26.2.0 ELECTRICAL POWER GENERATION AND TRANSMISSION

26.2.1 Introduction

This module unit is designed to provide the trainee with knowledge, skills and attitudes required to understand the application and operation of power systems including the generation, transmission and distribution of electric energy.

26.2.2 General Objectives

At the end of this module unit the trainee should be able to;

a) Operate various power generation plants
b) Observe safety in the work place
c) Ensure efficiency in power generation and utilization
d) Install, service and repair generation plant, overhead and underground distribution networks

26.2.2 Module Unit Summary and Time Allocation

Electrical Power Systems

Code	Sub Module Unit	Content	Time Hrs
26.2.1	Power generation	• Types of generating stations • Typical layout for generating stations • Operation of generating	12
26.2.2	Excitation systems	• Types of excitation schemes • Operation of exciters	10
26.2.3	Economics of power supply	• Generating costs • Load development • Economical conductor cross section area	10
26.2.4	Power factor improvement	• Causes of low power factor • Effects of low power factor • Methods of improving power factor • Location of power factor improvement equipment • Calculation on power factor improvement	16
26.2.5	Overhead transmission	• Conductor materials for transmission lines • Transmission line supports	16

		• Transmission line insulators • String efficiency • Methods of improving line efficiency • Insulator failures and tests • Derivation of line constraints (R-L-C)	
26.2.6	Under ground cables	• Insulating materials for underground cables • Cable conductor materials for underground cables • Types of under ground cables • Underground cable faults • Methods of locating underground cable faults • Calculations on underground cable parameters	10
26.2.7	Switch gear	• Symmetrical faults • Short circuit currents • Operating principles of various types of circuit breakers • Principle of arc extinction in circuit breakers • High Rupturing Capacity switches HRC fuses	14
Total Time			**88**

26.2.1 POWER GENERATION

Theory

26.2.1T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:

d) describe various types of generating stations
e) describe typical layouts of generating stations plants
f) outline the operation of generating stations.

Content

26.2.1T1 Types of generating stations
i) Hydro-electric
ii) Thermal
iii) Diesel
iv) Gas
v) Nuclear
vi) Geo-thermal
vii) Magneto-Hydro

26.2.1T2 Typical layouts of generating stations plants
i) Hydro
ii) Thermal
iii) Diesel
iv) Gas
v) Nuclear
vi) Geothermal
vii) Magneto-hydro

26.2.1T3 Operation of generating stations
i) Hydro
ii) Diesel
iii) Nuclear
iv) Geothermal
v) Magneto-hydro

26.2.1P0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:

c) Sketch layouts for various generating
d) Operate in a power generating station

Content

26.2.1P1 Layout of generating stations
i) Hydro
ii) Thermal
iii) Diesel
iv) Gas
v) Nuclear
vi) Geothermal
vii) Magneto-hydro

26.2.1P2 Operating sequence of generating stations
i) Hydro
ii) Thermal
iii) Diesel
iv) Gas
v) Nuclear
vi) Geothermal
vii) Magneto-hydro

26.2.1C Competence
The trainee should have the ability to:
i) Draw power station schematics
ii) Carry out operating sequence for generating stations in model form

Suggested Teaching/Learning Resources
- Power station model
- Overhead projector
- Field visit to various power generating stations

Suggested Evaluation Methods

- Oral tests
- Timed written tests
- Assignments
- Timed practical tests

26.2.2 EXCITATION SYSTEMS

Theory

26.2.2T1 *Specific Objectives*
By the end of the sub-module, the trainee should be able to:
a) draw the schematic diagram of various machine excitation schemes
b) explain the operation of machine excitation schemes

Content

26.2.2T2 Drawing the schematic diagram of excitation schemes
i) Direct current pilot exciter
ii) Direct current pilot exciter

26.2.2T3 Explaining the operation of the excitation schemes
i) Magnetic amplifier
ii) Thyristor amplifier
iii) Brushless excitation

Practice

26.2.2P *Specific Objectives*
By the end of the sub-module, the trainee should be able to:
a) draw schematic diagrams for various excitation schemes
b) connect and operate various excitation schemes

Content

26.2.2P1 Drawing the schematic diagrams of excitation schemes
i) Direct current pilot exciter
ii) Direct current main exciter

26.2.2C Competence
The trainee should have the ability to:
i) Draw schematic diagrams of excitation schemes
ii) Connect and operate pilot exciter and main exciter

Suggested teaching/Learning Activities

- Discussion
- Illustration
- Demonstration
- Note taking
- Visits to industries

Suggested Teaching/Learning Resources

- Visit a power station
- Model power station

Suggested Evaluation Methods

- Oral tests
- Timed written tests
- Assignments
- Timed practical tests

26.2.3T ECONOMICS OF POWER SUPPLY

Theory

26.2.3T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) explain generating costs in power generation and supplies
b) describe the concept of load development
c) derive the economical cross-sectional area of a transmission line

