the terms: ratio error (current error), accuracy class and rated accuracy limit factor
- test on the performance of the current transformer at over-current
- assembly of the common current transformer circuit for measurement on three-phase network
- measurement of the zero-phase sequence current of a three-phase system
- measurements on a summation current transformer
- demonstration of the principle of differential protection
- determination of the transformation ratio of a voltage transformer for various primary voltages and investigation on the influence of the load on the transformation ratio
- explanation of the terms: ratio error (voltage error) and accuracy class
- assembly of the common voltage transformer circuit for measurements in three-phase network
- measurement of the residual voltage in a three-phase system with a fault to ground
- assembly of a voltage transformer circuit in open delta connection
- measurement of the three conductor voltages on symmetrical and asymmetrical loads

Protective relays - GTU103.2

- connection of an under/over voltage relay in a three-phase net- work and investigation on its behaviour with respect to under and over-voltages
- determination of the resetting ratio of an under/over voltage relay
- measurement of the operating time of an under/over voltage relay
- connection of a definite time over-current relay in a three-phase network and investigation on its behaviour with respect to different settings
- determination of the resetting ratio of a definite time over-current relay
- measurement of the operating time of a definite time over-current relay
- connection of an inverse time over-current relay in a three-phase network and investigation on its behaviour with respect to different settings
- measurement of the operating time of an inverse time over-current relay
- investigation on an earth-fault relay
- check of the operate time set
- demonstration of an earth-fault alarm in a three-phase network
- reaction to so-called transient earth faults
- investigation on a directional earth-fault relay behaviour for effective currents and on the direction of operation
- investigation on a combined over-current and earth-fault relay behaviour connected in a solid earthed three-phase network
- demonstration of how the external blocking input works

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Finally, special attention is given to the issue of protection of the generation (GTU 103A), of the transmission (GTU 103B) and of transformers (GTU 103C).

Generation protection - GTU103A

- Overcurrent protection
- Earth fault protection
- Unbalanced protection
- Over voltage/under voltage protection
- Frequency protection
- Differential protection

Transmission protection - GTU103B

- Overcurrent protection
- Unbalanced load protection
- Directional power protection
- Distance protection
- Differential protection

Transformer protection - GTU103C

- Overcurrent protection
- Unbalanced load protection
- Directional power protection
- Differential protection

		GTU103.1	GTU103.2	GTU103.3	GTU103A	GTU103B	GTU103C	TOTAL
Variable three-phase power supply	DL 1013T1	1	1					1
Variable DC power supply	DL 1013T2				1			1
Line model	DL 7901TT			1		2		2
Three-phase transformer	DL 1080TT		1	1		1	1	1
Resistive load	DL 1017R	1	1	1	1	1	1	1
Inductive load	DL 1017L					1		1
DC motor	DL 1023PS				1			1
Three-phase synchronous machine	DL 1026A				1			1
Base	DL 1013A				1			1
Electronic tachometer	DL 2025DT				1			1
Experiment transformer	DL 1055TT	1						1
Three-phase power supply	DL 2108TAL-SW		1	1	1	1	1	1
Variable DC power supply	DL 2108T01				1			1
Power circuit breaker	DL 2108T02		1	1	1	2	1	2
CT load	DL 2108T10	1						1
VT load	DL 2108T11	1						1
Under/over-voltage time relay	DL 2108T12		1	1				1
Inverse time over-current relay	DL 2108T13		1					1
Definite time over-current relay	DL 2108T14		1	1				1
Combined over-current & earth fault relay	DL 2108T15		1					1
Single-phase directional relay	DL 2108T16		1					1
L/C loads	DL 2108T17		1					1
Three-phase over/under voltage relay	DL 2108T18			1				1
Differential transformer relay	DL 2108T21						1	1
Distance protection relay	DL 2108T22					1		1
Feeder manager relay	DL 2108T23				1	1	1	1
Generator differential relay	DL 2108T24				1	1		1
Moving coil ammeter (100-500-1000mA)	DL 2109T1A	4			2			4
Moving coil ammeter (1.25-2.5A)	DL 2109T2A5		1	1			1	1
Moving iron ammeter (5A)	DL 2109T5A	2						2
Moving iron voltmeter (125-250-500V)	DL 2109T3PV	4	1	1			2	4
Double voltmeter	DL 2109T17/2				1			1
Single-phase current transformer	DL 2109T21	1						1
Three-phase current transformer	DL 2109T22	1			2	2	2	2
Single-phase voltage transformer	DL 2109T23	1						1
Three-phase voltage transformer	DL 2109T24	1	1	1	1			1
Summation current transformer	DL 2109T25	1						1
Acoustic continuity tester	DL BUZ		1	1				1
Electronic stopclock	DL CRON		1					1
Connecting leads	DL 1155GTU	1	1	1	1	1	1	1
Table	DL 1001-1	1	1	1	1	1	1	1
Frame	DL 2100-3M	2	2	2	2	2	2	2
Accessory: Storage cabinet	DL 2100TA	1	1	1	1	1	1	1
For Countries with 3-phase mains different from 380V :								
Three-phase transformer	DL 2100TT	1	1	1	1	1	1	1

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Energy Utilization

Energy consumers, in particular the large ones like the industrial plants, are now obliged, either by contract or for reasons of economy, to provide reactive power compensation for their equipment.
If the consumer refuses to set up a compensating facility, the power supply companies install reactive power meters and the reactive power which is consumed must be paid for.
However, even modern and efficient compensating facilities often create difficulties in generating harmonic currents and generate harmonic-related problems in conjunction with other components of the network.
In fact, the compensating capacitors and the feeding transformers or the supply network form a parallel oscillating circuit that can result in resonances which may cause damage to all the adjoining network installations.
The subjects related to reactive power compensation and reactive power controllers are addressed in this laboratory.
Finally, the laboratory deals also with the problem of the measurement of active and reactive power. Induction meters are usually employed for measuring electrical energy in ac current and in three-phase networks.

These meters firstly provide the basis for calculating the cost of the power to be debited to the consumer and secondly are an important mean for the power supply companies to identify the need for an extension or a modification of the supply network.
These topics are analyzed from the theoretical point of view and also by means of practical examples.

