

calyxo

OPERATING MANUAL

CX SERIES

REV2.0 May 2017 – EN/EU-USA-Canada

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# 1. Introduction

This operating manual is a customer document of the company Calyxo GmbH, based in Thalheim, Germany. It describes how to handle Calyxo solar modules and construct solar fields using modules made by Calyxo. Please read this operating manual carefully before you store, install or handle the modules in any other manner. This manual includes safety instructions for using, installing, mounting, wiring and storing Calyxo CdTe solar modules.

Calyxo CdTe solar modules allow you to transform the unlimited energy provided by the sun into environmentally friendly electrical power. Please take note of all the following requirements and instructions in order to be able to make full use of the performance capacity of Calyxo solar modules.

Ensure that the installation, operational and maintenance work is only undertaken by qualified personnel having the specialist expertise described in this operating manual, are being familiar with this operating manual and are aware of and observe the applicable regulations for occupational safety and accident prevention.

Store this operating manual for future reference.

This manual exclusively applies to installations in Germany, Europe, USA and Canada. Prior to installing Calyxo solar modules at any other location, please contact your distributor. Additional guidelines and instructions or indication about country-specific information will be provided upon request.

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## 2. Before you begin

### Introductory NOTES

This operating manual includes notations and symbols that make it easier for you to read this document and which are intended to ensure that you are able to work safely with Calyxo solar modules.

### SYMBOLS FOR SAFETY INSTRUCTIONS



Possible danger, injuries or damage



Warning: dangerous electrical voltages



Important information

### 2.1 Product features

#### PROPER USE

Calyxo solar modules are used to generate electrical power in photovoltaic systems. To generate power, the solar modules are attached to connectors and electrically connected to a control device such as an inverter or a charge controller.

Calyxo solar modules are developed and constructed in keeping with the latest technological developments. When used properly, in accordance with all of the instructions outlined in this operating manual and in combination with regular maintenance, they guarantee the highest level of safety.

The operator is responsible for full compliance with the instructions for mounting, transporting, wiring, storing, operating, cleaning and maintaining Calyxo solar modules outlined in this operating manual.



Any usage of Calyxo solar modules other than that described in this operating manual is prohibited. Calyxo shall assume no liability for damage to or caused by solar modules resulting from improper use.

## DISCLAIMER

This manual only applies to the products in the CX series (CX1, CX3, CX3<sup>PRO</sup>, CX4) made by Calyxo GmbH. Calyxo does not assume any liability for damage caused by failure to comply with this manual. Please note that the person setting up the system is responsible for wiring and dimensioning the system as well as complying with all necessary safety guidelines during the layout planning and installation processes. This manual does not provide a basis for liability on the part of Calyxo GmbH. Calyxo GmbH shall only be liable in the context of contractual agreements or accepted warranties. Calyxo shall not assume any responsibility extending beyond the functionality and safety of the modules. Calyxo GmbH shall particularly not be held liable in cases of force majeure or external influences over which Calyxo GmbH has no control. Please also observe the instructions for the other system components that could be included in the solar power system. It may be necessary to generate statics for the entire project. If this manual does not sufficiently answer your questions, please contact your system suppliers. In the event of misinterpretation, inconsistencies or misunderstanding, the German version of this limited warranty clause shall prevail. Information contained within is subject to change without notice.

Further information is available on our website: [www.calyxo.com](http://www.calyxo.com).

## 2.2 Safety instructions

### ELECTRICAL SYSTEMS



#### **WARNING!**

**Danger of death due to electric shock!**

Solar modules generate electric current and voltage even at low levels of illumination. Physically disconnecting a closed electrical circuit could cause electrical voltage and currents, such as electric arcs to arise. These could result in life-threatening injuries. The risk increases when several modules are connected. Requirements for special installations or locations - Photovoltaic (PV) power systems- must be observed.

- Cover the solar module with opaque material during the entire assembly process. This is the only way to ensure that the modules are reliably de-energized.
- All guidelines and safety instructions that apply to the installation of electrical devices and systems e.g. IEC60364 -7-712 , must be observed.
- Installation shall be in accordance with the National Electrical Code, ANSI/NFPA 70 (in the US) and with CSA C22.1, Safety Standard for Electrical Installations, Canadian Electrical Code, Part I (in Canada).
- The extra-low voltage range is exceeded for module or phase voltages of over 120 V. Take the necessary safety and precautionary measures.
- Do not insert any electrically conductive parts into the plugs or junction box. Do not touch the contacts or exposed terminals.
- Keep children and unauthorized persons away from the modules.
- In the event of malfunctions or damage to installed modules, always contact your installer or the Calyxo After Sales service (see 'Troubleshooting').
- Immediately take damaged solar modules (such as ones with broken glass) out of operation.
- Do not disconnect the plugs under load.
- Wear electrically rated PPE when working on interconnected modules or system components.

Please inform yourself about actual or additional information on handling electrical systems, and about the regulations of your local energy supplier.

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## PRODUCT PROTECTION

Protect the modules from scratches and other damage, especially impact at the edges and improper temporary storage.

Do not submit the module surface to any mechanical stress. Do not stand on the modules. Do not drop or place any objects on the modules.

Only make changes to the modules that have been previously confirmed by Calyxo in writing. Do not carry out any additional drilling (for example, for fasteners) on the solar modules. Do not under any circumstances open the splash-proof junction box.

Never use light concentrators (such as mirrors or lenses or any other means to artificially concentrate light) to increase the power output of the modules. Doing so can damage the modules and shall render the extended warranty void.

## TRANSPORT AND STORAGE

Transport the module in its original packaging through to installation.

Use a glass suction cup to remove and transport the module, or hold the module by the edges. You need to carry the module upright across longer distances.

Do not under any circumstances lift or move the module by the connecting cables or the junction box!

