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Participant Handbook

Sector
Electronics

Sub-Sector
Solar Electronics

Occupation
Installation

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NSQF Level 4

Solar Panel Installation Technician

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"Skilling is building a better India. If we have to move India towards development then Skill Development should be our mission."

Shri Narendra Modi
Prime Minister of India

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Certificate

COMPLIANCE TO

QUALIFICATION PACK - NATIONAL OCCUPATIONAL STANDARDS

is hereby issued by the

ELECTRONICS SECTOR SKILL COUNCIL OF INDIA

for

SKILLING CONTENT : PARTICIPANT HANDBOOK

Complying to National Occupational Standards of

Job Role/ Qualification Pack: **"Solar Panel Installation Technician"** QP No. **"ELE/Q5901, NSQF Level 4"**

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Authorised Signatory
(Electronics Sector Skill Council)

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The need for having a standard curriculum for the Job Role based Qualification Packs under the National Skills Qualification Framework was felt necessary for achieving a uniform skill based training manual in the form of a Participant Handbook.

I would like to take the opportunity to thank everyone who contributed in developing this Handbook for the QP Solar Panel Installation Technician.

The Handbook is the result of tireless pursuit to develop an effective tool for imparting the Skill Based training in the most effective manner.

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CEO

Electronics Sector Skills Council of India

About this Book

This Participant Handbook is designed to enable training for the specific Qualification Pack (QP). Each National Occupational (NOS) is covered across Unit/s.

Key Learning Objectives for the specific NOS mark the beginning of the Unit/s for that NOS.

- Measure voltage, current and power of solar photovoltaic modules
- Identify the components of solar photovoltaic system
- Identify types of solar photovoltaic systems
- Define solar cell parametersList the types of connections of solar photovoltaic panel
- List the types of PV modules and their characteristics
- Identify the batteries used in PV system
- Describe standard parameter of battery
- Recognize functions of a charge controller
- Recognize the roles of a solar panel installation technician
- Identify prerequisites for installing a solar PV system
- Construct the design of the solar PV system
- Analyse the size and calculation of the components
- Evaluate the location for installation
- List the types of charge controllers
- Explain work ethics
- Interact with supervisor
- Interact with colleagues
- Evaluate the practices of working in a team
- Implement quality and safety procedure
- Explain the meaning of health
- List common health issues
- Discuss tips to prevent common health issues

Symbols Used


Key Learning Outcomes


Steps


Role Play


Tips


Notes


Unit Objectives


Activity


Practical

Table of Contents

S. No.	Modules and Units	Page No.
1.	**Basics of Electricity and Solar Energy (ELE/N5901)**	**1**
	Unit 1.1 – Basics of Electricity and Power Generation System	3
	Unit 1.2 – Renewable Energy and Solar Energy System	13
	Unit 1.3 – Solar Cells	22
	Unit 1.4 – Photovoltaic (PV) Panels	28
	Unit 1.5 – Electrical Power System	37
2.	**Components for Solar PV System (ELE/N5901/ ELE/N5902)**	**44**
	Unit 2.1 – Solar PV Modules	46
	Unit 2.2 – Batteries in a PV System	53
	Unit 2.3 – Charge Controller	66
	Unit 2.4 – Inverters	75
	Unit 2.5 – Mounting Structures	80
3.	**Role of a Solar Panel Installation Technician (ELE/N5901, ELE/N5902)**	**88**
	Unit 3.1 – Responsibilities of Solar Panel Installation Technician	90
	Unit 3.2 – Installation Pre-requisites	92
	Unit 3.3 – Site Analysis	112
	Unit 3.4 – Installation and Maintenance of Solar Panel	119
4.	**Work Ethics and Workplace Safety (ELE/N9952, ELE/N9953)**	**150**
	Unit 4.1 – Work Ethics	152
	Unit 4.2 – Workplace Safety	160
	Unit 4.3 – Soft Skills	179
5.	**Employability & Entrepreneurship Skills**	**188**
	Unit 5.1 – Personal Strengths & Value Systems	192
	Unit 5.2 – Digital Literacy – A Recap	209
	Unit 5.3 – Money Matters	214
	Unit 5.4 – Preparing for Employment & Self Employment	223
	Unit 5.5 – Understanding Entrepreneurship	232
	Unit 5.6 – Preparing to be an Entrepreneur	257