Power factor improvement - GTU104.1

- demonstration of the manual operation on the control of reactive power at various inductive loads
- demonstration of the automatic operation on the control of reactive power at various inductive loads and at different sensitivities

Energy meters and tariffs - GTU104.2

- demonstration of the measurement of active energy consumption
- demonstration of the measurement of reactive energy consumption
- determination of the meters constant
- demonstration of the measurement of the maximum demand
- demonstration of load cut-off operation

		GTU104.1	GTU104.2	TOTAL
Resistive load	DL 1017R		1	1
Inductive load	DL 1017L		1	1
Three-phase squirrel cage motor	DL 1021	1		1
Magnetic powder brake	DL 1019P	1		1
Brake control unit	DL 1054TT	1		1
Load cell	DL 2006E	1		1
Optical transducer	DL 2031M	1		1
Universal base	DL 1013A	1		1
Three-phase power supply	DL 2108TAL-SW	1	1	1
Power circuit breaker	DL 2108T02		1	1
Reactive power controller	DL 2108T19	1		1
Switchable capacitor battery	DL 2108T20	1		1
Moving coil ammeter (1.25-2.5A)	DL 2109T2A5	2	1	2
Moving iron voltmeter (125-250-500V)	DL 2109T3PV		1	1
Power meter	DL 2109T26	1	2	2
Power factor meter	DL 2109T27	1		1
Three-phase power meter	DL 2109T29		1	1
Three-phase Active and Reactive Energy Meter	DL 2109T34		1	1
Electronic stopclock	DL CRON		1	1
Connecting leads	DL 1155GTU	1	1	1
Table	DL 1001-1	1	1	1
Frame	DL 2100-3M	2	2	2
Accessory: Storage cabinet	DL 2100TA	1	1	1
For Countries with 3-phase mains different from 380V :				
Three-phase transformer	DL 2100TT	1	1	1

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Summary

		TOTAL GTU101	TOTAL GTU102	TOTAL GTU103	TOTAL GTU104	TOTAL GTU
Variable three-phase power supply	DL 1013T1		1	1		1
Variable dc power supply	DL 1013T2	1		1		1
Line model	DL 7901TT		2	2		2
Three-phase transformer	DL 1080TT		1	1		1
Resistive load	DL 1017R	1	1	1	1	1
Inductive load	DL 1017L	1	1		1	1
Capacitive load	DL 1017C	1	1			1
Shunt dc motor	DL 1023PS	1		1		1
Three-phase synchronous machine	DL 1026A	1		1		1
Three-phase squirrel cage motor	DL 1021				1	1
Magnetic powder brake	DL 1019P				1	1
Brake control unit	DL 1054TT				1	1
Motor driven power supply	DL 1067S	1				1
Optical transducer	DL 2031M	1			1	1
Load cell	DL 2006E				1	1
Universal base	DL 1013A	1		1	1	1
Electronic tachometer	DL 2025DT	1		1		1
Experiment transformer	DL 1055TT	1		1		1
Three-phase power supply	DL 2108TAL-SW	1	1	1	1	1
Variable dc power supply	DL 2108T01	1		1		1
Power circuit breaker	DL 2108T02	2	4	1	1	4
Double busbar with two disconnectors	DL 2108T02/2		1			1
Double busbar with four disconnectors	DL 2108T02/4		1			1
Line capacitor	DL 2108T03		2			2
Petersen coil	DL 2108T04		1			1
CT load	DL 2108T10			1		1
VT load	DL 2108T11			1		1
Under/over-voltage time relay	DL 2108T12			1		1
Inverse time over-current relay	DL 2108T13			1		1
Definite time over-current relay	DL 2108T14			1		1
Combined over-current & earth fault relay	DL 2108T15			1		1
Single-phase directional relay	DL 2108T16			1		1
L/C loads	DL 2108T17			1		1
Three-phase over/under voltage relay	DL 2108T18			1		1
Reactive power controller	DL 2108T19				1	1
Switchable capacitor battery	DL 2108T20	1			1	1
Differential transformer relay	DL 2108T21			1		1
Distance protection relay	DL 2108T22			1		1
Feeder manager relay	DL 2108T23	1		1		1
Generator differential relay	DL 2108T24			1		1
Generator synchronising relay	DL 2108T25	1				1
Brushless motor with controller	DL 2108T26	1				1
Communication ModBus hub	DL HUBRS485F	1				1
SCADA software	DL SCADA-WEB	1				1
Moving coil ammeter (100-500-1000mA)	DL 2109T1A	2	1	4		4
Moving coil ammeter (1.25-2.5A)	DL 2109T2A5	2	3	1	2	3
Moving iron ammeter (5A)	DL 2109T5A			2		2
Moving iron voltmeter (600V)	DL 2109T1PV	1	2			2
Moving iron voltmeter (125-250-500V)	DL 2109T3PV		3	4	1	4
Synchronization indicator	DL 2109T1T	1				1
Phase sequence indicator	DL 2109T2T	1				1
Double frequencymeter	DL 2109T16/2	1				1
Double voltmeter (250-500V)	DL 2109T17/2	1		1		1
Single-phase current transformer	DL 2109T21			1		1
Three-phase current transformer	DL 2109T22			2		2
Single-phase voltage transformer	DL 2109T23			1		1
Three-phase voltage transformer	DL 2109T24	1		1		1
Summation current transformer	DL 2109T25			1		1
Power meter	DL 2109T26	1	2		2	2
Power factor meter	DL 2109T27	1	1		1	1
Three-phase power meter	DL 2109T29				1	1
Synchronoscope	DL 2109T32	1				1
Three-phase Active and Reactive Energy Meter	DL 2109T34				1	1
Moving coil ammeter (100-1000mA)	DL 2109T1AB	1				1
Moving coil voltmeter (15-30V)	DL 2109T2VB	1				1
Electronic stopclock	DL CRON			1	1	1
Acoustic continuity tester	DL BUZ			1		1
Connecting leads	DL 1155GTU	1	1	1	1	1
Table	DL 1001-1	1	1	1	1	1
Frame	DL 2100-3M	2	2	2	2	2
Accessory: Storage cabinet	DL 2100TA	1	1	1	1	1
For Countries with 3-phase mains different from 380V: Three-phase transformer	DL 2100TT	1	1	1	1	1

ELECTRICAL POWER ENGINEERING

Variable three-phase power supply

DL 1013T1

Power supply unit for variable 3-phase voltage suitable for supplying AC machines.

- 16 A, 30 mA differential magneto-thermal main switch
- key operated emergency push-button
- start and stop push-buttons
- motor protection circuit breaker: 6.3 to 10 A
- multifunctional digital instrument that supplies voltage, current and power
- ac output: 3 x 0 ... 380 V, 8 A
- Modbus interface connectors

The output voltage is set by a rotary knob with 0-100% scale.
Supply voltage: three-phase from mains.

Variable DC power supply

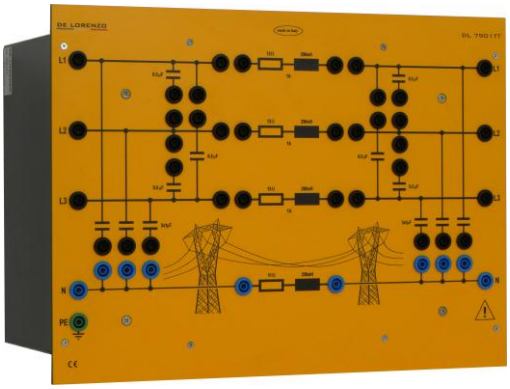
DL 1013T2

Power supply unit for variable dc voltage suitable for supplying DC machines.

