



# **ESCOM**

ELECTRICAL SAFETY  
COMMITTEE

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## **GUIDELINES AND BEST PRACTICES FOR SOLAR PHOTOVOLTAIC DESIGN, INSTALLATIONS AND MAINTENANCE (OUTDOOR)**

**DOCUMENT No: ESCOM/2026/05, REVISION 1.0**

## **What is ESCOM?**

The Safety, Health and Environment National Authority (SHENA) and Autoriti Elektrik Negara Brunei Darussalam (AENBD) established the Electrical Safety Committee or “ESCOM” in January 2023; with the objectives of promoting regulatory compliance and raising electrical safety standards within Brunei Darussalam.

## **Who are the ESCOM members?**

The Electrical Safety Committee (ESCOM) comprises representatives and industry experts drawn from relevant government institutions and private organisations, collectively bringing extensive technical experience in electrical engineering, safety management, and industry practice.

ESCOM is **chaired by a representative from the Safety, Health and Environment National Authority (SHENA)**, with a **Deputy Chairperson appointed in accordance with the Committee’s Terms of Reference**. Subject matter experts from regulatory bodies, utilities, and industry may be invited to participate in specific working groups or provide technical input where required.

## ELECTRICAL SAFETY BEST PRACTICES

<b>DOCUMENT TITLE</b>	<b>GUIDELINES AND BEST PRACTICES FOR SOLAR PHOTOVOLTAIC DESIGN, INSTALLATIONS AND MAINTENANCE (OUTDOOR)</b>		
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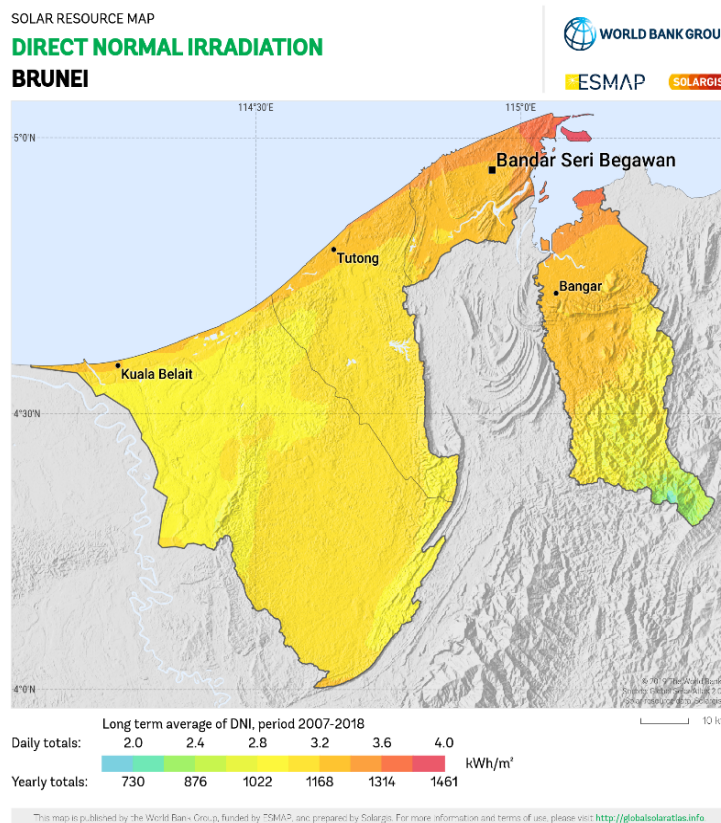
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# 1 INTRODUCTION

## 1.1 Background

Brunei Darussalam, situated near the equator line hosts a tropical climate, providing ample amounts of sunlight throughout the year. This strategic location has bolstered the country’s potential to tap into this sun-dense resource. The relatively high solar irradiance of an average annual solar irradiance of 1,022 to 1460 kWh/m<sup>2</sup>/year. Real-time information on solar energy generated can be seen under a Solar Irradiance Map.



**Figure 1-1: Solar Resource Map<sup>1</sup> © 2021 Solargis**

Published in July 2020, the first volume of the “Brunei Darussalam National Climate Change Policy” hereout referred to as “BNCCP” highlighted a Whole-of-Nation approach to address adverse changing climate patterns; one of which Strategy 4 is to focus on increasing the total share of renewable energy to at least 30 % of the total capacity in the power generation mix using mainly solar photovoltaic (PV) by 2035.

In 2020, renewable energy accounts for just 0.14 % of Brunei Darussalam’s total electricity generation mix. Rapid growth of solar installations is expected to achieve the renewable energy target; however, this growth also introduces complex

<sup>1</sup> Solar resource maps & GIS data for 200+ countries | Solargis

electrical safety challenges that need to be proactively managed. Hence, it is imperative that an electrical safety guideline is created for various types of PV installations.

## 1.2 Purpose

The purpose of this document is to define the minimum technical requirements and provide guidelines for the installation of PV (solar) installations while considering the inherent electrical safety risks with solar installations. This document can be used together with the EIR (Electrical Installation Requirement, DES).

## 1.3 Scope

### 1.3.1 Scope of work

This scope covers all PV installations within Brunei Darussalam, which includes the following Large Scale Solar PV and Small-Scale Solar applications, but not limited to:

- 1.3.1.1 PV installations on Commercial Spaces e.g. Warehouses, Shophouses, Factories, Processing facilities, Offices, Restaurants, Billboards, Schools, Recreational Clubs, Carparks
- 1.3.1.2 PV installations at government spaces/locations
- 1.3.1.3 PV installations at outdoor Public Spaces, Public parks, Recreational Spaces, Beaches
- 1.3.1.4 PV installations on Residential Buildings, High-rise apartment complexes, Landed Housing,
- 1.3.1.5 PV Lighting
- 1.3.1.6 Hybrid/Microgrid systems
- 1.3.1.7 PV installations for EV charging

### 1.3.2 Exclusion

The following equipment/applications are excluded from the scope of this document:

- 1.3.2.1 Industry: quarry / onshore /offshore / marine / ports / construction
- 1.3.2.2 PV-connected Battery Energy Storage Systems (BESS)
- 1.3.2.3 Aviation Warning Lights (AWL)
- 1.3.2.4 Marine lights/lanterns - inland waters and high seas
- 1.3.2.5 Floating Solar
- 1.3.2.6 Product safety requirements, product performance requirements, product tests, selection and system design methods, and government energy regulation.

## 2 REFERENCE

### 2.1 Applicable Standards

2.1.1 A list of relevant safety standards and regulations applicable to electrical safety in photovoltaic installations is provided in Table 2-1: Relevant Standards and Regulations.

**Table 2-1: Relevant Standards and Regulations**

Standard/Regulation	Description
<b>General</b>	
WSH (Construction) Regulations 14	SHENA Workplace Safety & Health Requirement
WSH (General Provisions) Regulations 2014, Regulation 6	SHENA Workplace Safety & Health Requirement
WSH Publications (IGNs, NTIs, WSHN)	SHENA Workplace Safety & Health Requirement Publications (Industry Guidance Notes, Note to Industry, Workplace Safety and Health Notice)
BS 7671	IET Wiring Regulations: Requirement for Electrical Installations
IEC 60529	Degrees of Protection Provided by Enclosures (IP Code)
IEC 60364	Low-voltage electrical installations
IEC 61439-1	Low-voltage Switchgear and Controlgear Assemblies – General Rules
IEC 62305	Protection against Lightning
IEC 62485-1	Safety Requirements for Secondary Batteries and Battery Installations
IEC 62619	Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes – Safety Requirements for Secondary Lithium Cells and Batteries for Use in Industrial Applications
IEEE 1548	Requirements for Interconnection of Distributed Energy Resources with Electrical Power Systems
<b>PV system</b>	
IEC 60364-7-712 (PV specific)	Low-voltage electrical installations - Requirements for special installations or locations - Solar photovoltaic (PV) power supply installations
IEC 61215	Terrestrial photovoltaic (PV) modules - Design qualification and type approval
IEC 61643-32	Low-Voltage Surge Protection Devices – Part 32: Surge Protective Devices Connected to the DC Side of Photovoltaic Installations
IEC 61701 (for salt laden environments)	Salt Mist Corrosion Testing

Standard/Regulation	Description
IEC 61727	PV Systems – Characteristics of the Utility Interface
IEC 61730	Photovoltaic (PV) module safety qualification: Requirements for construction
IEC 62109	Safety of Power Converters for use in Photovoltaic Power Systems
IEC 62116	Test Procedures of Islanding Prevention Measures for Utility-Interconnected PV Inverters
IEC 62446-1	Photovoltaic (PV) systems - Requirements for testing, documentation and maintenance
IEC 62548	Photovoltaic (PV) Arrays: Design Requirements
IEC 62716 (for agricultural environments)	Ammonia Corrosion Testing
IEC 63027	PV Power Systems – DC Arc Detection and Interruption
IEC 63112	Photovoltaic (PV) Arrays – Earth Fault Protection Equipment – Safety and Safety-Related Functionality
<b>Mounting Structure</b>	
ASCE 7	Minimum Design Loads and Associated Criteria for Buildings and Other Structures
IRENA	Solar PV Installation Guidelines (2021)
ISO 1461	Hot-Dip Galvanized Coatings on Fabricated Iron and Steel Articles

2.1.2 The user of this document shall use the latest revisions of the applicable standards and are currently active in the industry. Any standard that has been superseded shall not be used.