Store the module securely in cool and dry rooms. The packaging is not weather-resistant! Do not rest the module unprotected on its edges. Doing so can damage the module.

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## 3. Rules, standards and legal requirements

### APPLICABLE RULES/GENERAL SAFETY INSTRUCTIONS

The rules and instructions below will help you handle Calyxo solar modules safely. They provide an overview, without making any exclusive claim to completeness, of the most important aspects of safely working with Calyxo solar modules. They do not in any way replace expert instruction or training. Please inform yourself prior to beginning work of the current national or regional regulations on occupational safety and accident prevention.

The accident prevention regulations 'Fundamentals of prevention' (BGV A1) and 'Construction work' (BGV C22), especially the provisions on fall protection, 'Electrical systems and equipment' (BGV A3), as well as the respectively applicable security regulations, guidelines and data sheets on occupational safety published by professional associations need to be upheld.



**Failure to comply with safety regulations may lead to damage and injury!**

### HANDLING GLASS

Glass is a durable, long-lasting material. Handling glass requires complying with several basic rules and guidelines. The key to safely handling glass is correctly selecting and using personal protective equipment. Always ensure your own safety and wear safety goggles, safety shoes and cut-resistant gloves. Gauntlet gloves protect your forearms. You need to wear them when you are wearing short-sleeved clothing.



**WARNING!**

**Danger of being cut by broken glass! Risk of injury from falling modules!**

Since the modules consist mainly of glass, they need to be handled with corresponding caution. Before transporting the modules, ensure that the transport route is clear and that the mounting location of the solar modules is easily accessible. When using a hand vacuum for transport, ensure that the sealing surface of the hand vacuum is clean, dry and free of damage in order to ensure sufficient holding force. If you are carrying the modules by hand, ensure that you have a good grip on the modules and that your gloves are clean and dry. In order to guarantee safe mounting, act in keeping with the national regulations on occupational safety and accident prevention. Wear suitable protective work wear (such as protective footwear and cut-resistant gloves) to prevent injuries.



Never place the module on its edges, even for a short period of time. This runs the risk of damaging the edges of the module, even when no damage is visible. Never stand on the modules, not even on their outsides or for a short period of time. Doing so may damage the modules, generate voltage and cause damage that could detract from the modules' longevity.

Additional information on handling glass is available from sources such as the DGUV (German Social Accident Insurance) or the German Federal Flat Glass Association.

- DGUV-SI 8027 Safely handling broken glass
- BGI 5084 Glass and window work
- TRLV-2006 'Technical regulations for the use of glazing with linear supports'
- TRPV-2006 'Technical regulations for the use of glazing with punctual supports'
- Wear safety glasses (ANSI Z87.1-2003) and cut-resistant gloves when working on non-interconnected modules or systems

## WORKING AT HEIGHTS



**WARNING!**  
**Danger of unprotected falls from heights**

Calyxo solar modules are suitable for assembly at ground level or installation on rooftops. Ensure that the substructure is correspondingly designed for local wind and snow loads in accordance with DIN 1055-4 (2007) and 1055-5 (2005). Ensure that the regionally or locally applicable building regulations are upheld. Comply at all times with the BVG C 22 regulations of the German Builder's Union for accident prevention at construction sites.

If you intend to install the modules on a rooftop or at a height, observe the specialist regulations set out by the roofing trade. Ensure proper fall protection, since falls from heights are the most common cause of fatal workplace accidents. Ensure that the modules can be safely transported with protection from the ground-level unloading site to the mounting location on the rooftop.

- BGV C 22: Accident prevention at construction sites
- BGI 694 Handling ladders and steps
- BGI 720 Lifting platforms

If you have additional questions or require training for yourself or the people who are or will be storing, assembling or installing the Calyxo solar modules, please contact your system supplier or vendor.



## ADDITIONAL INFORMATION FOR INSTALLERS

Ensure that the solar power system is installed, expanded, changed and kept in good operating condition in accordance with all applicable laws and regulations as well as the generally recognized national regulations for technology. The products must be installed by a licensed electrician in accordance with the applicable electrical code (i.e. the NEC for the USA and CEC for Canada).

After installation, hand over the operating manual as well as the corresponding installation documentation (construction drawings, site plans, wiring diagrams, data sheets on components, measurement and test reports such as VDE 0126-23 , DIN EN 62446 and so on) to the respective operator of the solar power system. Inform the operator that this manual is part of the product and is to be kept for the duration of the system's service life.



## ADDITIONAL INFORMATION FOR OPERATORS

Request documentation, an acceptance report and an inspection report for the PV system with the minimum requirements set out by IEC (DIN EN) 62446 or VDE 0126-23 from the installer.

Store these reports together with this manual for the duration of the module's service life. Without presenting these documents, especially the inspection or commissioning report in accordance with the above standards, the guarantee or warranty (in accordance with PAS-11-05-0173-EN) shall not apply.

Pay particular attention to the 'Troubleshooting' and 'Cleaning and maintenance' sections. For information on the formal requirements for solar power systems, please refer to your system suppliers. Prior to installing the solar power system, make sure to inform yourself of the guidelines and approval requirements set out by the relevant local authorities and energy suppliers. To protect your own interests, please obtain the required approvals from authorities as well as the necessary contracts with energy suppliers. We recommend that you secure your solar power system against natural hazards (such as lightningstrikes).

