24.2.0 ELECTRIC CIRCUIT ANALYSIS

24.2.01 Introduction

The module unit deals with the analyses of networks that contain electrical and electronic components, and it is designed to provide the trainee with knowledge, skills and attitude necessary in understanding the behaviour of electronic components and other circuit devices when used in electrical and electronic circuits. Upon completion of the unit, the trainee will gain knowledge necessary to construct diagnose faults and test functional electric circuits.

24.2.02 General Objectives

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

a) Understand the principles of electric circuit components
b) Analyse electrical networks
c) Perform experiments to verify various electric circuit theories
d) Apply network, theories in solving engineering problems
e) Observe safety regulations and standards when carrying out electrical work

easyvet.com

24.2.03 Module Unit Summary and Time Allocation

Electric Circuit Analysis

Code	Sub-Module Unit	Content	Time Hrs
24.2.1	Electric circuit analysis	• Complex quantities • Single phase circuits • Circuit theories • Star delta/delta-star transformation	6
24.2.2	Transients	• Growth and delay in R-C circuits • Growth and delay in R-L circuits • Calculations	6
24.2.3	Three phase Induction Motors	• Construction of 3 phase induction motors • Principles of operation of three phase induction motor • Starless three phase induction motor • Characteristics of three phase induction motor • Applications of three phase induction motors	6
24.2.4	Three-Phase Synchronous Machines	• Construction • Operation • Synchronization	6

		• Applications • Calculations	
24.2.5	Two Port Networks	• Basic passive networks • Characteristic impedance • Transmission lines • ABCD constants • Network in cascades	4
24.2.6	Three Phase Systems	• Principles of three phase • Methods of three phase • Line and phase quantities • Calculations on three • Methods of power	6
24.2.7	Complex wave forms	• Complex waveforms • Sources of harmonics • Analysis of complex waveforms • Calculations on complex waveforms • Harmonics in transformers • Problem solving	8
24.2.8	dc Machines	• Construction • Operation • Classification • Starting methods • Armature reaction • Characteristics of dc machines • Applications of dc machines	6
24.2.9	Single Phase Motors	• Construction of single phase motors • Operation of single phase motors • Characteristics of single phase motors • Application of single phase motors	8
24.2.10	Special Machines	• Construction of various special machines • Operation of various special machines • Characteristics of various special machines • Application of special machines	4
24.2.11	Three-Phase Transformers	• Construction • Operation • Characteristics • Applications • Calculations	6
Total Time			**66**

easyhai.com

24.2.1 ELECTRIC CIRCUIT ANALYSIS

Theory

24.2.1T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) describe the principles of complex quantities
b) solve single phase ac circuits using complex quantities
c) solve network problems using theories
d) explain the principle of star-delta and delta-star transformation

Content

24.2.1T1 principles of complex quantities
i) Polar exponential and rectangular co-ordinates
ii) Concept of impedance and admittance
iii) Series and parallel resonance
iv) Q factor of a coil
v) Selectivity
vi) Calculation of power in single phase circuits

24.2.1T2 single phase ac circuits
i) Series
ii) parallel

24.2.1T3 network problems
i) Thevernin's theorem
ii) Nortons theorem
iii) Millman's theorem
iv) Maximum power transfer theorem

24.2.1T4 Star-delta and delta-star transformation calculations

Practice

24.2.1P0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) perform experiments to establish the relationship between current and voltage in R-L-C series and
b) parallel circuits
c) measure Q factor of a coil
d) measure power in single phase ac circuits
e) build circuits to demonstrate network theorems and power transfer

Content

24.2.1P1 Relationship between current and voltage in R-L-C series and parallel circuit.

