

ABB SOLAR INVERTERS

# Quick Installation Guide

PVS-166/175-TL-US  
(166.5 to 185 kW)



BCM.V3102.1





## **IMPORTANT SAFETY INSTRUCTIONS**

This manual contains important safety instructions that must be followed during the installation and maintenance of the equipment.



## **SAVE THESE INSTRUCTIONS**

Keep this document in a safe place near the inverter for easy access during installation, operation and maintenance.

The installer must read this document in its entirety before installing or commissioning this equipment.

In addition to what is explained below, the safety and installation information provided in the installation manual must be read and followed.



For more detailed information regarding proper installation and use of this product, refer to the product manual located at [www.abb.com/solarinverters](http://www.abb.com/solarinverters).

The device must be used in the manner described in the manual. If this is not the case the safety devices guaranteed by the inverter might be ineffective.



This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

- (1) this device may not cause harmful interference
- (2) this device must accept any interference received, including interference that may cause undesired operation.



All pictures and illustrations shown in this document are indicatives and must be intended as support for installation instruction only. Actual product may vary due to product enhancement. Specifications subject to change without notice. The latest version of this document is available on the ABB website.

---

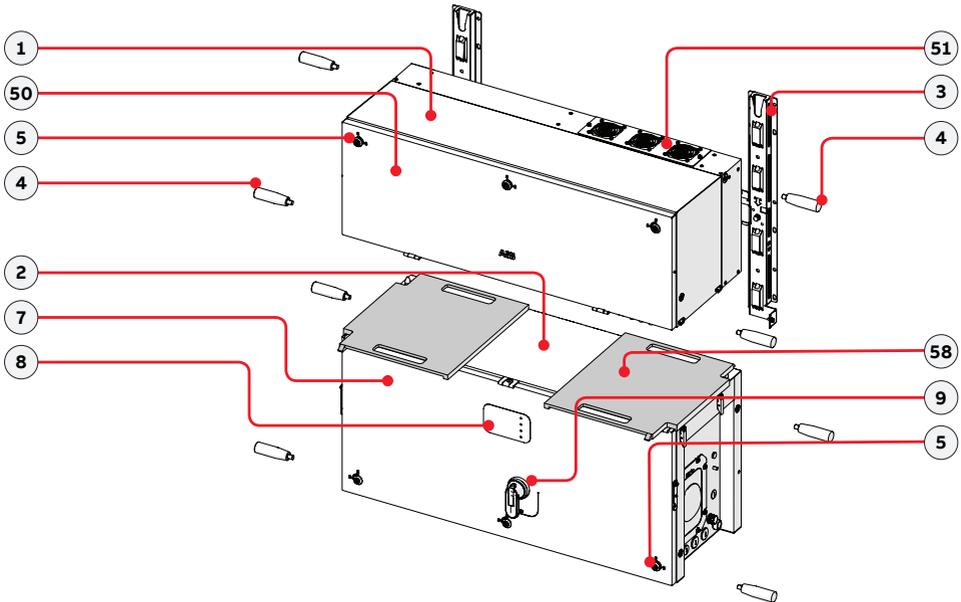
## Table of contents

|           |   |
|-----------|---|
| <b>2</b>  | <b>Reference number index</b>   |
| <b>5</b>  | <b>Models and range of equipment</b>  |
| <b>6</b>  | <b>Labels and Symbols</b>   |
| <b>7</b>  | <b>Lifting and transport</b>  |
| <b>10</b> | <b>List of supplied components</b>  |
| <b>10</b> | <b>Kit of recommended spare parts</b>   |
| <b>11</b> | <b>Choice of installation location</b>  |
| <b>14</b> | <b>Mounting Instruction</b>   |
| <b>24</b> | <b>Routing the cable to the inverter</b>                                      |
| <b>25</b> | <b>Installation planning</b>  |
| <b>26</b> | <b>Grid output connection (AC side)</b>                                       |
| <b>27</b> | <b>Checking the correct polarity of the strings and Input connection (DC)</b> |
| <b>29</b> | <b>Connection of the communication and control signals</b>                    |
| <b>33</b> | <b>Description of LED panel</b>   |
| <b>35</b> | <b>Commissioning</b>  |
| <b>36</b> | <b>Arc fault detection</b>  |
| <b>37</b> | <b>Grid support functions and Voltage &amp; Frequency trip limits</b>         |
| <b>38</b> | <b>Technical data table</b>   |

