ELECTRIC MACHINES - OPENLAB - 0.2 kW

AUTOMATIC ELECTRIC MACHINES LABORATORY

DL OPENLAB-A

The DL OPENLAB-A offers a “first glance” at the vast and complex world of electric machines.

The main characteristic of this laboratory is its "open" structure, where rotor windings, stator windings and brushes are completely exposed to perform didactic experiences such as the analysis of magnetic fluxes and magnetic fields. In this way, the students can learn in detail the internal construction and assembly of different types of electrical machines and carry out practical tests for the acquisition of their operating characteristics.

This modular system operates at low voltages providing a safe hands-on training environment with the addition of the plexiglass protection preventing direct contact with the rotating electrical machines to avoid injury.

The DL OPENLAB-A includes a software developed in LabVIEW that communicates with the main components of the modular system allowing a data acquisition system and an automatic approach of the experiments.

Ideal for 4 students to work simultaneously.
Vocational and technical schools.
Applicable to courses in: **Magnetism and Electromagnetism, Electromechanics, Electric machines**, **Power Engineering**.

DIDACTIC EXPERIENCE AND APPLICATION

The DL OPENLAB-A trainer is a hands-on learning platform that provides a comprehensive course on electrical machines. It introduces the basic concepts of electrical machines construction starting from the electromagnetism principles with the analysis of magnetic fields and fluxes, until more advanced experiments with the characterization and the efficiency analysis of rotating machines in different working conditions.

Through this system, it is possible to assemble the most common types of electrical machines found in the industry to carry out the following didactic experiences:

- Study of the magnetic field
- Principles of the electromagnetic induction
- Separately shunt, series and compound excited dc motors
- Separately shunt, series and compound excited dc generators
- DC motor and DC generator with permanent magnet stator
- Induction motors: three-phase slip ring and squirrel cage, single-phase repulsion and with capacitor
- Dahlander connection
- Synchronous three-phase motor, induction regulator and phase shifter, alternator, universal motor

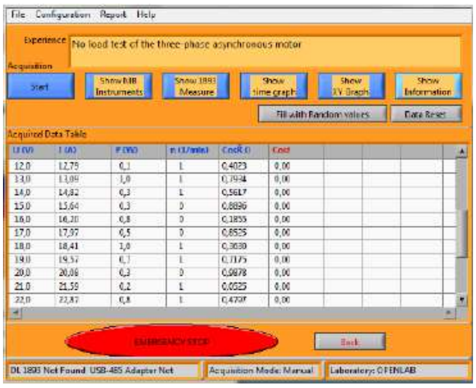
SET OF ASSEMBLABLE MACHINES

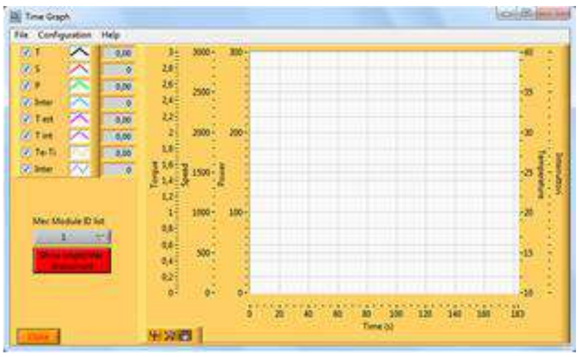
The core of the system is the DL 10280, which includes all the components needed to assemble different types of rotating machines. The set consists of:

1. Base plate
2. Supports with bearing
3. Coupling joints
4. Flexible coupling
5. Electronic speed transducer
6. Assembling screws
7. Wrenches
8. DC stator
9. AC stator
10. Rotor with commutator
11. Brush holder with 2 brushes
12. Squirrel cage rotor
13. Slip-Ring rotor
14. Brush holder with 6 brushes

DATA ACQUISITION AND PROCESSING SOFTWARE

The **DL 8330SW** is a software developed for the acquisition and display the data of the DL OPENLAB_A laboratory. It is developed in LabVIEW and communicates with the instruments (DL 10065N and DL 10050N) through the data acquisition module (DL 1893) and collect mechanical data (speed and torque) as well as electrical data (AC and DC, Voltage, current and Power).





