1 Module Details

Module Name

Microwave Devices and Components

Nominal duration

It is expected that students with the appropriate entry knowledge and skills will successfully complete this module in 40 hours

Module code

NUE170

Discipline code

0703230 Electronic Installation and Maintenance

2 Module purpose

This module will provide the student with the basic knowledge and skills to assess, measure, maintain, test and replace microwave devices and components.

3 Prerequisites

Communications Fundamentals (NE 39)
and
Introduction to Radar (NUE177)

4 Relationship to competency standards

This module provides some of the knowledge and skills underpinning competency in the following standards:
National Electrotechnology Industry Standards, Units: NES106, NES206, NES301, NES402, NES501;
Metals and Engineering Industry Standards, Units: 18.51, 18.57A, 18.62A.

5 Content

1. Safety
   - safety symbols and signs
     - high voltages
     - ionising radiation hazards
     - non-ionising radiation hazards
   - personnel safety in the vicinity of:
     - radiation hazards
     - high voltage hazards
   - high voltage arcing
   - insulation

2. Propagation of electromagnetic waves
   - through the atmosphere
   - transmission lines
   - waveguides
   - characteristic impedance Z_o
   - impedance matching
   - standing waves
   - microwave frequency bands

3. Microwave device parameters
   - wavelength
   - phase
   - VSWR
   - impedance matching
   - circuit parameters
   - amplifiers
     - transmit
     - receive

- oscillators
- noise figure
- noise temperature

Microwave devices and components

- microwave operational constraints
- operating parameters:
  - power
  - bandwidth
  - gain
  - noise figure
  - efficiency
  - life
  - voltage
  - stability
  - cooling
  - size
  - signal flow
  - linearity
  - testing
- active devices:
  - diodes
    - Gunn
    - tunnel
    - IMPATT
    - PIN
    - Step-recovery
  - transistors
    - bipolar
    - GaAs FET
    - HEMT
    - MMIC
  - valves
    - magnetrons
    - klystrons
    - reflex klystrons
    - travelling wave tubes
    - masers
    - lasers
    - beam focussing and accelerator coils
  - amplifiers
    - cross field
    - solid state
    - parametric
  - oscillators
  - modulators
  - mixers and detectors
  - microwave switches
- passive components:
  - chip components
  - printed components
  - ferrites
    - attentuators
    - isolators
    - circulators
  - cavity resonators

4. Microwave measurements

- active devices
  - signal sources

- amplifiers
- detectors

- passive devices
  - attenuators
  - isolators
  - circulators

Test equipment

- Equipment
  - S parameter analysers
  - frequency generators - fixed and sweeping
  - spectrum analysers
  - dummy loads - air and water cooled
  - power meters and associated sensors
  - VSWR meters
  - calibrated RF cables
  - RF voltmeters/millivoltmeters and associated sensors
- Calibration
- Errors of measurement and their effects
- Charts and graphs

5. EMI/EMC
   - generation
   - suppression
   - reduction

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

Describe the risks to personnel from radiation hazards and materials associated with microwave devices.

Assessment criteria

1.1 Demonstrate safety techniques and precautions appropriate to microwave components and radiation.
1.2 Interpret the safety signs and symbols associated with high voltages.
1.3 State the physiological effects of microwave radiation.

Learning Outcome 2	Describe electromagnetic wave propagation at microwave frequencies
Assessment criteria	2.1 Describe the transmission of microwaves through the atmosphere and describe the limitations and transmission losses. 2.2 Describe the transmission of microwaves through waveguides and transmission lines and state the limitations and transmission losses. 2.3 Describe the requirement for correct impedance matching in waveguides and transmission lines. 2.4 Describe the production of standing waves. 2.5 List the frequency bands for microwave signals and list typical applications.
Learning Outcome 3	Describe the operating principles and function of common microwave components.
Assessment criteria	3.1 Define terms and parameters used to characterise microwave devices and components 3.2 Describe the effect on the operation of typical electronic components when used at microwave frequencies. 3.3 Describe the techniques used to overcome the problems of using typical electronic components at microwave frequencies. 3.4 Describe the operating principles and function of common active and passive microwave components in terms of appropriate operational parameters. 3.5 List common faults for common active and passive microwave components and describe appropriate diagnostic procedures and measurements. 3.6 List the advantages and disadvantages of solid state replacements for conventional RF power source devices. 3.7 Describe the techniques used to create high power solid state RF sources.
Learning Outcome 4	Measure the operating parameters of microwave devices and components.
Assessment criteria	4.1 Measure the operating parameters of typical active microwave devices. 4.2 Measure the operating parameters of typical passive microwave devices. 4.3 Calibrate test equipment so as to obtain readings to a specified accuracy. 4.4 Describe the effects of measurement errors that can occur when measuring the parameters associated with microwave devices and components. 4.5 Draw charts and graphs to determine: loss, mismatch, SWR, and dielectric constant
Learning Outcome 5	Describe the constraints and consequences of EMI/EMC, both as a source and a recipient of interference, when operating at

microwave frequencies.

Assessment criteria

5.1 Describe how EMI can be generated within a microwave device and how it can be suppressed or reduced.
5.2 Detect EMI within a microwave circuit.
5.3 Demonstrate and discuss the reduction of the effects of EMI in microwave circuits using: filtering, shielding, and decoupling

Delivery of the module

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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 to 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
- power meters and associated sensors
- VSWR meters
- attenuators
- detectors
- directional couplers
- calibrated RF cables
- precision connectors
- RF voltmeters/millivoltmeters and associated sensors

The laboratory used for the teaching of practical aspects of this module will require a small working microwave system, with suitable rigid waveguide and couplings connecting the antenna and power amplifier output. The system 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 system as an item of test equipment will provide the student with a much greater "real world" experience.

Useful references include

Blake R 1993, *Basic Electronic Communication*
West Publishing Co. Minneapolis.
The ARRL UHF / Microwave Experimenter's Manual, 1990
American Radio Relay League, Connecticut

Young P H 1998, *Modern Electronic Communication* 6th Ed

	Prentice Hall, Englewood Cliffs Roddy D 1986, *Microwave Technology* Prentice Hall, Englewood Cliffs
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.