Australian Government

MARL038 Apply advanced principles of marine electrotechnology

Release: 1

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Modification History

Release 1. This is the first release of this unit of competency in the MAR Maritime Training Package.

Application

This unit involves the skills and knowledge required to apply advanced marine electrotechnology principles and to perform advanced electrical calculations.

This unit applies to people working in the maritime industry in the capacity of:

- Electro-Technical Officer (STCW Electro-Technical Officer Unlimited)
- Engineer Class 1 (STCW Chief Engineer Unlimited)
- Engineer Class 2 (STCW Second Engineer Unlimited).

Licensing/Regulatory Information

Legislative and regulatory requirements are applicable to this unit.

- This unit is one of the requirements to obtain Australian Maritime Safety Authority (AMSA) certification as an Electro-Technical Officer (STCW Electro-Technical Officer Unlimited), Engineer Class 1 (STCW Chief Engineer Unlimited) or Engineer Class 2 (STCW Second Engineer Unlimited) and to meet regulatory requirements this unit must be delivered consistent with Marine Orders and with the relevant sections of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW).
- Those regulatory requirements include STCW International Maritime Organization (IMO) model course competencies and areas of knowledge, understanding and proficiency, together with the estimated total hours required for lectures and practical exercises. Teaching staff should note that timings are suggestions only and should be adapted to suit individual groups of trainees depending on their experience, ability, equipment and staff available for training.

Pre-requisite Unit

Not applicable.

Competency Field

L – Engineering

Unit Sector

Not applicable.

Elements and Performance Criteria

ELEMENTS	PERFORMANCE CRITERIA
Elements describe the essential outcomes.	Performance criteria describe the performance needed to demonstrate achievement of the element.

1	**Analyse circuits incorporating resistance, inductance and capacitive elements in alternating current (AC) and direct current (DC) circuits**	**1.1**	Mathematical problems involving resistor inductor (RL) and resistor capacitor (RC) combinations in DC circuits are solved
		1.2	Mathematical problems involving resistive, inductive and capacitive reactance and overall circuit impedance in AC circuits are solved
		1.3	Reasons why large power factors are desirable in AC circuits are explained
		1.4	Mathematical problems related to power factor correction mechanisms are solved
		1.5	Conditions for resonance in series and parallel RLC circuit combinations are analysed
		1.6	Mathematical problems involving resonance in series and parallel RLC circuit combinations are solved
		1.7	Calculations are performed

			to solve problems related to solve resistance, voltage drop, current and power in series and parallel circuits
		1.8	Calculations are performed to solve problems related to temperature coefficient of resistance and change of resistance of a conductor with a change of temperature
2	**Apply complex number theory to analyse AC circuit performance**	**2.1**	J operator is explained
		2.2	Rectangular notation of j operator is related to comparable trigonometric and polar notations
		2.3	J operator is used in the addition and subtraction of phasors, applying the most appropriate notation to the solution of phasor problems involving current, voltage and impedance
		2.4	Conductance, admittance and susceptance are distinguished from each other in terms of resistance, impedance and the j operator
		2.5	Problems involving RL and RC elements in different circuit combinations using j operator theory are solved
		2.6	Power in AC circuit applications using j operator theory is calculated
3	**Analyse operating principles of**	**3.1**	Mathematical calculations are performed to

	electrical instrumentation		demonstrate how moving coil and moving iron instruments may have their ranges changed
		3.2	Mathematical calculations are performed to demonstrate how dynamometer type wattmeters may have their measuring ranges extended
		3.3	Construction, operating principles and functions of electrical meters are outlined
		3.4	Principal methods and instruments used in resistance measurement are detailed
		3.5	Resistance measurements are conducted and verified using appropriate electrical instrumentation
4	**Analyse operating principles of DC generators**	**4.1**	Electromotive force (EMF) equation is applied to solve problems related to DC generators
		4.2	Losses that may occur in DC generators are analysed
		4.3	Appropriate parametric relationships for DC. generator losses, together with expressions for output power and efficiency, are derived and associated numerical problems are solved
		4.4	Basic principles of DC armature winding techniques are explained
		4.5	Generator armature reaction