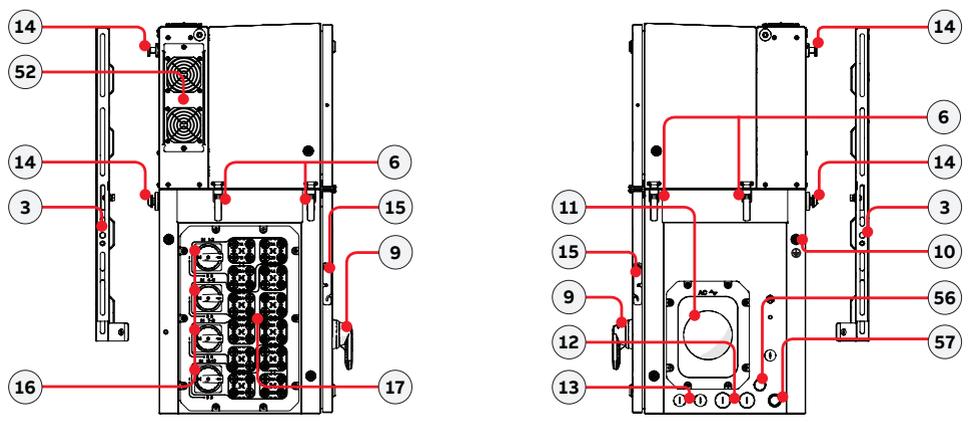
## Reference number index

|  |  |  |
|--|--|--|
| 01 Power module                        | 19 ARC fault connector                             | 38 Remote ON/OFF terminal block                        |
| 02 Wiring box                          | 20 Junction screws                                 | 39 RS485 line terminal block                           |
| 03 Mounting bracket                    | 21 DC surge arrester plate                         | 40 Ethernet connector 1 (RJ45)                         |
| 04 Handles                             | 22 AC connection busbar                            | 41 Ethernet connector 2 (RJ45)                         |
| 05 Cover quarter cam locks             | 23 AC overvoltage surge arresters                  | 42 USB connector                                       |
| 06 Side latch                          | 24 Interface signal cables                         | 44 CR2032 coin battery                                 |
| 07 Wiring box front cover              | 25 AC interface power board                        | 45 Memory board  |
| 08 LEDs panel                          | 26 Interface Protective Earth connection point     | 46 RS485 line communication board                      |
| 09 AC disconnect switch (-SX2 only)    | 27 AC protective shield                            | 50 Power module front cover                            |
| 10 EGC connection point                | 28 Communication and control board                 | 51 Cooling section (top side)                          |
| 11 AC opening (size 3" conduit)        | 29 DC interface connection point                   | 52 Cooling section (left side)                         |
| 12 Service opening (size 3/4" conduit) | 31 Interface signal connector                      | 53 Internal fan  |
| 13 Service opening (size 1/2" conduit) | 32 AC interface power cable                        | 54 Cable duct  |
| 14 Rear pins for bracket assembly      | 33 Alarm terminal block                            | 55 Protective earth connection point                   |
| 15 Cover support brackets              | 34 RS485 ABB service 120Ohm termination res.       | 56 RS-485&Rem.ON/OFF external connector (Service only) |
| 16 DC disconnect switches              | 35 DRMO activation switch                          | 57 AFD reset button                                    |
| 17 DC input quick fit connectors       | 36 RS485 line 120Ohm termination res.              | 58 Gasket protective cover                             |
| 18 DC and ARC fault interface cables   | 37 ABB RS485 service RJ45 connector (service only) | 59 AFD interface cable                                 |

