

Module Outline

PV SYSTEM PROTECTIONS AND MARKING





Disclaimer

All rights reserved.

The authors assert their moral rights.

The text in this book is those of the authors and the facts are as reported by them, which have been verified to the extent possible, and the publisher is not in any way liable for the same.

The publisher has used its best endeavours to ensure that URLs for external websites referred to in this book are correct and active at the time of going to press. However, the publisher has no responsibility for the websites and can make no guarantee that a site will remain live or that the content is or will remain appropriate.

No part of this publication may be reproduced, transmitted, or stored in a retrieval system, in any form or by any means, without permission in writing from the International Solar Alliance.

Relevance and Background

This module is highly relevant as earthing, Lightning Protection System (LPS), and proper marking and labelling are critical aspects of solar PV plant design – ensuring operational safety, reliability, and regulatory compliance.

Participants will grasp the importance of these practices in safeguarding personnel, equipment, and the environment, thereby enhancing the performance and longevity of solar PV systems.

Theme – Technical

Competency – Electrical

Code of the Module – To2Co3Mo8


Learning Outcomes

By the end of this module, participants will be able to:

- Understand the fundamental concepts of earthing, grounding, and neutral in electrical systems.
- Recognize the significance of proper earthing in mitigating electrical hazards and fault currents.
- Comprehend the principles and procedures for selecting the most suitable earthing system for solar PV plants.
- Be familiar with different types of earthing used in solar installations and their respective applications.
- Gain insights into the design and implementation of effective LPS in solar PV plants.
- Learn the methods of lightning protection, including angle protection and rolling sphere techniques.
- Understand the role of lightning arresters in safeguarding solar PV systems from lightning-induced surges.
- Be equipped with the knowledge to conduct earthing resistance testing using earth testers and clamp earth testers.
- Acquire the ability to calculate the appropriate earthing conductor size based on fault current requirements.
- Gain an understanding of marking and labelling practices, and their significance in enhancing communication and safety in solar PV plants.

Method of Delivery

Duration	Resource Code	Resource Delivery
----------	---------------	-------------------



60 min.	Mo8 L01	Lecture on PV System Protections and Marking
---------	---------	----------------------------------------------

Mo8 L01: Lecture Presentation

Participants will gain comprehensive insights into earthing, LPS, and marking and labelling practices. The presentation will be detailed, with clear explanations, practical examples, and visual aids to enhance participant learning. It will focus on best practices to foster an interactive and engaging learning experience.

Key safety aspects in solar PV installations will cover the fundamentals of earthing, grounding, and neutral in electrical systems, emphasizing their role in mitigating electrical hazards and fault currents.

Various types of earthing are used in solar plants and this presentation provides guidelines for selecting the appropriate system based on soil conditions. It delves into lightning protection methods, highlighting the importance of lightning arresters in diverting surges and safeguarding equipment.

Participants would learn the significance of proper marking and labelling of components and equipment, thus enhancing communication and safety in solar PV plants. Practical considerations, like earthing resistance testing and conductor size calculation, are discussed, ensuring accurate and efficient implementation.

Overall, the presentation will equip participants with the essential knowledge and skills to create safe, reliable, and compliant solar PV installations, benefiting both residential and grid-connected projects.

Key Topics to be Covered

- 1 Why earthing?
- 2 Lightning Protection System (LPS)
- 3 Marking and Labelling In Solar PV
- 4 Standards:

Table of Contents

1	Introduction.....	6
2	Why earthing?	6
2.1	Selection of Earthing.....	7
2.2	Earthing for SPV Plants	8
2.3	Earthing in Plants with and Without Galvanic Isolation (With Transformer).....	8
2.4	Connecting Components to Earthing.....	9
2.5	Earth Tester, 3-Point Earth Testing, and Testing with Clamp Earth Tester	9
3	Lightning Protection System (LPS).....	10
3.1	World Lightning Map and Damage Statistics of Photovoltaics	10
3.2	Methods of Lightning Protection	10
3.3	Types of Lightning Arresters.....	11
4	Marking and Labelling In Solar PV	11
5	Standards.....	11

1 Introduction

This module presents a comprehensive overview of the essential aspects of earthing, lightning protection system (LPS), and proper marking and labelling practices in solar PV plants. It is designed to provide a detailed understanding of the key concepts, procedures, and considerations involved in ensuring the safety, reliability, and compliance of solar PV installations across various scales.

