1. Module details

Module name — **Advanced Oscillators**

Module duration — It is expected that students with the appropriate entry knowledge and skills will successfully complete this module in 18 - 20 hours.

Module code — NUE701

Discipline code — 0703120 Electric Circuits, Networks and Systems.

2. Module purpose

This module will provide students with knowledge of the range of common oscillator circuits, both sinusoidal and non-sinusoidal, and the skills to perform adjustments and diagnose faults.

3. Prerequisites

NUE158 Introduction to Resonance, Filters and Oscillators.

4. Relationship to competency standards

This module provides part of the underpinning knowledge and skills in the 'Evidence Guide' of specific units of competency in the National Electrotechnology Training Package and provides similar support, where mapped, to equivalent units in the National Metals and Engineering Competency Standards. For details refer to the module to unit maps, available from NUEITAB.

5. Content

LC oscillators using discrete or lumped components
Colpitts
Clapp
Hartley
Miller

Electromechanically-controlled oscillators (quartz crystal and/or ceramic resonators)
Adaptations of LC oscillators
Pierce
Butler

Variable-frequency oscillators

Voltage-controlled oscillators

Synthesised-tuning phase-locked loops

RC oscillators
Phase shift oscillators
Wien Bridge oscillators

Non-sinusoidal oscillators
Astable and bistable circuits
The 555 integrated circuit oscillator
Discrete component circuits (blocking oscillators and integrated circuit VCOs)

6. Assessment strategy

Assessment methods

Assessment should be progressive reflecting a 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.

Conditions of assessment

Learning and assessment will take place in an environment that is conducive to a learner's development.

7. Learning outcome details

Learning outcome 1

Examine and describe the operation of LC oscillators using discrete or lumped components.

Assessment criteria

1.1 State the Barkhausen criterion for oscillation and describe a tuned LC (discrete component and lumped-component such as a resonant line) circuit as a frequency-determining network.

1.2 Describe a tuned LC circuit as an inverting or non-inverting network and as a voltage step-down or a voltage step-up network.

1.3 State the need for power gain in an oscillator.

1.4 Select a suitable LC circuit to provide the correct phase and amplitude of feedback for a given amplifier configuration (inverting/non-inverting, voltage gain > 1.0 and voltage gain < 1.0).

1.5 Recognise examples of typical LC oscillator circuits and state the advantages and disadvantages of each type.

1.6 Construct typical LC oscillator circuits, measure output voltage waveforms and calculate (and confirm by measurement) the operating frequency.

1.7 Observe and record the effects of power supply voltages on operating frequency and power output of typical LC oscillators.

1.8 Observe and record the effects of ambient temperature on the operating frequency of typical LC oscillator circuits and comment on the temperature-dependence of LC oscillators.

1.9 Take measurements to locate and rectify faults given suitable (single fault) LC oscillator circuits.

Learning outcome 2 **Examine and describe the operation of electromechanically-controlled Oscillators (quartz crystal and/or ceramic resonators).**

Assessment criteria

2.1 Describe the piezo-electric and electrical characteristics of a quartz crystal.

2.2 Describe the quartz crystal as the equivalent of a resonant LC circuit, and state that it may act as a series or a parallel LC circuit.

2.3 Identify quartz crystal variants of LC oscillator circuits.

2.4 Describe the Pierce Oscillator as a variant of the Colpitts Oscillator.

2.5 Describe the use of quartz-controlled oscillators using Transistor-Transistor Logic (TTL) and Complementary Metal Oxide Silicon (CMOS) Integrated Circuits as the active elements.

2.6 Describe the use of integrated (“all-in-the-can”) quartz crystal oscillators commonly used as clock generators in small computer systems and peripherals.

2.7 Describe overtone operation in quartz crystal oscillators and state its advantages and disadvantages.

2.8 Describe the characteristics of a ceramic resonator that allow its substitution for a quartz crystal as a frequency-determining element.