- 16 A, 30 mA differential magneto-thermal main switch
- key operated emergency push-button
- start and stop push-buttons
- motor protection circuit breaker: 6.3 to 10 A
- multifunctional digital instrument that supplies voltage, current and power
- dc output: 0 ... 240 V, 8 A
- Modbus interface connectors

The output voltage is set by a rotary knob with 0-100% scale.
Supply voltage: three-phase from mains

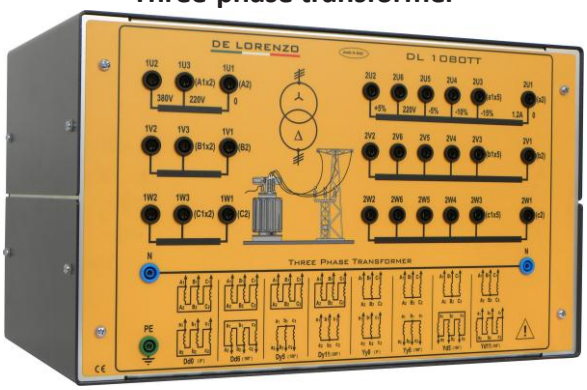
Line model



DL 7901TT

Three-phase model of an overhead power transmission line 360 km long, voltage 380 kV and current 1000 A.
Scale factor: 1:1000
Line resistance: 13 Ω
Line inductance: 290 mH
Mutual capacitance: 1 µF
Earth capacitance: 2 µF
Earth resistance: 11 Ω
Earth inductance: 250 mH

Three-phase transformer



DL 1080TT

Three-phase transformer for feeding a transmission line model 380 kV with scale factor 1:1000
Primary: 3 x 380 V windings with tap at 220 V

- star or delta connection

Secondary: 3 x 220 V windings with taps at +5%, -5%, -10%, -15%

- star connection for 3 x 380 V
- various star connections possible
- rated power: 800 VA

Tertiary: 3 x 220 V windings

- delta connection for stabilizing the third harmonic voltage components
- rated power: 266 VA

ELECTRICAL POWER ENGINEERING

Resistive load

DL 1017R

Composed of three resistances, with possibility of star, delta and parallel connection, controlled by three switches with seven steps each.
Max. power in single or three-phase connection: 1200 W
Rated voltage: 380/220 V Y/D
Rated voltage in single-phase: 220 V

Inductive load

DL 1017L

Composed of three inductances, with possibility of star, delta and parallel connection, controlled by three switches with seven steps each.
Max. reactive power in single or three-phase connection: 900 VAr
Rated voltage: 380/220 V Y/D
Rated voltage in single-phase: 220 V

Capacitive load

DL 1017C

Composed of three batteries of capacitors, with possibility of star, delta and parallel connection, controlled by three switches with seven steps each.
Max. reactive power in single or three-phase connection: 825 VAr
Rated voltage: 380/220 V Y/D
Rated voltage in single-phase: 220 V

Shunt DC motor

DL 1023PS

Power: 1.8 kW
Voltage: 220 V
Speed: 3000 rpm
Excitation voltage: 170 V

ELECTRICAL POWER ENGINEERING

Three-phase synchronous machine

DL 1026A

Machine with smooth inductor and three-phase stator armature winding for operation either as alternator or synchronous motor.
Alternator: 1.1 kVA
Motor: 1 kW
Voltage: 220/380 V D/Y
Current: 2.9/1.7 A
Speed: 3000 rpm
Dc rotor excitation winding

Three-phase squirrel cage asynchronous motor

DL 1021

Induction motor with three-phase stator winding and buried squirrel cage in the rotor.
Power: 1.1 kW
Voltage: 220/380 V D/Y
Current: 4.3/2.5 A D/Y.
Speed: 2870 rpm, 50 Hz

Magnetic powder brake

DL 1019P

Electromagnetic brake suitable for testing the motors of the laboratory.
Rated power: 1.1 kW at 3000 rpm
Maximum speed: 4000 rpm
Complete with water level, arms, weights and counterweights for torque measurement and optical transducer.
Possibility for connection to a load cell.
The brake includes an axial cooling fan powered by the mains voltage.

Brake control unit

DL 1054TT

Control unit for the powder brake. It allows measuring the rotating speed and the torque generated by an electrical motor. It also provides the excitation voltage to the brake. The speed and the torque are displayed by means of instruments; analogue outputs are also available.
Speed section: 40 division instrument, class 1.5
ranges: 2000 - 4000 - 6000 rpm, with switch
Torque section: 50 division instrument, class 1.5
ranges: 10 - 20 Nm, with switch
Power supply section for the brake:
Output: from 0 to 20 Vdc, 1 A
Supply voltage: 230 V, 50/60 Hz

ELECTRICAL POWER ENGINEERING

Motor-driven power supply

DL 1067S

Suitable for power supplying with variable voltage the braking systems and the excitation of the machines through manual or automatic operation.

Technical features:

- DC output: 0 to 210 V, 2 A
- Automatic regulation of excitation to keep a constant voltage
- Power supply: 220 V, 50/60 Hz

Optical transducer

DL 2031M

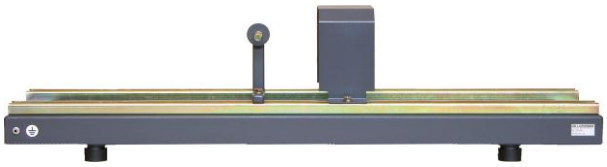
For measuring the rotation speed through a slotted optical switch with encoder disc, used also for stroboscopic measurements. Complete with built-in signal transmission socket to the electronic tachometer and suitable for being mounted on the machines of the laboratory.

Load cell

DL 2006E

Strain-gauge with 150 N range, to be mounted on the brake for mechanical torque measurement.

Universal base



DL 1013A

Duralumin alloy structure mounted on anti-vibration rubber feet, provided with slide guides for fixing one or two machines. Complete with coupling guard. Provided with rotor locking device for short-circuit test.