2.1.3 General PV Balance of Systems Equipment Minimum Installation and Safety Standards can be found in Table A-1 in Appendix A. The intent is to help the PV system installer to verify work to be undertaken in a typical PV installation.

### 3 ELECTRICAL REQUIREMENTS

#### 3.1 General

3.1.1 PV system installations shall be fully designed to standardised supply voltages in Brunei Darussalam, i.e., Single phase: 230 Vac +20/-10 %, 50 Hz and three phase: 400 Vac +20/-10 %, 50 Hz.

3.1.2 Typical PV system designs have been illustrated in a block diagram format for the following types of PV system installations. Appendix B:

3.1.2.1 Domestic Single String Inverter Installations

3.1.2.2 Commercial buildings with Centralised Inverter installation

3.1.2.3 Commercial buildings with string inverters for TN-S/TT Earthing Systems

3.1.2.4 Commercial buildings with string inverters for IT Earthing Systems

3.1.3 As a good general practice, manufacturer manuals and procedures shall be followed.

### 3.2 Electrical Safety Requirements

This section aims to provide a general understanding of the risks and dangers associated with the installation of PV systems. There is a wide range of hazards associated with the installation PV system, starting from the equipment handling up to commissioning and then maintenance; electrical hazards such as electric shock leading to electrocution, arc flash due to faults and electrical fires as the panels constantly produce DC electricity when exposed to sunlight, and mechanical hazards such as dropped objects and working at height. These hazards are encountered at an installation site, but rarely all at once. While roofers may be accustomed to minimising risks of falling or injury due to manual handling problems, they may not be used to dealing with the risk of electric shock. Similarly, electricians would be familiar with electric shock hazards but not with handling large objects at heights.

The general safety precautions related to PV system installations are further defined below:

3.2.1 The supply from PV modules cannot be switched off, so special precautions should be taken to ensure that live parts are either not accessible or cannot be touched during installation, operation, and maintenance.

3.2.2 Work on solar panel strings should be carried out when illumination/light intensity is low e.g. at night, or by suitable means of obstructing light from hitting the PV panel surfaces e.g. by placing an opaque canvas on top of the PV panels.

3.2.3 As much as reasonably practicable, PV balance of systems e.g. PV inverters shall be installed at a distance not in direct proximity to the public and shall be treated similarly to standard electrical installations e.g. switchgears, transformers.

3.2.4 Warning labels for industrial should be installed at locations visible to each equipment in a PV system to warn the public in vicinity of live PV equipment. A sample warning label is as shown:



**Figure 3-1: A typical warning label for live electrical equipment**

3.2.5 PV modules are current-limiting devices, which require a non-standard approach when designing fault protection systems, as fuses are not likely to blow under short-circuit conditions.

- 3.2.6 Additional safety precautions shall be taken while working with DC voltages in PV systems since few electrical installers are familiar in the industry.
- 3.2.7 The installation of PV systems presents a unique combination of hazards – due to risk of electric shock, falling and simultaneous manual handling difficulty.
- 3.2.8 Key PV system components such as isolation points, DC Voltages and metering points shall be labelled properly.  
  
Rationale: Clear, standardised labelling at the key components is crucial for minimising human error and ensuring personnel safety.
- 3.2.9 To account for fire safety, installers shall use fire-rated materials and ensure clearances from combustible structures are considered. Fire extinguishers rated for electrical fires (Class C) should be readily available during installation and maintenance.
- 3.2.10 For installers working at height, fall protection measures (harnesses, anchor points, guardrails) shall be implemented per OSHA 1926 Subpart M or equivalent local regulations.
- 3.2.11 Lifting and hoisting shall comply to relevant guidelines under SHENA WSH Publications (IGNs, NTIs, WSHN).
- 3.2.12 Workers should use Personal Protective Equipment (PPE): insulated gloves, arc-rated clothing, and appropriate eye protection when handling live or energized components.
- 3.2.13 Installation, commissioning and maintenance work on PV installation should be performed by qualified and competent persons.
- 3.2.14 Operators and Maintenance teams shall adhere to safe work practices when working on PV installations such as Lock-out Tag-out (LOTO) as part of safe isolation where possible and only use proper insulated tools.
- 3.2.15 Operators and Maintenance teams shall perform scheduled inspection of PV balance of systems including inverter terminals, fans, filters, and firmware updates as per manufacturer's O&M manual.

### 3.3 PV System Design Requirements – PV Panels

- 3.3.1 All solar panels shall meet the minimum standards and certifications according to their latest revisions as listed in Section 2.
- 3.3.2 Electrical equipment on the DC side shall be suitable for the rated voltage and current.
- 3.3.3 PV modules may be connected in series up to the maximum allowed operating voltage of the PV modules ( $U_{oc}$  at STC of the PV strings) and the PV converter, whichever is lower.

3.3.4 All junction boxes (PV generator and PV array boxes) shall carry a warning label indicating that parts inside the boxes may still be LIVE after isolation from PV converter.

3.3.5 Solar panels shall be equipped with by-pass diodes to prevent hotspots, which can lead to fire hazards or permanent module damage when partial shading occurs.

Rationale: When a shadow is cast on a portion of a solar module, the affected cells may experience reverse voltage. By-pass diodes provide an alternate current path, allowing the remaining cells to continue generating power safely and efficiently.

3.3.6 A higher number of by-pass diodes improves system performance and reliability by minimizing power loss and thermal stress in shaded or defective modules. For PV arrays connected in series, each PV module should be fitted with at least three by-pass diodes.

3.3.7 The use of blocking diodes shall only be considered when the design requires them; in a PV system that is connected to batteries.

Rationale: The function of blocking diodes is to allow flow from a PV panel to charge a battery and prevents the flow of current from the battery back to the PV panel, to prevent battery from discharging.

3.3.8 If blocking diodes are used, their reverse voltage shall be rated for  $2 \times U_{oc}$  standard test condition of the PV string. The blocking diodes shall be connected in series with the PV strings.

3.3.9 The PV modules shall be installed in such a way that there is adequate heat dissipation under conditions of maximum solar radiation for the site.

#### 3.4 PV System Design Requirements – Inverters

3.4.1 Solar inverters connected to the local electrical grid shall be of the grid-following type, designed to synchronize with the utility grid and convert DC power generated by the PV array into AC power.

3.4.2 The inverter should be appropriately sized to match the installed PV array capacity, considering the minimum and maximum DC power and voltage inputs.

3.4.3 The inverter shall be of a transformerless, grid-following configuration, capable of safely and automatically shutting down in the event of AC grid loss or instability.

3.4.4 The inverter enclosures shall be rated for minimum IP65 for outdoor installations.

3.4.5 All cable entries for outdoor installations shall be bottom entry to prevent water ingress. Top-entry cable routing is strictly prohibited.

- 3.4.6 If mounted in exposed areas, the inverter shall be fitted with a weatherproof canopy to protect against direct sunlight and splashing rain.
- 3.4.7 Installers shall maintain a minimum clearance around the inverter (typically  $\geq 300$  mm on sides and  $\geq 500$  mm at the front) to ensure adequate ventilation and heat dissipation.
- 3.4.8 Each inverter should include both active and passive grid protection systems and be equipped with the following minimum safety and protection features:
  - 3.4.8.1 Anti-islanding protection
  - 3.4.8.2 Input-side disconnection switch
  - 3.4.8.3 DC reverse polarity protection
  - 3.4.8.4 Type 2 AC and DC surge protection
  - 3.4.8.5 Overcurrent and short-circuit protection (AC & DC)
  - 3.4.8.6 Dynamic power factor control (grid following)
  - 3.4.8.7 Earth fault monitoring (AC & DC)
  - 3.4.8.8 Underfrequency and overfrequency protection
  - 3.4.8.9 Undervoltage and overvoltage protection (AC Type 3)
  - 3.4.8.10 Arc Fault Circuit Interrupter (AFCI) for DC arc detection and interruption
  - 3.4.8.11 (Optional) Online and remote monitoring capability (e.g., Modbus TCP, RS485, or cloud-based system)
  - 3.4.8.12 (Optional) Insulation resistance monitoring (DC & AC)
- 3.4.9 The inverter should be mounted on a wall or securely on the solar module support structure near the PV array to minimise DC cable length and voltage drop.
- 3.5 PV System Design Requirements – Mounting Structures
  - 3.5.1 The mounting structure of the PV shall be designed to withstand environmental loads and ensure proper drainage and ventilation. For roof top PV installations, load capacity of the installation should be verified.
  - 3.5.2 Installers working on rooftop solar installations shall use safety harnesses hooked to an appropriate anchor point to prevent falling from height.
  - 3.5.3 The mounting structures shall:
    - 3.5.3.1 Ensure compliance with ASCE 7, EN 1991 (Eurocode 1), or local structural design codes.
    - 3.5.3.2 Use corrosion-resistant materials such as hot-dip galvanized steel, aluminum alloys (6000 series), or stainless steel (grade 304 or higher).