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1. Basics of Electricity and Solar Energy

Unit 1.1 – Basics of Electricity and Power Generation System

Unit 1.2 – Renewable Energy and Solar Energy System

Unit 1.3 – Solar Cells

Unit 1.4 – Photovoltaic (PV) Panels

Unit 1.5 – Electrical Power System

ELE/N5901

Key learning Outcomes

At the end of this module, you will be able to:

1. Measure voltage, current and power of solar photovoltaic modules
2. Identify the components of solar photovoltaic system
3. Identify types of solar photovoltaic systems
4. Define solar cell parameters
5. List the types of connections of solar photovoltaic panels
6. Explain the main factors affecting the output of solar photovoltaic modules

UNIT 1.1: Basics of Electricity and Power Generation System

Unit Objectives

At the end of this unit, you will be able to:

1. Measure voltage, current, power and energy
2. Define Ohm's law
3. Explain the difference between alternating current (AC) and direct current (DC)
4. Identify the use of multimeter
5. Explain the power generation system

1.1.1 Introduction to Electricity

Electricity is a natural force that comes into existence whenever there is a flow of electric charge between two components. When working with circuits, there is need for the users to be aware about some of the basic concepts of electricity, otherwise an incorrect connection in a circuit may cause high damage to people and the circuit components.

The main terms associated with electricity are as follows:

- Current
- Voltage
- Power
- Energy

Current

When electrons inside any material move, flow of electricity takes place. This flow is called current. It is measured in ampere.

Voltage

In an electrical circuit, the current flows only when there is a voltage source. Voltage is the force pushing electrons through the wire.

Power

When electricity flows in an electrical circuit, it results in some work done. For example, when electricity flows in a fan, the blades of the fan rotate and when the electricity flows in a refrigerator, it cools things inside. Thus, when electricity flows through an appliance, it results in some work done.

Electrical power is the rate at which an electric circuit transfers electrical energy. Electrical power is similar to mechanical power and can be considered as the rate at which electrical work is done. It is measured in watts (one joule per second) and represented as *P*. Electric power in watts is also called wattage. Consider the formula:

P= work done per unit time = VQ/t = VI

Where P is the electric power in watts determined when an electric current represented by I in amperes with a charge *Q* in coulombs passes through an electrical potential difference denoted by V in time t seconds.

Electric power is produced by electric generators in an electric power generation unit called a grid. This power is further supplied to residential and commercial location. It can also be produced by other sources such as electric batteries. The energy delivered and consumed by electric utilities is measured using an electricity meter.

Energy

If the electrical power is the rate or speed of work done, then electrical energy is the total amount of work done in a given time period. It is product of power of electrical appliance and duration of its usage. Consider the following equation to determine electrical energy:

Electrical Energy (E) = Power (P) x Duration of Energy usage (T) = Power (Watt) x Time (hour)

E (Wh) = P (W) x T (h)

Power = Energy / Time

1.1.2 Ohm's Law

According to Ohm's law, current flowing through a conductor is directly proportional to the voltage across the conductor. The mathematical equation of Ohm's law is as follows:

$$I=V/R$$

Where,

I is current flowing through the conductor,

V is the potential difference or voltage across the conductor, and

R is proportionality constant, known as the resistance of the conductor.

Problem Statement: A fan works on 24V DC and while running it takes 3A current. Calculate the DC power consumed by the fan?

Solution: The fan is a DC fan and the current flowing through the fan, I_{dc} is 3A. The voltage of the fan, V_{dc} is 24V. Then DC power consumed by the fan is:

$$P_{dc}=I_{dc} \times V_{dc}$$

$$P_{dc}= 3 \times 24= 72 \text{ watts}$$

1.1.3 Electrical Circuit

The interconnection of various electrical components is called electrical circuit. The basic components of a circuit are:

- Power source such as a battery
- Wire running from the hot side to a load
- Wire running from the load to the power source
- Switch to open or close the circuit

The load will operate when the circuit is closed or complete. The following figures show an open and a close circuit:

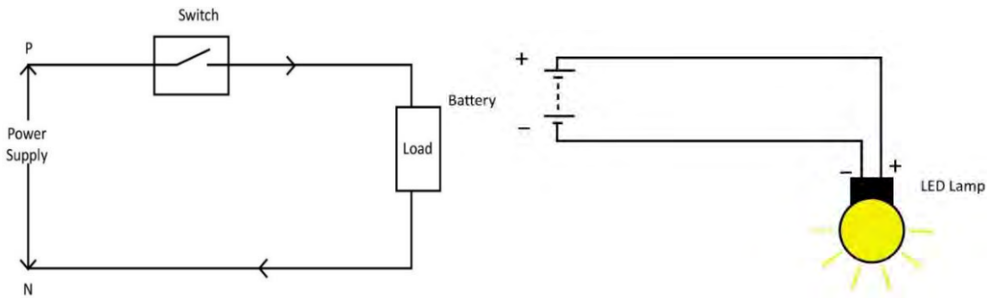

Fig. 1.1.1: An open and a close circuit

In an electrical circuit, power flows in two forms:

- DC power
- AC Power

DC Circuit and AC Circuit

DC power flows in a DC circuit. A DC circuit is a circuit in which current flows in only one direction. The direction of current does not change with time.

In AC circuit, current flows in both the directions; clockwise and counter clockwise. For time period 0 to T/2 current flows in clock wise direction and for time period T/2 to T, the charge flow reverses to counter clockwise direction. It is not only the direction but the value of current that keeps changing with time.

The AC current changes its direction 50 times in one second which means the power supply has 50 Hertz frequency. The following figure shows the voltage-time relationship between AC and DC:

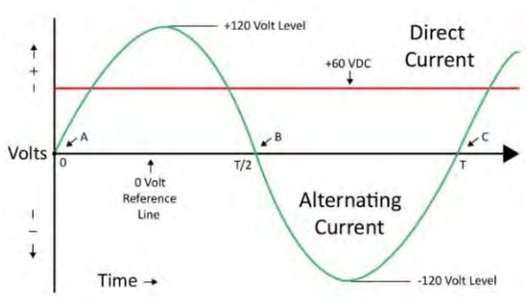

Fig. 1.1.2: Voltage-Time relationship for AC and DC

Most of the home appliances such as light bulbs and TV, fans operate on AC power at 220 volts. Solar panels and batteries produce DC power. Appliances such as DC CFL lights, DC LED lights and DC fans can run on DC power by connecting them to solar panels or batteries. These are incapable of running on AC power supplied from the national grid.

Series and Parallel Circuit

Complex circuits, in which more than one load is connected, may be either in series or in parallel or a combination of both. The basic working of the circuits is explained as follows:

- In a series circuit, all the components are connected as a chain and the current flowing through the components is same all over the circuit. There is only one path in the circuit in which the current can flow. So, the current passes through each and every component. Opening or breaking any point of a series circuit causes the whole circuit to stop functioning and the entire circuit needs to be replaced.
- In a parallel circuit, two or more components are connected in parallel. All the components have the same voltage across them. The current flow varies across the components. If any point of the circuit gets damaged, only that part needs to be replaced.

The following figure shows a series and a parallel circuit:

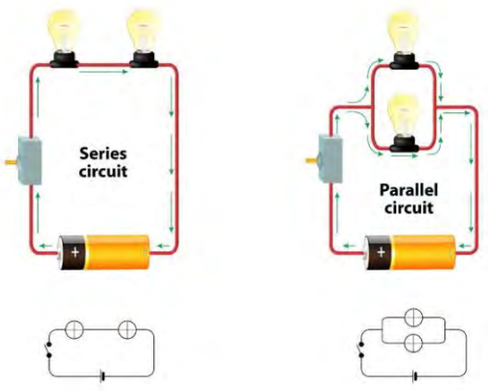

Fig. 1.1.3: Series and parallel circuits

Typically circuit breakers and fuses are in series with the load and multiple loads are in parallel.

1.1.4 Measurement of Electrical Parameters

There are many types of measuring tools available such as voltmeter, ammeter and multimeter, which can measure voltage, current, power and energy. Among these, one of the most versatile measuring tools is called multimeter.