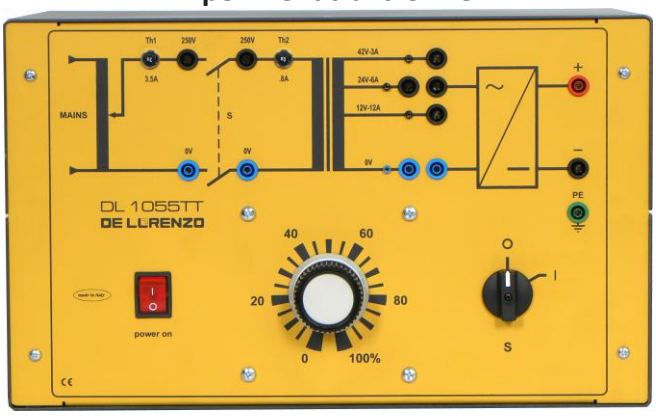
Electronic tachometer

DL 2025DT

Analogue instrument that, coupled to an optical speed transducer, allows measuring the rotating speed of the electrical machines.
Range: from 0 to 1500, 3000, 6000 rpm, with signals coming from the standard optical transducers
Accuracy: 1.5 %
Supply voltage: single-phase from mains

ELECTRICAL POWER ENGINEERING

Experiment transformer



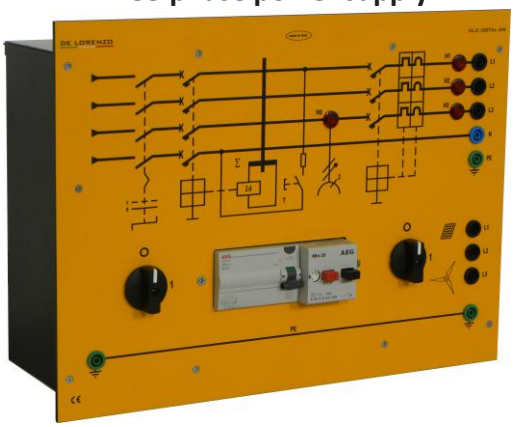
DL 1055TT

Transformer with knob to adjust the single-phase voltages. It is also possible to tap off three single-phase floating voltages by means of an isolating transformer.
Provided with bridge rectifier for DC voltage output.
Outputs:
single-phase: 0 ... 250 V / 3 A
low voltage single-phase:

- 0 ... 42 V / 3 A floating or
- 0 ... 24 V / 6 A floating or
- 0 ... 12 V / 12 A floating

dc voltage: 25 A bridge rectifier for all ranges
Output protection:
2 magneto-thermal circuit breakers, 3.5 A and 0.8 A

Three-phase power supply



DL 2108TAL-SW

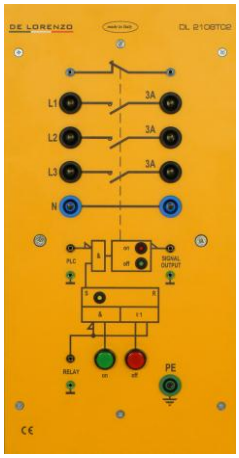
Power supply unit for three-phase connection with 4-pole cam mains switch.
25 A current operated earth leakage circuit breaker, sensitivity 30 mA.
Triple-pole motor protection switch: 6.3 to 10 A.
Three-phase indicator lamps.
Output through 5 safety terminals: L1, L2, L3, N and PE.

Variable DC power supply

DL 2108T01

Suitable for carrying out some tests on electrical starting from 0 V by replacing the excitation rheostats.
Output: from 0 to 220 V, 0.6 A

Power circuit breaker

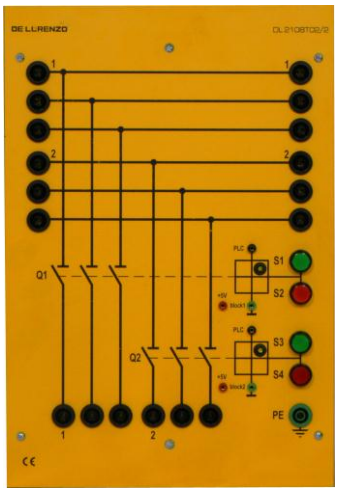


DL 2108T02

Three-phase power circuit breaker with normally closed auxiliary contact.
Contact load capability: 400 Vac, 3 A
Supply voltage: single-phase from mains

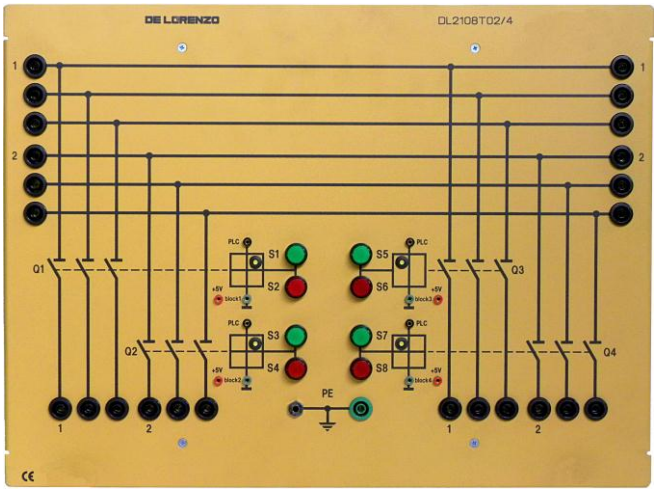
ELECTRICAL POWER ENGINEERING

Double busbar with two disconnectors



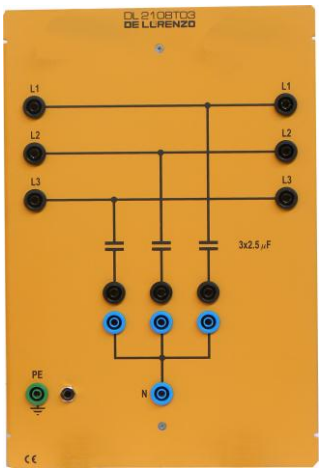
DL 2108T02/2

Double busbar with four disconnectors



DL 2108T02/4

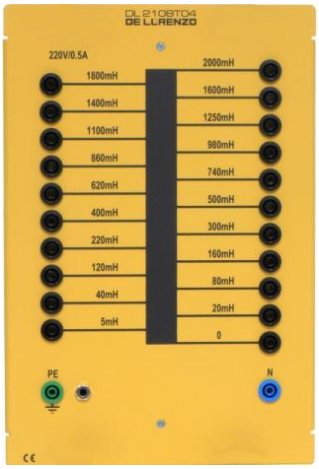
Line capacitor



DL 2108T03

Three-phase capacitors in star connection with exactly half of the operating capability of the 380 kV transmission line model with a length of 360 km.
Capacitance: 3 x 2.5 µF, 450 Vac

Petersen coil

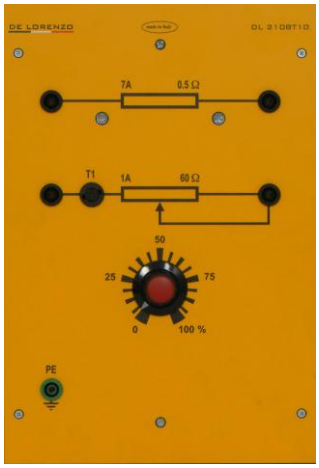


DL 2108T04

Inductance with 20 taps for earth fault compensation in transmission lines.
Inductance: 0.005 ... 2 H
Rated voltage: 220 V
Rated current: 0.5 A

