POWER ELECTRONICS

INTRODUCTION

Technological development in the electronic field has transformed power electronics from static conversion technology to its essential element in the electrical and electronic area. Its aim is the power flow control through the voltage conversion from mains by power semiconductors capable to perform switching, control and convert electrical energy functions efficiently and reliably.

On the last years there have been significant improvements on this technology sector.

Results achieved on the microelectronics field have allowed the use of linear circuits with integrated components such as controllers on power electronics systems.

The new production techniques have improved components voltage and current characteristics and increased their switching speed.

Furthermore, computers development, communication systems and commercial electronics products, on the need for a better use of the available energy, have led to an increase stable power supply requirement. As a particular interest is the use of power electronics on a DC and three-phase motors at constant and variable speed control.

All of this fits into a wide and reliable applications on many sectors, from residential (cooling systems, air conditioning, kitchen lighting), to commercial (similar to residential, but with additional office equipment and a computer, continuity group, elevators), from industrial (pumps, compressors, fans, robots, welding systems, industrial laser) to an absolutely important area, transportation (electric train, battery loaders, tram, metro, car); from telecommunications (power supply and battery loaders) to space technology (power supply systems on satellites and aircrafts).

De Lorenzo has designed a laboratory on power electronics study, which allows students a practical learning based on a practical implementation of guided exercises. All components that make up the laboratory are industrial used, mounted on didactic panels for a proper handling; all of this enables the laboratory to be used for educational purposes, as well as, design, development and research, thanks to its modular qualities.

Starting from basic principles, with the aid of high-training manuals, the student follows a didactic path into a gradual study of complex circuits.

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ALTERNATE CURRENT - DIRECT CURRENT CONVERSION

In most of the applications of power electronics, the input power is in the form of a sinusoidal wave coming from the mains network which is then converted to direct current.
In many cases the conversion is of the non-controlled type, with the use of diode rectifiers.
However, in some applications, such as, for example, some types of drives of ac and dc motors, it is necessary that the dc output voltage be controllable.
In this case, thyristor converters for the mains frequency phase control are used. They are utilized in particular in high voltage dc power transmission or in all those applications where it is necessary to control the power flow in both directions between the dc side and the ac side.

LIST OF EXPERIMENTS

DCA 201.1 DIODES AND UNCONTROLLED RECTIFIERS

Uncontrolled diodes

- Selenium diode
- Silicon diode

Uncontrolled static converter circuits

- Single pulse rectifier E1UK, ohmic load
- Single pulse rectifier E1UK, ohmic-inductive load
- Two-pulse rectifier M2UK, ohmic load
- Two-pulse rectifier M2UK, ohmic-inductive load
- Two-pulse bridge rectifier B2UK, ohmic load
- Two-pulse bridge rectifier B2UK, ohmic-inductive load
- Three-pulse rectifier M3UK, ohmic load
- Three-pulse rectifier M3UK, ohmic-inductive load
- Six-pulse rectifier M6UK, ohmic load
- Six-pulse rectifier M6UK, ohmic-inductive load
- Six-pulse bridge rectifier B6UK, ohmic load
- Six-pulse bridge rectifier B6UK, ohmic-inductive load

DCA 201.2 SCR AND CONTROLLED RECTIFIERS

Thyristors

- SCR

Single pulse converters

- Single pulse converter E1CK, ohmic load
- Single pulse converter E1CK, inductive load
- Single pulse converter E1CK, ohmic-inductive load
- Single pulse converter E1CK, ohmic-inductive load and free-wheeling diode
- Single pulse converter E1CK, ohmic-inductive load and back e.m.f.
- Single pulse rectifier E1UK, ohmic-capacitive load
- Single pulse converter E1CK, ohmic-capacitive load

Two-pulse midpoint converters

- Two-pulse midpoint converter M2CK, ohmic load
- Two-pulse midpoint converter M2CK, ohmic-inductive load

Multi-phase converters

- Three-pulse midpoint converter M3CK, ohmic load
- Three-pulse midpoint converter M3CK, ohmic-inductive load
- Six-pulse midpoint converter M6CK, ohmic load
- Six-pulse midpoint converter M6CK, ohmic-inductive load

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Drainage-coil converters

- Double three-pulse star converter M3CK2, ohmic load

Bridge converters

- Half-controlled bridge B2HK, ohmic load
- Half-controlled bridge B2HK, ohmic-inductive load
- Half-controlled bridge B2HZ, ohmic load
- Half-controlled bridge B2HZ, ohmic-inductive load
- Fully-controlled bridge B2C, ohmic load
- Fully-controlled bridge B2C, ohmic-inductive load
- Fully-controlled bridge B2C, ohmic load and back e.m.f.
- Fully-controlled bridge B2C, dc motor load
- Fully-controlled bridge B2C, ohmic load and supplementary dc voltage
- Fully-controlled bridge B2C, dc generator load
- Three-phase half-controlled bridge B6HK, ohmic load
- Three-phase fully-controlled bridge B6C, ohmic load
- Three-phase fully-controlled bridge B6C, ohmic-inductive load

Code	Description	DCA 201.1	DCA 201.2	Total quantities
DL 2601	SELENIUM RECTIFIER	1		1
DL 2602	SILICON DIODE	1		1
DL 2603	GROUP OF DIODES	1	1	1
DL 2604	SCR		1	1
DL 2605	GROUP OF SCR		1	1
DL 2613	DC POWER SUPPLY		1	1
DL 2614	VOLTAGE REFERENCE GENERATOR		1	1
DL 2615	TRIGGER POINT LIMITER		1	1
DL 2616	TWO PULSE CONTROL UNIT		1	1
DL 2617	SIX PULSE CONTROL UNIT		1	1
DL 2626	MAINS TRANSFORMER	1	1	1
DL 2628	SUPER-FAST FUSES	2	2	2
DL 2635	LOAD	1	1	1
DL 2636	SOCKETS WITH LAMPS		1	1
DL 2637	STABILIZED POWER SUPPLY		1	1
DL 2642	ISOLATION AMPLIFIER	1	1	1
DL 2643	SUPPORT WITH 3 SHUNTS 1 OHM	1	1	1
DL 2644	SUPPORT WITH 3 SHUNTS 0,1 OHM		1	1
DL 12B12	BATTERY STACK		1	1
DL 2025DT	TACHOMETER		1	1
DL 2109T33	TRUE RMS METER	2	2	2
DL 2109T3PV	MOVING IRON VOLTMETER	1	1	1
DL 2109T2A5	MOVING IRON AMMETER	1	1	1
DL 10200A1	SHUNT EXCITATION DC MOTOR		1	1
DL 10250A1	SHUNT EXCITATION DC GENERATOR		1	1
DL 10400	BASE		1	1
DL 2100-3M	FRAME	2	2	2
DL 1001-1	WORKING BENCH	1	1	1
DL 1155POW	CONNECTING LEADS	1	1	1
	Accessory:			
DL 2100TA	STORAGE CABINET	1	1	1
	For the Countries where the 3-phase mains supply is different from 380V:			
DL 2600TT	THREE PHASE TRANSFORMER	1	1	1

POWER ELECTRONICS

ALTERNATE CURRENT - ALTERNATE CURRENT CONVERSION

The electrical power in alternate current is controlled by means of thyristors.
The main fields of application of the control of alternate current are in the control of temperature, lighting and induction motors.
The main types of control are: phase control, on-off control and proportional time control.

LIST OF EXPERIMENTS

DCA 202.1 THYRISTORS AND CONTROLLED AC/AC CONVERTERS

Thyristor

- TRIAC

Single-phase controllers

- Single-phase ac controller W1C, ohmic load
- Single-phase ac controller W1C, inductive load
- Single-phase ac controller W1C, ohmic-inductive load
- Single-phase ac controller W1, ohmic load
- Single-phase ac controller W1, ohmic-inductive load
- Half-controlled single-phase controller W1H, ohmic load

Three-phase controllers

- Fully controlled three-phase controller W3C, star ohmic load without neutral
- Fully controlled three-phase controller W3H, star ohmic load without neutral
- Three-phase controller W3C2, star ohmic load without neutral

DCA 202.2 LIGHT DIMMER FAULT SIMULATOR

Phase control for the regulation of lighting with fault simulation.
Double time-constant standard light dimmer circuit consisting of triac, diac, two control potentiometers, resistors and capacitors.
A total of 20 faults can be switched on using switches located behind a cover.
Typical faults: interruptions, short-circuit, faulty components and faulty design.

