**Solar Electric Technician (Level 2)**

**Module 6: Testing and commissioning**

**E3: Assignment – Perform troubleshooting of three-phase solar photovoltaic (PV) systems**

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| **E3: ASSIGNMENT MEMO** | |
| **Date** | …. |
| **To** | Participants |
| **From** | Trainers |
| **Subject** | **Perform troubleshooting of three-phase solar photovoltaic systems.** |
| **What** | Practice diagnosing and troubleshooting issues in a three-phase solar photovoltaic (PV) system. |
| **Why** | Trainees will practice diagnosing and troubleshooting issues in a simulated three-phase solar photovoltaic (PV) system, including solar panels, an inverter, battery bank, and an optional water pump. By the end of the assignment, participants will develop skills to identify, analyse, and resolve common faults in a PV system. |
| **How** | 1. Work in group of 3 or 4. 2. Gather the required tools, equipment's and demo setup of the solar PV system. 3. Understand the demo setup of solar PV system together with the expected outcomes. 4. As this exercise involves simulating a set of common faults or issues in a three-phase PV system and having trainees troubleshoot them. The trainer will intentionally create faults in different parts of the system, which the trainees will have to identify and resolve. 5. Trainees must follow a structured troubleshooting process, including system analysis, isolation of faults, testing, and resolution 6. Discuss and present the results with the class and get help from the trainer. |
| **Time** | 180’ |

**Required tools/equipment and expected outcomes**

1. **Three-phase solar PV system setup**

* Solar panels
* On-grid inverter (with grid-tied functionality)
* Battery bank (optional for backup or hybrid systems)
* Water pump (optional)
* DC and AC disconnects
* Wiring (AC and DC)
* Fault simulation components (disconnects, loose wires, bypassed fuses, faulty breakers, etc.)

1. **Tools and equipment**

* Multimeter (for voltage, current, and continuity testing)
* Clamp meter (for measuring current in live circuits)
* Battery tester (if battery bank is used)
* Torque wrench, wire strippers, crimping tools, screwdrivers
* Personal protective equipment (PPE): gloves, safety goggles, insulated boots
* Wiring diagrams and system manuals

1. **Expected outcomes**

* Safety adherence: Trainees consistently follow safety procedures and use appropriate PPE.
* Troubleshooting skills: Trainees demonstrate the ability to systematically diagnose and resolve faults in a solar PV system.
* Technical proficiency: Trainees use tools such as multimeters, clamp meters, and IV curve tracers to identify faults.
* Problem resolution: Trainees successfully identify the root causes of issues and implement corrective actions to restore system.

1. **Safety briefing and system overview (15 minutes)**

Objective: Understand and follow safety procedures and review the components of the three-phase solar PV system.

1. **Safety first**

* Wear appropriate Personal protectives equipment's, PPE (gloves, safety goggles, insulated boots).
* Follow lockout/tagout procedures before working on any electrical component.
* Treat the system as live until confirmed otherwise (especially in the case of an on-grid inverter and batteries).

1. **System review**

* Review key system components: Solar panels, inverter, battery bank (if used), disconnects, fuses, breakers, and water pump (if included).
* Study the wiring diagram and specifications of the system.

1. **Fault scenarios explanation (15 minutes)**

Objective: Each team will be assigned to troubleshoot one specific simulated problem within a solar PV system in the upcoming task. By the end of the following tasks, learners will enhance their diagnostic skills, learn to identify common faults and develop effective troubleshooting strategies.

Instructions: Trainees/learners will be made aware that several issues will be simulated within the system. These faults may occur in various parts of the system, including the solar panels, wiring, inverter, batteries, or water pump.

The possible faults might include:

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| **Possible faults** | **Descriptions** | **Symptoms** |
| Open circuits or loose connections | Disconnected or loose wires that interrupt the flow of electricity. | Inconsistent performance or complete failure of connected devices. |
| Undervoltage or overvoltage conditions | Input or output voltages that fall below or exceed acceptable levels. | Devices may not operate correctly (undervoltage) or may be damaged (overvoltage |
| Ground faults | Issues arising from improper grounding or insulation failures | Potential safety hazards such as electric shocks or short circuits. |
| Inverter malfunctions | Inverter fails to sync with the grid or displays error codes. | Loss of power conversion efficiency and possible system shutdowns. |
| Battery issues | Problems related to poor charge/discharge cycles or incorrect wiring. | Insufficient energy storage leading to device failures. |
| Water pump failures | Electrical or mechanical issues affecting pump operation. | Disruption in water flow impacting cooling systems or other processes. |

1. **Fault scenario assignment and group work (60 minutes)**

**Task 1:** Each group of trainees will be assigned a specific fault to diagnose and resolve.

1. **Divide trainees into groups**

* Trainees will be divided into groups of 3-4 individuals.
* Each group will be given one or more fault scenarios to investigate and troubleshoot.