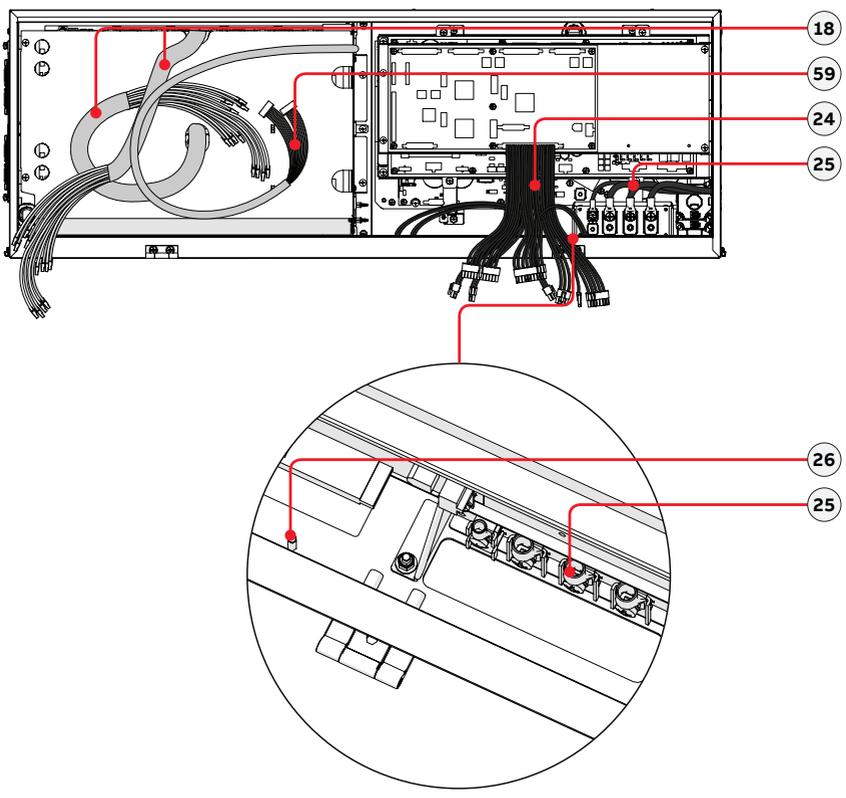
### PVS-166/175-TL-US - External view



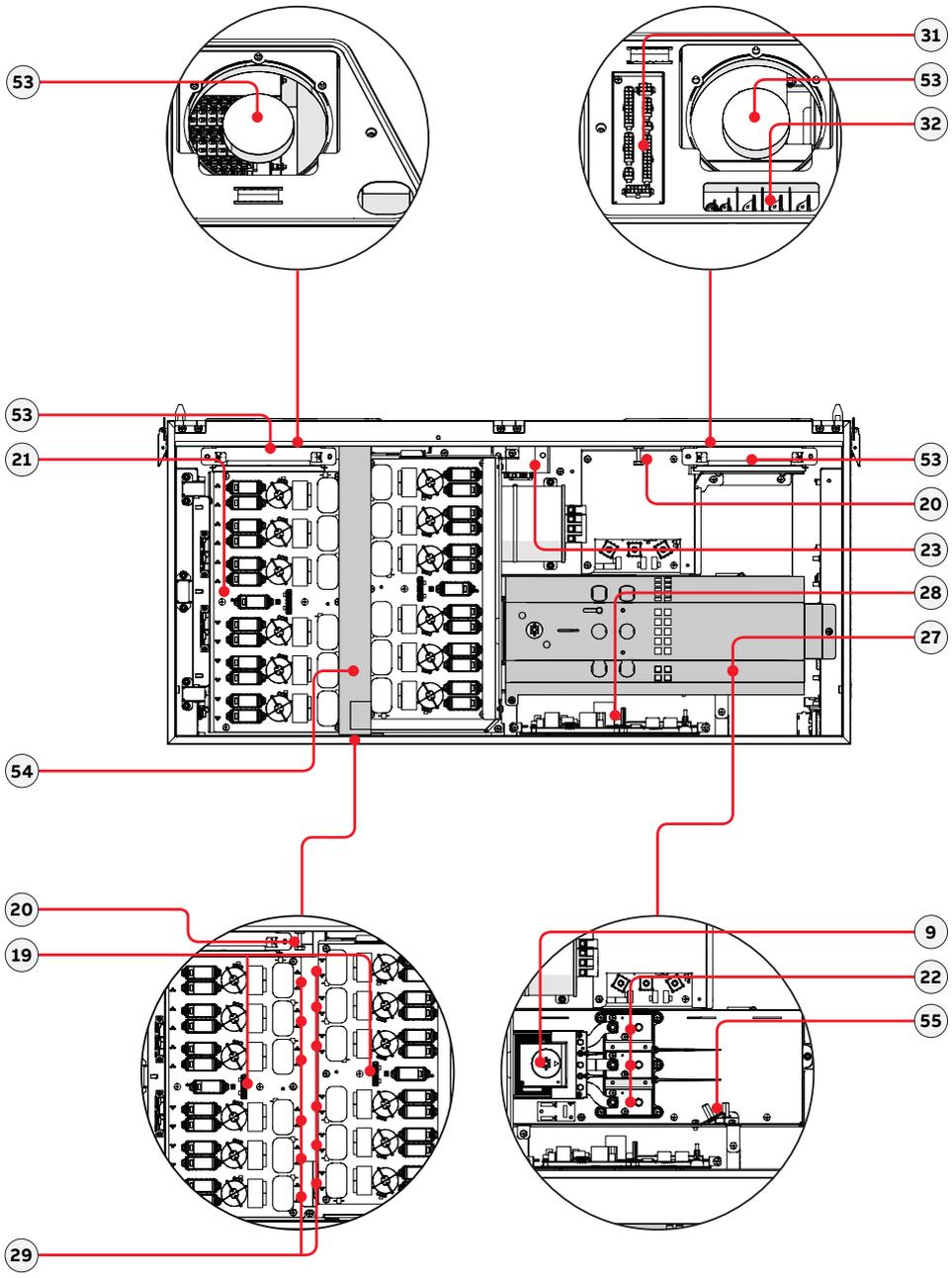
PVS-166/175-TL-US - External sides view



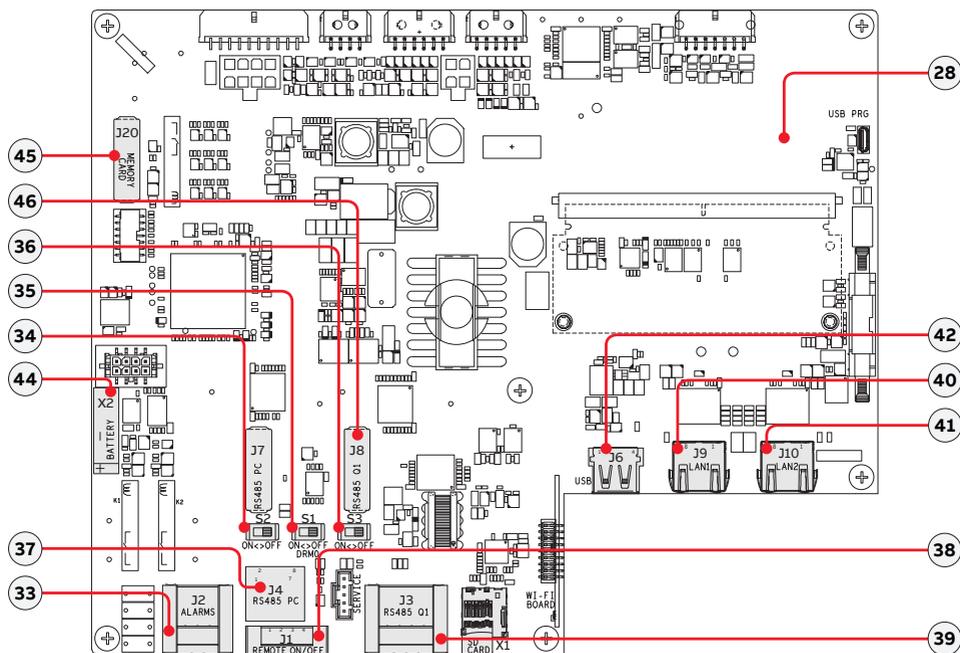
PVS-166/175-TL-US Power module- Internal view



PVS-166/175-TL-US Wiring box- Internal view

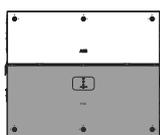
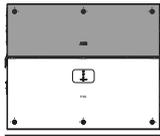


PVS-100/120-TL “B version” - Communication board (28)



## Models and range of equipment

 The choice of the inverter model must be made by a qualified technician who knows about the installation conditions, the devices that will be installed outside the inverter and possible integration with an existing system.

| "Wiring box" Model Number  |  | Description   |
|--|--|---|
|  | WB-SX-PVS-166-TL-US<br>WB-SX-PVS-175-TL-US   | <ul style="list-style-type: none"> <li>• 24 quick fit connector pairs (2 each MPPT)</li> <li>• DC switches</li> <li>• SPD Type 2 Pluggable Cartridges (DC &amp; AC)</li> </ul>                                    |
|  | WB-SX2-PVS-166-TL-US<br>WB-SX2-PVS-175-TL-US | <ul style="list-style-type: none"> <li>• 24 quick fit connector pairs (2 each MPPT)</li> <li>• DC switches</li> <li>• AC disconnection switch</li> <li>• SPD Type 2 Pluggable Cartridges (DC &amp; AC)</li> </ul> |
| "Power module" Model Number  |  | Description   |
|  | PVS-166-TL-POWER MOD-<br>ULE                 | Inverter section / power module with 166kW output power   |
|  | PVS-175-TL-POWER MODULE                      | Inverter section / power module with 175kW output power   |
| "Bracket" Model Number   |  | Description   |
|  | PVS-175-TL-BRACKET                           | Bracket allowing vertical installation only.  |

## Labels and Symbols

The labels on the inverter carry the markings, main technical data and identification of the equipment and manufacturer.