24.2.1P2 Q factor of a coil

24.2.1P3 Power in single phase AC circuits

24.2.1P4 Network theorems
i) Thevernin's
ii) Norton's
iii) Millman's
iv) Maximum power transfer

24.2.2C **Competence**

easytvet.com

The trainee should have the ability to:
i) Measure power in AC circuits
ii) Design electric circuits

Suggested teaching/Learning Activities
- Question and answer
- Illustration
- Demonstration
- Note taking
- Observation
- Practical exercise
- Calculations

Suggested Teaching/Learning Resources
- Bread boards
- Measuring instruments
- Electronics components
- Circuit diagrams

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

24.2.2 TRANSIENTS

Theory

24.2.2T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) explain the growth and decay in R-C circuits
b) explain the growth and decay in the RL circuits
c) solve problems in capacitive and inductive circuits

Content

24.2.2T1 Growth and decay in R-C circuits
i) Charge ad discharge curves on RC circuits
ii) Equation for instantaneous voltages currents and transient currents

24.2.2T2 Growth and decay in R-L circuits
i) Charge and discharge curves for R-L circuits
ii) Equation for instantaneous voltages and current

24.2.2T3 Solution of problems
i) Capacitive circuits
ii) Inductive circuits

Practice

24.2.2P0 *Specific Objectives*
By the end of the sub-module unit, the trainee should:
a) perform an experiment to pilot growth and decay curves for RC and LC circuits
b) determine the time constants
c) plot the resonance curves for LC series and parallel circuits

Content

24.2.2P1 Growth and decay curves
i) RC circuits
ii) RL circuits

24.2.2P2 Resonance curves
i) Series circuits

easytvet.com

ii) Parallel circuits

24.2.2C Competence

The trainee should have the ability to: demonstrate transient in ac and dc circuits

Suggested teaching/Learning Activities

- Discussion
- Question and answer
- Illustration
- Demonstration
- Note taking
- Observation
- Practical exercise
- Calculations

Suggested Teaching/Learning Resources

- Bread boards
- Measuring instruments
- Electronics components
- Circuit diagrams
- *Suggested Evaluation Methods*
- Oral tests
- Timed written tests
- Assignments
- Timed practical tests

24.2.3 THREE PHASE INDUCTION MOTORS

Theory

24.2.3T0 *Specific Objectives*

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

a) describe the construction of a three phase induction motor
b) explain the principle of operation of three induction motor
c) describe the starless three phase induction motor
d) describe the characteristics of three phase induction motor
e) state the applications of three phase induction motor

Content

24.2.3T1 Construction of three phase induction motor
- i) Stator
- ii) Rotor

24.2.3T2 Principle of operation of three phase induction motor
- i) Production of rotating field
- ii) Production of torque
- iii) Slip
- iv) Relationship between speed pole pairs and frequency
- v) Power stages and power loses

24.2.3T3 Starters for:
- i) Direct-on-line starter
- ii) Star-delta starter
- iii) Auto transformer starter
- iv) Resistance starter

24.2.3T4 Characteristics of three phase induction motor
- i) Torque / speed
- ii) Torque slip
- iii) Torque current

24.2.3T5 Application of three phase induction motors
- i) Industrial / commercial
- ii) Domestic

easytvet.com

Practice

24.2.3P0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) install three phase induction motors - starter
b) trouble shoot faults in three phase motors

Content
24.2.3P1 Three phase motor starters
i) Direct on line
ii) Star delta
iii) Auto reverse
iv) Slip-ring starter
v) Auto transformer
24.2.3P2 Faults in three phase motors
i) Short circuits
ii) Open circuits
iii) heating

24.2.3C **Competence**
The trainee should have the ability to:
i) Install 3 phase induction motors
ii) Maintain 3 phase induction motors

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

Suggested Teaching/Learning Resources
- 3 phase motors
- Measuring instruments
- Motor starters
- Tools and equipments
- Ac power supply
- Three phase power supply

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

24.2.4 THREE PHASE SYNCHRONOUS MACHINE

Theory

24.2.4T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) describe the construction of three phase synchronous
b) explain the principles of operation of three phase synchronous machine
c) explain the starting and synchronizing methods of three phase synchronous machine
d) explain the characteristics of three-phase synchronous machine
e) state the application of three-phase synchronous machine
f) solve problems on synchronous machines

easytvet.com

Content

24.2.4T1 Construction of three phase
- i) Stator
- ii) Rotor
- iii) Salient pole rotor
- iv) Cylindrical rotor