- 3.5.3.3 Accommodate thermal expansion and contraction without causing stress on the PV modules.
- 3.5.3.4 Include proper drainage and prevent water pooling on rooftops or ground surfaces.
- 3.5.3.5 Use fasteners that are of same material as the mounting structures. Example, stainless steel (minimum A2-70) used with a stainless-steel mounting structure to prevent galvanic corrosion.
- 3.5.3.6 Use non-conductive washers or separators to avoid galvanic corrosion when there is contact between dissimilar metals.
- 3.5.4 The following apply to workmanship during the installation of PV mounting structures:
  - 3.5.4.1 All cuts, welds, and drilled areas should be treated or recoated to restore corrosion protection.
  - 3.5.4.2 Welded joints should be visually inspected and, where necessary, non-destructively tested (NDT).
  - 3.5.4.3 Bolted connections should be torqued to the manufacturer's specifications.
- 3.5.5 The following apply to site preparation works during the installation of a PV system:
  - 3.5.5.1 The working area should be level, cleared, and free of debris before installation.
  - 3.5.5.2 Temporary barricades or safety signs should be erected to restrict unauthorized access.
  - 3.5.5.3 Underground utilities shall be verified before foundation excavation or piling.
- 3.5.6 The following apply to roof-mounted PV system installations outside of domestic applications:
  - 3.5.6.1 Walkways or access paths should be designed to prevent roof damage during installation and maintenance.
  - 3.5.6.2 Adequate ventilation clearance beneath modules should be considered to avoid heat buildup.
  - 3.5.6.3 Safe distances from roof edges and clear pathways for emergency egress should be available.
- 3.5.7 The following apply to ground mounted PV system installations outside of domestic applications:
  - 3.5.7.1 Foundations shall be designed based on soil bearing capacity and geotechnical survey results.
  - 3.5.7.2 Installers should use pile-driven, screw, or concrete footing systems appropriate for site conditions.

3.5.7.3 Installers should ensure minimum clearance from the ground to PV panels avoid flooding or vegetation shading.

3.5.7.4 Drainage and erosion control measures around mounting structures should be considered.

3.5.8 Before commissioning, all mounting structures shall be:

3.5.8.1 Visually inspected for alignment, tightness, and corrosion protection.

3.5.8.2 Verified for structural integrity, foundation stability, and proper earthing.

3.5.8.3 Documented through installation inspection checklists, including photographic evidence.

### 3.6 Cable Identification

3.6.1 Cables shall follow the BS7671 wiring colour codes such that:

3.6.1.1 Identification colour for an unearthed DC circuit (typical PV circuits) are: Positive cable – Brown and Negative cable – Grey. Alternatively, black can also be used.

3.6.1.2 Identification colour for an AC circuit connected to typical PV circuits: Brown, Black, Grey and Blue for L1, L2, L3 and N phases respectively.

3.6.1.3 Identification colours for earthing cables : Green/Yellow.

3.6.1.4 Each core of a cable shall be tagged and as a minimum, identifiable by lettering/numbering at both termination points.

3.6.2 All DC string cables should be properly labelled with associated string numbers, positive and negative polarities to maintain polarity identification and clear labelling for ease of maintenance and troubleshooting.

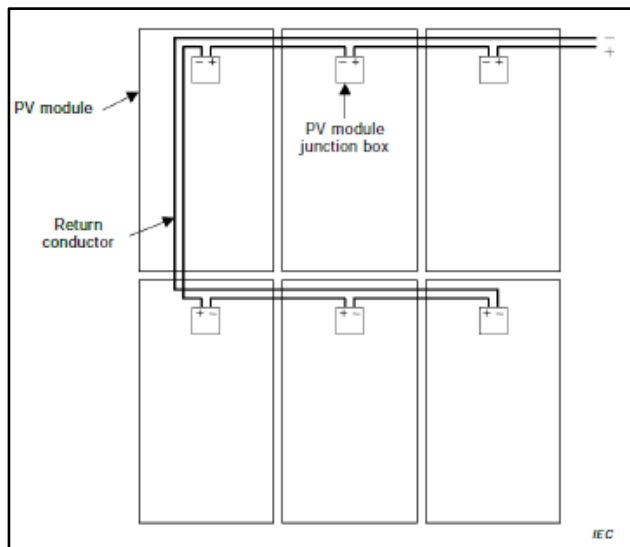
### 3.7 Cable Installation Methods

3.7.1 Double insulated equipment shall be used for all PV systems with an open-circuit voltage of >120 VDC.

3.7.1.1 Rationale: 120 VDC is the threshold where voltage is considered as Extra Low Voltage (ELV) where there is significantly lower risk of electric shock (e.g. reduced accidental shock current paths via cable conductor to a solar panel frame). Appropriate barriers and separation of parts need to be considered when selecting equipment for PV balance of systems.

3.7.2 Where DC PV cables are over 50 m in length, installers shall install danger labels along the DC cables as follows: "Danger solar PV array cable – high voltage DC - live during daylight"

- 3.7.2.1 Rationale: Danger and caution labels are important to inform anyone that the section of DC cables cannot be easily isolated and poses a risk to anyone in contact.
- 3.7.3 DC Cables shall be routed behind PV panels and connected in between each PV module junction box to form a DC string – refer to Figure 3-2: Example of Installation of String DC Cables from IEC 61730 below.
- 3.7.4 During installation, string DC cables shall be laid in parallel to minimize the loop area of conductive circuits as depicted in Figure 3-2: Example of Installation of String DC Cables from IEC 61730. This helps to reduce transient over-voltage magnitude and residual current imbalance, thereby enhancing the electrical safety of the system.



**Figure 3-2: Example of Installation of String DC Cables from IEC 61730**

- 3.7.5 Where PV string wiring between solar modules is not protected by conduit or enclosure, the following additional requirements shall apply:
  - 3.7.5.1 Cables shall be adequately protected from mechanical damage, UV radiation, and environmental exposure.
  - 3.7.5.2 Cable routes shall be designed and installed to prevent excessive tension, thereby avoiding conductor detachment or terminal loosening.
  - 3.7.5.3 UV-resistant, double-insulated solar DC cables shall be used in compliance with IEC 62930 or equivalent.
  - 3.7.5.4 Installers shall avoid sharp cable bends and ensure cable supports are installed at appropriate intervals to prevent sagging.
- 3.7.6 Cables routed between PV array junction boxes shall be rated for a minimum temperature of 80° C and be selected with the appropriate PV connector types from the PV array manufacturers. Some examples of well-known PV connectors are: Universal Solar Connectors, and MC4 (replacing MC3 connector).

- 3.7.6.1 Rationale: Other than the selection of cables, these PV connectors are usually UV protected, provide IP68 rating suitable for outdoor usage, and are classified as Safety Class II. Other known connectors such as T4, TYCO SolarLok, Radox, or equivalent connectors may also be used.



**Figure 3-3: Example of MC4 connector**

- 3.7.7 PV connectors shall be rated 1.5 times the DC voltages and current ratings of the PV strings and DC main cable to which they are fitted.
- 3.7.8 PV DC connectors shall be rated to a minimum ingress protection of greater than IP 21 to prevent accidental contact with any exposed conductive material on the DC connectors.
- 3.7.9 PV DC connectors shall be selected with a design that can be distinguished from any connectors used for the AC system.
- 3.7.9.1 Rationale: This is to prevent any confusion regarding the type of connectors used between AC and DC installation in the event of a missing tag, or lack of identification on the installed system.
- 3.7.10 PV DC connectors shall not be used as a means of electrical switching.
- 3.7.10.1 Rationale: Disconnecting a PV DC connector under load (high DC voltage) can cause permanent damage to the connectors due to high DC arcing energy at the disconnection point. This can also pose a risk of electric shocks to installers/operators/maintenance teams.
- 3.7.11 All PV DC connections shall be secure, corrosion-resistant, and easily accessible for inspection.
- 3.7.12 All DC plugs and sockets under load shall not be disconnected as this will cause a high DC arc equivalent to the PV string voltage, thus potentially

electrocuting anyone working on PV systems, start an electrical fire on a PV installation, and cause permanent damage to the connectors.

