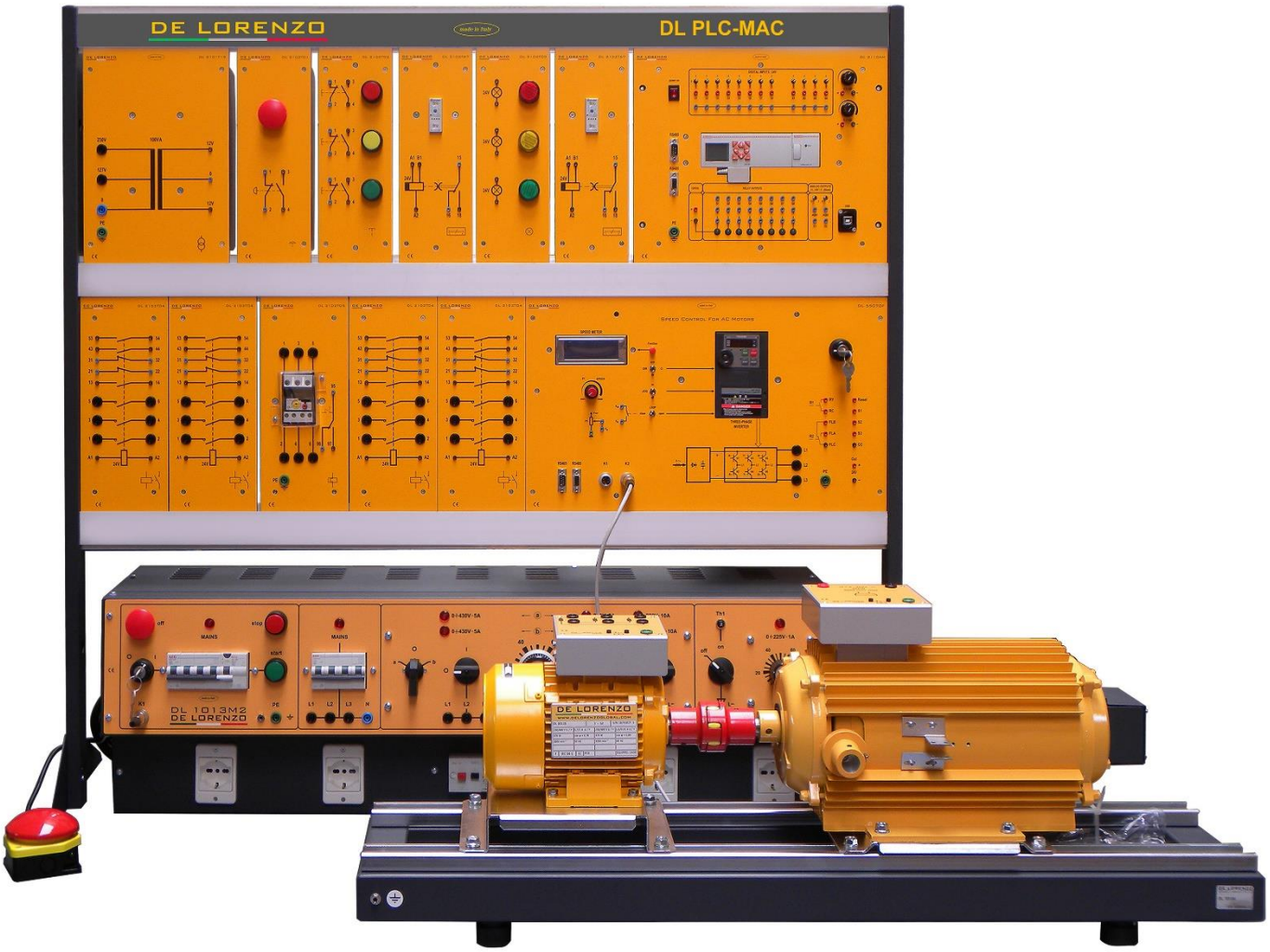
BENCH FOR THE STUDY OF THE MOTOR AUTOMATION

DL PLC-MAC



The DL PLC-MAC is a multipurpose bench for the study of PLC programming techniques used to start and control a three-phase asynchronous electrical motor using an inverter drive.

The starting and control of an induction asynchronous motor can be tested in two different modes:

- Manual operation using timed relays or an inverter.
- Automatic operation using a PLC to control the inverter drive and contactors.