24.2.4T2 Principle of operation of three phase synchronous machine
- i) Not self starting
- ii) Operation of synchronous speed only
- iii) Operation characteristics

24.2.4T3 Starting and synchronizing methods
- i) Pony motor starting
- ii) Induction starting
- iii) Synchronising methods
- iv) Lamps methods
- v) Dark lamp
- vi) Lamp in sequence
- vii) Synchro-scope

24.2.4T4 Characteristics of three phase synchronous machine
- i) Operates at synchronous constant speed
- ii) Inherently not self starting
- iii) Operates at loading and logging power factor
- iv) V-curves characteristics

24.2.4P5 Application of three phase synchronous machine
- Constant speed drive
- Improvement of power factors

24.2.4T6 Problems on three phase synchronous machine
- Power factor implement problems

Practice

24.2.4P0 *Specific Objectives*

By the end of the sub-module unit, the trainee should be able to:
- a) install 3 phase synchronous machine
- b) synchronise of three phase synchronous machines

Content

24.2.4T1 3-phase synchronous machine
- i) Induction starting
- ii) Pony motor starting

24.2.4T2 Synchronization of three phase synchronous machine
- i) Lamps method
- ii) Dark lamp
- iii) Lamps in sequence
- iv) Synchroscope method

24.2.4C **Competence**

The trainee should have the ability to: install and test three phase synchronous machine

Suggested teaching/Learning Activities
- Discussion
- Illustration
- Demonstration
- Note taking
- Practical exercise
- Calculations
- Visits to industries

easytvet.com

Suggested Teaching / Learning Resources

- 3 phase synchronous machines
- Synchroscope
- Lamps
- Tools and equipment
- Measuring instruments

Suggested Evaluation Methods

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

24.2.5 TWO PORTS NETWORKS

Theory

24.2.5T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) describe basic passive networks
b) analyse characteristics impendance of network circuits
c) analyse equivalent circuits on transmission line
d) derive ABCD constant
e) explain network in cascade

Content

24.2.5T1 Basic passive networks
i) π networks
ii) T-networks
iii) Lattice networks
iv) Balanced T-network

24.2.5T2 Characteristics impedance of network circuits
i) Symmetrical T-circuit
ii) Symmetrical π circuit
iii) Insertion loss
iv) Logarithmic ratios

24.2.5T3 Equivalent circuits on transmission line
i) Short transmission lines
ii) Medium length lines

24.2.5T4 ABCD constants
i) Evaluation of ABCD constant
ii) Characteristics impedance

24.2.5T5 Network in cascade

Practice

24.2.5P0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) construct passive networks
b) demonstrate impedance characteristics

Content

24.2.5P1 Construction of passive networks
i) π-networks
ii) T-networks
iii) Lattice networks
iv) Balanced T-networks

24.2.5P2 Impedance characteristics of network circuits
i) Symmetrical T-circuit
ii) Symmetrical π circuit

24.2.5C Competence
The trainee should have the ability to:
i) Apply two port networks to solve problems in electric
ii) circuits

easytvet.com

iii) Teaching / Learning Resources
iv) Electronics components
v) Tools
vi) Bread board
vii) Measuring instruments

Suggested teaching/Learning Activities

- Discussion
- Illustration
- Demonstration
- Note taking
- Practical exercise
- Calculations
- Visits to industries

Suggested Evaluation Methods

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

24.2.6 THREE PHASE SYSTEMS

Theory

24.2.6T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) explain the principles of three phase generation
b) describe various methods of three phase connections
c) explain the difference between line and phase quantities
d) solve problems on three phase balanced systems
e) explain methods of power measurement in three phase balanced systems

Content

24.2.6T1 Principles of three phase generation
i) Three phase windings
ii) Rotating magnetic field
iii) Electromagnetic induction
iv) Waveforms

24.2.6T2 Methods of three phase connections
i) Star connection
ii) Delta connection

