



Republic of Rwanda
Ministry of Education



RTB | RWANDA
TVET BOARD

ELTBM401

ELECTROMAGNETIC CIRCUIT OF ELECTRICAL MACHINE BUILDING

BUILD ELECTROMAGNETIC CIRCUIT OF ELECTRICAL MACHINE

Competence

RQF Level: 4

Learning Hours



100

Credits: 10

Sector: Energy

Trade: Electrical Technology

Module Type: Specific

Curriculum: ENGELT4001-TVET Level 4 in Electrical Technology

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Purpose statement	This particular module describes the skills, knowledge and attitude required to build electromagnetic circuit of electrical machine. The electrician will be able to Assemble electromagnetic circuit of rotating machines, assemble electromagnetic circuit of static machines, Test electromagnetic circuit, carry out finishing activities, develop and attach the nameplate and Prepare user manual. It applies to electricians working in maintenance and electrical machines fabrication.					
Learning assumed to be in place	Industrial technical drawing, installation of industrial electrical control circuit and accessories, Industrial electrical motor installation.					
Delivery modality	Training delivery		100%	Assessment		Total 100%
	Theoretical content		30%	Formative assessment	30%	50%
	Practical work:		70%		70%	
	1. Group work and presentation	30%				
	2. Individual work	40%				
			Summative Assessment		50%	

Elements of Competency and Performance Criteria

Elements of competency	Performance criteria
1. Carry-out preliminary activities	1.1 Tools, materials, and equipment are appropriately identified based on types
	1.2 Electrical diagrams are properly interpreted in line with diagram types
	1.3 Personal Protective Equipment (PPE)s are properly used based on safety precautions
	1.4 Workplace is well prepared according to the workplace preparation policy and procedures
2. Assemble electromagnetic	2.1 The coils are properly formed according to the coil types, coil structure, coils inputs and outputs

circuit of rotating machines	2.2 The insulators are correctly shaped according to the slots size
	2.3 The insulators and coils are correctly inserted into slots according to the process
	2.4 Windings are properly insulated according to insulation method
3. Assemble electromagnetic circuit of static machines	3.1 Laminated sheets are properly formed according to laminated sheets shapes and cutting techniques
	3.2 Coil structure of static machines is appropriately fabricated according to the core types and size
	3.3 Transformer windings are constructed according to types of transformer windings
	3.4 Laminated sheets are properly inserted into transformer windings based on laminations insertion techniques
	3.5 Windings are properly insulated according insulation method
4 Test electromagnetic circuit	4.1 Insulation, Continuity and short-circuit are properly tested according to the testing technics
	4.2 Windings resistance is properly measured according to measurement technics
	4.3 Electromagnetic circuit of electrical machines is supplied in accordance with types of power supply and rating parameters
5 Carry out finishing activities	5.1 Electrical Machines are properly cleaned according to the cleaning technics
	5.2 Electrical machines are painted according to the painting techniques
	5.3 Electrical Machines paint is correctly cured according to paint curing techniques
	5.4 Name plate is properly developed and attached according to nameplate attaching methods and electrical machine technical specifications
6 Perform post-fabrication activities	6.1 components of electromagnetic circuit are correctly labelled according to labelling methods
	6.2 As-built diagram is correctly developed based on As-built diagram drawing procedures
	6.3 Workplace is properly rearranged according to the waste disposal procedures
	6.4 Cost is correctly estimated according to the cost estimation procedures

Intended Knowledge, Skills, and Attitude

Knowledge	Skills	Attitude
✓ Ability to use hand tools ✓ Ability to use power tools ✓ Proficiency in the use of test meters ✓ Ability to diagnose the equipment ✓ Ability of electrical measurement ✓ Mathematical analysis ✓ Electrical circuits analysis	✓ Apply Computer skills ✓ Communication skills ✓ Troubleshooting skills ✓ Reporting skills ✓ Interpersonal skills ✓ Analytical skills ✓ Problem solving skills ✓ Use of tools skills	✓ Honest ✓ Integrity ✓ Royalty ✓ Confident ✓ Time management ✓ Critical thinking ✓ Dignity

