

EXASUN

X-ROOF



INSTALLATION GUIDELINES: ELECTRICAL SAFETY



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For any questions regarding this installation guidelines or any other specific aspect related to the X-Roof BIPV modules or X-Roof BIPV System, please contact EXASUN's sales department via the following contact:

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About EXASUN

EXASUN B.V. is an innovative Dutch company focused on the research, development, and manufacturing of building-integrated photovoltaic (BIPV) modules. We use high efficiency mono-c Si PERC solar cells, innovative colouring processes, and a glass/glass module construction. This combination of technologies allows EXASUN to continuously improve and develop BIPV modules with long operating life, fire safe, with excellent aesthetics and easy building integration for truly building-integrated photovoltaic roofing systems.

X-Roof Series

The X-Roof BIPV System is a fully building-integrated PV system that employs small solar panels designed with 36 half-cut solar cells. The X-Roof module, also referred to as *X-Roof*, acts both as an electrical generator and as a building construction element. The result is a beautiful, waterproof, fire tested and wind/snow load resistant module with wide warranty coverage. The fact that the X-Roof is a fully integrated module completely avoids the need to use conventional ceramic tiles. This not only results in 40% to 60% lower area density (kg/m^2), relative to conventional ceramic tiles, but allows to also reduce the installation time and costs. The X-Roof is available in black and will be available in terracotta colour version.

As with conventional roofing systems, the recommended tolerances and limits for the primary roofing substructure must be followed to ensure the smooth installation and the integrity of the BIPV modules and BIPV roofing system.

Mission

EXASUN is committed to become a leading company on BIPV technology solutions by accelerating sustainable development through innovation. EXASUN achieves this through continuous close collaborations with installers, architects, research institutes, certifying bodies and other main players in the PV industry.

Disclaimer of Liability

At EXASUN, as a BIPV photovoltaic module manufacturer, we strive to inform and instruct our collaborators to the best of our knowledge. However, the installation techniques, handling, correct PV system dimensioning, integration and correct use of these BIPV modules are beyond EXASUN's control. Therefore, EXASUN does not assume any liability and/or responsibility for the loss, damage, direct or indirect hazards to human or animals, or expenses resulting from improper installation, handling, attempt to reverse engineer, misuse or for any claim that resulted due to failing to adopt the required local codes, guidelines, and norms for PV technology. Any attempt to modify, refit parts, reverse engineer, signs of mishandling, act of negligence or of acting in bad faith will void the module warranty.

As part of EXASUN's policy to continuously improve its products and adjust to customer needs, EXASUN reserves the right to make changes to the product, specifications, manuals, or technical datasheets without prior notice.

Guide Intended Use

This installation guide is intended for the **X-Roof** product FAMILY, MODELS: XR036H-111BK-B. The guidelines and recommendations herein presented are intended for the European photovoltaic market regarding electrical safety and basic building code requirements. For applications or markets not explicitly covered in this guide, please contact EXASUN's sales.

1. General Information

1.1 Introduction

This document has been prepared by EXASUN B.V. and is based on the marking and documentation requirements for photovoltaic modules according to IEC 61730-1:2016 and NEN-EN 50380:2016 standards. It contains information regarding the safe handling and installation of EXASUN's BIPV glass/glass photovoltaic modules. This guide was thought for certified or qualified professionals with the expertise necessary to perform installation or maintenance on PV systems built with EXASUN's BIPV modules.

Installers must read and understand the suggested guidelines before starting any task related to installation, operation, and maintenance (O&M) involving EXASUN's solar modules. The installation should follow all the safety recommendations in this guide as well local, national, and European directives related to the photovoltaic industry and necessary infrastructure used for installation, O&M.

2. Safe Handling and Installation



WARNING: All the handling and installation of the products in question must be done by qualified personnel only. Always ensure extreme safety precautions.



Handling and installation must be performed according to national, local, and European guidelines and norms.

2.1 Workplace Safety Rules

- Wear protective safety clothing, namely: work clothing (that do not limit movement), non-slip shoes, insulating gloves and helmet.
- Do not wear metallic jewellery or other personal items that may cause electrical shock while working with the PV modules.
- Use only insulated tools that are approved for working on electrical installations.

- Make sure that there is always at least two people working together.
- Do not work in bad weather. PV modules may be blown away due to strong winds.
- Check scaffolding and ladders and ensure they are safe and working well.
- Do not expose unconnected modules to rain. Nor work while raining or snowing, it may result in accidents due to slipping or loss of balance.
- Use only approved equipment (connectors, wiring, grounding, ...) in the PV system. Do not combine third-party modules with EXASUN's modules in the same BIPV system.
- Check every module for damage or loose components. Never install faulty or damaged modules.

2.2 Module Handling

- When unpacking and handling, always lift the module. Do not scratch, drop, stand on or hit the module with sharp tools.
- Keep the module front-glass free of dirt or finger marks by wearing gloves.
- Do not lift or carry the module by the junction-box (J-box) cables.
- For temporary repacking, always use soft spacers to prevent direct contact of glass/metal or glass/glass parts.
- For long storing periods, always take measures to cover the DC connectors to prevent dust or water ingress. Store the modules in a cool and dry environment.
- Do not use excessive pressure to force the module into its final mounting position.

- Do not carry the BIPV modules on the back or the head. Nor attempt to carry multiple BIPV modules simultaneously.

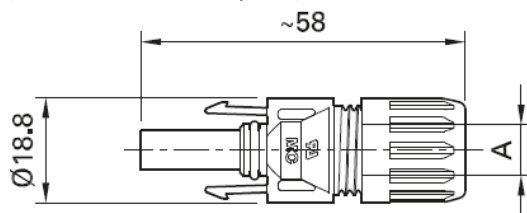


ISO 7010 – M009: Wear protective gloves that can also protect from hazards due to possible sharp edges on metal parts.

