35.3.0 ELECTRICAL POWER TRANSMISSION SYSTEMS

35.3.01 Introduction

The module unit is designed to equip the trainee with knowledge, skills and attitudes to install and maintain power transmission lines. The unit covers in-depth analyses of transmission lines, conductor faults and line protection.

35.3.02 General Objectives

At the end of the module unit, the trainee should be able to:

a) Design electrical overhead transmission schemes
b) Understand the operating principles of transmission and distribution units
c) Observe safety and standards when operating transmission lines
d) Design power systems regulation schemes
e) Interpret control systems charts in power generating and transmission systems

35.3.03 Module Unit Summary and Time Allocation

Power Systems II

Code	Sub Module Unit	Content	Time Hrs
35.3.1	Protection	• Protection schemes • Relaying systems • Unit protection • Non unit protection	16
35.3.2	Overhead Line Construction	• Conductor vibrations • Conductor tension and sag • Corona • Synchronous phase modifier	18
35.3.3	Overhead Line Transmission	• Classification of lines • Surge • Surge power and energy • Protection against surges	16
35.3.4	Overhead Lines Faults	• Symmetrical and asymmetrical faults • Equivalent circuits and phase sequence impendence matrix • Equivalent circuit for	18

		asymmetrical faults	
35.3.5	Power System Stability	• Stability of asynchronous machine feeding infinite bus bars • Steady state stability • Surge angle • Methods of improving power system stability	20
Total Time			**88**

35.3.1 PROTECTION

Theory

35.3.1T0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:
a) describe the systems of protective schemes
b) explain the types of relaying systems
c) explain the type of unit protection
d) describe the types of non unit protection

Content

35.3.1T1 Protective schemes
i) Core balance protective schemes
ii) Merze price protective schemes
iii) Pilot
iv) Pilotless

35.3.1T2 Types of relaying systems
i) Permanent magnet moving coil
ii) Balanced beam
iii) Induction type over current relay
iv) Distance relays
v) Directional relays
vi) Non directional relays
vii) Solid state relays

35.3.1T3 Types of unit protection
i) Generator protection
ii) Transformer protection
iii)Bus bars protection
iv)Feeder protection

35.3.1T4 Non unit protection
i) Directional over current protection
ii) Distance protection
iii) Grade time protection

Practice

35.3.1P0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:
a) Perform tests to show the tripping characteristics of different protective devices
b) Demonstrate the working of different types of protection relays

Content

35.3.1P1 Performance tests for the tripping characteristics of protective devices
i) High Rupturing Capacity fuse (HRC)
ii) Miniature Circuit Breakers (MCB)

35.3.1P2 Demonstration of the working of different types of relays
i) Distance
ii) Directional
iii) Non directional

35.3.1C Competence
The trainee should have the ability to control power lines in transmission systems to maintain

Suggested teaching/Learning Activities
- Discussion
- Illustration
- Demonstration
- Note taking

- Practical exercise continuity of supply

Suggested teaching /learning resources

i) Assorted relays
ii) Cabling and accessories
iii) Test board
iv) Measuring instruments

Suggested Evaluation Methods

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

35.3.2 OVER HEAD LINE CONSTRUCTION

Theory

35.3.2T *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:
a) explain the types of conductor vibrations
b) differentiate between types of conductors sag and tension
c) describe the corona phenomena in overhead transmission lines
d) explain the principles of the operation of the synchronous phase modifiers

Content

35.3.2T1 Types of conductor vibrations
i) Swinging
ii) Dancing
iii) Galloping of conductors
iv) High frequency vibrations

35.3.2T2 Differentiation of conductor sag and Tension
i) Catenary methods
ii) Unequal and equal ground level
iii) Effects of wind and ice loading

35.3.2T3 Description of the corona phenomena
i) Disruptive
ii) Visible
iii) Critical

35.3.2T74 Explaining the principles of operator of the synchronous phase modifier
i) lagging and leading VARs
ii) Voltage drop compensation

Practice

35.3.2P0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:
a) install different types of model transmission lines using different materials
b) perform experiments to demonstrate conductor sag

Content

35.3.2P4 Experiments to demonstrate conductor sag

35.3.2C **Competence**
The trainee should have the ability to Install, test and maintain overhead line poles and conductors

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

Suggested Teaching/Learning Resources
i) Overhead line insulators
ii) Test instruments

