1. Module details

Module name

Electronics for Renewable Energy Systems

Module duration

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

Module code

NUER03

Discipline code

1105

2. Module purpose

This module provides the basic skills and knowledge required by renewable power systems technicians. It includes an introduction to the semiconductor devices and electronic circuits found in renewable energy systems, and basic maintenance and repair of electronic equipment under the direction of an electronics technician. The theory component focuses primarily on the "black box" behaviour, characteristics, ratings and application of the devices and circuits covered, supported by essential electronics concepts. Practical skills are those required by technicians working at remote sites where technical support by telephone may be available.

3. Prerequisites

NUE058 – Electrical Concepts and Applications *or* equivalent modules;

NUER01 – Introduction to Renewable Energy Technologies

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, namely NES219, NES305, NES412, NES506, NES710.

5. Content

Semiconductors, diodes and transistors

rectifier diodes:
- electrical characteristics
- ratings
- circuit symbol
- R.E. applications (gating, flywheel diode, blocking and bypass diodes in PV arrays)

other diodes: LEDs, zeners and Schottky diodes;
- characteristics, applications and circuit symbols

Bipolar transistors:
- semiconductor structure
- circuit symbols and terminal identification
- common emitter configuration : current gain
- saturation and cut-off
- major device ratings
- darlington pairs

Linear regulated DC power supplies

- single phase half wave
- single phase full wave bridge and centre tapped
- three phase: half wave, full wave
- voltage waveforms, ripple, capacitor filtering
- simple zener shunt regulator
- linear regulator ICs: major features
- block diagram structure and physical components of regulated d.c. power supply

Switching power control circuits

- bipolar transistors as switches
- FETs: structure, operation, symbol, major device ratings
- IGBTs: structure, operation, symbol, major device ratings
- Pulse Width Modulation (PWM) in switch mode regulators
- comparison of linear and switch mode circuits
- simple photovoltaic series voltage regulator
- other renewable energy applications for switchmode circuits
- SCRs and Triacs: symbols, operation and major device ratings
- a.c. power control using SCRs and triacs
- Radio Frequency Interference (RFI): cause and suppression methods

Digital Electronics

- comparison of analogue and digital circuits basic boolean logic
- representation of data in binary form
- voltage comparators, A-D and D-A converters: operation and application
- microcontrollers, volatile and non-volatile memory device types and uses
- differential controllers for SHW systems as an example of logic

Inverters

- function and purpose of inverters and d.c.-d.c. converters
- inverter bridge and half bridge functions and types: output waveforms
- use of PWM techniques for modified square and sine waveforms
- block diagram structure of common inverter types
- block diagram structure of d.c.-d.c. converters

Maintenance

- Safety procedures and practices; hazards in equipment containing LV equipment

	functional testing of equipment common faults in RE equipment typical test equipment Fault location and testing under the direction of an electronics technician handling precautions for MOS circuits; PCB replacement replace socketed ICs

6. Assessment strategy

Assessment methods	Assessment should encompass both progressive and holistic elements in recognition of the interdependence between learning outcomes to ensure the module purpose is met. To assist in ensuring validity, reliability and fairness assessment instruments should include practical and written exercises, consisting of a number of item types, such as multiple choice, short answer and problem solving.
Conditions of assessment	Normally learning and assessment will take place in a classroom/ laboratory environment.

7. Learning outcome details

Learning outcome 1	**Describe the operating characteristics, ratings and applications of a range of common semiconductor components.**
Assessment criteria	1.1 Draw and label circuit symbols for common semiconductor components including rectifier diodes, LED's, zener diodes, bipolar transistors, darlington pairs, MOSFETs, IGBT's, SCRs, and triacs. 1.2 Describe the basic function of these devices. 1.3 List the major rating parameters of these devices. 1.4 List two applications for each device, including at least one application in a Renewable Energy System. 1.5 Verify the I-V characteristics of diodes and the current gain characteristic of bipolar transistors by experimentation.
Learning outcome 2	**Describe the structure and operation of linear regulated DC power supplies and their major components.**
Assessment criteria	2.1 Draw and label circuit diagrams for half wave and full wave, single phase and three phase rectifiers. 2.2 Draw and label voltage and current waveforms for these rectifier circuits with and without capacitor filtering. 2.3 Calculate peak output voltages from single phase and three phase rectifier circuits. 2.4 Draw and label a block diagram showing the structure of a regulated DC power supply. 2.5 Outline the main features of linear integrated circuit voltage regulator ICs. 2.6 Identify each of the major components and their physical location in a regulated power supply.
Learning outcome 3	**Describe the basic operating principles, characteristics and applications of switching power control circuits.**
Assessment Criteria	3.1 Explain why the power dissipation of a transistor is low when operated as a switch.