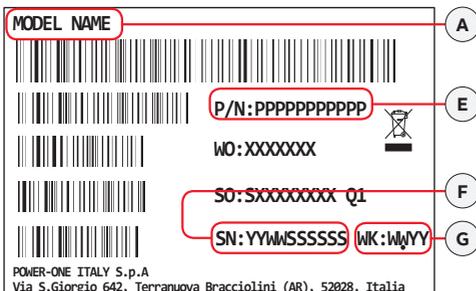
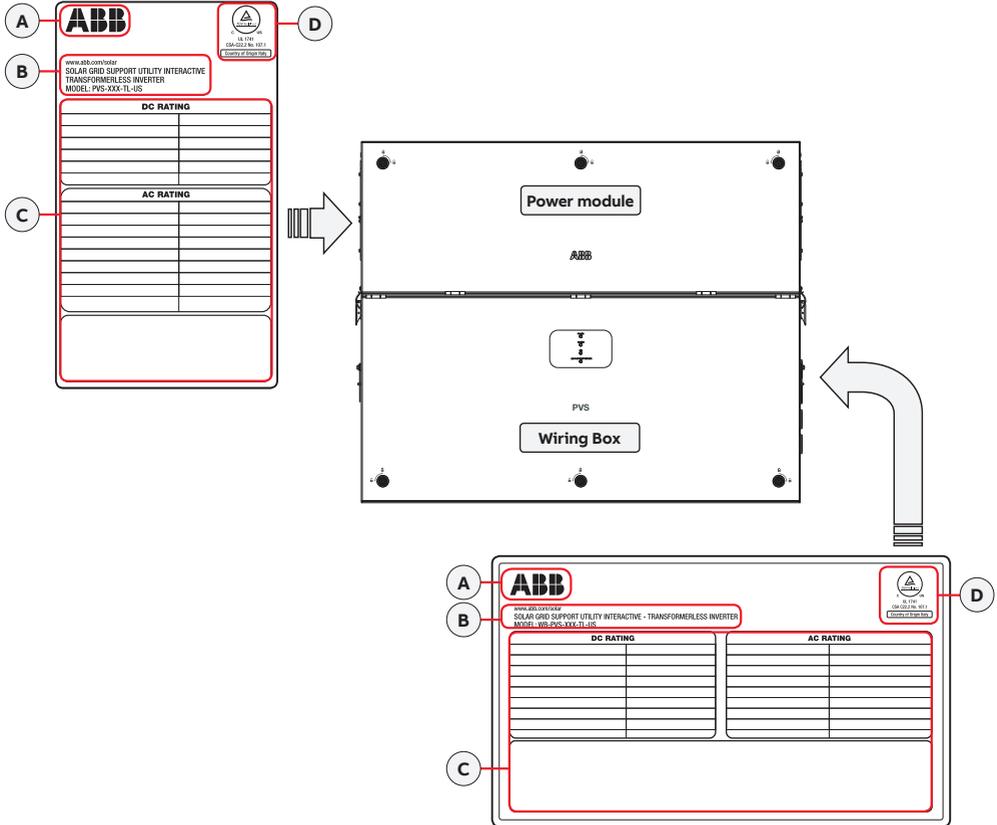


**The technical data shown in this quick installation guide does not replace that shown on the labels attached to the equipment.**

The labels on the power module and on the wiring box have the Agency marking, main technical data and identification of the equipment and manufacturer



**The labels shown below have to be intended as example only.**



**A** Manufacturer

**B** Inverter/wiring box model

**C** Main technical data

**D** Certification marks

**E** Power module/wiring box Part Number

**F** Power module/wiring box Serial Number

**G** Week/Year of manufacture

**Communication Identification label:**

The Communication Identification label (applied on the wiring box) is divided in two separate parts by a dashed line; take the bottom part and apply it on the plant documentation (ABB recommend to create a plant map and apply the Communication Identification label on it).



- I WLAN embedded board Serial Number
- J WLAN embedded board Part Number
- MAC address:
  - To be used to obtain the SSID of the wireless access point created by the inverter: ABB-XX-XX-XX-XX-XX-XX(where "X" is a hex digit of the MAC address).
- K - To be used to obtain the "Host Name": http://ABB-XX-XX-XX-XX-XX.local (where "X" is a hex digit of the MAC address).
  - MAC address is the only required information to register the inverter with Aurora Vision.
- L To be used to commission inverter using ABB Installer for Solar Inverters for claiming process.
- I Product Key: to be used as wireless access point password, or to be used to access to the Web UI as username and password in case of lost credentials, and to commission inverter using ABB Installer for Solar Inverters.

**The labels attached to the equipment must NOT be removed, damaged, dirtied, hidden, etc...**  
 If the Admin Plus password is requested, the field to be used is the power module serial number -SN: YYWSSSSSS-

In the manual and/or in some cases on the equipment, the danger or hazard zones are indicated with signs, labels, symbols or icons.

|  |   |  |  |  |                                |
|--|---|--|--|--|--------------------------------|
|  | These are nationally recognized test laboratory marks showing certification to UL 1741 and CSA-C22 No. 107.1-01 |  | General warning - Important safety information |  | Stored energy discharge time   |
|  | General warning - Important safety information  |  | Hazardous voltage                              |  | Hot parts                      |
|  | Positive pole and negative pole of the input voltage (DC)   |  | Direct and alternating currents, respectively  |  | Phase                          |
|  | System earth conductor (main grounding protective earth, PE) and Equipment Grounding Conductor (EGC)            |  | Equipment Grounding Conductor (EGC)            |  | Without insulation transformer |

## Lifting and transport

**Transport and handling**

Transportation of the equipment, especially by road, must be carried out using appropriate vehicles and methods to protect the components (particularly electronic components) from violent shocks, humidity, vibration, etc.

**Unpacking and checking**

The components of the packaging must be disposed on in accordance with the regulations in force in the country of installation. When you open the package, check that the equipment is undamaged and make sure all the components are present. If you find any defects or damage, stop unpacking and consult the carrier, and also promptly inform the Service ABB.

**Equipment weight**

| Device       | Weight (kg/lb)    | Lifting points | Holes for handles (optional) or Eyebolts UNI2947 (not supplied) |
|--------------|-------------------|----------------|---|
| Power module | 76.5 kg / 168 lbs | 4              | M8. Kit of handles (04) (to be ordered)                         |
| Wiring box   | 76.8 kg / 169 lbs | 4              | M8. Kit of handles (04) (to be ordered)                         |

## Lifting



### Risk of injury due to the heavy weight of the equipment!

ABB usually stores and protects individual components by suitable means to make their transport and subsequent handling easier. Nonetheless, as a rule, it is necessary to turn to the experience of specialised staff to take charge of loading and unloading components. The power module and the wiring box must be lifted using the 4 handles **(04)** (to be ordered) or alternatively using suitable lifting equipment.

The means used for lifting must be suitable to bear the weight of the equipment.