2.9 Construct typical quartz crystal oscillator circuits, measure output voltage waveforms and calculate (and confirm by measurement) the operating frequency.

2.10 Replace the quartz crystal in an oscillator circuit with a ceramic resonator and determine the accuracy of operating frequency.

2.11 Compare the performance of quartz crystal-controlled and ceramic resonator-controlled oscillators in terms of applications, operating frequency and frequency stability.

2.12 Take measurements to locate and rectify faults given suitable (single fault) electromechanically-controlled oscillator circuits.

Learning outcome 3 — **Examine and describe the operation of variable-frequency oscillators.**

Assessment criteria

3.1 Describe the characteristics of a LC oscillator circuit with variable-value inductors and with variable-value capacitors.

3.2 Calculate the maximum and minimum frequencies of oscillation for nominated oscillator circuits with given variable values.

3.3 Construct LC oscillator circuits with variable-value capacitor and/or inductor tuning, measure output voltage waveforms and calculate (and confirm by measurement) the operating frequency.

3.4 Calculate the values of variable inductance and variable capacitance to deliver the required frequencies, given oscillator circuits with specified frequency ranges.

3.5 Take measurements to locate and rectify faults given suitable (single fault) variable-frequency oscillator circuits.

Learning outcome 4	**Examine and describe the operation of voltage-controlled LC oscillators (VCOs).**
Assessment criteria	4.1 Describe the characteristics of a reverse-biased semiconductor diode as a voltage-variable capacitor. 4.2 Calculate the resonant frequency of typical LC oscillator circuits with voltage-variable tuning element. 4.3 Construct LC oscillator circuits with a voltage-variable tuning element, measure output voltage waveforms and calculate (and confirm by measurement) the operating frequency. 4.4 List applications for voltage-controlled LC oscillators. 4.5 Take measurements to locate and rectify faults given suitable (single fault) Voltage-controlled oscillator circuits.
Learning outcome 5	**Examine and describe the operation of synthesised-tuning phase-locked loops (PLLs).**
Assessment criteria	5.1 Describe the operation of a phase comparator. 5.2 Describe the combination of a phase comparator and a VCO as a phase-locked loop. 5.3 Describe the combination of a phase-locked loop and a programmable frequency divider as a frequency synthesiser. 5.4 Describe how a frequency synthesiser may be designed to divide and multiply the reference frequency. 5.5 Measure the output voltage waveform and calculate (and confirm by measurement) the operating frequency of a synthesised-tuning phase-locked loop given a prepared PLL circuit. 5.6 Describe the use of phase-locked loops as demodulators in frequency modulation communications and signaling systems.

Learning outcome 6 — **Examine and describe the operation of RC oscillators.**

Assessment criteria

6.1 Describe the phase change in a single series RC network, and calculate the overall phase change for three or four identical cascaded networks.

6.2 Describe the operation of an inverting amplifier with an RC network providing a phase shift of 180º as a phase-shift oscillator.

6.3 State the minimum amplifier gain for a three-section and a four-section phase shift oscillator.

6.4 Construct a phase shift oscillator circuit, measure output voltage waveforms and calculate (and confirm by measurement) the operating frequency.

6.5 List the advantages and disadvantages of the phase-shift oscillators.

6.6 Describe the phase change in a single shunt RC network, and state the phase change in networks with identical RC values, but connected in series and in parallel.

6.7 State that the Wien Bridge gives a phase shift of zero degrees at one particular frequency.

6.8 State that the Wien Bridge oscillator uses a voltage amplifier with no signal inversion and a gain > 1.0 to create the conditions for oscillation, and that the negative feedback path is required to stabilise the oscillator's output and reduce distortion.

6.9 Calculate the operating frequency of a Wien Bridge oscillator circuit.

6.10 Measure output voltage waveform and calculate (and confirm by measurement) the operating frequency of a prepared Wien Bridge oscillator circuit.