## 4. Mechanical specification

Specification	CX1, CX3, CX3pro, CX4
Length	1200 mm
Width	600 mm
Weight	12 kg
Structure	Glass/Glass Laminate
Surface (Total area)	0.72 m <sup>2</sup>
Operating Temperature	-40°C to +85°C

Figure 1  
Rear side view  
CX3, CX4

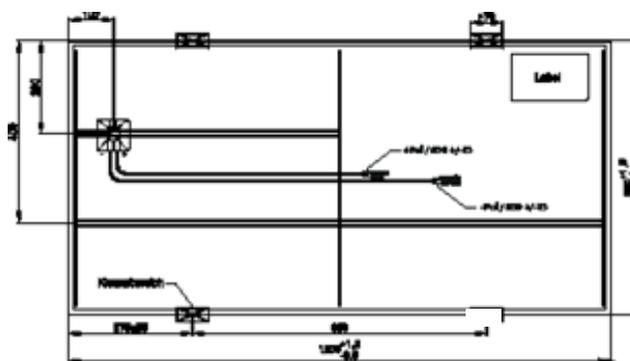


Figure 2  
Rear side view  
CX3<sup>pro</sup>

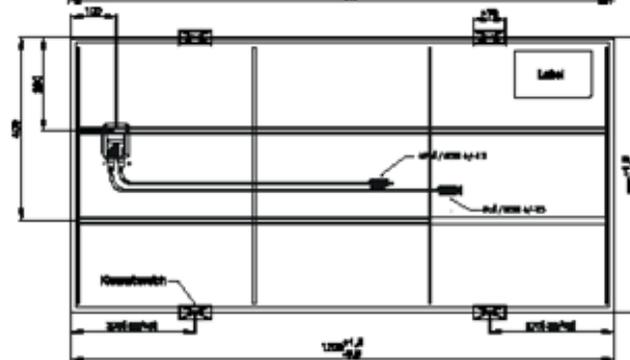


Figure 3  
Rear side view  
CX1

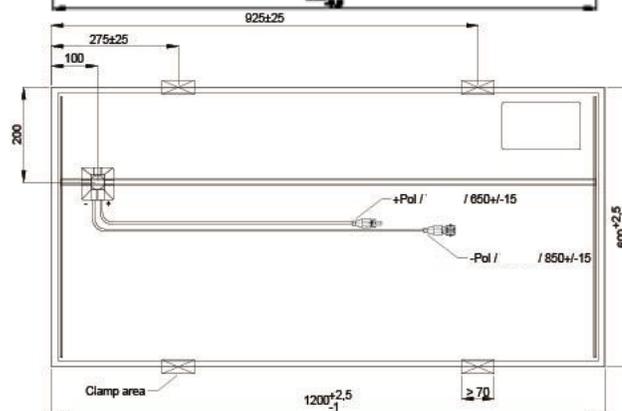
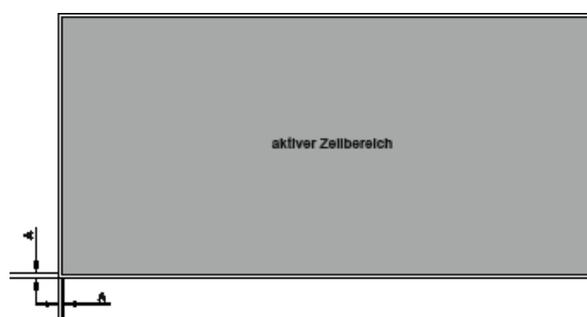


Figure 4  
Front side view

A=

- CX3 → 9.0 mm
- CX3<sup>pro</sup> → 7.0 mm
- CX1 → 9,0 mm
- CX4 → 7,0 mm





## 5. Electrical specification

In normal operation, a photovoltaic module can generate more energy and/or more voltage under the influence of climatic conditions than it can under standard test conditions. Please also note the instructions in 6.5 – Electrical layout.

The desired system fire class rating can be obtained by using a properly rated mounting system approved for use with type 6 modules as the module fire classification for Calyxo modules is Type 6. The fire rating of the CX Series modules are valid only when mounted in the manner specified in section 6 of this manual and observing instruction as per PAS-11-05-0190EN (available from calyxo.com).

The electrical ratings of CX series modules are given in the respective Data sheets for CX1, CX3, CX3pro and CX4 and are available for download at [www.calyxo.com](http://www.calyxo.com).

The electrical characteristics are within  $\pm 10$  percent of the indicated values of  $I_{sc}$ ,  $V_{oc}$ ,  $I_{MPP}$ ,  $V_{MPP}$  and  $+10/-5$  percent for  $P_{max}$  under standard test conditions (irradiance of 100 mW/cm<sup>2</sup>, AM 1.5 spectrum, and a cell temperature of 25°C (77°F)).

TECHNICAL DATA	
Additional data including details of the electrical characteristics for the CX series power classes is available from the respective data sheet at <a href="http://www.calyxo.com">www.calyxo.com</a>	
Product type	CX1, CX3, CX3 <sup>pro</sup> , CX4
Max. system voltage $V_{sys}$	1000 V (600V (UL))
Limiting reverse current $I_R$	CX1 → 2.0A CX3 → 4.0 A CX3 <sup>pro</sup> → 3.5 A CX4 → 2.5 A
Maximum Series Fuse $I_{cf}$	CX1 → 2.0 A CX3 → 3.5A CX3 <sup>pro</sup> → 3.5 A CX4 → 2.5 A
Junction box	Protection class IP65 without bypass diode
Connector	CX1 → Multicontact MC3 or MC4 CX3, CX3 <sup>pro</sup> → Multicontact MC4 CX4 → Multicontact MC4
Cable	Studer Betaflam 125 Flex, 2.5 mm <sup>2</sup> (14AWG)
Cable lengths	650 mm (+Cable)/850 mm (-Cable)
Fire class	C (Type 6)
Wind/snow load	2400 Pa [IEC]; 50 lb/ft <sup>2</sup> [UL]
Certificates/Approvals	CE, IEC 61646 (ed.2); IEC 61730 (Ed.1) Application class A; BRE MCS; UL 1703
Serial number	Serial number through end of 2012: LYMMDDTWWBBGXXX
	Serial number from 2013: LYDWWBBGOxxxXXX
	Serial number from 2016: LYMMDDOxxxxXXX
	<b>L</b> = Production line; <b>YY</b> = Production year; <b>M</b> =Month; <b>DD</b> = Day; <b>D</b> = Weekday; <b>T</b> = Type designation; <b>WW</b> = Calendar week; <b>BB</b> = Batch; <b>G</b> = Glass type; <b>O</b> = Oven; <b>xxx</b> = empty; <b>XXX</b> = Consecutive number

# 6. Installation

## 6.1 Mounting

### GENERAL

The module is considered to be in compliance with UL 1703 only when the module is mounted in the manner specified by the mounting instructions below. Any module without a frame (laminate) shall not be considered to comply with the requirements of UL 1703 unless the module is mounted with hardware that has been tested under this standard or by a field inspection certifying that the installed module complies with the requirements of UL 1703. When installing a module in the USA or Canada, please refer to “*PAS-11-05-0190EN mounting instructions UL*” for further details on mounting and installation of a CX series module.