Measurement Voltage, Current and Resistance

A multimeter can be used for measuring voltage, current and resistance. It can also be used for fault detection in small circuits or to find out the broken wires in a circuit.

It can be of two types:

- Analog Multimeter
- Digital Multimeter

The following image shows the different types of multimeters:

Analog Multimeter

It consists of a needle which points at the scale built on it for giving the measured value.

Digital Multimeter

It is an electronic meter which displays the measured values in digital form.

Fig. 1.1.4: Types of multimeters

Usually, a standard multimeter can measure the following electrical quantities:

- DC Voltage
- AC Voltage
- DC Current
- AC Current
- Resistance

Measurement of DC Voltage and Current

Voltage can be measured by directly connecting the voltage meter or the multimeter to the terminals of the voltage source. To measure the voltage using the multimeter, it should be used in voltmeter mode. The range selector knob of the meter should point towards the sign, volts or 'V'.

Current can be measured by connecting the current meter or the multimeter to the terminals of voltage source, provided the current is controlled by appropriate value of resistance or load in path. Multimeter should be in current mode to measure current. The range selector knob of the meter should point towards sign, amperes or 'A'.

Appropriate precaution should be taken to position the knob or the probe properly for:

- Expected range of voltage or current level
- AC or DC form
- Position of the red probe for AC or DC current measurement
- Position of the red probe for AC or DC voltage measurement

The following figure shows measurement of DC voltage using multimeter:

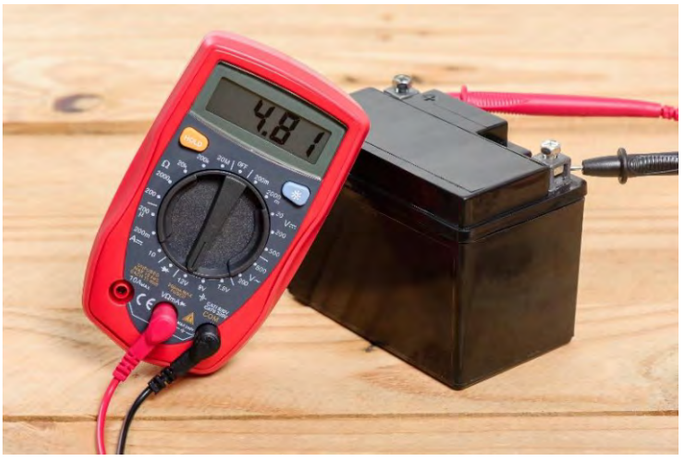

Fig. 1.1.5: Measurement of DC voltage

Measurement of AC Voltage and Current

In principle, the procedure for measurement of both DC and AC, current and voltage are similar. For measurement of AC voltage by using a multimeter, it is essential to select the AC form (~) with the range selector knob on the multimeter. It is also essent ial to check the position of the red probe, as it should be kept in voltage or current mode in the multimeter as per the measuring parameter.

The red and black probes are to be connected to phase and neutral points in the circuit, respectively. The following figure shows measurement of AC current using multimeter:

Fig. 1.1.6: Measurement of AC current

Measurement of Resistance

Resistance measurement is an important part in the field of electricity. The flow of current in a circuit depends on its resistance. Thus, it is very important to know the value of resistance in a circuit.

For measurement of resistance using a multimeter, the range selector knob should be first placed on the 'Resistance' mode or Ohms mode, which is normally shown on a multimeter with Ω symbol.

The following figure shows measurement of resistance using a multimeter:

Fig. 1.1.7: Measurement of resistance

Measurement of Electrical Power

Current and voltage can be measured by using an ammeter and a voltmeter respectively. The output power in an electric circuit can be measured using the formula:

Power = Voltage x Current

Measurement of Electrical Energy

Electrical energy is the power consumed by a load during a specified time period. The product of power and time gives the value of electrical energy consumed by the load in watt-hour.

The meters available for measurement of energy are called energy meter. As the unit of energy is watt-hour, the meters are also called watt-hour meter. The following image show a meter:

Fig. 1.1.8: Energy meter

1.1.5 Power Generation System

There are different processes, such as chemical, photo-voltaic, and electromechanical, with which energy is transformed into an electrical form to generate electrical power. This transformation or conversion process happens at a power station or a power plant. A power station has generators and a rotating machine that converts mechanical power into electric power.