FEATURES

1. Several data acquisition modalities: single, timed and fully automatic

2. Trace the characteristic curves of the elements under study using the acquired data

3. Export data in CVS file for further analysis

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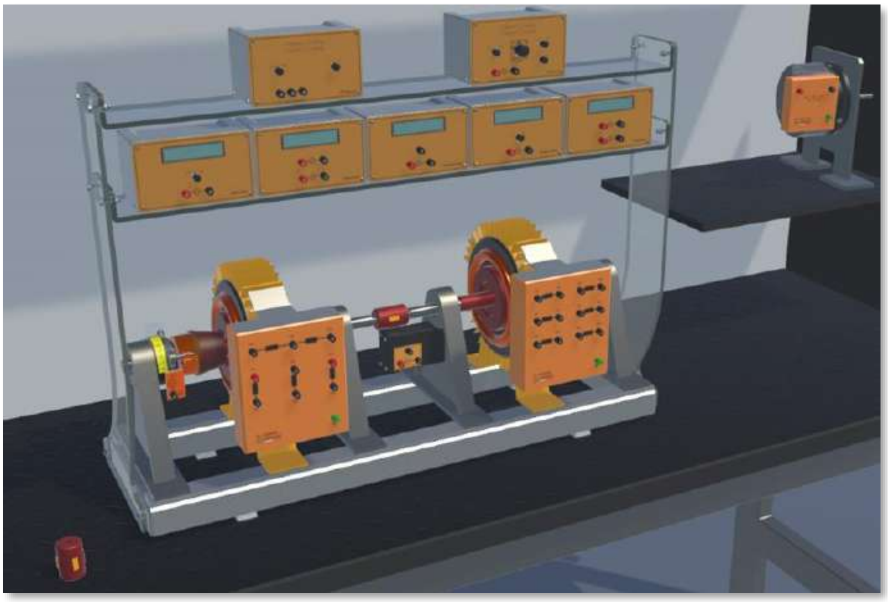
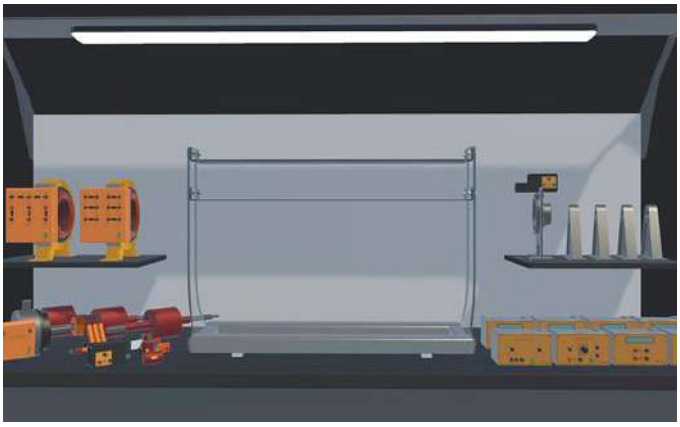
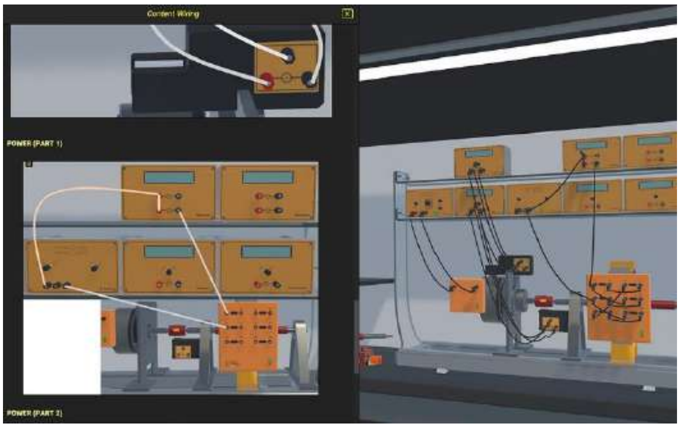
ELECTRICAL MACHINES SMART SIMULATOR SOFTWARE

The DL OPENLAB-SA includes the smart simulator DL OPENLAB-SSEM. It is a performant new generations educational course that permits a complete and innovative didactic experience on electric machines in a virtual reality environment.