Examples of exercises:

- Fault-free dimmer
- DIAC shorted
- DIAC with high resistance
- The gate of TRIAC works like a diode
- Control circuit break
- Assembly or component fault
- Trimmer shorted
- Auxiliary RC circuit not included
- Variable resistance R shorted
- TRIAC shorted

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Code	Description	DCA 202.1	DCA 202.2	Total quantities
DL 2603	GROUP OF DIODES	1		1
DL 2605	GROUP OF SCR	1		1
DL 2607	TRIAC	1		1
DL 2613	DC POWER SUPPLY	1		1
DL 2614	VOLTAGE REFERENCE GENERATOR	1		1
DL 2616	TWO PULSE CONTROL UNIT	1		1
DL 2617	SIX PULSE CONTROL UNIT	1		1
DL 2626	MAINS TRANSFORMER	1	1	1
DL 2628	SUPER-FAST FUSES	1		1
DL 2635	LOAD	1		1
DL 2636	SOCKETS WITH LAMPS		1	1
DL 2639	PHASE CONTROL FAULT SIMULATOR		1	1
DL 2642	ISOLATION AMPLIFIER	1	1	1
DL 2643	SUPPORT WITH 3 SHUNTS 1 OHM	1		1
DL 2109T26	POWER METER	1		1
DL 2109T33	TRUE RMS METER	2		2
DL 2109T3PV	MOVING IRON VOLTMETER	1		1
DL 2109T2A5	MOVING IRON AMMETER	1		1
DL 2100-3M	FRAME	2	2	2
DL 1001-1	WORKING BENCH	1	1	1
DL 1155POW	CONNECTING LEADS	1	1	1
	Accessory:			
DL 2100TA	STORAGE CABINET	1	1	1
	For the Countries where the 3-phase mains supply is different from 380V:			
DL 2600TT	THREE PHASE TRANSFORMER	1	1	1

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DIRECT CURRENT DIRECT CURRENT CONVERSION

Dc - dc converters are widely used in dc power supplies and in some applications of dc motor drive.
Often, the input to this type of converters is a dc non-regulated voltage, obtained by rectifying the mains voltage and, consequently, fluctuating due to changes in the amplitude of the line voltage.
The result of the conversion is a controlled dc output at the desired voltage level.

LIST OF EXPERIMENTS

DCA 203.1 CHOPPERS

- Main SCR
- MOSFET
- IGBT
- Step-down converter with SCR with turn-off circuit. PWM contol.
- Step-down converter with IGBT. PWM control.
- Speed control of a dc motor
- Step-down converter with MOSFET. PWM control.
- Step-down converter with MOSFET. PFM control.
- Step-down converter with MOSFET. TPC control .
- Step-up converter with IGBT. PWM control.
- Step-up converter with IGBT. TPC control.
- Inverting converter with IGBT. PWM control.

DCA 203.2 SWITCHABLE POWER SUPPLY

- Flyback converter with IGBT. PWM control.
- Forward converter with IGBT. PWM control.
- Asymmetric half-bridge forward converter with IGBT. PWM control.

Code	Description	DCA 203.1	DCA 203.2	Total quantities
DL 2602	SILICON DIODE	1	4	4
DL 2608	MOSFET	1		1
DL 2609	IGBT	1	2	2
DL 2611	BRIDGE THREE PHASE RECTIFIER	1	1	1
DL 2612	SCR WITH TURN OFF CIRCUIT	1		1
DL 2613	DC POWER SUPPLY	1	1	1
DL 2614	VOLTAGE REFERENCE GENERATOR	1	1	1
DL 2619	PWM/PFM/TPC CONTROL UNIT	1	1	1
DL 2626	MAINS TRANSFORMER	1	1	1
DL 2627	CAPACITORS	1	1	1
DL 2628	SUPER FAST FUSES	1	1	1
DL 2629	SWITCHING TRANSFORMER		1	1
DL 2630	CURRENT TRANSFORMER	1		1
DL 2635	LOAD	1	1	1
DL 2640	EMI FILTER		1	1
DL 2642	ISOLATION AMPLIFIER	1	1	1
DL 2643	SUPPORT WITH 3 SHUNTS 1 OHM	1	1	1
DL 2644	SUPPORT WITH 3 SHUNTS 0,1 OHM		1	1
DL 2025DT	TACHOMETER	1		1
DL 2109T33	TRUE RMS METER	2	2	2
DL 10200A1	SHUNT EXCITATION DC MOTOR	1		1
DL 10400	BASE	1		1
DL 2100-3M	FRAME	2	2	2
DL 1001-1	WORKING BENCH	1	1	1
DL 1155POW	CONNECTING LEADS	1	1	1
	Accessory:			
DL 2100TA	STORAGE CABINET	1	1	1
	For the Countries where the 3-phase mains supply is different from 380V:			
DL 2600TT	THREE PHASE TRANSFORMER	1	1	1

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DIRECT CURRENT ALTERNATE CURRENT CONVERSION

This type of converters are used in ac motor drives and in ac uninterruptible power supplies, where the objective is to supply a sinusoidal ac output with controlled amplitude and frequency.
In this section of the laboratory inverters and frequency converters are studied.

LIST OF EXPERIMENTS

DCA 204.1 INVERTERS

- Single-phase full-bridge dc chopper. PWM control.
- Single-phase full-bridge inverter. Square-wave PWM control.
- Single-phase full-bridge inverter. Sinusoidal PWM control.

DCA 204.2 FREQUENCY CONVERTERS

- Frequency converter
- Input controlled rectifier
- Output power inverter

Code	Description	DCA 204.1	DCA 204.2	Total quantities
DL 2610	GROUP OF IGBT	1		1
DL 2611	BRIDGE THREE PHASE RECTIFIER	1		1
DL 2613	DC POWER SUPPLY	1	1	1
DL 2614	VOLTAGE REFERENCE GENERATOR	1	1	1
DL 2619	PWM/PFM/TPC CONTROL UNIT	1		1
DL 2625	MATCHING AMPLIFIER	1		1
DL 2626	MAINS TRANSFORMER	1		1
DL 2627	CAPACITORS	1		1
DL 2628	SUPER FAST FUSES	1		1
DL 2633	FUNCTION GENERATOR	1		1
DL 2635	LOAD	1	1	1
DL 2637	STABILIZED POWER SUPPLY	1		1
DL 2640	EMI FILTER	1		1
DL 2642	ISOLATION AMPLIFIER	1	1	1
DL 2643	SUPPORT WITH 3 SHUNTS 1 OHM	1		1
DL 2644	SUPPORT WITH 3 SHUNTS 0,1 OHM	1		1
DL 2646	FREQUENCY CONVERTER		1	1
DL 2108SAL	SINGLE PHASE SUPPLY UNIT		1	1
DL 2109T33	TRUE RMS METER	2	2	2
DL CRON	ELECTRONIC STOPCLOCK		1	1
DL 2100-3M	FRAME	2	2	2
DL 1001-1	WORKING BENCH	1	1	1
DL 1155POW	CONNECTING LEADS	1	1	1
	Accessory:			
DL 2100TA	STORAGE CABINET	1	1	1
	For the Countries where the 3-phase mains supply is different from 380V:			
DL 2600TT	THREE PHASE TRANSFORMER	1	1	1

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APPLICATIONS

Motor drives are used in a wide range of power values, from few watts up to many thousands of kilowatts, in applications ranging from high precision position control in robotics to variable speed drives for regulating the rate of flow in pumps.
In all drives where speed and position must be controlled, a power electronics converter is needed as interface between input power and motor.
Constant, or slightly variable according to load, speed drives use almost exclusively induction motors, thanks to their simple, robust and cheap construction, in addition to the fact that they do not need special maintenance.
However, the multi-phase motors supplied at constant network voltage and frequency have a rigid relationship between supply frequency and speed.
Direct current motor drives are mainly used in applications requiring the control of the speed of the motor (DCA 205.1). In variable speed drives direct current machines are used everywhere; however, today, with the development of power electronics, induction motor drives are also widely used .
In these cases, the speed of the motor can be varied in three different ways: by varying the number of polar couples, by varying the slip speed (DCA 205.2), by varying the supply frequency (DCA 205.3).

LIST OF EXPERIMENTS

DCA 205.1 DC MOTOR DRIVE

- Single-quadrant drive with converter B2C
- Single-quadrant drive with converter B2C and armature voltage feedback
- Single-quadrant drive with converter B2C and armature voltage feedback with RI compensation
- Single-quadrant drive with converter B2C and tacho-voltage feedback
- Single-quadrant drive with converter B2C and tacho-voltage feedback with inner current loop
- Two-quadrant drive (I-IV) with converter B2C
- Two-quadrant drive (I-III) with converter (B2C)2I
- Two-quadrant drive (I-III) with converter (B2C)2I and tacho-voltage feedback with inner current loop
- Four-quadrant drive with converter (B2C)2I
- Four-quadrant drive with converter (B2C)2I and tacho-voltage feedback with inner current loop
- Single-quadrant drive with converter B6C
- Single-quadrant drive with converter B6C and tacho-voltage feedback with inner current loop

DCA 205.2 AC SLIP-RING MOTOR DRIVE

- Control of stator voltage with transformer
- Control of stator voltage with controller W3C
- Control of stator voltage and tacho-voltage feedback
- Rotor starter
- Rotor pulsed resistor
- Rotor pulsed resistor and tacho-voltage feedback
- Scherbius static drive
- Scherbius static drive and tacho-voltage feedback

DCA 205.3 AC SQUIRREL CAGE MOTOR DRIVE

- Preliminary investigation of the squirrel cage motor
- Six-pulse PAM
- Pulsed square-wave triggering
- Trapezoidal modulation
- Pulse width modulation (PWM)
- Voltage vector control (VVC)
- Motor magnetization for linear U/f characteristic

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- Extra start magnetization
- IxR compensation
- Operation in standard converter setting
- Slip compensation
- Motor operation in star connection
- Brake chopper
- Speed control with tacho-voltage feedback