Course content

Learning outcomes	At the end of the module the learner will be able to: 1. Carry-out preliminary activities 2. Assemble electromagnetic circuit of rotating machines 3. Assemble electromagnetic circuit of static machines 4. Test electromagnetic circuit 5. Carry out finishing activities 6. Perform post-fabrication activities
Learning outcome 1: Carry-out preliminary activities	Learning hours: 5
Indicative content	
• Definition of key concepts • Identification of Tools, materials, and equipment ✓ Type of tools and Materials used while building magnetic circuit of electrical machines ✓ Equipment used while building magnetic circuit of electrical machines	

- **Interpretation of Electrical machines electromagnetic diagrams**

- ✓ Electrical machines windings diagrams

- **Use of Personal Protective Equipment (PPE)**

- ✓ Safety precautions

- **Preparation of the Work place**

- ✓ Workplace preparation policy and procedures
 - ✓ Types of fire extinguishers and their application
 - ✓ Types of workplace ventilation
 - ✓ Workplace cleaning procedures

Resources required for the learning outcome

Equipment	windings making machines, multimeter, PPE, Bench work, Wattmeter and Energy meter
Materials	Wires, rotating machines parts, static machines parts, soldering wires, winding cord, bamboo, scotches, Insulation materials, Connectors and Gain pipes
Tools	knives, Hammers, Screw drivers, Coil tamping tools, Mallet, Wire brushes, Wire strippers, slotting files, cutting pliers, Neon tester, Crimping tool, Multimeter, Nose Pliers, Line tester, soldering iron, Standard wire gauge, Soldering iron, hummers and Electromechanical tool kit.
Facilitation techniques	▪ Demonstration (Video show) ▪ Individualized, ▪ Trainer guided, ▪ Group discussion, ▪ Practical exercises,
Formative assessment methods I(CAT)	▪ Written assessment, ▪ Presentation, ▪ Product based assessment, ▪ Performance assessment

Learning outcome 2: Assemble electromagnetic circuit of rotating machines	Learning hours: 35
Indicative content	
• Formation of Coils (windings) ✓ Coils (windings) types ✓ Winding inputs and outputs calculations ✓ Winding (coils) diagrams ✓ Types of structures • Shaping of the insulators ✓ Slots size measurement methods • Insertion of the insulators and coils ✓ Insulator insertion process ✓ Coils insertion process • Insulating windings ✓ Windings insulation method	
Resources required for the learning outcome	
Equipment	Windings making machines, Multimeter, PPE, Bench work Wattmeter and Energy meter
Materials	Wires, rotating machines parts, static machines parts, soldering wires, winding cord, bamboo, scotches, Insulation materials, Connectors and Gain pipes
Tools	Knives, Hammers, Screw drivers, Coil tamping tools, Mallet, Wire brushes, Wire strippers, slotting files, cutting pliers, Neon tester, Crimping tool, Multimeter, Nose Pliers, Line tester, soldering iron, Standard wire gauge, Soldering iron, hummers, winding paddle and Electromechanical tool kit,
Facilitation techniques	▪ Demonstration (Video show) ▪ Individualized, ▪ Trainer guided, ▪ Group discussion, ▪ Practical exercises,
Formative assessment methods /(CAT)	▪ Written assessment, ▪ Presentation, ▪ Product based assessment,

Learning outcome 3: Assemble electromagnetic circuit of static machines

Learning hours: 35

Indicative content

- **Formation of laminated sheets**
 - ✓ Laminated sheets shapes
 - ✓ Sheet metal cutting techniques
- **Fabrication of coil structure**
 - ✓ Magnetic core type
 - ✓ Magnetic core size
 - ✚ Core area calculation
 - ✓ Calculation of number of turns (primary secondary)
- **Construction of transformer windings (coils)**
 - ✓ Winding of step-up transformer
 - ✓ Winding of step-down transformer
- **Insertion of laminated sheets**
 - ✓ Laminated sheets insertion technique
- **Insulation of windings**
 - ✓ Windings insulation method