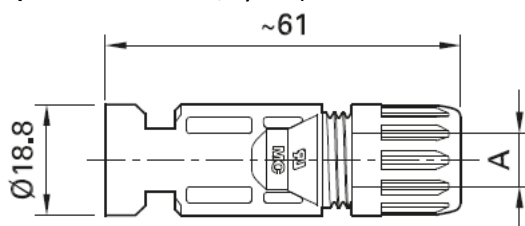
3. Electrical Information

3.1 Polarity of Leads

- Female MC4 connector: **Positive (+)**
(Stäubli: PV-KBT4/xy-UR)



- Male MC4 connector: **Negative (-)**
(Stäubli: PV-KST4/xy-UR)



3.2 J-Box Electrical Ratings

J-Box Electrical Ratings acc. IEC 62790

J-box rated input current	21 A
Diode technology	Schottky
Number of diodes per module	3
Diode max. forward current (I_F)	35 A
Diode max. reverse voltage (V_R)	45 V

3.3 Protection Against Electrical Shock

- Safety Class II protection against electrical shock acc. to IEC 61730-1: For applications where general user access and contact with insulated live parts is anticipated.
- Safety Class II PV modules (single module or combined) may have electrical outputs with voltage, current, and power at hazardous levels.

- Class II equipment is marked acc. to IEC 60417-5172 with the following symbol and meaning.



IEC 60417-5172: Class II equipment.

3.4 Wiring, Cables, and Connectors

- Minimum cable diameter of $1 \times 4 \text{ mm}^2$ (AWG 12). And working temperatures of -40°C to $+85^\circ\text{C}$. Use of black coloured cables with high UV-resistance is recommended.
- Use DC H1Z2Z2-K (acc. to EN 50618) standard DC solar cable intended for the interconnection of photovoltaic systems / module arrays. Use appropriate cable harnessing components to guide and fix the wiring
- To prevent short-circuit and grounding problems, cables of opposite polarities should be laid apart from each other. Use lay-in lugs or any other grounding component, Al compatible, to ground the Al rail and the entire PV system.
- While designing the string layout, avoid large induction loops by routing the return wire along the string path, minimizing enclosed surface area. See the examples of good and bad string layouts in ANNEX A.
- Use only safe and certified MC4 original connectors with IP67 or higher protection degree.



WARNING: PV industry demands that connector compatibility should only be accepted for connectors of same type family and manufacturer!

- J-box connectors must be mated with original MC4 approved connectors. DC connectors in use are approved acc. to IEC 62852 and marked with the following symbol and meaning:



IEC 60417-6070

Do not disconnect under load.



Do not disconnect under load.

3.5 BIPV Module Electrical Ratings

Module FAMILY: X-Roof

ELECTRICAL DATA ^{1,2,3}		X-ROOF MODEL
PROPERTIES	UNITS	XR036H-111BK-B (BLACK)
Module max. power (P_{MAX}) ($\pm 5\%$)	[W]	111
Open-circuit voltage (V_{OC}) ($\pm 1\%$)	[V]	25.2
Short-circuit current (I_{SC}) ($\pm 2\%$)	[A]	5.6
Max. power-point voltage (V_{MPP})	[V]	21
Max. power-point current (I_{MPP})	[A]	5.3
Max. System DC voltage (V_{SYS})	[V]	1000 V
Electrical shock protection (Safety Class)	[-]	Class II
Max. Overcurrent protection rating	[A]	15 A
Temperature coefficient for V_{OC} (β)	[%/°C]	-0.251
Temperature coefficient for I_{SC} (α)	[%/°C]	+0.048
Temperature coefficient for P_{MAX} (γ)	[%/°C]	-0.320
Nom. Module Operating Temperature (NMOT)	[°C]	32.8
Performance at NMOT (MQT 06.2)	[W]	83.7
Performance at low irradiance (MQT 07)	[W]	20.4
Recommended maximum series N_n (and parallel) ⁴ PV module configuration ⁴	[-]	31 modules 2 strings

1) Data given relative to standard test conditions (STC): 1000 W/m², 25°C, AM 1.5.

2) And based on laboratory tests performed according to IEC 61215-2:2016 (MQT 06.1) and IEC 60904-1 Ed. 3.

3) Environmental temperature range of at least -40°C to +40°C and up to 100% relative humidity as well as rain.

4) This recommendation is based on V_{SYS} with a safety factor of 1.25. Qualified personnel may define their own safety factor using local expectations for irradiation and temperature. When doing so, ensure the DC string voltage never exceeds V_{SYS} .

3.6 Protective Devices

- Three photovoltaic bypass diodes are employed as protective devices.



Bypass replacement or uncovering by means of removing the potting adhesive, or by any other means, is not allowed!

3.7 Altitude of Operation

- The BIPV module (design clearances and creepage distances) is rated to operate at an altitude up to 2000 [m] acc. IEC 61730-1. For applications that require greater altitudes please contact EXASUN's sales.

3.8 Ratings – Important Note

- Under normal conditions, a PV module is likely to experience conditions that produce current and voltage higher than the values reported at standard test conditions (STC).

- The values of I_{SC} and V_{OC} marked on the BIPV modules should be multiplied by a factor of 1.25 to define component ratings, conductor current ratings, sizing of controls and other Balance of System (BoS) active components.

NOTE: The safety factor of 1.25 for V_{OC} and I_{SC} is recommended given that solar irradiance may occasionally be higher than 1000 W/m². Temperature below 25°C may increase V_{OC} . Qualified personnel may define their own safety factor based on local expectations for irradiation and temperature. When doing so, ensure the string voltage of V_{SYS} is not exceeded under any circumstances.

- External or any other source of artificially concentrated sunlight shall not be directed onto the front- or back-face of the BIPV

modules. Doing so may result in permanent damage and safety risks.

3.9 Cell and Module Interconnection

- According to the IEC 61215-2:2 norm, cell interconnection is classified as Case S: Series connection of all cells in a single string. The 36 cells are connected using three substrings, each protected by a bypass diode. A representative electrical schematic for these BIPV modules is given in ANNEX B – Cell and Module Interconnection.

3.10 Earthing and Lightning Protection

- Good practices, structural earthing and lightning protection systems for buildings should be adopted acc. to IEC 62305, national, and other relevant EU directives.
- Air termination systems for roof structures (e.g., peaked roofs) must be used. Lightning protection components must comply with the EN 50164, local, national, and other relevant norms.

4. Module and Assembly

4.1 Mounting Type

- According to IEC 63092-1, the BIPV modules mounting type belongs to:
Category A: Sloped, roof-integrated, not accessible from within the building.
- The allowed minimum and maximum roof tilt angle are 20° and 75°, respectively. Mutual shading of PV module may occur depending on the geographical latitude and azimuth of the system.