Code	Description	DCA 205.1	DCA 205.2	DCA 205.3	Total quantities
DL 2603	GROUP OF DIODES		1		1
DL 2605	GROUP OF SCR	2	1		2
DL 2609	IGBT		1		1
DL 2613	DC POWER SUPPLY	1	1	1	1
DL 2614	VOLTAGE REFERENCE GENERATOR	1	1	1	1
DL 2615	TRIGGER POINT LIMITER	1	1		1
DL 2616	TWO PULSE CONTROL UNIT	1			1
DL 2617	SIX PULSE CONTROL UNIT	1	1		1
DL 2619	PWM/PFM/TPC CONTROL UNIT		1		1
DL 2620	RUN-UP CONTROL UNIT	1	1		1
DL 2622	PID CONTROLLER	1	1	1	1
DL 2623	ABSOLUTE VALUE GENERATOR	1			1
DL 2624	ADAPTIVE PID CONTROLLER	1			1
DL 2625	MATCHING AMPLIFIER	1			1
DL 2626	MAINS TRANSFORMER	1	1		1
DL 2628	SUPER FAST FUSES	1	2		2
DL 2630	CURRENT TRANSFORMER	1			1
DL 2631	TRIGGER PULSE SWITCH	1			1
DL 2632	SWITCHING LOGIC	1			1
DL 2634	VOLTAGE DIVIDER 20:1	1			1
DL 2635	LOAD	1	1	1	1
DL 2636	SOCKETS WITH LAMPS	1			1
DL 2637	STABILIZED POWER SUPPLY	1			1
DL 2642	ISOLATION AMPLIFIER	1	1	1	1
DL 2643	SUPPORT WITH 3 SHUNTS 1 OHM	1	1		1
DL 2646	FREQUENCY CONVERTER			1	1
DL 2648	PWM CONTROL UNIT			1	1
DL 2655	VARIABLE THREE PHASE TRANSFORMER		1		1
DL 2025DT	TACHOMETER	1			1
DL 2108SAL	SINGLE PHASE SUPPLY UNIT			1	1
DL 2108TAL-SW	THREE PHASE SUPPLY UNIT		1		1
DL 2109T33	TRUE RMS METER	2	2	1	2
DL 2109T3PV	MOVING IRON VOLTMETER		1		1
DL 2109T2A5	MOVING IRON AMMETER	1	1		1
DL 10115A1	SQUIRREL CAGE THREE PHASE MOTOR			1	1
DL 10120A1	SLIP RING THREE PHASE MOTOR		1		1
DL 10120RA	ROTOR STARTER		1		1
DL 10200A1	SHUNT EXCITATION DC MOTOR	1			1
DL 10250A1	SHUNT EXCITATION DC GENERATOR	1			1
DL 10300P	POWDER BRAKE		1	1	1
DL 2006D	LOAD CELL		1	1	1
DL 10300PAC	POWDER BRAKE CONTROL UNIT		1	1	1
DL 10400	BASE	1	1	1	1
DL 10410	FLYWHEEL			1	1
DL 2100-3M	FRAME	2	2	2	2
DL 1001-1	WORKING BENCH	1	1	1	1
DL 1155POW	CONNECTING LEADS	1	1	1	1
	Accessory:				
DL 2100TA	STORAGE CABINET	1	1	1	1
	For the Countries where the 3-phase mains supply is different from 380V:				
DL 2600TT	THREE PHASE TRANSFORMER	1	1	1	1

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SOFTWARE

In the Power Electronics laboratory De Lorenzo has realized two software that allow for an automatic analysis through PC of some of the subjects already dealt in the previous pages. In particular:

Software	Code	Description
DL 201SW	DCA 201SW	DIODES AND UNCONTROLLED RECTIFIERS (DCA 201.1) SCR AND CONTROLLED RECTIFIERS (DCA201.2)
	DCA 202.1SW	THYRISTORS AND CONTROLLED AC/AC CONVERTERS (DCA 202.1)
DL 205.3SW	DCA 205.3SW	INDUCTION MOTOR DRIVES (DCA205.3)

Software DL 201SW allows for the automatic measurement of voltage and current waveforms in the circuits that are used for ac-dc and ac-ac conversion. The software allows also for the variation of the trigger angle of the control devices through the six pulse control unit.

Software DL 205.3SW allows for the control of the frequency converter by means of the method of the U/f characteristic curve through the control unit DL 2648, that provides the possibility to use any one of the following types of modulation: PWM, VVC, trapezoidal and block modulation.

Code	Description	DCA 201SW	DCA 202.1SW	DCA 205.3SW	Total quantities
DL 2602	SILICON DIODE	1			1
DL 2603	GROUP OF DIODES	1	1		1
DL 2604	SCR	1			1
DL 2605	GROUP OF SCR	1	1		1
DL 2607	TRIAC		1		1
DL 2613	DC POWER SUPPLY	1	1	1	1
DL 2617	SIX PULSE CONTROL UNIT	1	1		1
DL 2626	MAINS TRANSFORMER	1	1		1
DL 2628	SUPER FAST FUSES	2	1		2
DL 2635	LOAD	1	1		1
DL 2636	SOCKETS WITH LAMPS	1			1
DL 2637	STABILIZED POWER SUPPLY	1			1
DL 2642	ISOLATION AMPLIFIER	1	1	1	1
DL 2646	FREQUENCY CONVERTER			1	1
DL 2648	PWM CONTROL UNIT			1	1
DL 2650	PC INTERFACE	1	1	1	1
DL 201SW	POWER ELECTRONICS SOFTWARE	1	1		1
DL 205.3SW	INDUCTION MOTOR CONTROL SOFTWARE			1	1
DL 12B12	BATTERY STACK	1			1
DL 2025DT	TACHOMETER	1			1
DL 2108SAL	SINGLE-PHASE SUPPLY UNIT			1	1
DL 2109T26	POWER METER		1		1
DL 2109T33	TRUE RMS METER	2	2		2
DL 2109T3PV	MOVING IRON VOLTMETER	1	1		1
DL 2109T2A5	MOVING IRON AMMETER	1	1		1
DL 10115A1	SQUIRREL CAGE THREE PHASE MOTOR			1	1
DL 10200A1	SHUNT EXCITATION DC MOTOR	1			1
DL 10250A1	SHUNT EXCITATION DC GENERATOR	1			1
DL 10300P	POWDER BRAKE			1	1
DL 2006D	LOAD CELL			1	1
DL 10300PAC	POWDER BRAKE CONTROL UNIT			1	1
DL 10400	BASE	1		1	1
	PC (not included)	1	1	1	1
DL 2100-3M	FRAME	2	2	2	2
DL 1001-1	WORKING BENCH	1	1	1	1
DL 1155POW	CONNECTING LEADS	1	1	1	1
	Accessory:				
DL 2100TA	STORAGE CABINET	1	1	1	1
	For the Countries where the 3-phase mains supply is different from 380V:				
DL 2600TT	THREE PHASE TRANSFORMER	1	1	1	1