It has been developed to reproduce the features and behaviours of the real electric machines' laboratory. The didactic experience includes electric machines assembly (rotos, stators, supports, couplers), wiring the machines following the software instructions, the students submit them to different working conditions and make measurements to study its behaviour.







FEATURES:

- ***VIRTUAL SIMULATION OF ELECTRIC MACHINE LABORATORY***: Students can replicate experiments of the real system away from the classroom like a home environment.

- ***AUTOMATIC VALIDATION OF STUDENTS' TASKS***: the software automatically verifies if the student successfully completed each task to allow him/her to go ahead with the next one.

- ***TRACKING OF STUDENTS' PROGRESS***: the teacher can verify the students' progress any time consulting the specific summary in the software or exporting it to a spreadsheet.

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LABORATORY COMPOSITION

CODES	DESCRIPTION	QTY
DL 10280	Set of assembled machines	**1**
DL 10280MP	Permanent magnet stator	**1**
DL 10017	Motorized DC and AC power supply module	**1**
DL 10050N	Mechanical power measurement module	**1**
DL 2006D	Load cell	**1**
DL 10065N	Electric power measurement module	**2**
DL 10045	Motor driven resistive load unit	**1**
DL 10284	Adapter bracket	**1**
DL 10185	Pole changing unit	**1**
DL 10285	Locking and rotatable device	**1**
DL 10310	Parallel board	**1**
DL 10300A	Electromagnetic brake	**1**
DL 10116	Star-delta starter	**1**
DL 10125	Starting and synchronization unit	**1**
DL 10306	Motorized power supply for brake	**1**
DL 1893	Data acquisition system	**1**
DL 10281	Power supply module	**1**
DL 8330SW	Data acquisition and processing software	**1**
DL OPENLAB-SSEM	Electric machines smart simulator software	**1**

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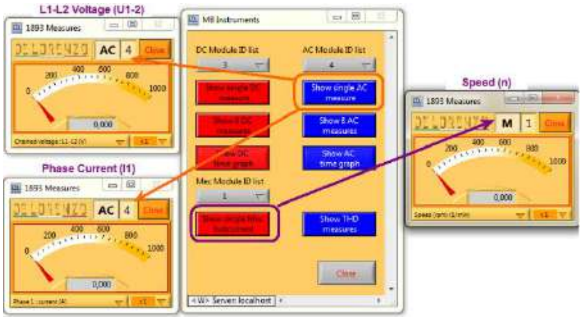
EXPERIMENTS LIST

	EXPERIMENTS	MODULES																	
		DL 10280	DL 10281	DL 10281	DL 10284	DL 10285	DL 10017	DL 10065N	DL 10050N	DL 10116	DL 10185	DL 10300A	DL 2006D	DL 10306	DL 10125	DL 10045	DL 10310	DL 1893	DL 8330SW
	Asynchronous motors																		
1	No load test	X					X	X	X	X	X							X	X
2	Transformation ratio	X					X	2		X								X	X
3	Internal resistance	X					X	X										X	X
4	Short circuit	X				X	X	X		X								X	X
5	Direct test	X			X		X	X	X			X	X	X				X	X
	DC machines																		
1	Internal resistance	X					X	X										X	X
2	Conventional efficiency																		X
3	Magnetization characteristics	X					X	2	X						X			X	X
4	External characteristic	X					X	2	X						X	X		X	X
5	Regulation characteristic	X					X	2	X						X	X		X	X
6	No load test	X	X				X	2	X									X	X
7	Direct test	X	X		X		X	2	X			X		X				X	X
	Synchronous machines																		
1	Magnetization characteristics	X		X			X	2	X									X	X
2	Short circuit	X		X			X	2	X									X	X
3	Winding resistance	X					X	X										X	X
4	External characteristic	X		X			X	2	X							X		X	X
5	Regulation characteristic	X					X	2	X							X		X	X
6	No load test	X		X			X	2	X								X	X	X
7	Parallel with the mains	X		X			X	2	X	X							X	X	X
8	V curve	X		X			X	2	X	X							X	X	X