4.2 Module PD and MG

- The pollution degree (PD) is 2, which means that normally, dry, non-conductive pollution occurs, but temporary conductivity caused by condensation is to be expected.
- The material Group (MG) is 1. Crucial solid insulating materials were tested acc. to IEC 60112 resulting Proof Tracking Index (PTI) ≥ 600 [V].

4.3 Assembly Information

- Assembly instructions and technical data are provided in ANNEX A to facilitate the complete and safe BIPV module assembly.
- The manual only covers basic physical installation and electrical safety guidelines. The detailed physical installation will be covered in a separate manual.
- Design Load: Front 3600 Pa and back 1600 Pa. The test load is therefore set to 5400 Pa and 2400 Pa, respectively, with the safety factor of 1.5.
- However the Exasun X-Roof modules have been designed to withstand the temporary live load of an adult person (weighing max. 100 kg) during installation or maintenance, it is strongly recommended not to step on the modules, or impose mechanical stress, to prevent damage to the cells and to reduce the risk of falling or slipping. At all times avoid impact with hard and/or sharp objects of all sizes.
- The mounting of the BIPV modules requires a customized Al rail provided by EXASUN. The mounting of the Al rail on the timber substructure must be done at minimum, every 600 mm, in the top and bottom notches on the rail using Wienerberger 4.5 x 45 mm stainless steel (AISI 304) roof tile screws. Pre-drill the aluminium rail with 6 mm holes to counter thermal expansion of the rail. In saline environments (within 10 km from the coast of a salt water body), use non-conductive barrier materials like rubber or neoprene to galvanically separate the aluminium and stainless steel.

NOTE: The effective screw-in length, pull-out and bearing resistance, loads and safety factors must be determined for each individual case according to the materials in use (wood density), plank thickness, angle to wood grain, type of connections, thread penetration depth, climatic region, and others. The screws used during tests

may not be the perfect choice for all situations. Please consult with EXASUN to select a suitable fastening screw length and alloy.

IMPORTANT: EXASUN cautions against the use of roof flashing materials prone to release metal oxides that may cause irreversible glass stains.

5. BIPV System-Level Tests

- The X-Roof BIPV system was subjected to wind-uplift resistance, weathertightness (wind-driven rain), and exposure to external fire tests according to Dutch national and EU standards.
- The tests were performed with mounting Al profiles, the water retaining connecting strips, and the modules. Fitting modules (Alucobond Plus) were also used for the fire tests.

6. Certification and Compliance

6.1 Module Qualification

The BIPV modules were subjected to a full qualification according to:

- IEC 61215-1:2016 / EN 61215-1:2016.
- IEC 61215-2:2016 / EN 61215-2:2016.
- IEC 61215-1-1:2016 / EN 61215-1-1:2016.
- IEC 61730-1:2016 / EN IEC 61730-1:2018.
- IEC 61730-2:2016 / EN IEC 61730-2:2018.
- IEC 61701:2022 / EN IEC 61701:2020 (M:6)
- DIN EN ISO 12543-4:2022-03

The X-Roof BIPV system was tested for:

- Wind-uplift resistance acc. to NEN EN 14437:2020 Ontw. and NEN 7250:2021.
- Weathertightness (wind-driven rain tests: Combination A and B) performed acc. to NEN 2778:2015 and CEN/TR 15601:2012.
- Exposure to external fire tests acc. to NEN 6063:2019 and CEN/TS 1187:2012.
- Extreme mechanical loading 5400/2400 Pa (Front/Back) acc. to MST 34 IEC 61730-2:2016/ EN IEC 61730-2:2016

- Extreme hail test 55 mm diameter @ 33.9 m/s. acc. to MQT 17 IEC 61215-1:2021/ EN IEC 61215-1:2020
- Proof Tracking Index (PTI): Solid insulating materials tested acc. to IEC 60112.

The BIPV module marking (nameplate - see ANNEX C) and documentation are written based on the IEC 61730-1:2016, NEN-EN 50380, and the IEC 61215-1:2016 standard.

The BIPV module is compliant with:

- CE Mark: Product assessment in conformity with the relevant EU harmonized legislation. And conform the Low Voltage Directive (LVD) (2014/35/EU) and the norms abovementioned.
- Directive (EU) 2018/849 on circular economy, end-of-life cycle, and management on waste electrical and electronic equipment (WEEE).
- Collection and recycling of Dutch PV modules through the Stichting Organisatie Producentenverantwoordelijkheid E-waste Nederland ([Stichting OPEN](#)).

6.2 Relevant Norms

[IEC 61215-1:2016](#) (as amended): Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 1: Test requirements.

[IEC 61215-2:2016](#) (as amended): Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 2: Test procedures.

[IEC 61730-1:2016](#) (as amended): Photovoltaic (PV) module safety qualification – Part 1: Requirements for construction.

[IEC 61730-2:2016](#) (as amended): Photovoltaic (PV) module safety qualification – Part 2: Requirements for testing.

[IEC 63092-1:2020](#) (as amended): Photovoltaics in buildings – Part 1: Requirements for building-integrated photovoltaic modules.

[IEC 63092-2:2020](#) (as amended): Photovoltaics in buildings – Part 2: Requirements for building-integrated photovoltaic systems.

[EN 14437:2020 Ontw.](#) (as amended): Determination of the uplift resistance of installed clay or concrete tiles for roofing – Roof system test method.

[NEN 7250:2021](#) (as amended): Solar energy systems – Integration in roofs and facades – Building aspects.

[NEN 2778:2015](#) (as amended): Moisture control in buildings.

[CEN/TR 15601:2012](#) (as amended): Hygrothermal performance of buildings – Resistance to wind-driven rain of roof coverings with discontinuously laid small elements – Test methods.

[NEN 6063:2019](#) (as amended): Test method for external fire exposure to roofs.

[CEN/TS 1187:2012](#) (as amended): Test methods for external fire exposure to roofs.

[NEN-EN 50380:2017](#) (as amended) - Marking and documentation requirements for Photovoltaic Modules.

[EN 62305-1:2010](#) (as amended): Protection against lightning – Part 1: General principles.

