Gewaarmerkt als behorende bij besluit
9 oktober 2017

PowerField

Datasheets en constructiebrief zonnepark

1. Datasheet frames Schletter
2. Datasheet panelen JA Solar
3. Datasheet omvormers SMA
4. Installatie handboek SMA
5. Constructeursbrief zonnepark

PowerField

1. Datasheet frames Schletter

FS Duo

- Maximum level of pre-fabrication
- No soil sealing
- Quick and simple mounting
- Perfectly synchronized system components
- High economic efficiency
- 5-year durability guarantee

The FS open area mounting system has been installed by Schletter for many years in a large number of projects in Germany, Europe and other parts of the world.

All the experience gained in these projects was made use of in the development of this new steel design, which resulted in an even more price-efficient fastening system for solar mounting, because especially in the sector of open area plants, the increasing cost-pressure makes an optimum material utilization unavoidable. With our the FS steel system, this principle was implemented uncompromisingly.

Two-support design without diagonal struts

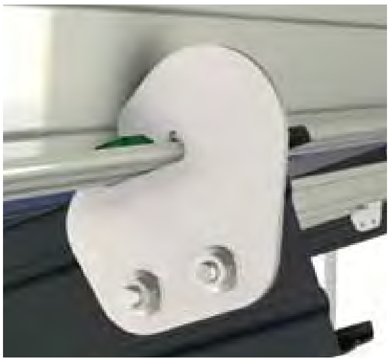
On request, all possibilities of project-specific in-house pre-fabrication are utilized to reduce the mounting time on the construction site.
Two different designs of the two-support rack are available - with or without diagonal struts. Depending on the soil conditions, these two basic designs allow an individual project planning with maximum economic efficiency.

FS Duo - your advantages

- Efficient material utilization
- Wider support distances modified to the terrain are possible
- Galvanized sheet metal edges made of strip galvanised material
- Average thickness of zinc layer up to 80µm

Two-support design with diagonal struts

Short description of the mounting

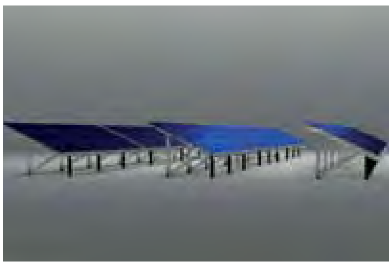


The girder profile is fastened to the pile-driven U-profiles. The module-bearing profiles are hooked in using connector hooks and are fastened with a fastening device made of high-grade steel. For this purpose, the fastening device is accurately hammered in using a hammer in order to create a fixed connection with prestress. This safeguards durable stability also in difficult conditions.

Technical data

Material	Fastening elements, bolts: Steel, hot-dip galvanised respectively high-grade steel (fixing device, bolts) Profiles: Steel, hot-dip galvanized Pile-driven foundations: Steel, hot-dip galvanized
Logistics	• Delivery of single components as well as a maximum level of pre-assembly are possible. • Transport to the installation site appropriate to the specific kind of mounting
Construction	• Quick and easy mounting
Delivery and services	• Ground survey and structural analysis • Structural analysis of the individual rack based on regional data • Pile driving of the foundations and delivery of the complete mounting material • **Optional:** Rack mounting • **Optional:** Complete module mounting
Structural analysis	• Structural analysis of the respective terrain based on a geological survey • Individual systems analysis based on regional load values Load assumptions according to DIN 1055, part 4 (03/2006), part 5 (06/2005), part 100 (03/2001), Eurocode 1 (06/2002), DIN 4113, DIN 18800, Eurocode 9 DIN 4113, DIN 18800, Eurocode 9 and further respectively country-specific standards • Highly efficient, material-saving profile geometries • Verification of all construction components based on FEM-calculation

Further information at www.schletter.eu



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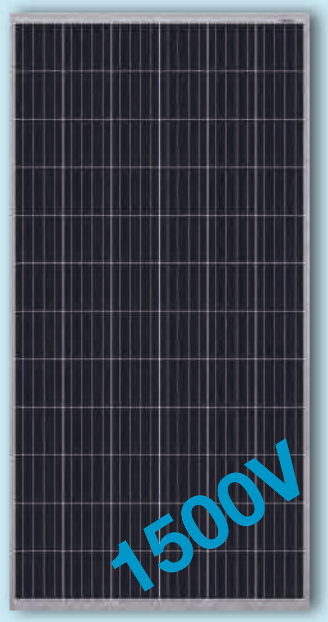
JA SOLAR

JAP6

-72/305-325/4BB/1500V

MULTICRYSTALLINE SILICON MODULE



JA Solar Holdings Co., Ltd.

JA Solar Holdings Co., Ltd. is a world-leading manufacturer of high-performance photovoltaic products that convert sunlight into electricity for residential, commercial, and utility-scale power generation. The company was founded on May 18, 2005, and was publicly listed on NASDAQ on February 7, 2007. JA Solar is one of the world's largest producers of solar cells and modules. Its standard and high-efficiency product offerings are among the most powerful and cost-effective in the industry.

Add: NO.36, Jiang Chang San Road, Zhabei, Shanghai 200436, China

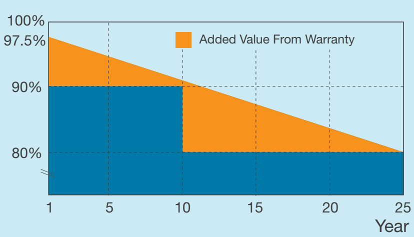
Tel: +86 21 6095 5888 / +86 21 6095 5999

Fax: +86 21 6095 5858 / +86 21 6095 5959

Email: sales@jasolar.com market@jasolar.com

Superior Warranty

- 10-year product warranty
- 25-year linear power output warranty



Key Features

- JA 4BB design module reduce cell series resistance and stress between cell interconnectors improves module reliability and module conversion efficiency
- High output, 16.51% highest conversion efficiency
- Designed for IEC DC 1500V system applications
  50% longer strings fewer components and lower BOS cost
- Anti-reflective and anti-soiling surface reduces power loss from dirt and dust
- Outstanding performance in low-light irradiance environments
- Excellent mechanical load resistance: Certified to withstand high wind loads (2400Pa) and snow loads (5400Pa)
- High salt and ammonia resistance certified by TÜV NORD

Reliable Quality

- Positive power tolerance: 0~+5W
- 100% EL double-inspection ensures modules are defects free
- Modules binned by current to improve system performance
- Potential Induced Degradation (PID) Resistant

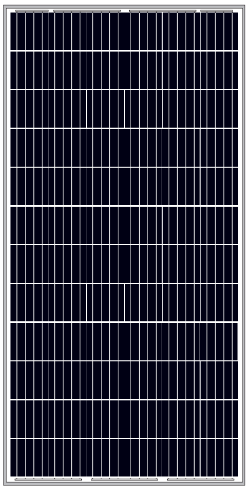
Comprehensive Certificates

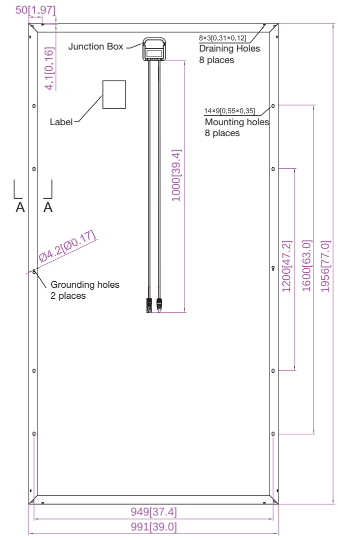
- IEC 61215, IEC 61730, UL1703, CEC Listed, MCS and CE
- ISO 9001: 2008: Quality management systems
- ISO 14001: 2004: Environmental management systems
- BS OHSAS 18001: 2007: Occupational health and safety management systems
- Environmental policy: The first solar company in China to complete Intertek's carbon footprint evaluation program and receive green leaf mark verification for our products

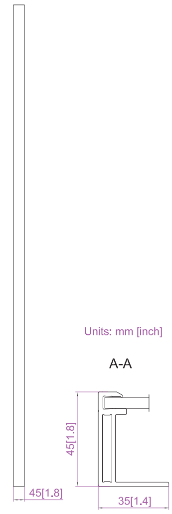
JAP6-72/305-325/4BB/1500V

JA SOLAR

Engineering Drawings







■ customized cable length available upon request

MECHANICAL PARAMETERS

Cell (mm)	Poly 156x156
Weight (kg)	26 (approx)
Glass Thickness	4 mm
Dimensions (L×W×H) (mm)	1956×991×45
Cable Cross Section Size (mm^2)	4
No. of Cells and Connections	72 (6×12)
Junction Box	IP67, 3 diodes
Connector	Amphenol UTX
Packaging Configuration	23 Per Pallet

WORKING CONDITIONS

Maximum System Voltage	DC 1500V (IEC)
Operating Temperature	-40℃~+85℃
Maximum Series Fuse	15A
Maximum Static Load, Front (e.g., snow and wind) Maximum Static Load, Back (e.g., wind)	5400Pa (112 lb/ft^2) 2400Pa (50 lb/ft^2)
NOCT	45±2℃
Application Class	Class A

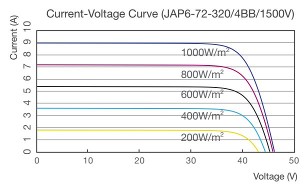
ELECTRICAL PARAMETERS

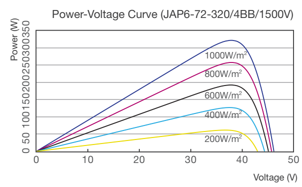
TYPE	JAP6-72-305 /4BB/1500V	JAP6-72-310 /4BB/1500V	JAP6-72-315 /4BB/1500V	JAP6-72-320 /4BB/1500V	JAP6-72-325 /4BB/1500V
Rated Maximum Power at STC (W)	305	310	315	320	325
Open Circuit Voltage (Voc/V)	45.37	45.66	45.95	46.22	46.48
Maximum Power Voltage (Vmp/V)	36.88	36.99	37.19	37.38	37.49
Short Circuit Current (Isc/A)	8.81	8.89	8.98	9.06	9.14
Maximum Power Current (Imp/A)	8.27	8.38	8.47	8.56	8.67
Module Efficiency [%]	15.73	15.99	16.25	16.51	16.77
Power Tolerance (W)	-0~+5W				
Temperature Coefficient of Isc (αIsc)	+0.058%/℃				
Temperature Coefficient of Voc (βVoc)	-0.330%/℃				
Temperature Coefficient of Pmax (γPmp)	-0.410%/℃				
STC	Irradiance 1000W/m^2, Cell Temperature 25℃, Air Mass 1.5				

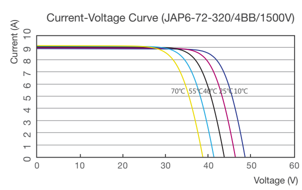
NOCT

TYPE	JAP6-72-305 /4BB/1500V	JAP6-72-310 /4BB/1500V	JAP6-72-315 /4BB/1500V	JAP6-72-320 /4BB/1500V	JAP6-72-325 /4BB/1500V
Max Power (Pmax) [W]	221.43	225.06	228.69	232.32	235.95
Open Circuit Voltage (Voc) [V]	41.53	41.71	41.92	42.12	42.32
Max Power Voltage (Vmp) [V]	33.81	33.95	34.08	34.27	34.45
Short Circuit Current (Isc) [A]	6.95	7.01	7.06	7.12	7.18
Max Power Current (Imp) [A]	6.55	6.63	6.71	6.78	6.85
Condition	Under Normal Operating Cell Temperature, Irradiance of 800 W/m^2, spectrum AM 1.5, ambient temperature 20℃, wind speed 1 m/s				

I-V CURVE







Electrical data in this catalog do not refer to a single module and they are not part of the offer. They only serve for comparison among different module types.

PowerField

2. Datasheet panelen JA Solar

3. Datasheet omvormers SMA

MV POWER STATION
2200SC / 2500SC-EV

Flexible

- Global solution for international markets
- For system voltage of 1,000 V_{DC} or 1,500 V_{DC}
- Various options for monitoring

Robust

- Station and all individual components type-tested
- 5-year statutory warranty
- Optimally suited to extreme ambient conditions

Easy to Use

- Plug and play concept
- Ideally suited to be exported to overseas markets
- Pre-installed and mechanically protected cabling

Cost Effective

- Easy planning and installation
- High power density per m^3 for maximum profitability
- Low transport costs due to 20 foot container

MV POWER STATION 2200SC / 2500SC-EV

Turnkey system solution with the new Sunny Central inverter

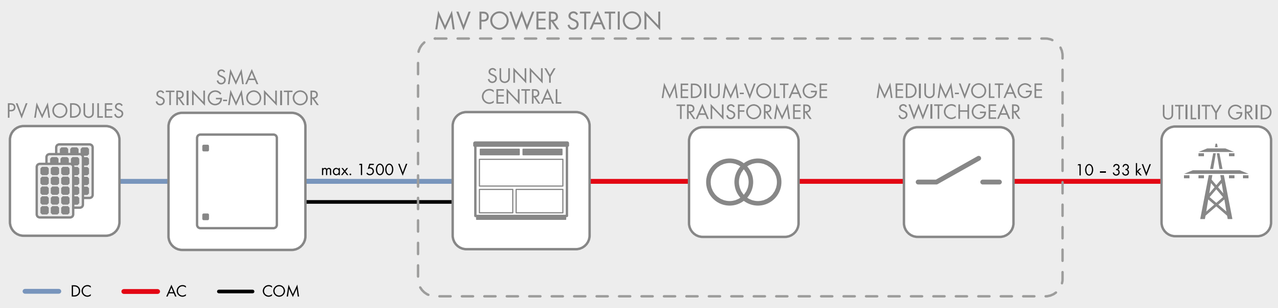
With the compact power of the new, robust Sunny Central inverter and with matching medium-voltage components, the MV Power Station is a turnkey solution that is available worldwide. It represents the ultimate utility scale solution in compactness with 1,000 V_{DC} (2,200 kW) or 1,500 V_{DC} (2,500 kW). Being the ideal choice for large-scale PV power plants, the integrated 20 foot container station is quick to assemble and commission as well as easy and cost-effective to transport. The compact station itself (IEC 62271-202) and all its components are type-tested. The MV Power Station combines rigorous plant safety with maximum energy yield and minimized operating risk. The MV Power Station's components are delivered completely pre-installed and pre-commissioned to speed up station commissioning as much as possible.

MV POWER STATION 2200SC / 2500SC-EV

Technical data	MV Power Station 2200SC	MV Power Station 2500SC-EV
Input (DC)		
Max. DC input voltage	1,100 V	1,500 V
MPP voltage range (at 25 °C / at 50 °C)	570 V to 950 V / 800 V	850 V to 1,425 V / 1,275 V
Max. input current (at 25 °C / at 50 °C)	4,110 A / 3,960 A	3,000 A / 2,700 A
Number of DC inputs	24	24
Available DC fuse sizes (per input)	200 A, 250 A, 315 A, 350 A, 400 A	
Integrated zone monitoring (+/− 0.5 % shunt resistors)	○	○
Output (AC) on the medium-voltage side		
AC- power at cos φ = 1 (at 25 °C / at 40 °C / at 50 °C)[1]	2,200 kVA / 2,080 kVA / 2,000 kVA	2,500 kVA / 2,350 kVA / 2,250 kVA
Typical AC voltages	10 kV to 33 kV	10 kV to 33 kV
AC power frequency	50 Hz / 60 Hz	50 Hz / 60 Hz
Transformer vector group Dy11 / YNd11	● / ○	● / ○
Transformer cooling method	ONAN[2]	ONAN[2]
Max. output current at 20 kV	64 A	73 A
Transformer no-load losses[3]	1.595 kW	1.76 kW
Transformer short-circuit losses[3]	19.8 kW	22 kW
Max. total harmonic distortion	< 3%	< 3%
Power factor at rated power / displacement power factor adjustable	1 / 0.8 overexcited to 0.8 underexcited	
Feed-in phases / connection phases	3 / 3	3 / 3
Inverter efficiency[4]		
Max. efficiency	98.4%	98.4%
European efficiency	98.3%	98.1%
CEC weighted efficiency	98.0%	98.0%
Protective devices		
Input-side disconnection point	DC load-break switch	
Output-side disconnection point	AC circuit breaker	
DC overvoltage protection	Type II surge arrester	
DC ground-fault monitoring / remote ground-fault monitoring	○ / ○	○ / ○
DC insulation monitoring	○	○
Galvanic isolation	●	●
Arc fault resistance control room (according to IEC 62271-202)	IAC A 20 kA 1 s	IAC A 20 kA 1 s
General data		
Dimensions (W / H / D)[5]	6.058 m / 2.591 m / 2.438 m	6.058 m / 2.591 m / 2.438 m
Weight	< 16 t	< 16 t
Operating temperature range −25 °C to +40 °C / +50 °C	● / ○	● / ○
Self-consumption (max. / partial load / average)[1]	< 8,100 W / < 1,800 W / < 2,000 W	
Self-consumption (stand-by)[1]	< 300 W	< 300 W
Internal auxiliary power supply for inverter self-consumption	8.4 kVA transformer	8.4 kVA transformer
Degree of protection according to IEC 60529	Control room IP23D, inverter IP54	
Degree of protection according to IEC 60721-3-4 (4C1, 4S2 / 4C2, 4S2)	● / ○	● / ○
Application / use in chemically active environment	In unprotected outdoor environments / ○	
Maximum permissible value for relative humidity	15% to 95%	15% to 95%
Max. operating altitude above mean sea level 1,000 m / >1,000 m to 2,000 m	● / ○	● / ○
Fresh air consumption (inverter)	6,500 m^3/h	6,500 m^3/h
Features		
DC connection	Ring terminal lug or busbar	Ring terminal lug or busbar
AC connection, MV side	Outer-cone angle plug	Outer-cone angle plug
Display	HMI touch display (10.1")	
Communication protocols / SMA String-Monitor	Ethernet, Ethernet/IP, Modbus	
SC-COM	●	
Station enclosure color	RAL 7004	
Transformer for external loads 10 kVA / 20 kVA / 30 kVA	○	
Medium-voltage switchgear	○	
Oil tray	○	
Standards (more available on request)	IEC 62271-202, IEC 62271-200, IEC 60076	
● Standard features ○ Optional features – Not available		
Type designation	MVPS 2200SC-10	MVPS 2500SC-EV-10

1) Data based on inverter
2) ONAN = Oil-natural, air-natural cooling
3) Losses in accordance with the Ecodesign regulations, based on grid voltage 20 kV
4) Efficiency measured at inverter with internal power supply
5) Dimensions without feet, service platforms and protection roofs

SYSTEM DIAGRAM



DESIGN NOTES

Inverter compartment
DC connections are made from below in the inverter's DC connection compartment. An integrated transformer and additional space is available for the installation of customer equipment. The air cooling system OptiCool TM ensures smooth operation, even in extreme ambient temperatures.

Transformer compartment
Outdoor transformer optimized for PV without active fan for reduced maintenance. The side panels are equipped with protective grids. The transformer is connected directly to the inverter by a highly efficient three-phase busbar. This cuts costs, reduces losses and allows a highly compact design.

Control room
The following features are installed:
Medium-voltage switchgear with three feeders, including two cable feeders with load-break switch and one transformer feeder with circuit breaker. For optimal user protection, the medium-voltage switchgear contains the standard internal arc classification IAC AFL 20 kA 1s according to IEC 62271-200.
Transformers with EMC filters in 10 kVA, 20 kVA and 30 kVA power classes can be installed to support additional communications and control functions and to operate tracker motors.
The station subdistribution board and circuit breakers for control, lightning and socket can optionally be supplied via the 2.5 kVA transformer in the SC or the low-voltage transformer in the control room.

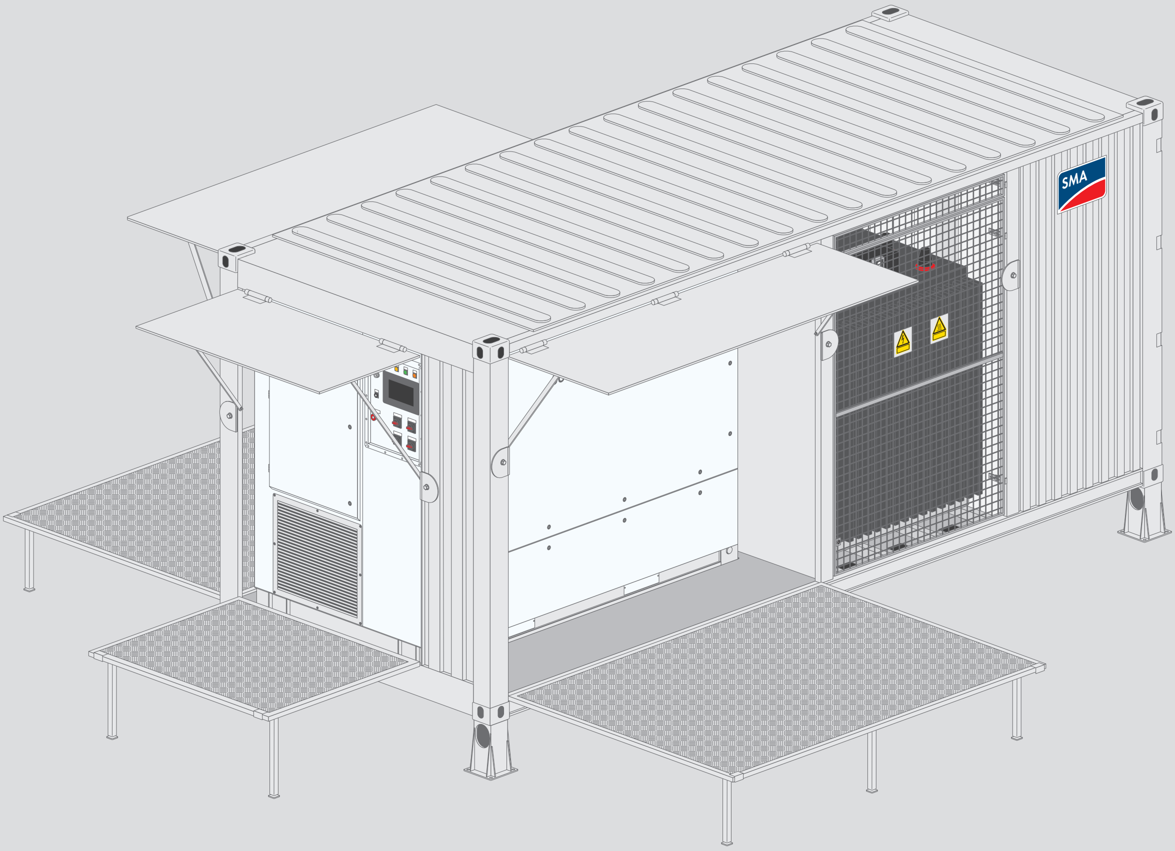
www.SMA-Solar.com

SMA Solar Technology

4. Installatie handboek SMA

Transportation and Installation Requirements

MEDIUM VOLTAGE POWER STATION 2200SC / 2500SC-EV



ENGLISH

MVPS2200_2500-EV-TA-en-11 | Version 1.1

Table of Contents

1 Information on this Document

1.1 Validity

This document is valid for the following device types of the MV Power Station with Sunny Central 2200 and Sunny Central 2500-EV:

- Medium Voltage Power Station 2200SC (MVPS-2200SC-10)
- Medium Voltage Power Station 2500SC-EV (MVPS-2500SC-EV-10)

The production version is indicated on the type label.

Illustrations in this document are reduced to the essential and may deviate from the real product.

SMA Solar Technology reserves the right to make changes to the product.

1.2 Additional Information

Links to additional information can be found at www.SMA-Solar.com.

1.3 Nomenclature

Complete designation	Designation in this document
Medium Voltage Power Station	MV Power Station
Sunny Central 2200 Sunny Central 2500-EV	Inverter
Medium-voltage transformer	MV transformer
Medium-voltage switchgear	MV switchgear

The products installed on the MV Power Station, such as the inverter or the MV transformer, are also referred to as components.

2 Product Overview

2.1 Design of the MV Power Station

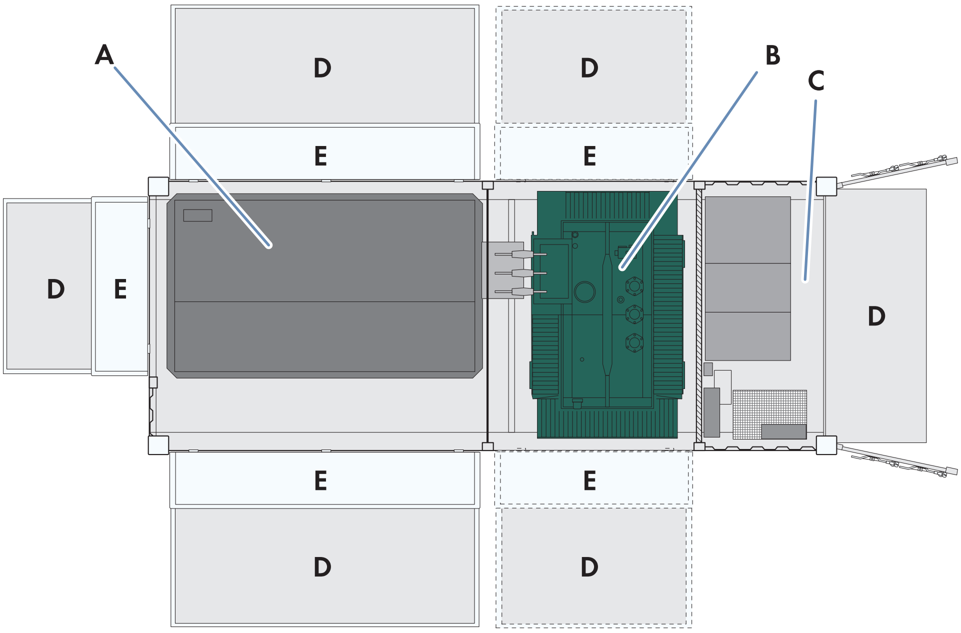


Figure 1: Design of the MV Power Station

Position	Designation	Explanation
A	Sunny Central	The Sunny Central is a PV inverter that converts the direct current generated in the PV arrays into grid-compliant alternating current.
B	MV transformer	The MV transformer converts the inverter output voltage to the voltage level of the medium-voltage grid.
C	Medium-voltage compartment	**Medium-voltage switchgear*** The medium-voltage switchgear connects and disconnects the MV transformer to and from the medium-voltage grid.
		MV Power Station low-voltage transformer* The 2.5 kVA low-voltage transformer of the inverter provides the supply voltage for the MV Power Station and its components. If the low-voltage transformer of the inverter does not have sufficient power available for external loads, a larger low-voltage transformer will be necessary. The low-voltage transformer of the MV Power Station in the power classes 10 kVA, 20 kVA and 30 kVA is connected on the low-voltage side of the MV transformer.
		Station subdistribution The station subdistribution contains fuse and switching elements for the supply voltage.
		Control device for cascade control* The order option "Cascade control" allows for staggered reconnection of several medium-voltage switchgears after a grid failure or maintenance work.

Position	Designation	Explanation
D	Service platform**	The elevated position of the service platform facilitates device operation.
E	Protective roof**	The roof protects the devices from direct solar irradiation.

* optional

** The protective roof and service platform for the MV transformer are only included if the MV Power Station is ordered with the order option "Sea freight".