Resources required for the learning outcome

Equipment	Windings making machines, multimeter, PPE, Bench work, Wattmeter, Energy meter
Materials	Wires, static machines parts, soldering wires, scotches, Insulation papers, Connectors, Gain pipes, varnish
Tools	knives, Hammers, Screw drivers, Coil tamping tools, Mallet, Wire brushes, Wire strippers, slotting files, cutting pliers, Neon tester, Crimping tool, Multimeter, Nose Pliers, Line tester, soldering iron, Standard wire gauge, Soldering iron, hummers, Electromechanical tool kit

Facilitation techniques	▪ Demonstration, ▪ Individualized, ▪ Trainer guided, ▪ Group discussion, ▪ Practical exercises, ▪ Video show.
Formative assessment methods / (CAT)	▪ Written assessment, ▪ Presentation, ▪ Product based assessment, ▪ Performance assessment.

Learning outcome 4: electromagnetic circuit	Test	Learning hours: 10
Indicative content		
• Testing electrical machines Insulation, Continuity and short-circuit ✓ Insulation testing technics (between windings and magnetic core) ✓ Continuity testing technics (input and output of winding) ✓ Short-circuit testing technics (between different windings) ✓ Transformer open circuit test ✚ Constant losses ✓ Transformer short-circuit test ✚ Variable copper losses • Measuring electrical machines windings resistance ✓ Windings resistance measurement technics • Supplying Electromagnetic circuit of electrical machines ✓ AC power supply ✚ Single phase supply parameters ✚ Three phase supply parameters		
Resources required for the learning outcome		
Equipment	Power supply, Multimeter, Bench work, Wattmeter and Energy meter	
Materials	-	
Tools	Knives, Hammers, Screw drivers, Coil tamping tools, Mallet, Wire brushes, Wire strippers, slotting files, cutting pliers, Neon tester, Crimping tool, Nose Pliers, Line tester, soldering iron, Standard wire gauge, Soldering iron, hummers and Electromechanical tool kit,	

Facilitation techniques	▪ Demonstration (Video show) ▪ Individualized, ▪ Trainer guided, ▪ Group discussion, ▪ Practical exercises,
Formative assessment methods / (CAT)	▪ Written assessment, ▪ Presentation, ▪ Product based assessment, ▪ Performance assessment

Learning outcome 5: Carry out finishing activities	Learning hours: 10
Indicative content	
• Cleaning electrical machine ✓ Electrical machine cleaning technics • Painting electrical machine ✓ Electrical machine painting technics • Paint Curing ✓ Paint curing techniques • Developing and attaching electrical machine nameplate ✓ Electrical machine technical specifications ✓ nameplate attaching methods	
Resources required for the learning outcome	
Equipment	PPE, Bench work, Painting machines, Riveting gun, Drill machine, Angle grinder and Sheet metal cutting machine
Materials	Paint, thinner and rivets
Tools	knives, Hammers, Screw drivers, Coil tamping tools, Mallet, Wire brushes, Wire strippers, slotting files, cutting pliers, Neon tester, Crimping tool, Nose Pliers, Line tester, soldering iron, Standard wire gauge, Soldering iron, hummers, pen scribe, chisel, Electromechanical tool kit,
Facilitation techniques	▪ Demonstration, ▪ Individualized, ▪ Trainer guided,

	▪ Group discussion, ▪ Practical exercises, ▪ Video show
Formative assessment methods I(CAT)	▪ Written assessment, ▪ Presentation, ▪ Product based assessment, ▪ Performance assessment