Content

26.2.3T1 Explaining the cost of generating and supply
i) Capital investment
ii) Interest and depreciation
iii) Fixed cost
iv) Semi-fixed cost
v) Running cost

26.2.3T2 Describing load development in a power system
i) Variable load on a power station
ii) Load curves
iii) Load factors and diversity factor
iv) Base load
v) Peak load and peak lopping
vi) Interconnected grid system

26.2.3T3 Deriving the expression for the most economical cross-sectional area
i) Annual cost of capital outlay
ii) Annual cost of energy lost
iii) Application of the Kelvin's law

Practice

26.2.3P0 *Specific Objectives*
By the end of the sub-module unit, the learner should be able to:
d) draw load curves
e) simulate load curves on a load chart
f) determine the factors associated with power plant development

Content

26.2.3P1 Drawing and simulating the load curves
i) Daily load curve
ii) Monthly load curve
iii) Yearly load curve

26.2.3P2 Determining factors associated with power plant development
i) Load factor
ii) Diversity factor
iii) Plan capacity factor

26.2.3C Competence
The trainee should have the ability to:
i) Simulate load curves in order to verify load factors and units generated in a power station

Suggested teaching/Learning Activities
- Discussion
- Illustration
- Demonstration

- Visits to industries
- Note taking

Suggested Teaching/Learning Resources
- KWH meter
- KVA meter

Suggested Evaluation Methods
- Oral tests
- Timed written tests
- Assignments

26.2.4 POWER FACTOR IMPROVEMENT

Theory

26.2.4P0 *Specific Objectives*
By the end of the sub-module, the trainee should be able to:
a) state causes of low power factor
b) describe the effects of low power factor to the system
c) explain the methods of improving the power factor
d) explain the need to identify a suitable location for the installation of power factor improvement/correction equipment
e) apply power factor improvement knowledge to solve problems

Content

26.2.4T1 Stating the causes of low power factor
i) Induction motors
ii) Line transformers
iii) Industrial heating furnaces
iv) Arc lamps

26.2.4T2 Describing the effect of low power factor
i) Greater copper loss
ii) Large copper loss
iii) Poor voltage regulation
iv) Large KVA equipment rating
v) Reduced handling capacity of the system

26.2.4T3 Explaining methods of improving power factor
i) Static capacitors
ii) Synchronous condensers
iii) Phase advances

26.2.4T4 Explaining the location of power factor improvement equipment
i) Capacitors
ii) Synchronous condensers
iii) Phase advances

26.2.4T5 Applying power factor knowledge to solve problems
i) Power triangle
ii) Leading KVAR

Practice

26.2.4. P0 *Specific Objectives*
By the end of the sub-module, the trainee should be able to:
a) connect power factor improvement equipment
b) design power factor improvement schemes

Content

26.2.4P1 Power factor improvement equipment
i) Static capacitors
ii) Synchronous condensers
iii) Phase advances

26.2.4P2 Designing power factor improvement schemes
i) Static capacitors
ii) Synchronous condensers
iii) Phase advances

26.2.4C Competence

The trainee should have the ability to:
i) Connect power factor improvement equipment
ii) Design power factor improvement schemes

Suggested teaching/Learning Activities
- Discussion
- Illustration
- Demonstration
- Note taking
- Practical exercise
- Calculations
- Project work

Suggested Teaching/Learning Resources
- Capacitors
- Synchronous motors
- Induction motors

Suggested Evaluation Methods
- Oral tests
- Timed written tests
- Assignments
- Timed practical tests

26.2.5 OVERHEAD TRANSMISSION LINES

Theory

26.2.5T0 *Specific Objectives*

By the end of the sub-unit, the learner should be able to:
a) describe various conductor materials used in the construction of transmission lines
b) describe various line supports used in transmission system
c) explain the different types of insulators used in transmission lines
d) carry out string efficiency calculations
e) explain methods of improving string efficiency
f) describe the insulator failures and their tests
g) derive the line constants (R-L-C)

Content

26.2.5T1 Describing the various conductor materials
i) Copper
ii) Aluminium
iii) Steel – cored aluminium
iv) Galvanized steel

v) Cadmium copper

26.2.5. T2 Describing various line supports
- i) Wooden poles
- ii) Steel tubular poles
- iii) Reinforced concrete poles
- iv) Steel towers

26.2.5T3 Explaining different types of insulators
- i) Pin type
- ii) Strain type
- iii) Suspension insulator

26.2.5T4 Performing string efficiency calculation
- i) Voltage distribution
- ii) String efficiency

26.2.5T5 Explaining methods used to improve string efficiency
- i) Use of longer cross-arms
- ii) Insulator grading
- iii) Guard ring

26.2.5T6 Describing the insulator failures and tests
- i) Flash over test
- ii) Puncture test
- iii) Porosity test
- iv) Mechanical test