			is explained
		4.6	Expression for armature EMF is derived and applied to solve problems related to DC generators
		4.7	Commutator arcing and how this might be minimised or eliminated is explained
		4.8	Open circuit and load characteristic curves for separately excited, shunt and compound wound DC generators are derived
		4.9	Faraday’s and Lenz’s Laws are applied to solve problems relating to the electromagnetic induction of EMF and current
		4.10	Generation of EMF is illustrated by a simple, single loop conductor rotating in a uniformed magnetic field and how this EMF may be tapped to an external circuit as either AC or DC is explained
5	**Analyse operating principles of DC motors**	**5.1**	DC torque equation is applied to solve problems related to DC motors
		5.2	Losses that may occur in DC motors are analysed
		5.3	Appropriate parametric relationships for DC motor losses, together with expressions for output power and efficiency. are derived and associated numerical problems are solved

		5.4	Speed equation for a DC motor is derived and corresponding characteristics for different winding configurations are sketched
		5.5	Speed equation and characteristics of different DC motor configurations are applied to explain how DC motor speed may be controlled
		5.6	Reasons for armature reaction and methods of compensating for its effects are identified
		5.7	Reasons why DC motors need variable starting resistors are explained
		5.8	Schematic circuits are prepared for separately excited, series, shunt and compound connected generators and motors to illustrate wiring arrangements used with DC machines
6	**Compare operation of synchronous motors and generators**	**6.1**	Marine applications of synchronous motors and generators are identified
		6.2	Mathematical expression for the magnitude and rotational speed of the magnetic field produced by a three phase supply is derived
		6.3	Operating principles of synchronous motors are explained

6.4	Operation of synchronous motors and generators are compared and contrasted
6.5	Problems using phasor diagrams and mathematical expressions involving the effects of loads and excitation on synchronous motors are solved
6.6	Advantages and disadvantages of AC synchronous motors and generators are analysed
6.7	How alternating electrical quantities may be represented by rotating phasors is illustrated and explained
6.8	Relationships between instantaneous, maximum, average and root mean square (RMS) values of sinusoidally alternating electrical quantities is derived
6.9	Mathematical problems are solved by applying relationships between instantaneous, maximum, average and RMS values of sinusoidally alternating electrical quantities
6.10	Construction features of the AC induction motor are explained
6.11	Expression for slip of an induction motor rotor is derived and applied to frequency of its rotor EMF and current

		6.12	Expression for magnitude of rotor EMF and current is derived, taking into account distribution and pitch factors
		6.13	Relationships between rotor torque, rotor losses and slip indicating factors that affect torque are outlined
		6.14	Significance of torque/slip curves for an induction motor is explained
		6.15	Relationship between starting torque and applied voltage is established and consequences of this upon starting methods are outlined
7	**Analyse operation of single and three phase transformers**	**7.1**	Basic transformation ratio and EMF equation for an ideal transformer is derived
		7.2	No load and on load phasor diagrams for an ideal transformer are constructed, with negligible voltage drop through its windings
		7.3	Causes of actual transformer losses are explained and relationships associated with the transformer equivalent circuit are derived
		7.4	Open circuit and short circuit tests are applied to calculate transformer efficiency and voltage regulation
		7.5	Problems related to the operation of autotransformers are solved

8	**Analyse requirements for parallel operation of AC and DC generators**	**8.1**	Conditions required for shunt, series and compound wound DC generators to operate in parallel are identified
		8.2	Numerical problems related to parallel operation of shunt, series and compound wound DC generators are solved
		8.3	Conditions required for AC generators to operate in parallel are identified
		8.4	Numerical problems related to parallel operation of AC generators are solved
		8.5	EMF equation for an AC generator is derived, taking into account distribution and pitch factors
		8.6	Voltage regulation for synchronous generator is defined
		8.7	Effect of power factor on load characteristic of an AC generator is illustrated
9	**Explain how principles of electrolytic action apply to electrical cells and batteries**	**9.1**	Kirchhoff's circuit laws are explained
		9.2	Calculations to solve problems involving currents, voltage drop and terminal potential difference for cells connected to form batteries in series and in parallel are performed
		9.3	Calculations to solve secondary cell charging and