2.2 Option code

The MV Power Station is available in different power classes:

MV Power Station	Inverter
MV Power Station 2200SC	Sunny Central 2200
MV Power Station 2500SC-EV	Sunny Central 2500-EV

You can use the option code to select an MV Power Station configuration which is tailored specifically to your project. However, not all order options can be combined with each other. Consult your SMA contact person if you have any questions.

Order option	1	2	3	4	5	6	7	8	9	Description
Transformer	2									Mineral oil with full hermetic protection
Nominal voltage		1								10.0 kV
		2								11.0 kV
		3								12.0 kV
		4								12.5 kV
		5								13.2 kV
		6								13.8 kV
		7								15.0 kV
		8								20.0 kV
		9								22.0 kV
		A								23.0 kV
		B								30.0 kV
		C								33.0 kV
Nominal frequency			0							50 Hz
			1							60 Hz
Transformer vector group				0						Dy11
				2						YNd11

Order option	1	2	3	4	5	6	7	8	9	Description
Oil tray					0					Without
					1					With (separate component, transported in the inverter compartment)
Medium-voltage switchgear						0				Without
						2				Ring (3-field), transformer panel with circuit breaker, rated voltage 24 kV
						4				Ring (3-field), transformer panel with circuit breaker, rated voltage 36 kV
Accessory for medium-voltage switchgear							0			Without
							4			Spatial separation (between medium-voltage switchgear and low-voltage devices)
Low-voltage transformer								0		Without When selecting this order option, the inverter must be ordered with a low-voltage transformer (2.5 kVA, 230 V) in order to supply the lighting, the outlet and the fan in the medium-voltage compartment.
								2		10 kVA with EMC filtering device and surge arrester
								3		20 kVA with EMC filtering device and surge arrester
								4		30 kVA with EMC filtering device and surge arrester
Uninterruptible power supply									0	Without

Continuation of the option code

Order option	10	11	12	13	14	15	16	Description
Packaging	0							Standard
	1							Sea freight
Ambient temperature		0						−25 °C to +40 °C
		1						−25°C to +50°C (achieved via an additional fan in the medium-voltage compartment)

Order option	10	11	12	13	14	15	16	Description
Installation altitude			0					0 m to 1000 m
			1					1001 m to 2000 m
Environment				0				Standard
				1				Protection against chemically active environment, e.g. sea salt (achieved via special paint on the MV transformer and resin casting of the low-voltage transformer)
				3				Protection against chemically active environment and dust (additional dust protection of the medium-voltage compartment and of the low-voltage transformer)
Additional equipment					0			Without
Country package						0		Without
Language							DE	German
							EN	English
							FR	French
							ES	Spanish

2.3 Scope of Delivery

Scope of delivery of the station container

The scope of delivery of the station container is located in the medium-voltage compartment.

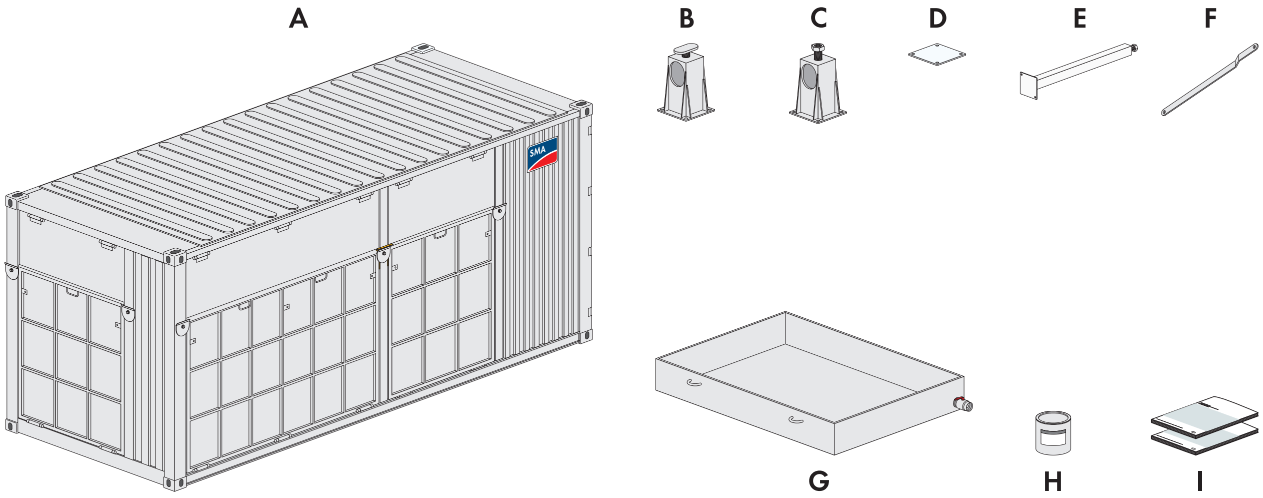


Figure 2: Scope of delivery of the station container

Position	Quantity	Designation
A	1	MV Power Station
B	4	Support foot for the container corners
C	2	Support foot for the container sides
D	12	Base plates for the support feet for compensation of unevenness (six units available in two thicknesses: 2 mm and 5 mm)
E	8 / 12*	Support foot for the service platform Three longer support feet for the service platform in front of the inverter operating elements
F	6 / 10*	Protective roof bracket
G	1	Oil tray with oil drain valve**
H	1	Spare paint
I	1	Documentation, circuit diagram

* With the order option "Sea freight"
** Optional Depending on the production version, the oil drain valve is mounted or not.

Scope of Delivery of the Medium-Voltage Switchgear

The scope of delivery of the medium-voltage switchgear is located in the medium-voltage compartment.

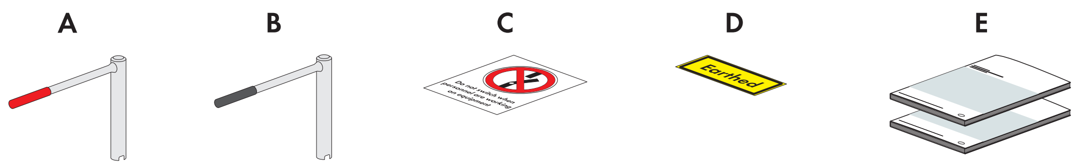


Figure 3: Scope of Delivery of the Medium-Voltage Switchgear

Position	Quantity	Designation
A	1	Actuation lever for grounding switch
B	1	Actuation lever for disconnection unit, load-break switch and circuit breaker
C	1	Magnetic sign "Do not switch"
D	1	Magnetic sign "Earthed"
E	1	Documentation for the medium-voltage switchgear

Scope of delivery of the inverter for option "DC Input Configuration"

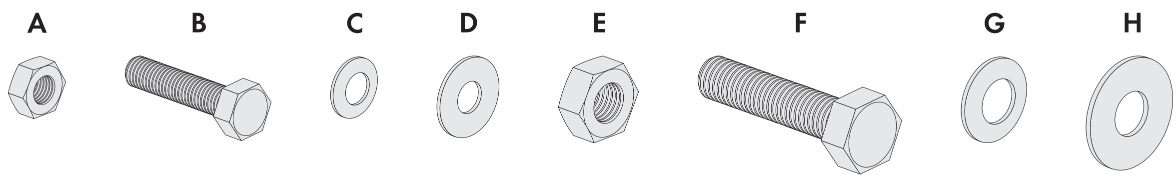


Figure 4: Scope of delivery for option "DC Input Configuration"

Position	Quantity for option "DC Input Configuration":					Designation
	9 fused inputs	12 fused inputs	18 fused inputs	21 fused inputs	24 fused inputs	
A	9	12	18	21	24	Nut M8
B	9	12	18	21	24	Screw M8
C	18	24	36	42	48	Spring washer M8
D	18	24	36	42	48	Fender washer M8
E	36	48	72	84	96	Nut M12
F	36	48	72	84	96	Screw M12
G	72	96	144	168	192	Spring washer M12
H	72	96	144	168	192	Fender washer M12

2.4 External dimensions and weights

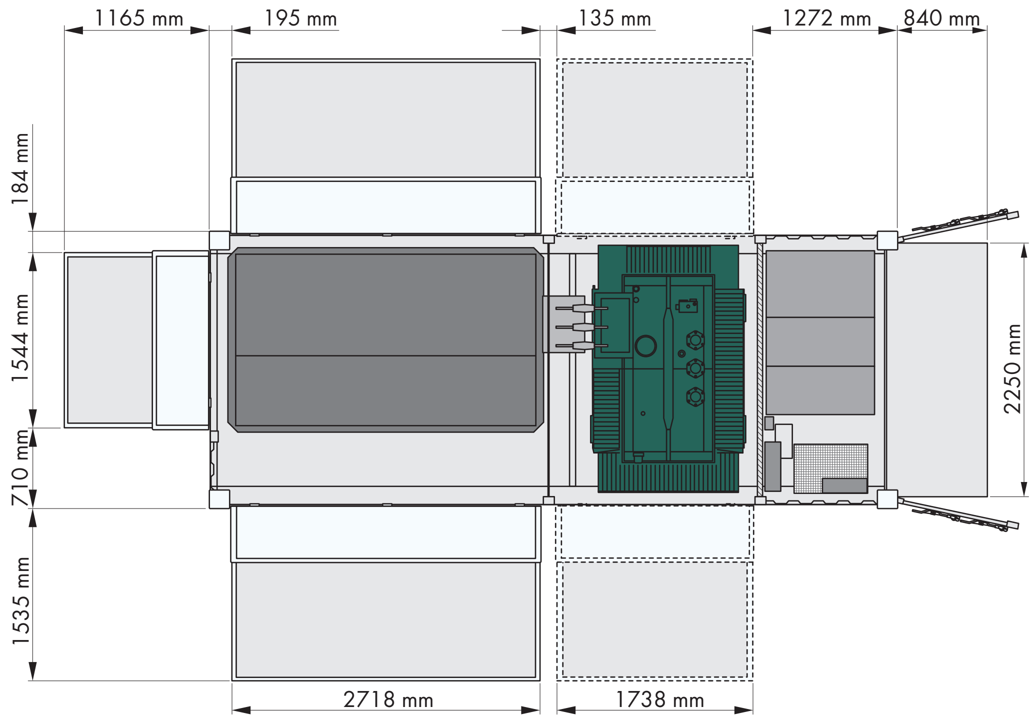


Figure 5: Dimensions of the MV Power Station

Dimensions of the MV Power Station without Platforms and Support Feet

	Width	Height	Depth	Weight
MV Power Station 2200SC MV Power Station 2500SC-EV	6058 mm	2957 mm	2438 mm	< 16 t

Dimensions of the MV Power Station with platforms and support feet

	Width	Height	Depth	Weight
MV Power Station 2200SC MV Power Station 2500SC-EV	8063 mm	2957 mm	5438 mm	< 16 t

3 Transport and Mounting

3.1 Transport by truck or ship

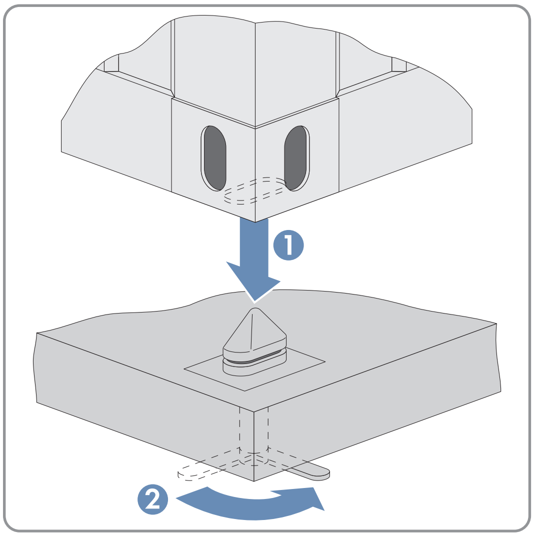
The dimensions and shape of the MV Power Station correspond to those of an ISO container. It can be transported by truck or ship. A truck 16 m long, 2.7 m wide, 5 m high, and with a total weight of 50 t is capable of transporting up to two MV Power Stations.

During transport and unloading, damage to the paint of the station container may occur. Damage to the paint does not impair the function of the MV Power Station. However, any damage must be remedied using the spare paint supplied within three weeks at the latest.

For transportation by truck or ship, the MV Power Station must be secured at least at all four lower corner castings. This can be done by various methods, depending on the fastening system of the means of transportation. The most common methods are described below.

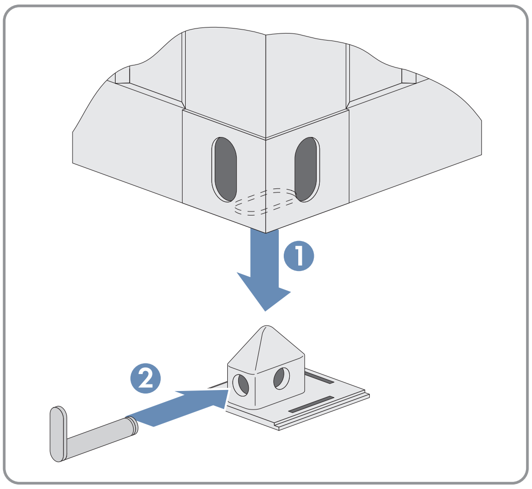
Twistlock

- The MV Power Station is set down on the locking mechanisms. By turning the twistlock, an interlocking is made.



Pinlock

- The MV Power Station is set down on the locking mechanisms. Any slippage of the load is prevented by inserting the pinlock.



3.2 Storage

For storage of the MV Power Station note the following points:

- Do not place the MV Power Station on an unstable, uneven surface.
- Once the MV Power Station has been set down on the surface, do not attempt to adjust its position by pulling or pushing.
- Prior to storage, ensure that the doors of the MV Power Station are tightly closed.

3.3 Requirements and Ambient Conditions

☐ The maximum permissible gradient of the access road is 4%.

☐ During unloading, a distance of at least 2 m to neighboring obstacles must be observed.

☐ The access road must be constructed to ensure that a truck (16 m long, 2.70 m wide, 5 m high, and a total weight of 50 t) can reach the unloading site. The curve radius of the truck must be taken into account.

☐ It is recommend to use a truck with an air-sprung chassis.

☐ For trucks with several containers, the access roads and the unloading site must be designed corresponding to the length, width, height, total weight and curve radius of the truck.

☐ The unloading site for the crane and truck must be firm, dry and horizontal.

3.4 Unloading

The MV Power Station is unloaded by a crane. To unload the MV Power Station, the crane requires a swivel radius of at least 6 m. To facilitate unloading, we recommend maintaining a distance of at least 2 m to neighboring obstacles such as fences or trees.

Depending on the conditions on-site, further measures may be necessary (for example, when installation is to take place near overhead lines). The conditions at the unloading site must have been thoroughly checked before transport.

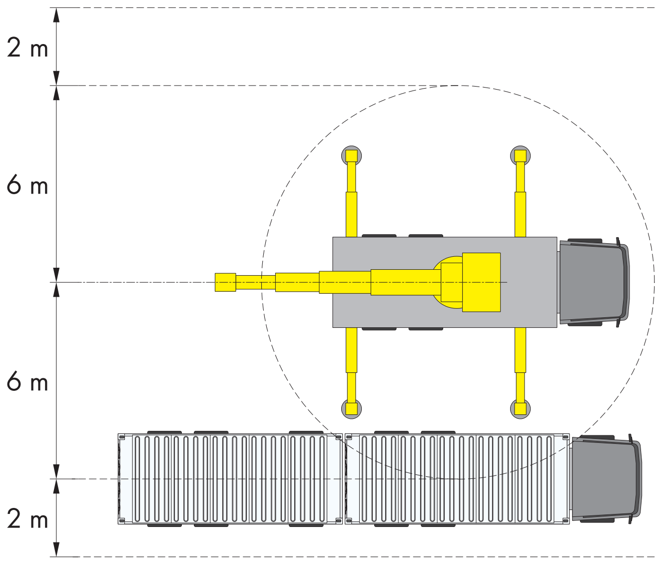
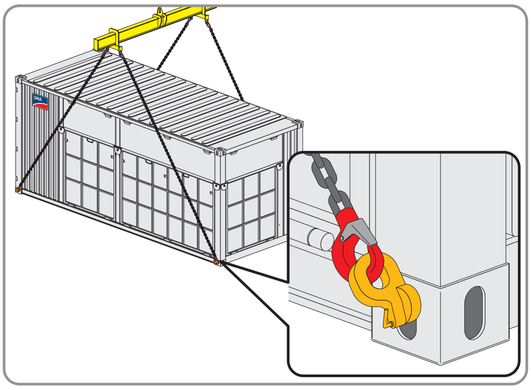
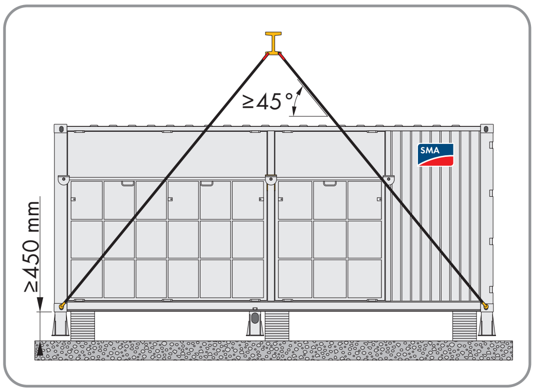


Figure 6: Swivel radius for unloading the MV Power Station

- It is recommend to transport the MV Power Station with a container crossbeam and chain slings. The chain slings must be attached to the four corner castings at the bottom of the MV Power Station. Lifting lugs must be used for attachment. Protect the enclosure of the MV Power Station from mechanical damage by the hoist.
- The transport of the MV Power Station with chain slings at the upper corner castings is only allowed with a lifting frame.



- The angle between chain sling and the ground must be greater than 45 °. For the assembly of the support feet, the MV Power Station must be placed on platforms at least 450 mm high.



Attaching the support feet during unloading

The MV Power Station must be mounted on six support feet. The support feet can be found in the accessory kit in the medium-voltage switchgear compartment. The support feet must be fitted to the MV Power Station before it is placed on the foundation. To attach the support feet, open-end wrenches (AF 30 and AF 36) are required.

i Attaching the support feet of the MV Power Station

To attach the support feet to the MV Power Station, you can set the MV Power Station down for a short while on temporary platforms (for example, crane support plates). For the assembly of the support feet, the platforms must be at least 450 mm high.

or

The support feet can be attached while the MV Power Station is suspended by the crane. The MV Power Station should not be raised higher than 600 mm off the ground to attach the support feet. Intermediate storage on temporary platforms is recommended.

The space underneath the MV Power Station serves several purposes and must not be blocked by any other object than the oil tray:

- Escape of pressure from the medium-voltage switchgear in case of electric arcs
- Easy insertion of cables
- Protection from minor flooding

The clearance between the mounted MV Power Station and the ground must be at least 367 mm.

If the mounting location is subject to strong winds (from 32 m/s to 40 m/s), the support feet should be anchored to the foundation.

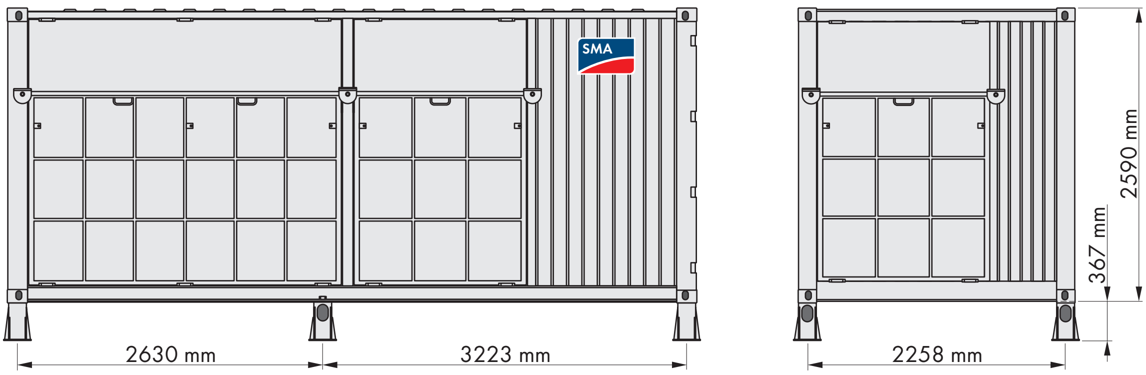


Figure 7: Position of the support feet

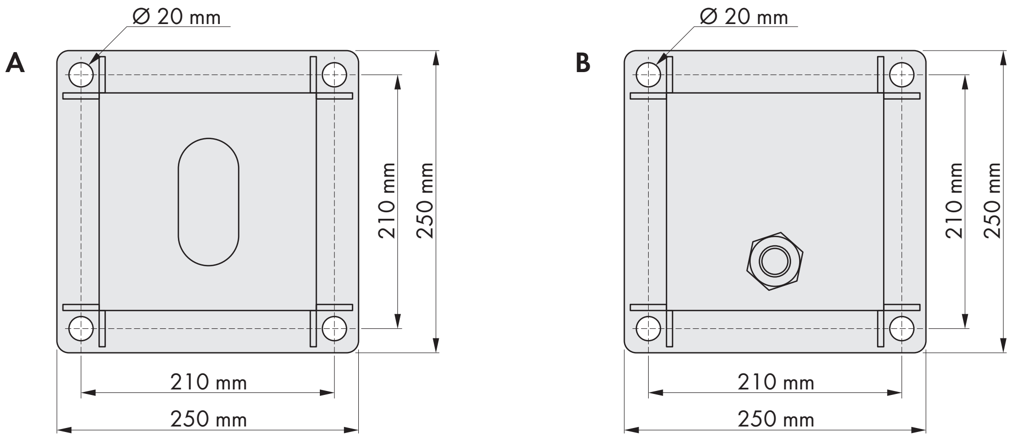


Figure 8: Dimensions of the support feet

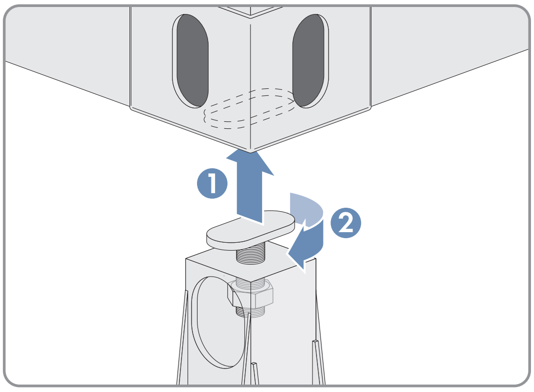
Position	Designation
A	Outer support foot with a height of 365 mm
B	Central support foot with a height of 367 mm

Additionally required mounting material for the attachment of the support feet to the foundation (not included in the scope of delivery):

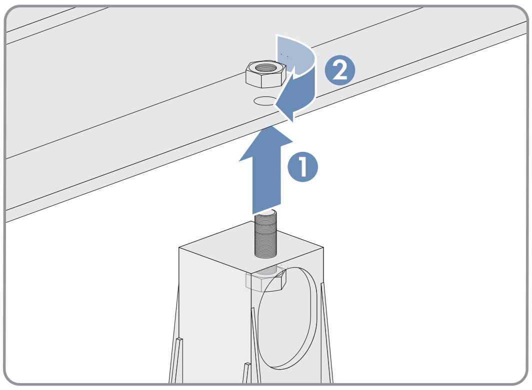
- ☐ Without washers: 24 x screws M16
- ☐ With washers: 24 x screws M12

Mounting the support feet

- The outside support feet are connected to the MV Power Station via a twistlock.



- The central support feet must be fixed to the MV Power Station using nuts. Ensure that the support feet are aligned with their contact surface flush with the MV Power Station. The stud bolt of the central support foot must point outwards.



- Any unevenness of the support surface must be compensated for using base plates.

4 Information for Installation

4.1 Minimum Clearances

Observe the following minimum clearances to ensure trouble-free operation of the MV Power Station. The minimum clearances are required to ensure trouble-free installation of the MV Power Station and easy replacement of the devices (for example, with a forklift) during service and maintenance. In addition, locally applicable regulations must be observed.

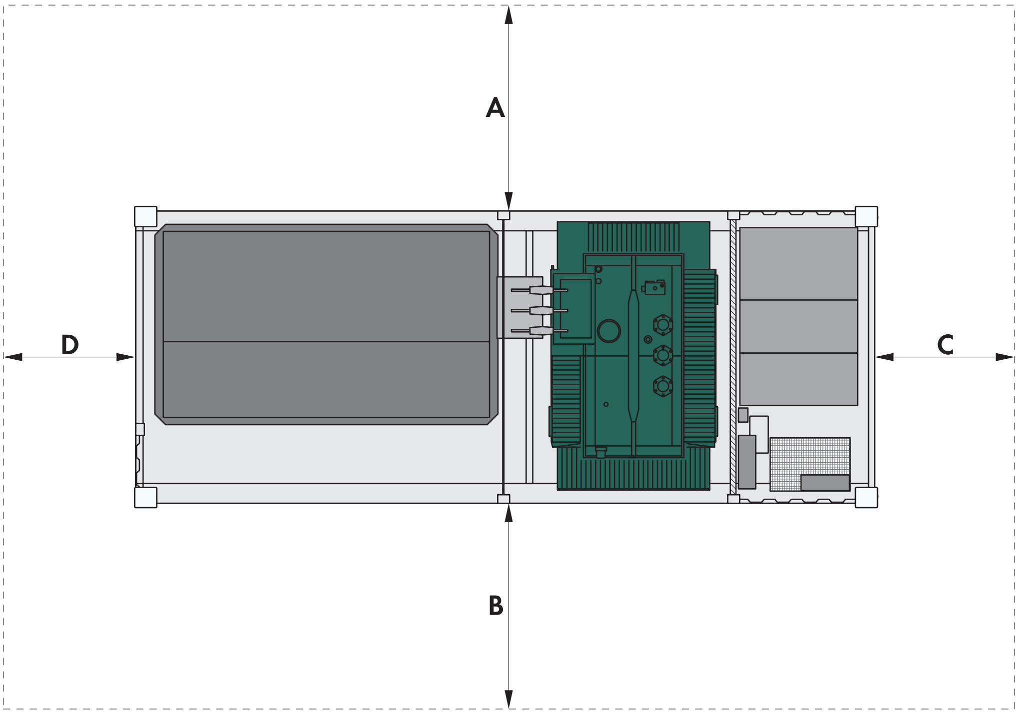


Figure 9: Minimum clearances

	Minimum clearances			
	A	B	C (Medium-voltage side)	D (Inverter side)
Minimum clearances for servicing	6000 mm	3000 mm	3000 mm	3000 mm
Minimum clearances for trouble-free operation	2000 mm			

The service platforms are included in the specification of the minimum clearances.

4.2 Supply Air and Exhaust Air

The standard version of the MV Power Station is suitable for mounting locations with ambient temperatures up to +40°C. Ambient temperatures of up to +50°C are possible if the appropriate order option is selected.

Fresh air is drawn in through the ventilation grids on the DC side of the inverter. The protective roofs must be open to allow the air to circulate unhindered. The MV Power Station must always be operated with open service platforms.