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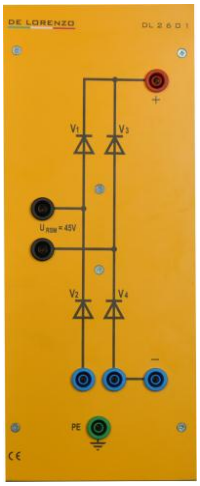
Code	Description	DCA 201.1	DCA 201.2	DCA 202.1	DCA 202.2	DCA 203.1	DCA 203.2	DCA 204.1	DCA 204.2	DCA 205.1	DCA 205.2	DCA 205.3	DCA 201SW	DCA 202.1SW	DCA 205.3SW	Total Quant.
DL 2601	SELENIUM RECTIFIER	1														1
DL 2602	SILICON DIODE	1				1	4						1			4
DL 2603	GROUP OF DIODES	1	1	1							1		1	1		1
DL 2604	SCR		1										1			1
DL 2605	GROUP OF SCR		1	1						2	1		1	1		2
DL 2607	TRIAC			1										1		1
DL 2608	MOSFET					1										1
DL 2609	IGBT					1	2				1					2
DL 2610	GROUP OF IGBT							1								1
DL 2611	BRIDGE THREE PHASE RECTIFIER					1	1	1								1
DL 2612	SCR WITH TURN OFF CIRCUIT					1										1
DL 2613	DC POWER SUPPLY		1	1		1	1	1	1	1	1	1	1	1	1	1
DL 2614	VOLTAGE REFERENCE GENER.		1	1		1	1	1	1	1	1	1				1
DL 2615	TRIGGER POINT LIMITER		1							1	1					1
DL 2616	TWO PULSE CONTROL UNIT		1	1						1						1
DL 2617	SIX PULSE CONTROL UNIT		1	1						1	1		1	1		1
DL 2619	PWM/PFM/TPC CONTROL UNIT					1	1	1			1					1
DL 2620	RUN-UP CONTROL UNIT									1	1					1
DL 2622	PID CONTROLLER									1	1	1				1
DL 2623	ABSOLUTE VALUE GENERATOR									1						1
DL 2624	ADAPTIVE PI CONTROLLER									1						1
DL 2625	MATCHING AMPLIFIER							1		1						1
DL 2626	MAINS TRANSFORMER	1	1	1	1	1	1	1		1	1		1	1		1
DL 2627	CAPACITORS					1	1	1								1
DL 2628	SUPER FAST FUSES	2	2	1		1	1	1		1	2		2	1		2
DL 2629	SWITCHING TRANSFORMER						1									1
DL 2630	CURRENT TRANSFORMER					1				1						1
DL 2631	TRIGGER PULSE SWITCH									1						1
DL 2632	SWITCHING LOGIC									1						1
DL 2633	FUNCTION GENERATOR							1								1
DL 2634	VOLTAGE DIVIDER 20:1									1						1
DL 2635	LOAD	1	1	1		1	1	1	1	1	1	1	1	1		1
DL 2636	SOCKETS WITH LAMPS		1		1					1			1			1
DL 2637	STABILIZED POWER SUPPLY		1					1		1			1			1
DL 2639	PHASE CONTROL FAULT SIM.				1											1
DL 2640	EMI FILTER						1	1								1
DL 2642	ISOLATION AMPLIFIER	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
DL 2643	SUPPORT WITH 3 SHUNTS 1 OHM	1	1	1		1	1	1		1	1					1
DL 2644	SUPPORT WITH 3 SH. 0.1 OHM		1				1	1								1
DL 2646	FREQUENCY CONVERTER								1			1			1	1
DL 2648	PWM CONTROL UNIT											1			1	1
DL 2650	PC INTERFACE												1	1	1	1
DL 201SW	POWER EL. SW												1	1		1
DL 205.3SW	INDUCTION MOTOR CONT. SW														1	1
DL 2655	VARIABLE THREE-PHASE TRANSF.										1					1
DL 12B12	BATTERY STACK		1										1			1
DL 2025DT	TACHOMETER		1			1				1			1			1
DL 2108SAL	SINGLE PHASE SUPPLY UNIT								1			1			1	1
DL 2108TAL-SW	THREE PHASE SUPPLY UNIT										1					1
DL 2109T26	POWER METER			1										1		1
DL 2109T33	TRUE RMS METER	2	2	2		2	2	2	2	2	2	1	2	2		2
DL 2109T3PV	MOVING IRON VOLTMETER	1	1	1							1		1	1		1
DL 2109T2A5	MOVING IRON AMMETER	1	1							1	1		1	1		1
DL 10115A1	SQUIRREL CAGE THREE PHASE M.											1			1	1
DL 10120A1	SLIP RING THREE PHASE MOTOR										1					1
DL 10120RA	ROTOR STARTER										1					1
DL 10200A1	SHUNT EXCITATION DC MOTOR		1			1				1			1			1
DL 10250A1	SHUNT EXCITATION DC GENERA.		1							1			1			1
DL 10300P	POWDER BRAKE										1	1			1	1
DL 2006D	LOAD CELL										1	1			1	1
DL 10300PAC	POWDER BRAKE CONTROL UNIT										1	1			1	1
DL 10400	BASE		1			1				1	1	1	1		1	1
DL 10410	FLYWHEEL											1				1
DL CRON	ELECTRONIC STOPCLOCK								1							1
	PC (not included)												1	1	1	1
DL 2100-3M	FRAME	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
DL 1001-1	WORKING BENCH	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
DL 1155POW	CONNECTING LEADS	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Accessories:															
DL 2100TA	STORAGE CABINET	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
DL 2600TT	THREE PHASE TRANSFORMER	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

POWER ELECTRONICS

SELENIUM RECTIFIER

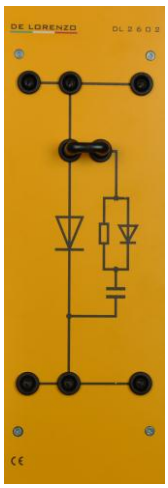


DL 2601

Selenium components used in the rectifiers to convert the alternated current in a pulse current in low voltage systems.

Technical features:
Rated alternated voltage: 30 Vrms
Rated continuous voltage: 24 Vav
Rated continuous current: 10 Aav

SILICON DIODE

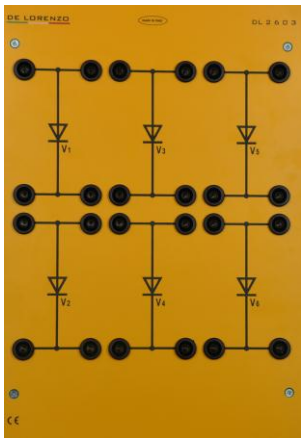


DL 2602

Fast acting silicon diode suitable for realizing rectifying circuits; it can be used also as a free-wheeling diode in the converters.

Technical features:
Direct average current:
I_{FAV} = 12 A max.
Direct non repetitive overload current:
I_{FSM} = 75 A (tp = 10 ms)
Repetitive peak reverse voltage: U_{RRM} = 1000 V
Recovery reverse time:
t_{rr} = 65 ns max.

GROUP OF DIODES

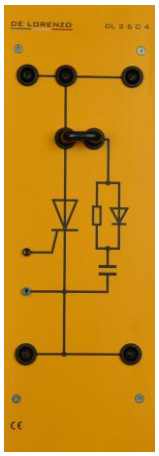


DL 2603

Six fast acting silicon diodes with RCD protection network suitable for realizing non-controlled rectifying circuits.

Technical features:
Direct average current:
I_{FAV} = 12 A
Direct non repetitive overload current:
I_{FSM} = 75 A (t_p = 10 ms)
Repetitive peak reverse voltage: U_{RRM} = 1000 V
Recovery reverse time:
t_{rr} = 65 ns max.

SCR



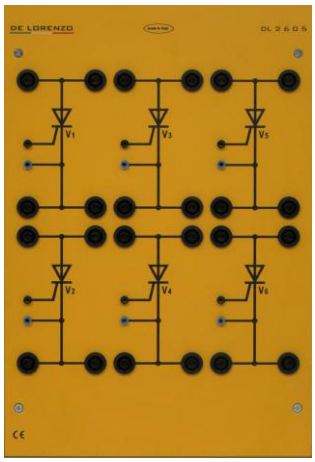
DL 2604

Silicon controlled rectifier used in the control of power, in controlled rectifiers and in inverters.

Technical features:
Direct average current:
I_{TAV} = 7.6 A max.
True RMS value of the direct current:
I_{TRMS} = 12 A
Max. repetitive reverse voltage: U_{RRM} = 800 V
Trigger current:
I_{GT} = 15 mA max.
Trigger voltage:
U_{GT} = 1.5 V max.
I^2t = 72 A^2s

POWER ELECTRONICS

GROUP OF SCR

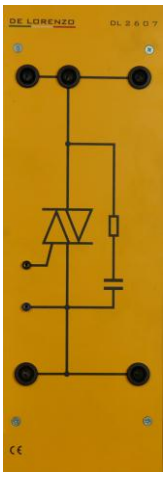


DL 2605

Six silicon controlled rectifiers with RCD protection network used for realizing controlled rectifiers and inverters.

Technical features:
Direct average current:
I_{TAV} = 7.6 A max.
True RMS value of the direct current:
I_{TRMS} = 12 A
Max. repetitive reverse voltage: U_{RRM} = 800 V
Trigger current:
I_{GT} = 15 mA max.
Trigger voltage:
U_{GT} = 1.5 V max.
I^2t = 72 A^2s

TRIAC

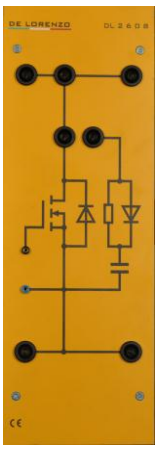


DL 2607

Bidirectional thyristor used for the control in alternated current. Complete with RC suppressor network.

Technical features:
True RMS value of the direct current:
I_{TAV} = 8 A max.
Non-repetitive peak current:
I_{TSM} = 70 A, 50Hz (77A, 60Hz)
Max. repetitive reverse voltage: U_{DRM} = 800 V
Trigger current:
I_{GT} = 25 mA max. (all the quadrants)
Trigger voltage:
U_{GT} = 2.5 V max.
State keeping current:
I_H = 25 mA max.
I^2t = 24 A^2s

MOSFET

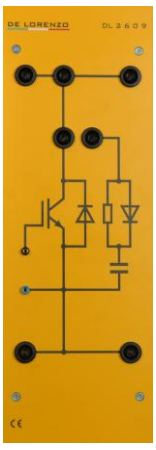


DL 2608

N-channel enhancement mode power MOS with integrated reverse diode (FRED, Fast Recovery Epitaxial Diode) used as very fast switch in switching regulators and inverters.

Technical features:
Drain-source voltage:
U_{DS} = 400 V
Continuous drain current: I_D = 10 A
Drain-source on-state resistance:
R_{DS}(on) = 0.55 Ω
Gate-source voltage:
U_{GS} = +-20 V

IGBT



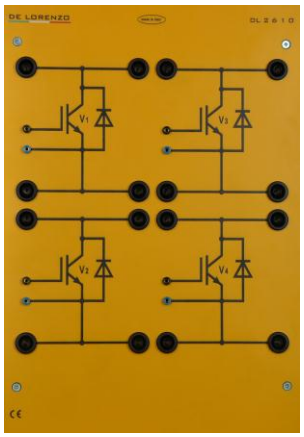
DL 2609

N-channel Insulated Gate Bipolar Transistor (IGBT) with anti parallel hyper fast protection diode used as very fast switch in switching regulators and inverters.

