The DL PLC-MAC is a multipurpose bench that allows to learn the PLC programming techniques used to start a three-phase asynchronous electrical motor and control it 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.
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**

The De Lorenzo’s electric machines automation 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:

- **Advanced level**: Automatic control of variable frequency inverter and industrial components programming a PLC.
- **Intermediate 2**: Study the features and functionality of a variable frequency inverter used as an electric machine drive.
- **Intermediate 1**: Study of the starting techniques of a three-phase asynchronous motor through the use of industrial components.
- **Basic level**: Study of the basic components used in electrical installations such as thermal relays, timed relays, counters, buttons, etc.
4. LIST OF MODULES

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<th>CODE</th>
<th>DESCRIPTION</th>
<th>QTY</th>
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<tbody>
<tr>
<td>DL 55070</td>
<td>Motor speed control</td>
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<tr>
<td>DL 30115</td>
<td>Squirrel cage three-phase asynchronous motor</td>
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<td>DL 1013A</td>
<td>Universal base for electrical machines</td>
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<td>DL 30300</td>
<td>Electromagnetic brake</td>
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<td>DL 2110AM</td>
<td>Programmable Logic Controller</td>
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<td>DL 2101T13</td>
<td>Transformer</td>
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<td>DL 2102T01</td>
<td>Mush-room button</td>
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<td>DL 2102T02</td>
<td>Pushbutton</td>
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<td>DL 2102T03</td>
<td>Pilot lights</td>
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<td>DL 2102T04</td>
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<td>Thermal relay</td>
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<td>DL 2102T67</td>
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<td>DL 30016</td>
<td>Power supply</td>
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<td>DL 1155A-SC</td>
<td>Connecting leads with safety terminals</td>
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<tr>
<td>DL 2100-3L</td>
<td>Three-level work frame</td>
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5. EXPERIMENT LIST

BASIC INDUSTRIAL INSTALLATIONS
Single-pole control auxiliaries
Study of the Contactor
Implementation of logic operators using 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 stating 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