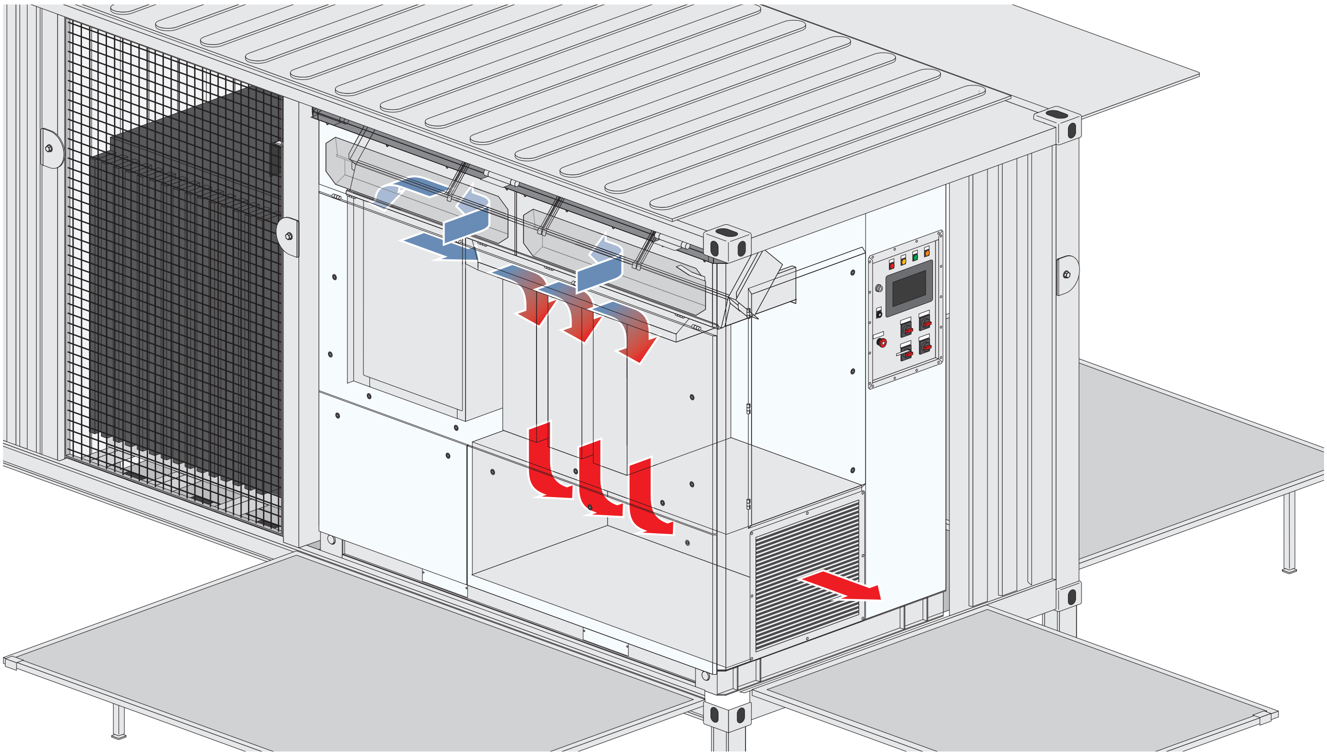


Figure 10: Air circulation principle in the MV Power Station

The inverter in the MV Power Station requires 6500 m^3/h of fresh air. The ambient conditions must comply with classification 4S2. The inverter is protected against salt spray in accordance with IEC 60721-3-4 class 4C2.

The MV Power Station can be installed in chemically active environments, e.g. in coastal areas. In this case, you must select the appropriate order option. This order option provides the MV Power Station with enhanced protection against mechanically and chemically active substances. The ambient conditions must then comply with classifications 4S2 and 4C2. In the standard version, the MV Power Station meets the requirements of the classifications 4S2 and 4C1.

The air quality requirements are given in the following tables.

Air Quality Classification for Mechanically Active Substances

Ambient conditions for stationary application	Class 4S2
a) Sand in air [mg/m^3]	300
b) Dust (suspended matter) [mg/m^3]	5.0
c) Dust (precipitation) [mg/m^3]	20
Installation sites where appropriate measures are taken to keep dust levels to a minimum	x
Installation sites where no special measures have been taken to reduce the sand or dust levels and which are not located in the vicinity of sand or dust sources	x

The air quality must comply with the following classification of air quality for chemically active substances:

Ambient conditions for stationary application	Class 4C1	Class 4C2	
	Limiting value	Mean value	Limiting value
a) Sea salt	–	Occurrence of salt spray	

Ambient conditions for stationary application	Class 4C1	Class 4C2	
	Limiting value	Mean value	Limiting value
b) Sulfur dioxide [mg/m^3]	0.1	0.3	1.0
c) Hydrogen sulfide [mg/m^3]	0.01	0.1	0.5
d) Chlorine [mg/m^3]	0.1	0.1	0.3
e) Hydrogen chloride [mg/m^3]	0.1	0.1	0.5
f) Hydrogen fluoride [mg/m^3]	0.003	0.01	0.03
g) Ammonia [mg/m^3]	0.03	1.0	3.0
h) Ozone [mg/m^3]	0.01	0.05	0.1
i) Nitrogen oxides [mg/m^3]	0.1	0.5	1.0
Installation sites in rural or densely populated areas with little industry and moderate traffic volume	x	x	
Installation sites in densely populated areas with industry and high traffic volume	–	x	

4.3 Installation

4.3.1 Design of the PV System with MV Power Station

Closed electrical operating area

For safety reasons, the PV system with the MV Power Station must be installed in a closed electrical operating area in accordance with IEC 61936-1.

- Ensure that unauthorized persons have no access to the inverter.

4.3.2 Support surface

☐ The support surface must be a dry and solid foundation, e.g. gravel.

☐ In areas subject to strong precipitation or high groundwater levels, a drainage system must be implemented.

☐ The support surface underneath the MV Power Station should be clean and firm to avoid any dust circulation.

4.3.3 Pea gravel ground

The subgrade must meet the following minimum requirements:

☐ The compression ratio of the subgrade must be 98%.

☐ The soil pressure must be 150 kN/m^2.

☐ The unevenness must be less than 0.25%.

☐ For convenient working on the service platforms and trouble-free maintenance, it is recommended to increase the width of the subgrade by 2000 mm on each side for the service platforms or providing a level, paved surface area.

☐ This area must have the following dimensions:

Position	Dimensions
Width	10060 mm
Depth	6440 mm

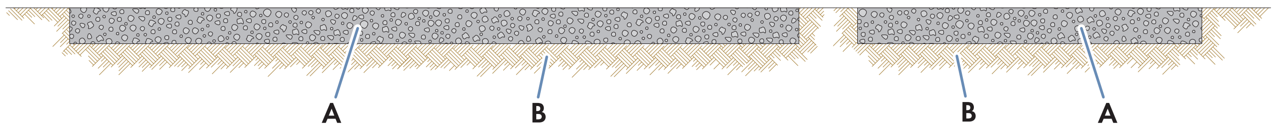


Figure 11: Structure of the support surface

Position	Designation
A	Pea gravel ground as required
B	Solid ground, e.g. gravel

4.3.4 Weight load

The weight load on each of the six support feet of the MV Power Station is 4000 kg.

The installation surfaces (e.g. strip foundations) are to be designed accordingly.

4.3.5 Mounting options

The MV Power Station can be mounted on flagstones, pile-driven steel pillars, concrete pillars, strip foundations or foundation plate. The unevenness must be less than 0.25%.

The type of mounting foundation is the responsibility of the customer.

The service platforms must be taken into account when planning the support surface (see Section 4.3.6, page 24).

4.3.5.1 Flagstones

Recommended dimensions of flagstones: 600 mm x 600 mm x 60 mm (with sufficient stability)

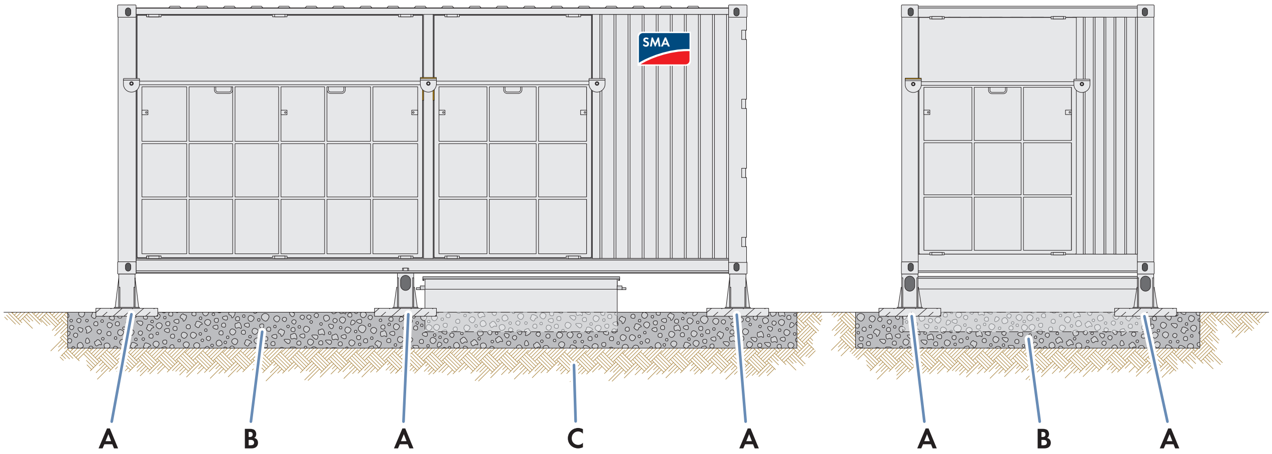


Figure 12: Pea gravel ground and flagstones (example)

Position	Designation
A	Flagstones for weight distribution
B	Pea gravel ground as required
C	Solid ground, e.g. gravel

4.3.5.2 Pile-driven steel pillars

Minimum length of the steel pillars

The steel pillars must be pile-driven into the ground at least to the frost line.

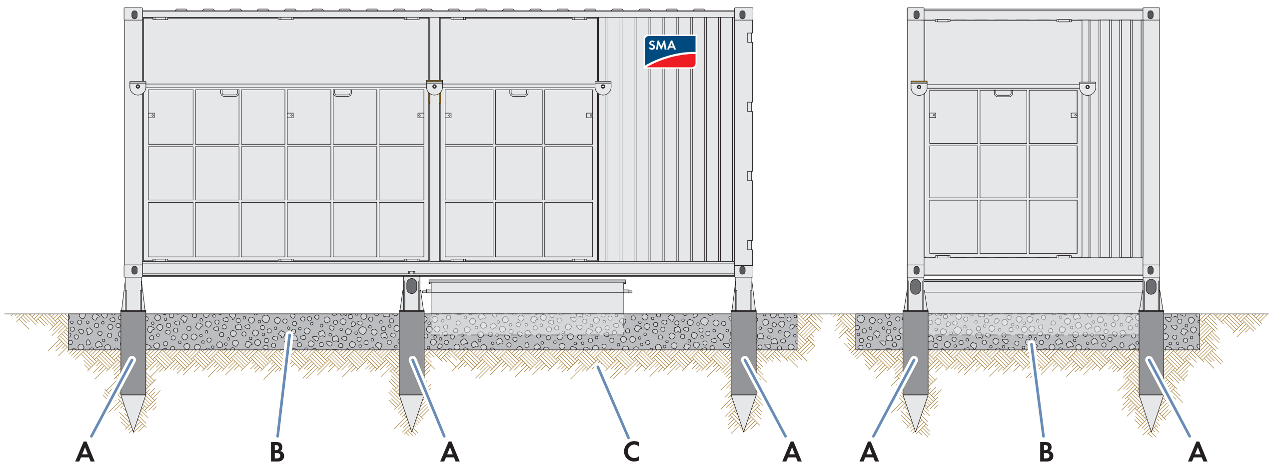


Figure 13: Pile-driven steel pillars (example)

Position	Designation
A	Pile-driven steel pillars
B	Pea gravel ground
C	Solid ground, e.g. gravel

4.3.5.3 Concrete pillar

The concrete pillars must have the following properties:

☐ The concrete pillars must be suitable for the weight of the product.

☐ The concrete pillars must be mounted on solid ground.

☐ The concrete pillars should have the following minimum dimensions:

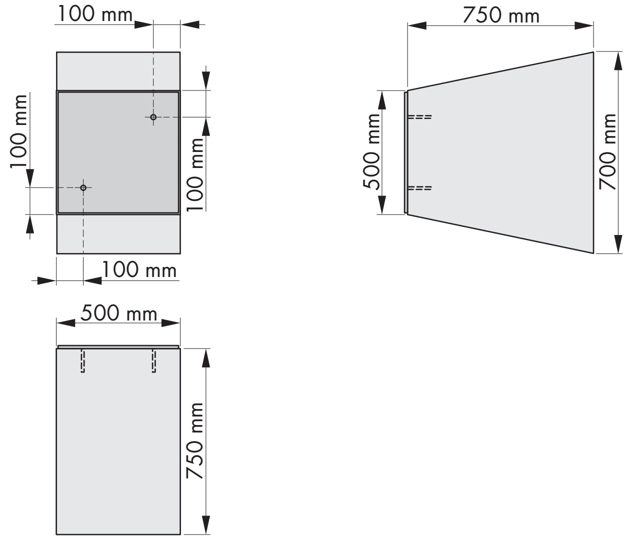


Figure 14: Dimensions of the concrete pillars

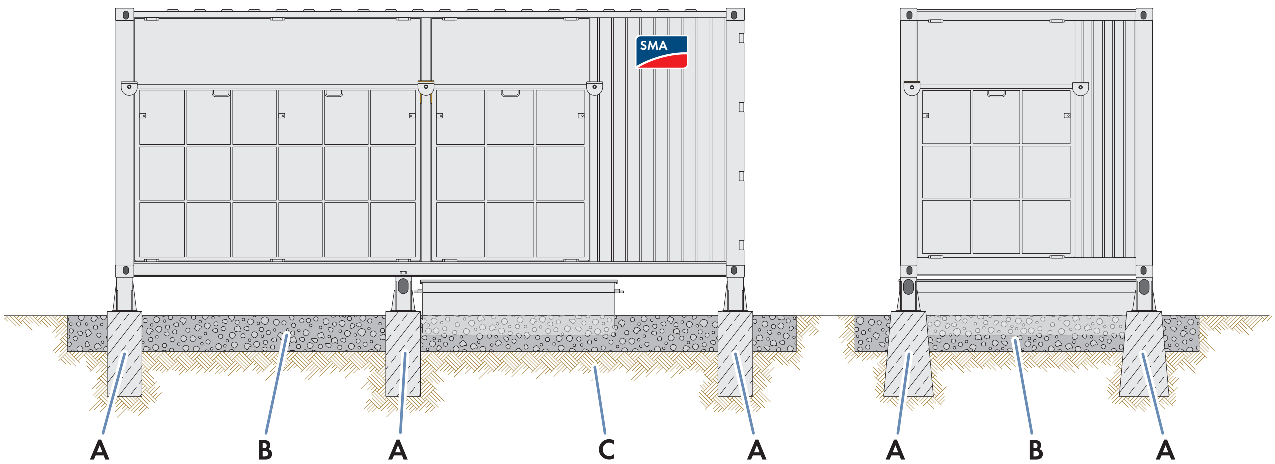


Figure 15: Concrete pillars (example)

Position	Designation
A	Concrete pillar
B	Pea gravel ground
C	Solid ground, e.g. gravel

4.3.5.4 Strip foundations

The strip foundations must have the following properties:

☐ The strip foundations must be suitable for the weight of the product.

☐ The strip foundations must extend at least down to the frost line.

☐ Each strip foundation must have the following width: 500 mm to 600 mm.

☐ The depth of the strip foundation must be at least 200 mm greater on each side than the depth of the container.

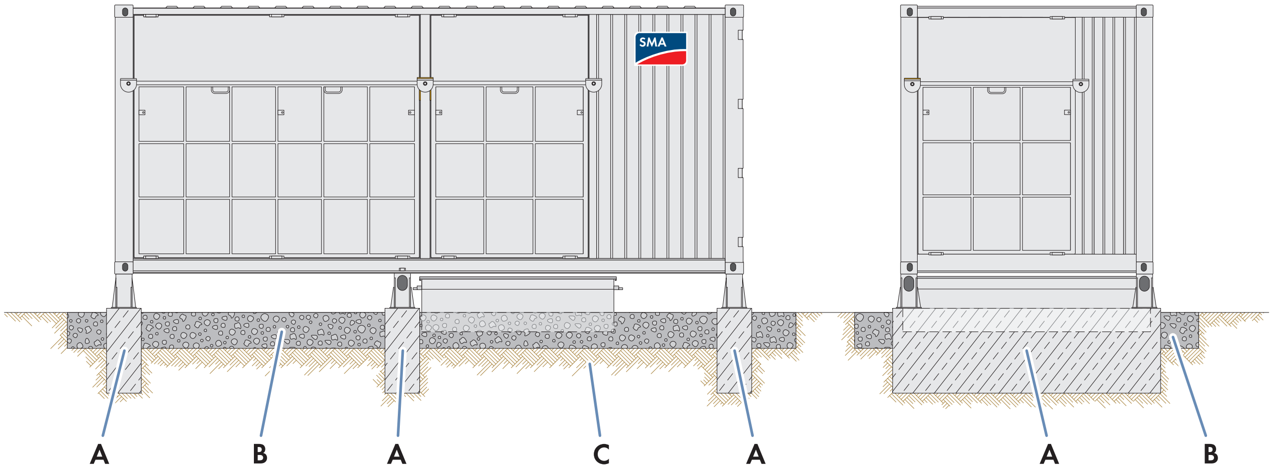


Figure 16: Strip foundations (example)

Position	Designation
A	Strip foundation
B	Pea gravel ground
C	Solid ground, e.g. gravel

4.3.5.5 Foundation plate

The foundation plate must have the following properties:

☐ The foundation plate must be suitable for the weight of the MV Power Station.

☐ The foundation plate must be flush with the ground level. This will facilitate vehicle access to the concrete foundation for device replacement.

☐ The foundation plate must have at least the following dimensions:

Position	Dimensions
Width	10060 mm for foundation including mounting surface for work platforms 6450 mm for foundation of the station container The support surface for the support feet of the work platforms must be constructed separately.
Depth	6440 mm for foundation including mounting surface for work platforms 2850 mm for foundation of the station container The support surface for the support feet of the work platforms must be constructed separately.

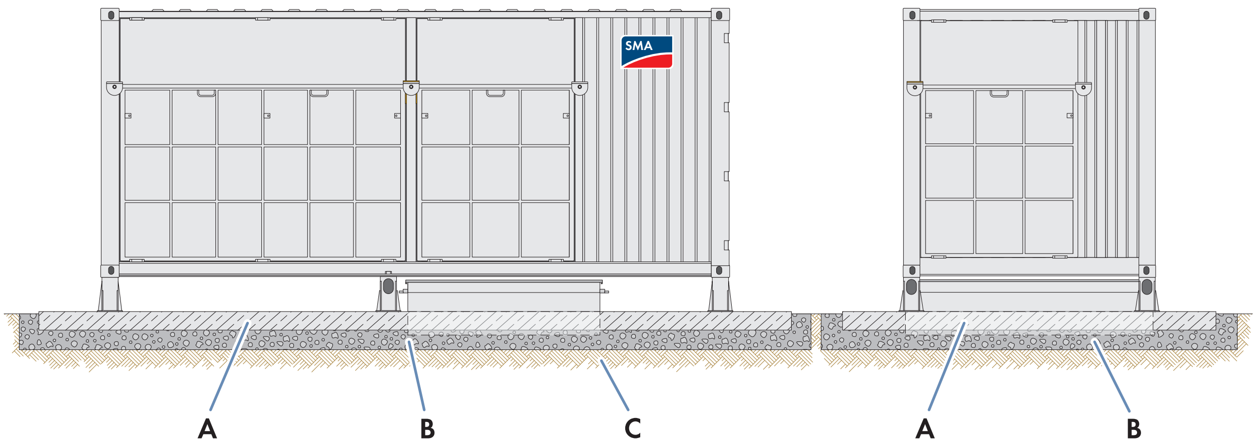


Figure 17: Foundation plate (example)

Position	Designation
A	Foundation plate
B	Pea gravel ground*
C	Solid ground, e.g. gravel

* optional

4.3.6 Erecting the service platforms

Foundation planning must include support surfaces for the feet of the service platforms.

To connect the DC cables, it is necessary to open up and step onto the service platforms. Consequently, it must be possible to erect the service platforms safely and firmly enough to guarantee personal safety when stepping onto the platform.

The weight load for the support feet is 150 kg each. The use of flagstones is recommended for the support surface.

- Recommended dimensions of flagstones: 400 mm x 400 mm x 60 mm

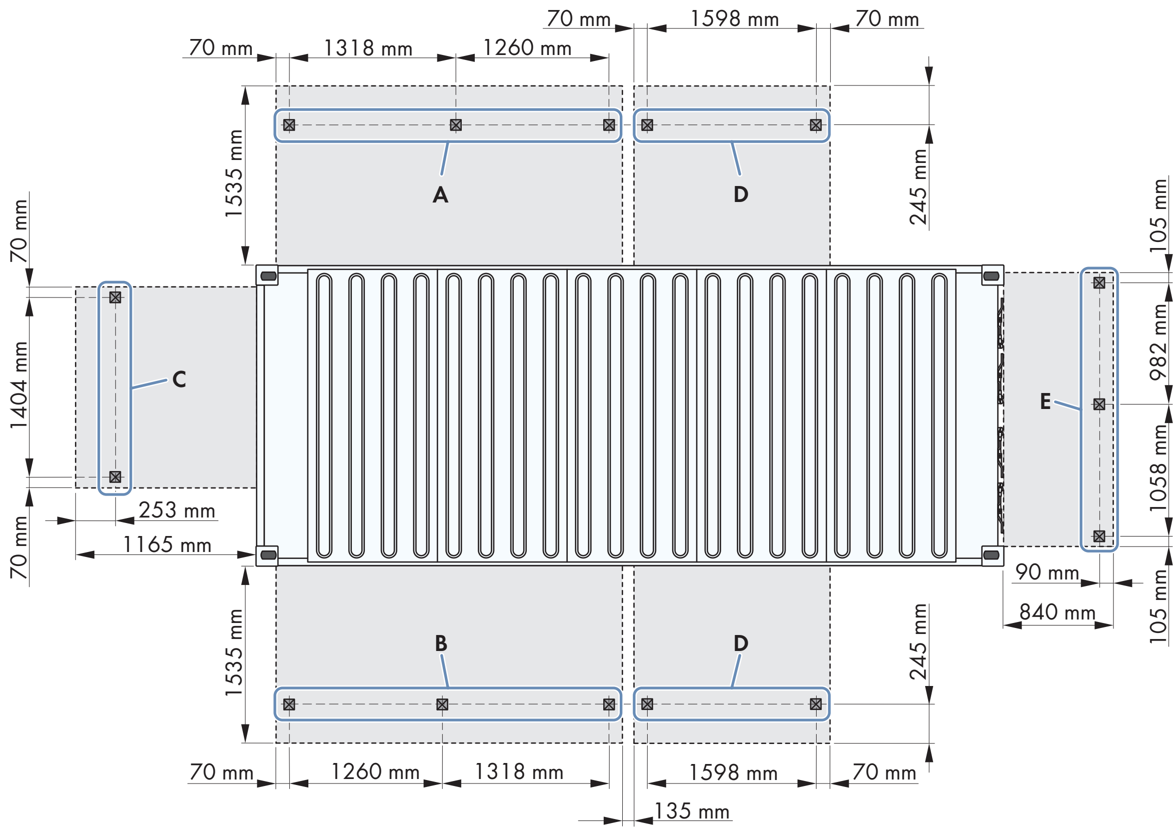


Figure 18: Position of the support feet of the service platforms

Position	Designation
A	Support feet of the service platform in front of the DC side of the inverter
B	Support feet of the service platform in front of the AC side of the inverter
C	Support feet of the service platform in front of the inverter operating elements
D	Support feet of the service platform in front of the MV transformer compartment*
E	Support feet of the service platform in front of the medium-voltage switchgear compartment **

* The protective roof and service platform for the MV transformer are only included if the MV Power Station is ordered with the order option "Sea freight".

** Only folded out temporarily

The service platforms are included in the specification of the minimum clearances.

Observe, during territory planning, that the service platform in front of the inverter operating elements (C) is 100 mm higher than the other service platforms.

Local regulations for hand rails must be observed. Hand rails for the service platforms are not included in the scope of delivery of the product and must be provided on-site.

Open areas below the MV Power Station

The open areas below the MV Power Station must not be blocked by any other installations or groundfill. The only permissible exception is the oil tray. The areas underneath the MV Power Station are needed for pressure dissipation in the event of arc faults.

Disregarding this information can lead to personal injury or device failure. SMA Solar Technology AG does not accept liability for any resulting damage.

4.3.7 Recesses in the foundation for enclosure openings and inspection shaft

Recesses for cable routing must be provided in the support surface. During planning of the recesses in the support surface, the positions of the support feet for the station and the service platforms must be taken into account.

Recesses for the MV Power Station

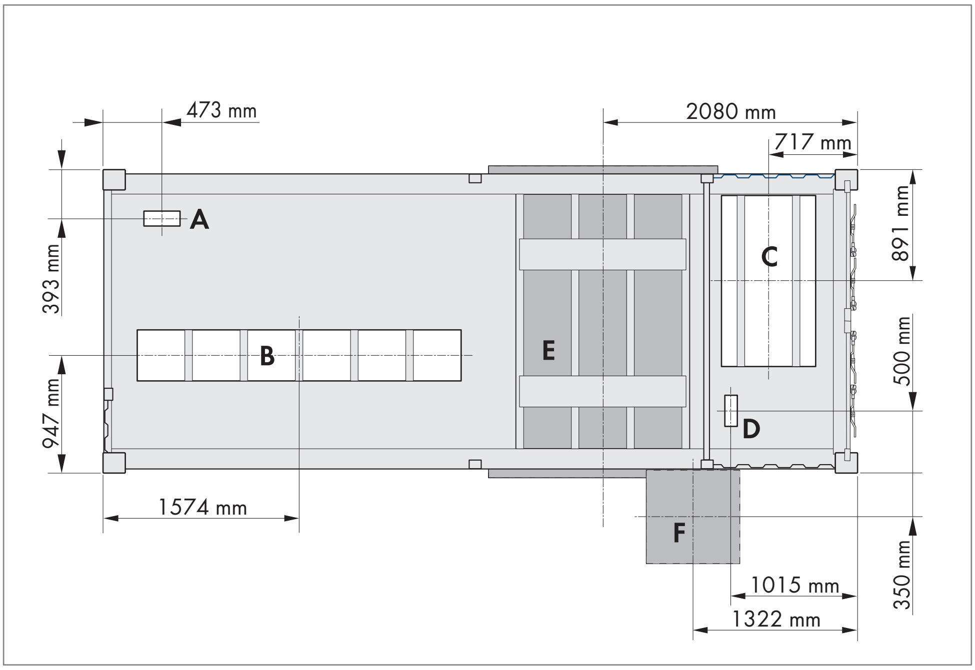


Figure 19: Position and recommended dimensions of recesses with recommended foundation area

Position	Designation	Recommended dimensions Width x depth
A	Recess underneath the inverter for insertion of the following cables: • Cable for analog setpoint • Connecting the cable for remote shutdown • Cable for external insulation monitoring	290 mm x 120 mm
B	Recess underneath the inverter for insertion of the DC cables	2600 mm x 410 mm
C	Recess underneath the medium-voltage switchgear for the insertion of the AC cables: • Maximum 6 cables per cable panel • Maximum cable diameter: 55 mm	With a 24 kV MV switchgear: 714 mm x 1050 mm With a 36 kV MV switchgear: 765 mm x 1375 mm
D	Recess for insertion of the data cables and grounding cables: • 3 x PG9 for cable diameters from 6 mm to 8 mm • 3 x PG11 for cable diameters from 8 mm to 10.5 mm • 4 x PG16 for cable diameters from 13 mm to 16 mm • 4 x PG21 for cable diameters from 17 mm to 20 mm	100 mm x 250 mm
E	Recess underneath the transformer compartment for oil tray	1960 mm x 2500 mm*
F	Inspection shaft for oil drain valve	750 mm x 750 mm*

* Only with the order option "oil tray"

4.4 Oil Tray

The oil tray collects any oil which may leak from the MV transformer.