24.2.6T3 Line and phase quantities in three phase star and delta connected loads

24.2.6T4 Calculations on three phase balanced systems

24.2.6T5 Methods of power measurement
i) One wattmeter method
ii) Two wattmeter method

Practice

24.2.6P0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) demonstrate three phase generation
b) measure active reactive and apparent power

Content

24.2.6P1 Three phase generation

easytvet.com

i) Star
ii) Delta

24.2.6P2 Power measurements
i) One wattmeter method
ii) Two wattmeter method

24.2.6C Competence

The trainee should have the ability to:
i) Install three phase circuits
ii) Measure power in three phase circuits

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

Suggested Teaching/Learning Resources
- Charts
- Generator set
- Oscilloscope
- Watt meters

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

24.2.7 COMPLEX WAVEFORMS

Theory

24.2. 7T0 *Specific Objectives*

By the end of the sub-module unit, the trainee should be able to:
a) explain the complex waveform
b) describe the sources of harmonics
c) analyse the effects of harmonics in single phase circuits
d) explain the effects of harmonics in three phase transformers
e) solve problems on complex waveforms

Content

24.2. 7T1 Complex waveforms
i) Definitions
ii) Fundamental
iii) Harmonics
iv) Complex waveforms
v) Sketch
vi) Even harmonics
vii) Odd harmonics

24.2. 7T2 Sources of harmonics
i) Rectifier circuits
ii) Valve circuits
iii) Transistor circuits
iv) Iron-cored coils
v) Generators

24.2. 7T3 Effects of harmonics in single phase circuits
i) Selective resonance
ii) Third harmonics and triplets
iii) RMS values
iv) Power and power factor

24.2. 7T4 Effects of harmonics in three phase transformers
i) Star-delta connection
ii) Delta-star connection
iii) Tertiary connection
iv) Harmonic contents in phase and line values

easytvet.com

for various connections

24.2. 7T5 Solution of problems on complex waveforms
i) Harmonic contents
ii) RMS values
iii) Line and phase values

Practice

24.2. 7P0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) display complex waveforms
b) demonstrate the effects of harmonics

Content

24.2. 7P1 Display of complex waveforms
i) Rectifier circuits
ii) Valve circuits
iii) Transistor circuits
iv) generators

24.2.7P2 Effects of harmonics
i) single phase circuits
ii) transformers

Suggested Learning Resources
- Generator sets
- Electronic circuits
- Measuring instruments
- Charts

24.2.8 DC MACHINES

Theory

24.2. 8T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) describe the construction of dc machines
b) explain the principle of operation of dc machines
c) describe the classification of dc machines
d) describe the operation of face plate starter
e) explain armature reaction and commutation
f) describe the characteristics of the machines
g) state the applications of dc machines

Content

24.2. 8T1 Construction of dc machines
i) Yoke
ii) Main poles
iii) Field/magnetizing coins
iv) Armature
v) Commutator
vi) Brushes and brush gear
vii) Bearings

24.2. 8T2 Principle of operation of dc machine

24.2. 8T3 Classification of dc machines
i) Separately excited
ii) Self excited
iii) Long compound
iv) Short compound

24.2. 8T4 Face-plate starter
i) Need
ii) Protective devices
iii) Operation

24.2. 8T5 Armature reaction and commutation

24.2.8T6 Characteristics of dc machines
i) Generators
ii) Motors

easytvet.com

24.2. 8T7 Application of dc machines

Practice

24.2. 8P0 *Specific Objectives*
By the end of the sub - module unit, the trainee should be able to:
a) demonstrate the operation of dc machines
b) install and operate a face-plate starter

Content
24.2.8P1 Dc machines operation
- Separately excited
- Self excited

24.2.8P2 Installation and operation of face-plate starter

24.2.8C Competence
- The trainee should have the ability to: install and test dc machines

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

Suggested Teaching/Learning Resources
- Dc generators
- Dc motors
- Face plate starter
- Measuring instruments
- Charts
- Dismantling tools

