1 Module Details

Module Name

Waveguides and Devices

Nominal duration

It is expected that students with the appropriate entry knowledge and skills will successfully complete this module in 54 - 60hours

Module code

NUE098

Discipline code

0703230 Electronic Installation and Maintenance

2 Module purpose

This module will provide the student with the necessary theoretical and practical skill to assess, measure, maintain and monitor radar and associated equipment utilising waveguides and antenna devices.

3 Prerequisites

NUE170 Microwave Devices & Components

4 Relationship to competency standards

This module provides some of the knowledge and skills underpinning competency in the following standards: National Electrotechnology Industry Standards, Unit NES803 Metals and Engineering Industry Standards, Units 18.51, 18.57A, 18.62A.

5 Content

1. Safety with non-ionising sources
   - safety symbols and signs
   - precautions
   - Australian Standard AS2772
   - safe absorption rate (SAR)
   - peak power limits
   - average power limit
   - time limited exposure
   - leg currents
   - measuring equipment
   - E and H field intensity
   - power density of RF directed fields
   - power density of RF leakage fields

2. Test equipment
   - measure and characterise waveguides network
   - measure and characterise antenna devices
   - network analysers -polar and cartesian
   - S parameter analysers
   - frequency generators - fixed and sweeping
   - spectrum analysers
   - dummy loads - air or water cooled
   - peak power meters and associated sensors
   - average power meters and associated sensors
   - VSWR meters
   - attenuators
   - detectors
   - directional couplers
   - calibrated horn antenna
   - antenna factor (AF)

- calibrated RF cables
- precision connectors
- RF voltmeters/millivoltmeters and associated sensors
- waveguide/coaxial transitions
- system specific built in test equipment (BITE)
- special purpose test sets such as (IFF)
- calibration status of test equipment
- errors of measurement and their relevance
- charts and graphs
- loss
- mismatch
- SWR
- dialectric constants

3. Waveguide – installation, operation, testing and maintenance
   - wave guide electric and magnetic propagation modes (review)
   - optimum wave launching and detection points
   - mismatches and discontinuities
   - attenuators
   - irises
   - vanes
   - joint gaskets
   - seals
   - pressure windows
   - materials
   - frequency
   - power
   - internal and external finishes
   - mechanical damage
   - pressurisation
     - safety
     - gases
     - actual pressure
   - E and H bends and corners
   - flexible waveguide versus rigid waveguide
   - couplings
   - “O” rings and groove size
   - circulators
     - 3 and 4 port
     - faraday rotation
     - materials
     - operation
   - diplexors
   - duplexors
   - cavity resonators
   - ferrites
     - materials
     - curie temperature
     - use in isolators, circulators and other devices
   - rotary joints
     - single
     - multi port
   - transmit/receive cells (T/R)
     - types
     - speed of operation
     - power handling capability

- losses

4. Antennas – operation, testing and maintenance
   - principles of gain, directivity and polarisation
   - types (review)
     - parabolic
     - phased arrays
     - slotted arrays
     - end fed arrays
     - centre fed arrays
     - geometrical shaped reflectors
   - scan modes (review)
     - search
     - track
     - helical
     - horizontal
     - vertical
     - spiral
     - conical
     - nodding
   - point source and line source models
   - near and far field distances
   - field distributions
   - side or rear lobes in antenna patterns
     - effects
     - presence
   - location of feed points with respect to the reflector
   - squint and boresight errors
     - measurement
     - effects
     - correction
   - mechanical and electronic array scanning
   - electronic array phase switching
   - radomes and effect on radar performance
   - ranging and use of ranging information
   - type of wave launching sources (horn, dipole, etc)
   - mechanical mountings and platforms
     - stabilisation
     - fixed ground
     - aircraft
     - shipboard
   - antenna rotation
     - methods
     - elevation
     - positioning

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 a classroom/laboratory environment and in a real or simulated