AUTOMATION

1. KEY CHARACTERISTICS

Modularity

- Reconfigurable lab composed of discrete elements
- Industrial grade components

Didactic approach

- The bench is equipped with an exhaustive instruction manual and thus it can be considered a theoretical and practical "textbook". It includes diagrams and detailed explanation on PLC programs
- Hands-on, experiment based, training platform

Multidisciplinary

- Basic electrical industrial installations
- Motor starting
- Inverter- based advanced motor control
- Automation using PLC
- Open and closed loop control

Skills development

- Students interact with real industrial equipment
- Development of analytical and troubleshooting skills

2. HARDWARE CHARACTERISTICS

Industrial grade equipment has been integrated into a controlled environment, providing a flexible and reconfigurable learning platform to study motor automation applications.

The modular approach allows for the expansion and integration of the test bench with other De Lorenzo laboratories to expand its capabilities.

The machines are built for continuous operation and withstand an overload of about 20÷30% even for long duration.

Real components used in industrial environments.

Power supply and industrial inverter provide all the necessary voltages.

Industrial PLC for laboratory automation.

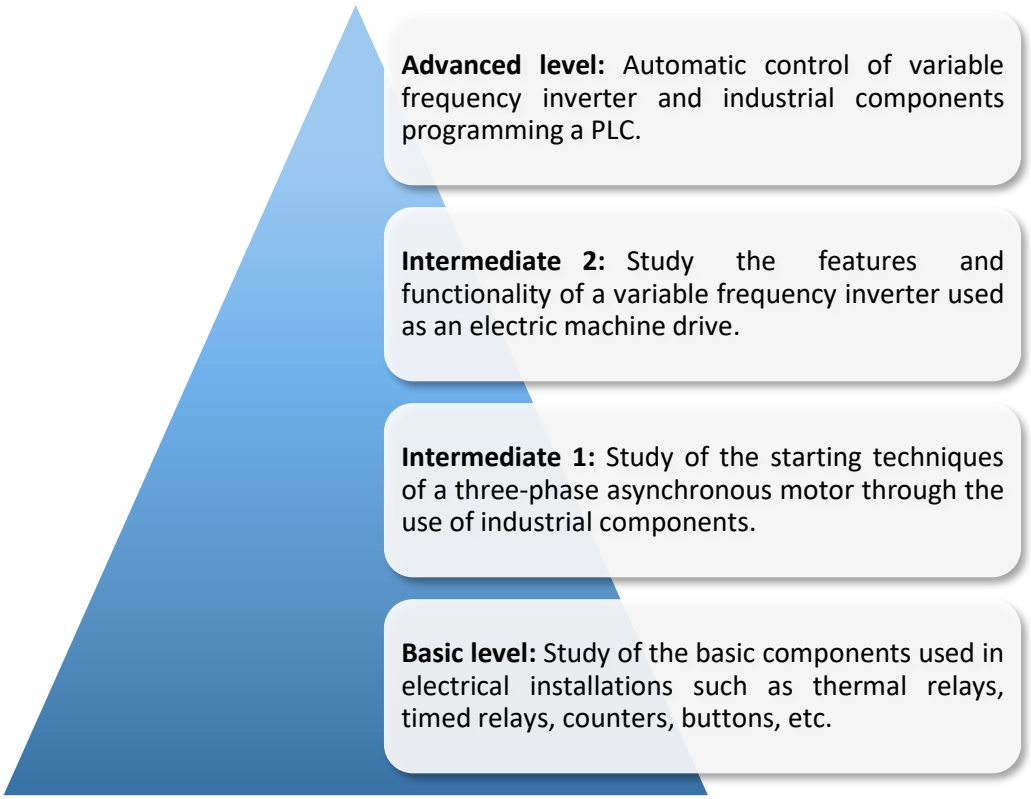
Instruments collect electrical data as well as mechanical data (speed).