ASYNCHRONOUS MOTORS

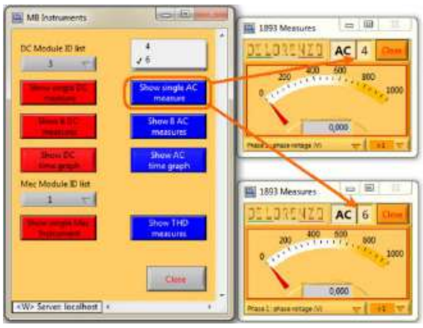


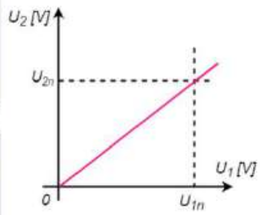
No load test of a Three-phase Asynchronous Motor

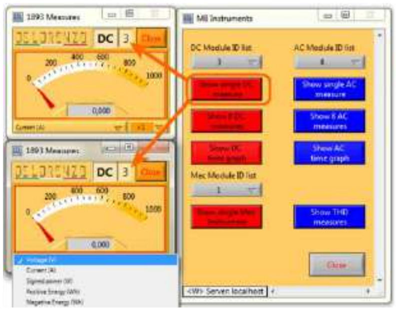
Starting with this first experiment students will assemble together the stator and the squirrel cage rotor to build the induction motor, and no-load characteristics of current and power vs voltage will be recorded by real data acquisition.

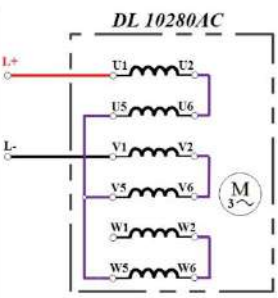
Measurement of the transformation ratio of a Three-phase Asynchronous Motor

Performing this experiment, students will get familiar with the wound rotor. They will learn about the transformation ratio of a slip-ring induction motor that is defined as the ratio existing, in no-load operation, between the stator and rotor side voltages.









Measurement of the internal resistance of a Three-phase Asynchronous Motor

Students will learn the importance of measuring the asynchronous motor winding resistances and what are the conditions to perform this measurement.

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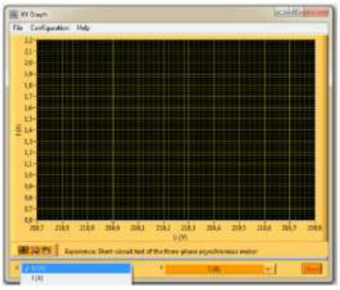
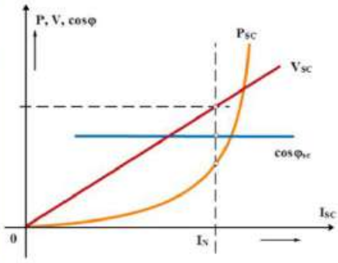
Short circuit test of a Three-phase Asynchronous Motor

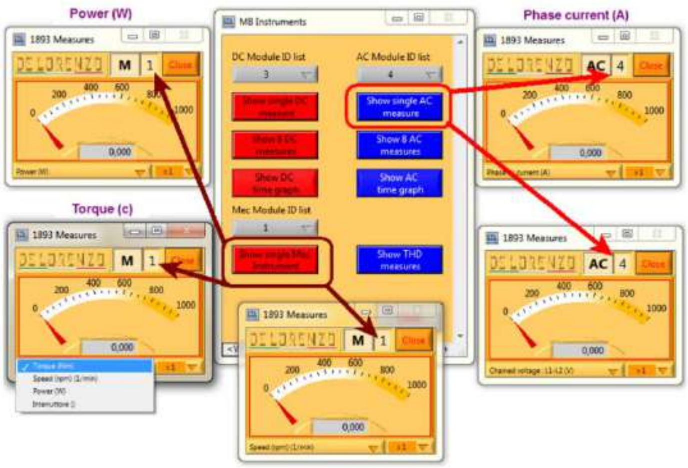
The main purpose of short-circuit test is the determination of the short circuit current at normal voltage and the power factor. In this test, the rotor is locked so that it cannot move; a low voltage is applied to the motor to avoid overheating and damage of the windings, and the resulting voltage, current and power are measured.