[IEC 62561-1:2017](#) (as amended): Lightning protection system components (LPSC) – Part 1: Requirements for connection components.

[EAD 330046-01-0602 \(2016\)](#) – Fastening Screws for Metal Members and Sheetting.

ANNEX A – System Installation

EXASUN's X-Roof BIPV System is a watertight fully building-integrated photovoltaic (BIPV) roofing system. Designed with only few parts, it allows a fast and easy installation.

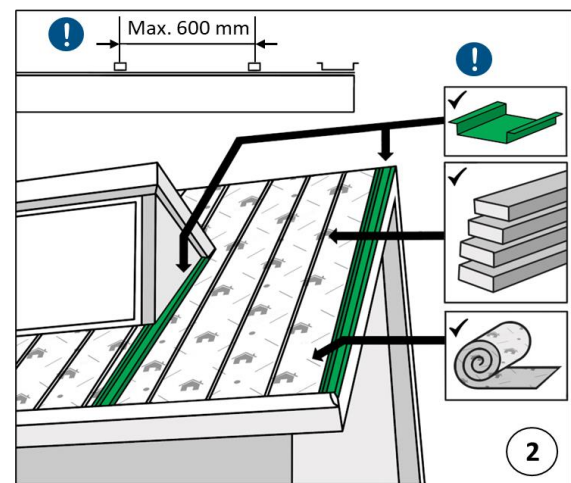
The following instructions are to ensure proper installation of the basic EXASUN X-Roof

components. Please refer to www.exasun.com for a full installation manual for the physical installation with tips and CAD details to ensure a complete and safe mounting of the BIPV-module.

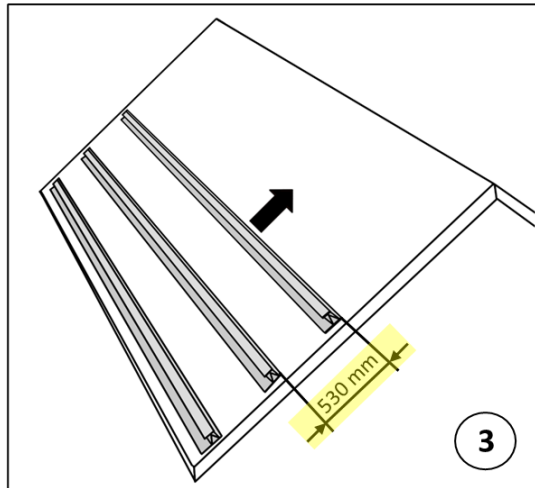
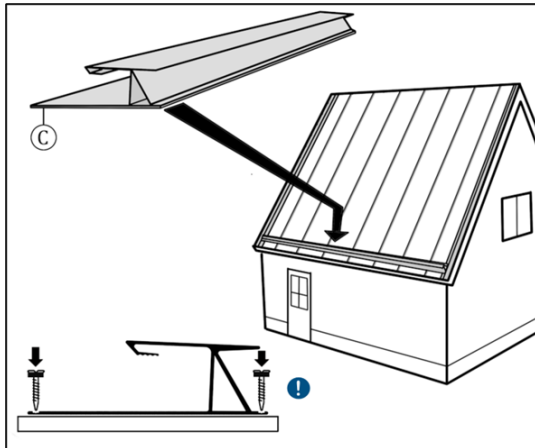
Mounting Guidelines, O&M

1. The installation parts are A) X-Roof BIPV module, B) fitting panel with edge profiles, C) mounting rail and D) connecting strip.
2. Before the BIPV modules can be installed, the roof needs to be equipped with a vapour-permeable watertight roofing membrane suitable for the use under BIPV systems. Recommended specifications are membrane with min. flammability class of B-s1,d0 (EN 13501-1), working temperature of -40°C to 90°C, and water tightness class W1.

First, the 21 mm vertical counter-battens, spaced at a max. 600 mm, must be installed together with other roofing elements, such as concealed gutters, dormers, and chimneys.

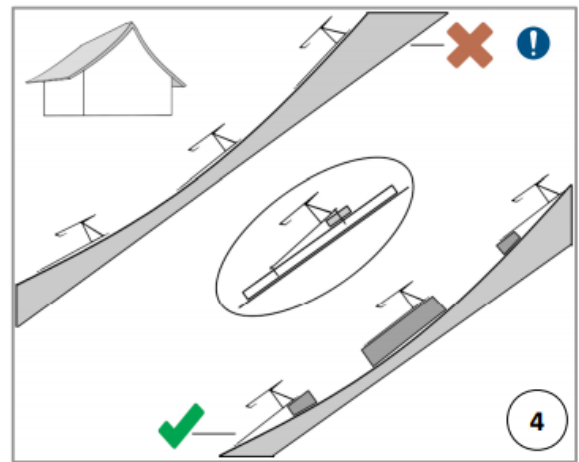
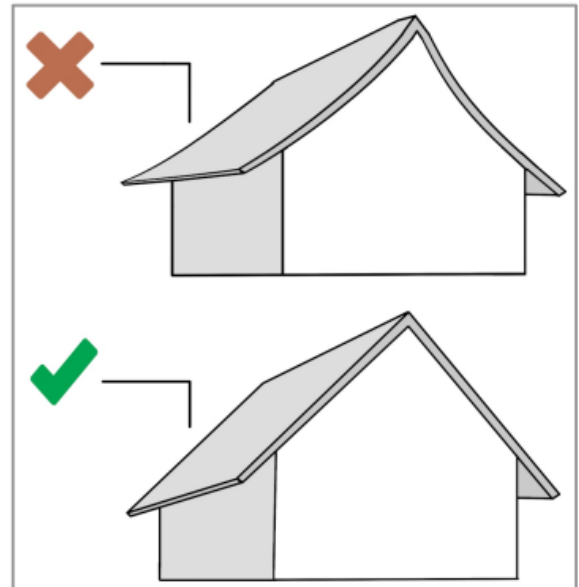


3. The X-Roof mounting rails are then installed, with an interspacing of 530 mm. The rails must be secured at the top and bottom ridges, at every intersection with the vertical counter battens, by using two 4.5 x 45 mm stainless steel Wienerberger's roof tile screws with EPDM ring as illustrated in the next figures.