3. LEARNING EXPERIENCE

This test bench is a multidisciplinary laboratory aimed at providing a progressive hands-on learning tool to be used in electric machines and automation courses to develop skills at various levels:

- Electrical installations
- Electric machines drive
- Automation techniques
- PLC programming

The didactic program is organized in four classes of experiments, with progressive difficulties levels:



4. LIST OF MODULES

CODE	DESCRIPTION	QTY
DL 55070	Motor speed control	**1**
DL 30115	Squirrel cage three-phase asynchronous motor	**1**
DL 1013A	Universal base for electrical machines	**1**
DL 30300	Electromagnetic brake	**1**
DL 2110AM	Programmable Logic Controller	**1**
DL 2101T13	Transformer	**1**
DL 2102T01	Mush-room button	**1**
DL 2102T02	Pushbutton	**1**
DL 2102T03	Pilot lights	**1**
DL 2102T04	Contactor	**4**
DL 2102T05	Thermal relay	**1**
DL 2102T67	Time relay	**2**
DL 2109T29	Maximum demand meter	**1**
DL 30016	Power supply ***Note:*** The code is **DL 30018** for country with 220V three phase power supply	**1**
TL 2102T	Connecting leads with safety terminals	**1**
DL 2100-3L/3	Three-level work frame	**1**

5. LIST OF EXPERIMENTS

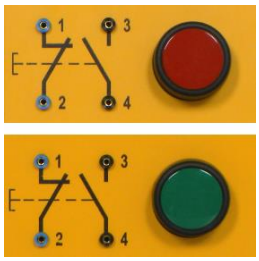
BASIC INDUSTRIAL INSTALLATIONS
Single-pole control auxiliaries
Study of the Contactor
Implementation of logic operators with contacts
Study of the self-supplied power contactor
Interlock between contactors
Sequential control of contactors
Implementing an Exclusive-OR operator using classical relays
Implementing a static excitation delayed timer
Implementing a static de-excitation delayed timer
Study of the thermal relays

THREE-PHASE ASYNCHRONOUS MACHINE STARTING
Manual STAR/DELTA starting control of a motor
Manual motor reversing control
Timed sequence control
Designing a pulse generator
Automatic STAR/DELTA starting control of a motor
Automatic STAR/DELTA starting control of a motor, with reverser
Counter-current braking of asynchronous motor

THREE-PHASE MOTOR INVERTER DRIVE
Motor parameter setting / Auto-tuning
Open loop speed control
Jog speed control
Multistep control
Motor power curve
Motor torque-speed curve
Closed loop speed regulation

AUTOMATION USING A PLC
Introduction to PLC programming
PLC automation basics
Automatic motor starting using a PLC
Motor automation and control using a PLC and a three-phase inverter
Multistep motor automation and control using a PLC and a three phase inverter

6. DESCRIPTION OF THE EXPERIMENTS

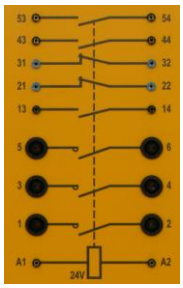


Single pole control auxiliaries

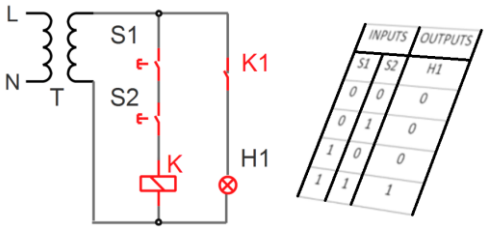
Students can understand the behaviour of the circuit when one or both contacts are operated.

Study of power contactors

Students can understand the operation of a power contactor (remote switch) as an electromagnetically driven switch.



Implementation of logic operators using with contacts



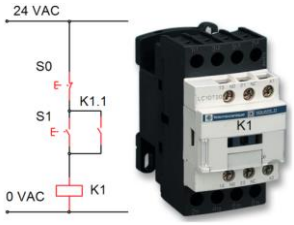
Students can:

- carry out with electromechanical components AND, OR, and NOT logic operations
- understand the logical implementation when using different triggering logics.

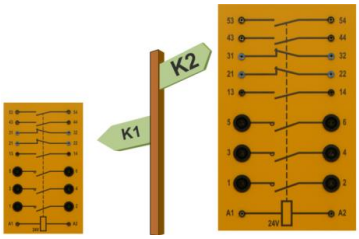
AUTOMATION

Study of the self-supplied power contactor

Students will be able to carry out, using the auxiliary contacts, the self-supply of the contactor exciting coil when the command performed by the operator is over.