ELECTRICAL POWER ENGINEERING

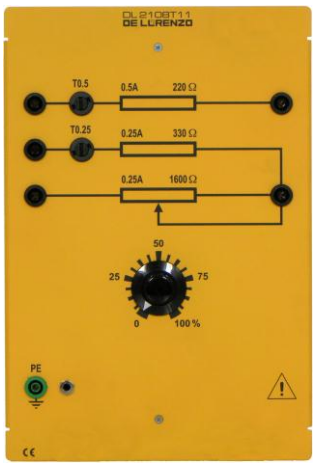
Ct load



DL 2108T10

Load for the single-phase current transformer consisting of two separated ohmic resistors.
Fixed resistor: 0.5 Ω, load 7 A
Variable resistor: 0 ... 60 Ω, load 1 A
Range: 0 ... 100%
The variable resistor is protected with a 1 A fuse

Vt load



DL 2108T11

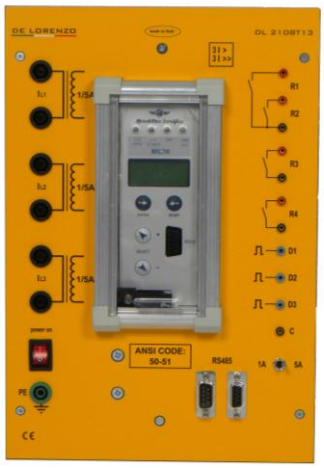
Load for the single-phase voltage transformer consisting of three separated ohmic resistors.
Fixed resistor: 220 Ω, load 0.5 A (0.5 A fuse)
Variable resistor: 330 ... 1930 Ω, load 0.25 A (0.25 A fuse)

Under/over-voltage time relay

DL 2108T12

Relay for monitoring the over-voltage and the under-voltage in an alternating three-phase mains.
Max. adjustable set point: 0/+20% of the rated voltage
Min. adjustable set point: 0/-20% of the rated voltage
Adjustable delay timer activated when the max. set point is exceeded.
Adjustable delay timer activated when the min. set point is exceeded.

Inverse time three phase over current and earth fault relay



DL 2108T13

Three phase over current and earth fault relay with programmable time-current curves suitable for protection of power distribution systems with insulated, resistance earthed or compensated neutral.
Rated input current selectable 1A or 5A, 50/60 Hz.
Connection through 3 CTs. Three independent over current elements. Three earth fault elements.
Breaker failure protection. Time tagged multiple event recording. Oscillographic wave form capture.
Modbus RTU / IEC870-5-103 Communication Protocols.

ELECTRICAL POWER ENGINEERING

Definite time over-current relay

DL 2108T14

Relay for monitoring the current of a three-phase load (typically a motor) and performing a protection with alarm.
Max. adjustable set point, divided in 10 parts
Adjustable timer (0.1 ... 6 s).
The delay time starts as soon as the current exceeds the max set point.
Adjustable initial timer (0.1 ... 6 s).
The timer activates when the current exceeds 5% of the max range.
Current range: 0.25 ... 5 A with direct insertion (galvanic isolation).
For currents higher than 5 A an external CT.../5 A must be used)
One changeover contact: 5 A / 230 Vac with resistive load.
NC contacts: device not supplied or in alarm
Supply voltage: single-phase from mains.

Combined over-current and earth-fault relay

DL 2108T15

Over current and earth fault relay with programmable time-current curves suitable for protection of power distribution systems with insulated, resistance earthed or compensated neutral.
Rated input current selectable 1A or 5A, 50/60 Hz.
Three phase-fault elements.
Three earth fault elements.
Breaker failure protection.
Trip Circuit Breaker control via serial port.
Time tagged multiple event recording.
Oscillographic wave form capture.
Modbus RTU / IEC870-5-103 Communication Protocols.

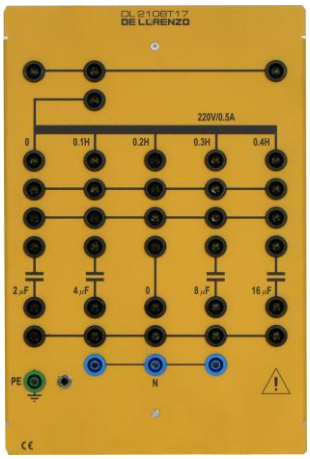
ELECTRICAL POWER ENGINEERING

Directional relay

DL 2108T16

Multifunction relay suitable for protection of HV, MV, LV power transmission and distribution systems.
Accidental earth-fault directional relay for selective protection of the power supply in isolated neutral and earthed networks.
Three independent over current elements.
Two different thresholds for directional and non-directional current, with selectable trip.
Time tagged multiple event recording.
Oscillographic wave form capture.
Modbus RTU / IEC870-5-103.
Switch control through serial port.
Communication protocol.
Complete with Data Logger system.

L/C loads



DL 2108T17

Inductive and capacitive loads suitable for simulating various fault types, in order to trigger the single-phase directional relay.
Inductance: 0.1 / 0.2 / 0.3 / 0.4 H
Rated voltage: 220 V, 50 Hz
Rated current: 0.5 A
Capacitance: 2 / 4 / 8 / 16 µF
Rated voltage: 450 Vac

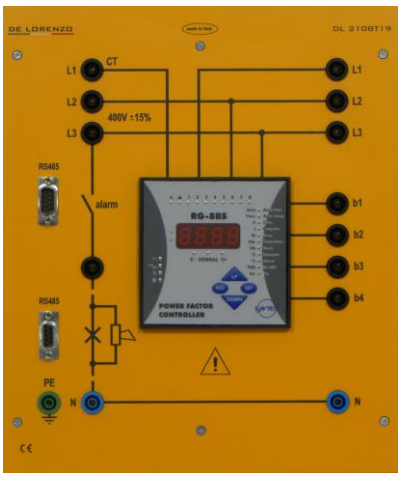
ELECTRICAL POWER ENGINEERING

Multifunction three phase overvoltage / undervoltage relay

DL 2108T18

Three-phase voltage relay, suitable for protection of HV, MV, LV power transmission and distribution systems.
The relay measures the true RMS value of the 3 phase to neutral voltages fed to three transformers isolated high-impedance inputs.
Two Under Voltage elements.
Two Over Voltage elements. One Under Frequency element.
One Over Frequency element.
One omopolar sequence Over Voltage element.
One negative sequence Over Voltage element.
One positive sequence Under Voltage element.
Time tagged multiple event recording.
Oscillographic wave form capture.
Modbus RTU / IEC870-5-103.
Display LCD 16 (2x8) characters.

