Vietnamese-German Development Cooperation

trained in Viet Nam
Việt Nam
Được Đào Tạo Tại Việt Nam

Module

Programming of mechatronic systems with microcontroller

MD 10

GDVT   gtz   COOPERATION
FEDERAL REPUBLIC OF GERMANY

SOCIALIST REPUBLIC OF VIETNAM

GDVT gtz

Training module:
Assemling, commissioning and maintenance of mechatronic systems

Code of Module: MD11
Time: 240 h. (Theory: 44h; Practice:196h)

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, read and apply the documentation and circuit diagrams, dismantle and mount the mechanical section and install the electrical part of the system, download the program, 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 and PLC programming.

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, sensors, controller and interfaces.

- 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 (pneumatic, hydraulic and electric) and functional diagrams for mechatronic systems.

- To plan maintenance and repair of mechatronic systems and draw up maintenance plans.

- Describe functions and applications of pneumatic, electric and electronic components in mechatronic stations and systems.
- Operate industrial PLC and peripheral devices.
- Configure the hardware of PLC.
- Understand, modify and develop applied control programs in at least one programming language according to IEC 1131.
- Develop programs for sequence controls in SFC-language (Simatic GRAPH 7)
- Determine the working steps required for carrying out the mounting and installation of PLC-operated mechatronic stations and systems.
- Dismantle and assembly mechatronic stations and systems, change and adjust components.
- Install contactor and motor circuits for applications operated by PLC.
- Install industrial PLC, carry out the industrial wiring of PLC and mechatronic station and connect via interface.
- Download programs to PLC, commission, operate and test mechatronic stations and systems.
- Recognize and describe the structure and application of bus-systems and networks.
- Install and operate industrial bus-systems in mechatronic systems.
- Carry out systematic trouble-shooting and repair in PLC-operated systems.
- Describe and follow safety regulations, particularly those arising from electrical power.
- Acquire information from documents and internet.
- 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	Characteristics and applications of sensors	18	8	8	2
2	Programming of sequence controls in SFC-language	8	2	4	2
3	Building up mechatronic station 1	20	4	16	0
4	Building up mechatronic station with sensor applications	20	4	16	0

5	Building up mechatronic station : handling	20	4	16	0
6	Building up mechatronic station production	20	4	16	0
7	Building up industrial transfer (conveyor) system	40	6	32	2
8	Application of industrial fieldbus in mechatronic system	16	4	10	2
9	Operation of process visualization	6	2	4	0
10	Project work: Developing own mechatronic station	56	10	44	2
11	Final examination	16*			16

 * including preparation and evaluation

2. Detailed contents:

Lesson 1:
Characteristics and applications of sensors (18h)
Objectives:

After finishing this lesson, the trainees are able to;

- Describe characteristics and applications of sensors.

- Procure, read and apply information from technical documents, diagrams and internet.

- Assign digital and analogue sensors to given applications.

- Read and draw up symbols and circuit diagrams for controls with sensors.

- Develop programs for controls with analogue sensors.

- Download programs to PLC and test controls with analogue sensors.

- 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 Detection of objects with magnetic sensors.
1.2 Detection of objects with inductive sensors.
1.3 Detection of objects with optical sensors.
1.4 Detection of objects with capacitive sensors.
1.5 Measuring distances with linear potentiometer
1.6 Measuring pressure with analogue pressure sensor.
1.7 Measuring force with analogue force sensor.
1.8 Design PLC-programs with analogue sensors.

Lesson 2:
Programming of sequence controls in SFC - language (8h)
Objectives:

After finishing this lesson, the trainees are able to;

- Analyze functional connections in automated processes, especially movement sequences and logical conditions.
- Develop functional charts of automated processes as function plans or graftec plans.
- Operate computer, PLC and peripheral devices.
- Program sequence controls in SFC-language (Simatic GRAPH7)
- Download programs to PLC, commission, operate and test mechatronic stations.
- Carry out systematic trouble-shooting at sequence controls in SFC-language, assisted by online watch-function.
- Acquire and apply information from documents and internet, especially international standards IEC-1131 and Graftec.
- Develop readiness for self learning to improve knowledge and working skills.
- Solve problems systematically in a team.