4. For the X-Roof roofing system to perform correctly, the installation of the timber or steelwork substructure must comply with the tolerances and serviceability limits required for roofing systems.

Deviations from these tolerances require rectification to prevent adverse effects on the roofing system, flashing, and/or mounting of the BIPV modules, and other roofing components.

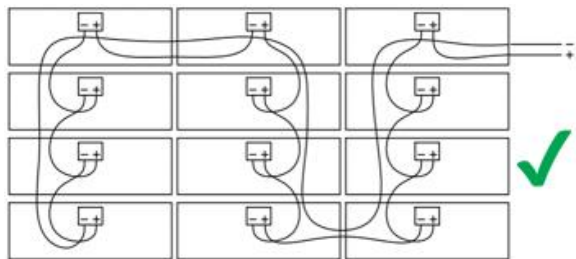
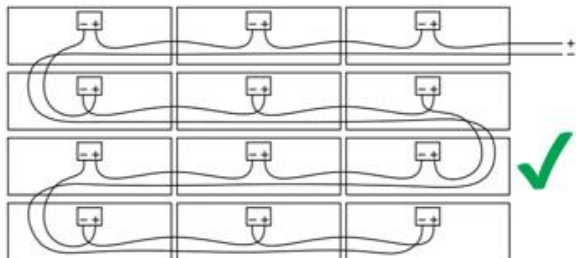
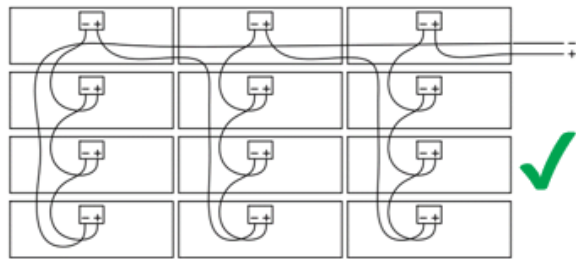
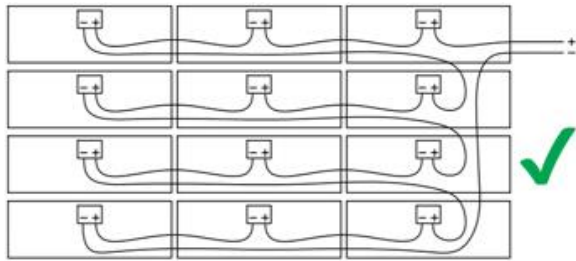


5. After having installed all the mounting rails, the installation of the BIPV module can proceed. This is achieved by tilting the module and sliding it fully upwards between the base and the “hook” of the upper mounting rail. This allows to lock the module retaining (top) blocks into the hook of the upper mounting rail.

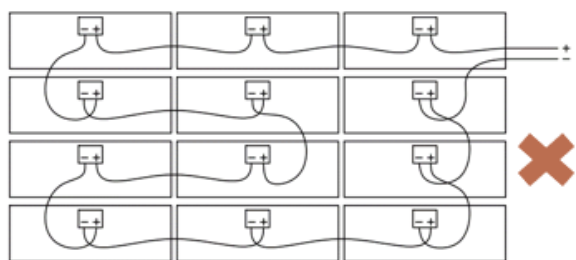
The BIPV module support (bottom) blocks are then mated with the lower mounting rail by reducing the module tilt angle (while ensuring the top blocks remain interlocked) towards the lower mounting rail, then, by sliding down evenly the whole module.

NOTE: Minimize induction loop enclosed area by routing the return wire along the string path. The figures below illustrate good and bad wire routing layouts.

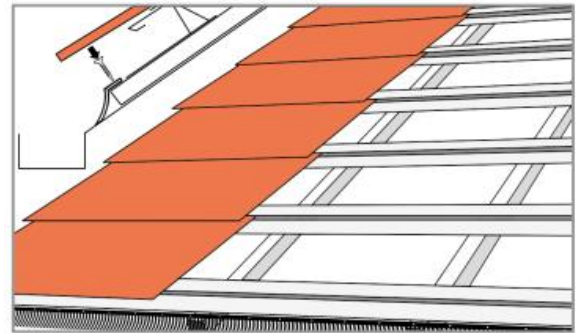
Example of good routing layouts



An example of a bad routing layout



Make sure the bottom blocks are fully latched on the edge of the lower mounting profile. Ensure that the top blocks remain interlocked with the upper profile.

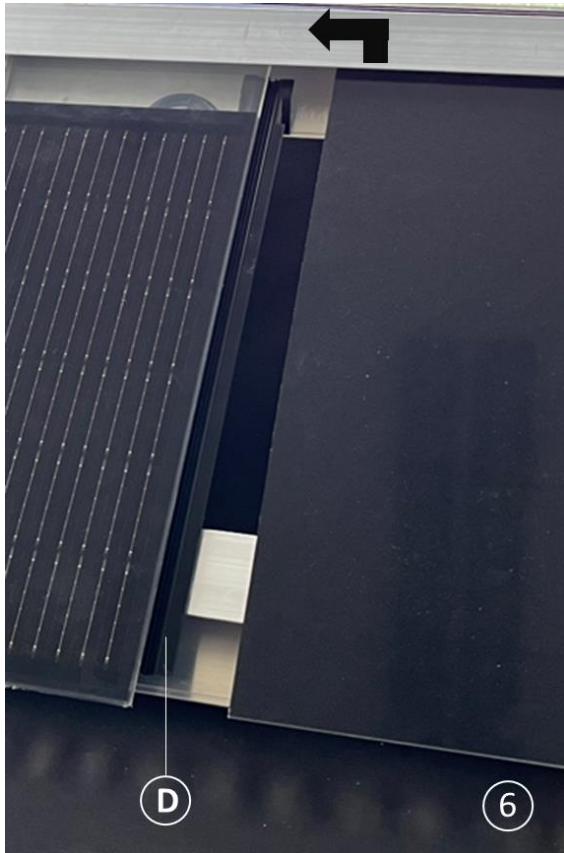


6. Before proceeding with the positioning of the adjacent BIPV module, an interlock-like connecting strip (part D) must be installed.

To mount the connecting strip, first, position the strip against the short edge of the BIPV module. Then, slide it upwards, using the module edge as a guide, until the two punched-out protruding flaps click into the screw slot on the base of the upper mounting rail. Doing so will cause the strip to spring-load the module (from the back) against the upper rail. Do not push the strip beyond the screw slot as this may cause the strip to slide out over time.

