



Republic of Rwanda
Ministry of Education



RTB | RWANDA TVET BOARD

CSASA501

SYSTEM AUTOMATION WITH PLC

Automate System Using PLC

Competence

RQF Level: 5 Learning Hours



80

Credits: 8

Sector: ICT AND MULTIMEDIA

Trade: COMPUTER SYSTEM AND ARCHITECTURE

Module Type: Specific

Curriculum: ICTCSA5001-TVET CERTIFICATE V IN COMPUTER SYSTEM
AND ARCHITECTURE

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Purpose statement	This specific module describes the skills, knowledge and attitude required to Automate Systems using PLC. Upon completion of this module, the learners will be able to prepare automation system, develop PLC program and deploy PLC program.					
Learning assumed to be in place	N/A					
Delivery modality	Training delivery		100%	Assessment		
	Theoretical content		30%	Formative assessment	30%	
	Practical work:		70%		50%	
	Group project and presentation	20%				
	Individual project /Work	50%				
			Summative assessment		50%	

Elements of Competence and Performance Criteria

Elements of competence	Performance criteria
1. Prepare automation system	<p>1.1. Automation system requirements are correctly identified based on existing design and user's needs.</p> <p>1.2. Tools, materials and equipment are properly selected according to automation system requirements.</p> <p>1.3. Automation system is neatly designed based on analysis findings</p> <p>1.4. System hardware is properly installed according to manufacturer guidelines and automation system design</p>
2. Develop PLC Program	<p>2.1. PLC simulation software is successfully installed basing on installation guide.</p> <p>2.2. PLC programming language is properly selected basing on</p>

	needed features
	2.3. PLC program is properly written based on PLC programming concepts
3. Deploy PLC program	3.1. PLC program is successfully downloaded based on downloading techniques
	3.2. Automated system is successfully tested according to intended use
	3.3. Automated system is properly documented according to system operation.
	3.4. Automation system is properly maintained according to system functionality

Knowledge	Skills	Attitudes
<ul style="list-style-type: none"> • Description of fundamentals of system automation • Description of programmable logic controllers (PLC) • Description of PLC programming languages • Description of PLC programming concepts 	<ul style="list-style-type: none"> • Troubleshooting automation system • Configuration of PLC hardware • Developing PLC programs • Deploying PLC program • Analysing automation system • Designing automation system • Testing and debugging automation system • Documenting automation system 	<ul style="list-style-type: none"> • Teamwork • Technical curiosity • Attention to detail • Collaboration • Adaptability • Continuous improvement

Course content

Learning outcomes		At the end of the module the learner will be able to: <ol style="list-style-type: none"> 1. Prepare automation system 2. Develop PLC Program 3. Deploy PLC program
Learning outcome 1: Prepare automation system		Learning hours: 20 hours
Indicative content		
<ul style="list-style-type: none"> • Identification of automation system requirements <ul style="list-style-type: none"> ✓ Introduction to system automation <ul style="list-style-type: none"> ⊕ Definition ⊕ Types ⊕ Application ⊕ Working principles ✓ Description of Programmable Logic Controller (PLC) <ul style="list-style-type: none"> ⊕ Definition ⊕ Types ⊕ Application ⊕ Characteristics • Analysing Automation system <ul style="list-style-type: none"> ✓ Analysing the existing System <ul style="list-style-type: none"> ⊕ System analysis techniques ⊕ Description of system components ⊕ Identify user's needs ✓ System requirements analysis <ul style="list-style-type: none"> ⊕ Performance requirement ⊕ Usability requirement ⊕ Recoverability requirement 		

-  Maintainability requirement
-  Accessibility requirement
- **Selecting of tools, materials and equipment**
 - ✓ Tools
 - ✓ Materials
 - ✓ Equipment
- **Designing automation system**
 - ✓ Preparation of drawing environment
 -  Installation of a drawing tool
 -  Identification of symbols and notation
 -  Drawing templates
 -  Applying colour scheme and styling
 - ✓ Drawing system architecture
 -  Identification of system components
 -  Create hardware block diagram
 -  Create The Functional Flow Diagram(flowchart)
 -  Create an architecture diagram.
 -  Dataflow and communication (sequence diagram)
- **Installation of system hardware**
 - ✓ Prepare installation site
 - ✓ Connect hardware components
 - ✓ Test hardware connection