3.7.13 Cables shall be selected to minimise the risk of earth faults and short-circuits. This can be achieved by reinforcing the protection of the wiring either through:

3.7.13.1 Single conductor cable – both insulated and sheathed PV cable.

3.7.13.2 Single conductor cable in suitable conduit / trunking (typically non-conducting; however, earthed metal trunking may be required where additional mechanical protection is required. Alternatively, single-core Steel Wire Armoured (SWA) may be a suitable, mechanically robust solution.

3.7.13.3 Multi-core Steel Wire Armoured (SWA) (only suitable for main DC cable and typically utilized where an underground or exposed run is needed)

3.7.13.4 For overground outdoor cables, exposed to weather conditions, UV resistant and water-resistant properties may be considered during cable selection.

3.7.13.5 For underground cables, anti-termite properties may be considered as an additional precaution depending on the existence of termites underground at the site.

3.7.13.6 For cables installed within a building, Low Smoke Zero Halogen (LSZH) or Low Smoke Halogen Free (LSHF) cables should be considered due to having minimal smoke and hazardous gas emission properties to ensure better air quality during building evacuation.

### 3.8 Safe Isolation of AC and DC Circuits

3.8.1 To properly handle a PV system during installation and maintenance, a means of isolating PV converters from the DC side and the AC side shall be provided.

3.8.2 Disconnection devices shall be included in the overall PV system design and adequately tested before being put to operation. This may be done using string fuses, DC breakers and DC switches.

3.8.2.1 Rationale: Isolation of individual strings at both positive and negative string cables are important to disconnect an always live system during the day.

3.8.3 A switch-disconnector shall be provided on the DC side of the PV inverter. Double pole (2P) DC switches should be used to effectively isolate both positive and negative terminals of the PV strings.

3.8.4 AC isolators shall not be used for isolation of the PV string and arrays.

3.8.4.1 Rationale: AC switching is inherently safer than cutting off supply in a DC system because of the cyclic nature of AC voltage and current which passes the zero-volt (0 V) crossing point multiple times in one cycle and hence, AC isolators/switches are not rated to break a DC circuit.

3.8.5 Additional DC switches shall be used for systems with long DC cable runs where it is not easy to isolate the PV system at the inverter e.g. inverters located within a building or at an inconvenient distance away from the PV panels.

3.8.6 Additional DC switches shall also be considered when an inverter does not have built-in DC isolation switches, to provide a means of isolating the cable for safety reasons or maintenance works.

3.8.7 DC switches shall be labelled as 'PV array DC isolator' or 'PV array DC switch', with the ON and OFF positions clearly marked.

### 3.9 Protection Against Fault Currents

3.9.1 DC breakers suited for breaking DC fault currents should be considered in the design to protect the inverters that are installed indoors.

3.9.1.1 Rationale: DC switches are not meant to be used for breaking fault currents. Within an inverter, there may not be sufficient internal fault protection, and the inverter is at risk of permanent damage from arc faults hence, the installer may opt to include DC breakers to prevent further equipment damage and potential escalation into fires.

3.9.2 An MCB/MCCB may be used to protect against overcurrent and potential DC fault current provided that it is specifically designed to break DC fault currents and not lead to nuisance tripping during switching and transient currents.

3.9.3 The PV supply cable on the AC side shall be protected against fault current by an overcurrent protective device e.g. MCB, MCCB, fuses, installed at the connection to the AC mains.

### 3.10 Earthing Requirements

Improper or failed grounding has been identified as one of a few root causes in PV rooftop fire incidents, often linked to short circuits to earth. As such, solar practitioners shall put additional focus to safeguard against earthing-related faults.

3.10.1 General earthing of PV module frames and supporting metallic structures shall be executed according to IEC 62548 and other applicable standards.

3.10.2 Protective earthing of any of the conductors of the PV array is not permitted. Earthing of one of the conductors of the PV array for functional reasons is not allowed, unless there is a degree of separation from the mains earth provided, either internally in the inverter or externally via a separate transformer.

- 3.10.3 A comprehensive site assessment and soil resistivity testing is crucial to determine the suitability of the location of earthing for any large-scale solar PV installation.
  - 3.10.3.1 Rationale: The soil resistivity report determine the required number of earthing rods in an earthing system to be installed.
- 3.10.4 All parts of a photovoltaic balance of systems such as solar panels, mounting structures, inverters, lightning protection system, AC/DC distribution boxes and auxiliary earthing shall be connected to the overall earth at the location.
- 3.10.5 The metallic enclosures of electrical equipment and non-electrical equipment shall be earthed to minimize risk of touch potentials.
- 3.10.6 Earthing continuity shall be verified using resistance testing during commissioning (target  $\leq 1 \Omega$  or per local standard).
- 3.10.7 Earth bonding points shall be accessible, labelled, and corrosion protected.
- 3.10.8 Grid-connected PV installation shall adopt the same earthing arrangement as the TN-S or TT supply system depending on the existing earthing arrangement at the location.
  - 3.10.8.1 Rationale: TN-S (and TT for some domestic installations) earthing systems provide reliable fault protection, ensure compatibility with transformer-less inverters and RCDs, and minimize risks from DC leakage and PEN conductor faults.
  - 3.10.8.2 In a TN-S/TT earthing system, when the fault current exceeds a set threshold, the inverter shall automatically isolate and shut down to prevent fire hazards or further damage to the system.
- 3.10.9 Where an IT earthing system is used, an earth fault monitoring device, or an insulation monitoring device (IMD) that indicates the first fault and keeps the alarm active while the fault exists shall be provided.
  - 3.10.9.1 Rationale: The IT earthing configuration is suitable for stand-alone or islanded PV systems as it minimizes fault current magnitude and enhances supply continuity; insulation monitoring, as required by IEC 62548 Clause 5.2.2.3, ensures early detection of insulation faults in these systems that operate independently from any earthed utility grid.
  - 3.10.9.2 If there is an alarm, the operator shall locate and clear the alarm before any switching activity can be done.
- 3.10.10 Aluminum cables shall not be used as earthing conductors.
- 3.10.11 All metallic module frames, support structures, and mounting rails shall be properly earthed using a minimum 6 mm<sup>2</sup> copper conductor or as required by local electrical regulations.

- 3.10.12 The earthing conductor shall be looped across all solar panel frames to maintain equipotential bonding.
- 3.10.13 Electrode connections shall be done by exothermic weld, pressure connectors, clamps or other suitable mechanical connectors. Solder-only joints are not acceptable as they are susceptible to fatigue from thermal expansion which may contribute to reliability issues.
- 3.10.14 Bond all exposed metalwork (inverters, combiner boxes, module frames and racking, metallic cable containment, metallic roofs, etc.) into the protective equipotential bonding; provide a main earthing terminal (MET) and connect PE/bonding/earthing/earthing (and any functional earthing) conductors to it. Each conductor at the MET shall be individually disconnectable for testing.
- 3.10.15 Regular inspections should be conducted to identify any signs of corrosion, damage, or wear and tear in the earthing system.

### 3.11 Lightning Protection

- 3.11.1 The designer or installer shall perform a lightning risk assessment in accordance to IEC 62305-2 to decide whether to install surge protection devices (SPDs) or a full lightning protection system (LPS). High risk factors include:
  - 3.11.1.1 The site is in a region with high lightning frequency.
  - 3.11.1.2 The PV installation is on a tall structure or in an open, exposed terrain.
  - 3.11.1.3 The system involves large PV arrays, extensive metal roof or long AC/DC cable runs.
- 3.11.2 For high-risk or large-scale installations, a basic LPS shall consist of the following:
  - 3.11.2.1 Lightning Air Terminals.
  - 3.11.2.2 Down conductors.
  - 3.11.2.3 Earth termination system.
  - 3.11.2.4 Equipotential bonding.
  - 3.11.2.5 Surge Protection devices (SPDs) installed at sensitive points such as inverters, control panels and communication circuits.
- 3.11.3 All metallic parts of the solar PV system shall be bonded and connected to earth to safely disperse lightning or fault currents. This includes module frames, mounting structures, conduits, cable trays, inverter chassis, and metallic enclosures.
- 3.11.4 Bonding the metal frames of a new solar PV system directly to the existing LPS using a suitably sized conductor (minimum 16 mm<sup>2</sup> Cu or equivalent) is acceptable, provided it maintains proper potential equalization and

complies with the separation distance requirements of IEC 62305-3 Clause 6.3.2.