Technical features:
Collector-emitter voltage: U_{CES} = 600 V
Continuous collector current:
I_c=24 A at T_c=25ºC
Collector-emitter saturation voltage:
U_{CEsat} = 1.8 V_{typ} at I_c=15 A
Gate-emitter voltage:
U_{GE} = ± 20 V

POWER ELECTRONICS

GROUP OF IGBT

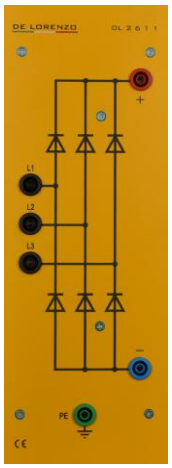


DL 2610

4 N-channel Insulated Gate Bipolar Transistors (IGBT) with anti parallel hyper fast protection diode used as very fast switches in switching regulators and inverters.

Technical features:
Collector-emitter voltage: U_{CES} = 600 V
Continuous collector current:
I_c = 24 A at T_c = 25ºC
Collector-emitter saturation voltage:
U_{CEsat} = 1.8 V_{typ} at I_c=15 A
Gate-emitter voltage:
U_{GE} = ± 20 V

BRIDGE THREE PHASE RECTIFIER

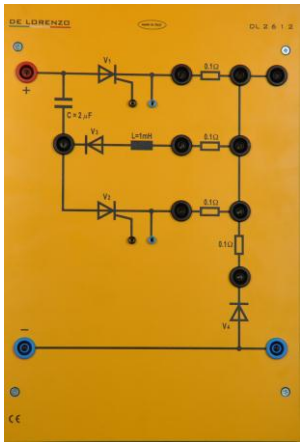


DL 2611

Non-controlled three-phase rectifier in six pulse bridge connection B6UK for the generation of a DC voltage from a three phase mains.

Technical features:
Rated alternating input voltage: U_{VN} = 400 V
Direct output voltage:
U_d = 540 V
Rated direct current:
I_{dN} = 10 A
Surge forward current
I_{FSM} = 300 A
I^2t = 400 A^2s
Voltage drop: U_F = 1 V per diode

SCR WITH TURN OFF CIRCUIT



DL 2612

SCR with turn off circuit and freewheeling diode.

Technical features:
Technical features:
Main SCR and auxiliary SCR, complete with RC suppressor circuit.
Direct average current:
I_{TAV} = 13 A max.
Max. repetitive reverse voltage:
U_{DRM} = 800 V tq = 35 ms
Block diodes and flywheel, complete with RC suppressor circuit.
Max. repetitive reverse voltage:
U_{DRM} = 600 V I_{AV} = 8 A
Turn off capacitor:
C = 2 µF
Oscillation coil: L = 1 mH
Shunt for the measurement of the currents in each branch:
4 x 0.1 Ω

DC POWER SUPPLY

DL 2613

Two outputs fixed voltage laboratory stabilized power supply. Protection from short circuit.

Technical features:
Output voltages:
+15 V / 0 V / - 15 V
Output current:
2.4 A (3 A for a short time)
Power supply:
single-phase from mains
Complete with two LED and a mains switch with pilot lamp.

POWER ELECTRONICS

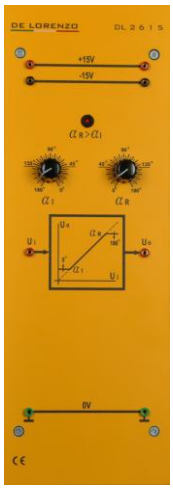
VOLTAGE REFERENCE GENERATOR

DL 2614

Suitable for realizing a reference signal through an internal potentiometer or for transferring an external reference signal.

Technical features:
Output voltage:
0...+10 V
or
-10 V ...+10 V
Power supply:
+15 V / 0 V / - 15 V

TRIGGER POINT LIMITER

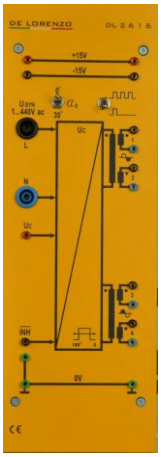


DL 2615

Voltage limiter to set the stability limit for rectifiers and inverters together with the two and six pulse control units.

Technical features:
Stability limit for rectifier: 0° to 180°
Stability limit for inverter: 180° to 0°
Power supply:
+15 V / 0 V / - 15 V

TWO PULSE CONTROL UNIT

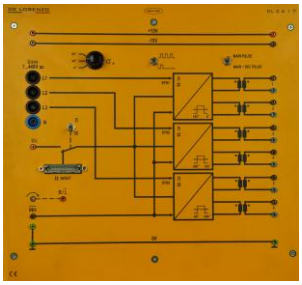


DL 2616

Trigger pulse generator for the triggering of thyristors or triacs in single-phase rectifier and inverter circuits as well as in AC controllers.

Technical features:
Power supply:
+15V/ 0V / - 15V (25mA)
Synchronization voltage:
1 to 440 V
Control voltage:
U_c: 0 V to 10 V
Trigger angle: 180° to 0°
Number of outputs:
2 x 2
Possibility of pulse train or single pulse.
Possibility of selecting two natural switching points: 0° and 30°.
Inhibit voltage:
U_{INH} = 15 V (open): trigger pulses.
U_{INH} = 0 V: no trigger pulses.

SIX PULSE CONTROL UNIT



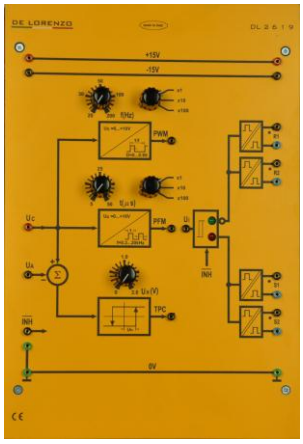
DL 2617

Trigger pulse generator for the triggering of thyristors or triacs in the single-phase and three-phase rectifier and inverter circuits as well as in AC controllers.
Possibility of analogue control or digital control through interface.

Technical features:
Power supply:
+15V/0V/- 15V (300mA)
Synchronization voltage:
1 to 440 V
Analogue control voltage U_c: 0 to 10V
Digital TTL control:
$DW_H = F_H...F_{FH}$
$(15...255)_{10}$
Trigger angle: 180° to 0°
(300°...120°/60°...240°)
Number of outputs:
3 x 2
Possibility of pulse train or single pulse.
Possibility of excluding the secondary pulse.
Possibility of selecting three natural switching points: 0°, 30° and 60°.
Inhibit voltage:
U_{INH} = 15 V (open): trigger pulses.
U_{INH} = 0 V: no trigger pulses

POWER ELECTRONICS

PWM, PFM, TPC CONTROL UNIT



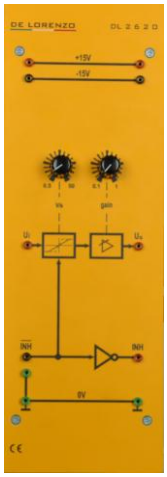
DL 2619

Technical features:
Power supply:
+15V/0V/- 15V (600 mA)
Control voltage:
U_c: 0 to 10V
PWM: 20-200 Hz/0.2-2 kHz/2-20 kHz
Duty cycle
D = ton/T = 0-0.95
PFM: 5-50 ms/50-500 ms/0.5-5 s

Unit for the control of the conduction time of the electronic switches. Control methods: PWM (Pulse Width Modulation), PFM (Pulse Frequency Modulation) and TPC (Two-Point Control).

Frequency:
20 Hz to 20 kHz
TPC: Hysteresis: U_H = 0 to 2 V
Number of outputs: 2 x 2, with led indication of the status
Output amplifier: threshold voltage 5 V, short-circuit proof
Inhibit voltage:
U_{INH} = 15 V (open): trigger pulses.
U_{INH} = 0 V: longer pulses at certain outputs only.

RUN-UP CONTROL UNIT

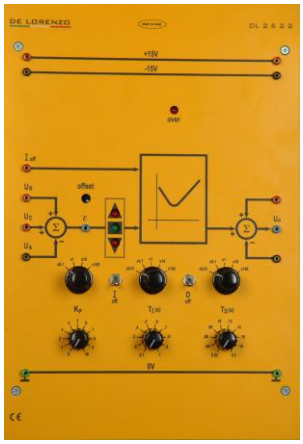


DL 2620

For generating a ramp voltage for a step change at the input, mainly applied in automatic speed control loops.

Technical features:
Power supply:
-15 V/0 V/ 15 V
Input signal range:
U_i = -10 V ... 10 V
Fine adjustment of the slew-rate:
0.5 . . . 50 V/s
Fine adjustment of the voltage gain:
0.1 . . . 1
Inhibit voltage:
U_{INH} = 0 V: zero output voltage U0 and output
U_{INH} = 15 V
U_{INH} = 15 V (open): output voltage U_0 runs up and output U_{INH} = 0 V

PID CONTROLLER



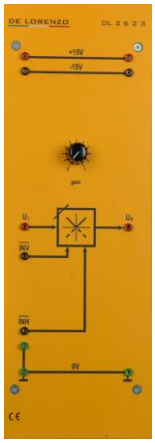
DL 2622

Technical features:
Power supply:
-15 V/0 V/+15 V
Input summing point for two different reference variables U_R and U_C and one controlled variable U_A.

Standard industrial controller for use as P, PI, PD or PID regulator in automatic closed-loop control systems.

