

**1. Module details**

**Module name**

**Applied Electricity — a.c. systems**

**Module duration**

It is expected that students with the appropriate entry knowledge and skills will successfully complete this module in 72 – 80 hours.

**Module code**

NUE059

**Discipline code**

0703

**2. Module purpose**

This module helps prepare Learners for further development in the power applications of electricity. It provides Learners with the fundamentals concepts of alternating current and the terms used to describe waveforms and sine waves in particular. They will gain an understanding of how resistive, inductive and capacitive components behave in an a.c. circuit. Learners will develop skills in working with and solving problems in single source series and parallel a.c. circuits.

Further, it provides Learners with knowledge of the consequences of low power factor and how this is dealt with in practice. They will gain an understanding of three phase systems and circuits and the relationship between line and phase values. Learners will develop skills in solving systems problems involving balanced and unbalanced systems. Also, the module introduces the problems associated with harmonics in a.c. systems.

**3. Prerequisites**

Applied Electricity (d.c.)

**4. Relationship to competency standards**

This module provides part of the underpinning knowledge and skills identified in the ‘Evidence Guide’ of specific units in the National Electrotechnology Competency Standards. The module provides similar support for equivalent units in the National Metals and Engineering Competency Standards.

**5. Content**

1. Sinusoidal alternating voltage and current
  - generation of a sinusoidal waveform
  - sinusoidal waveform characteristics
  - measuring and calculating values
  - phase relationships

2. Phasors
  - phase relationship terms
  - phasor representation conventions
  - phase relationships using phasors
3. Resistance in a.c. circuits
  - determine V, I, R, P
  - relationship between voltages and currents
4. Inductance in a.c. circuits
  - reactance
  - inductance in series
  - inductance in parallel
  - Applying Ohm's Law
  - inductive components in power circuits and systems
5. Capacitance in a.c. circuits
  - reactance
  - capacitance in series
  - capacitance in parallel
  - applying Ohm's Law
  - capacitance components in power circuits and systems
6. Resonance
  - conditions
  - resonance and frequency
  - effects on current
7. Power and power factor
  - true, apparent and reactive power
  - effects of low power factor
  - improvement
  - requirements

8. Multiphase systems
  - comparison of multiphase system
  - advantage of three phase system
9. Three phase principles
  - generation
  - relationship between generated voltages
  - phase sequence
10. Three phase star-connections
  - connections
  - line and phase voltages and currents
  - typical loads
11. Three phase four wire systems
  - purpose of neutral conductor
  - line and phase voltages and currents
  - neutral current
  - requirements
12. Three phase delta-connections
  - connections
  - line and phase voltages and currents
  - typical loads
13. Interconnected star and delta systems
  - connections
  - line and phase currents and voltages
14. Energy and power requirements of a.c. systems
  - purpose of energy, power, power factor and demand measurement
  - methods
  - power factor improvement

	<p>15. Harmonics</p> <ul style="list-style-type: none"> <li>• harmonics and selective resonance</li> <li>• sources in a.c. systems</li> <li>• problems</li> </ul>
<p><b>6. Assessment strategy</b></p>	
<p><b>Assessment methods</b></p>	<p>Assessment should be progressive reflecting an holistic approach to ensure the module purpose is met. To assist in ensuring validity, reliability and fairness assessment instruments should include practical exercises, assignments and written tests consisting of a number of item types, such as multiple choice, short answer and problem solving.</p>
<p><b>Conditions of assessment</b></p>	<p>Normally learning and assessment will take place in a classroom / laboratory environment</p>
<p><b>7. Learning outcome details</b></p>	
<p><b>Learning outcome 1</b></p>	<p>Demonstrate an understanding of alternating voltage and current waveforms and how they are generated.</p>
<p><b>Assessment criteria</b></p>	<p>1.1 Explain how a sinusoidal voltage is generated in a single turn coil rotated in a uniform magnetic field.</p> <p>1.2 Define the terms ‘period’, ‘maximum value’, ‘peak-to-peak value’, ‘instantaneous value’, ‘average value’, ‘root-mean-square (r.m.s.) value’, ‘crest factor’ and ‘form factor’ in relation to a sinusoidal waveform.</p> <p>1.3 Calculate the instantaneous value of induced voltage of a generated sinusoidal waveform.</p> <p>1.4 Measure the instantaneous, peak, peak-to-peak values and the period of a sinusoidal waveform.</p> <p>1.5 Calculate the, root-mean-square (r.m.s.) value and frequency of a sinusoidal waveform from values of peak voltage and period.</p> <p>1.6 Determine the phase relationship between two or more sinusoidal waveforms from a given diagram or measurements.</p>
<p><b>Learning outcome 2</b></p>	<p>Show the phase relationship between sinusoidal alternating voltages and current.</p>