Depending on the regulations and directives applicable at the mounting location, an oil tray may be required for the MV Power Station. The oil tray for the MV Power Station can be ordered from SMA.

The oil tray is stored in the inverter compartment during transportation.

Oil tray design

The oil tray must be positioned underneath the transformer compartment. The oil tray should be fitted with theft protection.

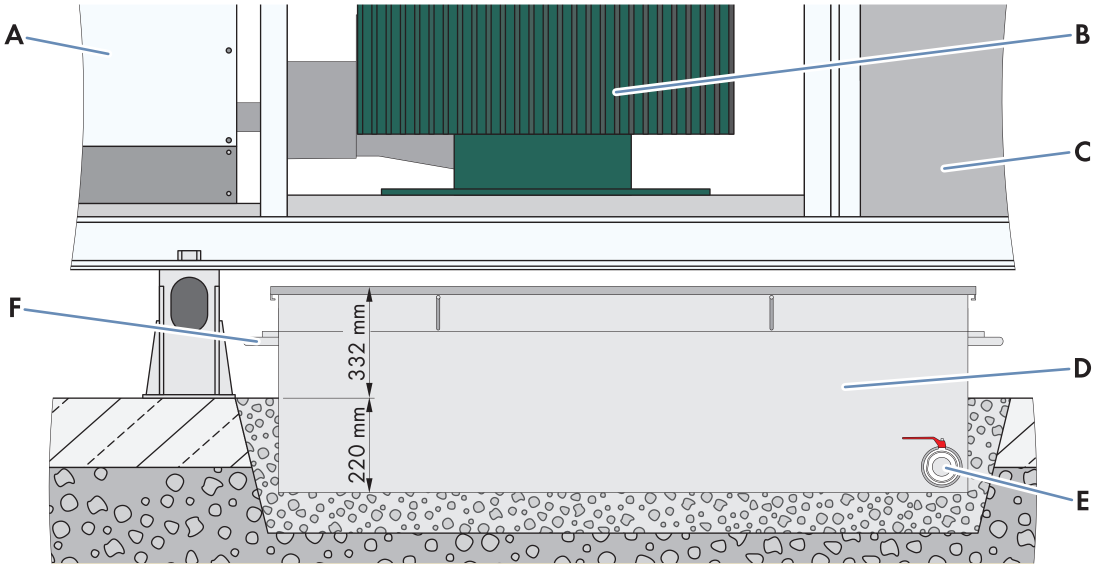


Figure 20: Oil tray for the MV Power Station

Position	Designation
A	Inverter
B	MV transformer
C	Medium-voltage switchgear
D	Oil tray with four oil separators
E	Oil drain valve (2")
F	Grounding bolt of the oil tray (diameter: 8 mm)

Dimensions and weight of the oil tray

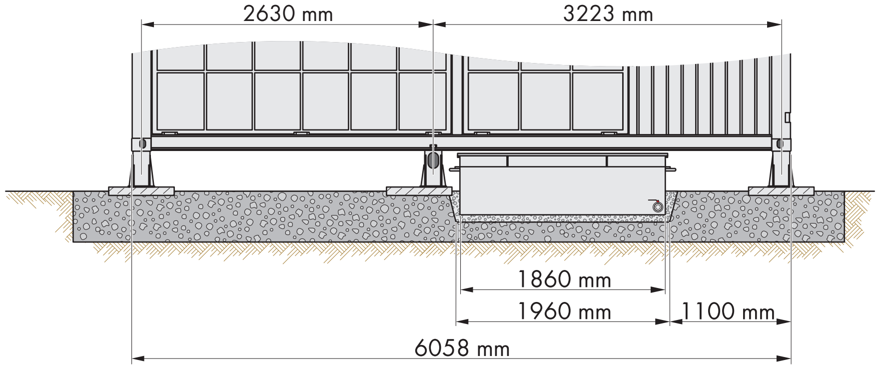


Figure 21: Position of the oil tray (example)

Width	Height	Depth	Weight
1860 mm	> 552 mm*	2400 mm	160 kg

* The height of the oil tray can be adjusted.

5 Installation Information

5.1 Communication, Control, Supply Voltage and Monitoring

5.1.1 Feedback DC Switch

5.1.1.1 Mode of Operation of the Feedback DC Switch

The inverter comes equipped with a switching status indicator of the DC switch at terminal **-X416**. The switching status of the DC switch for applications provided by the customer can be displayed via this terminal.

5.1.1.2 Terminal Assignment of the Feedback DC Switch

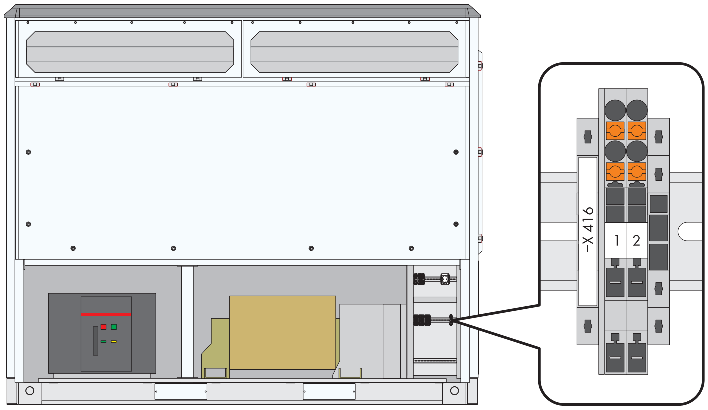


Figure 22: Position of the connecting terminal plate for the switching-state light repeater of the DC switch

Cable requirements:

☐ Multi-wire cable with bootlace ferrules: 2.5 mm^2

☐ Single-wire cable: 4 mm^2

☐ Number of conductors: 2

5.1.2 External Fast Stop Function

5.1.2.1 Mode of Operation of the External Fast Stop

The inverter comes equipped with a fast stop input at terminal **-X440:1.3**.

The following options are available for configuring the external fast stop:

- **External fast stop is deactivated**

  The terminals of the active fast stop are bridged. The fast stop function is thus deactivated. The terminals were bridged during production.

- **External fast stop is operated with internal or external 24 V supply**

  An external switch (break contact) is connected to the inverter terminals via the internal supply voltage or the external 24 V supply of the inverter. When the switch is closed, the relay is activated and the inverter feeds into the grid. If the fast stop is tripped, the switch opens and the relay is deactivated. The inverter is stopped and no longer feeds into the utility grid.

If the external fast stop is tripped, the AC disconnection and the DC switchgear are opened. The external fast stop does not result in rapid discharge of the capacitors.

Tripping the fast stop

The fast stop should only be tripped in case of imminent danger. Tripping of the fast stop does not entail fast discharge of the capacitors. If the inverter is to be switched off and properly shut down via an external signal, the remote shutdown input is to be used.

5.1.2.2 Terminal Assignment of the External Fast Stop Function

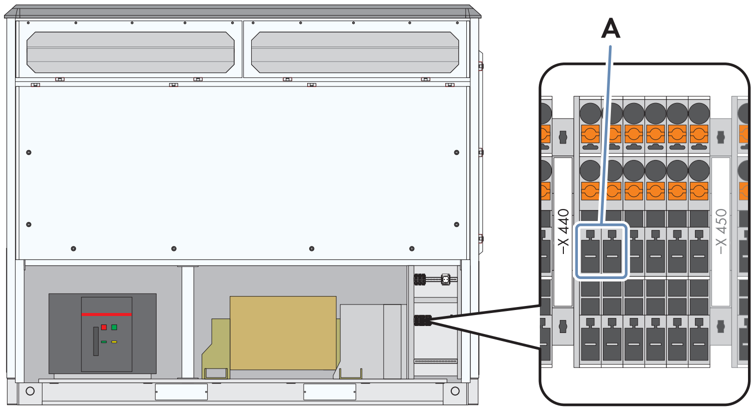


Figure 23: Position of the connecting terminal plate for external fast stop function

Position	Designation
A	Connecting terminal plate

Cable requirements:

- ☐ Multi-wire cable with bootlace ferrules: 2.5 mm^2
- ☐ Single-wire cable: 4 mm^2
- ☐ Number of conductors: 2

5.1.3 External Standby

5.1.3.1 Mode of Operation of the External Standby

The inverter comes equipped with an external standby input at terminal **-X440:5.7**.

This function lets you switch the inverter to the "Standby" operating state from a control room, for example. The AC disconnection unit and the DC switchgear of the inverter remain closed. This makes a fast switch to the operating state "GridFeed" possible if the standby signal has been reset.

The external standby is designed as an open-circuit fail-safe function and must be connected to an external 24 V supply voltage. If 24 V is present at the external standby, the inverter continues to operate in the current operating state. If the external standby is tripped or if a wire-break occurs, 0 V is present at terminal **-X440:5.7** and the inverter switches from the current operating state to the operating state "Standby".

5.1.3.2 Terminal Assignment of the External Standby

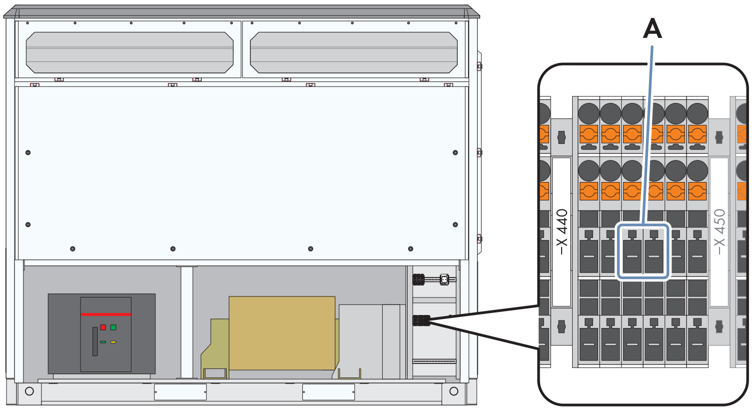


Figure 24: Position of the connecting terminal plate for external standby

Position	Designation
A	Connecting terminal plate

Cable requirements:

- ☐ Multi-wire cable with bootlace ferrules: 2.5 mm^2
- ☐ Single-wire cable: 4 mm^2
- ☐ Number of conductors: 2

5.1.4 Communication

5.1.4.1 Communication Network in the Customer Communication System

If the inverter does not contain a managed switch, the inverter can be integrated in a PV system with single feeders.

Figure 25: Inverter without managed switch

If the inverter without managed switch is to be integrated in a customer communication system, a switch can be installed in the customer installation location.

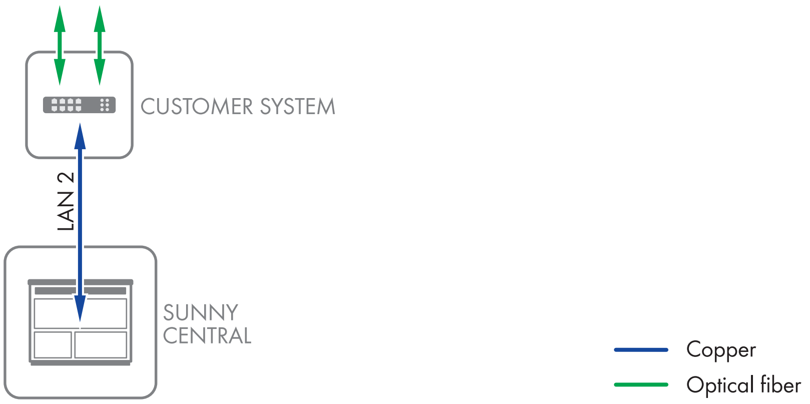


Figure 26: Inverter with customer communication system

In order to guarantee the implementation of control commands, the network that manages the control should be kept free from applications with a high network load, e.g. webcams. Using a separate network is recommended to implement data-heavy applications.

For a stable transmission of Modbus protocols, the frequency of the Modbus requests may not exceed 1/100 ms.

5.1.4.2 Communication Network in Cluster Ring with One Managed Switch

To set up a redundant network with several devices, a managed switch must be present in the inverter.

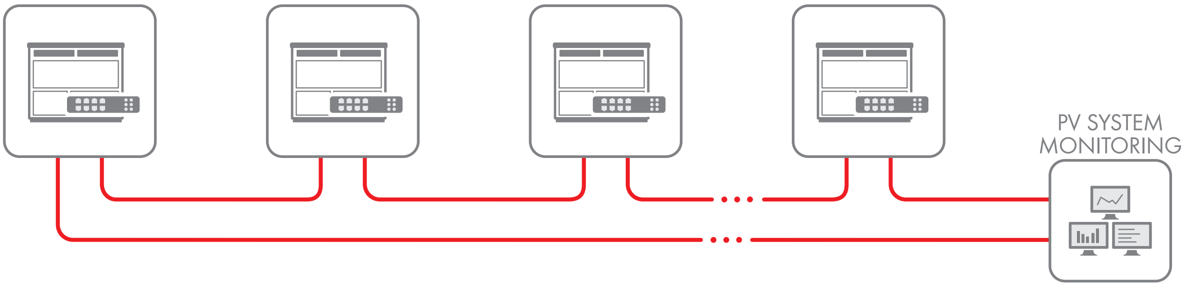


Figure 27: Inverter in cluster ring

The managed switch provides the option to set up a network with optical fibers via LAN 2 and to connect a customer communication system to the terminal **LAN 2 Port 4**. A connection of two ports of the managed switch to a splice box has been factory-set internally to which two optical fibers can be connected for the communication system A.

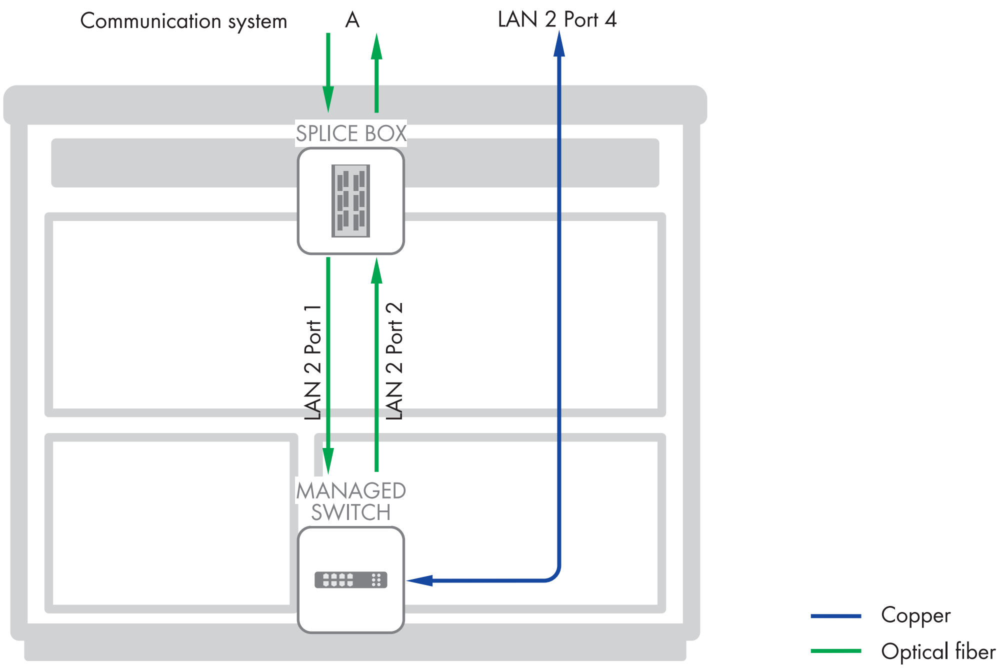


Figure 28: Inverter with one managed switch

In order to guarantee the implementation of control commands, the network that manages the control should be kept free from applications with a high network load, e.g. webcams. Using a separate network is recommended to implement data-heavy applications.

For a stable transmission of Modbus protocols, the frequency of the Modbus requests may not exceed 1/100 ms.

5.1.4.3 Communication Network in Backbone Ring with Two Managed Switches

To ensure a safe and fast system network in large-scale PV power plants, it is recommended to set up the system network with a ring coupling. Several cluster rings are coupled to a backbone ring.

In the cluster ring, ports 1 and 2 must be connected in each case. One of the managed switches in the cluster ring must be set up as the ring manager which controls the direction of the data flow. We recommend that the managed switch at the coupling point assumes this task.

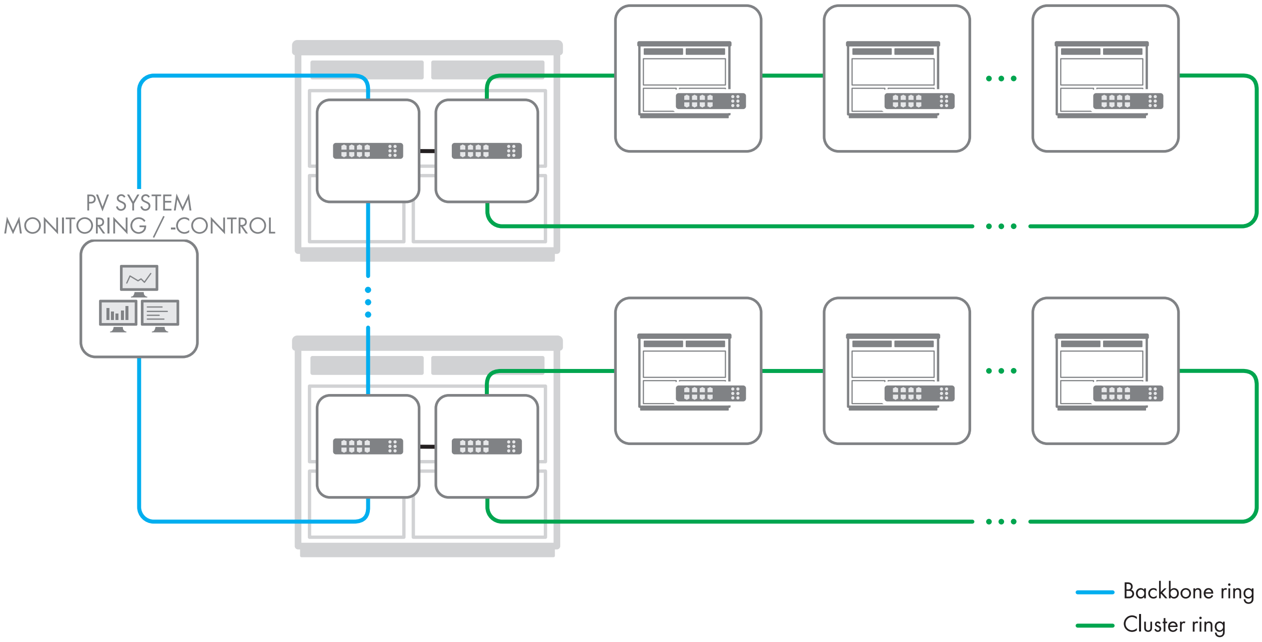


Figure 29: Communication network with backbone ring and cluster ring

The inverters at the coupling points must each contain two managed switches: one switch for the cluster ring in communication network A and one switch for the backbone ring in communication network B. These two managed switches have been connected internally ex works with a splice box to which two optical fibers can be connected for each communication network. In addition, a customer communication system can be connected to terminal **LAN 2 Port 4** of the managed switch of the cluster ring.

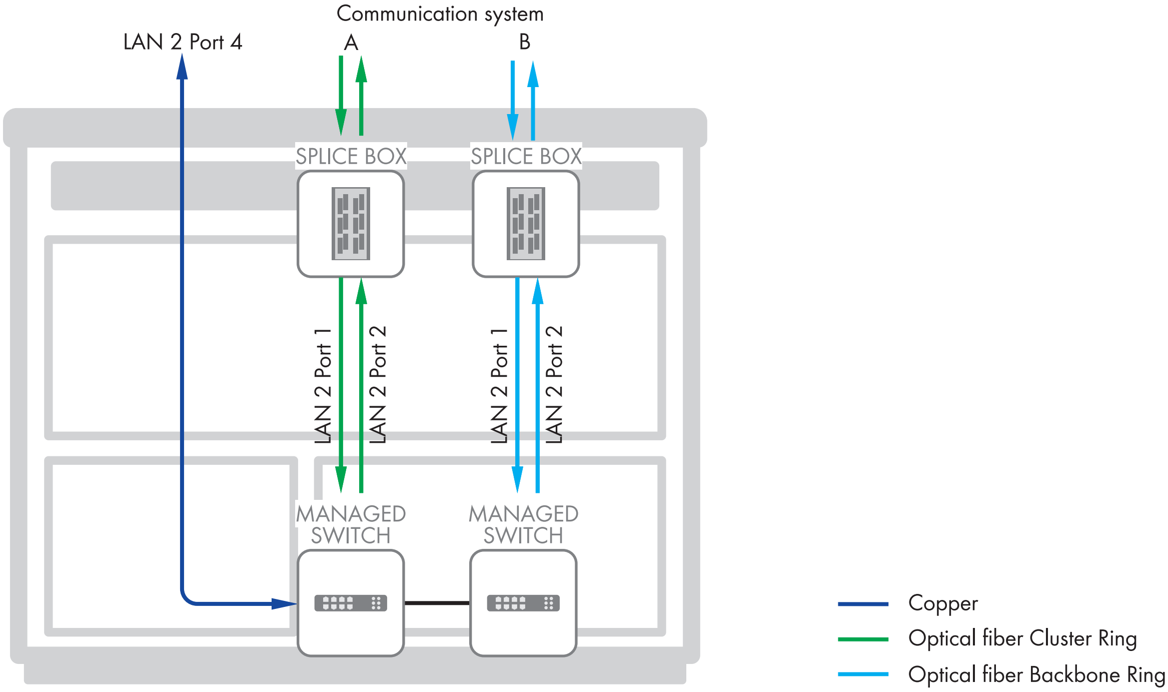


Figure 30: Inverter with two managed switches

In order to guarantee the implementation of control commands, the network that manages the control should be kept free from applications with a high network load, e.g. webcams. Using a separate network is recommended to implement data-heavy applications.

For a stable transmission of Modbus protocols, the frequency of the Modbus requests may not exceed 1/100 ms.

5.1.4.4 Terminal Assignment of Communication

Communication via Optical Fiber Cluster Ring

The following contents are only part of the product if one of the following options was selected:

- Communication System A: Managed Switch MMF
- Communication System A: Managed Switch SMF

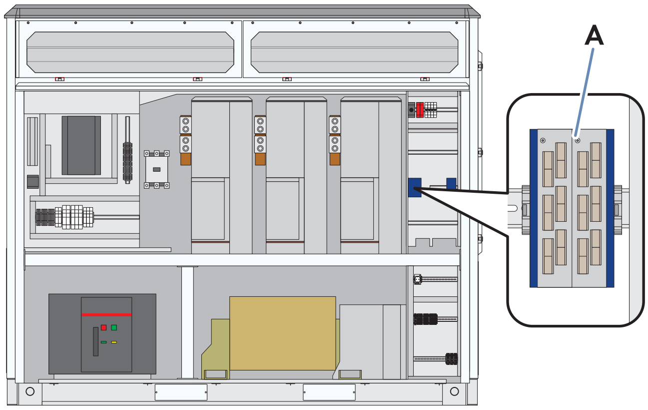


Figure 31: Position of the splice box of communication via optical fiber ring

Position	Designation
A	Splice box

Communication via Optical Fiber Backbone Ring

The following contents are only part of the product if one of the following options was selected:

- Communication System B: Managed Switch MMF Backbone
- Communication System B: Managed Switch SMF Backbone

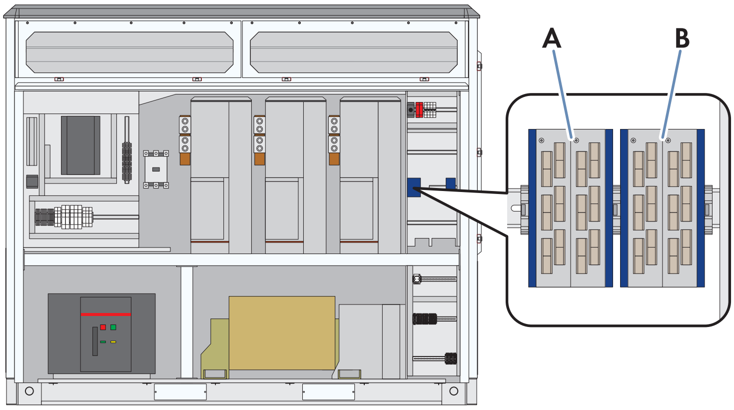


Figure 32: Position of the splice box of the communication via optical fiber backbone ring

Position	Designation
A	Splice box for the cluster ring
B	Splice box for the backbone ring

Optical fiber requirements in single mode:

☐ 9/125 µm

☐ Category: OS2

☐ Plug: SC SMF

Optical fiber requirements in multi mode:

☐ 50/125 µm

☐ Category: OM2

☐ Plug: SC MMF

Communication System A: Customer Communication System via Ethernet Interface

Communication System A: Customer communication system via Ethernet interface (see Section 5.2.1, page 38).

5.1.5 External Setpoint of Active Power

5.1.5.1 Mode of Operation of the External Setpoint of the Active Power

The inverter comes equipped with an input for the external setpoint of the active power at terminal **-X740:1.3**. Standard signals can be processed in the inverter from 4 mA to 20 mA.

Depending on the selected procedure for active power reduction, the applied signal is converted to a setpoint for active power according to a characteristic curve.

5.1.5.2 Terminal Assignment of the External Setpoint of the Active Power

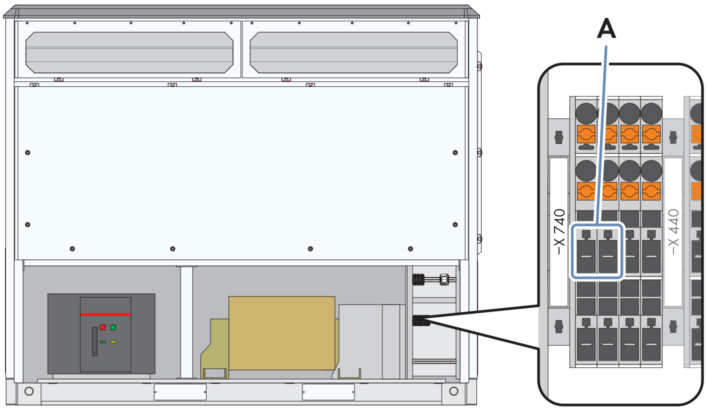


Figure 33: Position of the connecting terminal plate for external setpoint of active power limitation

Position	Designation
A	Connecting terminal plate

Cable requirements:

- ☐ Multi-wire cable with bootlace ferrules: 2.5 mm²
- ☐ Single-wire cable: 4 mm²
- ☐ Number of conductors: 2

5.1.6 External Setpoint of Reactive Power

5.1.6.1 Mode of Operation of the External Setpoint of Reactive Power

The inverter comes equipped with an input for the external setpoint of the active power at terminal **-X740:5.7**. Standard signals can be processed in the inverter from 4 mA to 20 mA.