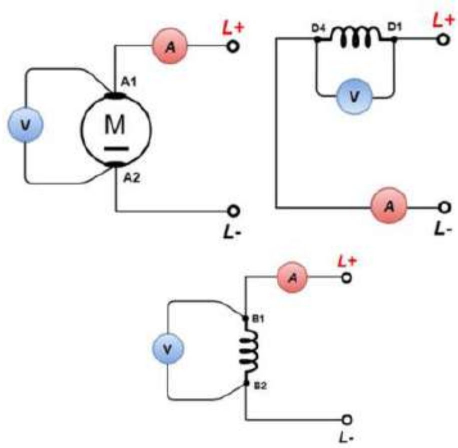


Direct test of a Three-phase Asynchronous Motor with Electromagnetic Brake (Pasqualini)

This experiment points out the behavior of the three-phase squirrel cage motor in the effective work conditions. The mechanical load included in this trainer is therefore necessary to be applied to the motor. The main objective of the experiment is to study the characteristic curves related to the brake test. Using the software, the mechanical (speed and torque) and electrical parameters will be measured.



DIRECT CURRENT MACHINES



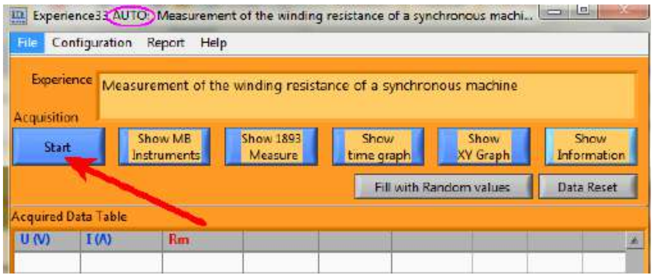
Measurement of the internal resistance of a Direct Current Machine

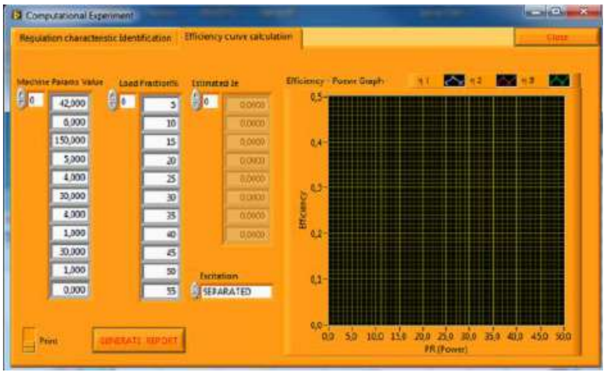
In this experiment, students will learn about the direct current machine construction and they can analyze and compare the real laboratory machines with the theoretical models. This will surely make them more confident in performing and understanding the behavior of the DC machines.

Thanks to the use of the software and the data acquisition board (DAQ), students will obtain the characteristic curves of the windings resistance measurements.

Measurement of the inductor winding resistance of a Direct Current Machine

Performing this experiment, students will obtain the characteristic curves related to the measurement of the inductor winding resistance of a DC machine. The software will automatically acquire data in terms of voltage and current.





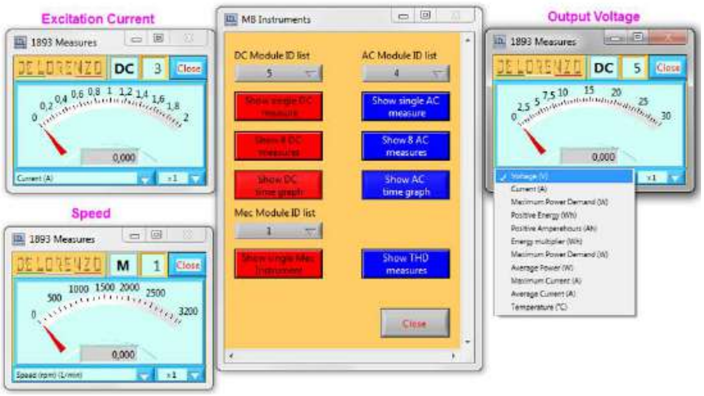
Conventional efficiency of DC Machine

Determination of the conventional efficiency can be done by indirect tests using classical calculation method and using software approach.