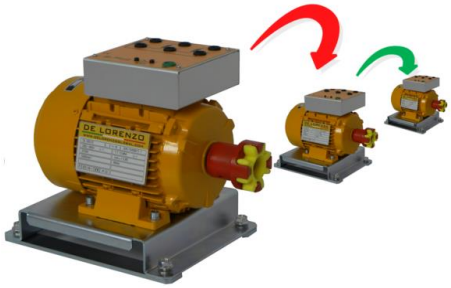
Interlock between contactors



Students will be able to carry out an interlock circuit able to prevent two contactors from being simultaneously switched on.

Sequential control of contactors

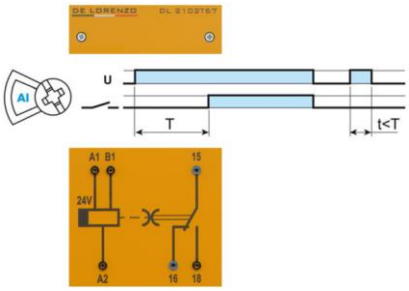
Students will be able to carry out a circuit in which a second contactor can be closed only after the first contactor is closed



Implementing an Exclusive-OR operator using classical relays

Students will be able to carry out an “inequality comparator” using electromechanical devices.

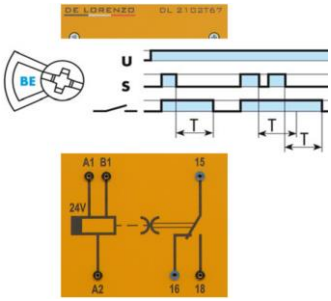
Implementing a static excitation delayed timer



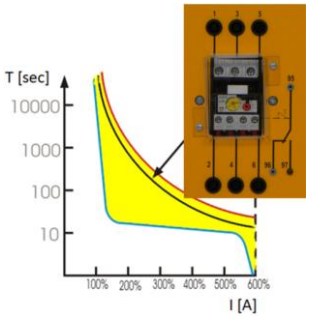
Students can investigate the operation of a static multifunction delayed timer configured with a delayed excitation function.

Implementing a static de-excitation delayed timer

Students can study the thermal relay as protection device for motors.



AUTOMATION

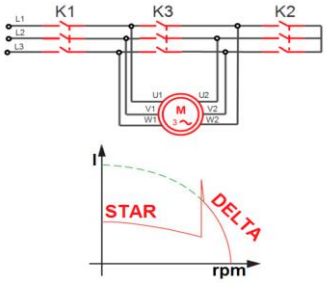


Study of thermal relays

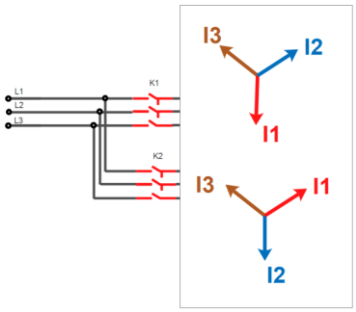
Students can study the thermal relay as protection device for motors.

Manual STAR/DELTA start control of the motor

Students wil be able to carry out a control circuit allowing the starting of a three-phase asynchronous motor with short-circuited rotor.



Manual motor reversing control

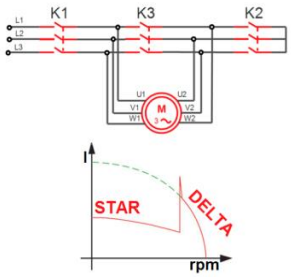


Students wil be able to carry out a circuit allowing the rotating direction of a three-phase asynchronous
motor to be reversed.

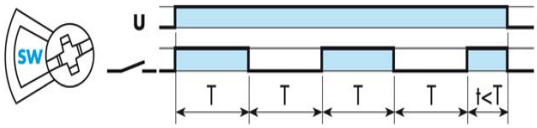
AUTOMATION

Timed sequence control

Students will be able to reproduce a circuit in which two contactors are closed in different times and simultaneously opened.



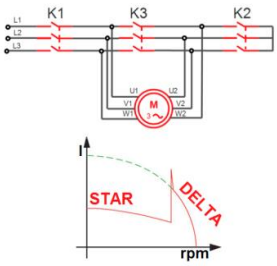
Designing a pulse generator



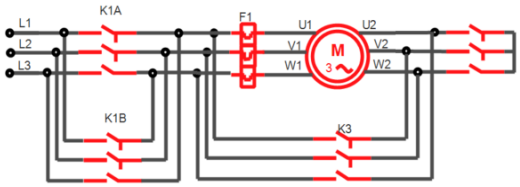
Students will be able to carry out a rectangular-signal generator with individually
adjustable OFF and ON times.