Depending on the selected procedure for reactive power regulation, the applied signal is converted to setpoints for reactive power or displacement power factors according to a characteristic curve.

5.1.6.2 Terminal Assignment of the External Setpoint of Reactive Power

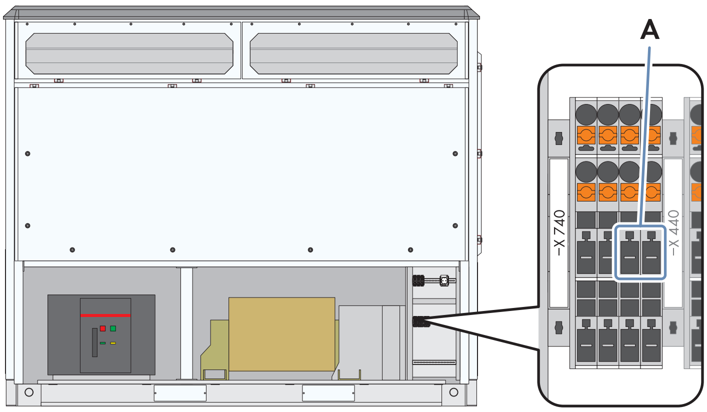


Figure 34: Position of the connecting terminal plate for external setpoint of reactive power control

Position	Designation
A	Connecting terminal plate

Cable requirements:

☐ Multi-wire cable with bootlace ferrules: 2.5 mm^2

☐ Single-wire cable: 4 mm^2

☐ Number of conductors: 2

5.2 Customer Devices

5.2.1 Customer Installation Location

5.2.1.1 Description of Customer Installation Location

The customer installation location can be used to install further devices necessary for your PV power plant (e.g. another managed switch) in the inverter. Customer devices can be connected to connecting terminal plate **-X310** and must meet the connection requirements.

For the connection of customer communication devices, the Ethernet interface **LAN 2 port 4** can be used with the option "Communication system A: Customer communication system".

5.2.1.2 Terminal Assignment of the Customer Installation Location

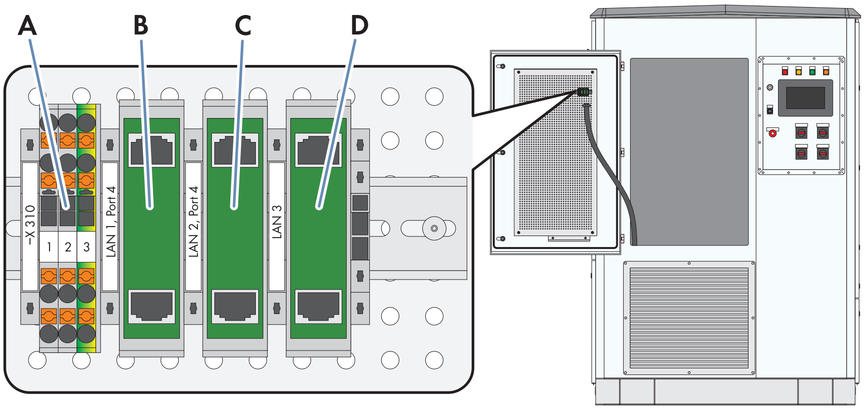


Figure 35: Position of the connections at the customer installation location

Position	Designation
A	Connecting terminal plate for voltage supply at customer installation location **-X310**
B	Internal Ethernet interface for customer connections **LAN 1 Port 4**
C	Ethernet interface for connecting customer communication devices **LAN 2 Port 4***
D	Ethernet interface for customer applications **LAN 3**

* Only for option: Communication System A: Customer Communication System Present

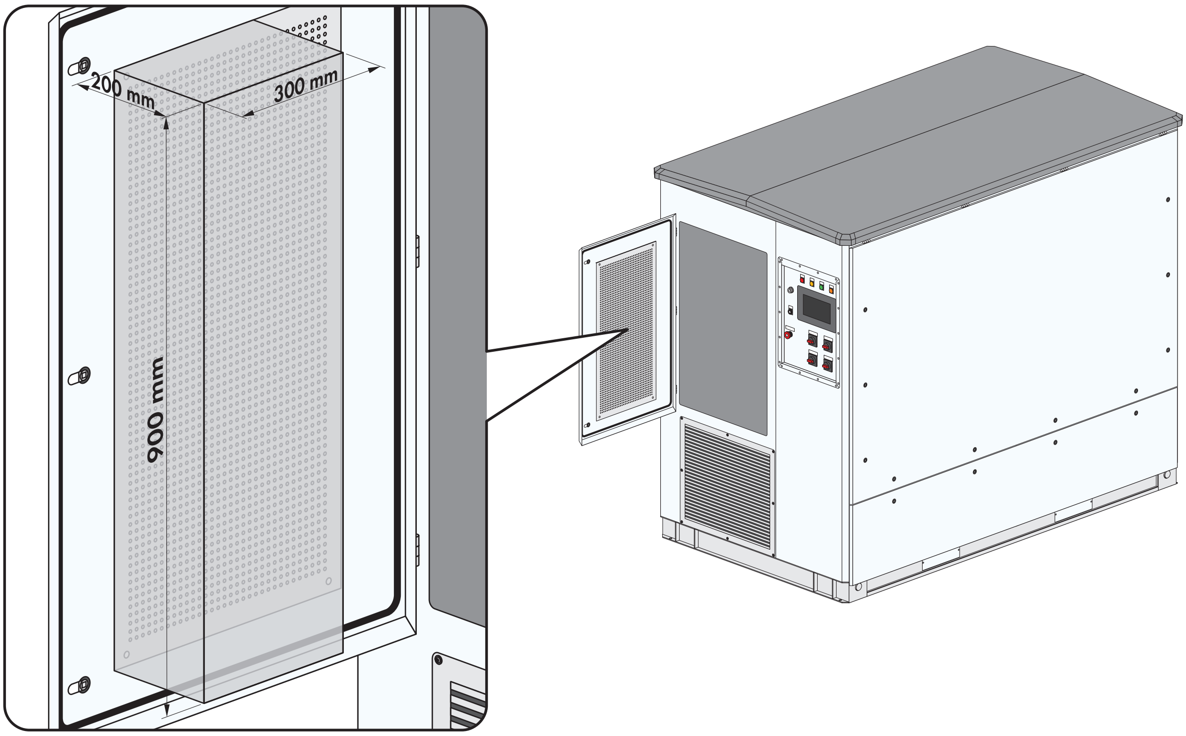


Figure 36: Area for customer devices in the customer installation location

Connecting terminal plate for voltage supply at customer installation slot -X310

Requirements for the Connection of Customer Devices:

- ☐ The total maximum power consumption of all customer devices at connecting terminal plate **-X310** must not be exceeded. The maximum continuous power consumption is: 300 VA.
  To ensure a higher power consumption, you can select the option Auxiliary supply for external loads (see Section 5.2.2, page 40).
- ☐ The customer devices must be designed for the permissible voltage. The permissible voltage is: 230 V.
- ☐ Voltage fluctuations that occur at the grid-connection point are transmitted to connecting terminal plate **-X310** in the same proportion. The customer devices must be designed for these voltage fluctuations.
- ☐ The total weight of all customer devices may not be exceeded. The total weight is: 20 kg.
- ☐ Customer devices may be mounted on the mounting plate. An area of 300 mm x 900 mm x 200 mm is available for this. The area may not be exceeded.
- ☐ The customer devices must be designed for a temperature of 60 °C in normal operation.

Cable requirements:

- ☐ Multi-wire cable with bootlace ferrules: 2.5 mm²
- ☐ Single-wire cable: 4 mm²
- ☐ Number of conductors: 3

Ethernet interface for connecting customer communication devices LAN 2 Port 4

Requirements for cable routing:

- ☐ Data cables must be laid in a conduit or cable channel. This prevents crushing or squeezing of the cables.

Ethernet cable requirements:

- ☐ The cable must be shielded.

☐ The insulated conductors must be pair-twisted.

☐ The cable must be at least of category 5 (CAT 5).

Requirements for wired communication:

☐ In case of wired communication, an overvoltage protection for the data cables must be provided.

5.2.2 Auxiliary Voltage Supply for External Loads

5.2.2.1 Description of the Auxiliary Voltage Supply for External Loads

With the options Auxiliary supply for external loads: 2.5 kVA / 230 V and Auxiliary supply for external loads: 2.5 kVA / 120 V, the inverter is equipped ex works with terminals for connecting external loads. Customer devices can be connected to the connecting terminal plate **-X371** to **-X373** with a wired connection. External loads can be connected via a Schuko socket-outlet to outlet **-X374**.

5.2.2.2 Terminal Assignment of the Auxiliary Voltage Supply for External Loads

The following contents are only part of the product if one of the following options was selected:

- "Additional supply for external loads: 2.5 kVA / 230 V"
- "Additional supply for external loads: 2.5 kVA / 120 V"

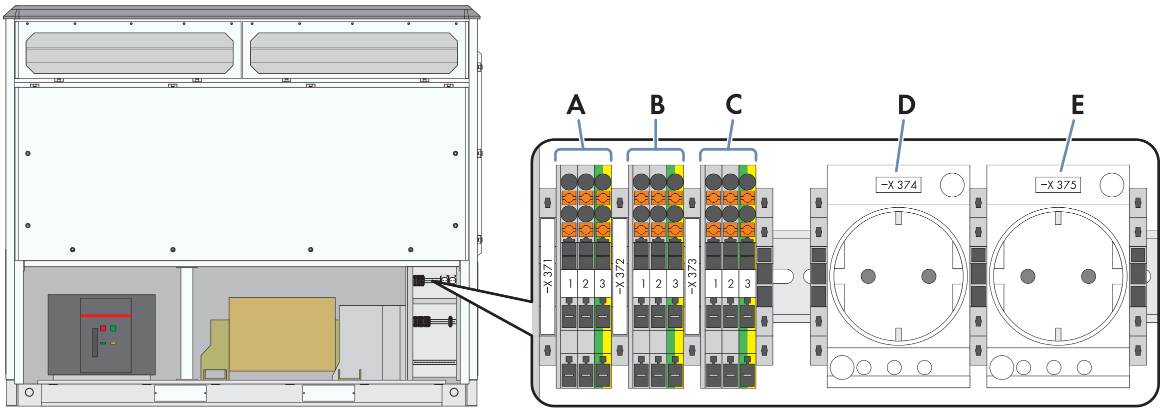


Figure 37: Position of the connecting terminal plates and the outlet for external loads

Position	Designation
A	Connecting terminal plate **-X371**
B	Connecting terminal plate **-X372**
C	Connecting terminal plate **-X373**
D	Outlet **-X374**
E	Outlet **-X375**

Requirements for the connection of customer devices to the outlets -X374 and -X375:

☐ The total maximum power consumption of all customer devices at both outlets must not be exceeded. The maximum continuous power consumption is: 1440 VA.

☐ The customer devices must be designed for the permissible voltage. The permissible voltage is: 230 V.

☐ The customer devices muss be suitable for the connection to the circuit breaker. The type of the circuit breaker is: B16 A.

Requirements for the connection of customer devices to the connecting terminal plate -X371 to -X373:

☐ The total maximum power consumption of all customer devices at the connecting terminal plates must not be exceeded. The maximum continuous power consumption for every single connecting terminal plate is: 350 VA.

☐ The customer devices must be designed for the permissible voltage. The permissible voltage is: 230 V.

☐ The customer devices muss be suitable for the connection to the circuit breaker. The type of the circuit breaker is: B16 A.

Requirements for cable routing:

☐ Data cables must be laid in a conduit or cable channel. This prevents crushing or squeezing of the cables.

Cable requirements:

☐ Multi-wire cable with bootlace ferrules: 2.5 mm^2

☐ Single-wire cable: 4 mm^2

☐ Number of conductors: 3

5.3 Grounding

5.3.1 Grounding Concept

In accordance with the latest technology, the inverters are discharged to ground. As a result, leakage currents to ground occur which must be taken into account when planning the PV power plant. The magnitude and distribution of such leakage currents is influenced by the grounding concept of all devices in the PV power plant. It is recommend that optical fiber technology is used for the transmission of signals, for example, when using cameras and monitoring equipment. This will counteract possible interference sources.

The recommended grounding of inverter and MV transformer in meshed design reduces leakage current levels.

Grounding of the oil tray must be carried out during installation. The two grounding bolts located on the left side of the oil tray can be used for this.

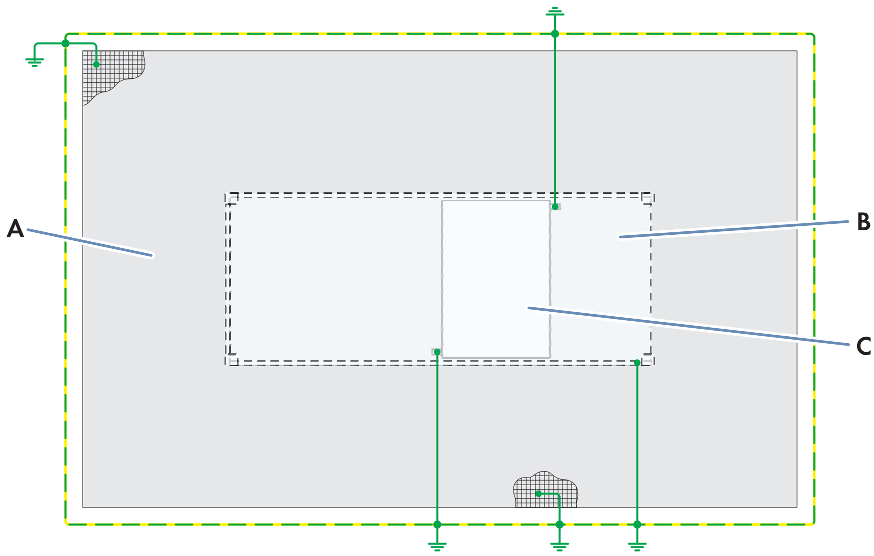


Figure 38: Grounding of the concrete foundation (example)

Position	Designation
A	Concrete foundation
B	MV Power Station
C	Oil tray

Double grounding of the MV Power Station

We recommend that the grounding concept provides for double grounding of the MV Power Station.

Tripping time of the circuit breaker panel

The grounding inside the MV Power Station is laid out in such a way that the tripping time of the circuit breaker panel is less than 170 ms in the event of a short circuit. The protection device must be configured accordingly. SMA Solar Technology AG recommends to set the parameter for the tripping time **t>>** to 40 ms.

5.3.2 Requirements for the Grounding Arrangement

Cable Requirements for the Grounding Connection:

- ☐ All cables must be suitable for temperatures of up +90°C and must be in accordance with the national standards and directives.
- ☐ Use copper or aluminum cables only.
- ☐ The cable cross-sections of the grounding conductor connections depend on the installed overcurrent protective device. Calculating the required cross-sections depends on the national standards and directives.
- ☐ Connect a maximum of two grounding cables to the grounding connection.
- ☐ The grounding of the PV system must be designed in accordance with the national standards and directives and is the responsibility of the installer.

Requirements for the cable connection with terminal lugs:

- ☐ All terminal lugs used must comply with the national standards and directives.
- ☐ The width of the terminal lugs must exceed the washer diameter. This will ensure that the specified torques are effective over the whole surface.
- ☐ Use only tin-plated terminal lugs made from copper or aluminum.
- ☐ The specified torques must always be complied with.

Requirements for the Grounding Arrangement Design:

- ☐ The recommended grounding of inverter and MV transformer in meshed design reduces leakage current levels as well as the interference in the medium-wave and long-wave band.
- ☐ The connection of the grounding arrangement must be made with at least one grounding conductor on the equipotential bonding rail in the medium-voltage compartment.
- ☐ Use copper or aluminum cables only.
- ☐ The cable cross-sections of the grounding depend on the installed overcurrent protective device. Calculating the required cross-sections depends on the national standards and directives. The following cable cross-sections are recommended:
  For copper cable, at least: 240 mm^2
  For aluminum cable, at least: 400 mm^2
- ☐ Cable cross-section for the grounding of the oil tray: 50 mm^2

5.4 DC Connection

5.4.1 Requirements for the Cables and Terminal Lugs for the DC Connection

Cable requirements for the DC connection:

- ☐ Maximum cable cross-section per DC input:2 x 400 mm^2.
- ☐ Use copper or aluminum cables only.
- ☐ The dielectric strength must be dimensioned for the maximum DC voltage.
  - Minimum dielectric strength for Sunny Central 2200: 1100 V

– Minimum dielectric strength for Sunny Central 2500-EV: 1500 V

☐ The ampacity of the DC cables must be calculated according to IEC 60287. The maximum occurring string current must not exceed the ampacity of the DC cables.

Cable requirements for the cable connection with terminal lugs:

☐ All terminal lugs used must have a valid approval.

☐ The terminal lugs must be fastened with two securement holes (diameter: 13 mm). A minimum clearance of 44 mm must be maintained between the holes.

☐ Both holes have to be utilized in installation.

☐ The terminal lug width must be larger than the diameter of the washers (32 mm). This will ensure that the specified torques are effective over the whole surface.

☐ Use only tin-plated terminal lugs made from copper or aluminum.

☐ Only use screws, nuts and washers included in the scope of delivery.

☐ The specified torques must always be complied with.

Requirements for laying in conduits:

☐ If conduits are used, they must be rain-tight and moisture-proof.

5.4.2 DC Connection Area on the Inverter

For inverters without DC switch in front of the input fuses

Overview of the DC connection area for the following options:

- DC input configuration: 9 fused inputs
- DC input configuration: 12 fused inputs
- DC input configuration: 18 fused inputs
- DC input configuration: 21 fused inputs
- DC input configuration: 24 fused inputs

DC Connection Brackets

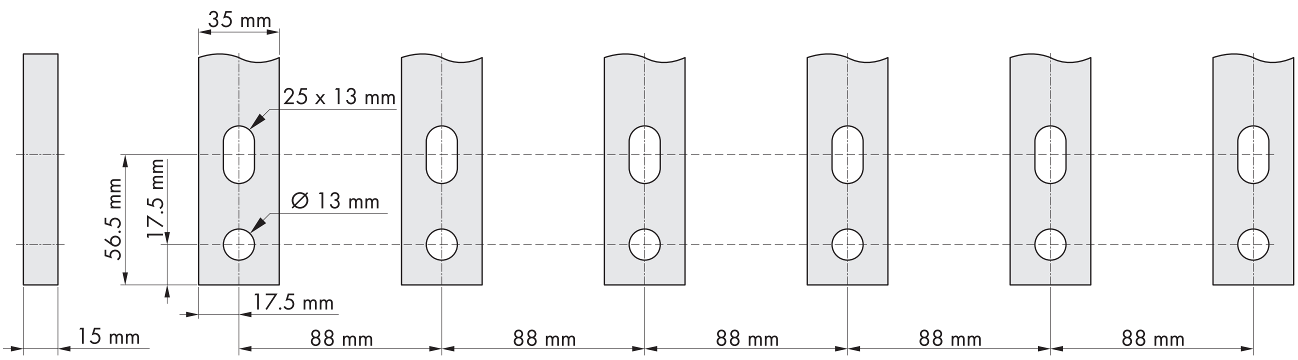


Figure 39: Dimensions of the DC connection brackets

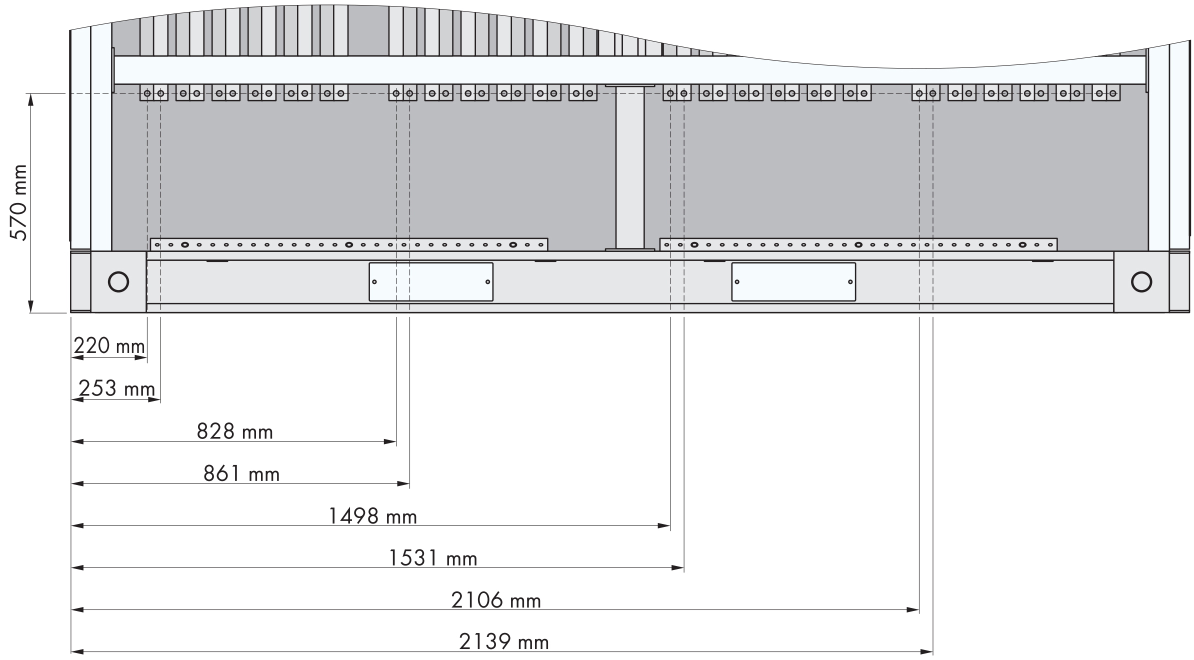


Figure 40: Dimension and position of the DC connection brackets

5.5 AC Connection

5.5.1 Cable Requirements for Medium-Voltage Connections

Cable and plug requirements:

- ☐ The cables used must be made of aluminum or copper.
- ☐ The cables used must be designed for the maximum continuous current. The maximum continuous current depends on the material of the cables.
- ☐ The cable cross sections used depend on the nominal currents of the MV transformer and the layout of the PV power plant and are the responsibility of the customer.
- ☐ Outer-cone angle plugs of type C with 630 A and the required rated voltage must be used.
- ☐ Use of a double cable connection with a T screw connector and angle plug is not permitted.

5.6 Cable Entry

Cable entries are fitted underneath the inverters, the medium-voltage switchgear and the station sub-distribution. Plastic tubing without grooves is recommended for cable. The use of plastic tubes without grooves makes for easier cable insertion.

Upon completion of the installation work, the cable entry areas must be covered to prevent animals from entering the connection area.

6 On-Site Services

The following supplies and performances are not included in the scope of delivery of the product:

- Transport to the construction site (can be carried out by SMA Solar Technology AG on request)
- Crane for unloading the product at the construction site including the lifting lugs the lower corner castings (can be supplied by SMA Solar Technology AG on request)
- Foundation for the product
- Inspection shaft for the oil drain valve
- Installation of the optional oil tray including grounding of the oil tray
- Protective tubes for cable entry
- External grounding system
- All mounting and connection work at the construction site
- Door locks
- Commissioning (can be carried out by SMA Solar Technology AG on request)
- Screws and wall plugs for the attachment of the support feet at the foundation
- Protection test of the medium-voltage switchgear

ENERGY
THAT
CHANGES

SMA

PowerField

5. Constructeursbrief zonnepark

A&I | KWANT adviseurs & ingenieurs

A&I | KWANT BV
adviseurs & ingenieurs
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9645 KZ VEENDAM
Postbus 387
9640 AJ VEENDAM

Telefoon
(0598) 619 357
(0598) 393 739

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info@ibkwant.nl

Internet
www.ibkwant.nl

Constructieve ontwerpnota t.g.v. aanvraag omgevingsvergunning

Projectnummer: 17-110 ME-01 V1.0
Project: Zonnepark Vlagtwedde
Opdrachtgever: POWERFIELD
Contactpersoon: de heer J. van Leeuwen
Datum: 17-05-2017
Onderwerp: Modules zonnepanelen
Auteur: D. Scheven
Bureaucheck: D. van Dijk

Inleiding:
Aan de vloeiveldweg te vlagtwedde wordt een zonnepark gerealiseerd. De zonnepanelen worden geplaatst op stalen modules van dunwandige gezette stalen profielen. Dit document dient als begeleidend schrijven op het constructief ontwerp ten geleide van de Aanvraagprocedure voor de Omgevingsvergunning voor de stalen modules.

In dit document worden de constructieve uitgangspunten vastgelegd voor de stalen modules en dient als basis voor de in een later stadium te verzorgen UO-berekening.

Figuur 1: Locatie zonnepark Vlagtwedde

Referentie
Document: MD Landschapsarchitecten, Inpassingsplan zonneakker Vlagtwedde, SO 03-05-2017

Normen
Deze berekening is gebaseerd op de volgende Nederlandse normen:
- ❑ NEN-EN 1990:2011 Grondslagen van het constructief ontwerp + NB:2011;
- ❑ NEN-EN 1991:2011 Belastingen op constructies + NB:2011;
- ❑ NEN-EN 1993:2011 Ontwerp en berekening van staalconstructies + NB:2011.
- ❑ NEN-EN 1997:2011 Geotechnisch ontwerp.
- ❑ NEN-EN 1999:2008 Ontwerp en berekening van aluminiumconstructies

Eigenschappen materialen
Staalkwaliteit
Voor de modules wordt gebruik gemaakt van Duitse profielen met Duitse staalkwaliteiten.
Gordingen: S380 GD (zie berekening 01 9600 t/m 03 9600)
Liggers S500 GD (zie berekening 01 9600 t/m 03 9600)
Kolommen: S380 GD (zie berekening 01 9600 t/m 03 9600)

De berekeningen zijn voor een project in Hoogezand maar worden in dit stadium ook voor dit project aangehouden.

Verbindingsmiddelen: A2-70

Fundering: Vaste grondslag dient nader bepaald te worden.

