



Module

Installation and wiring of 3 - Phase motor control circuits and drivers

MD 08

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General Directorate for Vocational Training (GDVT)
37 B Nguyen Binh Khiem Street
Hanoi, Viet Nam

Tel. +84 4 397 45 207 (Department of Administration and International Affairs)
Fax +84 4 397 40 339

Deutsche Gesellschaft für
Technische Zusammenarbeit (GTZ) GmbH
2nd Floor, No. 1, Alley 17, Ta Quang Buu Street
Hanoi, Vietnam

Tel: +84 4 397 46 571/-2
Fax: +84 4 397 46 570

Website: www.tvet-vietnam.org

Author: Bernd Asmus,
Pham Thanh Tung,
Nguyen Duc Ho,
Nguyen Van Dien,
Tran Van Chuong,
Khuat Thanh Son

Translation: Pham Thanh Tung
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Training module:
Programming of mechatronic systems with PLC

Code of Module: MD09

Time: 120 h.

(Theory: 24h; Practice: 96h)

I. Position and characteristics of the module

- This module is built up from single projects (exercises), each of them developing and implementing a mechatronic system or subsystem.
- Every project is action orientated and carried out in such a way, that the trainee will be qualified for independent planning, conduction and checking of his work.
- Every project is standing alone and contains as many objectives as possible but only a limited number of contents.
- Starting with a real application the trainee has to analyze the process, design the documentation and circuit diagrams, develop, write and download the PLC-program, mount and install the system, commission the system and do the trouble-shooting.
- Before this module is implemented, the trainee should have basic skills in mechanical engineering, special in assembling technology, electrical installation and pneumatic controls.

II. Objectives of the module

After finishing this module, the trainees are able to;

- describe the structure of a mechatronic system in principle with pneumatic, hydraulic and electric drives.
- Procure, read and apply information from technical documents, diagrams and internet.
- Analyze functional connections in automated processes, especially movement sequences and logical conditions.
- develop solutions for problems related to automated processes and draw up in standardized diagrams.
- Read and draw up circuit diagrams for mechatronic stations.
- Describe functions and applications of pneumatic and electric components in mechatronic stations.
- Describe structure, working principle and applications of PLC.
- Operate computer, PLC and peripheral devices.
- Configure the hardware of PLC.
- Program logic control systems in at least one programming language according to IEC 1131.

- Program sequence controls
- Determine the work steps required for carrying out the mounting and installation of PLC-operated mechatronic stations.
- Select components, mount and install sensors and actuators in mechatronic systems and connect to interface.
- Install industrial PLC, carry out the industrial wiring to interface and connect to mechatronic station.
- Download programs to PLC, commission, operate and test mechatronic stations.
- Carry out systematic trouble-shooting and repair in PLC-operated systems.
- Describe and follow safety regulations, particularly those arising from electrical power.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.
- Solve problems systematically in a team.

III. Contents of the module

1. Content overview and time allocation:

No.	Name of lesson in the module	Duration			
		Sum	Theory	Practice	Tests
1	Programming of pneumatic stations with basic logic operations	16			
2	Programming of pneumatic stations with several actuators	30			
3	Programming of timer operations	8			
4	Programming of counter operations	6			
5	Installation of PLC-operated systems	18			
6	Control of electrical machines by PLC	20			
7	Pneumatic station programmed in a second programming language	4			
8	Programming of mechatronic stations with sequence controls	12			
9	Final examination	6			

2. Detailed contents:

Lesson 1: Programming of pneumatic stations with basic logic operations (16h)

Objectives:

After finishing this module, the trainees are able to;

- Describe the structure of a mechatronic system in principle with pneumatic, hydraulic and electric drives.
- Procure, read and apply information from technical documents, diagrams and internet.
- Analyze functional connections in automated processes, especially movement sequences and logical conditions.
- develop solutions for problems related to automated processes and draw up in standardized diagrams.
- Read and draw up circuit diagrams for mechatronic stations.
- Describe functions and applications of pneumatic and electric components in mechatronic stations.
- Describe structure, working principle and applications of PLC.
- Operate computer, PLC and peripheral devices.
- Configure the hardware of PLC.
- Program logic control systems in at least one programming language according to IEC 1131.
- Determine the work steps required for carrying out the mounting and installation of PLC-operated mechatronic stations.
- Download programs to PLC, commission, operate and test mechatronic stations.
- Describe and follow safety regulations, particularly those arising from electrical power.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.
- Solve problems systematically in a team.