### In case of manual lifting the number of required operators necessary to lift the equipment must be in accordance to local regulations relating lifting limits per operator

The handles **(04)** must be mounted into the designated holes located on the enclosures.

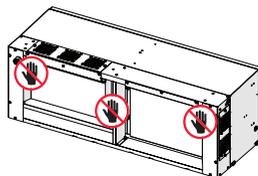
If lifting with ropes, M8 eyebolts can be mounted in the same holes.

**Handling and installation operations shall be performed only by using the special tools and accessories provided with "PVS-175 INSTALLATION KIT" that have to be ordered separately. The use of these equipment are mandatory to safely install the inverter. Refer to "Kit of recommended spare parts" chapter content in the product manual for further information.**



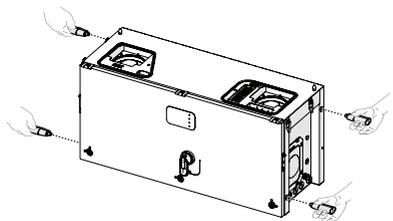
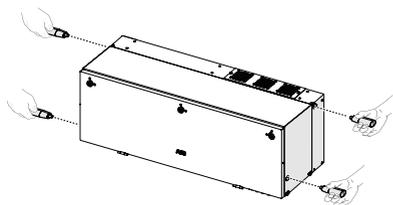
### DO NOT grab the equipment from the rear flange!

Risk of injury due to cutting surfaces and risk of equipment damage. Always use proper lifting equipment!



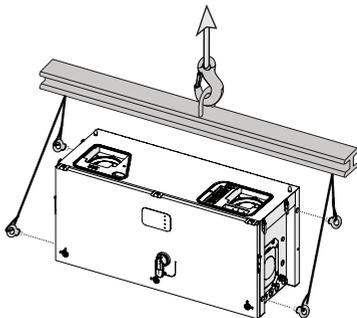
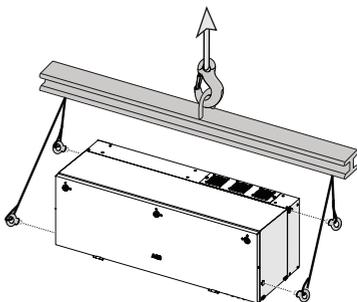
It is required to use one of the following lifting methods to move the equipment during installation or maintenance phases:

#### Manual lifting (handles)



M8. Kit of handles **(04)** (to be ordered)

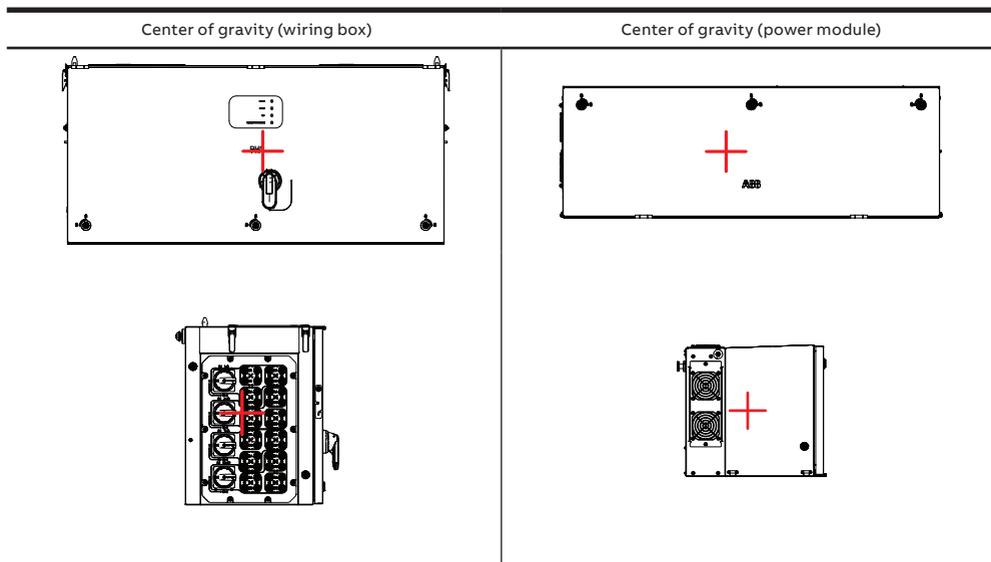
#### Vertical lifting (eyebolts and lifting balancer)



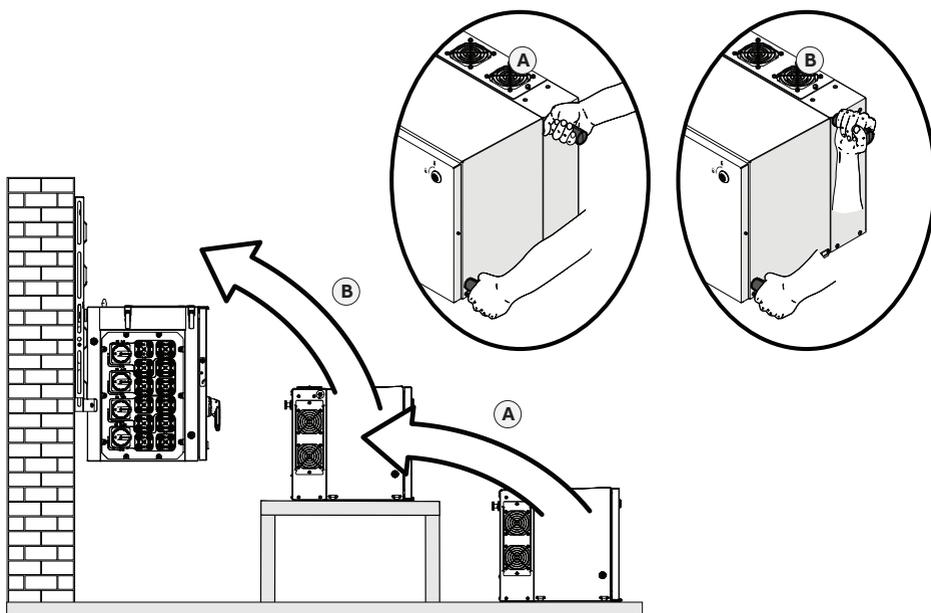
M8. Hole for Eyebolts UNI2947 (not supplied) \*lifting balancer must be 20 cm / 8" longer (per side) than the lifted device.