WARNING: The connecting strip (part D) is a crucial part for the fire safety and wind-driven rain tests. The strip must be part of the BIPV system to comply with the tests. DO NOT mount and unmount the connecting strip multiple times. Doing so may plastically deform the strip. The strip may lose the spring-load effect and cause it to become loose overtime.

Once the connecting strip is in place, connect the MC4 connectors of neighbouring modules (same string) before adjusting their final position.



WARNING: The max. number of series-connected PV modules in a single string must comply with the recommended electrical ratings as stated in section 3.5 BIPV Module Electrical Ratings.

As a truly BIPV system, the modules act as an individual construction element that can be easily replaced if needed. There are no constraints regarding the starting point or sequence for mounting in case of replacement.

7. For the roofing areas with complex geometries or where a full module does not fit, EXASUN provides a non-electrically functional fitting panel, of matching colour, accompanied by a self-adhesive edge profile. The fitting panel can be cut to size and assembled onsite with other finishing elements to achieve a fully homogeneous BIPV roof.

When applying the edge profiles to the fitting panels, clean the application area of the fitting panel using isopropyl alcohol (IPA) or rubbing alcohol. Remove the liner of the tape just before applying the strip to avoid contaminations.

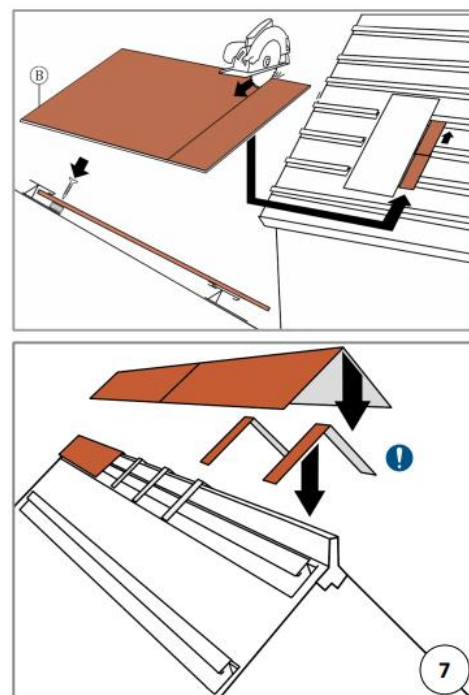
For a good seal, use the left strip on the left side of the profile and vice versa.

To avoid buckling of the fitting panel, ensure the maximum distance between two edge profiles never exceeds 500 mm. Install an additional edge profile (left or right) in the middle if needed.

When installed, fix the fitting panel in place with a screw in the upper edge through the profile and the fitting panel as an extra safety. The fitting panels therefore need to be installed from the bottom row to the top.

Precautions must be taken to protect the PV system against wildlife, namely:

- Bird screens, guards and barriers designed to prevent birds or rodents from nesting underneath the BIPV roofing system.
- Guards to prevent rodents from chewing the PV cables outer jacket or any other solid-insulating part.



Additional Notes

IMPORTANT: The installer bears responsibility of the installation. Always perform a visual inspection onsite. Ensure that mishandled or damaged panels are not installed in the BIPV roofing system.

For outdoor (fully exposed) screws, self-drilling screws with a sealing washer and anti-corrosion material must be selected. According to EAD 330046-01-0602, fastening screws that are partly or completely exposed to outdoors weather must be of stainless steel (\geq C2 corrosion acc. to EN ISO 12944-2) or protected against corrosion.

Detailed information regarding wind, snow, and other combined actions (loads) on PV modules is given in EN 1991-1-3:

- The Netherlands, Belgium, and France fall within the *Centre West* climatic region.
- Acc. to EN 1991-1-4, The Netherlands is divided into three wind-load zones (I, II and III) and sub-zones (costal, non-urbanized, and urbanized). Besides the PV module dead load, the builder and installer must consider these different structural factors.

- Use proper PPE gloves:

EN 60903



EN 60903: Live working – Electrical insulating gloves.

NOTE: Insulating gloves **Class 0** (VDC \leq 1500 V) must be worn to prevent and protect against electrical shock.

Operation and Maintenance (O&M)

- If the BIPV modules become dirty and the module can be accessed safely, it is recommended to clean with water and a lint-free non-abrasive soft cloth.
- When using other cleaning products, ensure its suitability for PV glass. Always

make a pre-test in a less visible spot to check whether it may cause harm or result in permanent discoloration.

- Do not use strong cleaning agents that may chemically attack the glass surface, create microcracks on plastic parts, or weaken the adhesive of surface mounted parts.
- When cleaning snow, especially for prolonged periods of snowy weather, it is recommended to use a roof rake with a soft rubber squeegee-like head and telescopic handle. However, the best way to remove snow is to let it melt by itself.
- Always ensure that no artificial or natural elements obstruct openings that prevent the cooling of the BIPV system by natural convection. Natural convection is needed to ensure the long-term stability of the BIPV modules and to obtain the maximum energy yield from the PV system. Ensure a well-ventilated system: Build a sufficiently ventilated ridge and roof base.
- Make sure that condensate water can always escape the roof by gravity drainage such that the water flow reaches the external walls of the building.
- Use PV System monitoring tools to check for any possible system fault. In case of electrical or mechanical intervention, the O&M must be performed by authorized professionals.

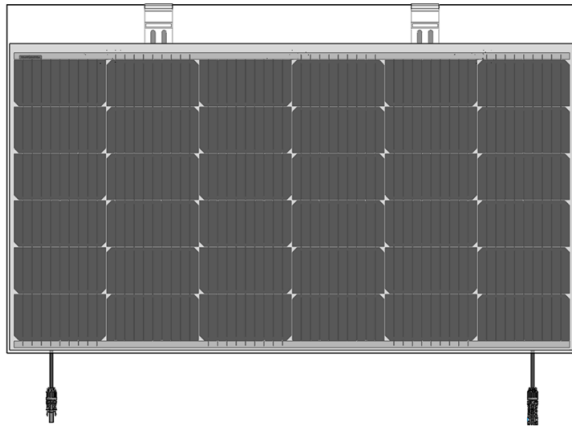
WARNING: As a truly BIPV system, the X-Roof roofing system provides the primary barrier against wind and rain. Therefore, the installation must be performed with the outmost care. Please refer to the complementary information available on the EXASUN website [Downloads](#) section for additional technical details on the PV system installation.