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

35.3.3 OVERHEAD LINE TRANSMISSION

Theory

35.3.3T0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:
a) classify transmission lines
b) explain the causes for surges in transmission lines
c) explain the phenomena of surges in transmission lines systems
d) describe the protection of surges against over voltages

Content

35.3.3T1 Classification of transmission lines
i) Short lines
ii) Medium lines
iii) Long line

35.3.3T2 Types of surges in transmission lines
i) Direct and indirect lighting strokes
ii) Switching surges due to
iii) Open circuited lines
iv) Short circuited lines
v) Load interruption
vi) Arching ground lines

35.3.3T3 Explanation of the phenomena of surges in transmission line systems
i) Surge velocity
ii) Surge impendence
iii) Open circuited lines
iv) Short circuited lines

35.3.3T4 Protection of transmission lines against surges effect and over currents
i) Overhead earth wire
ii) Horn gaps
iii) Silicon and zinc oxide surge diverter
iv) Peterson coil

Practice

35.3.3P0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to protect overhead lines against the phenomenon of surge

Content

35.3.3P1 Protection of overhead lines against surges
i) Overhead earth wire

ii) Horn gaps
iii) Silicon and Zinc oxide surge diverter
iv) Peterson coil

35.3.3C **Competence**
The trainee should have the ability to Install surge diverters to prevent the surge effects

Suggested Teaching/ Learning resources
- Protective devices
- Insulators
- Visits to industries

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

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

35.3.4 OVERHEAD LINE FAULTS

Theory

35.3.4T0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:
a) explain types of power line faults
b) describe the symmetrical and asymmetrical faults
c) outline the equivalent circuit for the asymmetrical faults
d) explain the operation of the equivalent circuit and phase sequence impendence matrix

Content

35.3.4T1 Types of power line faults
i) Single phase earth faults
ii) Three phase balanced fault
iii) Line to line ground fault
iv) Line to line fault
v) Arching ground fault

35.3.4T2 Description of symmetrical and asymmetrical faults
i) Balanced faults
ii) Unbalanced faults
iii) Positive, negative and zero sequence vectors
iv) Impendence connection matrix for faults

35.3.4T3 The equivalent circuit for the asymmetrical faults

35.3.4T4 Operation of the equivalent circuit and phase sequence impedance matrix

Practice

35.3.4P0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:
a) draw equivalent circuits for the phase sequence matrix
b) simulate equivalent circuit and determine the sequence impendence matrix

c) verify through experiment the difference between
d) symmetrical and asymmetrical faults

Content

35.3.4P1 Equivalent circuit for phase sequence matrix
35.3.4P2 Circuit simulation
35.3.4P3 Symmetrical and asymmetrical faults verification

35.3.4C **Competence**
The trainee should have the ability to:
- Determine line faults for symmetrical and asymmetrical
- conductors
- Simulate faults and apply them to determine protective devices ratings

Teaching /Learning resources
- Experimental models for fault levels
- Measuring instruments

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

35.3.5 POWER SYSTEM STABILITY

Theory

35.3.5T0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:
a) describe the stability of the synchronous generator feeding infinite bus bars
b) derive the equal area criteria for transient stability
c) derive the swing equation
d) describe the method for improving power system stability

Content

35.3.5T1 Description of synchronous generators stability
- Power transfer regulation

35.3.5T2 Derivation of equal area criteria
i) Change in load
ii) Change in transfer reactance due to switching
iii) Change in transfer reactance due to fault

35.3.5T3 Derivation of the swing equation
- Load angle/time curve

35.3.5T4 Description of methods of improving system stability Turbine governor
- Automatic voltage regulations

Practice

35.3.5P0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:

a) connect the synchronous machine to adjust to infinite bus bars
b) set the synchronous machine to adjust excitation

Content

35.3.5P1 Connection of synchronous machine to infinite bus bars
i) Syncro -scope
ii) Lamps dark method
iii) Lamps bright method

35.3.5P2 Setting of the synchronous machine to adjust excitation system:
i) Leading power factor
ii) Lagging power factor

35.3.5C **Competence**
The trainee should have the ability to connect test and run synchronous machine to infinite bus bars

Suggested *Teaching/Learning Resources*
- Synchro - scope
- Generating machine
- Lamps
- Accessories

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