Learning outcome 6: Perform post-fabrication activities		Learning hours: 5	
Indicative content			
• Labelling electromagnetic circuit components ✓ Labelling methods ✚ Heat Shrink Labels ✚ Self-Laminating Wire Labels ✚ Wire/Cable Tags. • Developing as-built diagram ✓ As-built diagram drawing procedures • Rearrangement of the workplace ✓ cleaning techniques of workplace ✓ cleaning tool, materials and equipment of workplace ✓ Waste disposal procedures ✓ waste disposal treatment method • Estimation of cost ✓ Elements of bill of quantity (BOQ) ✓ BOQ table			
Resources required for the learning outcome			
Equipment	Computer, printer, scanner,		
Materials	Papers,		
Tools	Computer software		
Facilitation techniques	▪ Demonstration, ▪ Individualized, ▪ Trainer guided, ▪ Group discussion, ▪ Practical exercises.		

	▪ Video show
Formative assessment methods / (CAT)	▪ Written assessment, ▪ Presentation, ▪ Product based assessment, ▪ Performance assessment

Integrated/Summative assessment

Integrated situation

GASABO SOUDURE COMPANY Ltd located in Nyarugenge District, Gisozi sector is manufacturing the hydraulic press machine that will be used in producing sheet metal gutters, door frames and roofing sheets; they have so far fabricated and assembled all other required machine components and they are hiring an electrical machine fabricator to fabricate for them an electrical machine that will be connected to their three phase supply in order to rotate and drive the hydraulic pump and the one to lower the voltage from 220Volts to 24Volts suitable for the machine control circuit within 5 days.

Resources

Tools	Knives, Hammers, Screw drivers, Coil tamping tools, Mallet, Wire brushes, Wire strippers, slotting files, cutting pliers, Neon tester, Crimping tool, Nose Pliers, Line tester, soldering iron, Standard wire gauge, winding paddle, Soldering iron, pen scribe, chisel, Computer software, Electromechanical tool kit,
Equipment	Windings making machines, multimeter, PPE, Bench work, tool kit, Energy meter, Power supply, Wattmeter, Painting machines, Riveting gun, Drill machine, Angle grinder, Sheet metal cutting machine, Computer, printer, scanner,
Materials/ Consumables	Wires, rotating machines parts, static machines parts, winding cord, bamboo, scotches, Insulation materials, Connectors, gain pipes, soldering wires, Connectors, Gain pipes, varnish, Paint, thinner, rivets, Papers,

Assessable outcomes	Assessment criteria (Based on performance criteria)	Indicator	Observation		Marks allocation
			Yes	No	
1. Carry-out preliminary activities	1.1 Tools, materials, and equipment are appropriately identified based on types	Tools, materials, and equipment correctly identified			2

	1.2 Electrical diagrams are properly interpreted in line with diagram types	Electrical drawing is properly drawn			2
		Electrical drawing is correctly interpreted			2
	1.3 Personal Protective Equipment (PPE)s are properly used based on safety precautions	PPEs are correctly used			2
	1.4 Workplace is well prepared according to the workplace preparation policy and procedures	Working place is well cleaned			1
		Workplace is correctly arranged			1
2. Assemble electromagnetic circuit of rotating machines	2.1 The coils are properly formed according to the coil types, coil structure and coils inputs and outputs	Windings inputs and outputs are correctly calculated			4
		Winding structure is correctly chosen/constructed			4
		Lap coil is properly wound			4
		Wave coil is properly wound			4
		Concentric coil is properly wound			4
	2.2 The insulators are correctly shaped according to the slots size	The insulators are accurately measured			3
		The insulators are correctly shaped			3
	2.3 The insulators and coils are correctly inserted into slots according to the process	The insulators are properly inserted into slots			3
		The coils are properly inserted into slots			3
	2.4 Windings are properly insulated according to insulation method	windings insulation method is properly applied			3

