Module Outline

MOUNTING STRUCTURES FOR PV SYSTEMS

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Relevance and Background

The importance of proper MMS is critical in ensuring the structural integrity and optimal performance of solar PV systems, thereby ensuring proper returns from the project and maximum energy production.

There are numerous examples, wherein due to this often-ignored component, which is low-cost and comparatively easy to procure, other costly components of the PV system such as modules and inverters get damaged, and the whole system's performance and life get hampered.

Therefore, it is essential to understand different mounting types for the efficient installation, maintenance, and durability of solar modules and other components. Designing a proper mounting structure for solar arrays, inverters, or batteries is equally important in ensuring the project's success.

Theme – Technical
Competency – Mechanical
Code of the Module – T02C04M12

Learning Outcomes

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

- Identify and compare different types of solar MMS
- Decide which type of MMS is best suited to the site requirements
- Understand mountings for different components and types of PV systems and products

An overview of the above topics would equip them with the necessary exposure so that they can contribute to developing solar projects in their respective countries as per their needs.

Method of Delivery

Duration	Resource Code	Resource Delivery
60 min.	M12 L01	Lecture on Mounting Structures for PV Systems

M12 L01: Lecture Presentation

- The MS PowerPoint presentation will provide a comprehensive overview of mountings for solar systems and their components, including MMS and their significance in solar PV systems. The focus will be on the different types of MMS, including fixed, tracker, rooftop, and ground-mounted structures.

- Participants will gain an understanding of the characteristics and applications of each type of MMS. The advantages of fixed MMS, such as its simplicity, cost-effectiveness, and reliability, will be highlighted. The concept and benefits of tracker MMS, which utilizes tracking systems to orient solar panels for maximum sun exposure, will be explored. Rooftop MMS will be discussed, with an emphasis on considerations such as structural integrity, waterproofing, and load-bearing capacity. Ground-mounted MMS, commonly used for larger-scale solar installations, will also be covered, including different ground mounting options and their applications.
- The presentation will address the importance of proper foundation design and selection for MMS stability. Participants will learn about the different types of foundations commonly used, including concrete foundations, ground screw foundations, and ballasted foundations. Key considerations such as soil conditions, structural analysis, and load-bearing capacity will be explained in the context of foundation selection and design.
- Throughout the presentation, visuals, diagrams, and real-world examples will be used to enhance understanding and illustrate key concepts related to MMS.
- By the end of the presentation, participants will be equipped with the knowledge necessary to make informed decisions when selecting and implementing MMS in solar PV systems, to ensure optimal performance and durability.

Key topics to be Covered

1. Types of Module Mounting Structures
2. Designing Module Mounting Structures
3. Fasteners and Clamps:
4. Maintenance Path or Walkway:
5. Drawings and Staad Analysis
6. Inverter Mounting
7. Off-grid Systems Mounting

Table of Contents

1 Introduction

Solar systems require various mountings for their components like modules, inverters, batteries, and lights or luminaires in some PV products. The MMS is the most important and critical as it can substantially impact the performance and life of the full PV system. MMS also has to withstand the harshest environmental conditions in their lifetime.

MMS, however, was the most ignored component of the solar system until the importance dawned on the engineering, procurement and construction (EPC) contractors and investors, after numerous accidents happened because of faulty MMS used in rooftop plants or even in MW-scale power plants. Due to this ignorance, the whole project economics was at high risk of being disturbed, resulting in project losses.

As the industry grew and many countries started adopting solar photovoltaic (PV) power, various design aspects of MMS developed, and more care is being taken in deploying the right type of structure so that the project performs well and stays undamaged for many years beyond the lifetime of the plant.

Presently, there is a better understanding of MMS among designers, engineers and installers, and newer types are evolving.

Since MMS has an important role in providing stability, support, and optimal positioning for PV modules, proper selection and design of MMS can affect the performance and efficiency of the solar system.

2 Types of Module Mounting Structures

2.1 Fixed Mounting Structure

This is one of the simplest forms of MMS and is commonly used in rooftop installations, off-grid applications and small-scale power plants. In multi-MW power plants as well it is still one of the common designs used, due to its low cost and sturdy design requiring no or low maintenance throughout the plant life. However, these large plants are seeing a significant shift to trackers being used to maximize output of a plant.