Content:

- 1.1 Control with double solenoid valve – statement assignment
- 1.2 Control of stack magazine – statement AND
- 1.3 Control with interrogation of positions – symbolic names
- 1.4 Alternative retraction of cylinder – statement OR
- 1.5 Interrogation of working area – statement NOT
- 1.6 Control with single-solenoid valve – function block SR

Lesson 2:**Programming of pneumatic stations with several actuators**

(30h)

Objectives:

After finishing this lesson, the trainees are able to;

- Analyze functional connections in automated processes, especially movement sequences and logical conditions.
- develop solutions for problems related to automated processes and draw up in standardized diagrams.
- Read and draw up circuit diagrams for mechatronic stations.
- Program logic control systems in at least one programming language according to IEC 1131.
- Determine the work steps required for carrying out the mounting and installation of PLC-operated mechatronic stations.
- Download programs to PLC, commission, operate and test mechatronic stations.
- Carry out systematic trouble-shooting and repair in PLC-operated systems.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.
- Solve problems systematically in a team.

Content:

- 2.1. Control with parallel working actuators -branching
- 2.2. Pneumatic station with 2 cylinders
- 2.3. Rotary drive with vacuum suction cup
- 2.4. Trouble shooting in mechatronic systems
- 2.5. Control with overlapping signals – flag command
- 2.6. Exercise with overlapping signals
- 2.7. Distribution station in single cycle
- 2.8. Distribution station with operation mode automatic
- 2.9. Distribution station with interrogations and indications
- 2.10. Exercise with 3 actuators and overlapping signals
- 2.11. Test: Programming of pneumatic stations

Lesson 3:**Programming of timer operations**

(8h)

Objectives:

After finishing this lesson, the trainees are able to;

- Procure, read and apply information from technical documents, diagrams and internet.
- Program control systems with timer operations.

- Download programs to PLC, commission, operate and test mechatronic stations.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.
- Solve problems systematically in a team.

Content:

- 3.1. Pneumatic press with time delay
- 3.2. Control with timer TP
- 3.3. Control with timer TOF3.

Lesson 4:

Programming of counter operations

(6h)

Objectives:

After finishing this lesson, the trainees are able to;

- Procure, read and apply information from technical documents, diagrams and internet.
- Program control systems with counter operations.
- Download programs to PLC, commission, operate and test mechatronic stations.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.
- Solve problems systematically in a team.

Content:

- 4.1 Counting work-pieces at distribution station with CTU-counter
- 4.2 Counting work-pieces in stack magazine with CTD-counter

Lesson 5:

Installation of PLC-operated systems

(18h)

Objectives:

After finishing this lesson, the trainees are able to;

- Procure, read and apply information from technical documents, diagrams and internet.
- Describe functions and applications of pneumatic and electric components in mechatronic stations.
- Operate computer, PLC and peripheral devices.
- Configure the hardware of PLC.
- Program logic control systems in at least one programming language according to IEC 1131.

- Determine the work steps required for carrying out the mounting and installation of PLC-operated mechatronic stations.
- Select components, mount and install sensors and actuators in mechatronic systems and connect to interface.
- Install industrial PLC, carry out the industrial wiring to interface and connect to mechatronic station.
- Download programs to PLC, commission, operate and test mechatronic stations.
- Carry out systematic trouble-shooting and repair in PLC-operated systems.
- Describe and follow safety regulations, particularly those arising from electrical power.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.
- Solve problems systematically in a team.