26.2.5T7 Derivation of the line constants
- i) Resistance (R)
- ii) Inductance (L)
- iii) Capacitance (C)

Practice

26.2.5P0 *Specific Objectives*

By the end of the sub-module, the learner should be able to:
- a) draw diagrams of different types of insulators
- b) construct a model transmission line
- c) perform an experiment to calculate string efficiency
- d) perform insulator performance tests

Content

26.2.5P1 Drawing diagrams of insulators
- i) Pin type
- ii) Strain type
- iii) Suspension

26.2.5P2 Constructing a model transmission line
- i) Line conductors
- ii) Line supports
- iii) Insulators

26.2.5P3 Experiment on string efficiency
- i) Insulators
- ii) String efficiency

26.2.5P4 Insulator performance test
- i) Flash-over test
- ii) Puncture test
- iii) Porosity test
- iv) Mechanical test

26.2.5C Competence

The trainee should have the ability to:
- Construct model transmission lines
- Perform insulator performance test

Suggested Teaching/Learning Resources
- Different samples of insulator
- Different samples of line conductors

26.2.6 **UNDER GROUND CABLES**

Theory

26.2.6T0 *Specific Objectives*

By the end of the sub-module, the trainee should be able to:

a) explain different types of insulating material for underground cables
b) explain cable conductor materials
c) describe the construction of different types of underground cables
d) explain the types of cable faults
e) explain the procedure of locating cable faults
f) solve problem involving underground cables parameters

Content

26.2.6T1 Explanation of insulating materials
- i) Vulcanized rubber
- ii) Poly vinyl chloride (PVC)
- iii) Polythene
- iv) Paper

26.2.6T2 Explaining the cable conductor materials
- i) Copper
- ii) Aluminium

26.2.6T3 Describing the construction of underground cables
- i) Belled
- ii) Shielded
- iii) Oil filled
- iv) Pressure cables

26.2.6T4 Explanation of cable faults
- i) Open-circuit fault
- ii) Short-circuit fault
- iii) Earth fault

26.2.6T5 Explaining the procedure of locating the cable fault
- i) Murray loop test
- ii) Varley loop test

26.2.6T6 Solving problems involving underground cables
- i) Dielectric stress
- ii) Thermal resistance

Suggested teaching/Learning Resources

- Electrical tool kit
- Electrical measuring instruments
- Assorted cables and other electrical materials

Suggested teaching/Learning Activities

- Discussion
- Illustration
- Demonstration
- Note taking
- Practical exercise

Suggested Evaluation Methods

- Oral tests
- Timed written tests
- Assignments
- Timed practical tests

42.2.7 SWITCH GEAR

Theory

26.2.7T0 *Specific Objectives*
By the end of the sub-module the trainee should be able to:
a) explain the occurrence of symmetrical faults
b) describe types of short circuit currents
c) describe various types and operating principles of circuit breakers
d) explain the methods of electric arc extinction
e) describe the High Rupturing Capacity (HRC)Fuses

Content

26.2.7T1 The symmetrical fault
i) Insulation failure
ii) Mechanical injury
iii) Short-circuit KVA

26.2.7T2 Types of short-circuits
i) Between single phase and earth
ii) Between phase and phase
iii) Between two phases and earth
iv) Between all three phases
v) Between all three phases and ground

26.2.7T3 Types and operating principles of circuit breakers
i) Oil circuit breakers
ii) Air-blast circuit breakers
iii) Sulphur hexafluoride
iv) Vacuum circuit breakers

26.2.7T4 Methods of arc extinction
i) High resistance method
ii) Current zero (low resistance method)

26.2.7T5 Types of fuses
i) Low voltage fuses
ii) High-rupturing capacity (H.R.C)
iii) Cartridge
iv) Liquid type

Practice

26.2.7P0 *Specific Objectives*
By the end of the sub-module, the trainee should be able to:
a) simulate the occurrence of symmetrical faults in a model power system
b) perform short-circuit tests
c) verify the circuit breaker performance characteristics from oscillogram
d) verify the operating characteristics of HRC fuses

Content

26.2.7P1 Simulation of the occurrence of symmetrical fault
i) Insulation failure
ii) Mechanical injury

26.2.7P2 Performing short-circuit tests
i) Phase and earth
ii) Phase and phase

iii) Two phases and earth
iv) All three-phases
v) All three phases and earth

26.2.7P3 Verification of the circuit breaker performance characteristics
i) Oscillogram

26.2.7P4 Verification of the operating characteristics of HRC fuses
i) HRC fuses

26.2.7C Competence

The trainee should have the ability to:
i) Simulate symmetrical fault
ii) Perform short-circuit test

Suggested Teaching/Learning Resources

- Circuit breakers
- HRC fuses
- Oscilloscope

Suggested Evaluation Methods

- Oral tests
- Timed written tests
- Assignments
- Timed practical tests