- 3.11.5 PV DC and AC cables shall be routed separately from lightning down-conductors to minimize the risk of induced voltages or flashover.
- 3.11.6 All inverters shall be protected by appropriate SPDs, selected and installed in accordance with IEC 61643-31 and IEC 60364-7-712. Table 3-2: Types of SPD and Application depicts types of SPDs and applications.

**Table 3-2: Types of SPD and Application**

SPD Type <sup>2</sup>	Function	Application(s)
Type 1	Designed to discharge partial lightning current and protect the electrical installation against direct lightning strikes or high-energy surges entering from external lightning protection systems (LPS).	Used in large rooftop, industrial, or floating PV plants equipped with lightning air terminals or exposed to direct lightning risk.
Type 2	Limits transient over-voltages caused by indirect lightning or switching operations within the installation.	Required for all PV systems, including residential rooftops, carparks, and commercial arrays, even when no external LPS is installed.
Type 3	Provides fine protection for sensitive electronic equipment after Type 2 SPDs, ensuring voltage levels remain within safe limits for connected devices.	Recommended for PV monitoring systems, control networks, and remote sensing devices in both rooftop and large-scale installations.
Type 1 + 2 (Combined Device)	Offers combined protection against both lightning currents and transient over-voltages, simplifying coordination between stages.	Commonly used in medium to large PV systems, floating PV skids, and commercial rooftops where compact protection is preferred.

- 3.11.7 To ensure continued safety and performance of the PV lightning and surge protection system, routine inspection and maintenance shall be carried out at least once every 12 months, and additionally after any known lightning event or major electrical fault.

### 3.12 Battery Installations

- 3.12.1 Battery systems are commonly used together with Solar installations to provide additional autonomy time to loads connected to the solar PV system, whether the PV installation is stand-alone (not connected to the grid) or part of a grid-linked with a battery system (BESS technology).

<sup>2</sup> IEC 61643 Classification

This section aims to provide precautions to be taken when installing battery connected solar PV systems.

- 3.12.2 Few of the most common methods to fit a battery in a PV system are:
  - 3.12.2.1 Together with the PV panels e.g. commercial solar lighting with built in battery pack, Batteries connected to a charge controller (or rectifier).
  - 3.12.2.2 The selection of solar PV components and accessories equipment (e.g. charge controllers, solar floodlights, etc.) shall use reputable manufacturers; that carry proper certification in accordance with licensing and directives such as the 'CE' marking as part of the equipment selection process.
  - 3.12.2.3 Charge controllers/Inverters shall be verified during installation, so that the input ratings lie in the range of the solar PV output.
- 3.12.3 All batteries shall be installed with secured connections between battery terminals by use of secure bolted connections or cable lugs.
  - 3.12.3.1 Rationale: Loose connections between terminals can lead to broken connection between batteries which may also lead to arc flash incidents if conductive parts of opposite polarities are shorted together.
- 3.12.4 All battery connections shall be torqued according to the manufacturer's recommendations/datasheets.
  - 3.12.4.1 Rationale: Over-torquing and under-torquing will lead to hot spots forming which will increase the risk of battery fires in a battery installation.
- 3.12.5 Insulated tools in addition to the electrical PPE shall be used when handling battery installations/connections.
- 3.12.6 All exposed battery terminals shall be covered by means of an insulator medium to minimize arc flash risk during installation.
- 3.12.7 All battery systems shall be fitted with a double pole DC switching device between the charge controller and the battery. DC breakers are preferable as they can be installed with a shunt trip device to protect the battery at low state of charge (SOC).
- 3.12.8 Over/under charging shall be managed by the charge controller.
- 3.12.9 Proper fire extinguishers shall be made available (as minimum) – dry powder/carbon dioxide (CO<sub>2</sub>).
- 3.12.10 Battery rooms shall be fitted with smoke detectors within the room as a minimum.

- 3.12.11 The location where batteries will be installed shall be properly ventilated to facilitate the movement of fresh air from outside the room, and to remove hazardous gases in the battery room especially during battery charging operation.

## **4 INSPECTION, TESTING AND COMMISSIONING**

### 4.1 General

- 4.1.1 The Contractor shall perform all testing and commissioning (T&C) works using calibrated instruments.
- 4.1.2 The Contractor shall ensure all personnel involved are competent and authorised.
- 4.1.3 Testing and commissioning shall not commence until all pre-commissioning documentation is approved by the relevant parties.
- 4.1.4 The Contractor shall submit the following prior to energization:
  - 4.1.4.1 As-built drawings (PV layout, SLD, cable routing)
  - 4.1.4.2 Datasheets for PV modules, inverters, cables, and junction boxes
  - 4.1.4.3 Start-up and shutdown procedures
  - 4.1.4.4 Calibration certificates
  - 4.1.4.5 Installer competency evidence
  - 4.1.4.6 Commissioning Test Plan (CTP)
- 4.1.5 All documentation shall reflect the actual installed configuration.

### 4.2 Inspection

- 4.2.1 The Contractor shall ensure all PV modules are installed as per design, undamaged, and securely fixed.
- 4.2.2 Module mounting structures shall be corrosion-protected, structurally sound, and properly earthed.
- 4.2.3 Inverters shall be installed per manufacturer requirements with adequate ventilation and correct terminations.
- 4.2.4 DC cabling and connectors shall be correctly sized, polarity-verified, and mechanically protected.
- 4.2.5 A DC isolator shall be installed and accessible.
- 4.2.6 AC cabling, isolators, and protective devices shall be installed as per approved design.

- 4.2.7 Earthing and bonding shall be completed for frames, structures, and equipment enclosures.
- 4.2.8 Refer to Appendix C for the sample inspection checklist.
- 4.3 Testing and Commissioning
  - 4.3.1 Testing shall be carried out in accordance with Commissioning Test Plan (CTP).
  - 4.3.2 The Contractor shall perform inverter start-up in accordance with the approved Standard Operating Procedures (SOP) or Method of Statement (MOS).
  - 4.3.3 The inverter shall successfully synchronize with the grid under normal conditions.
  - 4.3.4 The Maximum Power Point Tracker (MPPT) voltage and current values shall be within inverter operating limits.
  - 4.3.5 The Contractor shall verify anti-islanding by opening the AC isolator; the inverter shall shut down automatically.
  - 4.3.6 The Contractor shall confirm that grid voltage and frequency are within the inverter's operating range.

## APPENDIX A: INTERNATIONAL SAFETY STANDARDS

**Table A-1: General PV Balance of Systems Minimum Installation & Safety Standard**

Component/Item	Specification	Standard/Requirement	Where to Look/How to Verify
PV Modules	<ul style="list-style-type: none"> <li>- Safety certified</li> <li>- Performance certified</li> </ul>	<ul style="list-style-type: none"> <li>- IEC 61730 (Safety)</li> <li>- IEC 61215 (Performance)</li> </ul>	<ul style="list-style-type: none"> <li>- TUV / SGS certificate</li> <li>- Serial number on label</li> <li>- CE mark and datasheet</li> </ul>
Inverter	<ul style="list-style-type: none"> <li>- Electrical safety</li> <li>- EMC compliance</li> <li>- Anti-islanding protection</li> </ul>	<ul style="list-style-type: none"> <li>- IEC 62109-1 &amp; -2</li> <li>- IEC 61000 series- IEEE 1547</li> <li>- Local DES rules (as applicable)</li> </ul>	<ul style="list-style-type: none"> <li>- CE mark</li> <li>- Test report from CNAS/TUV lab</li> <li>- Manual or technical datasheet</li> </ul>
DC Isolator	<ul style="list-style-type: none"> <li>- Rated for DC (not AC)</li> <li>- Voltage <math>\geq</math> system voltage</li> <li>- IP65 minimum (outdoor)</li> <li>- Lockable handle</li> </ul>	<ul style="list-style-type: none"> <li>- IEC 60947-3</li> </ul>	<ul style="list-style-type: none"> <li>- Marking on isolator body</li> <li>- Manufacturer spec sheet</li> <li>- Label: voltage, current rating, polarity</li> </ul>
DC Fuses	<ul style="list-style-type: none"> <li>- PV-specific gPV type</li> <li>- Rated <math>\geq 1.25 \times I_{sc}</math></li> <li>- Touch-safe holders</li> </ul>	<ul style="list-style-type: none"> <li>- IEC 60269-6</li> </ul>	<ul style="list-style-type: none"> <li>- Look for gPV symbol</li> <li>- Holder and fuse markings</li> <li>- Panel or combiner box datasheet</li> </ul>
SPD (Surge Protection)	<ul style="list-style-type: none"> <li>- Type 2 on both DC and AC sides</li> <li>- Rated <math>\geq 1000V</math> DC or system voltage</li> <li>- Replaceable, status indicator</li> </ul>	<ul style="list-style-type: none"> <li>- IEC 61643-31 (DC)</li> <li>- IEC 61643-11 (AC)</li> </ul>	<ul style="list-style-type: none"> <li>- Label on SPD</li> <li>- LED/fault window</li> <li>- Installer manual/spec sheet</li> </ul>
Cables (DC)	<ul style="list-style-type: none"> <li>- UV &amp; ozone resistant</li> <li>- H1Z2Z2-K type (TUV/EN 50618)</li> <li>- Temp <math>\geq 90^{\circ}C</math></li> <li>- Rated <math>\geq 1000V</math> or <math>1500V</math> DC</li> </ul>	<ul style="list-style-type: none"> <li>- EN 50618</li> <li>- IEC 60228 (conductors)</li> </ul>	<ul style="list-style-type: none"> <li>- Print on cable jacket</li> <li>- Cable datasheet</li> <li>- TUV certification</li> </ul>