1. **Example fault scenarios**

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| **Scenarios** | **Fault name** | **Descriptions** | **Possible causes** |
| Scenario 1 | Solar panel fault | One or more strings of solar panels are not producing the expected voltage. | Loose connections, bypass diodes malfunction, shading, damaged panels. |
| Scenario 2 | Inverter fault | The inverter is showing an error code and not producing AC output | Grid synchronization failure, incorrect DC input voltage, internal inverter fault |
| Scenario 3 | Battery bank issue | The battery bank is not charging or discharging properly | Incorrect wiring, faulty charge controller, low state of charge, or damaged batteries. |
| Scenario 4 | Water pump issue | The solar-powered water pump is not operating | Incorrect AC voltage, faulty wiring, or motor failure |

1. **Troubleshooting approach**

Follow the below mentioned troubleshooting steps:

* **Identify the symptoms:** Each group should first observe the issue and document the symptoms (e.g., inverter error messages, low voltage readings, non-functioning pump) thereby gathering information about the system's behaviour and specific symptoms observed.
* **Visual inspection**: Check and insect for loose connections, damaged wires, and signs of wear or burning.
* **Check system parameters:** Compare readings with the expected values from the system manual (e.g., solar panel voltage, inverter input/output).
* **Isolation of the fault:** Use disconnects to isolate and test different parts of the system to pinpoint the issue.
* **Test grounding**: Ensure proper grounding and check insulation integrity.
* **Evaluate inverter performance**: Review inverter settings and error codes displayed.
* **Assess battery health:** Test battery charge levels and inspect wiring for errors.
* Inspect water pump mechanism (if applicable): Check electrical connections and mechanical components for functionality.

1. **Document findings**

* Each group must carefully document the tests they perform and the results they obtain.
* Note the cause of the issue and the proposed solution.

1. **Group presentations and trainer review (40 minutes)**

**Task 2:** Each group will present their findings, diagnosis, and the steps they took to troubleshoot the fault.

1. **Presentation format**

* Symptoms observed: What were the initial signs of the fault?
* Diagnostic steps: What tests were performed (e.g., voltage readings, continuity checks)?
* Root cause: What was the issue causing the fault?
* Solution: What corrective actions did the group take (e.g., reconnecting wires, replacing components)?
* Lessons learned: What troubleshooting strategies were most helpful?

1. **Trainer feedback:**

* The trainer will provide feedback on each group's approach, highlighting strengths and areas for improvement.
* Common mistakes and best practices will be discussed.

1. **Hands-on fault resolution (30 minutes)**

**Task 3:** Each group will perform the necessary corrective actions to resolve their assigned fault and restore the system to full functionality.

1. **Corrective actions**

* Trainees will physically repair the faults they have identified (e.g., reconnect wires, replace components, reconfigure settings).
* The trainer will supervise to ensure that all actions are performed safely and correctly.

1. **Final testing**

* After repairs, each group will test the system to confirm the issue has been resolved.
* This may involve using a multimeter, clamp meter, or PV analyser to verify voltage, current, and power output.

1. **Whole system testing and commissioning (30 minutes)**

**Task 4:** After all groups have completed their fault resolutions, perform final system tests to ensure the entire system is functioning correctly by carrying out following activities as:

1. **Final inspection**

* Inspect the entire PV system, checking for any remaining issues or unaddressed faults.
* Reconfirm all connections (DC and AC side), particularly after the system has been repaired.

1. **System tests**

* Perform a full voltage and current test across all components: solar panels, inverter, batteries (if used), and the water pump.
* Check the DC input from the solar panels and ensure it matches system specifications.
* Test the AC output from the inverter to ensure proper voltage and phase balance across the three-phase system.
* If a battery is included, ensure the battery bank is charging and discharging properly under load.

1. **Water pump test (if included)**

* Test the water pump by turning it on and monitoring its performance.
* Measure the current draw using a clamp meter to verify proper operation.

1. **System commissioning**

* If all tests are successful, the system can be commissioned (ready for use).
* Document the commissioning process and verify that all components are operating within the specified ranges.

1. **Review and debrief (30 minutes)**

**Task 5:** Discuss the results, troubleshooting strategies, and lessons learned from the exercise.

* 1. **Group discussion**
* What were the most common faults encountered?
* Which troubleshooting methods were most effective?
* Were there any challenges that required additional support or resources?
  1. **Trainer debriefing:**
* Provide feedback on the overall troubleshooting process.
* Highlight common mistakes or misconceptions encountered during the exercise.
* Discuss the importance of following systematic troubleshooting methods for diagnosing solar PV systems.