Klasse indeling Eurocode
Betrouwbaarheidsklasse: □ RC1
Gevolgklasse: □ CC1 (tabel NB.21 van NEN-EN1990+NB)
Ontwerplevensduurklasse: □ 2 (tabel NB.1 – 2.1 van NEN-EN1990+NB)
Ontwerplevensduur: □ 15 jaar
Uitvoeringsklasse: □ EXC1

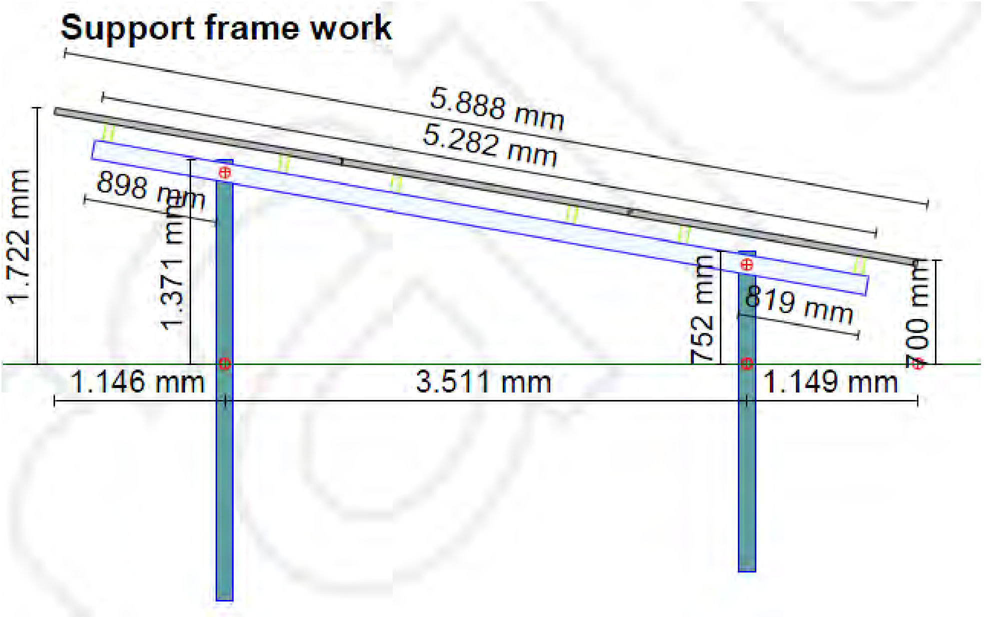
Belastingfactoren

	ULS	SLS
Permanent:	$\gamma_{f;G}$ = 0,9/1,08/1,22	$\gamma_{f;ser;G}$ = 1,0
Veranderlijk:	$\gamma_{f;Q}$ = 1,35	$\gamma_{f;ser;Q}$ = 1,0

Waarden Ψ-factoren

Ψ-factoren	Ψ_0	Ψ_1	Ψ_2
Categorie H: daken niet toegankelijk	0,00	0,00	0,00
Sneeuwbelasting	0,00	0,20	0,00
Belasting door regenwater	0,00	0,20	0,00
Windbelasting	0,00	0,20	0,00

Ontwerp constructie
Middels een stalen frame worden de zonnepanelen in het zonnepark gedragen. In het figuur hieronder wordt een doorsnede van het frame geplaatst.



Figuur 2: Doorsnede stalen module

<u>Opsomming kerngegevens</u>

Soort gebouw	: Bouwwerk geen gebouw zijnde
Locatie	: Vlagtwedde (Windgebied II).

<u>Kerngegevens stalen module</u>

Er zijn 3 type modules:
Type 01: Document 01 9600 Hoogezand–FS3V-Duo-10°-29-Conergy Global Solutions GmbH

Lengte	= 29,38m (in het grondvlak)
Breedte	= 5,80m (in het grondvlak)
Lengte panelen	= 5,89m (in het dakvlak)
Hoogte	= 1,72m (in het verticale vlak)
Aantal zonnepanelen	= 29 x 3 = 87 panelen

Type 02: Document 02 9600 Hoogezand–FS3V-Duo-10°-15-Conergy Global Solutions GmbH

Lengte	= 15,19m (in het grondvlak)
Breedte	= 5,80m (in het grondvlak)
Lengte panelen	= 5,89m (in het dakvlak)
Hoogte	= 1,72m (in het verticale vlak)
Aantal zonnepanelen	= 15 x 3 = 45 panelen

Type 03: Document 03 9600 Hoogezand–FS3V-Duo-10°-8-Conergy Global Solutions GmbH

Lengte	= 8,09m (in het grondvlak)
Breedte	= 5,80m (in het grondvlak)
Lengte panelen	= 5,89m (in het dakvlak)
Hoogte	= 1,72m (in het verticale vlak)
Aantal zonnepanelen	= 8 x 3 = 24 panelen

Constructie opzet

Staalconstructie: Stabiliteit wordt gehaald uit de inklemming van de kolommen in de grond.

Fundering op staal: De kolommen worden in de grond geslagen in de vaste laag.

Gordingen: Zeta – profiel, materiaal S350 GD (zie berekening 01 9600 Hoogezand–FS3V-Duo-10°-29-Conergy Global Solutions GmbH)

Liggers: Eta – profiel, materiaal S500 GD (zie berekening 01 9600 Hoogezand–FS3V-Duo-10°-29-Conergy Global Solutions GmbH)

Kolommen: SRF 6 – profiel, materiaal S380 (zie berekening 01 9600 Hoogezand–FS3V-Duo-10°-29-Conergy Global Solutions GmbH)

Zonnepanelen: Crystalline PV Module ASM6610P Series, 1654mm x 989mm x 40mm, gewicht 18,2kg
Belasting per m^2 = 0,182kN / (1,654m x 0,989m) = 0,11kN/m^2 → kies 0,12kN/m^2

Belasting aannames

Permanete belastingen

Materialen

stalen onderdelen ρ_{staal} = 78,5 kN/m^3

Zonnepaneel = 0,12kN/m^2

Windbelasting

NEN-EN 1991-1-4 art. 5.3, windkrachten $w_e = q_{p(ze)} \cdot c_{pe}$

Extreme stuwdruk $q_{p(ze)}$ = 0,60 kN/m^2 (windgebied II, onbebouwd, gebouwhoogte h = 1.7m)

Windvormfactor C_{f1} = 1,30

C_{f2} = -1,32

$C_{p,net}$ = 1,60 (neerwaarts)

$C_{p,net}$ = -1,80 (opwaarts)

Sneeuwbelasting

Sneeuw op plattedaken $s = \mu_1 \times C_e \times C_t \times s_k$ = 0,8 x 1,0 x 1,0 x 0,70 kN/m^2 = 0,56 kN/m^2.

NEN-EN 1991-1-3 Sneeuwbelastingen voor blijvende / tijdelijke ontwerpsituaties.

Belasting combinaties

Uiterste grenstoestanden

De volgende uiterste grenstoestanden zijn getoetst:

- STR: Intern bezwijken of buitensporige vervorming.

Belastingcombinaties

De volgende belastingcombinaties zijn, indien nodig, getoetst:

Uiterste grenstoestanden:

$1{,}35 * G_{kj,sup} + 1{,}5 * \psi_{0,i} * Q_{k,I}$	$(i \geq 1)$	(STR/GEO comb. 6.10a);
$1{,}2 * G_{kj,sup} + 1{,}5 * Q_{k,1} + 1{,}5 * \psi_{0,i} * Q_{k,i}$	$(i > 1)$	(STR/GEO comb. 6.10b)
$0{,}9 * G_{kj,inf} + 1{,}5 * \psi_{0,i} * Q_{k,I}$	$(i \geq 1)$	(STR/GEO comb. 6.10a)
$0{,}9 * G_{kj,inf} + 1{,}5 * Q_{k,1} + 1{,}5 * \psi_{0,i} * Q_{k,i}$	$(i > 1)$	(STR/GEO comb. 6.10b)
$1{,}0 * G_{kj,sup} + 1{,}3 * Q_{k,1} + 1{,}3 * \psi_{0,i} * Q_{k,i}$		(STR/GEO comb. 6.10)
$1{,}0 * G_{kj,inf} + 1{,}3 * Q_{k,1} + 1{,}3 * \psi_{0,i} * Q_{k,i}$		(STR/GEO comb. 6.10)

Bruikbaarheidsgrenstoestanden:

$G_{kj} + Q_{k,1} + \psi_{0,i} * Q_{k,i}$	$(i > 1)$	(Karakteristieke comb. 6.14b)
$G_{kj} + \psi_{1,1} * Q_{k,1} + \psi_{2,i} * Q_{k,i}$	$(i > 1)$	(Frequente comb. 6.15b)
$G_{kj} + \psi_{2,i} * Q_{k,i}$	$(i \geq 1)$	(Quasi-blijvende comb. 6.16b)

Acties UO-berekening

- Berekening staalconstructie en toetsing van het stalenframe;
- Berekening van de fundering.

Bovenstaande punten worden in de uitvoeringsfase nader uitgewerkt.

Versie 1.0
Veendam, 17-05-2017
D. Scheven
- constructeur-

FS3V10°1956x991_29ZetaFG26x8

Design calculations (FS3V)
For mounting of photovoltaic modules in open areas

Project	**01 9600 Hoogezand - FS3V-Duo-10°-29 - Conergy Global Solutions GmbH** NL-9600 Hoogezand
Customer	Schletter GmbH Gewerbegebiet B15 Alustraße 1 D-83527 Kirchdorf/Haag in Oberbayern
Owner	 Conergy Global Solutions GmbH Bleichenbrücke 10 D-20354 Hamburg
Design	Schletter GmbH Gewerbegebiet B15 Alustraße 1 D-83527 Kirchdorf/Haag in Oberbayern
Structural design	 Dr. Zapfe GmbH Ingenieurbüro für konstruktiven Ingenieurbau und Solartechnik Gewerbegebiet B15 Alustraße 1 D-83527 Kirchdorf/Haag in Oberbayern

The design calculation contains the following pages:
Structural analysis: Pages 1 - 9
Annex

Date 19/05/2016

1 General

1.1 Project description

This static calculation contains the determination following sections contain the calculation of the internal forces and the verifications of structural safety of the load carrying construction, which is set up in an open area.
The location is
NL-9600 Hoogezand 53° 9' 42" North 6° 45' 40" East
Height above sea level < 2 m

1.2 Construction

The support-system ist an inclined construction, to which the solar modules are fixed with clamps. The purlins are positioned on the girders, which are supported in several joint locations.
The modules have the following dimensions:

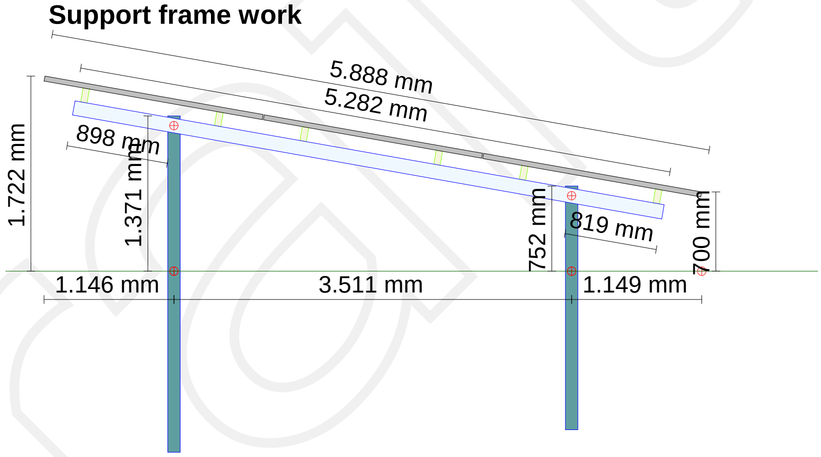
h = 1956 mm b = 991 mm c = 45 mm

Modules per row x = 29
Number of rows: y = 3
Peak power of module 320.0 Wp
Total dimensions of a solar mounting unit

L = 29.38 m Support frame length
B = 5.80 m Projection of the PV body
H = 5.89 m Total panel height
h = 1.72 m Total body height

Module type JAP6-72 4BB
Size of facility 98.72 MWp
Number of support frames 3546

Support frame work



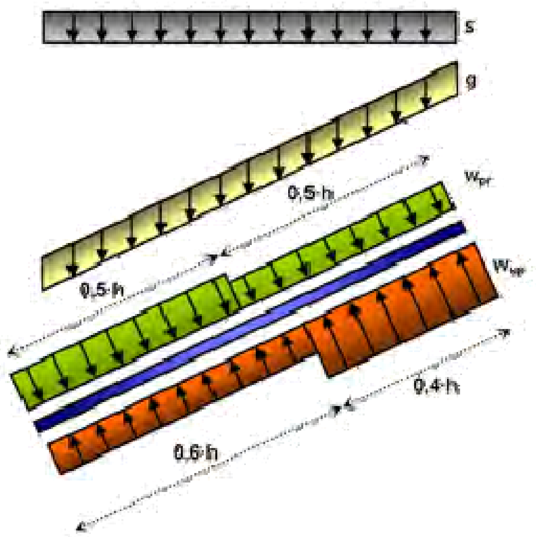
Number of support sections 8
Number of fields 7
Girder span 3.76 m
Purlin cantilever 1.54 m On both sides
Inclination of modules towards horizontal $\beta = 10°$
Minimum height above ground level $h_{min} = 70$ cm

1.3 Technical codes

Ausführungsklasse EXC1

- NEN-EN 1990 Basis of structural design
- NEN-EN 1991-1-3/NA General actions - Snow loads
- NEN-EN 1991-1-4/NA General actions - Wind actions
- NEN-EN 1993 Design of steel structures
- NEN-EN 1997 Geotecnical design
- NEN-EN 1998 Design of structures for earthquake resistance
- NEN-EN 1999 Design of aluminium structures
- NEN-EN 1090 Execution of steel structures
- NEN-EN ISO 14713 Zinc coatings. Guidelines and recommendations for the protection against corrosion of iron and steel in structures

2 Actions



With

β	°	Inclination to the horizontal
g	kN/m²	According to NEN EN 1991-1
		According to manufacturers certificate
s	kN/m²	NEN EN 1991-1-3
w	kN/m²	NEN EN 1991-1-4
W	kN/m	NEN EN 1991-1-4

2.1 Permanent loads

g = 0.12 kN/m² Self-weight of solar modules according to manufacturer`s data/ certificate

2.2 Snow loads

Snow zone

s_k = 0.70 kN/m²

μ = 0.80
$s = s_k \cdot \mu$ = 0.56 kN/m²

2.3 Wind loads

Wind zone **2** Terrain category **II**

Height above ground
z < 1.7 m
v_{ref} = 27.5 m/s
q_{ref} = 0.47 kN/m²
$q_{(z)}$ = 0.78 kN/m² (Peak velocity pressure)

Wind forces

Force coeffic.
c_{f1} = 1.30
c_{f2} = -1.32

Top	$c_{p,net}$	=	1.60	Loading
	$c_{p,net}$	=	-1.80	Uplifting
Center	$c_{p,net}$	=	1.60	Loading
	$c_{p,net}$	=	-1.80	Uplifting
Bottom	$c_{p,net}$	=	1.60	Loading
	$c_{p,net}$	=	-1.80	Uplifting

Load increase in sidewise edge zones
$f_{Suction}$ = 1.28 On a length A/10
$f_{Pressure}$ = 1.00 On a length A/10

2.4 Action combinations

Partial safety factors for actions and resistance

Importance factor K_{FI} = 0.90

$\gamma_g = 1.35 \cdot 0.90 = 1.22$ $\qquad \gamma_g = 0.90$ For favourable load action

$\gamma_q = 1.50 \cdot 0.90 = 1.35$

Combination coefficients $\Psi_{0,w} = 0.60$

$\Psi_{0,s} = 0.50$

For the verifications in the limit state of load-bearing capacity, the following load combination are examined:

LK 1: $\gamma_g \cdot g + \gamma_q \cdot s + \Psi_{0,w} \cdot \gamma_q \cdot w$

LK 2: $\gamma_g \cdot g + \Psi_{0,s} \cdot \gamma_q \cdot s + \gamma_q \cdot w$

LK 3: $0.9 \cdot g + \gamma_q \cdot w$ For lifting wind actions

3 Design calculations

3.1 Purlin

Steel purlins are applied for the transmission of the loads into the supporting elements. From a structural point of view, these are regarded as continuous beams with edge cantilevers. While producing and assembling these can be considered as beam with internal hinges and be jointed with splices in the specific gerber positions.

Material S350 GD $\qquad f_{yk}$ = 35.0 kN/cm² $\qquad \gamma_M$ = 1.1

f_d = 31.8

Profile Zeta

A = 5.0 cm²

W_y = 19.0 cm³

W_z = 4.5 cm³

I_y = 117.8 cm⁴

I_z = 12.2 cm⁴

g = 4.0 kg/m

Total length $\qquad l_{ges}$ = 29.383 m $\qquad \beta$ = 10°

a = 3.757 m $\qquad \sin\beta$ = 0.174

l_{kr} = 1.540 m $\qquad \cos\beta$ = 0.985

The load effects by wind and snow have to be positioned unfavourably span-wise for the determination of the internal forces. The calculation is performed using the factors for continous beams with equidistant spans.

$M_{1,Total\ load}$	$M_{1,Partial}$	$M_{B,Total\ load}$	$M_{B,Partial}$
0.040	0.055	-0.084	-0.102

Bending moment coefficients

$A_{Total\ load}$	$A_{Partial}$	$B_{Total\ load}$	$B_{Partial}$
0.910	0.527	1.000	1.110

Force coeffic.

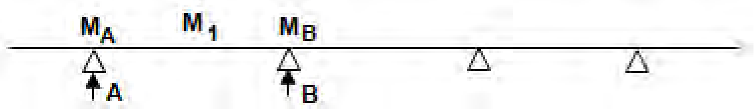
Permanent loads $\qquad g_{k,z}$ = 0.151 kN/m $\qquad g_{k,y}$ = 0.027 kN/m Incl. Profile

Snow loads $\qquad s_{k,z}$ = 0.531 kN/m $\qquad s_{k,y}$ = 0.094 kN/m

Wind load (pressure) $\qquad W_{k,D}$ = 5.999 kN/m $\qquad w_{k,D}$ = 1.226 kN/m

Wind load (suction) $\qquad W_{k,Z}$ = -6.092 kN/m $\qquad w_{k,Z}$ = -1.380 kN/m

Inner purlin



LK 1	$M_{1,y}$ = 1.433 kNm	$M_{1,z}$ = 0.117 kNm
LK 2	$M_{1,y}$ = 1.669 kNm	$M_{1,z}$ = 0.068 kNm
LK 3	$M_{1,y}$ = -1.368 kNm	$M_{1,z}$ = 0.014 kNm
LK 1	$M_{A,y}$ = 2.247 kNm	$M_{A,z}$ = 0.188 kNm
LK 2	$M_{A,y}$ = 2.607 kNm	$M_{A,z}$ = 0.113 kNm
LK 3	$M_{A,y}$ = -2.661 kNm	$M_{A,z}$ = 0.029 kNm
LK 1	$M_{B,y}$ = -2.681 kNm	$M_{B,z}$ = -0.221 kNm
LK 2	$M_{B,y}$ = -3.118 kNm	$M_{B,z}$ = -0.129 kNm
LK 3	$M_{B,y}$ = 2.520 kNm	$M_{B,z}$ = -0.035 kNm
LK 1	A = 4.013 kN	A_h = 0.361 kN
LK 2	A = 4.614 kN	A_h = 0.224 kN
LK 3	A = -3.218 kN	A_h = 0.082 kN
LK 1	B = 7.825 kN	B_h = 0.649 kN
LK 2	B = 9.092 kN	B_h = 0.386 kN
LK 3	B = -7.256 kN	B_h = 0.090 kN

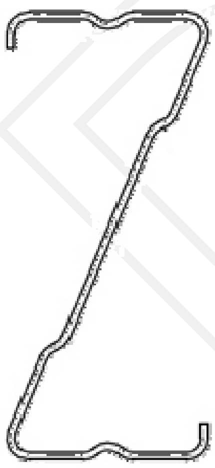
Stress verification of purlin profiles

	max M_y	σ_x	max M_z	σ_x	$\Sigma\sigma_x$		η %
LK 1	2.68	14.13	0.22	4.87	19.00	kN/cm²	59.7
LK 2	3.12	16.44	0.13	2.86	19.30	kN/cm²	60.6
LK 3	2.66	14.03	0.03	0.76	14.79	kN/cm²	46.5

Verification format

$$\frac{M_y}{W_y} + \frac{M_z}{W_z} \leq f_d$$

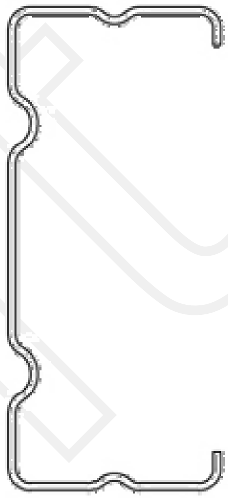
Purlin sections



3.2 Verification of cross beams

The transfer of the load components from purlins into the centrically positioned post follows an inclined girder, which ist fixed at the ram driven steel section with trapezoidal shape. The load actions on the girder result from the support reaction of the purlins. For the determination of forces unfavourable onesided acting variable loadings have to be applied.

Cross beam profile Extruded profile Eta

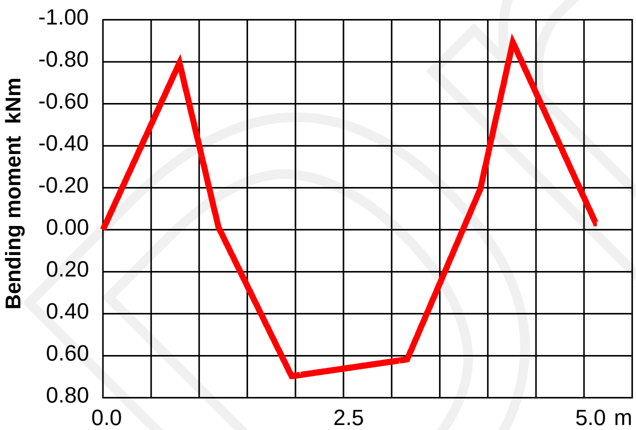


Material S500 GD — f_{yk} = 50.0 kN/cm²; f_d = 45.5 kN/cm²

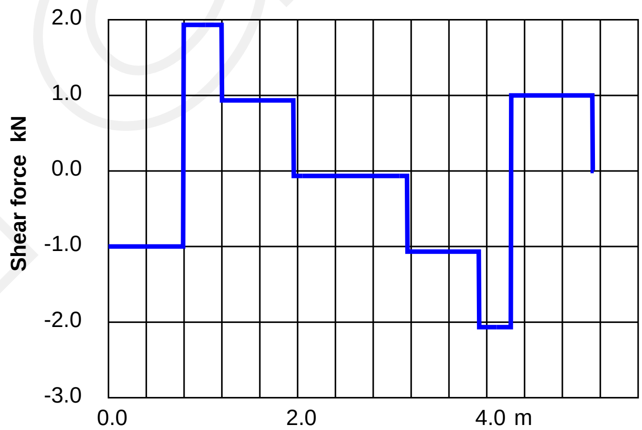
A =	5.05	cm²
W_y =	19.59	cm³
W_z =	4.31	cm³
I_y =	124.82	cm⁴
I_z =	16.87	cm⁴
g =	3.96	kg/m

Shapes of initial force variables with uniform concentrated load F ="1" at purlin connections

Bending moments (uniform load)



Shear force behavior (standardized)



Total girder length	l_R = 5.13 m		
Factor for moment in span	f_F = 0.70		
Factor for moment at support	f_S = -0.80 (Left)	f_S = -0.89 (Right)	
Shear force factor	f_V = 3.07		
Joint eccentricity of girder	e_z = 20 mm		

For determination of the internal force variables of the substructure the wind forces have to be positioned as a concentrated load in the quarter points of the module surface.
Hence are resulting two load postions of wind forces in each load combination. According to this 6 load combinations have to be evaluated for determination of the decisive loading.

Internal forces at the support construction	Load combination 1		Load combination 2		Load combination 3		
	Frontal	Rear	Frontal	Rear	Frontal	Rear	
Maximum of axial force	2.04		3.41		-4.81		kN
Eccentricity moment M_{ez}	0.04		0.07		-0.10		kNm
Max mid-span bending moment	5.46		6.34		-5.06		kNm
Max. moment at support left	-6.22		-7.23		5.77		kNm
Max. moment at support right	-6.99		-8.12		6.48		kNm
Vertical supporting force of the support	20.90	1.02	24.17	-9.29	-11.75	-21.65	kN
Horizontal supporting force of the support	2.94	0.58	4.90	0.96	-4.99	-0.97	kN
Mid-span stresses	28.26		33.03		-24.87		kN/cm²
Stresses moment at support left	-31.77		-36.92		30.41		kN/cm²
Stresses moment at support right	-35.67		-41.44		34.03		kN/cm²

Max mid-span bending moment $M_F = \max(A;B) \cdot f_F + M_{ez} = 9.09 \cdot 0.70 + 0.07 = 6.41$ kNm

Max. moment at support left $M_S = \max(A;B) \cdot f_S - M_{ez} = 9.09 \cdot -0.80 - 0.00 = -7.23$ kNm

Max. moment at support right $M_S = \max(A;B) \cdot f_S - M_{ez} = 9.09 \cdot -0.89 - 0.00 = -8.12$ kNm

Verification $\frac{N}{A} + \frac{M}{W_y} \leq f_d$

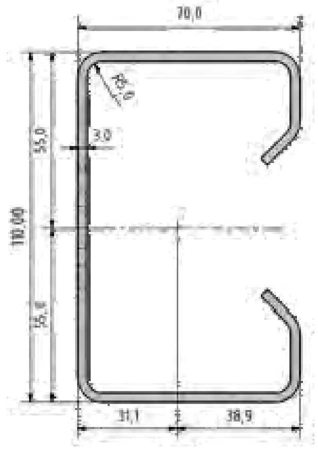
Maximum stress max $\sigma_x = 41.44$ kN/cm² Utilization ratio 91 %

Mounting system

Front support is connected at 16 % of the planned girder length
Rear support Is connected at 83 % Of the planned girder length

4 Verification of ram driven posts

The construction of the post ist planned by using a steel sheet with a trapazoidal shape, which is ram driven in ground with defined depth. This item affords soil examinations and eventually loading tests to evaluate the transferable forces.



Profile parameters SRF 6

b_f = 70 mm
h = 110 mm
t = 3 mm
A = 9.18 cm²
W_y = 30.23 cm³
I_y = 166.28 cm⁴
g = 7.10 kg/m

Material properties S380

$f_{y,k}$ = 38.00 kN/cm²
γ_M = 1.1
$f_{y,d}$ = 34.55 kN/cm²
σ_x = 16.59 kN/cm²

Utilization ratio η = 48 %

Non usable soil layer t = 0 cm
Estimated anchoring depth rear t_{soil} = 160 cm
Estimated anchoring depth frontal t_{soil} = 140 cm

Initial forces at bottom fixed support	Load combination 1		Load combination 2		Load combination 3		
	Frontal	Rear	Frontal	Rear	Frontal	Rear	
Axial force at fixed support	21.17	3.36	23.86	-6.17	-11.60	-20.49	kN
Shear force at fixed support	2.65	0.58	4.90	0.96	-4.99	-0.97	kN
Resulting for screw verification	21.33	3.41	24.36	6.24	12.63	20.51	kN
Cantilever moment	2.28	0.84	4.23	1.41	-4.30	-1.41	kNm
Stress verification	9.86	3.16	16.59	5.32	15.49	6.91	kN/cm²

Front support
Max. tensile loads on support N_{max} = 11.60 kN belonging to V = 4.99 kN
Max. compression force at post N_{min} = 23.86 kN belonging to V = -2.65 kN
Max. bendig moment at post M_e = 4.23 kNm

Rear support
Max. tensile loads on support N_{max} = 20.49 kN belonging to V = 0.97 kN
Max. compression force at post N_{min} = 3.36 kN belonging to V = -0.58 kN
Max. bendig moment at post M_e = 1.41 kNm

The restraint post support in the ground features a plastic reserve of 66 %
M_{pl} = 9.0 kNm

Verification in lateral direction under wind loads:
Friction factor: f_r = 0,04 A_{fr} = 22,1 m² F_{fr} = 0,9 kN M_{fr} = 0,65 kNm σ_x = 1,88 kN/cm²

Dr. Zapfe GmbH
Ingenieurbüro

5 Verification of joints and connections

5.1 Anchorage of modules on the purlins and connection of the purlins to the girder

The notch ist designed in such a manner that the bolt in operating position is located approximately in the center of gravity of the net section. Therefore, only negligible bending portions arise.

The connection of the purlins to the girder feature clamp festeners.Due to limited standards for reliable calculations, the strength of the clamp fasteners has been evaluated by tests.