The generator efficiency is defined as the ratio between the delivered electrical power and the mechanical power.

Magnetization characteristic of a DC Generator

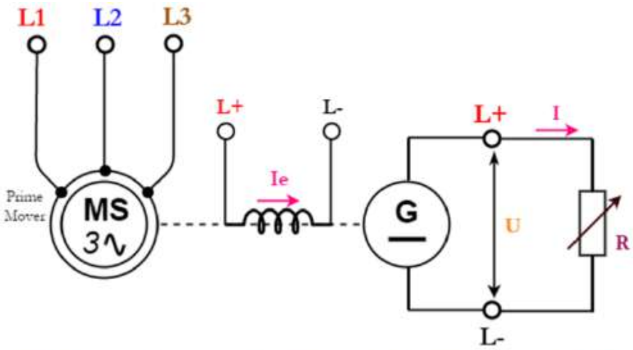
Thanks to the software and the DC generator armature output, students will measure the output voltage of the generator in correspondence with the excitation current.

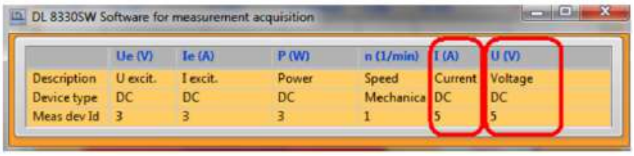


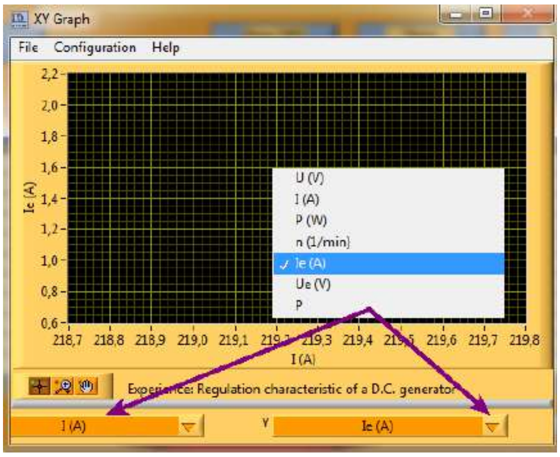
External characteristic of a DC Generator

External characteristics are very important to determine the suitability of a generator for a given purpose. Sometimes, this type of characteristic is called also performance characteristic or load characteristic.

The software will plot a graph showing the variation of the output voltage of the generator (U) as a function of the load current (I)





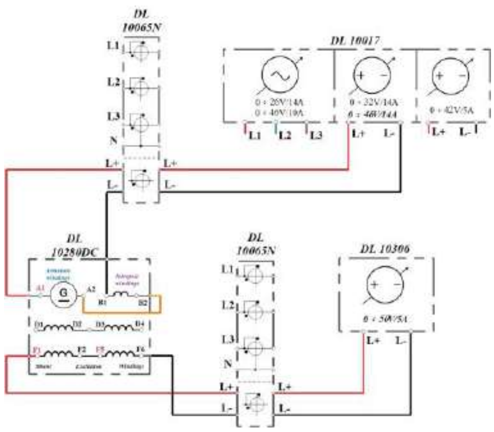


Regulation characteristic of a DC Generator

Through this test, thestudents will understand the ability of delivering output voltage of a DC generator with the change in load current from no load to full load. It is necessary to keep the voltage at the generator terminals constant as a function of the load current at constant speed..