Reactive power controller

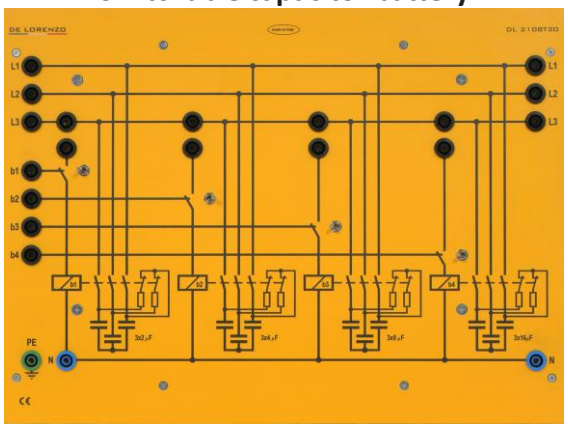


DL 2108T19

Relay for automatic adjustment of the power factor in systems with inductive load.
Power factor adjustment range: 0.9 ... 0.98 ind
Sensitivity: 0.2 ... 1.2 K
2 decimal digit display
Output relay for batteries connection: 4 NO contacts with LED indication
Output relay contact: 400 Vac, 5 A
Supply voltage: three-phase from mains
Ammetric input circuit: 5 A (250 mA min.)
Automatic detection of the frequency.

ELECTRICAL POWER ENGINEERING

Switchable capacitor battery



DL 2108T20

Switching system with which different capacitance values can be connected to the mains for reactive power compensation.
Four switching levels each consisting of 3 capacitors in star connection with discharging resistors:

- level 1 (b1 coil): 3 x 2 µF/450 V
- level 2 (b2 coil): 3 x 4 µF/450 V
- level 3 (b3 coil): 3 x 8 µF/450 V
- level 4 (b4 coil): 3 x 16 µF/450 V

Compensation power: max 1360 VAr at 50 Hz, 380 V
Each switching level can be controlled separately:

- internally, through 4 toggle switches
- externally, through 4 control inputs

Coil operating voltage: 220 Vac

Differential transformer relay

DL 2108T21

Three-phase percentage biased differential and restricted earth fault protection relay for 2 or 3 winding transformers with only one source of supply.

Two phase overcurrent plus earth fault relay with programmable time-current curves suitable for protection of HV and MV transmission and distribution systems.

Distance protection relay

DL 2108T22

Suitable for the requirements of a complex field unit for overhead lines and cables on compensated or resistance grounded networks.

It includes over current, over/under voltage and over/under frequency protection.

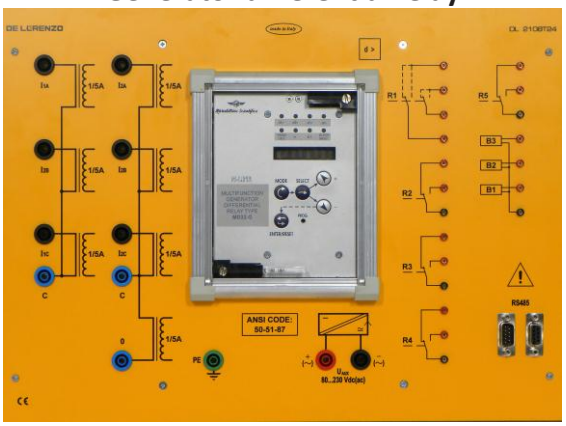
Feeder manager relay

DL 2108T23

Three-phase current, voltage and earth fault multifunction relay for protection and management of MV/HV distribution lines.

ELECTRICAL POWER ENGINEERING

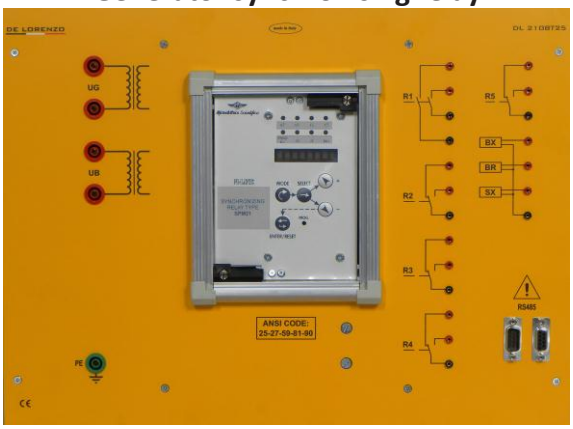
Generator differential relay



DL 2108T24

Three-phase percentage biased differential protection relay for generators and rotating machines.

Generator synchronising relay



DL 2108T25

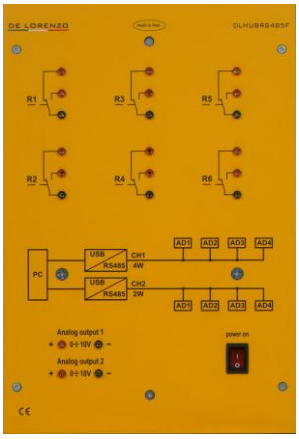
To measure voltage and frequency of two inputs; the voltage, frequency and phase angle of the Generator input (G) are individually compared with those of the Bus input (B) considered as reference.

Brushless motor with controller

DL 2108T26

Brushless motor with electronic encoder. Control of the system in frequency and voltage.
Mechanical braking system for the analysis of the torque.
Encoder outputs for the analysis of speed.
Two channel RS485 communication management system.
Two separate outputs controlled via software.

Communication ModBus hub

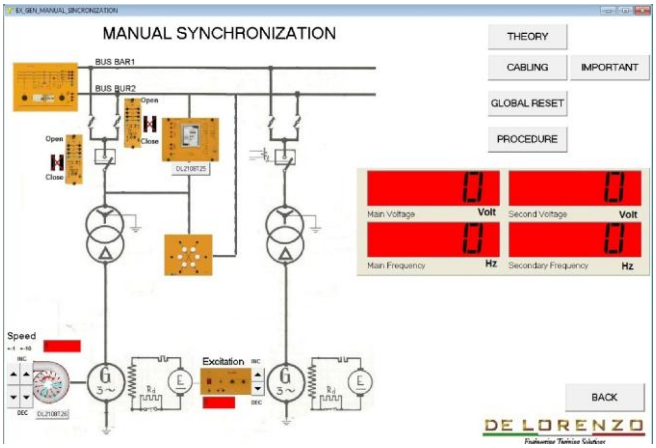


DL HUBRS485F

Hub that allows communication and control via PC of the measurement modules and brushless motor.
Two channel RS485 communication management system.
Two separate outputs controlled via software.

ELECTRICAL POWER ENGINEERING

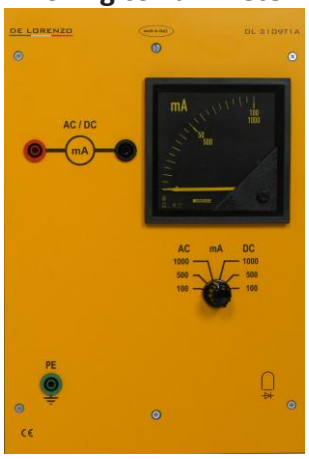
SCADA software



DL SCADA-WEB

For data acquisition and control.