Content:
2.1 Distribution station – linear sequence
2.2 Lifting and sorting station – alternative branching

Lesson 3: Building up mechatronic station 1 (20h)
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, sensors, controller and interfaces.
- 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 (pneumatic, hydraulic and electric) for mechatronic stations.
- Operate industrial PLC and peripheral devices.
- Configure the hardware of PLC.
- Understand, modify and develop applied control programs in at least one programming language according to IEC 1131

- Determine the working steps required for carrying out the mounting and installation of PLC-operated mechatronic stations.
- Dismantle and assembly mechatronic stations change and adjust components.
- Describe, mount and install valve terminal with multipol connection
- Install electrical components in mechatronic stations.
- Download programs to PLC, commission, operate and test mechatronic stations and systems.
- 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:
3.1 Dismantling of mechatronic station
3.2 Developing working plan for mounting and installation
3.3 Mounting mechanical part of station
3.4 Function, mounting and installation of valve terminal
3.5 Electrical installation to I/O-terminal
3.6 Downloading given program
3.7 Commissioning and testing
3.8 Writing own program as sequence control
3.9 Trouble shooting in mechatronic station 1

Lesson 4:
Building up mechatronic station with sensor applications (20h)
Objectives:
After finishing this lesson, the trainees are able to;

- Describe the structure of a mechatronic system in principle with pneumatic, hydraulic and electric drives, sensors, controller and interfaces.
- 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 (pneumatic, hydraulic and electric) for mechatronic stations.
- Develop technical drawing of mechanical parts.

- Produce mechanical parts related to handling station
- Operate industrial PLC and peripheral devices.
- Understand, modify and develop applied control programs in at least one programming language according to IEC 1131-3.
- Determine the working steps required for carrying out the mounting and installation of PLC-operated mechatronic stations.
- Dismantle and assembly mechatronic stations, change and adjust components.
- Install electrical components in mechatronic stations.
- Download programs to PLC, commission, operate and test mechatronic stations and systems.
- 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:
4.0 Pre-condition: station is unassembled
4.1 Problem-solving of sensor applications
4.3 Selection of sensors.
4.4 Design and production of mechanical parts (fixtures for sensors)
4.5 Modification of circuit diagrams (optional on computer)
4.6 Modification of program
4.7 Mounting and adjustment of mechanical parts and sensors
4.8 Electrical installation to I/O-terminals
4.9 Commissioning and testing
4.10 Trouble-shooting, special sensor-adjustment

Lesson 5:
Building up mechatronic station: handling   (20h)
Objectives:
    After finishing this lesson, the trainees are able to;

- Analyze functional connections in handling station, especially movement sequences and logical conditions.
- Procure, read and apply information from technical documents, diagrams and internet.
- Describe function and application of new pneumatic components related to handling process

- Develop solutions for problems related to handling station and draw up in standardized diagrams (displacement-step-diagram / function chart).

- Develop technical drawing of mechanical parts.

- Produce mechanical parts related to handling station

- Read and draw up circuit diagrams (pneumatic and electric) for handling station.

- Develop applied control program in SCL- language

- Determine the working steps required for carrying out the mounting and installation of handling station.

- Dismantle and assembly handling station, change and adjust components.

- Install electrical components in handling station.

- Download programs to PLC, commission, operate and test handling station.

- Carry out systematic trouble-shooting and repair.

- 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:

5.0 Pre-condition: station is unassembled
5.1 Problem-solving of handling station
5.2 Information about new components (actuators)
5.3 Design and production of mechanical parts
5.4 Develop working plan for mounting and installation
5.5 Mounting and adjustment of mechanical parts and sensors
5.6 Modification of circuit diagrams (optional on computer)
5.7 Electrical installation to I/O-terminals
5.8 Design of program in SCL - language
5.9 Commissioning and testing
5.10 Trouble-shooting,

Lesson 6:
Building up mechatronic station: production (20h)
Objectives:
After finishing this lesson, the trainees are able to;

- Analyze functional connections in production station, especially movement sequences and logical conditions.

- Procure, read and apply information from technical documents, diagrams and internet.

- Describe function and application of new pneumatic and electric components related to production process

- Develop technical drawing of mechanical parts.

- Produce mechanical parts related to production station

- Select motor-drive for production station (DC / AC)

- Develop solutions for problems related to production station and draw up in standardized diagrams (displacement-step-diagram / function chart).

- Read and draw up circuit diagrams (pneumatic and electric) for production station.

- Develop applied control program in SCL- language

- Determine the working steps required for carrying out the mounting and installation of production station.

- Dismantle and assembly production station, change and adjust components.

- Install electrical components in production station.

- Download programs to PLC, commission, operate and test handling station.

- Carry out systematic trouble-shooting and repair.

- 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:
6.0 Pre-condition: station is unassembled
6.1 Problem-solving of handling station
6.2 Information about new components (actuators and motors)
6.3 Design and production of mechanical parts
6.4 Develop working plan for mounting and installation
6.5 Mounting and adjustment of mechanical parts and sensors
6.6 Modification of circuit diagrams (optional on computer)
6.7 Electrical installation to I/O-terminals
6.8 Design of program in SCL - language
6.9 Commissioning and testing
6.10 Trouble-shooting,

Lesson 7:
Building up industrial transfer (conveyor) system (40h)
Objectives:
After finishing this module, the trainees are able to:

- Describe the structure of a conveyor system in principle with pneumatic and electric drives.