Typically, electricity is generated using fossil fuels such as coal, oil, and natural gas. Nuclear power is also used to generate electricity but nowadays renewable source of energy are such as solar, wind, wave and hydroelectric are becoming popular choice. The fuel cost and the efficiency of the power station determines the operating costs of generating electrical energy.

The following image shows the electric power being generated at a plant and supplied to the customer or end user:

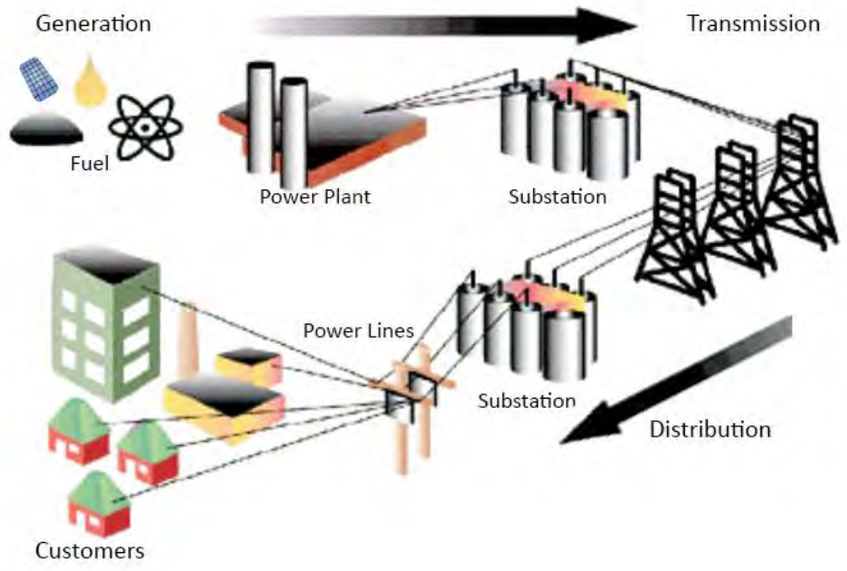

Fig. 1.1.9: Electric power supply from generating plant to end users

Activity

1. Fill in the following table for various DC loads.

Name of DC Load	Voltage across load Vdc (Volts)	Current Through the Load, Idc (Ampere)	Power Consumed by the load, Pdc (Watt)
Fan	12	2.5	-
LED	-	0.5	1.5
TV	-	3.3	80
Refrigerator	48	-	500
Motor	36	-	746

2. Fill the following table on estimation of electrical energy consumed by electrical appliances.

Type of appliance	Power of the appliance	Daily duration of usage of appliance	Electrical energy consumed
Tube Light	40 W	4 hours	= ..... Wh
Tube Light	40 W	..... hours	= 400 Wh
Fan 1	60 W	12 hours	= ..... Wh
Fan 2	30 W	12 hours	= ..... kWh
TV	150 W	2 hours	= ..... Wh
Cooler	200 W	10 hours	= ..... kWh
Computer	..... W	2 hours	= 400 Wh
LED Light	5 W	..... hours	= 20 Wh
AC	1.5 kW	10 hours	= ..... kWh
AC	1.5 kW	..... hours	= 7.5kWh
Unknown Appliance	..... W	10 hours	= 500Wh
Unknown Appliance	..... W	5 hours	=10 kWh

Activity

Solve the following problems.

Problem 1.0: What does electric power depend on? An electrical appliance is connected to 48V which results in 3A current through the load. What is the power consumed by the load?

Problem 2.0: For a 75W lamp, a voltage of 220V is applied. What is the value of the resultant current?

Problem 3.0: An electrical bulb consumes energy at the rate of 40 W per hour and is used for 12 hours. What is the energy consumed by the bulb?

Problem 4.0: Consider two bulbs, A and B with same power of 100 W. Bulb A is used for 12 hours and Bulb B is used for 25 hours. Which bulb will consume more energy? Assuming utilities charges of Rs. 6, what would be the cost of electricity consumed by the bulbs?