Always consider the center of gravity of the enclosures while lifting.



In case of manual lifting it's suggested to use a support plan (e.g. a table) to place the equipment during the lifting operation, to allow the change of hands position.



## List of supplied components

### Available components for power module (01) Q.ty

|  |  |     |
|--|--|-----|
|  | M6 bolts with washers for AC interface power cable connection point (phases)   | 3   |
|  | M5 bolts with washers for AC interface power cable connection point (MID BULK) | 1   |
|  | M5 nut and washers for protective earth point interface cable (26)             | 1+2 |
|  | Sheathing for DC interface cables 18   | 2   |

### Available components for bracket (03) Quantity

|  |  |   |
|--|--|---|
|  | M8 screws with washers for mechanically securing the half-brackets | 2 |
|  | M6 screws for mechanically securing the wiring box to the bracket  | 2 |

### Available components for wiring box (02) Q.ty

|   |   |       |
|---|---|-------|
|  | Multifunction and aux relay (33) connector (pre-installed on communication board (28))  | 2     |
|  | Remote ON/OFF (38) and RS485 (39) connector (pre-installed on communication board (28)) | 3     |
|  | M8 bolt and washers for EGC connection point (10)                                       | 1+1+1 |
|  | Key tool for front cover quarter cam-lock   | 1     |
|  | Technical documentation   | -     |

## Kit of recommended spare parts

| Code                     | Description   | Q.ty  |
|--------------------------|---|---|
| PVS-175 INSTALLATION KIT | Kit of handles 04   |  4                   |
|                          | M8 to M12 thread adapter  |  4                 |
|                          | Gasket protective covers (temporary installation)   |  2                 |
|                          | PV quick fit connector 17 disconnection tool  |  1                 |
|                          | IP65 protection covers protection covers for wiring box openings (long term installation) with screws |  2 (with 8 screws) |
| EYEBOLTS KIT             | Eyebolts for lifting  |  4                 |
| PVS-175 IP65 COVERS KIT  | IP65 protection covers protection covers for wiring box openings (long term installation) with screws |  2 (with 8 screws) |

| Code                                     | Description  | Q.ty  |
|--|--|---|
| KIT MC4 EVO mating part (complete)       | Quick fit connectors cable mating kit (24 couples)   | 24 female<br>24 male                              |
| KIT MC4 EVO mating part (single channel) | Quick fit connectors cable mating kit (2 couples)  | 2 female<br>2 male                                |
| PVS-175 FAN KIT                          | 1 external fan sets for power module (DC/DC),<br>1 external fan sets for power module (AC/DC),<br>2 internal air circulating fans for wiring box | 2 external fan sets<br>2 internal wiring box fans |

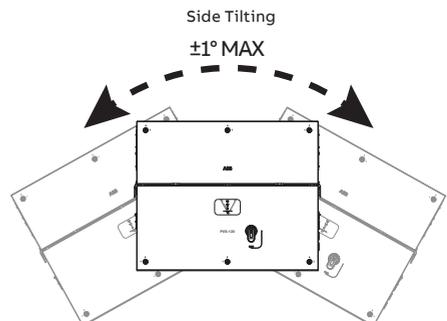
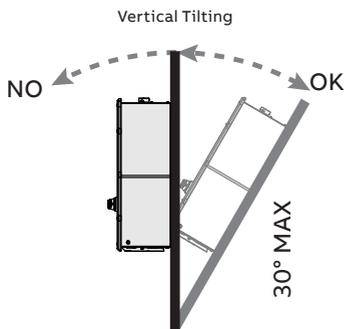
## Choice of installation location

### General recommendation on installation position

- See characteristics and technical data paragraph to check the required environmental conditions (protection rating, temperature, humidity, altitude, etc.).
- The installation location shall be easily accessible.
- Installation of the unit in a location exposed to direct sunlight is NOT acceptable (add awning in case of direct sunlight installation).
- Final installation of the device must not compromise access to any disconnection devices that may be located externally.
- Do not install in small closed rooms where air cannot circulate freely.
- Always ensure that the flow of air around the inverter is not blocked so as to prevent overheating.
- Do not install in locations where flammable substances or gases may be present (minimum distance 3 m).
- Do not install on wooden walls or other flammable supports.
- Install on a wall or strong structure suitable to bear the weight.
- Do not install in rooms where people live or where the prolonged presence of people or animals is expected, because of the high noise that the inverter produces during operation. The level of the sound emission is heavily influenced by where the appliance is installed (for example: the type of surface around the inverter, the general properties of the room, etc.) and the quality of the electricity supply.
- Never open the inverter in the case of rain (even light rain), snow or a level of humidity >95%. Always carefully seal all unused openings. In case of opening when the unit is wet, avoid any water infiltration inside the unit, either in WB or PM.
- All installations over 6500' (2,000 meters) must be assessed by ABB Technical Sales to determine the proper datasheet derating.

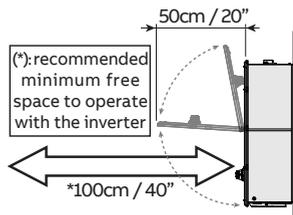
### Tilting admittance

- The installation can be carried out with a maximum inclination as indicated in the figures below.

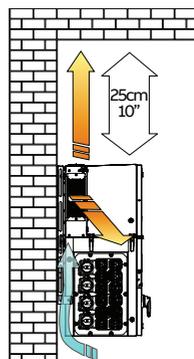
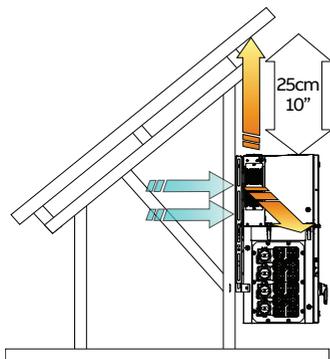
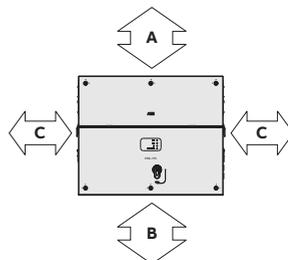


## Distances

- Hardware and software maintenance on device entails opening the front cover. Check that the correct installation safety distances are observed in order to allow routine check and maintenance operations.
- Provide sufficient working space in front of the inverter that allows to open the front covers and to make the internal connections.
- Install at a height which takes into consideration the weight of the appliance and in a position which is suitable for servicing, unless suitable means are provided to carry out the operation.
- If possible, install at eye-level so that the status LEDs **(08)** can be seen easily.