No load test of a Direct Current Motor

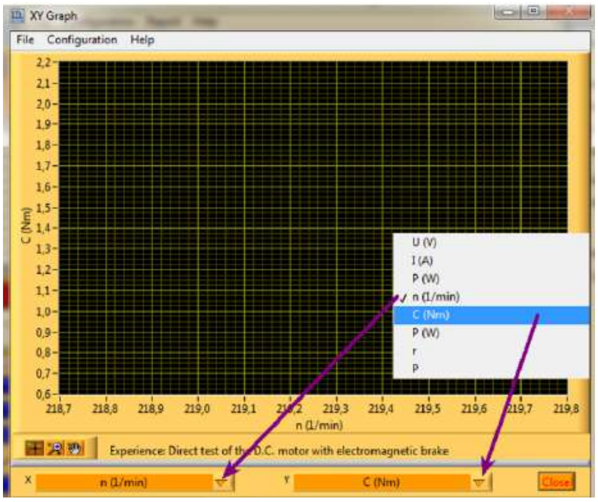
In order to design rotating DC machines with higher efficiency, it is important to study relevant losses that may occur. Students will learn about the iron and mechanical losses in the machine and will measure the power absorbed by the DC motor for different values of the armature voltage.



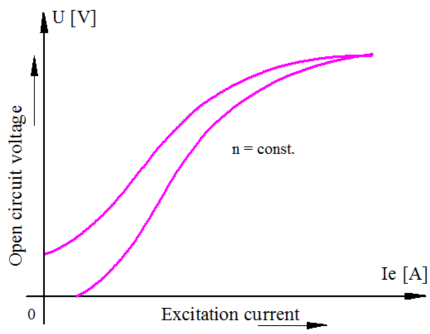
Direct test of a DC Motor with Electromagnetic Brake

The direct load test is a simple method to measure the effective efficiency of an electric motor by applying a mechanical load directly to it. The speed and efficiency can be measured at different load conditions to study the start and the speed control of a DC motor.

A mechanical load composed of the electro-magnetic brake should be applied to the shaft of the motor under test. .



SYNCHRONOUS MACHINE

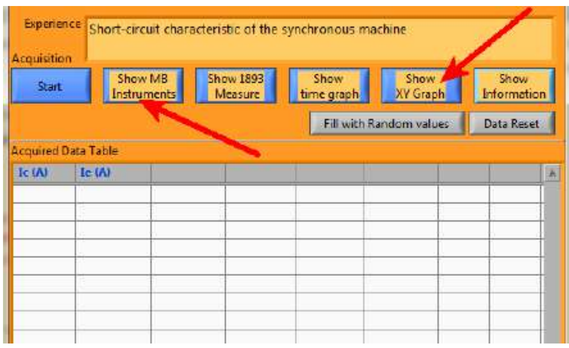


Magnetization Characteristic of a Synchronous Machine

With this experiment the students will learn how to record the magnetization characteristic of a synchronous machine measuring the output voltage delivered by the alternator kept at constant rated speed in correspondence of the values of the excitation current .

Short-circuit Characteristic of a Synchronous Machine

Students will learn which is the suitable speed to drive the alternator and how the armature terminals need to be connected.



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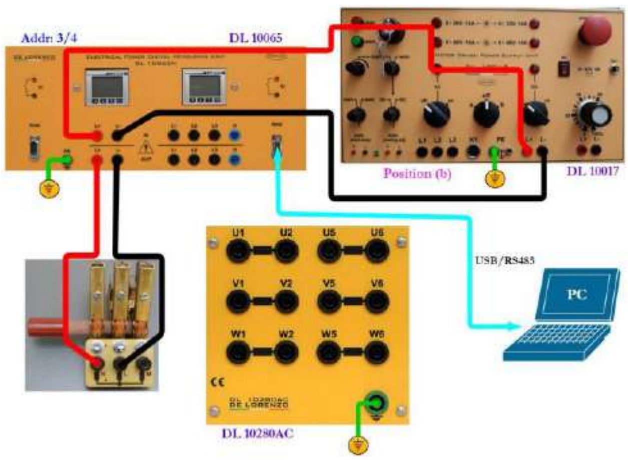
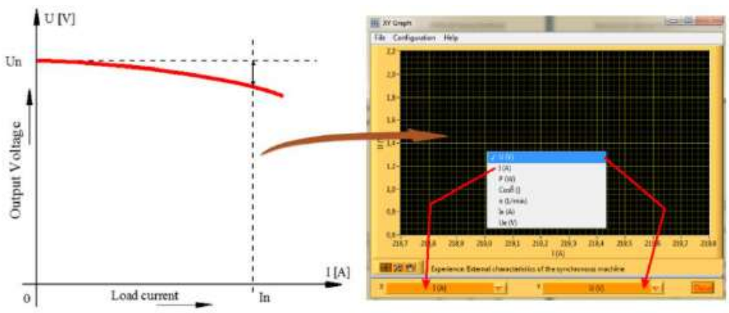