**Assessment criteria**

- 2.1 Define ‘in-phase’, ‘out-of-phase’, ‘phase angle’, ‘lead’, and ‘lag’.
- 2.2 Determine the phase angle between two or more alternating quantities from a given sinusoidal waveform diagram.
- 2.3 Show the convention for representing voltage, current and the reference quantity in a phasor diagram.
- 2.4 Draw phasor diagrams to show the relationship between two or more a.c. values of voltage and/or current.

**Learning outcome 3**

Work with single-source resistive a.c. circuits and solve problems related to voltages, currents and power dissipated in such circuit.

**Assessment criteria**

- 3.1 Set up and connect a single-source a.c. circuit and take resistance, voltage and current measurements.
- 3.2 Determine the voltage, current, resistances or power dissipated from measured or given values of any two of these quantities.
- 3.3 Show the relationship between voltage drops and current in a resistive a.c. circuit.

**Learning outcome 4**

Explain how inductance behaves in an a.c. circuit.

**Assessment criteria**

- 4.1 Define ‘inductive reactance’.
- 4.2 Calculate the inductive reactance of a given inductor and show the relationship between inductive reactance and frequency.
- 4.3 Apply series and parallel circuit rules to determine the equivalent inductive reactance in an a.c. circuit or any part of a circuit.
- 4.4 Apply Ohm’s Law to determine voltage, current or inductive reactance in a purely inductive a.c. circuit given any two of these quantities.
- 4.5 Give examples of inductive components in power circuits and systems and describe their effect on the phase relationship between voltage and current.
- 4.6 Compare the current limiting characteristics of inductors and resistors.

**Learning outcome 5**

Explain how capacitance behaves in an a.c. circuit.

**Assessment criteria**

- 5.1 Define 'capacitive reactance'.
- 5.2 Calculate the capacitive reactance of a given capacitor and show the relationship between capacitive reactance and frequency.
- 5.3 Apply series and parallel circuit rules to determine the equivalent capacitive reactance in an a.c. circuit or any part of a circuit.
- 5.4 Apply Ohm's Law to determine voltage, current or capacitive reactance in a purely capacitive a.c. circuit given any two of these quantities.
- 5.5 Give examples of capacitive components in power circuits and systems and describe their effect on the phase relationship between voltage and current.

**Learning outcome 6**

Work with single-source a.c. circuits and solve problems related to voltages, currents and impedance in such circuit.

**Assessment criteria**

- 6.1 Define 'impedance'.
- 6.2 Determine the impedance of series, parallel and series-parallel circuits and draw diagrams showing the relationship between resistive, inductive and capacitive components (impedance triangle).
- 6.3 Set up and connect a single-source a.c. circuit and take resistance, voltage and current measurements.
- 6.4 Determine the voltage, current or impedance from measured or given values of any two of these quantities.
- 6.5 Use phasor diagrams to solve problems and show the relationship between voltages and currents in a.c. circuits.

**Learning outcome 7**

Demonstrate a basic understanding of resonance, its effects and applications.

**Assessment criteria**

- 7.1 Describe the conditions in a circuit that produce resonance.
- 7.2 Show the relationship between resonance and frequency.

	7.3	Describe the effect on the current of series resonance and parallel resonance conditions.
	7.4	State applications where resonance is applied
<b>Learning outcome 8</b>		Demonstrate an understanding of the consequences of low power factor and how this is dealt with in practice.
<b>Assessment criteria</b>	8.1	Explain the difference between true power, apparent power and reactive power and the units in which these quantities are measured.
	8.2	Define the term "power factor".
	8.3	Describe the effects of low power factor.
	8.4	List typical applications of transformers.
	8.5	State local and AS 3000 requirements regarding the power factor of an installation and power factor improvement equipment.
<b>Learning outcome 9</b>		Discuss the principle of multiphase systems and the reasons for the adoption of a three phases for power systems.
<b>Assessment criteria</b>	9.1	Describe the features of a multiphase system.
	9.2	Compare the voltages generated by single and multiphase alternators.
	9.3	List the reasons for the adoption of three phases for power systems.
<b>Learning outcome 10</b>		Demonstrate an understanding of three phase principles and how three phases are generated.
<b>Assessment criteria</b>	10.1	Describe how three phases are generated in a single alternator.
	10.2	Calculate the r.m.s. value of voltage generated in each phase given the maximum value.
	10.3	Show the relationship between the phase voltages generated in a three phase alternator and the conventions for identifying each.
	10.4	Explain the term "phase sequence" (also, referred to as "phase rotation").