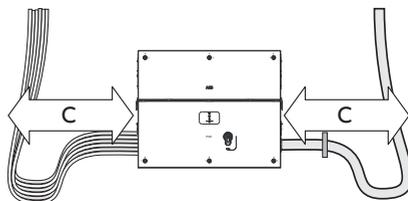


- Do not install any object (e.g. AC or DC cables) that could be damaged by overheating from outgoing hot air flow from top and side fan sections ( $\Delta T = +15\text{ }^\circ\text{C}$  compared to ambient temperature). In case of this kind of installation needs, please evaluate the installation of a proper air deflector. Always respect the minimum distances required.
- Respect the minimum distances from objects around the inverter that could prevent the inverter installation and restrict or block the air flow. The minimum clearance distances depends from multiple factor:
  - Ventilation flow on the top side of the inverter. The upper (A) minimum required free space must be 25 cm / 10".



- Possible flooding or damage during grass cutting. It changes the bottom (B) required free space: If the inverter is installed in a place where there are risks of flooding or there is need to cut the grass growing underneath the unit, the bottom (B) minimum recommended free space is 50cm / 20"; otherwise in case the inverter is installed in a place where there's no risks of flooding or grass cutting evenience, the bottom (B) minimum required free space can be reduced to 15 cm / 6".

- Cables bending radius. Sides (C) minimum required free space may depends from cable type (cable dimension, bending radius, etc.): this evaluation must be done by the installer during the plant design phase (refer to "Cable routing" chapter for more information). In any case minimum required free space for proper ventilation of the unit (near side fans) cannot be under 15 cm / 6" on the right side and 30cm / 12" on the left side.

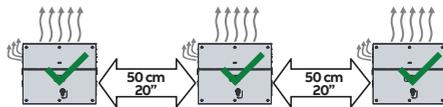


In case of manual installation, using handles (04), consider a free side space to lift the inverter of 60 cm / 24" minimum.

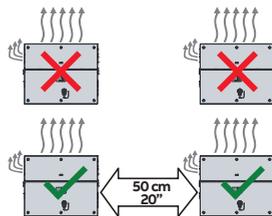


In case of installation with lifting equipments (eyebolts and ropes) the side distances (C) could be reduced at the minimum required but a subsequent manual lifting it will no longer be possible: in this case the lifting equipments must remain available on the field for any subsequent operation.

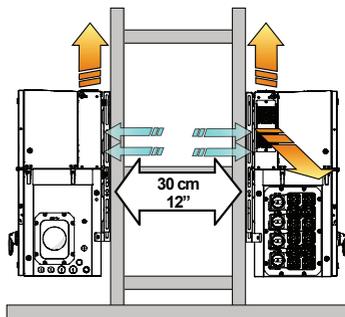
## Installation of multiple units



- When installing multiple units position the inverters side by side paying attention to keep the minimum clearance distances (measured from the outer edge of the inverter) for each inverter specified in the figure.



- The installation of two inverters positioned back to back is also permitted on a structure which must be composed of a 2 or 3 frame supports (refer to "Mounting with a support bracket" chapter). In this case the minimum recommended distance between the units in order to avoid the use of an air deflector is 30 cm / 12".



Please refer to the warranty terms and conditions to evaluate any possible warranty exclusions due to improper installation.

## Wireless signal environmental checks

The inverter can be commissioned and monitored using the wireless communication channel. The WLAN board of the inverter uses radio waves to transmit and receive data, it is therefore important to find a new position for the router considering the different materials which the radio signal will have to pass through:

| Material            | Relative signal reduction                |
|---------------------|--|
| Open field          | 0% (strength of approximately 40 meters) |
| Wood / Glass        | From 0 to 10%                            |
| Stone / Plywood     | From 10 to 40%                           |
| Reinforced concrete | From 60 to 90%                           |
| Metal               | Up to 100 %                              |



Final installation of the inverter must not compromise access to any externally located disconnection devices.



Please refer to the warranty terms and conditions to evaluate any possible warranty exclusions due to improper installation.

## Mounting Instruction



The inverter must be correctly installed, in a suitable location, to operate properly and safely.



Installers must know and understand applicable NEC requirements and any local codes for photovoltaic systems. Installers must know and understand OSHA and other applicable safety requirements, including lockout/tagout procedures.



Remember that when the photovoltaic panels are exposed to sunlight they provide continuous DC voltage to the inverter. Before installation may begin, photovoltaic panels must be shaded or isolated.



Before installation may begin, the inverter must be disconnected from the grid (power disconnect switch open and external AC disconnect locked out/tagged out).



Limit installation to licensed electricians experienced in PV plant wiring.



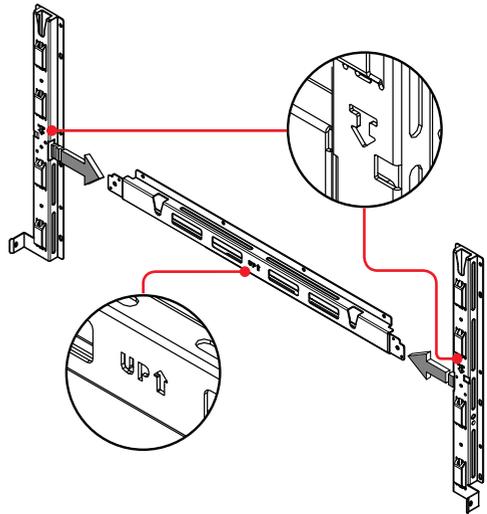
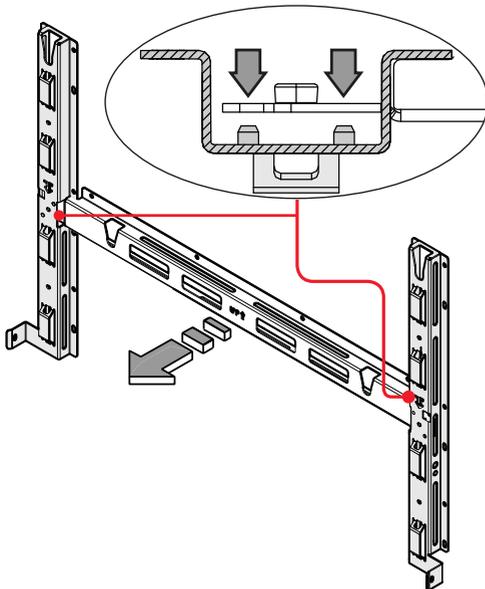
Obtain approval of the local AHJ before connecting the inverter to the electrical grid.