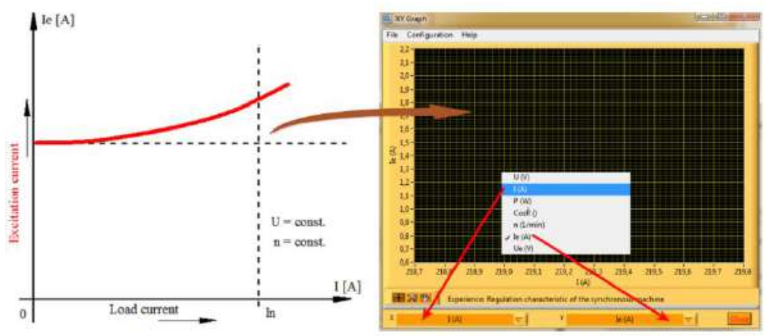
Measurement of the Winding Resistance of a Synchronous Machine

This experiment studies the voltage drops across the rotor winding resistance of an induction motor that can be calculated using Ohm's law. In order to calculate the voltage drop, students will need to determine the current through the internal windings. The winding resistance value of the alternator is useful to calculate the conventional efficiency.

External Characteristics of a Synchronous Machine

The behavior of a synchronous generator connected to an external load is different than that at no-load and performing this experiment, the, students will record the external characteristic of a synchronous machine comparing the laboratory measurements results with the theoretical knowledge.



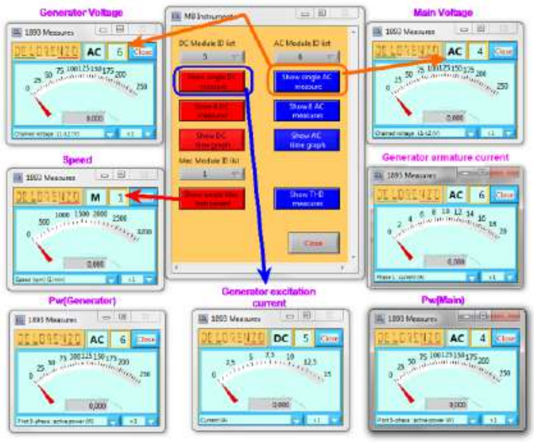


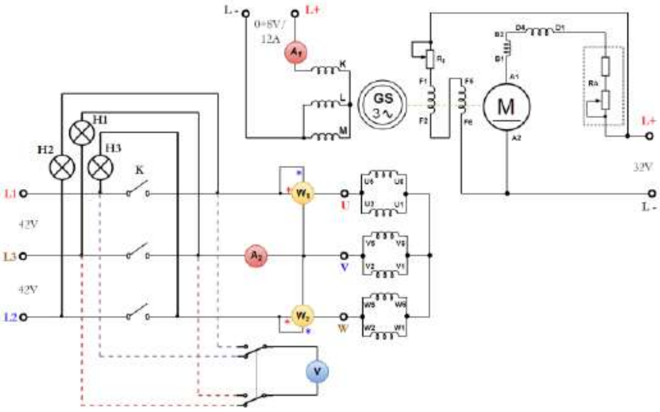
Regulation Characteristic of a Synchronous Machine

In this experiment, the students will learn the range over which the exciting current must be regulated in order to keep the voltage constant under the changing load.

No load Test of a Synchronous Machine as a Motor

With this experiment, the students will get familiar with the synchronous machine that works as a motor; and through it, they will compare and monitor the generator voltage with the main voltage.





Parallel of a Synchronous Machine with the Mains

This experiment performs the parallel of the synchronous machine with the mains. A synchronoscope will be used to monitor the voltage and the frequency between the two sources.

"V" curve plot of a Synchronous Machine

In this experiment, the students will learn how the V-curve of a synchronous machine shows its performance in terms of variation of the armature current with the field current when the load and the input voltage to the machine are constant. They will get different V curves for particular resistant torque on the motor axis.