Resources required for the learning outcome

Equipment	<ul style="list-style-type: none"> ● Input and output modules ● Power supply components ● PLC ● Multimeter ● Personal computer ● PPE
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	<ul style="list-style-type: none"> • Contactors
Materials	<ul style="list-style-type: none"> • Electrical wires • Labels • Sensors • Actuators • Relays • Conduit • Zip ties • Internet • White board • Marker
Tools	<ul style="list-style-type: none"> • TIA Portal software • Screwdriver set • Wire strippers/cutters • Crimping pliers
Facilitation techniques or Learning activity	<ul style="list-style-type: none"> • Demonstration • Group discussion • Practical exercise • Trainer-guided
Formative assessment methods /(CAT)	<ul style="list-style-type: none"> • Written assessment • Oral presentation • Practical Assessments
Learning outcome 2: Develop PLC Program.	Learning hours: 40 hours
Indicative content	
<ul style="list-style-type: none"> • Installation of PLC simulation software <ul style="list-style-type: none"> ✓ Simulation software preparation (TIA Portal). ✓ Perform system compatibility check up ✓ Run and configure software packages • Selecting PLC programming languages 	

- ✓ Description of PLC programming languages
 - ⊕ Types
 - ⊕ Application
 - ⊕ Characteristics
 - ⊕ Symbols and notations
- ✓ PLC Programming language selection criteria
 - ⊕ Language features
 - ⊕ Compatibility and interoperability
 - ⊕ Scalability
 - ⊕ Learning curve
 - ⊕ Security
 - ⊕ Advantages and disadvantages
- **Writing PLC program**
 - ✓ Ladder Diagram (LAD) programming language
 - ⊕ Defining system requirement
 - ⊕ Developing the logic flowchart
 - ⊕ Translating logic into rungs
 - ⊕ Program testing and debugging
 - ⊕ Documentation and maintenance
 - ✓ Function Block Diagram (FBD) programming language
 - ⊕ Defining system requirements
 - ⊕ Selecting function blocks
 - ⊕ Building the program logic
 - ⊕ Configuring block parameters
 - ⊕ Program testing and debugging
 - ✓ Structured Control Language (SCL)
 - ⊕ Defining system requirements
 - ⊕ Program structure and variables
 - ⊕ Coding logic with control statements
 - ⊕ Interfacing with I/O devices
 - ⊕ Program testing and debugging

- **Converting PLC programming language**
 - ✓ Ladder Diagram to Structure Control Language (LAD to SCL)
 - ✓ Ladder Diagram to Function Block Diagram (LAD to FBD)

Resources required for the indicative content

Equipment	<ul style="list-style-type: none"> • Computer
Materials	<ul style="list-style-type: none"> • Internet bundle • Whiteboard • Marker pen
Tools	<ul style="list-style-type: none"> • TIA Portal software
Facilitation techniques or Learning activity	<ul style="list-style-type: none"> • Demonstration • Group discussion • Practical exercise • Trainer-guided
Formative assessment methods /(CAT)	<ul style="list-style-type: none"> • Written assessment • Performance assessment • Practical assessment • Oral presentation

Learning outcome 3: Deploy PLC program

Learning hours: 20 hours

Indicative content

- **Downloading PLC program**
 - ✓ Program file preparation
 - ✓ Select connection method
 - ⊕ Method of connection
 - ⊕ Depth of connection
 - ✓ Flash the program file to PLC
- **Testing automation system**
 - ✓ Description of testing techniques
 - ⊕ Testing techniques
 - ⊕ Advantages and disadvantages
 - ⊕ STLC (Software Testing Life Cycle)
 - ✓ Applying testing techniques
 - ⊕ Unit test
 - ⊕ System test
- **Documenting automation system**
 - ✓ Technical documentation
 - ⊕ Hardware configuration
 - ⊕ Software configuration
 - ⊕ Control logic
 - ⊕ Network architecture
 - ✓ Prepare system's user manual
- **Maintaining automation system**
 - ✓ Apply preventive maintenance
 - ✓ System diagnosing
 - ✓ System troubleshooting

Resources required for the indicative content

Equipment	<ul style="list-style-type: none">• Input and output modules• Power Supply Components• PLC

	<ul style="list-style-type: none"> • Computer
Materials	<ul style="list-style-type: none"> • Internet • Whiteboard • Marker pen • Sensors • Actuators • Communication cable (Ethernet, USB, RS-232) • Human-Machine Interface (HMI) • Notebooks
Tools	<ul style="list-style-type: none"> • TIA Portal software
Facilitation techniques or Learning activity	<ul style="list-style-type: none"> • Demonstration • Group discussion • Practical exercise • Trainer-guided
Formative assessment methods /(CAT)	<ul style="list-style-type: none"> • Written assessment • Performance assessment • Practical assessment • Oral presentation

Integrated/Summative assessment (For specific module)

ABC Farms is a medium-sized agricultural company located in RUSIZI District, specializing in vegetable cultivation and exporting them outside the country. They are currently using traditional method of manually packaging vegetable with the help of their workers, the manual method of packaging vegetables has many challenges such as low quality of product caused by human error, longtime packaging process and higher packaging costs. To overcome those challenges ABC Company, bought a vegetable packaging machines, to boost packaging efficiency, to increase the quality of product by reducing human errors and reduce labor packaging costs. The company has challenges of installing this vegetable packaging machine and automate the packaging processes using PLC.