Automatic STAR/DELTA starting control of a motor

Students will be able to carry out a control circuit allowing the automatic starting of a three-phase asynchronous motor with short-circuited rotor, complete with over current protection through a thermal relay.



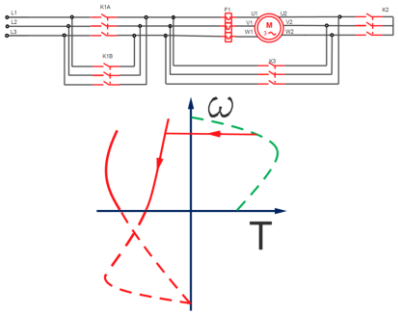
Automatic STAR/DELTA starting control of a motor, with reverser



Students will be able to carry out an automatic star/delta starting circuit for a threephase asynchronous motor provided with reverser.

AUTOMATION

Counter current braking of asynchronous motor



Students will be able to carry out a control circuit allowing a three-phase asynchronous motor to be quickly stopped.

Motor parameter setting

By performing the preset-speed operation experiment, students will be able:

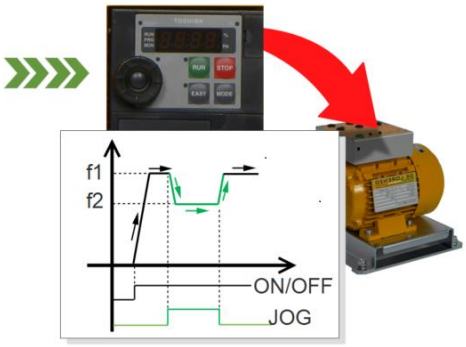
- To practice by programming the inverter with the correct parameters of the motor.
- To know how to use the PCM002Z software to perform the experiment.
- To make the wiring connections related to multistep control.
- To learn what is the parameter setting for this multistep experiment.
- To set the motor in start/stop by external contacts.
- To control the motor speed by external analog settings.

Open loop speed control

By performing the open-loop speed experiment, students will be able:

- The main objective is to practice by programming the inverter with the control of the speed and the direction of an asynchronous three-phase motor through external commands.
- To know how to use the PCM002Z software to perform the experiment.
- To make the wiring connections related to the acceleration/deceleration time control.
- To learn the parameter settings for the open loop speed experiment.
- To set the motor in acceleration/deceleration time by external contacts.
- To control the motor speed for 3 different times.

JOG speed regulator



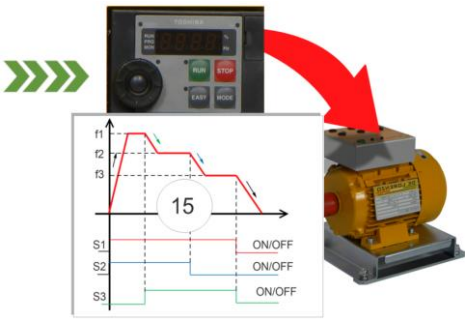
By performing the JOG speed experiment, students will be able:

- To practice by programming the inverter in different JOG mode operations.
- To know how to use the PCM002Z software to perform the experiment.
- To make the wiring connections.
- To learn what is the parameter setting for this JOG experiment.
- To set the motor running at jog speed.

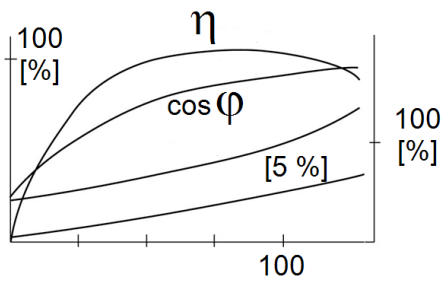
Multistep speed control

By performing the preset-speed operation experiment, students will be able:

- To practice by programming the inverter in different
- Multi-speed frequencies (speeds).
- To know how to use the PCM002Z software to perform the experiment.
- To make the wiring connections related to multistep control.
- To learn what is the parameter setting for this multistep experiment.
- To set the motor running at multistep speeds.