Content:

- 5.1. Installation and wiring of PLC on PLC-board
- 5.2. Installation of pneumatic press
- 5.3. Installation of distribution station
- 5.4. Installation of pneumatic press with emergency switch-off
- 5.5. Installation of mechatronic station (press with work-piece feed)

Lesson 6:

Control of electrical machines by PLC

(20h)

Objectives:

After finishing this lesson, the trainees are able to;

- Read and draw up power and control circuit diagrams for electrical machines.
- Operate computer, PLC and peripheral devices.
- Program logic control systems in at least one programming language according to IEC 1131.
- Determine the work steps required for carrying out the mounting and installation of PLC-operated controls for electrical machines.
- Download programs to PLC, commission, operate and test controls for electrical machines.
- Describe and follow safety regulations, particularly those arising from electrical power.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.
- Solve problems systematically in a team.

Content:

- 6.1 Inching operation of three-phase motor
- 6.2 Continuous operation from 1 position
- 6.3 Continuous operation from 2 positions
- 6.4 Three-phase motor with 2 directions of rotation
- 6.5 Automatic star-delta-connection

Lesson 7:**Programming of pneumatic station in a second programming language (STL, LAD, FBD) (4h)***Objectives:*

After finishing this lesson, the trainees are able to;

- Procure, read and apply information from technical documents, diagrams and internet.
- Operate computer, PLC and peripheral devices.
- Program logic control systems in two programming languages according to IEC 1131.
- Download programs to PLC, commission, operate and test mechatronic stations.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.
- Solve problems systematically in a team.

Content:

- 7.1 Pneumatic station programmed in a second programming language

Lesson 8:**Programming of mechatronic stations as sequence controls (12h)***Objectives:*

After finishing this lesson, the trainees are able to;

- Analyze functional connections in automated processes, especially movement sequences and logical conditions.
- develop solutions for problems related to automated processes and draw up in standardized diagrams.
- Operate computer, PLC and peripheral devices.
- Program sequence controls
- Download programs to PLC, commission, operate and test mechatronic stations.
- Carry out systematic trouble-shooting and repair in PLC-operated systems.
- Communicate with partners (customers, suppliers and colleagues)
- Develop readiness for self learning to improve knowledge and working skills.
- Solve problems systematically in a team.

Content:

- 8.1 Control with overlapping signals – linear sequence
- 8.2 Distribution station – linear sequence
- 8.3 Lifting and sorting station – alternative branching
- 8.4 Control with simultaneous branching

Lesson 9:**Final examination**

(6h)

Objectives:

After finishing this lesson, the trainees are able to;

- Analyze functional connections in automated processes, especially movement sequences and logical conditions.
- develop solutions for problems related to automated processes and draw up in standardized diagrams.
- Read and draw up circuit diagrams for mechatronic stations.
- Operate computer, PLC and peripheral devices.
- Configure the hardware of PLC.
- Program logic control systems and sequence controls in at least one programming language according to IEC 1131.
- Determine the work steps required for carrying out the mounting and installation of PLC-operated mechatronic stations.
- Select components, mount and install sensors and actuators in mechatronic systems and connect to interface.
- Download programs to PLC, commission, operate and test mechatronic stations.
- Carry out systematic trouble-shooting and repair in PLC-operated systems.
- Describe and follow safety regulations, particularly those arising from electrical power.