3. Assemble electromagnetic circuit of static machines	3.1 Laminated sheets are properly shaped according to the magnetic sheet metal cutting techniques	Laminated sheets are correctly shaped			4
		Sheet metal cutting technics are correctly applied			4
	3.2 Coil structure of static machines is appropriately fabricated according to the shape and size	Structure shape is well respected			4
		Structure size is well respected			4
	3.3 Transformer winding is formed according to types of transformers	Primary winding is correctly formed			3
		Primary winding is correctly formed			3
	3.4 Laminated sheets are properly inserted into transformer windings insertion techniques	Laminated sheets are properly inserted			8
4. Test electromagnetic circuit	4.1 Insulation, Continuity and short-circuit are properly tested according to the testing technics	Insulation test is correctly conducted			1
		Continuity test is correctly conducted			2
		short-circuit test is correctly conducted			1
		Open circuit test is correctly conducted			1
	4.2 Windings resistance is properly measured according to measurement technics	Motor winding resistance is correctly measured			2
		Transformer winding resistance is correctly measured			1
	4.3 Electromagnetic circuit of electrical machines is supplied in accordance with supply parameters	The motor is appropriately supplied			1
		The transformer is appropriately supplied			1
5. Carry out finishing activities	5.1 Electrical Machines are properly cleaned according to the cleaning technics	Machine is properly cleaned			2
		Cleaning technics is described			1
	5.2 Electrical machines are painted according to the painting techniques	Painting technics are properly applied			2
	5.3 Electrical Machines paint is correctly cured according to paint curing techniques	Paint curing techniques are correctly used			2
	5.4 Name plate is properly	Electrical machine			1

	developed and attached according to nameplate attaching methods and electrical machine technical specifications	technical specifications Are correctly described			
		Electrical machine technical nameplate attaching methods are correctly applied			2
6. Prepare user manual	6.1 components of electromagnetic circuit are correctly labelled according to labelling methods	Labelling methods are correctly applied			2
	6.2 As-built diagram is correctly developed based on As-built diagram drawing procedures	As built diagram procedures are correctly applied			1
	6.3 Workplace is properly rearranged according to the wastes disposal procedures	Cleaning techniques are appropriately applied			1
	6.4 Cost is correctly estimated according to the cost estimation procedures	BO Q table is correctly filled			1
Total marks		100			
Percentage Weightage		100%			
Minimum Passing line % (Aggregate):		70%			

List of abbreviations

1. **RQF:** Rwanda Qualification Framework
2. **PPE:** Personal Protective Equipment
3. **CAT:** Continuous Assessment Test
4. **ELT:** Electrical Technology
5. **ENG:** Energy
6. **BOQ:** Bill of Quantity

References

1. Electrical machine and appliances theory by tamil nadu textbook corporation
2. A Textbook of electrical technology, volume2, B.I theraja, A.K. theraja
3. *AC motor starting and projection systems*, Schneider electronics
4. <https://www.iqsdirectory.com/articles/electric-coil.html>
5. <http://pe.org.pl/articles/2011/3/16.pdf>
6. <https://www.elprocus.com/differences-between-lap-winding-and-wave-winding/>
7. <https://www.elmotec-statomat.eu/en/manufacturing-process/slot-insulation/>
8. <https://www.elmotec-statomat.eu/en/manufacturing-process/slot-insulation/>
(insulators insertion process)
9. https://jcboseust.ac.in/electrical/images/induction_motor_design.pdf (slot size calculation)
10. <https://dreisilker.com/blog/4-types-of-motor-winding-insulation-methods/>
(windings insulation method)
11. https://coefs.charlotte.edu/mnoras/files/2013/03/Transformer-and-Inductor-Design-Handbook_Chapter_3.pdf (magnetic core shape)
12. <https://www.homemade-circuits.com/how-to-make-transformers/#:~:text=Core%20Area%3A%201.152%20x%20%E2%88%9A,winding%20needs%20to%20be%20considered.&text=Here%2C%20the%20frequency%20is%20usually%2050Hz%20for%20Indian%20household%20mains%20source> (core area calculation)
13. <https://www.electronics-tutorials.ws/transformer/transformer-construction.html>
(lamination insertion techniques)
14. <https://www.ei-lamination.com/transformer-construction/> (lamination insertion techniques)
15. <https://electrical-engineering-portal.com/electrical-insulation-testing> (insulation testing technique)
16. <https://www.fluke.com/en/learn/blog/digital-multimeters/how-to-test-for-continuity>
(continuity testing technique)
17. <https://www.electronicshub.org/how-to-find-a-short-circuit-with-a-multimeter/>
(shortcircuit testing technique)