To solve those problems, they hired you as an Automation System Technician, to automate this vegetable packaging machine controlled by PLC.

Instructions:

- Integrate of sensors and PLC
- Integrate actuator and PLC
- Control conveyor belt
- Set sorting and grading parameters
- Perform weighing (10kg maximum) and filling
- Perform sealing and labeling
- Implement data logging and reporting
- Integrate Human-Machine Interface
- Incorporate error handling routines to detect and manage sensor failures or communication issues effectively. Display appropriate error messages on Human-Machine Interface (HMI) to notify users of any problems.
- After finishing this work, prepare clear and concise documentation explaining how to use this automated system, and all maintenance guidelines.

Note:

- Tools, materials and Equipment are provided.
- This work must be done in 10 hours.

Resources:

Tools	<ul style="list-style-type: none">• Pliers• Wire stripper• Allen wrench
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	<ul style="list-style-type: none"> PLC programming software (TIA Portal) Screw drivers
Equipment	<ul style="list-style-type: none"> Conveyor belt system with motor and drive mechanism PLC modules (e.g., Siemens S7-1200) PLC input and output modules PLC Power Supply Contactors Safety gloves (e.g., Mechanix Wear, Ansell) Protective clothing (e.g., coveralls, safety vests) HMI devices (e.g. Siemens wincc) Multimeter Personal computer
Materials/ Consumables	<ul style="list-style-type: none"> Electrical wires (various gauges) Relay Cable ties Sensors Labels Ethernet cables/USB Cable Power cables

Assessable outcomes	Assessment criteria (Based on performance criteria)	Indicator	Observation		Marks allocation
			Yes	No	
Learning outcome 1: Prepare automation system (30%)	Automation system requirements are correctly identified	Existing system components are analysed			4
		User's requirements are identified			5
		New system requirement is			

		analysed			7
Tools, materials and equipment are properly selected		Tools are selected.			3
		Materials are selected.			3
		Equipment is selected			3
Automation system is neatly designed		Drawing environment is prepared.			3
		System Architecture is drawn			5
2. Develop PLC program (40%)	PLC simulation software are correctly installed	Simulation software is prepared			3
		System compatibility check-up is Performed			3
		Gmwin4 simulation software is installed.			5
	PLC programming language is properly selected	PLC programming language selected.			2
	PLC program is properly written.	Program tructure is created			5
		Control logic is written			6

		Safety Interlocks Are Implemented			6
		Codes testing and debugging are performed			5
3. Deploy PLC program	PLC program is successfully downloaded	PLC program file is prepared			4
		Communication method is selected			3
		PLC software is flashed			6
	Automation system is successfully tested	Unit testing is performed			3
		System testing is performed			6
	Automated system is properly documented	Technical document is prepared			5
		User Manual is prepared			5
Total marks					100
Percentage Weightage					100%
Minimum Passing line % (Aggregate): 70%					

References:

1. <Https://www.solisplc.com/tutorials>.
2. <Https://inductiveautomation.com/blog/taxonomy/term/180>.
3. <Https://www.amazon.com/Mastering-plc-Programming-engineering-programming/dp/180461288X>
4. Https://en.wikipedia.org/wiki/Programmable_logic_controller.
5. Petruzella, F. D. (2017). Programmable Logic Controllers. McGraw-Hill Education.<Https://www.amazon.com/Programmable-Logic-Controllers-Frank-Petruzella/dp/0073373842>)
6. Hackworth, J. R., & Hackworth Jr., F. D. (2015). Programmable Logic Controllers: Programming Methods and Applications. Cengage Learning.
(<Https://www.amazon.com/Programmable-Logic-Controllers-Programming-Applications/dp/1337390195>)
7. Collins, K. (2013). PLC Programming for Industrial Automation. McGraw-Hill Education.
(<Https://www.amazon.com/PLC-Programming-Industrial-Automation-Collins/dp/0071810455>)
8. Ryan, H. (2013). Programmable Logic Controllers: A Practical Approach to IEC 61131-3 using codesys. Wiley.<Https://www.amazon.com/Programmable-Logic-Controllers-Practical-Approach/dp/1111125424>)
9. Stenerson, J., Deeg, D., & Krar, S. (2016). Programmable Logic Controllers: Hardware and Programming. Industrial Press, Inc.<Https://www.amazon.com/Programmable-Logic-Controllers-Hardware-Programming/dp/1259641635>)