Content:

- 9.1 Theoretical examination
- 9.2 Practical examination

IV. Prerequisites for implementation of module**• Basic mechatronic lab:**

- For 12 to 16 trainees, always two trainees working at 1 working station
- Size of room: min. 80m²

- 6 to 8 working stations
 - Power supply in cable duct round the lab. For every workstation 1 compressed air socket, 4x230V, 1 3-phase socket, 1 network socket
 - Control cabinet with fuses and emergency switch off
 - Working place for teacher with PC and printer
 - Blackboard, magnetic, min 2,5 x 1,2m
 - Overheadprojektor, Beamer and projection screen
 - Chairs and tables for theory and practice
 - Powerful compressor, extra silent
 - Storage cabinets for teaching aids and equipment.
- **Equipment of working stations (2 Students)**
 - Computertable with PC
 - Working station with horizontal profile plate, trolley with drawers for components, mounting frame
 - Basic set of components for pneumatic
 - Basic set of components for electro-pneumatic
 - Set of pneumatic sub-stations (Magazine, pneumatic press, rotary drive, vacuum)
 - PLC-board with PLC connected to interface (SUB-D, I/O-terminal) and socket board with 16 digital inputs and 16 digital outputs.
 - Set of electrical components for electrical installation
 - Wiring board with interfaces (SUB-D, I/O-terminal)
 - PLC-board with compact PLC and interfaces
 - Pneumatic components
 - Terminal strips
 - Electrical components (relays, lamps, switches)
 - Cable ducts, profile rail
 - Tool set, multimeter
 - **Teaching media**
 - Set of magnetic symbols pneumatic
 - Set of magnetic symbols electric
 - Software for design of circuits, demonstration of function of components

V. Evaluation methods and contents of tests

- The evaluation of this modules contains:

1. Intermediate tests after lesson 2

1.1 Written examination PLC-operated controls

The trainee solves in max. 90min questions and exercises, multiple choice or essay questions, related to objectives and contents of the lessons “Programming of pneumatic stations with basic logic operations” and “Programming of pneumatic stations with several actuators”.

1.2 Practical test PLC-operated control

The trainee installs in max 90min a mechatronic station or pneumatic control at a training station according to given documentation, develops the program, download the program to PLC and commissions the station or control..

2. Final examination

2.1 Written examination theory

The trainee solves in max. 120min questions and exercises, related to objectives and contents of this module.

2.2 Examination work piece

The trainee installs in max 180min a PLC-operated mechatronic system with industrial components according to given documentation., develops the program and commissions this system.

2.3 Working exercise

The trainee conducts in max. 60 min a working exercise. The working exercise contains the trouble-shooting in a PLC-operated system with finding and repair of 1 or more faults.

VI. Guide for implementation of the module

• Fields of implementation of this module:

- This module is used to qualify the trainees of vocational training program at 2-year intermediate level for mechatronic trade on the level of skilled worker.
- This module is a basic module, that could be also used to train:
 - mechatronic trade on college level
 - mechatronics at university level
 - trades in the field of mechanical or electrical engineering

• Organization:

- The lessons of this module should be organized in large blocks of at least one week up to 4 weeks duration to guarantee a steady work, especially in the practical parts. It is not practicable to interrupt the work of the students and use the components for assembling and installation for another group of students.

- **Some main guides in view of teaching methods for this module:**

- Before implementation of this module, the teaching staff should prepare all necessary prerequisites based on contents of individual lessons to ensure the teaching quality.
- The teaching staff should guide the students to the ability to plan, execute and monitor their work independently.
- The teaching staff should guide the students to independent problem solving.
- All exercises should be focused on real situations, as they could take place in their future work in mechatronic trade. This means in particular that the exercises should mirror real industrial processes.
- The teaching staff should instruct, give examples and correct errors while the trainees practice.
- The teaching staff should use real industrial components and applications to implement the exercises.

- **Reference documents**

- Teaching and learning materials for module 09 " Programming of mechatronic systems with PLC", published by GTZ, TVET Vietnam
- Step 7-fundamentals, GB from FESTO-DIDACTIC, Order.No. 184563
- Programmable Logic Controllers, Basic Level, GB from FESTO-DIDACTIC, Order-No. 93314
- Programmable Logic Controllers, Basic Level,Solutions, GB from FESTO-DIDACTIC, Order-No. 93316

