Republic of Rwanda
Ministry of Education

RTB | RWANDA TVET BOARD

BASIC EMBEDDED SYSTEM DEVELOPMENT

ETEED401

DEVELOP BASIC EMBEDDED SYSTEM

Competence

RQF Level: 4

Learning Hours 70

Credits: 7

Sector: Technical services

Trade: Electronics and Telecommunication

Module Type: Specific

Curriculum: TSVETE4001 -TVET Certificate IV in Electronics and Telecommunication

Issue Date: May 2023

<table>
<tr><td>Purpose statement</td><td colspan="6">This module describes the knowledge, skills, and attitudes required to develop the basic embedded system.
At the end of this module, the learners will be able to Perform pre-development activities, develop a basic embedded system prototype, and Perform post-development activities.</td></tr>
<tr><td>Learning assumed to be in place</td><td colspan="6">Apply computer skills, Apply Technical drawing, Apply digital electronic fundamentals, Build power conversion system</td></tr>
<tr><td rowspan="6">Delivery modality</td><td colspan="2">Training delivery</td><td>100%</td><td colspan="2">Assessment</td><td>Total 100%</td></tr>
<tr><td colspan="2">Theoretical content</td><td>30%</td><td rowspan="4">Formative assessment</td><td>30%</td><td rowspan="4">50%</td></tr>
<tr><td colspan="2">Practical work:</td><td rowspan="3">70%</td><td rowspan="3">70%</td></tr>
<tr><td>• Group work and presentation</td><td>30%</td></tr>
<tr><td>• Individual work</td><td>40%</td></tr>
<tr><td colspan="2"></td><td colspan="2">Summative Assessment</td><td>50%</td></tr>
</table>

Elements of Competency and Performance Criteria

Elements of competency	Performance criteria
1. Perform pre-development activities	1.1. Workplace is properly prepared according to the electronic workshop code of practices.
	1.2. The problem's block diagram is correctly drawn according to drawing standards.
	1.3. Tools, materials, and equipment are correctly selected according to the activities to be carried out.
2. Develop a basic embedded system prototype	2.1. Embedded system circuit is well built in the simulating software according to the block diagram elements and designing procedures.
	2.2. The source codes of the designed circuit are well created according to the programming language type.

	2.3. The written program is properly uploaded in designed circuit according to the uploading procedures.
	2.4. PCB is completely designed according to the PCB designing processes.
	2.5. The embedded system circuit diagram is well interpreted according to electronic components symbols on the diagram.
	2.6. Electronic components are well selected according to the embedded system circuit implementation procedures.
	2.7. Electronic components are well interconnected on PCB according to the soldering techniques.
	2.8. Intended outputs are accurately produced according to the application of embedded device.
3. Perform post-development activities	3.1. The workplace is well rearranged according to the type of waste disposal management.
	3.2. The user manual is well developed according to the parts of the user guide and standard indications.
	3.3. The cost of the developed embedded system is well estimated according to cost estimation procedures.

Knowledge, Skills, Attitudes

Knowledge	Skills	Attitudes
✓ Safety precautions, and security ✓ Technical Symbols and diagrams ✓ Interpret circuit diagrams ✓ Industrial codes and standards ✓ Basic electronic fundamentals ✓ Digital electronics ✓ PCB software	✓ Computer skills ✓ Proper use of measurement tools ✓ Computer-aided design ✓ Creating circuit diagram ✓ Analytical skills ✓ Diagnostic skills ✓ Communication skills ✓ Collaborative skills ✓ Task management skills ✓ Use of PCB designing software skills	✓ Honest ✓ Accountability ✓ Self-motivated ✓ Gender sensitive ✓ Customer care oriented ✓ Decisive ✓ Time management ✓ Humble ✓ Creative / Innovative ✓ Patient ✓ Responsible ✓ Flexible ✓ Integrity

		✓ Goal oriented ✓ Self-confident ✓ Good common sense ✓ Task-oriented ✓ Customer focused ✓ Energetic ✓ Able to work independently ✓ Strong moral character ✓ Personal hygiene ✓ Open-minded ✓ Organized ✓ Maintain health ✓ Positive work ethics ✓ Problem solver ✓ Goals oriented ✓ Teamwork / Collaboration ✓ Professionalism ✓ Strong Work Ethic ✓ Adaptability ✓ Safety Consciousness

