

## MODULE 3. ELECTRICAL FUNDAMENTALS

### 3.1 Electron Theory

Structure and distribution of electrical charges within: atoms, molecules, ions, compounds;  
Molecular structure of conductors, semiconductors and insulators.

### 3.2 Static Electricity and Conduction

Static electricity and distribution of electrostatic charges;  
Electrostatic laws of attraction and repulsion;  
Units of charge, Coulomb's Law;  
Conduction of electricity in solids, liquids, gases and a vacuum.

### 3.3 Electrical Terminology

The following terms, their units and factors affecting them: potential difference, electromotive force, voltage, current, resistance, conductance, charge, conventional current flow, electron flow.

### 3.4 Generation of Electricity

Production of electricity by the following methods: light, heat, friction, pressure, chemical action, magnetism and motion.

### 3.5 DC Sources of Electricity

Construction and basic chemical action of: primary cells, secondary cells, lead acid cells, nickel cadmium cells, other alkaline cells;  
Cells connected in series and parallel; Internal resistance and its effect on a battery;  
Construction, materials and operation of thermocouples;  
Operation of photo-cells.

### 3.6 DC Circuits

Ohms Law, Kirchoff's Voltage and Current Laws;  
Calculations using the above laws to find resistance, voltage and current;  
Significance of the internal resistance of a supply.

### 3.7 Resistance/Resistor

(a) Resistance and affecting factors;  
Specific resistance;  
Resistor colour code, values and tolerances, preferred values, wattage ratings;  
Resistors in series and parallel;  
Calculation of total resistance using series, parallel and series parallel combinations;  
Operation and use of potentiometers and rheostats;  
Operation of Wheatstone Bridge.

(b) Positive and negative temperature coefficient conductance;  
Fixed resistors, stability, tolerance and limitations, methods of construction;

Variable resistors, thermistors, voltage dependent resistors;  
Construction of potentiometers and rheostats;  
Construction of Wheatstone Bridge;

### **3.8 Power**

Power, work and energy (kinetic and potential);  
Dissipation of power by a resistor;  
Power formula;  
Calculations involving power, work and energy.

### **3.9 Capacitance/Capacitor**

Operation and function of a capacitor;  
Factors affecting capacitance area of plates, distance between plates, number of plates, dielectric and dielectric constant, working voltage, voltage rating;  
Capacitor types, construction and function;  
Capacitor colour coding;  
Calculations of capacitance and voltage in series and parallel circuits;  
Exponential charge and discharge of a capacitor, time constants;  
Testing of capacitors.

### **3.10 Magnetism**

(a) Theory of magnetism;  
Properties of a magnet  
Action of a magnet suspended in the Earth's magnetic field;  
Magnetisation and demagnetisation;  
Magnetic shielding;  
Various types of magnetic material;  
Electromagnets construction and principles of operation;  
Hand clasp rules to determine: magnetic field around current carrying conductor.

(b) Magnetomotive force, field strength, magnetic flux density, permeability, hysteresis loop, retentivity, coercive force reluctance, saturation point, eddy currents;  
Precautions for care and storage of magnets.

### **3.11 Inductance/Inductor**

Faraday's Law;  
Action of inducing a voltage in a conductor moving in a magnetic field;  
Induction principles;  
Effects of the following on the magnitude of an induced voltage: magnetic field strength, rate of change of flux, number of conductor turns;  
Mutual induction;  
The effect the rate of change of primary current and mutual inductance has on induced voltage;  
Factors affecting mutual inductance: number of turns in coil, physical size of coil, permeability of coil, position of coils with respect to each other;  
Lenz's Law and polarity determining rules;  
Back emf, self induction;

Saturation point;  
Principle uses of inductors;

### **3.12 DC Motor/Generator Theory**

Basic motor and generator theory;  
Construction and purpose of components in DC generator;  
Operation of, and factors affecting output and direction of current flow in DC generators;  
Operation of, and factors affecting output power, torque, speed and direction of rotation of DC motors;  
Series wound, shunt wound and compound motors;  
Starter Generator construction.

### **3.13 AC Theory**

Sinusoidal waveform: phase, period, frequency, cycle;  
Instantaneous, average, root mean square, peak, peak to peak current values and calculations of these values, in relation to voltage, current and power  
Triangular/Square waves;  
Single/3 phase principles.

### **3.14 Resistive (R), Capacitive (C) and Inductive (L) Circuits**

Phase relationship of voltage and current in L, C and R circuits, parallel, series and series parallel;  
Power dissipation in L, C and R circuits;  
Impedance, phase angle, power factor and current calculations;  
True power, apparent power and reactive power calculations.

### **3.15 Transformers**

Transformer construction principles and operation;  
Transformer losses and methods for overcoming them;  
Transformer action under load and no-load conditions;  
Power transfer, efficiency, polarity markings;  
Calculation of line and phase voltages and currents;  
Calculation of power in a three phase system;  
Primary and Secondary current, voltage, turns ratio, power, efficiency;  
Auto transformers.

### **3.16 Filters**

Operation, application and uses of the following filters: low pass, high pass, band pass, band stop.

### **3.17 AC Generators**

Rotation of loop in a magnetic field and waveform produced;  
Operation and construction of revolving armature and revolving field type AC generators;  
Single phase, two phase and three phase alternators;  
Three phase star and delta connections advantages and uses;

Permanent Magnet Generators.

### **3.18 AC Motors**

Construction, principles of operation and characteristics of: AC synchronous and induction motors both single and polyphase;

Methods of speed control and direction of rotation;

Methods of producing a rotating field: capacitor, inductor, shaded or split pole.