Fastening of modules to purlins	max F_z = 2.05 kN< P_{Rd} =	3.6 kN
Clamping of purlins to girders	max F_z = 7.26 kN< P_{Rd} =	11.0 kN

(strength of connections according to spec sheets from Schletter-Solarmontage GmbH)

5.2 Connection of the girder to the foundation post

The basical constructive feature of the construction is the design of the connection between the inclined girders and the post head of the ram driven profiles. The following technical requirements have to be considered:

- Transmission of forces in unfavourable distribution $\Delta z = \pm 20$ mm
- Compensation of tolerances caused by the pile driving of the support profiles $\Delta\beta = \pm 2°$
- Tolerances in longitudinal and lateral direction $\Delta x = \pm 15$ mm

By means of a bolt, the girder is connected to an adjustable strut that is hooked in in the course of the mounting process. The height adjustment is realized using a slotted hole whose position is secured by corrugated plates and a corrugated structure of the connection profile. The utilization of the basic material is verified, the screws are verified regarding shearing-off and bearing stress.

Bolts for load transmission
M12 A2-70

Shearing-off bolts
V_{aRd} = 34.90 kN η = 71 %
Bearing resistance steel U-Profile
V_{lRd} = 25.92 kN η = 95 %
Bearing resistance steel Coil sheet
V_{lRd} = 26.40 kN η = 93 %

Connection binder/support

max N = 21.65 kN
max V = 0.97 kN

F_{sd} = 24.66 kN < 33 kN (test report) η = 75 %

Schletter GmbH

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http://www.solar.schletter.de/

Planning documentation for the bearing system FS-Duo 3V for solar modules

Project: 02 9600 Vlagtwedde - FS3V-Duo-10°-15 -Conergy Global Solutions GmbH

Module type: JAP6-72 4BB 1956 x 991 mm

By order of

Conergy Global Solutions GmbH

Bleichenbrücke 10
D-20354 Hamburg

May 2016

FS3V10°1956x991_15ZetaFG26x4

Design calculations (FS3V)

For mounting of photovoltaic modules in open areas

Project	**02 9600 Hoogezand - FS3V-Duo-10°-15 - Conergy Global Solutions GmbH**
	NL-9600 Hoogezand
Customer	Schletter GmbH Gewerbegebiet B15 Alustraße 1 D-83527 Kirchdorf/Haag in Oberbayern
Owner	Conergy Global Solutions GmbH Bleichenbrücke 10 D-20354 Hamburg
Design	Schletter GmbH Gewerbegebiet B15 Alustraße 1 D-83527 Kirchdorf/Haag in Oberbayern
Structural design	Dr. Zapfe GmbH Ingenieurbüro für konstruktiven Ingenieurbau und Solartechnik Gewerbegebiet B15 Alustraße 1 D-83527 Kirchdorf/Haag in Oberbayern

The design calculation contains the following pages:
Structural analysis: Pages 1 - 9
Annex

Date 19/05/2016

1 General

1.1 Project description

This static calculation contains the determination following sections contain the calculation of the internal forces and the verifications of structural safety of the load carrying construction, which is set up in an open area.
The location is
NL-9600 Hoogezand 53° 9' 42" North 6° 45' 40" East
Height above sea level < 2 m

1.2 Construction

The support-system ist an inclined construction, to which the solar modules are fixed with clamps. The purlins are positioned on the girders, which are supported in several joint locations.
The modules have the following dimensions:

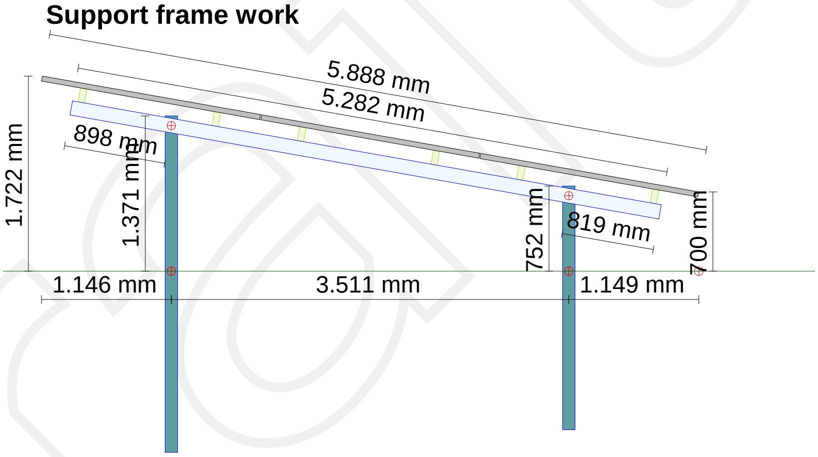
h = 1956 mm b = 991 mm c = 45 mm

Modules per row x = 15
Number of rows: y = 3
Peak power of module 320.0 Wp
Total dimensions of a solar mounting unit

L = 15.19 m Support frame length
B = 5.80 m Projection of the PV body
H = 5.89 m Total panel height
h = 1.72 m Total body height

Module type JAP6-72 4BB
Size of facility 2.88 MWp
Number of support frames 200

Support frame work



Number of support sections	4	
Number of fields	3	
Girder span	4.09 m	
Purlin cantilever	1.55 m	On both sides

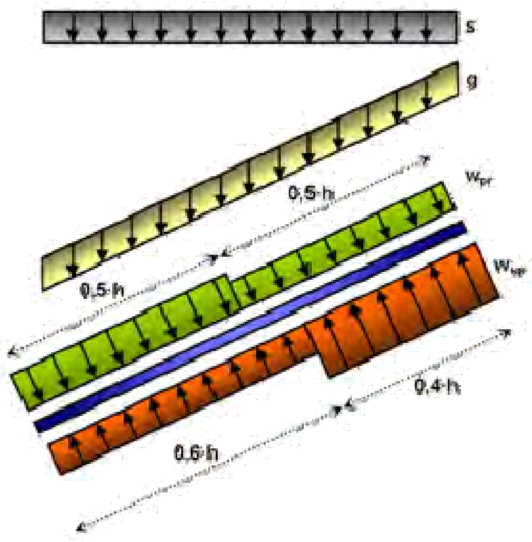
Inclination of modules towards horizontal β = 10°
Minimum height above ground level h_{min} = 70 cm

1.3 Technical codes

Ausführungsklasse EXC1

- NEN-EN 1990 Basis of structural design
- NEN-EN 1991-1-3/NA General actions - Snow loads
- NEN-EN 1991-1-4/NA General actions - Wind actions
- NEN-EN 1993 Design of steel structures
- NEN-EN 1997 Geotecnical design
- NEN-EN 1998 Design of structures for earthquake resistance
- NEN-EN 1999 Design of aluminium structures
- NEN-EN 1090 Execution of steel structures
- NEN-EN ISO 14713 Zinc coatings. Guidelines and recommendations for the protection against corrosion of iron and steel in structures

2 Actions



With

β	°	Inclination to the horizontal
g	kN/m²	According to NEN EN 1991-1
		According to manufacturers certificate
s	kN/m²	NEN EN 1991-1-3
w	kN/m²	NEN EN 1991-1-4
W	kN/m	NEN EN 1991-1-4

2.1 Permanent loads

g = 0.12 kN/m² Self-weight of solar modules according to manufacturer`s data/ certificate

2.2 Snow loads

Snow zone

s_k = 0.70 kN/m²

μ = 0.80
s = $s_k \cdot \mu$ = 0.56 kN/m²

2.3 Wind loads

Wind zone **2** Terrain category **II**

Height above ground z < 1.7 m
v_{ref} = 27.5 m/s
q_{ref} = 0.47 kN/m²
$q_{(z)}$ = 0.78 kN/m² (Peak velocity pressure)

Wind forces Force coeffic.

c_{f1} = 1.30
c_{f2} = -1.32

Top	$c_{p,net}$	=	1.60	Loading
	$c_{p,net}$	=	-1.80	Uplifting
Center	$c_{p,net}$	=	1.60	Loading
	$c_{p,net}$	=	-1.80	Uplifting
Bottom	$c_{p,net}$	=	1.60	Loading
	$c_{p,net}$	=	-1.80	Uplifting

Load increase in sidewise edge zones

$f_{Suction}$ = 1.28 On a length A/10
$f_{Pressure}$ = 1.00 On a length A/10

2.4 Action combinations

Partial safety factors for actions and resistance

Importance factor K_{FI} = 0.90

$\gamma_g = 1.35 \cdot 0.90 = 1.22$ $\gamma_g = 0.90$ For favourable load action

$\gamma_q = 1.50 \cdot 0.90 = 1.35$

Combination coefficients $\Psi_{0,w} = 0.60$

$\Psi_{0,s} = 0.50$

For the verifications in the limit state of load-bearing capacity, the following load combination are examined:

LK 1: $\gamma_g \cdot g + \gamma_q \cdot s + \Psi_{0,w} \cdot \gamma_q \cdot w$

LK 2: $\gamma_g \cdot g + \Psi_{0,s} \cdot \gamma_q \cdot s + \gamma_q \cdot w$

LK 3: $0.9 \cdot g + \gamma_q \cdot w$ For lifting wind actions

3 Design calculations

3.1 Purlin

Steel purlins are applied for the transmission of the loads into the supporting elements. From a structural point of view, these are regarded as continuous beams with edge cantilevers. While producing and assembling these can be considered as beam with internal hinges and be jointed with splices in the specific gerber positions.

Material S350 GD f_{yk} = 35.0 kN/cm² γ_M = 1.1

f_d = 31.8

Profile Zeta

A = 5.0 cm²
W_y = 19.0 cm³
W_z = 4.5 cm³
I_y = 117.8 cm⁴
I_z = 12.2 cm⁴
g = 4.0 kg/m

Total length l_{ges} = 15.187 m β = 10°

a = 4.087 m sin β = 0.174

l_{kr} = 1.550 m cos β = 0.985

The load effects by wind and snow have to be positioned unfavourably span-wise for the determination of the internal forces. The calculation is performed using the factors for continous beams with equidistant spans.

$M_{1,Total\ load}$	$M_{1,Partial}$	$M_{B,Total\ load}$	$M_{B,Partial}$
0.040	0.056	-0.080	-0.101

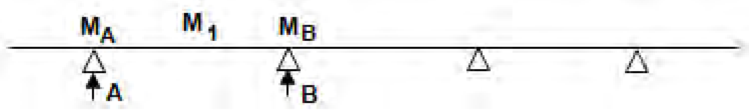
Bending moment coefficients

$A_{Total\ load}$	$A_{Partial}$	$B_{Total\ load}$	$B_{Partial}$
0.911	0.939	1.000	1.115

Force coeffic.

Permanent loads $g_{k,z}$ = 0.151 kN/m $g_{k,y}$ = 0.027 kN/m Incl. Profile
Snow loads $s_{k,z}$ = 0.531 kN/m $s_{k,y}$ = 0.094 kN/m
Wind load (pressure) $W_{k,D}$ = 5.999 kN/m $w_{k,D}$ = 1.226 kN/m
Wind load (suction) $W_{k,Z}$ = -6.092 kN/m $w_{k,Z}$ = -1.380 kN/m

Inner purlin



LK 1	$M_{1,y}$ = 2.060 kNm	$M_{1,z}$ = 0.165 kNm
LK 2	$M_{1,y}$ = 2.403 kNm	$M_{1,z}$ = 0.094 kNm
LK 3	$M_{1,y}$ = -2.010 kNm	$M_{1,z}$ = 0.017 kNm
LK 1	$M_{A,y}$ = 2.276 kNm	$M_{A,z}$ = 0.191 kNm
LK 2	$M_{A,y}$ = 2.641 kNm	$M_{A,z}$ = 0.115 kNm
LK 3	$M_{A,y}$ = -2.695 kNm	$M_{A,z}$ = 0.029 kNm
LK 1	$M_{B,y}$ = -3.143 kNm	$M_{B,z}$ = -0.259 kNm
LK 2	$M_{B,y}$ = -3.655 kNm	$M_{B,z}$ = -0.152 kNm
LK 3	$M_{B,y}$ = 2.952 kNm	$M_{B,z}$ = -0.041 kNm
LK 1	A = 3.872 kN	A_h = 0.325 kN
LK 2	A = 4.492 kN	A_h = 0.183 kN
LK 3	A = -3.528 kN	A_h = 0.049 kN
LK 1	B = 8.494 kN	B_h = 0.705 kN
LK 2	B = 9.869 kN	B_h = 0.419 kN
LK 3	B = -7.872 kN	B_h = 0.098 kN

Stress verification of purlin profiles

	max M_y	σ_x	max M_z	σ_x	$\Sigma\sigma_x$		η %
LK 1	3.14	16.57	0.26	5.71	22.27	kN/cm²	70.0
LK 2	3.65	19.27	0.15	3.35	22.62	kN/cm²	71.1
LK 3	2.95	15.56	0.04	0.90	16.46	kN/cm²	51.7

Verification format

$$\frac{M_y}{W_y} + \frac{M_z}{W_z} \leq f_d$$

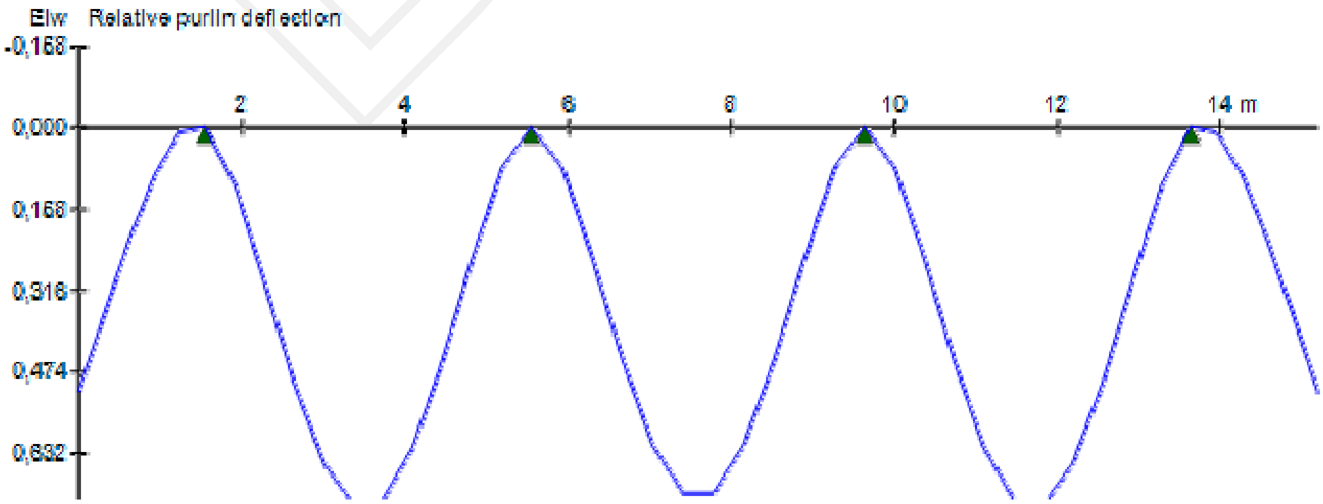
Deflections of purlins perpendicular to the module plane

Youngs modulus E = 21000 kN/cm²
Moment of inertia I_y = 117.80 cm⁴
Span deflections: EIw = 0.7315
Cantilever deflections: EIw = 0.5121

EI = 247.38 kN/m²

Self weight	Snow	Wind pressure	Uplift	
0.448	1.57	17.74	-18.01	mm
0.314	1.10	12.42	-12.61	mm

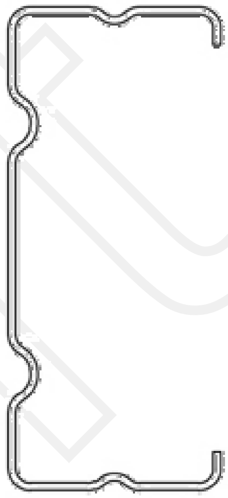
LK1:	12.66 mm (a / 323)		8.87 mm (a_{kr} / 175)	relativ
LK2 Midspan	18.97 mm (a / 215)	Cantilever	13.28 mm (a_{kr} / 117)	(a_{kr} / 124)
LK3:	-17.56 mm (a / 233)		-12.30 mm (a_{kr} / 126)	



3.2 Verification of cross beams

The transfer of the load components from purlins into the centrically positioned post follows an inclined girder, which ist fixed at the ram driven steel section with trapezoidal shape. The load actions on the girder result from the support reaction of the purlins. For the determination of forces unfavourable onesided acting variable loadings have to be applied.

Cross beam profile Extruded profile Eta

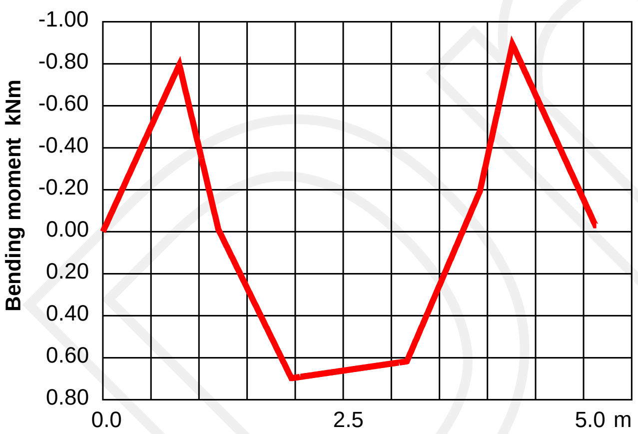


Material S500 GD f_{yk} = 50.0 kN/cm²
f_d = 45.5 kN/cm²

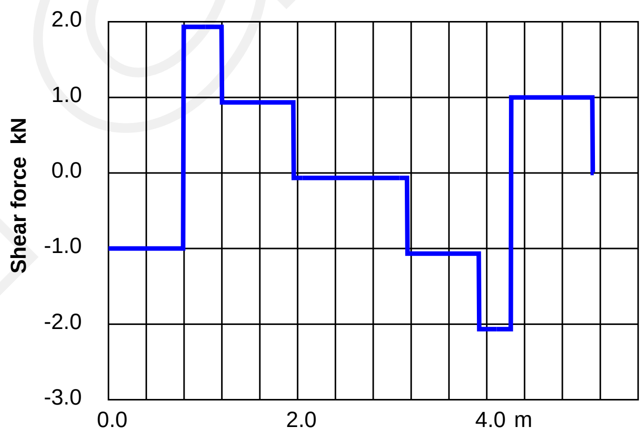
A = 5.05 cm²
W_y = 19.59 cm³
W_z = 4.31 cm³
I_y = 124.82 cm⁴
I_z = 16.87 cm⁴
g = 3.96 kg/m

Shapes of initial force variables with uniform concentrated load F ="1" at purlin connections

Bending moments (uniform load)



Shear force behavior (standardized)



Total girder length l_R = 5.13 m
Factor for moment in span f_F = 0.70
Factor for moment at support f_S = -0.80 (Left) f_S = -0.89 (Right)
Shear force factor f_V = 3.07
Joint eccentricity of girder e_z = 20 mm

For determination of the internal force variables of the substructure the wind forces have to be positioned as a concentrated load in the quarter points of the module surface.
Hence are resulting two load postions of wind forces in each load combination. According to this 6 load combinations have to be evaluated for determination of the decisive loading.

Internal forces at the support construction	Load combination 1		Load combination 2		Load combination 3		
	Frontal	Rear	Frontal	Rear	Frontal	Rear	
Maximum of axial force	2.22		3.70		-5.22		kN
Eccentricity moment M_{ez}	0.04		0.07		-0.10		kNm
Max mid-span bending moment	5.92		6.88		-5.49		kNm
Max. moment at support left	-6.76		-7.85		6.26		kNm
Max. moment at support right	-7.59		-8.81		7.03		kNm
Vertical supporting force of the support	22.68	1.11	26.23	-10.08	-12.75	-23.49	kN
Horizontal supporting force of the support	3.19	0.62	5.32	1.04	-5.41	-1.05	kN
Mid-span stresses	30.67		35.86		-26.99		kN/cm²
Stresses moment at support left	-34.49		-40.07		33.00		kN/cm²
Stresses moment at support right	-38.72		-44.99		36.92		kN/cm²

Max mid-span bending moment $M_F = \max(A;B) \cdot f_F + M_{ez} = 9.87 \cdot 0.70 + 0.07 = 6.96$ kNm
Max. moment at support left $M_S = \max(A;B) \cdot f_S - M_{ez} = 9.87 \cdot -0.80 - 0.00 = -7.85$ kNm
Max. moment at support right $M_S = \max(A;B) \cdot f_S - M_{ez} = 9.87 \cdot -0.89 - 0.00 = -8.81$ kNm

Verification $\frac{N}{A} + \frac{M}{W_y} \leq f_d$

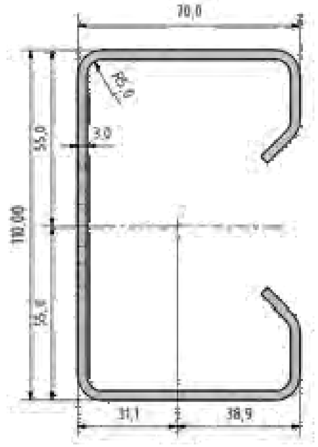
Maximum stress max σ_x = 44.99 kN/cm² Utilization ratio 99 %

Mounting system

Front support is connected at 16 % of the planned girder length
Rear support Is connected at 83 % Of the planned girder length

4 Verification of ram driven posts

The construction of the post ist planned by using a steel sheet with a trapazoidal shape, which is ram driven in ground with defined depth. This item affords soil examinations and eventually loading tests to evaluate the transferable forces.



Profile parameters SRF 6

b_f = 70 mm
h = 110 mm
t = 3 mm
A = 9.18 cm²
W_y = 30.23 cm³
I_y = 166.28 cm⁴
g = 7.10 kg/m

Material properties S380

$f_{y,k}$ = 38.00 kN/cm²
γ_M = 1.1
$f_{y,d}$ = 34.55 kN/cm²
σ_x = 18.01 kN/cm²

Utilization ratio η = 52 %

Non usable soil layer t = 0 cm
Estimated anchoring depth rear t_{soil} = 160 cm
Estimated anchoring depth frontal t_{soil} = 140 cm

Initial forces at bottom fixed support	Load combination 1		Load combination 2		Load combination 3		
	Frontal	Rear	Frontal	Rear	Frontal	Rear	
Axial force at fixed support	21.81	2.37	25.98	-6.73	-12.64	-22.32	kN
Shear force at fixed support	2.88	0.63	5.32	1.05	-5.41	-1.05	kN
Resulting for screw verification	22.00	2.45	26.52	6.81	13.75	22.35	kN
Cantilever moment	2.49	0.92	4.59	1.53	-4.67	-1.53	kNm
Stress verification	10.61	3.29	18.01	5.78	16.82	7.51	kN/cm²

Front support
Max. tensile loads on support N_{max} = 12.64 kN belonging to V = 5.41 kN
Max. compression force at post N_{min} = 25.98 kN belonging to V = -2.88 kN
Max. bendig moment at post M_e = 4.59 kNm

Rear support
Max. tensile loads on support N_{max} = 22.32 kN belonging to V = 1.05 kN
Max. compression force at post N_{min} = 2.37 kN belonging to V = -0.63 kN
Max. bendig moment at post M_e = 1.53 kNm

The restraint post support in the ground features a plastic reserve of 66 %
M_{pl} = 9.0 kNm

Verification in lateral direction under wind loads:
Friction factor: f_r = 0,04 A_{fr} = 24,1 m² F_{fr} = 1,0 kN M_{fr} = 0,71 kNm σ_x = 2,04 kN/cm²

5 Verification of joints and connections

5.1 Anchorage of modules on the purlins and connection of the purlins to the girder

The notch ist designed in such a manner that the bolt in operating position is located approximately in the center of gravity of the net section. Therefore, only negligible bending portions arise.

The connection of the purlins to the girder feature clamp festeners.Due to limited standards for reliable calculations, the strength of the clamp fasteners has been evaluated by tests.

Fastening of modules to purlins	max F_z =	2.05 kN< P_{Rd} =	3.6	kN
Clamping of purlins to girders	max F_z =	7.87 kN< P_{Rd} =	11.0	kN

(strength of connections according to spec sheets from Schletter-Solarmontage GmbH)

5.2 Connection of the girder to the foundation post

The basical constructive feature of the construction is the design of the connection between the inclined girders and the post head of the ram driven profiles. The following technical requirements have to be considered:

- Transmission of forces in unfavourable distribution — Δz = ± 20 mm
- Compensation of tolerances caused by the pile driving of the support profiles — Δβ = ± 2°
- Tolerances in longitudinal and lateral direction — Δx = ± 15 mm

By means of a bolt, the girder is connected to an adjustable strut that is hooked in in the course of the mounting process. The height adjustment is realized using a slotted hole whose position is secured by corrugated plates and a corrugated structure of the connection profile. The utilization of the basic material is verified, the screws are verified regarding shearing-off and bearing stress.