- Make a plan of installation and commissioning conveyor system

- Select electrical/electronics components and suitable tools, measurement instruments, material according to requirement.
- Mount mechanical parts and pneumatic components.
- Carry out electrical wiring.
- Connect pneumatic components.
- Write and download programs to PLC.
- Commission, operate and test industrial transfer system.
- Carry out systematically trouble-shooting and repair
- Describe and follow safety regulations, particularly those arising from electrical power.
- Solve problems systematically in a team.

Content:
7.1 Analyzing transportation process and conditions
7.2 Plan of installation process
7.3 Mounting of mechanical parts
7.4 Installation of pneumatic components
7.5 Installation of sensors
7.6 Installation of power circuit
7.7 Installation of control circuit
7.8 Downloading sample program, commissioning
7.9 Developing own programs
7.10 Commissioning and testing system
7.11 Trouble shooting
7.12 Evaluation

Lesson 8:
Application of industrial fieldbus in mechatronic system (20 h)
Objectives:
After finishing this lesson, the trainees are able to;
- Analyze functional connections in mechatronic system.
- Describe function and application of new pneumatic and electric components related to production process
- Define transfer parameters between stations
- Operate mechatronic system by cable connections between stations.
- Name and describe fieldbus systems in principle (ASI, Profibus, Ethernet, and CAN).
- Install one selected fieldbus system for a mechatronic station.
- Program and operate mechatronic station with selected fieldbus system
- Install fieldbus to mechatronic system.

- Download given program, commission and operate mechatronic system with fieldbus
- Do the trouble shooting in mechatronic system with selected fieldbus.
- 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 Combination of stations to a mechatronic system
8.2 Problem of communication between stations
8.3 Communication by I/O- connection
8.4 Fieldbus systems in principle
8.5 Installation of example fieldbus network
8.6 Programming of example fieldbus network
8.7 Design and building up system network
8.8 Operation of system network with given program
8.9 Commissioning and trouble shooting of system

Lesson 9:
Operation of process visualization (6 h)
Objectives:

After finishing this lesson, the trainees are able to;

- Analyze functional connections in automated processes, especially movement sequences and function parameters.
- Draw up process in flowchart.
- Operate software for process visualization.
- Do trouble shooting in mechatronic system with assistance of process visualization system.
- 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:

9.1 Analysis of process of mechatronic system
9.2 Symbols and drawing up of flowchart
9.3 Demonstration of process visualization
9.4 Operation of process visualization
9.5 Trouble shooting with assistance of process visualization

Lesson 10:

Project work: Developing and building up own mechatronic station (56h)

Objectives:

After finishing this lesson, the trainees are able to;

- Analyze functional connections in project, especially movement sequences and logical conditions.
- Procure, read and apply information from technical documents, diagrams and internet.
- Develop solutions for problems related to project and draw up in standardized diagrams (displacement-step-diagram / function chart).
- Develop technical drawings of mechanical parts and assembly drawings
- Produce mechanical parts on industrial standard
- Read and draw up circuit diagrams (pneumatic and electric).
- Develop applied control program
- Determine the working steps required for carrying out the mounting and installation of handling station.
- Assemble project and adjust components.
- Install electrical components with industrial wiring
- Download programs to PLC, commission, operate and test project.
- Present proposals and results to group of experts or colleagues, recommended in power point and partly in English language.
- 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:

10.1 Problem- or project description

10.2 Proposals for solution of project

10.3 Presentation of proposals

10.4 Developing of documents

- Description of process, positional sketch
- Displacement-step-diagram or function chart
- Technical drawings for mechanical parts
- Circuit diagrams
- Program

10.5 Mechanical production of project

10.6 Installation of electrical components

10.7 Commissioning and testing of system

10.8 Presentation of project

Lesson 11:
Final examination (16 h)

Objectives:

After finishing this lesson, the trainees are able to;

- Describe the structure of a mechatronic system in principle with pneumatic, hydraulic and electric drives, sensors, controller and interfaces.

- 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 circuit diagrams (pneumatic, hydraulic and electric)for mechatronic stations.

- Operate industrial PLC and peripheral devices.

- Configure the hardware of PLC.

- Understand, modify and develop applied control programs in at least one programming language according to IEC 1131-3 and SCL-language.

- Determine the working steps required for carrying out the mounting and installation of PLC-operated mechatronic stations.

- Read technical drawings, especially assembly-drawings

- Dismantle and assemble mechatronic stations, change and adjust components.

- Produce mechanical components

- Describe, mount and install valve terminal

- Install electrical components in mechatronic stations.