6.11 List the advantages and disadvantages of the Wien Bridge oscillator, with emphasis on its use in audio signal generators.

6.12 Take measurements to locate and rectify faults given suitable (single fault) RC oscillator circuits.

Learning outcome 7	**Examine and describe the operation of Non-sinusoidal Oscillators.**
Assessment criteria	7.1 State that two cascaded inverting amplifiers with voltage gains > 1.0 will meet the Barkhausen criteria.
	7.2 State that two cascaded, RC-coupled , inverting amplifier stages can be made to oscillate at a frequency determined by RC time constants in the coupling circuits and that this is an astable (flip-flop) oscillator.
	7.3 Calculate the oscillation frequency of nominated astable RC oscillators and comment on their applications.
	7.4 Describe the operation of the 555-class of astable integrated circuit oscillator in terms of its comparator trip voltages relative to the supply, charging and discharging of the timing capacitor, and comment on its applications.
	7.5 Describe the operation of the 555-class of xxxxx in terms of its quiescent state and trigger mechanism, comparator trip voltage relative to the supply, charging and discharging of the timing capacitor, circuit retriggeriability and comment on its applications.
	7.6 Construct a 555 astable oscillator circuit, measure output voltage waveform and calculate (and confirm by measurement) the operating frequency.
	7.7 Take measurements to locate and rectify faults given a suitable (single fault) 555 astable oscillator circuits.
	7.8 Modify a 555 astable oscillator circuit for monostable operation, measure the output voltage waveform and observe its characteristics, including programmable time delays, and test for retriggerability.
	7.9 Describe the operation of a typical blocking oscillator in terms of its on time, its off time, the regenerative cycle, and comment on its applications.
	7.10 Measure the output voltage waveform and calculate (and confirm by measurement) operating frequency of a prepared blocking oscillator circuit.

7.11 Describe the operation of an integrated circuit function generator in terms of its frequency-determining network, frequency control, and the available output waveforms and their purity.

7.12 Measure the output voltage waveform and calculate (and confirm by measurement) the operating frequency of a prepared integrated circuit function generator.

Note This device is commonly found in low-cost “sine-square-triangle” generators.

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 method to achieve this is by integration of theory and practice where students learn by experimentation, research and reports. It is recommended that learning and assessment be facilitated in a holistic manner that may require learning outcome sequence other than that indicated in the module.

Notes:

(1) This module encompasses a wide range of circuit philosophies and techniques. Training organisations are advised to treat the content at the descriptive and/or compare-and-contrast levels, rather than attempting to undertake detailed circuit analysis for the various topics.

(2) For practical work where construction of oscillator circuits is specified this may be implemented using suitable components and circuit construction methods (“breadboard”, “superstrip” or prepared circuits).
Trainers may already possess typical circuit boards for laboratory purposes. These are greatly preferred to having the students construct circuits for each practical session, since in-class construction often consumes valuable time in correcting construction errors. If construction is needed, trainers should consider setting the construction as out-of-class assignment work.
Given that this is a 20 nominal hour module, trainers may substitute trainer demonstrations and student report writing in place of hands-on practical work.

Resource requirements	*Resources should be sufficient for students to carry out learning activities on an individual basis. This will require the following:* Suitable laboratory equipment: benches, lighting, adequate working space, seating. Media for circuit construction: “breadboards”, “superstrip”. Components for circuit construction: fixed and variable resistors, fixed and variable capacitors, fixed and variable inductors, varicaps, transistors, quartz crystals, ceramic resonators, 555 ICs, connecting wire, test leads. Prepared and demonstration circuits. Test equipment: power supplies, multimeters, analog and digital signal generators, oscilloscopes, frequency meters. Data books or textbook descriptions of components: general electronic components, transistors, quartz crystals, ceramic resonators, varicaps ,PLL ICs, 555 ICs.
Occupational health and safety requirements	A safe and healthy environment will be provided for students and teachers as well as the particular safety procedures followed as part of the learning / teaching activity and content.