Signal voltage range:
-10 V . . . + 10 V
Controller continuously adjustable parameters:
proportional gain:
K_p = 0...1000
integral action time:
T_I = 1 ms...100 s
differential action time
T_D = 0.2 ms . . . 20 s
Separate input for integral element reset.
Output summing point for adding or subtracting disturbance variables.

ABSOLUTE VALUE GENERATOR



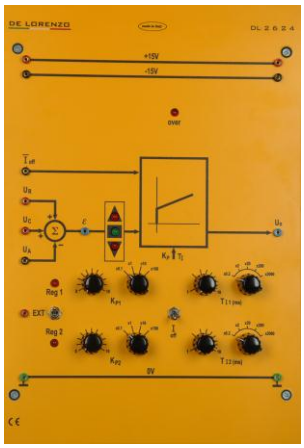
DL 2623

Absolute value circuit used primarily for inverting the analogue input signal in reversible converters, triggered via a switching logic.

Technical features:
Power supply:
-15 V/0 V/+15 V
Input signal range U_i:
-10 V . . . + 10 V
Adjustable gain: 0 . . . 1
Inverting control input:
U_{INV} = 0 V: the input signal is inverted
U_{INV} = 15 V or disconnected: the input signal is not inverted
Inhibit voltage:
U_{INH} = 0 V: the output signal is zero
U_{INH} = 15 V (open): the absolute value circuit is active

POWER ELECTRONICS

ADAPTIVE PI CONTROLLER



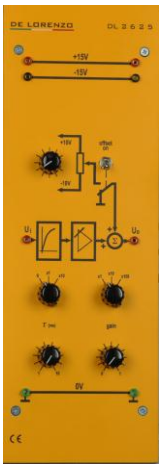
DL 2624

Technical features:
Power supply:
-15 V/0 V/+15 V
Input summing point for two different reference variables U_R and U_C and one controlled variable U_A.

Double compact PI controller for use as current controller in dc servo drives.

Signal voltage range:
-10 V . . . + 10 V
Continuously adjustable parameters of the two controllers:
proportional gain
K_p = 0 . . . 1000
integral action time
T_I = 0.2 ms . . . 20 s
Integral element reset by switch or via external signal.
Regulator selection by switch or via external signal.

MATCHING AMPLIFIER

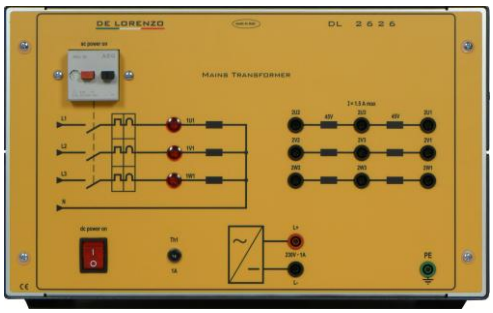


DL 2625

Amplifier as matching element between signal voltage levels and standard voltages used in automatic control systems.

Technical features:
Power supply:
-15 V/0 V/+15 V
Input signal range
U_i: -50 V . . . + 50 V
Coarse and fine gain setting:
0÷1/0÷10/0÷100
Connectable low pass filter with coarse and fine time constant setting:
0/ 1÷10 ms / 10÷100 ms
Connectable output offset voltage:
-10 V . . . +10 V

MAINS TRANSFORMER

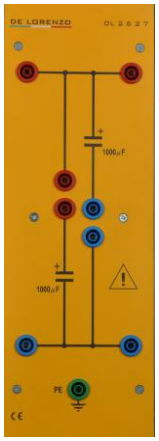


DL 2626

Three-phase transformer able to supply single and three-phase voltages as well as a rectified voltage for the excitation of the dc machines.
Three pilot lamps for signaling the mains voltage.
AC output through isolation transformer: 3 x 90 V/1.5 A with 3 intermediate sockets at 45 Vac.
DC output, non isolated from mains: 1 x 220 V/1 A, switch with pilot lamp and magneto-thermal protection 1 A

Technical features:
Power supply: three-phase from mains
Protection through three-pole magneto-thermal switch.

CAPACITORS



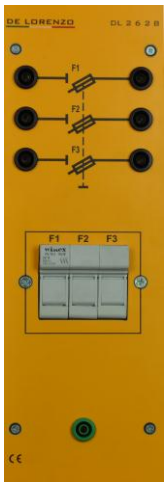
DL 2627

Two electrolytic high performance capacitors.
Particularly suitable to be used as filter capacitors or in the switching power supplies.

Technical features:
Rated value: 2 x 1000 µF
Rated voltage: 385 V
Protection against polarity inversion.
Discharge resistance:
330 kΩ (t = 330 s)

POWER ELECTRONICS

SUPER-FAST FUSES

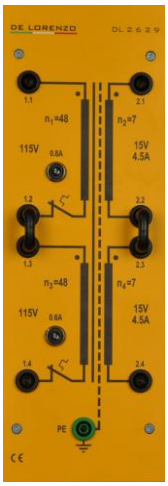


DL 2628

Three sectionable fuse-holders complete with super-fast fuses suitable for the protection of semiconductors.

Technical features:
Nominal voltage:
660 Vac
Nominal current:
3 x 6.3 A
3 x 10 A

SWITCHING TRANSFORMER

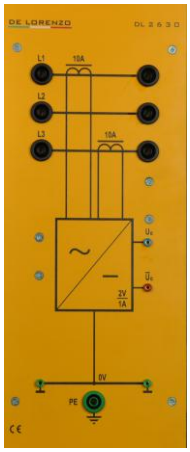


DL 2629

High frequency isolation transformer suitable for switching forward converters; restricted use of this transformer is also possible in flyback converters, but the rated values are not guaranteed.

Technical features:
Ferrite core N27 without air gap.
Primary:
2 x 115 V, 2 x 48 turns
Thermal protection:
2 x 0.6 A
Secondary: 2 x 15 V/ 4.5 A, 2 x 7 turns
Inter-winding shield.
Rated power: 135 VA
Rated frequency: 15 kHz

CURRENT TRANSFORMER

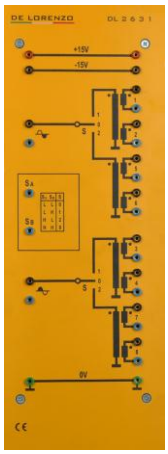


DL 2630

For potential-free measurements of ac currents in single and three-phase without neutral.

Technical features:
Current: 10 A
Unsmoothed output voltage for synchronization.
Smoothed output voltage for current regulator.
Transformation ratio:
2 V / 1 A
Insulation voltage: 3 kV

TRIGGER PULSE SWITCH



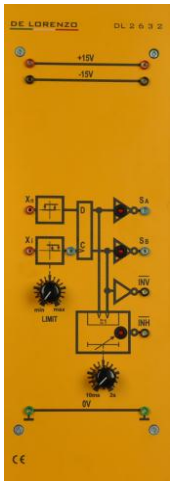
DL 2631

For switching the trigger pulses from the control unit DL 2616 to double converters in 4-quadrant systems.

Technical features:
Two pulse inputs.
Two control inputs.
Eight electrically isolated pulse outputs.
Power supply: +15 V

POWER ELECTRONICS

SWITCHING LOGIC



DL 2632

Logic circuit for switching the trigger pulse switch in 4-quadrant converter systems. The switching logic measures the polarity of the torque and switches the trigger pulses to the corresponding converter after a current-free delay time.

Technical features:
Input X_n for torque comparator (speed set point value).
Input Xi for current comparator with adjustable limit threshold.
Output S_A and S_B for the corresponding inputs of the trigger pulse switch with led indication of the active converter.
Output INV for the corresponding inverting input of the absolute value generator.
Output INH for the corresponding inhibit input of the two pulse control unit, with adjustable delay time from 10 ms to 2 s and led indication of the commutating time.
Current comparator output C for EXT selection input of the active elements of the adaptive PI controller.
Power supply:
+15 V/0 V/-15 V

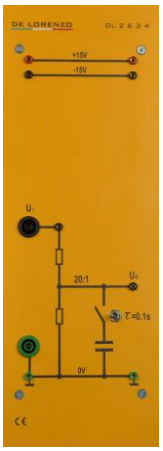
FUNCTION GENERATOR

DL 2633

Versatile function generator.

Technical features:
Functions:
sine / triangle / square wave / square wave with variable duty cycle.
Frequency range:
10 Hz . . . 100 kHz in 4 decades.
Output voltage:
0 V to 20 Vpp adjustable
Two additional outputs with attenuator:
-20 dB / -40 dB
TTL output for triggering.
VCO input, AC coupled.
Power supply:
single-phase from mains

VOLTAGE DIVIDER 20:1



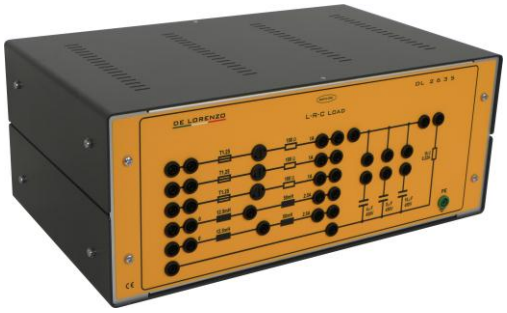
DL 2634

Electronic voltage divider used as an interface between the dc machines (200 V) and the automatic control circuits (-10 V …+15 V).