	3.2	Describe, with the aid of waveform diagrams, how Pulse Width Modulation (PWM) can provide a variable output voltage from a switch mode regulator.
	3.3	Outline the advantages and disadvantages of switch mode power circuits compared with linear power circuits.
	3.4	Draw and label a block diagram of a basic PV switching voltage regulator for battery charging.
	3.5	List at least three (3) applications of switch mode circuits found in renewable energy systems.
	3.6	Describe, with the aid of waveform diagrams, how power control in AC circuits is achieved using SCRs and triacs.
	3.7	Describe methods used to reduce radio frequency interference (RFI) in DC and AC circuits utilising high speed switching.
Learning outcome 4	**Outline the main features of digital electronic circuits.**	
Assessment Criteria	4.1	Describe the characteristic features that distinguish analogue and digital devices and circuits.
	4.2	Describe how numbers or text information can be represented using binary numbers and how these are represented in digital circuits.
	4.3	Describe the operation of voltage comparators and Analogue to Digital (A-D) converters, and give one example of each one's use in a renewable energy application.
	4.4	Describe the basic function of microcontrollers, volatile and non-volatile memory devices.
	4.5	Describe the operation of a solar hot water system pump differential controller, as an example of the use of logic in digital circuits.
Learning outcome 5	**Describe the structure, operating characteristics and output waveforms of inverters and d.c.-d.c. converters.**	
Assessment criteria	5.1	Describe the basic function of inverters and d.c.-d.c. converters and their use in renewable power systems.
	5.2	Describe, with the aid of a circuit diagram, the operation of an inverter bridge and half-bridge.

	5.3	Draw output voltage waveforms for square wave, modified square wave and synthesised sine wave inverters showing typical voltages and timing.
	5.4	Describe, with the aid of waveform diagrams, the function of PWM techniques in modified square wave and synthesised sine wave inverters.
	5.5	Draw and label block diagrams showing the topology of common forms of d.c.-d.c. converters and inverters used in renewable energy applications.
Learning outcome 6	**Perform basic maintenance on renewable energy electronics equipment.**	
Assessment criteria	6.1	State and apply the safety procedures for work on electronic systems, circuits and apparatus.
	6.2	List the hazards that may be encountered when performing tests on inverters, battery chargers or other equipment containing LV circuits.
	6.3	Establish the functionality of electronic equipment through appropriate client questioning and application of systematic tests and observation.
	6.4	Specify the various types of common faults and their causes in renewable energy electronic equipment.
	6.5	List typical test equipment used to repair electronic and electrical equipment
	6.6	Demonstrate safe and correct use of tools and test equipment to locate electronic equipment faults under the direction of an electronics technician.
	6.7	Replace faulty circuit components under the direction of an electronics technician.
	6.8	Replace circuit boards, observing appropriate handling precautions for static sensitive devices.
	6.9	Identify and replace socketed ICs such as EPROMs or microprocessors, using appropriate tools and methods.

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 practical application. 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. This module contains learning outcomes that require theory, practical instruction and demonstrations as well as practical work to be completed by the learner. For practical work it is recommended that there be a maximum of six (6) learners per teacher/tutor . The module may be offered through part-time, off-the- job and distance education modes.
Resource requirements	Resources should be sufficient for students to carry out practical work in pairs. This will require a range of experimental devices, measuring instruments and tools and programming of activities to allow access to costly equipment in turn.
Occupational health and safety requirements	A safe and healthy environment will be provided for students and teachers as well as adherence to safety procedures with regard to learning / teaching activity. Particular care should be exercised when working with lead acid batteries to avoid short circuit, acid or explosion due to the presence of hydrogen.
Minimum physical resources	Classroom or laboratory equipped with sample components, plug boards, multimeters, DC power supplies, sample circuits for demonstrations, inverters, regulators, CRO and isolating transformers, basic hand tools, anti-static soldering stations.