ANNEX B - Cell and Module Interconnection

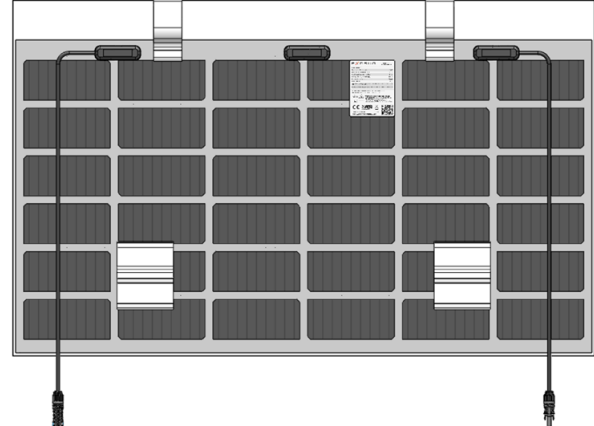
Cell Interconnection: According to IEC 61215-2:2016 the X-Roof cell interconnection is classified as *Case S: Series connection of all cells in a single string*. The main string has three substrings (of 12 series-connected cells) each protected by a single bypass diode.

- X-Roof BIPV module: Front and back CAD view (not-to-scale).

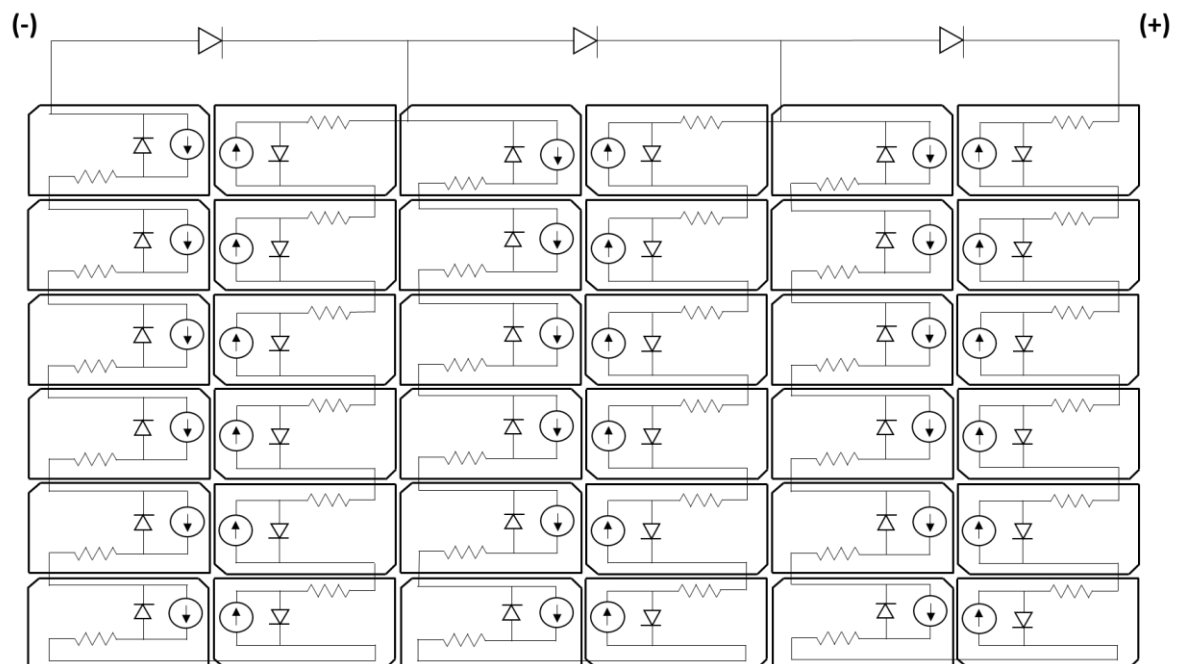
Module Front Side



Module Back Side



- X-Roof BIPV module: Simplified electrical schematic.



X-Roof Module Interconnection

- For series-connected PV modules the voltages add up. However, the currents do not add up.
- The maximum voltage from N_s series-connected modules in a single string (V_{string}) cannot exceed the system voltage (V_{sys}): $V_{string} \leq V_{sys}$.
- The temperature (T_M)-adjusted V_{OC} , I_{SC} and P_{mpp} are obtained as follows:

$$V_{OC}(T_M, G_{STC}) = V_{OC}(STC)[1 + \beta(T_M - T_{STC})] \quad (1)$$

$$I_{SC}(T_M, G_{STC}) = I_{SC}(STC)[1 + \alpha(T_M - T_{STC})] \quad (2)$$

$$P_{mpp}(T_M, G_{STC}) = P_{mpp}(STC)[1 + \gamma(T_M - T_{STC})] \quad (3)$$

- The maximum series-connected modules ($N_{s,max}$) can be obtained as follows:

$$V_{OC,max} = SF \times V_{OC}[1 + t_{2,up}/100\%] \quad (4)$$

$$N_{s,max} \leq \frac{V_{sys}}{V_{OC,max}} \quad (5)$$

The SF and $t_{2,up}$ values in equation (4) indicate the safety factor, which in this case is 1.25, and the V_{OC} upper tolerance, respectively.

For more accurate calculation of $N_{s,max}$ for a specific location, $V_{OC,max}$ can be obtained by inserting local minimum temperature in equation (1) ($V_{OC,max} = V_{OC}(T_M, G_{STC})$).

- The temperature-adjusted (T_M) string voltage (V_{string}) and current (I_{string}) must not exceed the inverter specification. ($V_{string} = N_s \times V_{OC}(T_M, G_{STC})$).
- The BIPV system Al mounting rails must be grounded for safety reasons.