### WIND/SNOW LOAD

The modules are suitable for use under a wind and snow load of up to 2400 Pa [IEC] / 50ft<sup>2</sup> [UL].

### WATER RUNOFF

Orient the modules in such a way that rainwater and snowmelt can run off freely and do not accumulate to create lasting soiling.

### MOUNTING STRUCTURE

Install the modules on a mounting structure:

- that corresponds to the required statics and the local wind/snow loads
- that can be properly fastened in the ground, on the roof or on the facade
- that can transfer forces on the modules to the assembly substructure
- that ensures that no mechanical stress (such as ones caused by vibrations, twisting or expansion) is placed on the modules
- that ensures sufficient rear ventilation of the modules
- whose electrochemical series does not give rise to galvanic corrosion in the case of direct contact between different metals
- The clamps and rail system need to be constructed as a coordinated unit.

### MODULE FASTENING

Fasten the module in accordance with the following mounting variants (see 6.2). The clamping ranges defined for this can be seen in figures 6 to 8 (pages 13 and 14).

Ensure that the modules do not bend or twist by more than 3 mm/m (without additional load from sources such as wind, snow etc.). Observe the technical regulations for the use of glazing with fix point or linear supports (TRLV, TRPV). Position the module so that it is planar.

Depending on the wind load and the angle of inclination, we recommend attaching additional non-slip safeguards and/or spacers.

## OCCUPATIONAL SAFETY REGULATIONS

In order to guarantee safe mounting, act in keeping with the national regulations on occupational safety and accident prevention.

The guidelines and safety instructions applicable to the installation of electrical devices and systems, such as DIN DVE0100-712 for Germany, must be observed.

## FIRE PROTECTION

Observe the applicable regulations and safety instructions regarding the fire protection class for rooftop installations. The CX product series meet fire class C (Type 6).

For rooftop mounting, modules must be mounted over a fire resistant roof covering rated for the application. The recommended minimum standoff height is 3.25 in (82.55 mm). Modules used in UL Listed rooftop applications must be installed with approved mounting systems. If alternate mounting means are employed, this may affect the Listing fire class ratings and additional UL fire testing may be required. The fire rating of this module is valid only when mounted in the manner specified in the mechanical mounting instructions.

## MECHANICAL ASSEMBLY

Only clamp or assembly systems approved by Calyxo (PAS-11-05-0166-EN; PAS-11-05-190EN when installing in USA or Canada under UL 1703, respectively) may be installed; otherwise, the extended warranty is not void. Calyxo shall test clamp systems upon request and approve them on a case-by-case basis. A list of approved clamp systems is available at [www.calyxo.com](http://www.calyxo.com).

## GENERAL REQUIREMENTS FOR THE CLAMP SYSTEM

Ensure that the clamps do not generate any additional stress on the modules. The modules should be supported so that they are 'floating'.

- The clamps to be used should have clamping limitations. Ensure that the insulation material on the top and bottom is compressed by a maximum of ten per cent.
- When the modules are installed, the clamp opening needs to be kept at 6.8 mm +/- 0.2 mm.
- Ensure that no direct contact is made between glass and metal.
- Use a suitable silicone-free rubber support between the modules and clamps.
- Clamp width (figures 7 to 8):  $\geq 70.0$  mm
- A minimum lateral distance between the edge of the glass and the side of the clamp of 1 mm needs to be 1 mm at 25°C/77°F (figure 6) to enable the thermal expansion of the modules shall be observed
- Glass inset (figure 6)
  - o 7.0 mm to 9.0 mm on the top of the module (according to the series)
  - o  $\geq 12.0$  mm on the bottom of the module

Figure 6

Module cross section

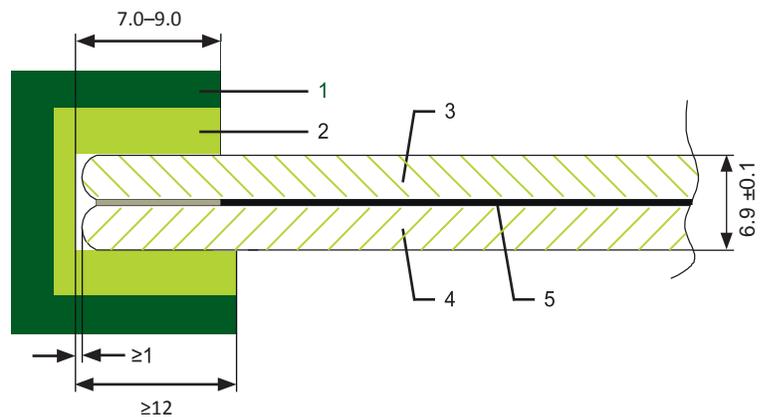
1= Module clamp

2= Rubber

3= Glass (front side)

4= Glass (rear side)

5= Active cell area



## 6.2 MOUNTING VARIANTS

### Fix Point SUPPORT/LINEAR SUPPORT

When set up with fix point support, the modules only touch the substructure via the clamps. When set up with linear support, however, the modules sit on top of the substructure. Thus, for a linear support, place a silicone-free rubber support between the substructure and the clamps so that the glass and metal do not touch at any point.