			discharging problems are performed
		9.4	Calculations to solve problems related to the efficiency of cells are performed
10	**Analyse a magnetic circuit**	**10.1**	Key parameters of magnetic circuits are identified
		10.2	Formula for calculating the amount of flux generated by a multi-turn solenoid coil carrying a current to give the B/H relationship is applied
		10.3	Significance of the varying slopes in the B/H curves for a solenoid coil with air, cast iron, cast steel and mild steel cores is explained
		10.4	How a magnetic circuit may be created by using a toroidal core within the solenoid coil is demonstrated
		10.5	Calculations to solve problems relating to magnetic circuits using different materials in different parts of their cores, including air gaps, are performed
		10.6	Effect on flux density of applying an alternating magnetising force to an iron core is shown diagrammatically
11	**Analyse operation of polyphase AC circuits**	**11.1**	How three phase AC may be developed out of simple single phase AC is explained

		11.2	Voltage and current relationships between line and phase in both Star and Delta three phase connections are derived
		11.3	Standard Star-to-Delta and Delta-to-Star conversion relationships for current and voltage are derived
		11.4	Numeric problems involving both balanced and unbalanced circuit loads are solved
		11.5	Relationships between kilowatt (kW), kilovolt-ampere (kVA) and kilovolt-ampere reactive (kVAr) for three phase AC circuits are derived
		11.6	Calculations are performed using the relationship between kW, kVA and kVAr to solve problems in three phase AC circuits
12	**Analyse circuits that incorporate combinations of resistive, inductive and capacitive elements**	**12.1**	Time constant for different circuit combinations subjected to DC EMFs is defined
		12.2	Calculations are performed to solve problems involving time constants in DC circuits with changing rates of current in resistive/inductive elements and changing voltages through resistive/capacitive circuit elements
		12.3	Differentiation is made between inductive reactance, capacitive

			reactance and impedance as applied to AC circuits
		12.4	Effects of inductive and capacitive reactance upon phasor relationships between applied AC voltage and current are shown
		12.5	Concept of total impedance is applied to solution of problems involving single phase AC quantities in the presence of both resistive/inductive and resistive/capacitive circuit elements, arranged in either series or parallel
		12.6	Power factor is defined and concepts of real and reactive power usage are applied to solution of problems involving RL and RC elements
13	**Describe basic operating principles of shipboard DC machinery**	**13.1**	EMF equation for a DC generator to solve shipboard problems is applied
		13.2	Torque equation for a DC motor to solve shipboard problems is applied
		13.3	Expression linking back EMF parameters for a DC motor is derived and used to solve shipboard problems
		13.4	Various losses that can occur in DC motors and generators are calculated
14	**Explain operating principles of basic electrical instrumentation**	**14.1**	Schematic circuit diagrams are prepared that illustrate the main features and applications of moving coil and moving iron voltmeters

	and ammeters
14.2	Schematic circuit diagrams are prepared that illustrate the main features and applications of air and iron cored dynamometer type wattmeters
14.3	Dangers associated with current and voltage transformers on high current and voltage systems are identified

Foundation Skills

Foundation skills essential to performance are explicit in the performance criteria of this unit of competency.

Range of Conditions

Range is restricted to essential operating conditions and any other variables essential to the work environment.

Unit Mapping Information

This unit supersedes and is not equivalent to MARL014 Apply intermediate principles of marine electrotechnology.

This unit replaces and is equivalent to MARL018 Apply advanced principles of marine electrotechnology.

Links

Companion Volume implementation guide can be found in VetNet - https://vetnet.gov.au/Pages/TrainingDocs.aspx?q=772efb7b-4cce-47fe-9bbd-ee3b1d1eb4c2