2.2 Rooftop Mounting Structure

It is possible to use any kind of roof to install the solar PV array – flat, sloping, tiled, galvanized iron (GI) sheet, steel roofing, and so on. This is achieved through the proper fixed type design of the MMS.

2.3 Ground-Mounted Structure

Structures for ground-mounted systems have other factors for consideration such as soil type, soil resistivity, contour and profile of the ground, and water drainage in the area of installation. There are different types of such MMS and their foundations, which are discussed in the module.

2.4 Tracker Mounting Structure

The use of trackers is fast growing in MW-scale power plants; and with the new module types, like bifacial, the use of trackers is giving higher performance improvement than the fixed type.

Tracking can be of two types, one for daily tracking from east to west, following the Sun's path from morning to evening. This is called single-axis tracking. The tracker table may be either horizontal or slightly tilted according to the location. The second type is double-axis tracking, where the tracking is from east to west during a day, and also north to south during a year. This literally tracks the Sun all year.

These trackers can give additional energy output of 10% to 25% depending on the type, location, modules and design.

3 Designing Module Mounting Structures

3.1 Fixed Mounting Structure

The tilt and orientation of the solar module is decided by the structure, and it can be designed to suit the location latitude, and also as per other conditions such as the surface conditions on which the modules are to be mounted, and historical wind data so that storms or cyclones have minimal impact on the modules. The tilt and orientation decisions are presently more flexible as the costs of overall plant equipment have gone down. So even a non-ideal but well-designed structure can provide good returns from a power plant.

3.2 Rooftop Mounting Structure

It is important to check the strength of the roof and its structure, known as structural integrity, to bear the load of the module including the structure weight. Normally the trend is to limit the weight to 60 kg per sq m.

Other safeguards involve waterproofing of the roof during and after the installation of the array. Also, wind load on the roof structure is dependent on the height of the roof, and proper calculation is necessary to arrive at the safe design.

3.3 Ground-Mounted Structure

Site selection and ground preparation are important activities to be included in the design. A point to note is that flattening of the ground is not necessary and the gentle contour of the ground can be utilized to directly erect the structure.

3.4 Tracker Mounting Structure

The trackers have moving components as the array must track the Sun travel. The logic of sun tracking can be either sun sensing cell giving exact location for the structure to move accordingly or in the second type the location-based GPS enabled system provides locations of Sun according to the time and day for the location giving signal for the movement. The design of both these types of trackers is more complex.

The tracking structure requires higher investment as compared to a fixed type due to additional material use and also requires higher maintenance due to moving parts and the complex design.

3.5 Common Design Parameters to All Types

Material of structure must withstand environmental conditions for the proposed life of the system without rusting, buckling, damaging or loosening. This calls for use of aluminium or galvanized iron, which are most commonly accepted. Other new types of suitable material like galvalume, zincalume, posmac, etc. are being developed and introduced in the market to cater to the growing market demand.

Wind load factors applicable to the project location based on recorded historical data of wind speeds, storms and seasonal variations are a major consideration and each major design needs to be type tested for withstanding applicable wind velocities so that the structural integrity is not compromised in any scenario during the system life.

3.6 Foundations in MMS Design

There are different types of foundations in MMS design and installation.

Concrete foundations: Use of concrete pads or footings as a stable foundation option.

Ground screw foundations: Use of ground screws as an alternative foundation option, and their ease of installation and adaptability to various soil conditions.

Ballasted foundations: Weight of the system provides stability; this is also used in some rooftop installations.

Key considerations when selecting and designing foundations for MMS are:

Soil conditions: Soil analysis is important to determine the appropriate foundation type, considering factors like soil bearing capacity and stability.

Structural analysis: Structural design analysis is important to ensure the foundations can withstand loads, accounting for factors like wind loads, seismic conditions, and other relevant factors.

3.7 Special types of MMS

Many special surfaces where the modules are to be fixed or mounted require special types of MMS. These include modules on water known as floating PV or building integrated known as BIPV or covering canal tops or canal banks. There are some designs developed over the period of time for using car parking space for module installation and this is known as carport PV. Modules for solar water pumps are mounted on different types of pumps – either single pole or tables of steel for fixed mounting.