2 Why earthing?

Earthing is a fundamental safety measure in electrical systems, including solar PV installations. It ensures the dissipation of fault currents to the ground, preventing electrical hazards, and protecting personnel and equipment. The basic concept of earthing involves creating a low-resistance path to divert fault currents to the ground. It neutralizes potential electrical hazards and stabilizes the system during faults.

Visualizing the earthing system as the roots of a tree illustrates the interconnectedness of multiple grounding points, providing a robust and efficient earthing network. Understanding the terms like earthing, grounding, bonding, and neutral clarifies their roles in electrical systems, facilitating a comprehensive understanding of their functions. Earthing means connecting (normally non-current carrying) metallic parts such as enclosure, body frame, etc. to the earth (ground). Grounding means connecting normally current carrying live parts of a machine to earth. Many a time these are used for similar concepts in different parts of the world.

The bonding, or electrical bonding, means connecting the two conductors like wires, pumps, machines and metallic bodies (normally non-current carrying) permanently so that the potential difference between these is nullified.

Exploring different types of earthing provides insights into their applications and advantages.

Type of Earthing	Description	Suitable for Solar Plant Size
Plate Earthing	Burying a metal plate (e.g., copper or galvanized iron) in the ground to serve as the electrode.	Small to medium-sized installations
Rod Earthing	Using metal rods (e.g., copper or galvanized iron) driven vertically into the ground as electrodes.	Medium-sized installations
Strip Earthing	Burying a metal strip (e.g., copper or galvanized iron) in a horizontal trench to provide a larger contact area with the soil.	Larger installations
Ring Earthing	Utilizing a circular metal ring buried in the ground as an electrode.	Larger installations
Pipe Earthing	Driving a metal pipe (e.g., copper or galvanized iron) vertically into the ground as the earth electrode.	Various sizes depending on pipe dimensions
Electrode Earthing	Employing a combination of different types of electrodes (e.g., rods, plates, pipes) to create an effective earthing system.	Larger installations

2.1 Selection of Earthing

A systematic procedure for selecting the appropriate earthing system considers factors like soil resistivity, fault current calculations, and specific plant requirements. Comprehensive descriptions of various earthing methods, along with their benefits and limitations, assist in selecting the most suitable method for a specific solar PV plant. These earth electrode installation methods, like vertical, horizontal, and inclined installations, accommodate different soil conditions and space constraints for optimal earthing.



The factors for selecting numbers and types of earthing to be used for a PV system are:

- **Size of the PV system**
- **Number of subarrays**
- **Earth strata - sometimes it is not possible to dig a pit and only a bore can be drilled or at some sites due to hard rock strata the boring or digging deep is not possible and one has to resort to horizontal strip earthing.**
- **Space availability - horizontal distances between different earthing's need to be maintained and sometimes there may be space constraint and in such cases, a mesh of earthing needs to be prepared.**

2.2 Earthing for SPV Plants

Considerations for earthing in solar PV plants, including modules, mounting structures, inverters, and other components, should be addressed to ensure comprehensive grounding.

A schematic diagram is provided in the presentation to showcase the earthing layout in a solar PV plant, which will aid in visualizing the earthing connections and grounding arrangement. Various components such as earth electrodes, earthing conductors, and earth pits, contribute to a robust earthing system, promoting safety and effectiveness.

Defining ground-faults and understanding their potential hazards emphasizes the role of proper earthing in mitigating fault currents and ensuring a safe operating environment.

2.3 Earthing in Plants with and Without Galvanic Isolation (With Transformer)

The presentation will consider earthing requirements in solar PV plants with galvanic isolation involving transformers, which ensure effective grounding despite isolation. On the other hand, understanding earthing practices for PV systems without galvanic isolation emphasizes the significance of proper bonding for effective earthing in such configurations.

Finally, exploring various materials used for earthing, such as copper, galvanized steel, and copper-bonded rods, helps in selecting the most suitable material for the specific application.



2.4 Connecting Components to Earthing

Guidelines for correct connection of various components, such as modules, module mounting structures (MMS), inverters, and lightning arresters (LA), to the earthing system promote an efficient grounding network.