Course content

Learning outcomes	At the end of the module the learner will be able to: 1. Perform circuit pre-development activities 2. Develop a basic embedded system prototype 3. Perform post-development activities
Learning outcome 1: Perform circuit pre-development activities.	**Learning hours: 10**
Indicative content	

- **Preparation of Electronics workplace**
  - ✓ Explanation of electronics workshop code of practices
    - Generic workshop practices
    - General housekeeping practices
    - Electrical safety practices
    - Machine tools, handheld power tools, and hand tools code of practices
    - Chemical process code practices
- **Identification of common specific standards of electronics block diagram**
  - ✓ Use Standard Symbols
  - ✓ Consistent Layout
  - ✓ Use Arrows for Signal Flow
- **Draw the basic block diagram of electronic projects**
  - ✓ Manual drawing
  - ✓ Electronic drawing
- **Identification of electronics workshop equipment, tools, and materials**

Resources required for the learning outcome

Equipment	Digital multimeter, Air blower, Soldering station, Glue gun, Computer, Personal protective equipment (PPE) kit, Embedded system kit, power supply, PCB milling machine.
Materials	Electronic passive components, Electronic active components, Integrated circuits (IC), Electronic relay, microcontrollers, copper boards, sensors, actuators, transducers, Foam Cleaner, Soldering paste, Desoldering wire, Soldering wire, USB connectors, cables and wires, Etchants for PCB manufacturing (Ferric chloride, Ammonium Persulfate), IC socket, Papers, internet, Board/chalk.
Tools	Computer software, drawing kit, Tape measure, Tweezer, Technician Knife Crimping tool, Pliers set, Screwdriver set, magnifying glass, Soldering iron, Desoldering pump, Proteus (ISIS Professional), Easy EDA.
Facilitation techniques	▪ Lectures ▪ Group discussion ▪ Practical exercise

	▪ Brainstorming
Formative assessment methods /(CAT)	▪ Written assessment ▪ Oral presentation ▪ Product-based assessment.

Learning outcome 2: Develop a basic embedded system	**Learning hours: 45**

prototype	
Indicative content	

- **Introduction to embedded system prototype**
- **Description of simulation software**
  - ✓ Proteus (ISIS Professional)
  - ✓ EasyEDA
- **Installation of simulation software**
- **Simulation steps of basic embedded circuit**
  - ✓ Process of building basic electronic embedded circuit
  - ✓ Running simulation process of basic electronic embedded circuit
- **Identification of programming languages types**
- **Creating a program of the basic embedded circuit in C programming language**
  - ✓ Program Flowchart
  - ✓ Program syntax
  - ✓ Steps of debugging and running a program
- **Uploading program procedures in designed embedded circuits**
  - ✓ Installation of programming environment (IDE).
  - ✓ Installation of transducer libraries
  - ✓ Identification of control board and ports
  - ✓ Uploading processes
- **Designing procedures of basic embedded Printed circuit Board (PCB)**
  - ✓ Creating schematic diagram
  - ✓ Designing PCB process
- **Interpretation of electronic components in embedded system circuit**
  - ✓ Description of Surface mounting devices (SMD)
  - ✓ Types and applications of Sensors
  - ✓ Types and applications of Actuators
  - ✓ Description of microprocessors and microcontrollers
- **Implementation procedures of electronic embedded system circuit**
  - ✓ Selection of electronic components factors
  - ✓ Implementation step by step of electronic embedded system
- **Fixation of electronic components onto a PCB of electronic embedded system**

- ✓ Through-Hole Soldering technique
- ✓ Surface mounting technology (SMT) technique

- **Testing the output of electronic embedded system circuit**
  - ✓ Measurement test
  - ✓ Functionality test

Resources required for the learning outcome	
Equipment	Digital multimeter, Air blower, Soldering station, Glue gun, Computer, Personal protective equipment (PPE) kit, Oscilloscope, Embedded system kit, power supply, PCB milling machine.
Materials	Electronic passive components, Electronic active components, Integrated circuits (IC), Electronic relay, microcontrollers, copper boards, sensors, actuators, transducers, Foam Cleaner, Thermal paste, Soldering paste, Desoldering wire, Soldering wire, USB connectors, cables and wires, Etchants for PCB manufacturing (Ferric chloride, Ammonium Persulfate), IC socket.
Tools	Computer software, Mobile phone software, Tape measure, Tweezer, Technician Knife krone/punching tool, Crimping tool, Electrician toolbox, Pliers set, Screwdriver set, Precision screwdriver set, magnifying glass, Soldering iron, Desoldering pump, Proteus (ISIS Professional), EasyEDA.
Facilitation techniques	▪ Lectures ▪ Group discussion ▪ Practical exercise ▪ Trainer guided.
Formative assessment methods /(CAT)	▪ Written assessment ▪ Oral presentation ▪ Product-based assessment