Sometimes the modules themselves are specially designed for such installations or same standard modules can be fixed by designing special structures. Some of these types like BIPV or Carport may require waterproof design, while some installations like BIPV may require aesthetically superior modules and structures.

Floating PV involves modules to be fitted on floaters that are fixed either through moors or anchors or a combination of these. Here the MMS material changes from heavy steel to kinds of plastic that are light and can withstand harsh aquatic conditions.

4 Fasteners and Clamps

PV modules have less or no flexibility in fixing these to the structure. Each manufacturer provides the mounting holes for the module model and fixing the module anywhere else voids the warranty. Small components—fasteners and clamps—are very critical in securing PV modules to the mounting structure.

Stainless steel bolts and screws are the most common fasteners in ground-mounted systems, whereas clamps are commonly used in rooftop installation. But all the MMS types are acceptable when it is designed properly.

In rooftop installation the use of aluminum clamps for module fixation has increased due to their low weight, rust-proof nature, and compatibility with different module frame sizes.

5 Maintenance Path or Walkway

In ground-mounted systems there is always sufficient space between two rows or two trackers, as this is left for avoiding the shadow, and this space is used for maintenance as well. On rooftop systems however, a special walkway may be needed on the sloping metal roof so that the worker does not step on the metal roof. Walkways should provide access to each and every module in the system to enable ease in module replacement when the need arises. It is commonly observed that ease of reaching the module motivates the cleaner to periodically clean these as necessary.

6 Drawings and Staad Analysis

6.1 General Arrangement (GA) Drawing and Structural Considerations

The preparation and approval of General Arrangement (GA) drawings in MMS design is extremely important in overall solar plant planning, as it can avoid future possible accidents.

Analyzing the effect of different velocity winds on the structure parts and components is another crucial activity in the design phase. Tools such as wind tunnel analysis and finite element analysis are used to finalize the design that can withstand the possible winds in a particular location. Each new design needs to be passed through these tests and be certified by a third-party agency to ensure high quality and proper design. Other factors like snow loads and seismic considerations are also considered in designing the MMS for solar systems.

6.2 Structural Analysis and Design (Staad)

Staad is commonly used structural analysis software in MMS design. It aids in determining structural integrity and load distribution, which helps to ensure longevity and non-damage of the structure in locational environmental conditions.

7 Inverter Mounting

Inverters can be mounted in the open or inside the building. In the open area, these can be on a special mounting stand or on the MMS below the modules. Inside the building these can be mounted on the wall or on stands. The mounting of inverters is carried out according to the site suitability, but adhering to the inverter manufacturer's instructions, which include sufficient ventilation space, maintenance area around the unit, easily accessible area for repairs, and for easily readable display.

Even in the open, inverters need a shed or some protection from direct sunlight, rain and dust.

8 Off-grid Systems Mounting

Mounting designs for standard systems like streetlights, home lighting systems and pumps have developed over the years and offer good, standardized solutions.

In streetlights, the module, battery, luminaire, and electronic control unit (ECU) are to be mounted on a single pole and different designs have evolved owing to the changing nature of these components. The batteries are now maintenance-free and sealed, and very small in size as compared to the earlier lead-acid bulkier battery, while the lamp has changed from compact fluorescent lamps (CFL) to light emitting diodes (LED). Therefore, the pole and other mounting designs have become very compact and easy to transport and install.

The mounting requirements for home lighting system components have also changed such as from the battery box or a rack for the earlier lead acid bulkier battery to the sealed maintenance-free (SMF) battery, which does not require maintenance area, as there is no spillover and no fumes.

9 Mounting for Cables

DC and AC cables in the system run between various components and also to the grid integration point. There may also be communication cables for system monitoring. These must be routed systematically and must run through conduits or cable trays as per the site requirement. Normally metal or fiber cable trays are used, and these trays have perforations for breathing purposes and have intermittently placed openings for easy maintenance.

Conduits are normally used for small distances underground in-trench cabling or locations where temperatures are moderate. In any type of routing these cables must be identified at various places so that maintenance personnel find these easily.

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/667620WP00PUBL005B0SOLAR0GUIDE0BOOK.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)*