Technical features:
Possibility of capacitive filter with time constant 0.1 s.
Protection against over voltages up to 1000 Vdc.
Power supply:
+15 V / 0 V / - 15 V

POWER ELECTRONICS

LOAD



DL 2635

Ohmic, inductive and capacitive load suitable for the experiments in the power electronics laboratory.

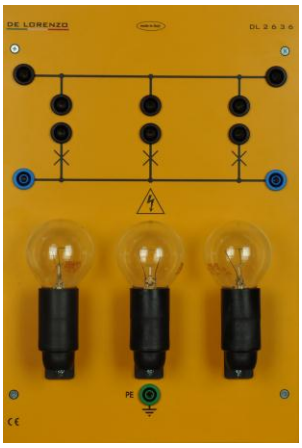
Technical features:

a) Load resistors:
3 x 100 Ω/1 A
Protection with fuses:
3 x T1.25 A
Possibility of connecting in series (300 Ω), in parallel (33.33 Ω) or in star and delta.

b) Load inductors:
2 x (12.5 - 50) mH/2.5 A
Possibility of connecting in series (100 mH) and in parallel (6.25 mH).

c) Load capacitors:
4-8-16 µF/450 Vac
Possibility of connecting in parallel (28 µF).
Discharge resistor:
1 kΩ/0.22 A

SOCKET WITH LAMPS



DL 2636

Three lamp-holders E14. Complete with three incandescent lamps: 40 W/220 V.
Possibility of connecting in parallel.

STABILIZED POWER SUPPLY

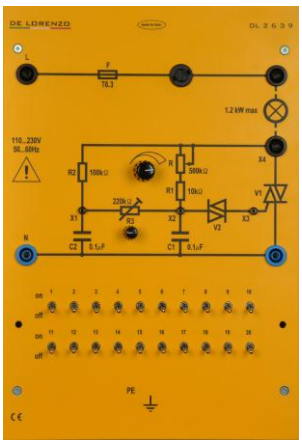
DC power supply for measuring with constant voltage the characteristics of the electrical machines.

Technical features:

The power supply has two sections:
Regulated variable voltage section, used to supply the armature of dc motors.
Output: 0 ÷ 240 Vdc, 5 A
Drive: manual or external via 0 ÷ 10 Vdc signal
Constant voltage section, used to supply the excitation circuit of dc machines.
Output: 220 Vdc, 1 A

DL 2637

PHASE CONTROL FAULT SIMULATOR



DL 2639

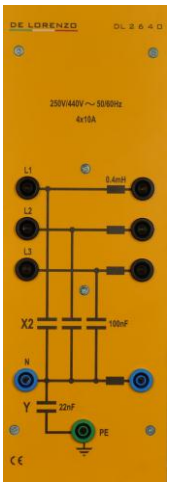
Double time-constant standard light dimmer circuit consisting of triac, diac, two control potentiometers, resistors and capacitors.
A total of 20 faults can be switched on using switches located behind a cover.
Typical faults: interruptions, short-circuit, faulty components and faulty design.

Technical features:

Power supply: 110 to 230 V, 47-63 Hz
Ohmic load: 1.2 kW max

POWER ELECTRONICS

EMI FILTER

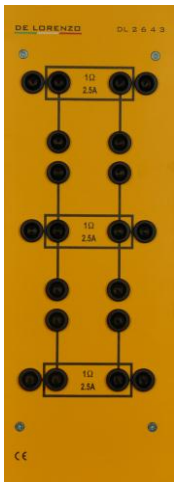


DL 2640

Line filter used to protect the mains network from the electromagnetic interference voltages generated by the switched-mode power supplies.

Technical features:
Inductances on the line: 0.4 mH
Capacitors between conductors and neutral: 100 nF
Capacitor between neutral and ground: 22 nF

SUPPORT WITH 3 SHUNTS 1 OHM

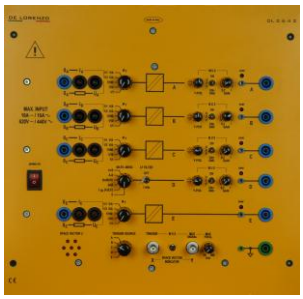


DL 2643

Support with 3 shunts, with different connection possibilities.

Technical features:
Resistance: 1 Ω
Accuracy: ± 1%
Max. current: 2.5 A

ISOLATION AMPLIFIER



DL 2642

Used in conjunction with an oscilloscope or with a computer interface for potential-free, safe measurement recording in particular in static converter systems and variable frequency drives.

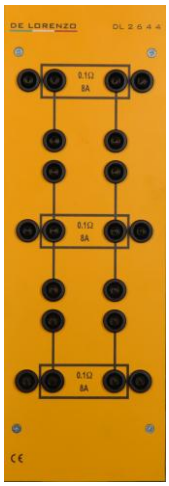
Technical features:
Isolation amplifier, channels A, B, C, E:
- Frequency range: dc to 80 kHz.
- Input voltage (between 0 and U)
Max 620 Vdc/460 Vac
Input resistance Ri = 1 MW in all ranges
Three-stage attenuator: MT = 1: 1; 1/10; 1/100
Accuracy: ±2% of full scale range
- Input current (between 0 and I)
Max: 10 A continuous; 16 A for t< 15 min; 20 A for t<2 min.
Internal resistance: 30 mW in all ranges
Two-stage attenuator: MT = 1 V/A; 1/3 V/A
Accuracy: ±5% of full scale range
Five outputs: A, B, C, D, E with led for over range indication
Output resistance RO: 100 W

- Multiplexer:
Mux channels, selectable: 1 to 8 (4 x signal; 4 x zero line)
Gain attenuator, adjustable: 0.2 to 1.
Y-position, adjustable: -8 V to + 8 V.
Trigger source, switchable to A, B, C, D, E.
Mux frequency, adjustable: 50 kHz to 500 kHz (typical).
Two BNC outputs for oscilloscope
Mathematical module and filter:
- Functional modes for channel D: Addition A+B; subtraction A-B; multiplication AxB/10 or AxB; reconstruction of the phase voltage LIN(A, B, C) from the line-to line voltages; channel E switched into channel D for multiplexing.

- Filter
Low pass active filter of the 2° order required for the recovery of the fundamental wave out of the PWM signals.
Cut-off frequency: 1 kHz.
Space vector indicator:
- Voltage vector: indication with 7 led.
- Magnetic flux vector: BNC outputs X e Y for oscilloscope.
Power supply:
- Single-phase from mains
Frequency: 50/60 Hz.

POWER ELECTRONICS

SUPPORT WITH 3 SHUNTS 0.1 OHM



DL 2644

Support with 3 shunts, with different connection possibilities.

Technical features:
Resistance: 0.1 Ω
Accuracy: ± 1%
Max. current: 8 A

PWM CONTROL UNIT

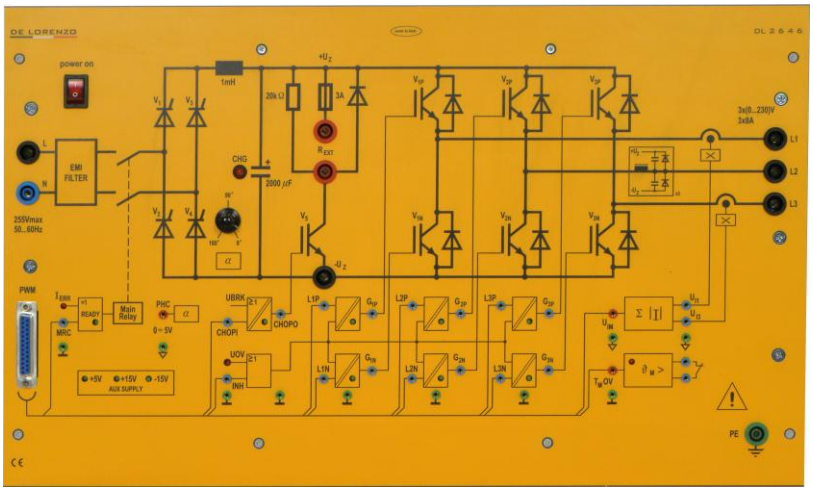
DL 2648

Control unit used in conjunction with the frequency converter to build a voltage-source inverter which operates according to different controls.

All of the control, monitoring and measuring functions are integrated into the control unit (a microcontroller implements the management via a program stored in EPROM) while the frequency converter contains solely the power components.
A PWM modulator controls the power transistors of the inverter and thus generates a sine-shaped motor current.
Modulation possibilities: PWM, VVC, trapezium shaped and block type.

FREQUENCY CONVERTER

Transistor pulse-converter with pulse driven voltage source inverter and transistor for the generation of a three-phase, variable frequency and variable voltage system. In conjunction with the PWM control unit DL 2648 this device is used for the realization of a frequency converter for asynchronous motor drive.



DL 2646

Technical features:
Output voltage: 3 x 0...230 V
Output current: 3 x 8 A max.
Supply voltages:
power circuit, 1 x 255 V max, 50/60 Hz control circuit, single-phase from mains

POWER ELECTRONICS

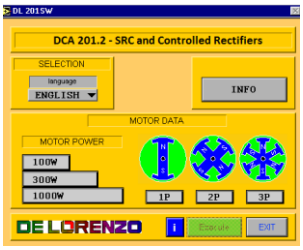
PC INTERFACE

DL 2650

Interface module, complete with extension board for IBM compatible PC, used for measurement and control in technical training. This module allows the connection between the digital electronics of the PC and the different signals.