<b>Learning outcome 11</b>	10.5 Determine the phase sequence of a three phase supply. Demonstrate an understanding of three phase star-connections.
<b>Assessment criteria</b>	11.1 Make a three phase star-connection. 11.2 Show the phase relationship between line and phase voltages and line and phase currents of a star-connected system. 11.3 Determine the r.m.s. value of line and phase voltage given any one of these quantities. 11.4 Determine the r.m.s. value of line and phase current given any one of these quantities. 11.5 Explain the terms “balanced load” and “unbalanced load”. 11.6 Give example of balanced and unbalanced loads in typical power systems.
<b>Learning outcome 12</b>	Demonstrate an understanding of three phase four wire systems.
<b>Assessment criteria</b>	12.1 Explain the purpose of the neutral conductor in a three phase four wire systems. 12.2 Determine the effects of a high impedance in the neutral conductor of a three phase four wire system supplying an unbalanced load where MEN earthing is employed. 12.3 Determine the value and phase relationship of neutral current in an unbalanced three phase four wire systems given line currents and power factors. 12.4 State the AS 3000 requirements regarding neutral conductors.
<b>Learning outcome 13</b>	Demonstrate an understanding of three phase delta-connections
<b>Assessment criteria</b>	13.1 Make a three phase delta -connection. 13.2 Show the phase relationship between line and phase voltages and line and phase currents of a delta - connected system. 13.3 Determine the r.m.s. value of line and phase voltage given any one of these quantities.

	13.4 Determine the r.m.s. value of line and phase current given any one of these quantities.
	13.5 Give example of delta - connection loads in typical power systems.
<b>Learning outcome 14</b>	Demonstrate an understanding of interconnected star and delta connected devices.
<b>Assessment criteria</b>	14.1 Show the relationship between line and phase voltages and line and phase currents in a system with a star-connected supply device and a delta-connected load.
	14.2 Show the relationship between line and phase voltages and line and phase currents in a system with a delta-connected supply device and a star-connected load.
<b>Learning outcome 15</b>	Demonstrate an understanding of the energy and power requirements of a.c. power systems and loads and how these are dealt with in practice.
<b>Assessment criteria</b>	15.1 Explain the purposes for measuring power, energy, power factor and maximum demand of a.c. power systems and loads.
	15.2 Describe the methods used to measure power, energy power factor and maximum demand.
	15.3 Determine how the power factor of a three phase installation can be improved.
<b>Learning outcome 16</b>	Identify sources that produce harmonics in a.c. power systems and the problems harmonics can cause.
<b>Assessment criteria</b>	16.1 Define the term “harmonic” in relation to the sinusoidal waveform of an a.c. power system.
	16.2 List sources in a.c. systems that produce harmonics.
	16.3 Describe some of the problems that may arise in a.c. circuits as a result of harmonics and how these are overcome.

**8. Delivery of the module**

**Delivery strategy**

Delivery strategies must be suitable for learning both theoretical and practical aspects described in the module purpose. It is considered that the most effective way to achieve this is by the integration of theory and practice where students learn by experimentation and through research and laboratory reports. It is recommended that learning and assessment be facilitated in a holistic manner which may require learning outcome sequence other than that indicated in the module.

**Resource requirements**

Resources should be sufficient for students to carry out experiments on an individual basis. This will require a range of experimental circuit devices and measuring instruments.

Useful references include:

Jenneson, J.R. 1996, *Electrical Principles for Electrical Trades*, 4th Ed., McGraw Hill, Sydney

Van den Bergen, B. 1996, *Mathematics for the Electrical Trades*. TAFE Publications, RMIT, Melbourne.

Standards Australia, Standards New Zealand:

AS/NZS 4836 *Safe working practice on low-voltage electrical installations*

WorkCover Codes of Practice

Where this module is used in an approved Traineeship or Apprenticeship program learners should be advised to obtain, where available, respective EEQSBA<sup>1</sup> **User Guides** (these outline in detail what training and work performance the Learner is required to undertake for the program).

**Occupational health and safety requirements**

A safe and healthy environment will be provided for learners and teachers. Safety procedures for the particular learning facilities shall be followed as part of the learning / teaching activity and assessment.

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<sup>1</sup> EEQSBA – ElectroComms and EnergyUtilities Qualifications Standards Body of Australia Ltd