	radar installation.
7 Learning Outcome Details	
Learning Outcome 1	Outline the risks to personnel from non-ionising radiation.
Assessment criteria	1.1 Interpret the safety signs and symbols associated with non-ionising sources. 1.2 State the physiological effects of non-ionising radiation.
Learning Outcome 2	Conduct an electrical/electronic evaluation of a waveguide/antenna installation for operational integrity and personnel safety.
Assessment criteria	2.1 Select equipment for measuring power and field strengths in waveguides and antennae. 2.2 Use suitable equipment to measure power and reflected power in waveguides. 2.3 Use suitable equipment to measure field strengths and scattered reflected point voltages/fields from radiating antennas or waveguide couplings using the criteria of AS2772. 2.4 Compare a waveguide/antenna installation against the criteria in AS2772. 2.5 Calculate ground range using Rg= Rs cos E given Rs and E 2.6 Define; I slant range, ground range target height
Learning Outcome 3	Measure parameters associated with devices used in waveguides and antennae.
Assessment criteria	3.1 Describe the characterising parameters associated with waveguides and antennae. 3.2 Select appropriate test equipment from commercial test equipment catalogues to properly carry out measurements related to waveguides and antennae. 3.3 Describe the features of systems that have built in test equipment (BITE). 3.4 Calibrate test equipment so as to obtain readings to a specified accuracy. 3.5 Calculate derived parameters (for example, Peak values from average values and duty cycle). 3.6 Operate test equipment make measurements of parameters in waveguide and antenna installations.
Learning Outcome 4	Install, operate, test and maintain waveguide systems.
Assessment criteria	4.1 Describe and perform calculations (where applicable) on the following aspects of waveguides: • frequency and physical size relationship • propagation • current and voltage distribution within wave guides • power handling - peak - pulse

- average
- continuous
- mismatch
- terminations
- losses
- installation
- materials

4.2 Select appropriate waveguide components from commercial catalogues to properly connect a radar power amplifier to an antenna input given:
- power output of radar
- frequency
- pulse repetition frequency
- pulsewidth

4.3 Install waveguide components to properly connect a radar power amplifier to an antenna input giving consideration to:
- physical stress
- potential mismatches
- effects of internal debris

4.4 Test waveguide components installed to connect a radar power amplifier to an antenna input.

Learning Outcome 5

Install, operate, test and maintain radar antenna facilities.

Assessment criteria

5.1 Describe and perform calculations (where applicable) on the following aspects of radar antenna facilities:
- antenna patterns
  polarisation type – rectangular, circular, elliptical
  ground reflections
- scanning modes
- methods of beam forming arrays and the advantages gained by such methods
- antenna patterns due to geometric reflector shapes such as cosecant and cosecant squared
- relationship of feed source to reflector for optimum performance
- scattering and reflections of antenna patterns

5.2 Select appropriate radar antennae for specific platforms:
- ground
- aircraft
- shipboard

5.3 Discuss the uses of various antenna types:
- navigation
- tracking
- search
- airport
- ground/air
- military
- civilian

5.4 Calculate power in directed beams and power in lobes.

5.5 Calculate near and far field transition and power.

5.6 Test radar antennae properties and radar antennae mechanical supports.

5.7 Describe maintenance procedures for radar antennae and their mechanical supports.

5.8 List the four main parameters used to measure the

effectiveness of a directive antenna.

5.9 List the two normal methods of horn feed.

5.10 Describe the operation of a typical cassegrain antenna.

5.11 Describe the principles of operation for a:
- dielectric lens antenna
- metal plate lens antenna
- resonant slotted waveguide radiator
- slotted array

5.12 State the major advantage of a non-resonant slotted array over a resonant type and described how this advantage is achieved

5.13 Describe the principles of "squint angle".

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 a learning outcome sequence other than that indicated in the module.

Resource requirements

Students will need access modern test equipment and components such as

- network analysers -polar and cartesian
- S parameter analysers
- frequency generators - fixed and sweeping
- spectrum analysers
- dummy loads - air or water cooled
- peak power meters and associated sensors
- average power meters and associated sensors
- VSWR meters
- attenuators
- detectors
- directional couplers
- calibrated horn antenna
- calibrated RF cables
- precision connectors
- RF voltmeters/millivoltmeters and associated sensors
- waveguide/coaxial transitions

It is expected that visits to an airport (military and/or civilian), a commercial ship and to a naval vessel fitted with a high power radar would be made. An opportunity to visit an antenna range would also be useful.

The laboratory used for the teaching of practical aspects of this module will require a small working radar with suitable rigid waveguide and couplings connecting the antenna and power amplifier output. The radar will need to have an adjacent clear area to enable students to gain experience in taking field measurements. Whilst measurements may be carried out using low power test equipment sources the use of

	a complete radar system as an item of test equipment will provide the student with a much greater "real world" experience. Useful references include • Kennedy. G. Electronic Communication Systems. McGraw Hill • Skolnik. M. Introduction to Radar Systems. McGraw Hill • Jasik. H. Antenna Engineering Handbook. McGraw Hill • IEEE. Microwave Engineers Handbook Volumes 1 and 2. Artech House • Blake. L. Antennas. Wiley and Sons • ITT. Reference Data for Radio Engineers. Sams • Standards Australia. AS2772 (latest issues of both parts)
Occupational health and safety requirements	A safe and healthy environment will be provided for students and teachers as well as safety procedures followed with regard to teaching/learning activities.