Moving coil ammeter



DL 2109T1A

Magneto-electric meter for AC and DC measurements.
Scale: 50 divisions
Range: 100, 500 and 1000 mA, ac/dc
Accuracy class: 1.5

Moving coil ammeter

DL 2109T2A5

Magneto-electric meter for AC and DC measurements.
Scale: 50 divisions
Range: 1.25 and 2.5 A, ac/dc
Accuracy class: 1.5

Moving iron ammeter

DL 2109T5A

Electromagnetic meter for AC and DC measurements.
Scale: 50 divisions
The scale is made open and reasonably uniform down to about 20 per cent of the full-scale reading.
Range: 5 A
Accuracy class: 1.5

ELECTRICAL POWER ENGINEERING

Moving iron voltmeter

DL 2109T1PV

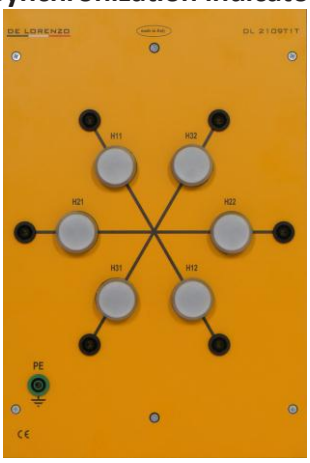
Electromagnetic meter for AC and DC measurements.
Scale: 30 divisions
The scale is made open and reasonably uniform down to about 20 per cent of the full-scale reading.
Range: 600 V
Accuracy class: 1.5

Moving iron voltmeter

DL 2109T3PV

Electromagnetic meter for AC and DC measurements.
Scale: 50 divisions
The scale is made open and reasonably uniform down to about 20 per cent of the full-scale reading.
Range: 125 – 250 - 500 V
Range changeover switch.
Accuracy class: 1.5

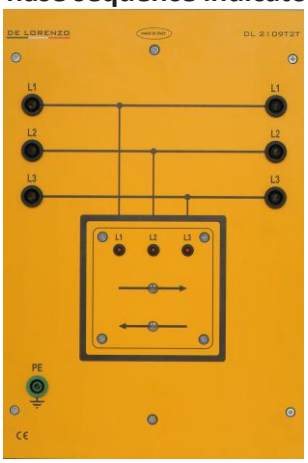
Synchronization indicator



DL 2109T1T

Synchronization indicator for qualitative indication of the phase relationship between mains and voltages of the generator.
3 series of 2 lamps each, 220 V:
H11 - H12, H21 - H22 and H31 - H32

Phase sequence indicator

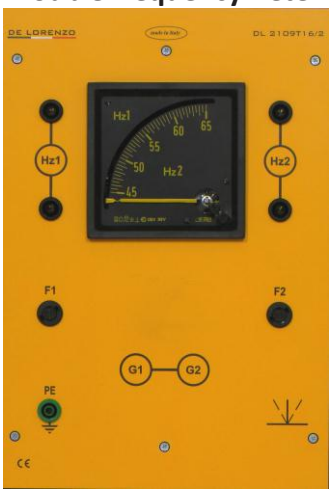


DL 2109T2T

Sequencyscope to establish the order of the cyclic direction of the phase.
Operating voltage: 90 to 660 V
Frequency: 45 to 1000 Hz

ELECTRICAL POWER ENGINEERING

Double frequencymeter



DL 2109T16/2

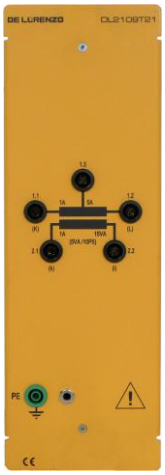
Measurement device, provided with two separate instruments, for comparing the frequencies of two voltages.
Range: 2 x (45 ... 65) Hz
Class of accuracy: 1.5

Double voltmeter

DL 2109T17/2

Measurement device, provided with two separate instruments of the moving coil type with rectifier, for comparing two voltages.
Range: 2 x 250/500 V with switch
Class of accuracy: 1.5

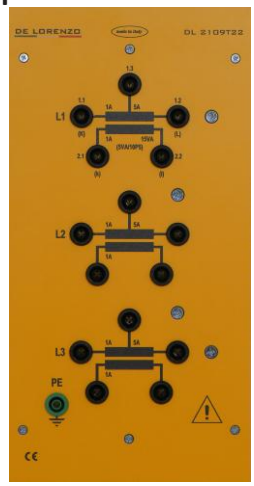
Single-phase current transformer



DL 2109T21

Current transformer for measuring and protection purposes.
Rated primary currents: 5/1 A
Rated secondary current: 1 A
Performance and class: 15 VA / 1 - 5 VA / 10P5
Frequency: 50 - 60 Hz

Three-phase current transformer

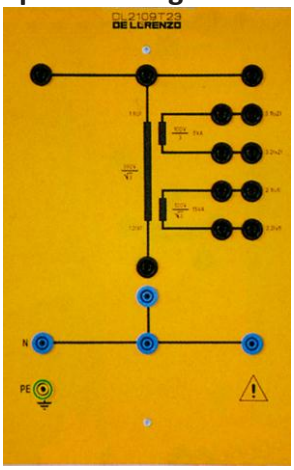


DL 2109T22

Three single-phase current transformers for measuring and protection purposes.
Rated primary currents: 5/1 A
Rated secondary current: 1 A
Performance and class: 15 VA / 1 - 5 VA / 10P5
Frequency: 50 - 60 Hz

ELECTRICAL POWER ENGINEERING

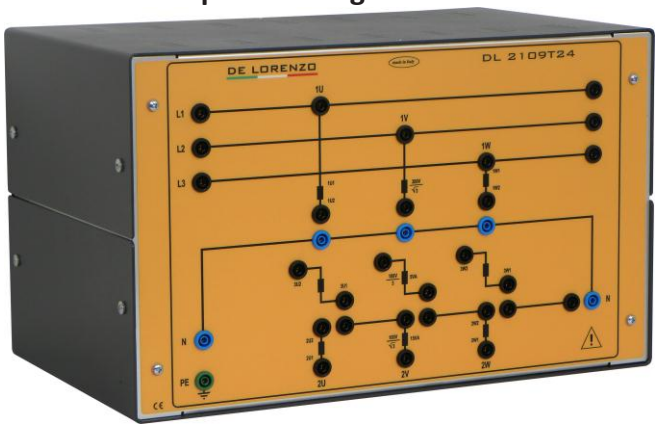
Single-phase voltage transformer



DL 2109T23

Voltage transformer for measuring and protection.
Rated primary voltage: 380 V/√3 (220 V)
Rated secondary voltages:
100 V/√3, Performance 15 VA
100 V/3, Performance 5 VA
Accuracy class: 1
Frequency: 50 - 60 Hz

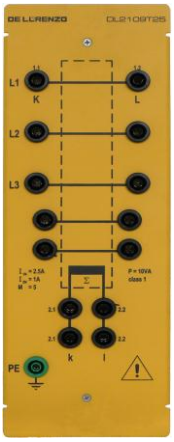
Three-phase voltage transformer



DL 2109T24

Three single-phase voltage transformers for measuring and protection.
Rated primary voltage: 380 V/√3 (220 V)
Rated secondary voltages:
100 V/√3, Performance 15 VA
100 V/3, Performance 5 VA
Accuracy class: 1
Frequency: 50 - 60 Hz