Technical features:
IN/OUT connector for connection to the control unit DL 2617 and display for the visualization in hexadecimal of the control word.
Two AO lines for analogue outputs: ±10 V.
Six AI lines for analogue inputs: ±10 V
The analogue signal is obtained from a D/A converter with 12 bit resolution. Auxiliary relay with led to show the switching status.
USB connection.

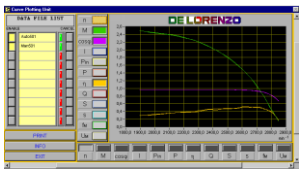
POWER ELECTRONICS SOFTWARE



DL 201SW

With this software it is possible to measure the wave forms for voltage and current that can be found in the static inverter and converter circuits.
Through a microprocessor based interface it is possible to detect the wave forms and to send the controls to obtain trigger angles through software, in order to evaluate the different performances of the various circuits.
The software features a very accurate graphic presentation and a user friendly interface with the end user.

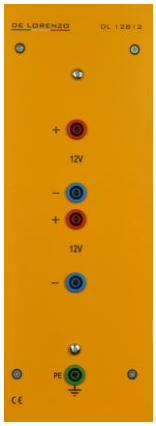
INDUCTION MOTOR CONTROL SOFTWARE



DL 205.3SW

With this software it is possible to realize the PWM, VVC, trapezium shaped and block type, full and half frequency control of the frequency converter DL 2646 and to do the acquisition of the mechanical characteristics of the induction motor under testing.
Voltages, currents and other main characteristics are calculated both in numbers and as curves.
The software features a very accurate graphic presentation and a user friendly interface with the end user.

BATTERY STACK



DL 12B12

Two rechargeable batteries, maintenance free.

Technical features:
Capacity: 1.8 Ah/12 V

POWER ELECTRONICS

SINGLE PHASE SUPPLY UNIT

Power supply unit for connection to the single-phase mains.

Technical features:
Power supply: single-phase from mains
Cam operated 2-pole mains switch 16 A
Automatic circuit breaker: 10 A, operated by thermal effect
Output terminals L and N, with pilot lamp
Pilot lamp for indication of mains false polarity

DL 2108SAL

VARIABLE THREE PHASE TRANSFORMER

Technical features:
Power supply: three-phase from mains
Rated output: 550 VA
Secondary phase current: 1.25 A
Secondary voltage: 0 to 440 V

Variable transformer suitable for fine-step adjustment of three-phase voltages from zero to maximum value. The voltage is set by means of a variable auto-transformer with rotary knob and the output is floating by means of an isolating transformer with subdivided secondary winding. Fitted with mains lamp and motor circuit breaker.

DL 2655

TACHOMETER

Equipped with an analogue meter that, coupled to an optical speed transducer, allows measuring the rotational frequency of the electrical machines.

Technical features:
Speed ranges: 1500/3000/6000 rpm
Accuracy class: 1.5
Output voltage: 1 V/1000 rpm
Power supply: single-phase from mains

DL 2025DT

THREE PHASE SUPPLY UNIT

Power supply unit for three-phase connection with 4-pole cam mains switch.

Technical features:
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.

DL 2108TAL-SW

POWER ELECTRONICS

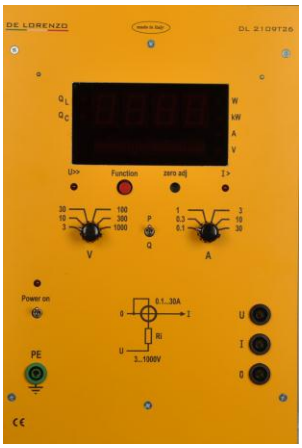
MOVING IRON VOLTMETER

DL 2109T3PV

Moving iron meter for ac and dc voltage measurements.

Technical features:
Scale: 50 divisions
Range: 125-250-500 V
Range changeover switch.
Accuracy class: 1.5

POWER METER



DL 2109T26

Demonstration single-phase meter for active power and capacitive/inductive reactive power.

Technical features:
Measurement ranges:
Voltage:
3/10/30/100/300/1000V
Current:
0.1/0.3/1/3/10/30 A
Frequency range:
Active power: 0 ... 20 kHz
Reactive power: 50 Hz
LED indicators:
capacitive reactive power, inductive reactive power, overload voltage (with acoustic signal), overload current (with acoustic signal).
Auxiliary supply: single-phase from mains

TRUE RMS METER

DL 2109T33

Demonstration meter for measuring the true rms of voltages and currents.

Technical features:
Voltage:
3/10/30/100/300/1000 V (input resistance 10 MW)
Current:
0.1/0.3/1/3/10/30 A
Continuous overload protection in all ranges.
Auxiliary supply: single-phase from mains

MOVING IRON AMMETER

DL 2109T2A5

Moving iron meter for ac and dc current measurements.

Technical features:
Scale: 50 divisions
Range: 2.5 A

POWER ELECTRONICS

ROTOR STARTER

DL 10120RA

Steps operated starter for three phase induction motor with slip ring rotor.

Technical features:
Step resistance value:
3 x (12-6-3-1-0) W
Current: 3 x 2.5 A max.

SQUIRREL CAGE THREE PHASE ASYNCRONOUS MOTOR

DL 10115A1

Induction motor with three-phase stator windings and buried squirrel cage in the rotor.

Technical features:
Power: 300 W
Voltage: 220/380 V D/Y
Current: 1.38/0.8 A D/Y
Frequency: 50 Hz
Cosϕ: 0.75
Speed: 2870 rpm
Thermal protection.

SLIP RING THREE PHASE ASYNCRONOUS MOTOR

DL 10120A1

Induction motor with both stator and rotor three-phase windings.

Technical features:
Power: 250 W
Voltage: 220/380 V D/Y
Current: 1.65/0.95 A D/Y
Excitation: 92 V, 2 A
Frequency: 50 Hz
Cosϕ: 0.66
Speed: 1350 rpm
Thermal protection.

SHUNT EXCITATION DIRECT CURRENT MOTOR

DL 10200A1

Technical features:
Power: 200 W
Voltage: 220 V
Current: 1.5 A
Excitation:
200 V, 0.067 A
Speed: 3000 rpm
Thermal protection.

POWER ELECTRONICS

SHUNT EXCITATION DIRECT CURRENT GENERATOR

DL 10250A1

Technical features:
Power: 160 W
Voltage: 220 V
Current: 0.73 A
Excitation: 220V, 0.075A
Speed: 2850 rpm
Thermal protection.

POWDER BRAKE

DL 10300P

Technical features:
Maximum braking torque: 12 Nm
Power: 400 W
Voltage: 0 ÷ 24 V
Speed: 4000 rpm max.
Thermal protection.

LOAD CELL

DL 2006D

Resistance electronic strain-gauge with 100 N range, to be mounted on the brake unit for measuring the mechanical torque

POWDER BRAKE CONTROL UNIT

Used in conjunction with the brake, it allows the measurement of the speed and the torque developed by an electric motor. It supplies the excitation voltage required by the brake in manual and automatic mode. Speed and torque are shown through analogue meters; signals for X-Y recording are also available.

Technical features:
Speed section:
- K2 connector for the speed transducer
- Circular scale three-range instrument: 1500/3000/6000 rpm
- Analogue output: 1 mV/rpm

Torque section
- K connector for the torque transducer
- Circular scale three-range instrument: 1.5/3/10 Nm
- Analogue output: 1 V/Nm

Brake control
- Output power: 0 to 12 Vdc, 0.5 A
- Manual, external or automatic regulation.

Thermal protection with alarm indication.
Recorder pen control.
Power supply: single-phase from mains

DL 10300PAC

POWER ELECTRONICS

BASE

Metallic structure, fire varnished, suitable for mounting the machine or the group under test. Complete with optical transducer for rotating speed detection and with anti-vibration rubber feet.

DL 10400

ELECTRONIC STOPCLOCK

Electronic stopwatch with LCD display.

Technical features:
Measuring range:
9 h, 59 min, 59 s, 99/100 s
Selectable split or lap function.
Battery: 1.5 V

DL CRON

CONNECTING LEADS

Set of connecting leads of different diameters and lengths.

DL 1155POW

FLYWHEEL

Used in deceleration tests on rotating machines for calculation of mechanical iron and copper losses at different excitations.

DL 10410

BENCH

Bilaminated wooden top and square legs with adjustable feet.
Dimensions:
2x0.8x0.9 (h) m. approx.

DL 1001-1

FRAME

Metal frame for fitting the modules of the laboratory.
Dimensions:
0.9x0.9 m. approx.

DL 2100-3M

POWER ELECTRONICS

TRANSFORMER

Module for adjusting a mains voltage different from 380 V three-phase (standard laboratory voltage).

Technical features:
Power of the transformer: 3 kVA
Outputs:
- 2 three-phase outputs on CEE sockets
- 6 single-phase outputs on 10/16 A + T sockets placed at the back.
Protection of the module through three-pole magnetothermal switch.

DL 2600TT

CABINET

Fire varnished steel-plate, provided with shelves for modules' storage.

DL 2100TA