- Download programs to PLC, commission, operate and test mechatronic stations and systems.

- Carry out systematic trouble-shooting and repair in PLC-operated systems.

- Describe and follow safety regulations, particularly those arising from electrical power.

Content:

11.1 Theoretical examination
11.2 Practical examination: work piece
11.3 Practical examination: working exercise

IV. Prerequisites for implementation of module

- **Advanced Mechatronic lab:**

  - For 12 trainees, always two trainees working at 1 working station

  - Size of room: min. 80m²

- 6 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
- 1 Power supply from ceiling for conveyor system
- Control cabinet with fuses and emergency switch off
- Working place for teacher with PC and printer
- Blackboard, magnetic, min 2,5 x 1,2m
- Overhead projector and projection screen
- Teachers computer and beamer
- Chairs and tables for theory and practice
- Powerful compressor, extra silent
- Storage cabinets for teaching aids and equipment.

- **Equipment of working stations** (2 Students):
    - Computer table with PC (including fieldbus)
    - Mechatronic station complete with :
        - Mechatronic station mounted on profile plate or stand-alone unit
        - Trolley
        - Industrial modular PLC with accessories
        - Operator panel
    - Tool set, multimeter
    - Set of electrical components for electrical installation
    - Training set sensors
    - Training set fieldbus
    - Set of components for project work
        - Profile plate
        - Set of aluminum profiles and connectors
        - Pneumatic components
        - Wiring board with I/O-terminals
        - Electrical components (relays, lamps, switches)
        - Cable ducts, profile rail

- **Important:**
- Two of the stations must contain an industrial conveyor system with 3-phase motor to connect the single stations to a complete mechatronic system

- **Additional room equipment:**

- Fielbus system for conveyor and stations
- Process visualization-software for mechatronic system

V. Evaluation methods and contents of tests

- The evaluation of this modules contains:

1. **Accompanied evaluation**

   Every exercise is evaluated in an evaluation form. The evaluation contains function check, working time, visual inspection and evaluation of documentation.

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 300min a PLC-operated mechatronic system with industrial components according to given documentation., develops the program and commissions this system. This includes the production of at least 1 mechanical part as spare part for 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 station or system with finding and repair of 1 or more faults.

3. **Project work**

   The trainees develop in a group of max. 4 in max.60h a mechatronic station individually, This includes documentation, production of mechanical parts, programming, commissioning and testing. The results are to be presented to the teacher or an examination board.

   The following parts are to be evaluated:

3.1 The documentation

3.2 Function and quality of the station

3.3 Presentation of project work.

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 the final module which should summarize the qualification of all previous modules.

- **Organization:**
- The lessons of this module should be organized in large blocks of at least one week up to 8 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.
- In this module, the teams of students are working at different mechatronic stations in a rotating system (compare annex 1)
- The students have to build up the mechatronic stations from the basis. It is to be ensured, that the stations have to be dismantled, before the students start work - if not, the first step 0 will be the complete dismantling of stations.
- The teaching staff should guide the students to the ability to plan, execute and monitor their work independently.
- The students should conduct their work as far as possible on their own and inform themselves from documents and internet.
- As far as the students are working in teams the teaching staff should instruct them in team-work and sharing of work.
- Some lessons, project work and examination contain production of mechanical components. It is from special importance to watch the quality and accuracy of this work.

- **Reference documents**
- Teaching materials for every mechatronic station
- FESTO-DIDACTIC: Fieldbus AS-Interface - working book   No. 534 272
- FESTO-DIDACTIC: Fieldbus Profibus-DP - working book   No. 534 273

ANNEX 1: ORGANIZATION OF WORK

GROUP (A)

| Station 1 |

GROUP (B)

| Station Sensors |

GROUP (E)

| Station Transfer 1 |

GROUP (F)

| Station Transfer 2 |

GROUP (D)

| Station Handling |

GROUP (C)

| Station Production1 |

Groups running through terms:

Time	Station 1	Station Sensors	Station Production	Station Handling	Station Transfer 1	Station Transfer 2
TERM 1	GROUP (A)	GROUP (B)	GROUP (C)	GROUP (D)	GROUP (E)	GROUP (F)
TERM 2	GROUP (D)	GROUP (A)	GROUP (B)	GROUP (C)		
TERM 3	GROUP (E)	GROUP (F)	GROUP (A)	GROUP (B)	GROUP (C)	GROUP (D)
TERM 4	GROUP (B)	GROUP (E)	GROUP (F)	GROUP (A)		
TERM 5	GROUP (C)	GROUP (D)	GROUP (E)	GROUP (F)	GROUP (A)	GROUP (B)
TERM 6	GROUP (F)	GROUP (C)	GROUP (D)	GROUP (E)		