### THE FOLLOWING MOUNTING VARIANTS ARE POSSIBLE:

- Substructure lateral beneath the module with two clamps per module side (figure 7)
- Substructure diagonal beneath the longer sides with two clamps per module side (figure 8)

Germany/Europe: Use approved clamps included on the Calyxo contact list (PAS-11-05-0166-EN) exclusively.

USA / Canada: Refer to PAS-11-05-0190EN when installing a UL 1703 compliant system.

**Figure 7**

A =  $\geq 70$  mm

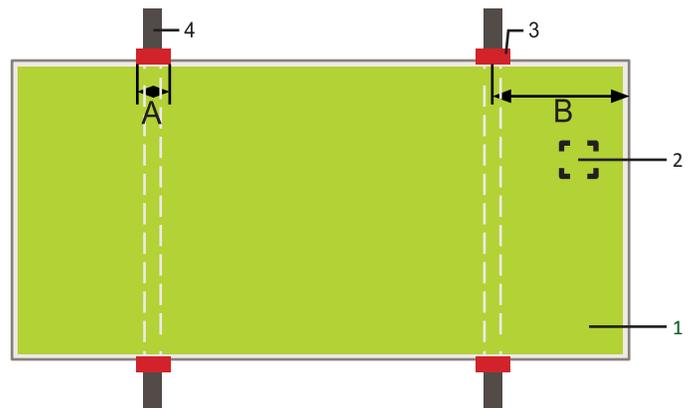
B = 275 mm  $\pm$  25 mm

1= Module

2= Junction box

3= Module clamp

4= Substructure



**Figure 8**

A =  $\geq 70$  mm

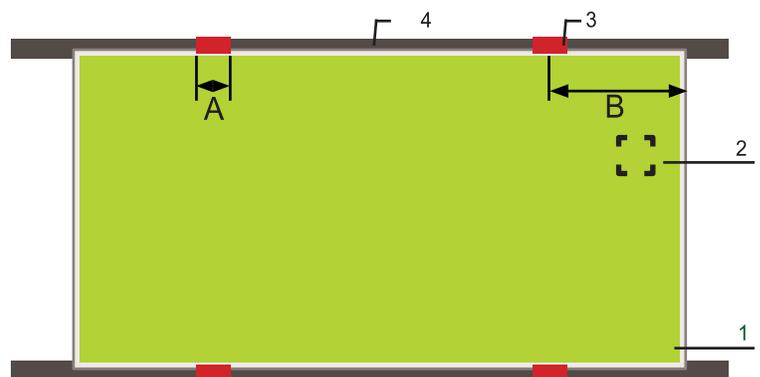
B = 275 mm  $\pm$  25 mm

1= Module

2= Junction box

3= Module clamp

4= Substructure



## 6.3 Installation site, module orientation

### INSTALLATION SITE

- The modules have been inspected for safe operation in a moderate climate in accordance with IEC 61646.
- The permitted module temperatures are between -40°C and +85°C. Ensure sufficient rear ventilation in order to avoid elevated module temperatures.
- Install the modules in coastal regions at least 1000 m removed from the sea.
- The modules cannot be used for installations at heights of over 2000 m above mean sea level, since here special conditions for the insulation properties of all electrical components and photovoltaic modules apply.
- Do not expose the modules to chemicals.
- The modules should not be placed in standing water. The junction box is only splash-proof.
- Solar modules are not explosion-proof equipment. Do not install the modules in the proximity of highly flammable gases and vapors (such as gas containers, petrol stations) or near open flames and flammable materials.
- The modules are not suitable for mobile use or indoor installation.

### MODULE ORIENTATION



#### **WARNING!**

**Fire hazard for improper module orientation!**

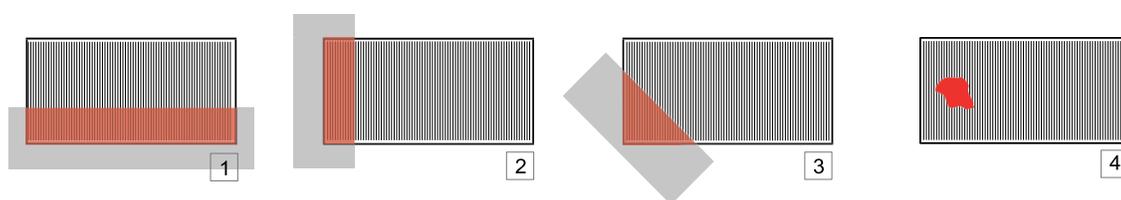
- Modules can be installed parallel to the roof with an angle of inclination of at least 3°.
- Install the module so that the junction box is located in the upper portion of the module and the cables hang down.
- The modules need to be installed with a minimum lateral distance of 10 mm from the next module. Exceptions to this rule must be explicitly approved by Calyxo. The approval is part of the operating license. Use all of the provided fastening points and prevent the glass and metal from touching (for example, on the mounting rails).

## 6.4 Avoiding shade

### Shadowing

Optimal solar radiation leads to maximum energy yields. Because of this, install the module in such a way that it faces the sun. The optimum angle of inclination for the module is dependent on the respective latitude of the installation location. To determine the optimum orientation of your model, we recommend using a photovoltaic simulation tool. For angles of inclination less than 3° (longitudinal side of the module from the eave), it needs to be ensured that adherent contamination is removed by sufficient precipitation or through regular manual cleaning (also see the section 'Cleaning and maintenance').

### TYPICAL SHADE SCENARIOS



- 1) Reduction in performance proportional to the shaded surface
- 2) Shade parallel to the cells can reduce the performance of the module/string by up to 100 per cent.
- 3) Combination of 1 and 2 leads to reduced performance
- 4) Reduction in performance proportional to the shaded cell length. Local heating is possible.