Component/Item	Specification	Standard/Requirement	Where to Look/How to Verify
Connectors (e.g., MC4)	<ul style="list-style-type: none"> <li>- Rated for PV use</li> <li>- IP67 or better</li> <li>- Same-brand male &amp; female pair</li> </ul>	<ul style="list-style-type: none"> <li>- IEC 62852</li> </ul>	<ul style="list-style-type: none"> <li>- Product markings</li> <li>- Visual inspection: tight fit, click engagement</li> <li>- Avoid mixing brands</li> </ul>
AC Isolator / Breaker	<ul style="list-style-type: none"> <li>- AC rated, IP54 (indoor), IP65 (outdoor)</li> <li>- Lockable preferred</li> </ul>	<ul style="list-style-type: none"> <li>- IEC 60947-3</li> </ul>	<ul style="list-style-type: none"> <li>- Marking on switch</li> <li>- Technical sheet from supplier</li> </ul>
RCD / RCBO	<ul style="list-style-type: none"> <li>- Type A (or B for some inverters)</li> <li>- 30 mA trip</li> <li>- Used on all final AC circuits</li> </ul>	<ul style="list-style-type: none"> <li>- IEC 61008 (RCD)</li> <li>- IEC 61009 (RCBO)</li> </ul>	<ul style="list-style-type: none"> <li>- Marking on breaker (Type A or B)</li> <li>- Panel schedule</li> <li>- Functional test switch</li> </ul>
Earthing & Bonding	<ul style="list-style-type: none"> <li>- All exposed metal bonded</li> <li>- Earth resistance <math>\leq 10 \Omega</math> (preferably <math>&lt;5 \Omega</math>)</li> <li>- Earth cable <math>\geq 6 \text{ mm}^2</math> (DC), <math>\geq 10 \text{ mm}^2</math> (AC)</li> </ul>	<ul style="list-style-type: none"> <li>- IEC 60364-5-54</li> <li>- IEC 60364-7-712</li> </ul>	<ul style="list-style-type: none"> <li>- Ground resistance test result</li> <li>- Bonding continuity test</li> <li>- Use of certified clamps and rods</li> </ul>
Junction / Combiner Boxes	<ul style="list-style-type: none"> <li>- IP65 or better</li> <li>- Flame retardant</li> <li>- Clear labelling</li> </ul>	<ul style="list-style-type: none"> <li>- IEC 61439-2 (assembly)</li> <li>- IEC 62208 (enclosure)</li> </ul>	<ul style="list-style-type: none"> <li>- Rating on box body</li> <li>- Internal busbar protection</li> <li>- Labelled strings</li> </ul>
Labelling & Signage	<ul style="list-style-type: none"> <li>- Danger: Dual Supply</li> <li>- DC Warning Labels</li> <li>- String layout and shutdown instructions</li> </ul>	<ul style="list-style-type: none"> <li>- IEC 60364-7-712 (labelling)</li> <li>- Local fire code</li> </ul>	<ul style="list-style-type: none"> <li>- Use UV-resistant labels</li> <li>- Install at inverter, DB, and entry points</li> </ul>
Commissioning Tools	<ul style="list-style-type: none"> <li>- IR Tester <math>\geq 1000\text{V}</math> DC</li> <li>- Clamp meter (TRMS)</li> <li>- Earth tester</li> <li>- Multimeter</li> </ul>	<ul style="list-style-type: none"> <li>- IEC 62446-1 (Testing &amp; documentation)</li> </ul>	<ul style="list-style-type: none"> <li>- Provide test reports</li> <li>- Keep commissioning log</li> <li>- Photos of key terminations</li> </ul>
Battery Systems (Li-ion or Lead Acid)	<ul style="list-style-type: none"> <li>- Compliant with IEC 62619 (Li-ion), IEC 60896 (VRLA)</li> <li>- Integrated BMS</li> </ul>	<ul style="list-style-type: none"> <li>- IEC 62619 (safety for Li-ion)</li> <li>- IEC 62933-5-1 (ESS safety)</li> </ul>	<ul style="list-style-type: none"> <li>- Look for certification on battery label and technical datasheet. Confirm BMS presence and alarm indicators.</li> </ul>

Component/Item	Specification	Standard/Requirement	Where to Look/How to Verify
	<ul style="list-style-type: none"> <li>- Short circuit, overvoltage, thermal protection</li> </ul>		
Battery Enclosure	<ul style="list-style-type: none"> <li>- Ventilated</li> <li>- IP54 or better</li> <li>- Non-combustible housing</li> <li>- Clear warning labels</li> </ul>	<ul style="list-style-type: none"> <li>- Based on installation guide &amp; local fire/electrical code</li> </ul>	Verify accessible location, spacing, and airflow. No flammable storage nearby.
Battery Disconnect	<ul style="list-style-type: none"> <li>- DC-rated breaker or isolator</li> <li>- Lockable, within 1 m of battery</li> </ul>	<ul style="list-style-type: none"> <li>- IEC 60947-3</li> </ul>	Check DC isolator sizing, proximity, and label "Battery Disconnect"

**Table A-2: Additional Installation & Safety Standard**

Item	Minimum Standard / Practice	Reference / Notes
AC Disconnect Location	<ul style="list-style-type: none"> <li>- Within line of sight of inverter or grid entry point</li> <li>- Lockable</li> <li>- Clearly labelled</li> </ul>	<ul style="list-style-type: none"> <li>- NEC 690.13 / IEC 60364-7-712</li> <li>- EIR Section 4.1</li> </ul>
DC Disconnect Location	<ul style="list-style-type: none"> <li>- At inverter</li> <li>- Optional rooftop if inverter not near array</li> <li>- Lockable rotary switch preferred</li> </ul>	<ul style="list-style-type: none"> <li>- IEC 60947-3</li> <li>- EIR Section 4.1</li> </ul>
Earthing Installation Standard	<ul style="list-style-type: none"> <li>- Rod <math>\geq 2\text{m}</math> deep</li> <li>- Concrete pit 300×300×300 mm</li> <li>- Resistance <math>\leq 1 \Omega</math></li> <li>- 2 redundant conductors from MSB or DB</li> </ul>	<ul style="list-style-type: none"> <li>- EIR Section 8.1–8.6</li> </ul>
Earthing Method	<ul style="list-style-type: none"> <li>- Cadweld / bolted clamp connection</li> <li>- No salt or unapproved treatment</li> <li>- Marked with "SAFETY ELECTRICAL CONNECTION – DO NOT REMOVE"</li> </ul>	<ul style="list-style-type: none"> <li>- EIR Appendix 9</li> </ul>
DB / Isolator Mounting Height	<ul style="list-style-type: none"> <li>- 1.6 m to 2.0 m from FFL for switchboards</li> <li>- Never in kitchen, bathroom, below staircase, or storage area</li> </ul>	<ul style="list-style-type: none"> <li>- EIR Section 4.1, Section 4.6</li> </ul>