18. [https://www.electrominst.com/test-summaries/winding-resistance-measurement/#:~:text=Winding%20resistance%20measurements%20are%20taken,milliohms\)%20according%20to%20Ohm's%20law](https://www.electrominst.com/test-summaries/winding-resistance-measurement/#:~:text=Winding%20resistance%20measurements%20are%20taken,milliohms)%20according%20to%20Ohm's%20law). (windings resistance measuring technics)
19. <https://wiki.testguy.net/t/cleaning-methods-for-electrical-preventive-maintenance/106> (machine cleaning method)
20. <https://www.spraysystems.com/the-different-types-of-paint-application-methods/> (paint method)
21. <https://www.blastone.com/the-fastest-ways-to-cure-paint-in-shop-environments/> (paint curing method)

Glossary

Activity: Activities include releases, events, and deployment plans that you develop, start, and complete with the product

Learning outcomes: Statements that indicate what learners will know or be able to do as a result of a learning activity. Learning outcomes are usually expressed as knowledge, skills, or attitudes.

Learning hours: Amount of hours required to acquire the competency, including the time allocated to evaluation, which is estimated between 5 and 10% of the total learning time of the competency

Knowledge: means the result of the adoption of information through the learning process. Knowledge is a set of facts, principles, theories and practices related to area of work or study. In CBE context lifelong learning knowledge is described as theoretical and / or factual

Skills: are the ability to apply knowledge and use the principle of “know how” to perform a specific task and to solve the problem. In the context of the CBE Framework, skills are defined as cognitive (involving the use of logical, intuitive and creative thinking), practical (including physical skill and use of methods, materials, devices and instruments) and social skills

(communication and cooperation skills, emotional intelligence and other

electromagnetic circuit: An electromagnet is a type of magnet in which the magnetic field is produced by an electric current

rotating machines: a machine with a rotating component that transfers energy to a fluid or vice versa

Credit: The acknowledgement that a person has satisfied the requirements of a module.

Assessment criteria: Statements which describe performances and place them in context with sufficient precision to allow valid and reliable assessment.

Electric motor (rotating machine): An electric motor is a device for converting electrical energy into mechanical energy in the form of rotation. In an electric motor, the moving part is called the rotor and the stationary part is called the stator.

Electrical Machine: An electrical machine is a device which converts mechanical energy into electrical energy or vice versa. Electrical machines also include transformers (static machine), which do not actually make conversion between mechanical and electrical form but they convert AC current from one voltage level to another voltage level

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.

Learning activities: Suggested activities that can be developed during lesson planning and activity preparation. The choice of learning activities must be tailored according to group size

Winding: A winding is one or more turns of wire that forms a continuous coil through which an electric current can pass.

open circuit: A circuit in which the continuity is broken due to which the electric current cannot flow is known as the open circuit. In an open circuit, the current flowing is zero, thus no power dissipates from an open circuit

Magnetic core: The magnetic core is a specific design of magnetic material in a particular shape that possesses high magnetic permeability. It is employed to confine and guide the magnetic fields in electrical, electromechanical, and magnetic devices.

Insulator: Materials that do not allow electricity to pass through them are called insulators. Insulators oppose electric current and so they are used as a protection from the dangerous effects of electricity. Examples of insulators are glass, air, wood, plastic and rubber

Assessment: A process of gathering and judging evidence in order to decide whether a person has attained a standard of performance.