Knowing the permissible value of earthing resistance ensures that the earthing system meets safety standards and efficiently dissipates fault currents. Factors influencing earthing resistance, such as soil resistivity, electrode material, and moisture content, should be explored to optimize the efficiency of the earthing system.

Guidance on calculating the appropriate earthing conductor size, based on fault current and earthing system requirements, aids in designing an efficient earthing network. Understanding the significance of the earth symbol in electrical diagrams and labelling ensures proper identification of the earthing connection.

Characteristics of an efficient earthing system, such as low resistance, proper bonding, and effective connection points, contribute to a safe and reliable grounding network. Efficient earthing is one where the fault current is passed with lowest resistance to the earth, and it is not allowed to flow to other parts of the circuit thereby saving any damage to the circuit. The resistance of earth must be maintained low all throughout life by keeping the soil moist. Similarly, the down conductors should be placed on the building walls and other areas with proper spacers so that they reach the earthing point without touching any building part.

The connections of earthing flat or wire to the rod in the pit should be rustproof and always tight. The loose bonding makes the resistance higher and rusting also may add to the resistance in the conductive material.

Also, addressing earthing practices for both DC and AC sides of solar PV plants, encompassing modules, module mounting structures (MMS), inverters, and lightning arresters (LA), ensures comprehensive grounding.

2.5 Earth Tester, 3-Point Earth Testing, and Testing with Clamp Earth Tester

Considering the impact of soil type on earthing resistivity and the importance of soil resistivity testing promotes optimal earthing system design. Methods of testing earthing resistance using earth testers and clamp earth testers ensure accurate and reliable verification of the earthing system.

3 Lightning Protection System (LPS)

Highlighting the significance of lightning protection in solar PV plants, along with potential damage statistics, emphasizes the importance of robust lightning protection measures.

3.1 World Lightning Map and Damage Statistics of Photovoltaics

Examining the world lightning map and photovoltaic damage statistics aids in identifying high-risk regions and implementing adequate lightning protection measures. Understanding the role of a lightning arrester in diverting lightning-induced surges away from PV systems, safeguards equipment and mitigates potential damage.



3.2 Methods of Lightning Protection

Exploring angle protection and rolling sphere methods of lightning protection provides insights into their application for safeguarding PV installations.

3.3 Types of Lightning Arresters

Different types of lightning arresters, such as rod-type and mesh-type, offer various advantages and are selected based on their specific applications. An overview of the IEC 62305-3 standard for calculating the minimum separation distance for lightning protection ensures effective positioning of lightning arresters.

4 Marking and Labelling In Solar PV

- Understanding the importance of marking and labelling of solar PV components, equipment in possible hazards, facilitates their safe operation, maintenance and trouble-shooting.
- Recognizing the purpose of marking and labelling in solar PV installations emphasizes safety, clarity, and compliance as essential objectives.
- Exploring different types and sizes of labels and markings used in solar PV installations considers visibility, durability, and compliance requirements.
- Examples of common markings and signage used in solar PV plants, including warning signs, equipment labels, and safety instructions, promote effective communication.

There are different ways of doing such labels and markings and these are used depending on the location and surface where these are placed. For any outdoor and metallic surfaces metal plates with itching or punching content on them are preferred. In the case of indoor and wooden or metal or fibre surface long lasting plastic is used with printed content and signages. Ferrules are most preferred for incoming and outgoing cable points for identification.

5 Standards

Understanding the standardized earthing systems schemes defined by IEC 60364, aids in adopting consistent and reliable earthing practices. Adhering to NEC guidelines and international standards, such as IEC and BIS, ensures compliance with safety regulations and industry best practices in earthing and lightning protection.

Reading Material

1. *Utility Scale Solar Power Plants – A Guide for Project Developers and Investors by International Finance Corporation*
<https://documents1.worldbank.org/curated/en/868031468161086726/pdf/667620WP00PUBL005BoSOLARoGUIDEoBOOK.pdf>
2. *Handbook for Rooftop Solar Development in Asia by Asian Development Bank*
<https://www.adb.org/sites/default/files/publication/153201/rooftop-solar-development-handbook.pdf>
3. *Best Practices for Operation and Maintenance of Photovoltaic and Energy Storage Systems; 3rd Edition by National Renewable Energy Laboratory*
<https://www.nrel.gov/docs/fy18osti/68469.pdf>