Bolts for load transmission
M12 A2-70

Shearing-off bolts
V_{aRd} = 34.90 kN η = 77 %
Bearing resistance steel U-Profile
V_{lRd} = 25.92 kN η = 103 %
Bearing resistance steel Coil sheet
V_{lRd} = 26.40 kN η = 101 %

Connection binder/support

max N = 23.49 kN
max V = 1.05 kN

F_{sd} = 26.76 kN < 33 kN (test report) η = 81 %

Schletter GmbH

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http://www.solar.schletter.de/

Planning documentation for the bearing system FS-Duo 3V for solar modules

Project: 03 9600 Vlagtwedde- FS3V-Duo-10°-8 - Conergy Global Solutions GmbH

Module type: JAP6-72 4BB 1956 x 991 mm

By order of

Conergy Global Solutions GmbH

Bleichenbrücke 10
D-20354 Hamburg

May 2016

FS3V10°1956x991_8ZetaFG26x3

Design calculations (FS3V)
For mounting of photovoltaic modules in open areas

Project	**03 9600 Hoogezand - FS3V-Duo-10°-8 - Conergy Global Solutions GmbH** NL-9600 Hoogezand
Customer	Schletter GmbH Gewerbegebiet B15 Alustraße 1 D-83527 Kirchdorf/Haag in Oberbayern
Owner	Conergy Global Solutions GmbH Bleichenbrücke 10 D-20354 Hamburg
Design	Schletter GmbH Gewerbegebiet B15 Alustraße 1 D-83527 Kirchdorf/Haag in Oberbayern
Structural design	Dr. Zapfe GmbH Ingenieurbüro für konstruktiven Ingenieurbau und Solartechnik Gewerbegebiet B15 Alustraße 1 D-83527 Kirchdorf/Haag in Oberbayern

The design calculation contains the following pages:
Structural analysis: Pages 1 - 9
Annex

Date 19/05/2016

1 General

1.1 Project description

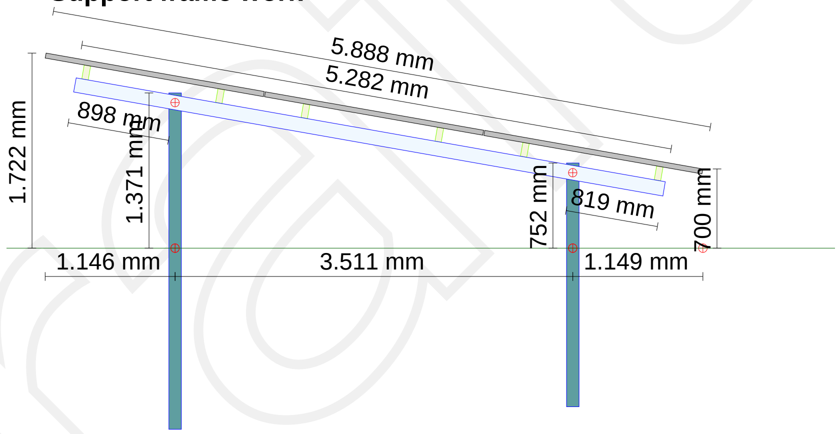
This static calculation contains the determination following sections contain the calculation of the internal forces and the verifications of structural safety of the load carrying construction, which is set up in an open area.
The location is
NL-9600 Hoogezand 53° 9' 42" North 6° 45' 40" East
Height above sea level < 2 m

1.2 Construction

The support-system ist an inclined construction, to which the solar modules are fixed with clamps. The purlins are positioned on the girders, which are supported in several joint locations.
The modules have the following dimensions:

h = 1956 mm b = 991 mm c = 45 mm

Support frame work



Modules per row x = 8
Number of rows: y = 3
Peak power of module 320.0 Wp
Total dimensions of a solar mounting unit

L = 8.09 m Support frame length
B = 5.80 m Projection of the PV body
H = 5.89 m Total panel height
h = 1.72 m Total body height

Module type JAP6-72 4BB
Size of facility 1.44 MWp
Number of support frames 188

Number of support sections 3
Number of fields 2
Girder span 2.87 m
Purlin cantilever 1.17 m On both sides
Inclination of modules towards horizontal β = 10°
Minimum height above ground level h_{min} = 70 cm

1.3 Technical codes

Ausführungsklasse EXC1

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- NEN-EN 1991-1-4/NA General actions - Wind actions
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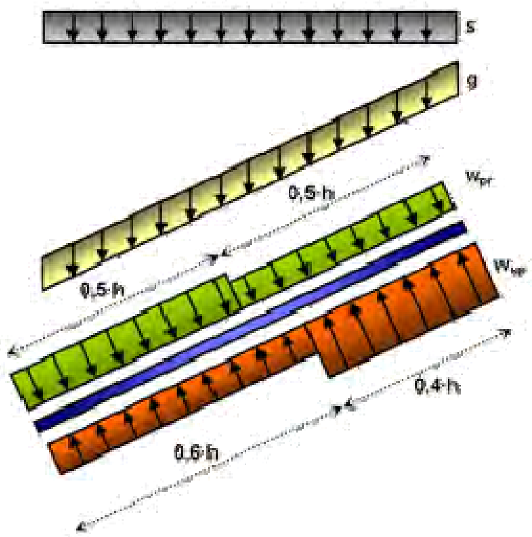
- NEN-EN ISO 14713 Zinc coatings. Guidelines and recommendations for the protection against corrosion of iron and steel in structures

2 Actions



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β	°	Inclination to the horizontal
g	kN/m²	According to NEN EN 1991-1
		According to manufacturers certificate
s	kN/m²	NEN EN 1991-1-3
w	kN/m²	NEN EN 1991-1-4
W	kN/m	NEN EN 1991-1-4

2.1 Permanent loads

g = 0.12 kN/m² Self-weight of solar modules according to manufacturer`s data/ certificate

2.2 Snow loads

Snow zone

s_k = 0.70 kN/m²

μ = 0.80

$s = s_k \cdot \mu$ = 0.56 kN/m²

2.3 Wind loads

Wind zone **2** Terrain category **II**

Height above ground z < 1.7 m

v_{ref} = 27.5 m/s

q_{ref} = 0.47 kN/m²

$q_{(z)}$ = 0.78 kN/m² (Peak velocity pressure)

Wind forces

Force coeffic. c_{f1} = 1.30

c_{f2} = -1.32

Top	$c_{p,net}$	=	1.60	Loading
	$c_{p,net}$	=	-1.80	Uplifting
Center	$c_{p,net}$	=	1.60	Loading
	$c_{p,net}$	=	-1.80	Uplifting
Bottom	$c_{p,net}$	=	1.60	Loading
	$c_{p,net}$	=	-1.80	Uplifting

Load increase in sidewise edge zones

$f_{Suction}$ = 1.28 On a length A/10

$f_{Pressure}$ = 1.00 On a length A/10

2.4 Action combinations

Partial safety factors for actions and resistance

Importance factor K_{FI} = 0.90

$\gamma_g = 1.35 \cdot 0.90 = 1.22$ $\quad\quad$ $\gamma_g = 0.90$ For favourable load action

$\gamma_q = 1.50 \cdot 0.90 = 1.35$

Combination coefficients $\quad$ $\Psi_{0,w} = 0.60$

$\Psi_{0,s} = 0.50$

For the verifications in the limit state of load-bearing capacity, the following load combination are examined:

LK 1: $\gamma_g \cdot g + \gamma_q \cdot s + \Psi_{0,w} \cdot \gamma_q \cdot w$

LK 2: $\gamma_g \cdot g + \Psi_{0,s} \cdot \gamma_q \cdot s + \gamma_q \cdot w$

LK 3: $0.9 \cdot g + \gamma_q \cdot w$ $\quad$ For lifting wind actions

3 Design calculations

3.1 Purlin

Steel purlins are applied for the transmission of the loads into the supporting elements. From a structural point of view, these are regarded as continuous beams with edge cantilevers. While producing and assembling these can be considered as beam with internal hinges and be jointed with splices in the specific gerber positions.

Material S350 GD $\quad$ f_{yk} = 35.0 kN/cm² $\quad$ $\gamma_M = 1.1$

f_d = 31.8

Profile Zeta

A = 5.0 cm²

W_y = 19.0 cm³

W_z = 4.5 cm³

I_y = 117.8 cm⁴

I_z = 12.2 cm⁴

g = 4.0 kg/m

Total length $\quad$ l_{ges} = 8.089 m $\quad$ β = 10°

a = 2.874 m $\quad$ $\sin\beta$ = 0.174

l_{kr} = 1.170 m $\quad$ $\cos\beta$ = 0.985

The load effects by wind and snow have to be positioned unfavourably span-wise for the determination of the internal forces. The calculation is performed using the factors for continous beams with equidistant spans.

$M_{1,Total\ load}$	$M_{1,Partial}$	$M_{B,Total\ load}$	$M_{B,Partial}$
0.041	0.058	-0.083	-0.010

Bending moment coefficients

$A_{Total\ load}$	$A_{Partial}$	$B_{Total\ load}$	$B_{Partial}$
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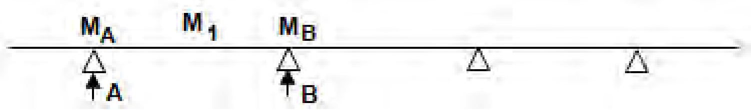
Force coeffic.

Permanent loads	$g_{k,z}$ = 0.151 kN/m	$g_{k,y}$ = 0.027 kN/m Incl. Profile
Snow loads	$s_{k,z}$ = 0.531 kN/m	$s_{k,y}$ = 0.094 kN/m
Wind load (pressure)	$W_{k,D}$ = 5.999 kN/m	$w_{k,D}$ = 1.226 kN/m
Wind load (suction)	$W_{k,Z}$ = -6.092 kN/m	$w_{k,Z}$ = -1.380 kN/m

Inner purlin



LK 1	$M_{1,y}$ = 0.939 kNm	$M_{1,z}$ = 0.076 kNm
LK 2	$M_{1,y}$ = 1.095 kNm	$M_{1,z}$ = 0.043 kNm
LK 3	$M_{1,y}$ = -0.909 kNm	$M_{1,z}$ = 0.008 kNm
LK 1	$M_{A,y}$ = 1.297 kNm	$M_{A,z}$ = 0.109 kNm
LK 2	$M_{A,y}$ = 1.505 kNm	$M_{A,z}$ = 0.065 kNm
LK 3	$M_{A,y}$ = -1.536 kNm	$M_{A,z}$ = 0.016 kNm
LK 1	$M_{B,y}$ = -1.601 kNm	$M_{B,z}$ = -0.131 kNm
LK 2	$M_{B,y}$ = -1.862 kNm	$M_{B,z}$ = -0.077 kNm
LK 3	$M_{B,y}$ = 1.510 kNm	$M_{B,z}$ = -0.021 kNm
LK 1	A = 2.722 kN	A_h = 0.228 kN
LK 2	A = 3.159 kN	A_h = 0.128 kN
LK 3	A = -2.481 kN	A_h = 0.035 kN
LK 1	B = 6.064 kN	B_h = 0.502 kN
LK 2	B = 7.047 kN	B_h = 0.298 kN
LK 3	B = -5.634 kN	B_h = 0.069 kN

Stress verification of purlin profiles

	max M_y	σ_x	max M_z	σ_x	$\Sigma\sigma_x$		η %
LK 1	1.60	8.44	0.13	2.90	11.34	kN/cm²	35.6
LK 2	1.86	9.82	0.08	1.70	11.51	kN/cm²	36.2
LK 3	1.54	8.10	0.02	0.46	8.55	kN/cm²	26.9

Verification format

$$\frac{M_y}{W_y} + \frac{M_z}{W_z} \leq f_d$$

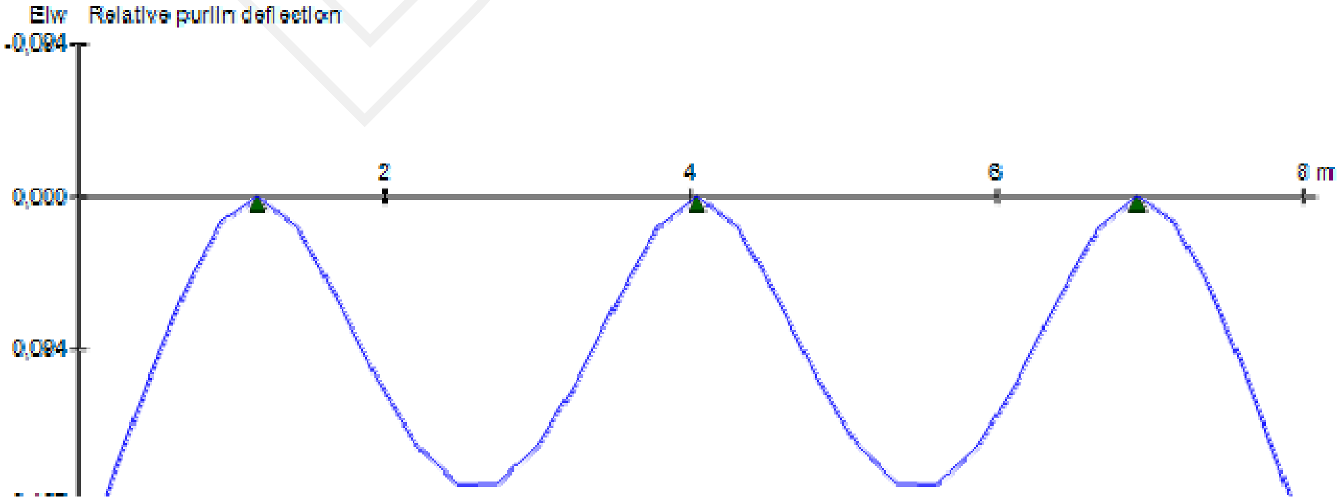
Deflections of purlins perpendicular to the module plane

Youngs modulus E = 21000 kN/cm²
Moment of inertia I_y = 117.80 cm⁴
Span deflections: Elw = 0.1760
Cantilever deflections: Elw = 0.2308

EI = 247.38 kN/m²

Self weight	Snow	Wind pressure	Uplift	
0.108	0.38	4.27	-4.33	mm
0.141	0.50	5.60	-5.68	mm

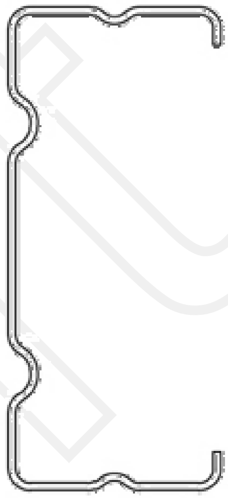
LK1:	3.05 mm (a / 943)		3.99 mm	(a_{kr} / 293)	relativ
LK2Midspan	4.57 mm (a / 630)	Cantilever	5.99 mm	(a_{kr} / 195)	(a_{kr} / 289)
LK3:	-4.23 mm (a / 680)		-5.54 mm	(a_{kr} / 211)	



3.2 Verification of cross beams

The transfer of the load components from purlins into the centrically positioned post follows an inclined girder, which ist fixed at the ram driven steel section with trapezoidal shape. The load actions on the girder result from the support reaction of the purlins. For the determination of forces unfavourable onesided acting variable loadings have to be applied.

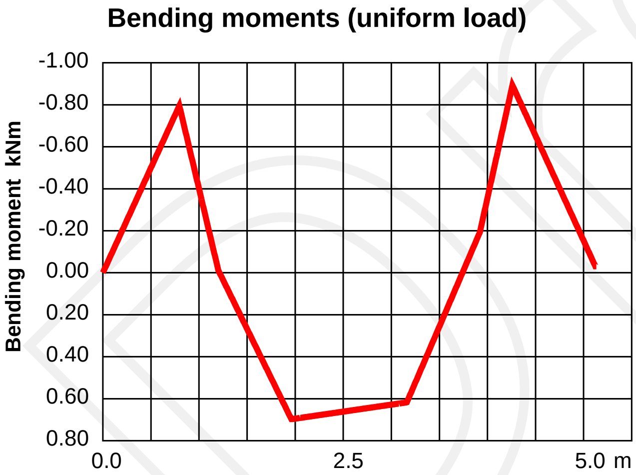
Cross beam profile Extruded profile Eta

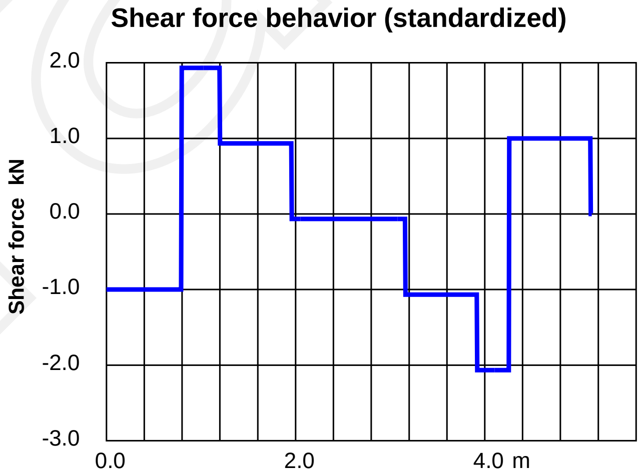


Material S500 GD f_{yk} = 50.0 kN/cm²
f_d = 45.5 kN/cm²

A = 5.05 cm²
W_y = 19.59 cm³
W_z = 4.31 cm³
I_y = 124.82 cm⁴
I_z = 16.87 cm⁴
g = 3.96 kg/m

Shapes of initial force variables with uniform concentrated load F ="1" at purlin connections





Total girder length l_R = 5.13 m
Factor for moment in span f_F = 0.70
Factor for moment at support f_S = -0.80 (Left) f_S = -0.89 (Right)
Shear force factor f_V = 3.07
Joint eccentricity of girder e_z = 20 mm

For determination of the internal force variables of the substructure the wind forces have to be positioned as a concentrated load in the quarter points of the module surface.
Hence are resulting two load postions of wind forces in each load combination. According to this 6 load combinations have to be evaluated for determination of the decisive loading.

Internal forces at the support construction	Load combination 1		Load combination 2		Load combination 3		
	Frontal	Rear	Frontal	Rear	Frontal	Rear	
Maximum of axial force	1.58		2.64		-3.73		kN
Eccentricity moment M_{ez}	0.03		0.05		-0.07		kNm
Max mid-span bending moment	4.23		4.91		-3.93		kNm
Max. moment at support left	-4.82		-5.61		4.48		kNm
Max. moment at support right	-5.41		-6.29		5.03		kNm
Vertical supporting force of the support	16.21	0.79	18.75	-7.21	-9.12	-16.80	kN
Horizontal supporting force of the support	2.28	0.45	3.80	0.75	-3.87	-0.75	kN
Mid-span stresses	21.90		25.61		-19.32		kN/cm²
Stresses moment at support left	-24.62		-28.61		23.62		kN/cm²
Stresses moment at support right	-27.64		-32.12		26.42		kN/cm²

Max mid-span bending moment $M_F = \max(A;B) \cdot f_F + M_{ez} = 7.05 \cdot 0.70 + 0.05 = 4.97$ kNm
Max. moment at support left $M_S = \max(A;B) \cdot f_S - M_{ez} = 7.05 \cdot -0.80 - 0.00 = -5.61$ kNm
Max. moment at support right $M_S = \max(A;B) \cdot f_S - M_{ez} = 7.05 \cdot -0.89 - 0.00 = -6.29$ kNm

Verification $\frac{N}{A} + \frac{M}{W_y} \leq f_d$

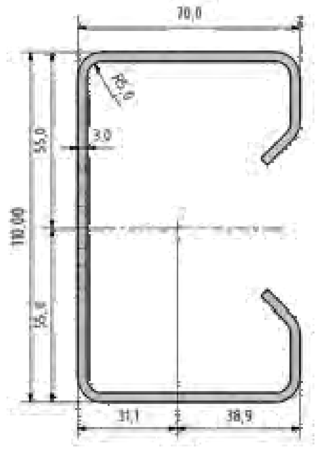
Maximum stress max $\sigma_x = 32.12$ kN/cm² Utilization ratio 71 %

Mounting system

Front support is connected at 16 % of the planned girder length
Rear support Is connected at 83 % Of the planned girder length

4 Verification of ram driven posts

The construction of the post ist planned by using a steel sheet with a trapazoidal shape, which is ram driven in ground with defined depth. This item affords soil examinations and eventually loading tests to evaluate the transferable forces.



Profile parameters SRF 6

b_f = 70 mm
h = 110 mm
t = 3 mm
A = 9.18 cm²
W_y = 30.23 cm³
I_y = 166.28 cm⁴
g = 7.10 kg/m

Material properties S380

$f_{y,k}$ = 38.00 kN/cm²
γ_M = 1.1
$f_{y,d}$ = 34.55 kN/cm²
σ_x = 12.84 kN/cm²

Utilization ratio η = 37 %

Non usable soil layer t = 0 cm
Estimated anchoring depth rear t_{soil} = 160 cm
Estimated anchoring depth frontal t_{soil} = 140 cm

Initial forces at bottom fixed support	Load combination 1		Load combination 2		Load combination 3		
	Frontal	Rear	Frontal	Rear	Frontal	Rear	
Axial force at fixed support	15.22	1.55	18.30	-4.70	-8.88	-15.67	kN
Shear force at fixed support	2.03	0.45	3.80	0.75	-3.87	-0.75	kN
Resulting for screw verification	15.36	1.61	18.69	4.76	9.68	15.69	kN
Cantilever moment	1.75	0.66	3.28	1.09	-3.34	-1.10	kNm
Stress verification	7.45	2.34	12.84	4.12	12.01	5.34	kN/cm²

Front support
Max. tensile loads on support N_{max} = 8.88 kN belonging to V = 3.87 kN
Max. compression force at post N_{min} = 18.30 kN belonging to V = -2.03 kN
Max. bendig moment at post M_e = 3.28 kNm

Rear support
Max. tensile loads on support N_{max} = 15.67 kN belonging to V = 0.75 kN
Max. compression force at post N_{min} = 1.55 kN belonging to V = -0.45 kN
Max. bendig moment at post M_e = 1.09 kNm

The restraint post support in the ground features a plastic reserve of 66 %
M_{pl} = 9.0 kNm

Verification in lateral direction under wind loads:
Friction factor: f_r = 0,04 A_{fr} = 16,9 m² F_{fr} = 0,7 kN M_{fr} = 0,50 kNm σ_x = 1,44 kN/cm²

5 Verification of joints and connections

5.1 Anchorage of modules on the purlins and connection of the purlins to the girder

The notch ist designed in such a manner that the bolt in operating position is located approximately in the center of gravity of the net section. Therefore, only negligible bending portions arise.

The connection of the purlins to the girder feature clamp festeners.Due to limited standards for reliable calculations, the strength of the clamp fasteners has been evaluated by tests.

Fastening of modules to purlins	max F_z =	2.05	kN< P_{Rd} =	3.6	kN
Clamping of purlins to girders	max F_z =	5.63	kN< P_{Rd} =	11.0	kN

(strength of connections according to spec sheets from Schletter-Solarmontage GmbH)

5.2 Connection of the girder to the foundation post

The basical constructive feature of the construction is the design of the connection between the inclined girders and the post head of the ram driven profiles. The following technical requirements have to be considered:

- Transmission of forces in unfavourable distribution — $\Delta z = \pm 20$ mm
- Compensation of tolerances caused by the pile driving of the support profiles — $\Delta\beta = \pm 2°$
- Tolerances in longitudinal and lateral direction — $\Delta x = \pm 15$ mm

By means of a bolt, the girder is connected to an adjustable strut that is hooked in in the course of the mounting process. The height adjustment is realized using a slotted hole whose position is secured by corrugated plates and a corrugated structure of the connection profile. The utilization of the basic material is verified, the screws are verified regarding shearing-off and bearing stress.

Bolts for load transmission
M12 A2-70

Shearing-off bolts
V_{aRd} = 34.90 kN η = 55 %
Bearing resistance steel U-Profile
V_{lRd} = 25.92 kN η = 74 %
Bearing resistance steel Coil sheet
V_{lRd} = 26.40 kN η = 72 %

Connection binder/support

max N = 16.80 kN
max V = 0.75 kN

F_{sd} = 19.13 kN < 33 kN (test report) η = 58 %

For USA Market

Datasheet
Crystalline PV Module
ASM6610P Series

240	245	250	255	260	265

EN

ELECTRICAL SPECIFICATIONS [1]

STC [2] rated output (P_{mpp})	240 Wp	245 Wp	250 Wp	255 Wp	260 Wp	265 Wp
Standard sorted output	-0/+5W					
Warranted power output STC ($P_{nominal}$)	240 Wp	245 Wp	250 Wp	255 Wp	260 Wp	265 Wp
Rated voltage (V_{mpp}) at STC	29.86 V	30.12 V	30.38 V	30.64 V	30.90 V	31.16 V
Rated current (I_{mpp}) at STC	8.10 A	8.20 A	8.29 A	8.39 A	8.48 A	8.57 A
Open circuit voltage (V_{oc}) at STC	36.45 V	36.78 V	37.12 V	37.45 V	37.78 V	38.12 V
Short circuit current (I_{sc}) at STC	8.59 A	8.68 A	8.76 A	8.85 A	8.93 A	9.01 A
Module efficiency	14.67%	14.98%	15.28%	15.59%	15.98%	16.20%
Rated output (P_{mpp}) at NOCT [3]	178.7 Wp	182.3 Wp	186.0 Wp	189.6 Wp	193.4 Wp	197.3 Wp
Rated voltage (V_{mpp}) at NOCT	27.83 V	28.07 V	28.31 V	28.56 V	28.80 V	28.90 V
Rated current (I_{mpp}) at NOCT	6.42 A	6.49 A	6.57 A	6.64 A	6.72 A	6.89 A
Open circuit voltage (V_{oc}) at NOCT	34.63 V	34.94 V	35.26 V	35.58 V	35.89 V	36.20 V
Short circuit current (I_{sc}) at NOCT	6.88 A	6.94 A	7.01 A	7.08 A	7.14 A	7.21 A

Temperature coefficient (P_{mpp})	- 0.42 % / K
Temperature coefficient (I_{sc})	+0.059 % / K
Temperature coefficient (V_{oc})	- 0.32 % / K
Normal operating cell temperature (NOCT)	46 °C ±2 °C

Maximum system voltage	1000 V_{DC}
Number of diodes	3
Reverse current loadability (IR)	20 A
Maximum series fuse rating	15 A

[1] Measuring uncertainty Pmpp: +/–3 %; Tolerance for Voc, Isc, Vmpp and Impp: +/–10 %
[2] Standard test conditions that are defined as follows:
1.000 W/m² irradiation at a spectral density of AM 1.5 and a cell temperature of 25° C,
[3] Nominal operating temperature of the cell at 800 W/m² irradiation, 20°C ambient temperature, wind speed of 1 m/s
[4] Manufactured in an UL 1703 certified facility

4

Made in Germany

A CHINT COMPANY

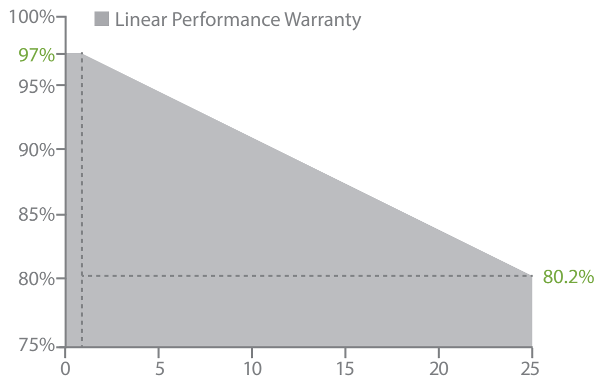
ASTRONERGY

RELATED PARAMETERS

Cell type	Polycrystalline cell, 3-busbar technology
Number of cells / cell arrangement	60 / 6 x 10
Cells dimension	156 x 156 mm²

QUALIFICATION AND LINEAR WARRANTIES

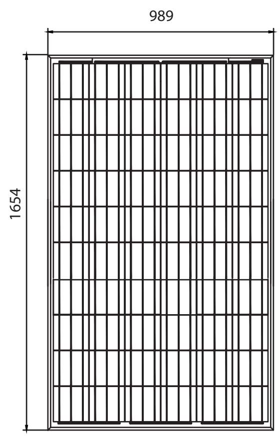
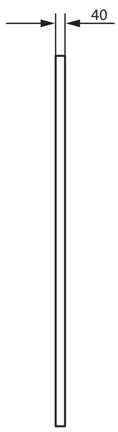
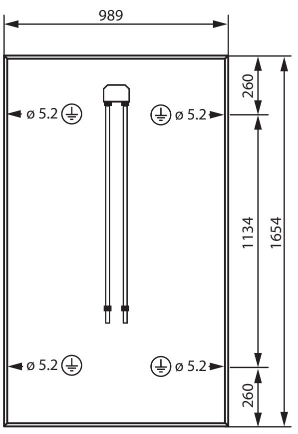
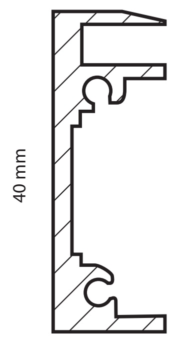
Product standard	UL ANSI/UL1703
Extended product warranty [6]	10 years
Performance warranty [6]	Linear performance warranty
Year 1	>97 % of warranted output power
Year 25	>80 % of warranted output power



MECHANICAL SPECIFICATIONS

Outer dimensions (L x W x H) [5]	1654 x 989 x 40 mm
Frame technology	Aluminum, silver anodized
Module composition	Glass / EVA / Backsheet (white)
Weight (module only)	18.2 kg
Front glass thickness	3.2 mm
Junction box IP rating	IP 67
Cable length (UL)	1000 mm
Cable diameter (UL)	12 AWG
Maximum load capacity	6000 Pa
Fire performance	Type 2
Connector type (UL)	MC4 pluggable

MODULE DIMENSION DETAILS

Front view	Side view	Rear view	Frame cross section
		 ◎ No mounting holes on the frame.	

[5] Dimensional tolerance: +/–2 mm
[6] According to the current warranty conditions of Astronergy Solarmodule GmbH