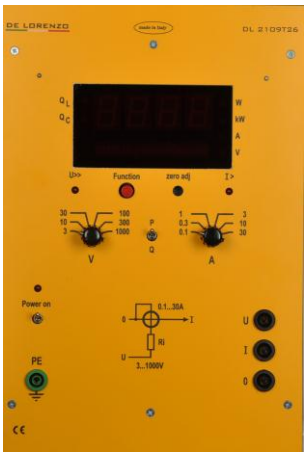
Summation current transformer



DL 2109T25

Ring-type core current transformer suitable for the detection of earth faults and for current determination with differential protection.
Primary rated current: 5 x 2.5 A
Transformation ratio: 2.5/1
Secondary rated current: 1 A
Rated power: 10 VA
Accuracy class: 1

Power meter



DL 2109T26

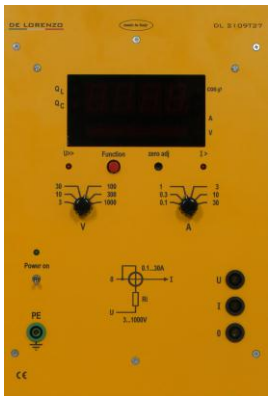
Single-phase panel meter for the measurement of active power and capacitive/inductive reactive power. Measurement ranges:
- voltage: 3/10/30/100/300/1000 V
- current: 0.1/0.3/1/3/10/30 A

Frequency ranges:
- active power: 0 ... 20 kHz
- reactive power: 50 Hz

LED indicators: capacitive reactive power, inductive reactive power, over-load voltage (with acoustic sound), overload current (with acoustic sound).
Auxiliary supply: single-phase from mains

ELECTRICAL POWER ENGINEERING

Power factor meter

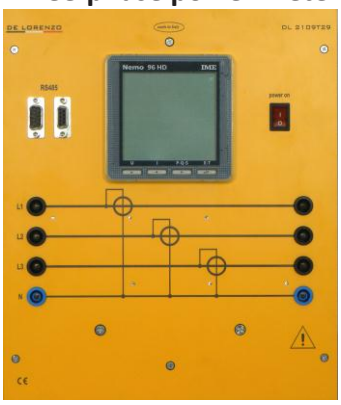


DL 2109T27

Single-phase panel meter for power factor and phase-angle of the connected load.
Measurement ranges:
- power factor: 0 ... 1 ... 0
- phase angle: -90°cap ... 0 ... +90°ind
- voltage: 3 ... 1000 V
- current: 0.1 ... 30 A

Frequency range: 50 / 60 Hz
Auxiliary supply: single-phase from mains

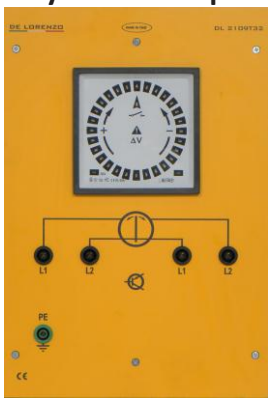
Three-phase power meter



DL 2109T29

Microprocessor controlled three-phase power analyzer.
Measurement of voltages, currents, frequencies, active power, reactive power, apparent power.
Input voltage: 450 V (max 800 Vrms)
Input current: 5 A (max 20 Arms)
Operating frequency: 47 ÷ 63 Hz
Auxiliary supply: single-phase from mains

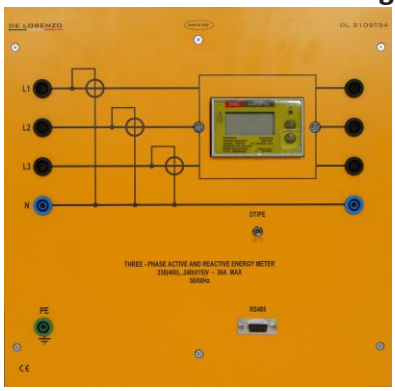
Synchronoscope



DL 2109T32

Rotating light meter with 28 LED on a circular scale and a zero voltage differential indication with 2 LED.
Operating voltage: 380 V (120 Vmin)
Operating frequency: 40 to 60 Hz

Three-phase active and reactive energy meter



DL 2109T34

Microprocessor controlled three-phase power analyzer.
Measurement of voltages, currents, frequencies, active power, reactive power, apparent power.
Connection: Three-phase - 3 or 4 wire
Reference voltage, Un: 230 (400)V...240 (415)V
Limit range of operation: 110 (190)V...254 (440)V
Basic current, In: 10A
Maximum current, Imax: 63A
Communication: RS485 galvanically insulated from input meas. Display type: LCD Backlit, 8 digit
Active energy: Total, Partial (resettable) or Double tariff
Reactive energy: Total, Partial (resettable) or Double tariff
Power: Active, Reactive, Apparent, max. demand (Averaging time period: 5/8/10/15/20/30/60') and peak max. demand (resettable)

ELECTRICAL POWER ENGINEERING

Moving coil ammeter

DL 2109T1AB

Ranges: 100 - 1000 mA
Class: 1.5

Moving coil voltmeter

DL 2109T2VB

Ranges: 15 - 30 V
Class: 1.5

Electronic stopclock

DL CRON

Electronic stopclock with LCD display.
Measuring range: 9h, 59 min, 59 s 99/100 s

Acoustic continuity tester

DL BUZ

Buzzer for diode continuity and transistor testing.
Acoustic continuity tester up to 1 kΩ.
Test current: 24 mA
Voltage protection: 100 mA fuse
Tone: 400 Hz base frequency
Battery: 9 V type 6F22

ELECTRICAL POWER ENGINEERING

Connecting leads

DL 1155GTU

Set of connecting leads.

Workbench

DL 1001-1

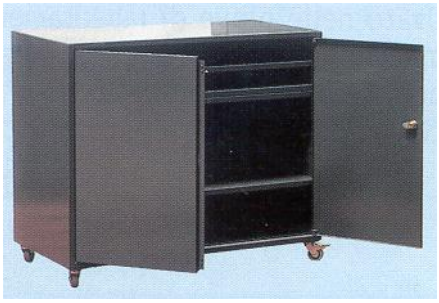
Bi-laminated wooden top. Metal construction.
Adjustable feet.
Dimensions: 2000x1000x900 mm (LxWxH)

Frame

DL 2100-3M

Metal frame for fitting the modules of the laboratory.

Storage cabinet



DL 2100TA

In fire varnished steel plate.
Provided with shelves for module storage and key-locked doors.
Supplied with 4 rubber casters, the cabinet can be placed under the table with frame.

Three-phase transformer

DL 2100TT

Necessary for mains voltages different from 380V.