Learning outcome 3: Perform post-development activities	Learning hours: 15

Indicative content

- **Waste disposal management**
  - ✓ Definition of key aspects
  - ✓ Types of waste disposal management
  - ✓ Application of waste disposal
- **Developing user guides and standard indications**
  - ✓ User guide key parts
  - ✓ Electronic product standard indications
- **Estimation cost of developed embedded system**
  - ✓ Description of cost estimation procedures
  - ✓ Cost estimation report parts

Resources required for the learning outcome

Equipment	Compactor, Incinerator, computer, Projector.
Materials	Papers, internet, Board/chalk.
Tools	Waste Bins and Containers, Personal protective equipment.
Facilitation techniques	▪ Lectures ▪ Group work ▪ Trainer guided.
Formative assessment methods /(CAT)	▪ Written assessment ▪ Oral presentation.

Integrated/Summative assessment

Integrated situation

AAA Tech LTD, a company specializing in mining, wishes to modernize the transportation of minerals production from the mine hole to the main stock. This last is located at Twelve meters. They are modernizing their mineral transportation because of a good quantity stolen during manhood transportation.

The company needs to construct automated permanent conveyor-belt-based transportation to avoid the above issue.

The company would like to put in place the automation control of the following categories:

As a technician, you are asked to perform the following tasks:

Task 1: Controlling conveyor belt so that lamps on the way are on as long as minerals production are deposited on conveyor belt until they reach the stock.

Task 2: Automation of stock door so that it must open automatically when minerals production reaches the stock door and closed after minerals production gets inside.

As a competent technician in embedded system, you are requested to perform the following activities in 8 hours:

- ✓ Selecting equipment, tools, and materials/consumables to be used
- ✓ Draw a block diagram for each above tasks
- ✓ Simulate the circuits of the above tasks
- ✓ Create the codes of control circuit of the above tasks
- ✓ Debugging and running the written codes
- ✓ Uploading codes in microcontroller for each task
- ✓ Printing PCB for each task
- ✓ Soldering the components of embedded system of task
- ✓ Testing the functionality of each embedded system task
- ✓ Rearrange the workplace
- ✓ Develop a user guide for implemented circuits.
- ✓ Elaborate a report of cost estimation of implemented circuits.

Resources

Tools	Soldering iron, Desoldering pump, set of screw drives, Precision screwdriver set, Magnifying glass microcontrollers, software (IDE), Cleaning tools, sensors, actuators, active components, and passive components.

Equipment	Digital Multimeter, soldering station, power supply, DC motors, PPE, PCB milling machine (CNC).
Materials/ Consumables	Connecting cables, Jumper wires, Electronic components, motors accessories, conveyor belt, lamps and supports, cleaning materials, Etchants for PCB manufacturing (Ferric chloride, Ammonium Persulfate).

Assessable outcomes	Assessment criteria (Based on performance criteria)	Indicator	Observation		Marks allocation
			Yes	No	
1. Perform pre-development activities	1.1. Workplace is properly prepared according to the electronic workshop code of practices.	General Cleanliness is respected			3
		Hazardous Material Handling is respected			3
		Personal protective equipment is used			3
		Working space organization is well respected			2
	1.2. The problem's block diagram is correctly drawn according to drawing standards.	Task block diagram according to drawing standards is well drawn			3
	1.3. Tools, materials, and equipment are correctly selected according to the activities to be carried out.	Soldering station is selected			1
		PCB milling machine is selected			1
		Multimeter is selected			1
		PPE are selected			1
		An integrated development environment (IDE) is			1

		selected			
		Screwdrivers are selected			1
		Computer is selected			1
		Pliers are selected			1
		Conveyor belt is selected			1
		Etchants for PCB manufacturing is selected			1
		Simulation software is selected			1
2. Develop a basic embedded system prototype	2.1. Embedded system circuit is well built in the simulating software according to the block diagram elements and designing procedures.	Embedded system circuit to simulate is designed			3
		Embedded system circuit is simulated			4
	2.2. The source codes of the designed circuit are well created according to the programming language type.	The source codes of the designed circuit are created			3
		The program codes are well compiled			4
	2.3. The written program is properly uploaded in the designed circuit according to the uploading procedures.	The program codes are uploaded into the microcontroller			3
	2.4. PCB is completely designed according to the PCB designing	PCB is designed			5