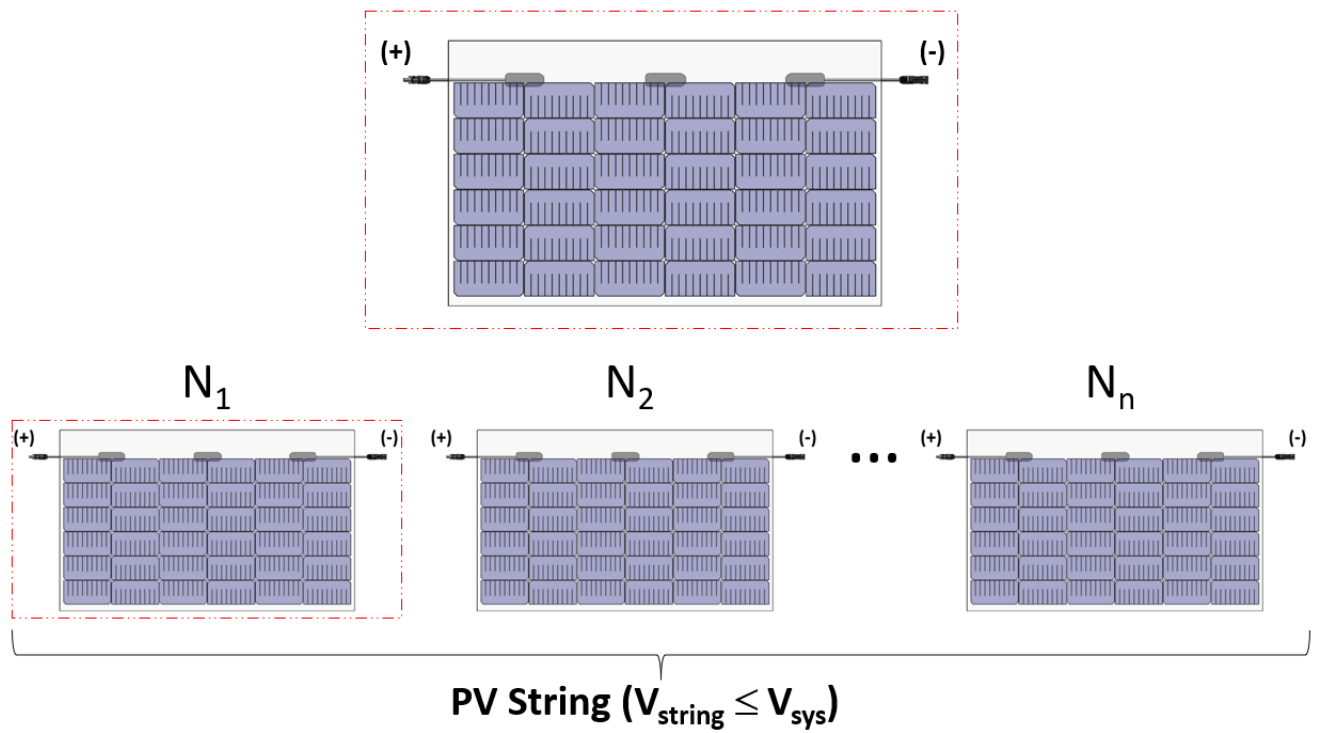


WARNING: BIPV systems for multifamily solar projects must ensure that the Al mounting rails (and any electrical connection for that matter) only span over the roof area corresponding to a single family-roof. The reasoning for these limitations are:



- Prevent acoustic related issues across multifamily roofs.
- Prevent islanding, grounding, and protection/safety related issues

- X-Roof PV System: String connection example (front view).



ANNEX C - Module Nameplate

The X-Roof module nameplate (label) is defined according to IEC 61730 and IEC 61215 standards. The image below shows an example of the nameplate for the BIPV module MODEL: **XR036H-111BK-B** with the respective description for each required field.

NOTE: The unique ID used for traceability purposes (place and data of manufacture) is a tamper-proof barcode ID, separated from the PV module nameplate, that is encapsulated within each PV module laminate.

EXASUN **X-ROOF**
XR036H-111BK-B

Electrical Data^{1,2}

Rated Power (P_{max}) (± 5%):	111 [W]
Open Circuit Voltage (V_{oc}) (± 1%):	25.0 [V]
Short Circuit Current (I_{sc}) (± 2%):	5.6 [A]
Max. System (DC) Voltage (V_{sys}):	1000 [V]
Electrical Shock Protection (Safety Class):	Class II
Max. Overcurrent Protection Rating:	15 [A]

1) Data given relative to Standard Test Conditions (STC): 1000 W/m², (25 ± 2)°C and AM 1.5, according to IEC 60904-3.

2) Traceability (date and place of manufacture) assured by anti-tampering serial number encapsulated within the PV module laminate.

• Safety Tested (MST) acc. IEC 61730.
• Qualification (MQT) acc. IEC 61215.

WARNING: Risk of electrical shock!
- Unit outputs HV even at low light conditions.
- Do not disconnect under load.
- Handling only by qualified personnel.
- Use approved-only MC4 electrical connectors.

CE partner van stichting **OPEN** e-waste opgelost

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BIPV MADE IN THE NETHERLANDS

QR code

Annotations:

- Name, registered trade name.
- Type or model number designation.
- Module maximum power (P_{max}), including binning and tolerances.
- Voltage at open-circuit (V_{oc}), including tolerances.
- Current at short-circuit (I_{sc}), including tolerances.
- Maximum system voltage (V_{sys}).
- Class of protection against electrical shock (acc. to IEC61140 and IEC 61730-1).
- IEC 61730-1: Max. Overcurrent Protection Rating (OCP) (verified by MST.26).
- Statement: Elec. Data shown relative to STC conditions.
- Date and place of manufacture (or statement regarding traceability).
- IEC 50380-2017: Reference to all relevant certificates (acc. to EN 45011) for safe installation and use.
- For Class II: The warning symbol (IEC 60417-6042) and message must be included.
Other symbols include:
- IEC 60417-5172 (Class II equipment).
- IEC 60417-6070 (Do not disconnected under load).
- IEC 60417-6070 (Direct current).
- QR code encoding a URL link to a specific PV module product listed on the website.
- Label reference number.
- Relevant logos:
- CE marking: indicates that the PV module fulfills the requirements acc. to relevant European product directives, quality and safety standards.
- Affiliated with Stichting Organisatie Producentenverantwoordelijkheid E-waste Nederland (Stichting OPEN) as of March 2021.