## 6.5 Electrical layout



### WARNING!

**Danger of death due to electric shock!**

- Never physically disconnect the plugs when the module is under load, since this creates electric arcs and could result in life-threatening injuries.
- Exercise the utmost caution when working with the inverter and the cables.
- Ensure that the modules on the inverter are activated before being disconnected.
- Once the inverter has been switched off, before beginning further work, make sure to uphold the time intervals prescribed by the manufacturer in order to allow the high-voltage components to unload.
- Cover solar modules with opaque material during the assembly process. This is the only way to make sure that the modules are reliably de-energized.
- Never touch the live contacts with bare hands. Only use isolated, dry tools for installation.
- During connection, ensure the correct polarity. The connectors are marked with a plus sign on the positive terminal and a minus sign on the negative terminal.
- Do not under any circumstances open the splash-proof junction box.



### WARNING!

**Damaged module components may be hazardous!**

- Only install undamaged solar modules.
- Ensure prior to installation that the junction box, cable, connectors and tools are dry and free of damage.
- Always store the solar modules in a secure, dry place. The packaging is not weather-resistant.
- Ensure that even at low temperatures and/or solar radiation of over 1000 W/m<sup>2</sup>, the maximum open-circuit voltage of the wired modules does not exceed the system voltage of 1000 V<sub>AC</sub> (IEC 61646/IEC 61730 or IEC 61215) or 600 V<sub>DC</sub> (UL1703).
- Integrate the solar plant into the existing lightning protection system in accordance with local regulations.
- Do not perform installation or maintenance work on the modules under conditions of heavy wind or rain. We recommend that you only perform installation or maintenance work during dry weather.
- When mounting the modules on buildings, there is a risk of tools, mounting materials or solar modules falling down and hurting people. Because of this, block off the danger zone on the ground prior to beginning mounting work.
- Warn people who are near the danger zone or inside the building. Keep children away from the installation site.
- Carry out wiring work in such a way that no people are endangered and no damage can occur.
- Protect all parts of the module from mechanical stress (such as pressure, tension or torsional stress) during transport and installation. Ensure that the bend radius for cables at the output of the junction box is kept at 60 mm as a minimum during installation or operation.

## MODULE SELECTION

Please refer to the detailed electrical characteristics from the product data sheet.

Only wire modules of the same type and performance class. This is the only way to ensure maximum yields and system operation that is secure and free from disruptions.

## GUIDELINES

Modules cannot be operated for more than 90 consecutive days under open-circuit or short-circuit conditions. Consult with Calyxo if you are unable to uphold this time frame.

All of the components attached to the system need to have an operating window that matches the 'Maximum Power Point' (MPP). The components need to be capable of operating at the MPP at all times.

## SAFETY FACTORS

Under normal conditions, a photovoltaic module is likely to experience conditions that produce more current and/or voltage than reported at standard test conditions. Accordingly, the values of ISC and VOC marked on this module should be multiplied by a factor of 1.25 when determining component voltage ratings, conductor ampacities, fuse sizes, and size of controls connected to the PV output. Refer to Section 690-8 of the National Electrical Code for an additional multiplying factor of 125 percent (80 percent derating) which may be applicable.

For a module the multiplying factor at conditions of an irradiance of 125 mW/cm<sup>2</sup>, AM 1.5 spectrum, and a cell temperature of minus 10°C (plus 14°F) for VOC and plus 75°C (167°F) for ISC is to be determined and this factor is to be indicated in the instructions. Thus, it is advised to take a security factor of 1.25 for the parameters listed below into account, in accordance with IEC 61730-1 Paragraph 12.7:

- Determining the voltage measurement values ( $V_{oc}$ ) of components
- Determining the current measurement values ( $I_{sc}$ ) of conductors
- Determining fuse sizes
- Measuring control systems to the outputs of the solar modules.

At any rate, the applicable national regulations for installing electrical systems need to be observed.

### 6.5.1 Series connection

Only wire modules of the same type and performance class. Please take special note of the positive sorting and the tolerance ranges for  $V_{oc}$  and  $V_{MPP}$  indicated in the datasheet of the respective CX series module.

Series connection of the modules is only permitted up to the maximum system voltage provided in the respective currently applicable data sheet.

When installing the modules, take into account all working conditions and relevant technical regulations and standards. Doing so ensures that the maximum system voltage, including the required safety margins, are not exceeded.

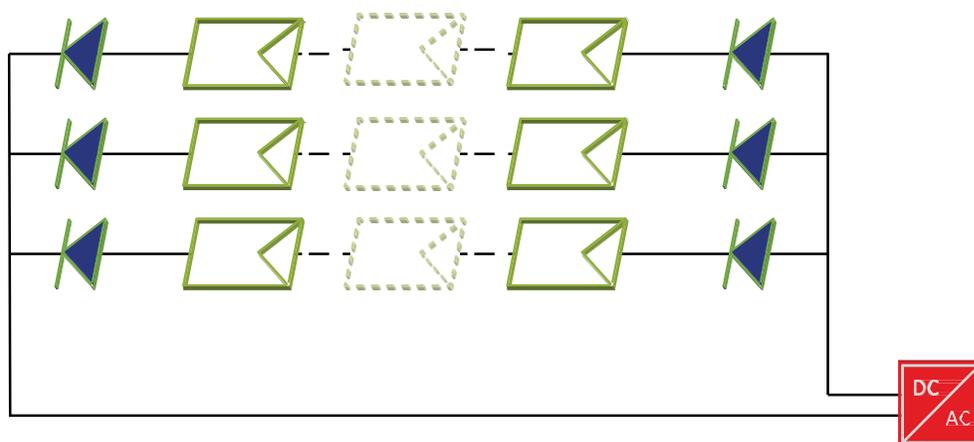
When determining the string length, also take the voltage limit of the inverter into account.