Item	Minimum Standard / Practice	Reference / Notes
Marking & Warning Labels	<ul style="list-style-type: none"> <li>- "DANGER – 400V", "PV DC DISCONNECT", "Battery Disconnect"</li> <li>- Labels must be fixed, not adhesive only</li> </ul>	<ul style="list-style-type: none"> <li>- IEC 60364-7-712</li> <li>- EIR Section 4.2, Section 4.3</li> </ul>
Ventilation (Inverter/Battery Room)	<ul style="list-style-type: none"> <li>- Adequate natural or mechanical ventilation required</li> <li>- No sealed battery or inverter rooms</li> </ul>	<ul style="list-style-type: none"> <li>- IEC 60364-7-712 guidance</li> </ul>
Workmanship	<ul style="list-style-type: none"> <li>- Neat routing</li> <li>- Secured cables (every 300–400 mm)</li> <li>- No exposed copper</li> <li>- Use of crimp lugs or ferrules</li> </ul>	<ul style="list-style-type: none"> <li>- EIR Section 1.1, Section 5.4, Section 5.5</li> </ul>
Commissioning Test Sheet	<ul style="list-style-type: none"> <li>- Earth loop impedance</li> <li>- Insulation test <math>\geq 1 \text{ M}\Omega</math></li> <li>- RCD trip time test</li> <li>- Polarity and continuity checks</li> </ul>	<ul style="list-style-type: none"> <li>- IEC 62446-1</li> <li>- EIR Appendix 11</li> </ul>

## APPENDIX B: EXAMPLES OF ROOFTOP PV SYSTEMS INSTALLATIONS

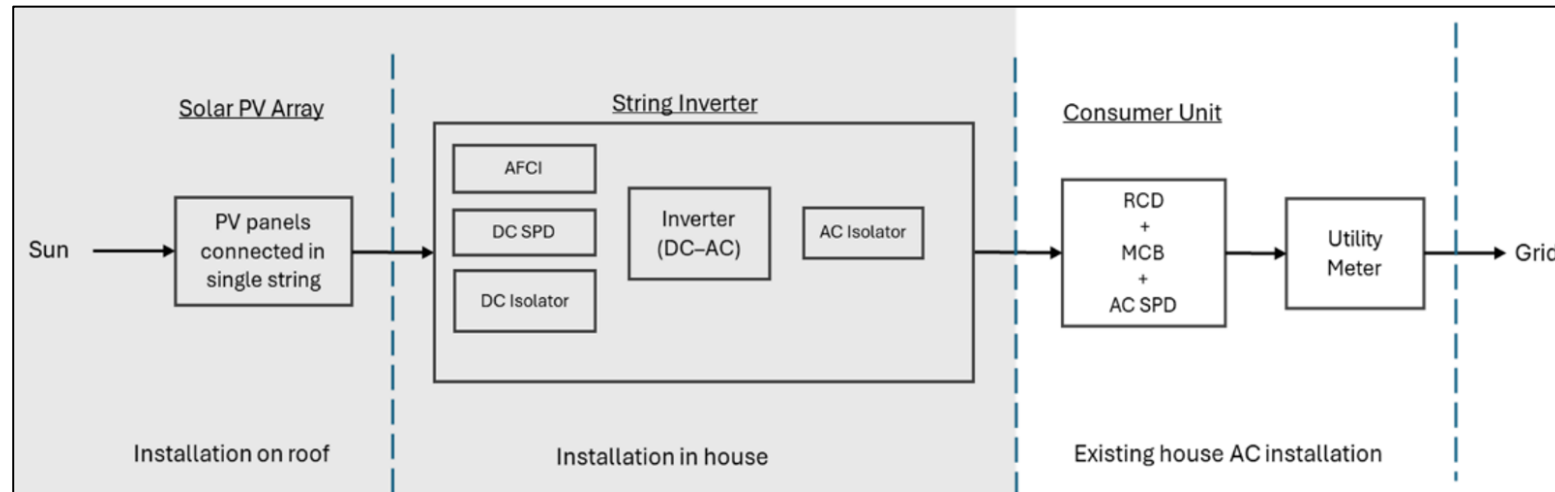
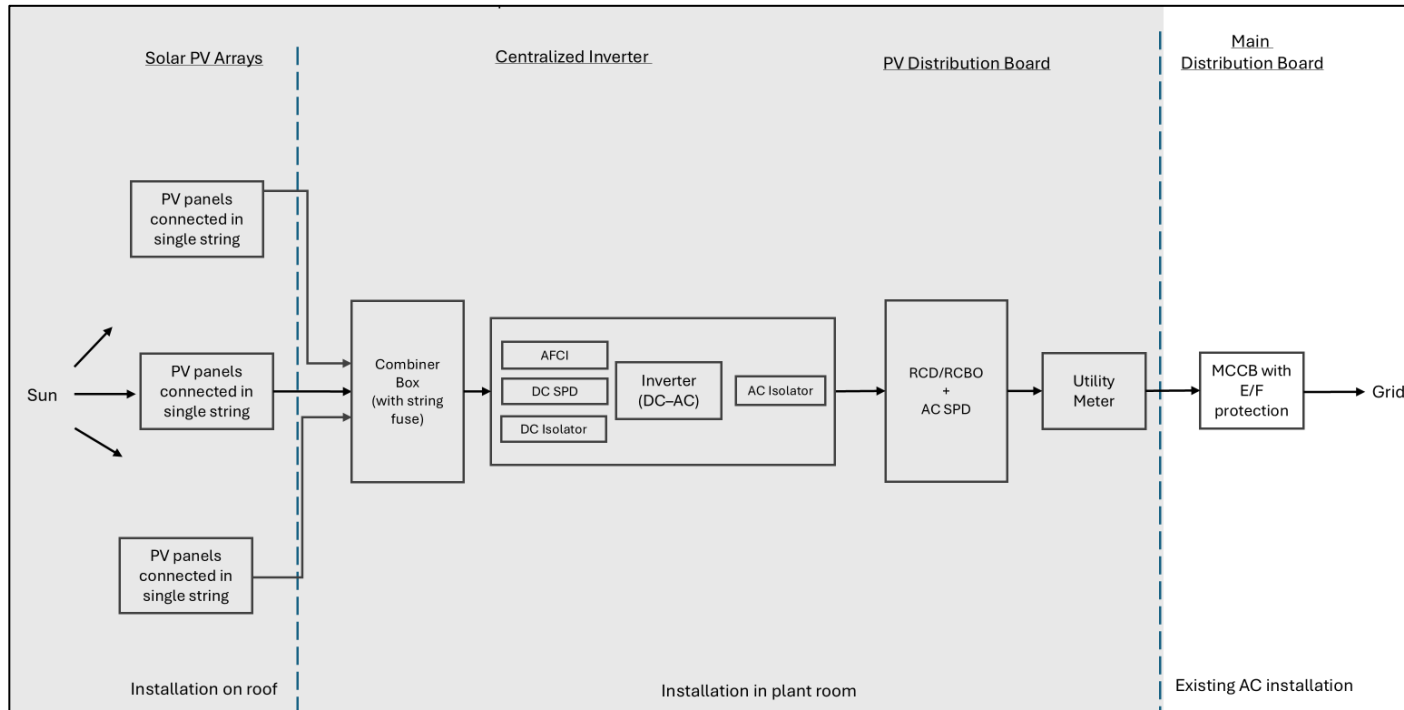
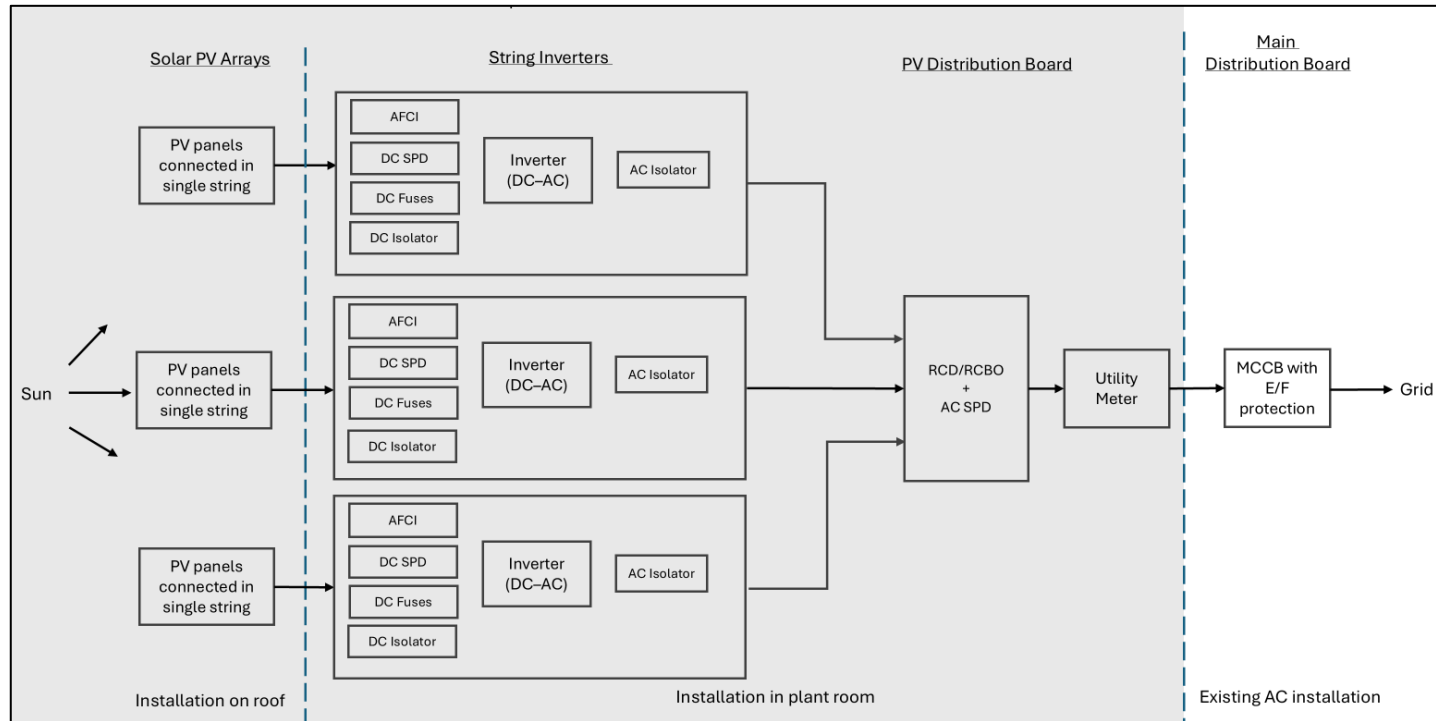