Motor power curve



By performing the experiment, students will be able:

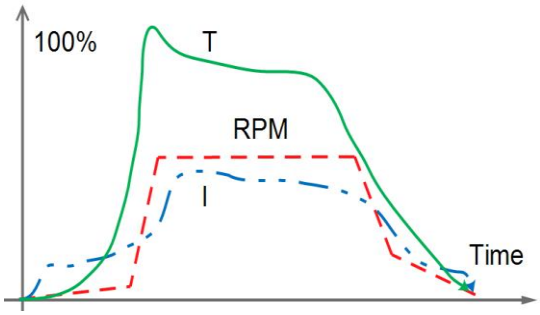
- To practice by programming the inverter with the control of the torque.
- To know how to use the PCM002Z software to perform the experiment.
- To make the wiring connections related to torque control.

AUTOMATION

Motor torque-speed curve

By performing the experiment, students will be able:

- To practice by programming the inverter with the control of the torque.
- To know how to use the PCM002Z software to perform the experiment.
- To make the wiring connections related to torque control.



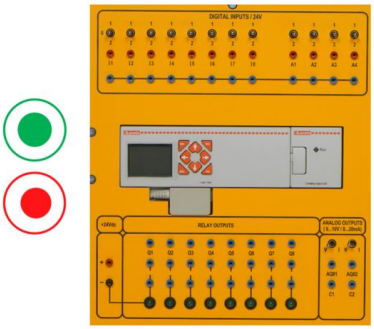
Closed loop speed regulator

By performing the closed-loop speed experiment, students will be able:

- To practice by programming the inverter with the closed loop speed.
- To know how to use the PCM002Z software to perform the experiment.
- To make the wiring connections related to PID control.
- To learn which are the parameters settings for the closed-loop speed experiment (PID configuration).

Running first programs with PLC

- Basics in Ladder programming
- Basics of programming for PLC through simple applications
- Running PLC programs from PC
- Using the integrated PLC trainer



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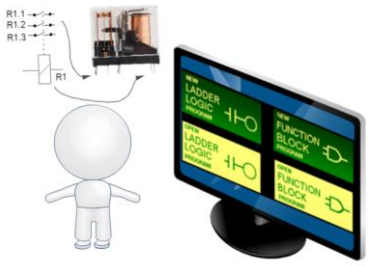


PLC automation basics

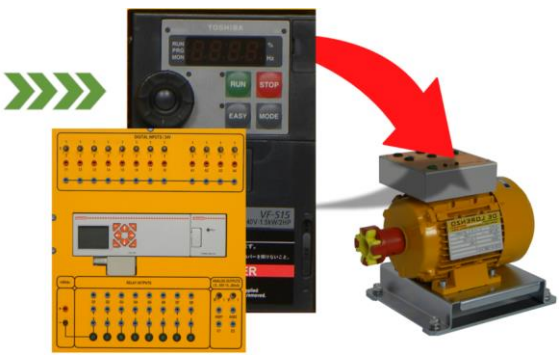
- PLC simple applications
- Applied PLC programs
- Analog inputs PLC programs
- Analog outputs PLC programs
- Adding external devices to PLC programs

Automatic motor starting using a PLC

By performing the open-loop speed experiment, students will be able:

- To practice by programming the inverter with the control of the speed and the direction of an asynchronous three-phase motor through external commands.
- To know how to use the PCM002Z software to perform the experiment and to learn the parameter settings for the open loop speed experiment.
- To use the PLC for inverter control

Motor automation and control using a PLC and a three phase inverter



By performing the JOG speed experiment, controlled by PLC, students will be able:

- To practice by programming the inverter in different JOG mode operations (which are the parameters to be set for this JOG experiment).
- To know how to use the PCM002Z software to perform the experiment.
- To implement the JOG algorithm in the PLC and to design a specific program.
- To make the wiring connections.
- To set the motor running at jog speed.

AUTOMATION

Multistep motor automation and control using a PLC and a three phase inverter

By performing the JOG speed experiment, controlled by PLC, students will be able:

- To practice by programming the inverter in different multi-speed frequencies (speeds).
- To know how to use the PCM002Z software to perform the experiment.
- To make the wiring connections related to the multistep control.
- To learn which is the parameter settings for this multistep experiment.
- To set the motor running at multistep speed.
- To implement a multi-steps algorithm in the PLC and to design a specific program.
- To make the wiring connections.