	processes.				
	2.5. The embedded system circuit diagram is well interpreted according to electronic components symbols on the diagram.	Electronic components are matching with the designed circuit			3
	2.6. Electronic components are well selected according to the embedded system circuit implementation procedures.	Microcontrollers are selected			3
		Actuators (Motors) are selected			3
		Jumpers are selected			3
		Soldering tin is selected			3
		Sensors are selected			3
		The power supply is selected			3
		Wires and cables are selected			3
		Active components are selected			3
		Passive components are selected			3
	2.7. Electronic components are well interconnected on PCB according to the soldering techniques.	All electronic components are fixed on PCB			4
	2.8. Intended outputs are accurately produced according to the	The embedded system circuit performs the desired functionality			4

	application of embedded device				
3. Perform post-development activities	3.1. The workplace is well rearranged according to the type of waste disposal management.	Waste segregation is done			5
	3.2. The user manual is well developed according to the parts of the user guide and standard indications.	The user guide is developed			5
	3.3. The cost of the developed embedded system is well estimated according to cost estimation procedures.	The cost estimation of the embedded system is developed			5
Total marks					100
Percentage Weightage					100%
Minimum Passing line % (Aggregate):					70%

List of abbreviations

1. **BIOS:** Basic input and output system

2. **CNC:** Computer Numerical Control
3. **PCB:** Printed Circuit Board
4. **PPEs:** Personal Protective Equipment
5. **DC:** Direct current
6. **IC:** Integrated Circuit
7. **IDE:** Integrated development environment
8. **ETEED:** Electronics and Telecommunication/Basic Embedded system Development.

References

1. D.Ibrahim. (2006). *PIC BASIC Project, 30 Projects using PIC BASIC and PIC BASIC PRO.*

2. Lipovski, G.J. (2004). *Introduction to microcomtrollers: architecture, programming and interfacing .* Freescale 68H12.Elsevier.

3. Lipvski, G.J. (1999). *Single and multi chip microcontroller interfacing.* Motorola6812.

4. M.Margolis, N.Weldin. (2011). *Arduino cookbook.* O' Reilly.

5. https://www.electronicshub.org/microcontrollers/

6. http://www.entcengg.com/criteria-choosing-microcontroller/

7. https://www.uomus.edu.iq/img/lectures21/MUCLecture_2022_41042696.pdf

8.https://mrcet.com/downloads/digital_notes/EEE/Microprocessors%20and%20Microcontrollers.pdf

9. https://www.vssut.ac.in/lecture_notes/lecture1423813120.pdf

10.https://getmyuni.azureedge.net/assets/main/study-material/notes/electrical-engineering_engineering_microcontroller_introduction_notes.pdf

11. https://chat.openai.com/c/e4226512-3fc0-40f1-831c-3731d6562546

12. https://www.slideshare.net/redwan1006066/microcontroller-

Glossary

.

Embedded: Fixed firmly and deeply in a surrounding mass.

Embedded system: An embedded system is a system in which the computer (generally a microcontroller or microprocessor) is included as an integral part of the system.

Application process: A process that is associated with an application. Unlike a component or generic process, an application process is created from application-level steps.

Microcontroller: Is a compact integrated circuit designed to govern a specific operation in an embedded system.

Architecture: The internal structure of a computer system or a chip that determines its operational functionality and performance.

Artifact: A deployable item such as a file, image, database, configuration material, or anything else that is associated with a

Duration: The time a task takes to run. Duration is measured from the time a task starts until it is resolved. When you create some task types, you can estimate its expected duration. Duration is reported in minutes.

Instruction Set Architecture: The set of instructions that a CPU is designed to execute. The Instruction Set Architecture (ISA) represents the repertoire of instructions that the designers determined to be adequate for a certain CPU. Note that CPUs of different making may have the same ISA. For instance, the AMD processors (purposely) implement the Intel IA-32 ISA on a processor with a different structure.

Integration: Regular communication between IBM Urban Code Velocity and external products and services. Communication with integrated products can be bidirectional.

Plugin: A separately installable software module that adds function to an existing program, application, or interface.

Resource: A user-defined construct that is based on the architectural model of IBM Urban Code Velocity. A resource represents a deployment target.

Task: Represents a business-meaningful activity that has starting and ending points

Version: A representation of an IBM Urban Code Deploy application snapshot.