## 6.5.2 Parallel connection

Only wire modules of the same type and performance class. Ensure compliance with the maximum permissible reverse current provided in the data sheet. In the event of reverse currents (caused by module defects, ground leakage or shading), modules connected in parallel can also be damaged. In order to limit reverse currents that occur, we recommend the following fuse variants:

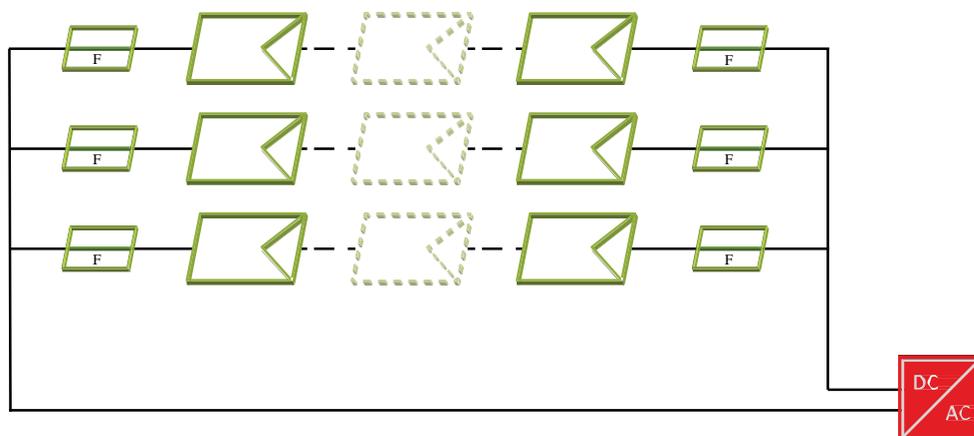
### LAYOUT WITH STRING DIODES

Every conductor needs to be protected against reverse currents from the rest of the system with a string diode. Within the scope of DIN VDE 0100-712: 2016-10, diodes are no longer permitted as reverse-current protection.



### LAYOUT WITH STRING FUSES

Usually, each string on the model needs to be protected with fuses (values see 5.) on the plus and minus sides. Check the calculated value of the fuse in accordance with IEC 60269-6, including the site and the orientation of the PV system.



#### PLEASE NOTE!

When installing modules from different product revisions, observe the minimal permissible limitation of the product revisions used.

## 6.5.3 Functional grounding



### WARNING!

**Fire hazard for improper grounding!**

A module with exposed conductive parts is considered to be in compliance with UL 1703 only when it is electrically grounded in accordance with the instructions presented below and the requirements of the National Electrical Code.

Common hardware items such as nuts, bolts, star washers, spilt-ring lock washers, flat washers and the like have not been evaluated for electrical conductivity or for use as grounding device and should be used only for maintaining mechanical connections and holding electrical grounding devices in the proper position for electrical conductivity. Such devices, where supplied with the module and evaluated through the requirements in UL 1703, may be used for grounding connections in accordance with the instructions provided with the module.

Install functional grounding for the solar power system when you are installing it in a country or a system in which functional grounding is necessary or prescribed.

Direct grounding with a direct connection between the pole and the ground is not permitted. We recommend functional grounding for large PV systems.

When installing the functional grounding, ensure that only the negative terminal of the module field is grounded.

Only use inverters or other components for which the manufacturer enables functional grounding or provides a ground kit that fulfils the above requirements.

### TRANSFORMERLESS INVERTERS

Insofar as this is permitted by regulations depending on the site of installation, transformerless inverters can also be used if the potential of the DC side to the ground or '0' is less than 600 volts (<600 V DC).

When using transformerless inverters, the instructions of the inverter manufacturer shall be observed.

## 6.5.4 Other instructions

### CHARGE CONTROLLERS OR STAND-ALONE INVERTERS

When using the solar module with charge controllers or stand-alone inverters, you must ensure that the module is constantly operated at MPP under solar radiation. Longer operation with an open circuit ( $V_{oc}$ ) is to be avoided.

### CABLES AND CONNECTORS

Calyxo CX1, CX3, CX3pro and CX4 modules are pre-configured with industry standard connectors that are “touch proof” with all live parts protected against accidental contact and protected against polarity reversal. The cables and MC4 connectors are UV and weather resistant from  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ , and rated for 1500VDC and 22.5A (minimum, before derating for ambient temperature). CX1 is also available with pre-configured connectors MC3. The cables and MC3 connectors are UV and weather resistant from  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ , and rated for 600VDC and 20 A (minimum, before derating for ambient temperature).

#### Connector Identification

CX1, CX3, CX3<sup>pro</sup>, CX4 - MC4 connectors of part numbers (PV-KST4/PV-KBT4):



CX1 (feature) - MC3 connectors of part numbers (PV-KST3/PV-KBT3):



Please note the following when selecting connecting cables and connectors:

- Only use pre-assembled connecting cables and safe-to-touch, identical connectors.
- Ensure that all electrical components are in a proper, dry and secure state. This prevents electrical short circuits or dangerous contact voltages from arising from defective or damaged cables.
- Always avoid placing mechanical stress on connecting cables.
- Ensure wire securement methods, such as use of cable ties, do not damage wire insulation. The minimum module lead wire bend radius is 5 times wire diameter. Observe minimum bend radius specifications on all other PV system wiring.
- Ensure sufficient strain relief for the cables, especially in the area of the junction boxes.
- Ensure firm connection between the individual plugs (especially to the inverter). When connecting, ensure that the two plugs properly click into place.
- If wiring method is cable, select the cable diameter according national rules (i.e. IEC, EN, UL, NEC, CSA) Minimum cable diameter is  $2,5\text{mm}^2$  (14AWG) Cu.