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

24.2.9 SINGLE PHASE MOTORS

Theory

24.2. 9T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) describe the construction of single phase motors
b) explain the principle of operation of single phase ac motors
c) describe the characteristics of single phase ac motors
d) state the application of single phase ac motors

Content
24.2. 9T1 Construction of single phase ac motors
i) Stator
ii) Rotor

24.2. 9T2 Principles of operation of single phase ac motors
i) Split phase
ii) Capacitor start
iii) Shaded pole
iv) Repulsion induction motor
v) Universal motor

24.2. 9T3 Characteristics of single phase ac motors

easytvet.com

i) Torque/speed characteristics
ii) Split phase
iii) Capacitor start
iv) Capacitor run
v) Shaded pole
vi) Repulsion induction motor
vii) Universal motor

24.2. 9T4 Applications of single phase motors

Practice

24.2.9P0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) identify the main parts of a single phase ac machine
b) install and test single phase motors

Content

24.2. 9P1 Parts of a single phase ac motor
i) Stator
ii) Rotor
iii) Commutators
iv) Brushes

24.2.9P2 Installation and testing of single phase ac motors

24.2.9C Competence
The trainee should have the ability to: install and test single phase ac motors

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

Teaching/Learning Resources
- Single phase motors
- Motor starter
- Charts
- Measuring instruments
- *Suggested Evaluation Methods*
- Oral tests
- Timed written tests
- Assignments
- Timed practical tests

24.2.10 SPECIAL MACHINES

Theory

24.2. 10T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) describe the construction of various special machines
b) explain the principle of operation of various special machines
c) explain the characteristics of various special machines
d) state the applications of various special machines

Content

24.2. 10T1 Construction of special machines
i) Amplidyne and metadynes
ii) Linear motors
iii) Stepper motors
iv) Series motors
v) Universal motors

easytvet.com

24.2. 10T2 Principle of operation of special machines
i) Amplidyne and metadynes
ii) Linear motors
iii) Stepper motors
iv) Series motors
v) Universal motors

24.2. 10T3 Characteristics of special machines

24.2. 10T4 Application of special machines

Practice

24.2. 10P0 *Specific Objectives*
By the end of the sub - module unit, the trainee should be able to demonstrate the principles of operation of various special machines

Content

24.2. 10P1 Principles of operation of special machines
i) Stepper motor
ii) Linear motor
iii) Servo motor

24.2.10C Competence
The trainee should have the ability to:
i) identify various special machines
ii) demonstrate the operation of various special machines
iii) Calculations

Suggested teaching/Learning Activities
i) Discussion
ii) Illustration
iii) Demonstration
iv) Note taking

Suggested Teaching/Learning Resources
- Various special machines
- Measuring instruments
- Charts
- Manuals

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

24.2.11 THREE PHASE TRANSFORMERS

Theory

24.2. 11T0 *Specific Objective*
By the end of the sub - module unit, the trainee should be able to:
a) describe the construction of three phase transformer
b) explain the principle of operation of three phase transformer
c) explain the three phase transformer characteristics
d) state applications of three phase transformers

Content

24.2. 11T1 Construction of three phase transformer
i) Primary windings
ii) Secondary windings
iii)Iron core types

24.2. 11T2 Principle of operation of three phase transformer
i) Current and voltage

easytvet.com

ii) Turns ratio
iii) Relationship between primary and secondary values
iv) Transformer E.M.F equation
v) Star-delta/delta-star connections

24.2. 11T3 Characteristics
i) Transformer on load
ii) Efficiency test
iii) Open circuit test and short circuit test
iv) Iron and copper losses

24.2. 11T4 Application of three phase transformers

Practice

24.2.11P0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) demonstrate the operation of three phase transformers
b) test three phase transformers

Content

24.2. 11P1 operation of three phase transformers

24.2.11P2 tests on three phase transformer

24.2.11C Competence
The trainee should have the ability to: install and test three phase transformers

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

Suggested Teaching/Learning Resources
- 3 phase transformers
- Measuring instruments
- Charts

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

easytvet.com