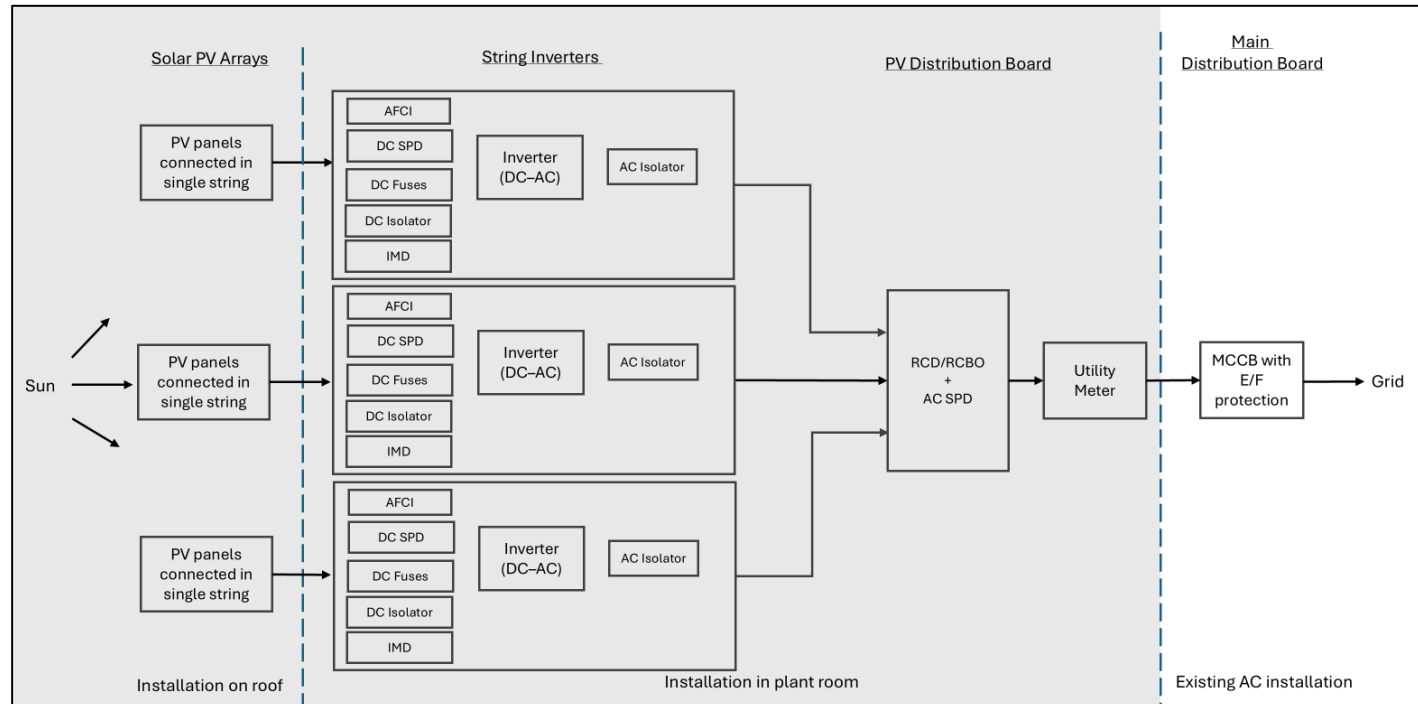
Figure B-1: Example of a typical domestic single string inverter installation



**Figure B-2: Typical commercial building PV system with centralised inverter**



**Figure B-3: Typical commercial building PV system with string Inverters for TN-S/TT earthing systems**



**Figure B-4: Typical commercial building PV system with inverters for IT earthing systems**

**APPENDIX C: SAMPLE INSPECTION CHECKLIST**

Installation Address : \_\_\_\_\_

Inspection By : \_\_\_\_\_

Date : \_\_\_\_\_

No.	Description	Pass	Fail	Not Applicable
<b>Solar PV Installation</b>				
1	Mounting structures are securely fixed and mechanically stable	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Mounting structures and accessories are corrosion resistant	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	Roof penetration / cable entries are fully weatherproof	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4	Adequate ventilation behind modules	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5	No visible damage to PV modules or connectors	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6	All equipment is accessible for operation, inspection and maintenance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7	Equipment and accessories are connected as per design with no loose or stray connection	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8	Array frame equipotential bonding installed	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9	Array frame integrated with lightning protection system	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Inverter</b>				
1	Mounting structures are securely fixed and mechanically stable	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Mounting structures and accessories are corrosion resistant	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	Inverter mounted securely with adequate ventilation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4	DC isolator installed and accessible	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5	AC isolator installed, lockable in OFF position	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6	Surge protection device (DC/AC) installed	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7	Inverter protected from water ingress and direct sun exposure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>DC conductors, combiner and isolators</b>				
1	Physical separation maintained between DC and AC cables	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	DC switch-disconnector installed	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	DC cables use appropriate protective or reinforced insulation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

No.	Description	Pass	Fail	Not Applicable
4	DC cables sizes meet current-carrying capacity and voltage-drop requirements	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5	Conductors are routed in safe zones and adequately protected	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6	String fuses/blocking diodes installed	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7	DC junction boxes labelled and weatherproof	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8	Cable insulation intact and free from damage	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>AC conductor &amp; AC system</b>				
1	AC cables are correctly sized and terminated	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	AC isolator clearly labelled and accessible	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	AC protective devices correctly rated and installed	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4	Conductors are routed in safe zones and adequately protected	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5	Cable insulation intact and free from damage	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>LV Distribution Board</b>				
1	Name plate is correct as per drawing and equipment schedule	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	DB/switchgear securely mounted and accessible	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	Adequate protection is in place against corrosion, weather and other adverse factors	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4	Verify the power fuse / circuit breaker sizes and type are correspond to design drawings	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5	Verify relays and meters are correspond to drawings and specifications	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6	Verify CT and VT ratios	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7	Verify CT polarities	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8	No exposed live parts	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9	Enclosure is lockable	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10	Earthing and grounding in place	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11	Bolts and glands are installed and torqued	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Transformer</b>				
1	Name plate is correct as per drawing and equipment schedule	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Transformer star point is earthed	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	Transformer enclosure is earthed	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4	Verify the protection and circuit breaker sizes and type are correspond to design drawings	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

No.	Description	Pass	Fail	Not Applicable
5	Protection settings are configured	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6	Ventilation and clearance are adequate	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7	Oil level/condition is acceptable (for oil-filled transformer)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8	Nameplate and warning labels installed	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Battery System</b>				
1	Batteries and controller ratings match PV output	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Charge controllers and related solar-linked equipment have proper certification	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	Battery connections bolted or lugged securely	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4	Exposed terminals covered with insulating caps	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5	Battery area has smoke detector and fire extinguisher	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6	Adequate ventilation provided	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7	Battery wiring clearly labelled and protected	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Labelling, drawings and site documentation</b>				
1	All circuits, switches, isolators and protection devices are labelled	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	PV single line diagram and schematic are displayed onsite	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	Emergency shutdown procedure available onsite	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4	Installer details and protection settings displayed	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5	All signages are durable and weather resistant, and fixed securely	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>