## AFTER INSTALLATION

After installation, ensure that:

- The wiring is not exposed or hanging and is protected from dirt and moisture.
- The connectors are not lying on a water collecting surface and are firmly connected to one another.
- All necessary security and functional inspections have been carried out in accordance with the state of the technology (for Germany, see 'Transport and Storage' on page 6).

# 7. Operations management

Calyxo CdTe solar modules have a long service life and require minimal maintenance work. Normally, light soiling is reliably washed away by rainfall. However, additional cleaning is necessary if the module is shaded by coarse soiling (such as plants, bird droppings, dust) and self-cleaning from rain no longer suffices. Soiling can reduce the performance of the module and also cause damage by causing reverse currents.

## SAFETY INSTRUCTIONS



### **WARNING!**

**Danger of injury due to heated modules under voltage!**

The modules should only be cleaned when the module temperatures fall between 10°C and 30°C; for example, in the early morning or late evening. Do not wear any conductive pieces or clothing.



### **WARNING!**

**Danger of falling from rooftop systems and building-integrated installations!**

Never enter the installation area alone and without protection. We recommend commissioning a specialist company with this work. Ask your installer about this on-site.

## TROUBLESHOOTING



### **WARNING!**

**Danger of death due to electric shock! Damaged module components may be hazardous!**

As system operator: Do not attempt to resolve the disruption on your own!

In the event of disruptions or damaged modules (such as cracked or broken glass or damaged cables or contacts), immediately contact your installer. Your installer needs to ensure that the module is removed from the system as quickly as possible.

## CLEANING

As the operator, you should regularly remove soiling from the modules. Please note the following (in addition to the safety instructions):

- Never stand on the module. Do not place any mechanical stress on the module.
- Avoid cleaning with water when there is a threat of frost forming or when there are large differences in temperature between the module, water and air.
- We recommend decalcifying highly calcareous water used for cleaning prior to cleaning. This prevents the water from staining the modules. Remove standing water from the modules.
- Do not use any abrasive cleaning agents or surfactants. Do not scratch off dirt. Doing so can damage the surface of the module and lead the module to break later on.
- Never apply force when removing ice or snow (for example, with a broom). Remove dirt from the top of the module in the following sequence:
  - Rinse off coarse soiling (dust, foliage etc.) from the modules with lukewarm water.
  - Moisten stubborn soiling and carefully remove it.
  - Use lukewarm water and a soft cloth/sponge. Isopropanol (IPA) can be used for spot cleaning. Please observe the safety instructions on the IPA packaging. Do not allow any IPA to run into the module edges.
- Remove soiling (foliage, bird's nests etc.) from the substructure
- For ground-mounted systems, we recommend regularly mowing the grass to prevent the modules from being partially shaded. When doing so, take care not to mow the cables or allow stones to fly up and hit the modules.

## MAINTENANCE

The solar power system should be annually inspected by a specialist installer to ensure that:

- The substructure and all attachments are free from corrosion
- All modules are intact
- The modules are all securely attached
- All electrical components are securely connected, clean and intact
- The contact resistances of the grounding are correct

## 8. Service

### DECOMMISSIONING AND RECYCLING

Do not decommission the module yourself. Always commission a specialist company with doing so. Dispose of the module in accordance with national and regional disposal regulations.

In accordance with the new version of the European Directive on WEEE (Waster Electrical and Electronic Equipment), owners of old devices need to transfer these from unsorted residential waste into a separate collection. Modules cannot be disposed of together with household waste.

### CROSSED-OUT WASTE BIN

The German Electrical and Electronic Equipment Act (ElektroG) on the entire life cycle and environmentally sustainable disposal of electrical and electronic devices is to be understood as a special law under the scope of the general German waste legislation, which is laid out in the Waste Management and Product Recycling Act (KrWG). The ElektroG replaces the EU directive on waste electrical and electronic equipment (WEEE). As a PV module manufacturer, we have registered ourselves with the EAR register ([www.stiftung-ear.de/en/](http://www.stiftung-ear.de/en/)).

OUR WEEE REGISTRATION NUMBER IS DE 97233335.

Further information on recycling is available on our website: [www.calyxo.com](http://www.calyxo.com).

## 9. Warranty terms and conditions

The respective applicable warranty terms and conditions (PAS-11-05-0173-EN) apply, as do the General terms and conditions of Calyxo GmbH. These can be found in the Download section of our homepage, [www.calyxo.com](http://www.calyxo.com).

## 10. General

Changes to the module components serve to continually improve the products. These include changes made through component improvements, change of suppliers or small design changes initiated by Calyxo. All products with the same classification have equal functionality and are fully compatible with one another, even when small differences may occur. Changes that do not influence the functionality of the product are usually made without informing customers. Before components or design changes are introduced into the manufacturing process, they are submitted to internal testing, inspections or repeated reviews. These are also conducted by a certification body.

Calyxo reserves the right to make changes to the solar module design and/or specifications at any time without prior notice. The customer will be accordingly notified to check that the data sheets are current before contracts are made or system designs are finalised. Calyxo ensures that data sheet and additional information is always accessible and corresponds to the latest status. However, Calyxo assumes no responsibility for its use, or for injuries to patents or the rights of third parties that may result from use. No licence – either implicit or explicit – is guaranteed under a patent or patent rights from Calyxo.

In the event of a discrepancy between this operating manual and other instructions from other system component manufacturers, the system component instructions should be followed.

Further information regarding Calyxo and our products is available at [www.calyxo.com](http://www.calyxo.com). If you have any support questions, please contact [service@calyxocom](mailto:service@calyxocom).

### ADDRESS

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This document is applicable to the following starting in February 2017: The CdTe thin film solar modules in the CX3/CX3<sup>pro</sup> product series. This document replaces all prior revisions to the operating manuals for this module range. Changes to the technical parameters and design are reserved. The current data sheets and customer information available at the time of manufacture of the affected module apply when carrying out installation, assembly or maintenance work to the modules.

# 11. Notes