The equipment owner must post the PPE level (per NFPA TDE-2012, Table 13)

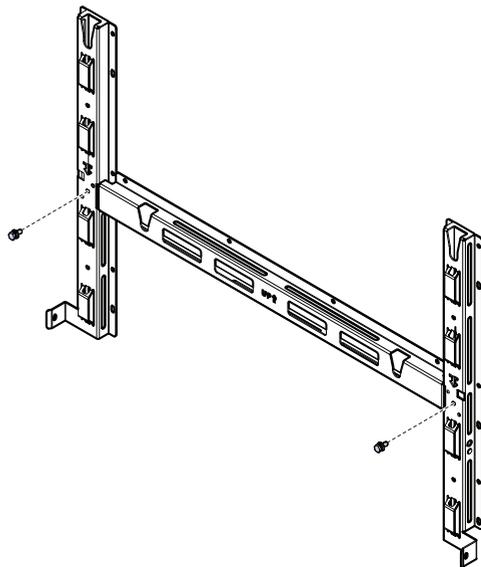
### MOUNTING WITH A SUPPORT BRACKET

- Assemble the two side bracket pieces together with the central bracket, by sliding it as shown in the picture and paying attention to the orientation of the pieces (refer to arrow and "UP" markings on the brackets): side brackets arrow have to be turned downwards, central bracket have to be turned upwards.

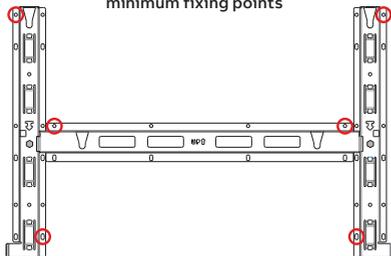


- Slide the central bracket in order to match the two holes with the centering pins of the side brackets.

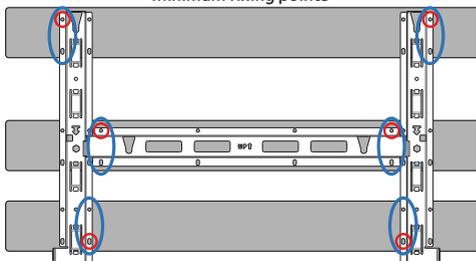
- Use the two M8 screws with flat and spring washers (supplied) to fix the pieces of the bracket together.
- Position the bracket **(03)** perfectly level on the support and use it as drilling template. Consider the overall dimensions of the power module **(01)** and the wiring box **(02)**.



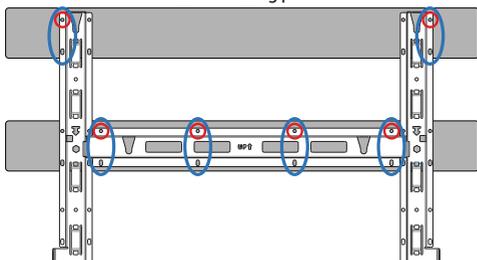
Wall/Floor mounting  
minimum fixing points



Frame mounting (3 supports)  
minimum fixing points



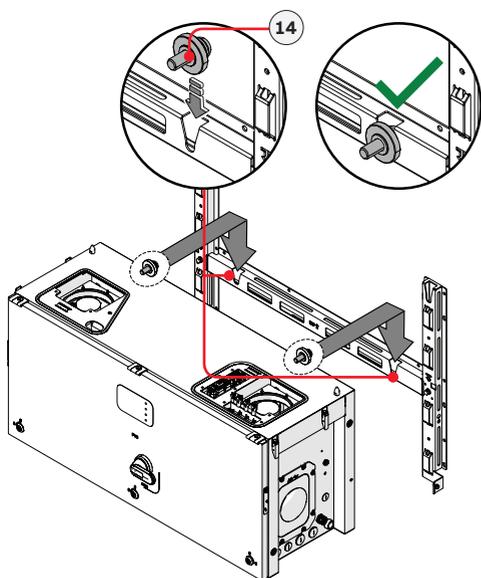
Frame mounting (2 supports)  
minimum fixing points



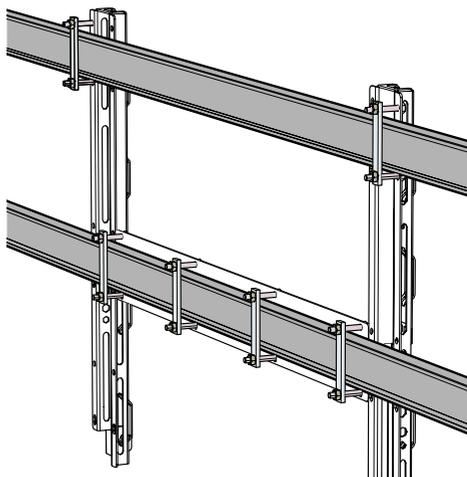
- It is the installer's responsibility to choose an appropriate number and distribution of attachment points. The choice must be based on the type of support (wall, frame or other support), the type of anchors to be used, and their ability to support 4 times the inverter's weight (4x153Kg/338lbs=612Kg/1352lbs for all models).
- Attach the bracket **(03)** to the support with at least 6 attachment screws (shown in RED) or at least 6 frame fixing bracket for frame mounting (shown in BLUE).

Depending on the type of anchor chosen, drill the required holes to mount the bracket **(03)**. The pictures show the recommended minimum fixing point depending to the type of support.

- In case of use of “frame fixing brackets” (see side picture as example) it will be possible to fix the bracket to the frame structure without drilling any additional holes.
- Fix the bracket **(03)** to the support.



- Remove handle or other lifting device (if used)
- Insert the two gasket protective covers (contained in the installation kit) and slide them till the positioning pins are into the proper bracket holes. If the mounting is correct the gasket protective cover will have a locked position.



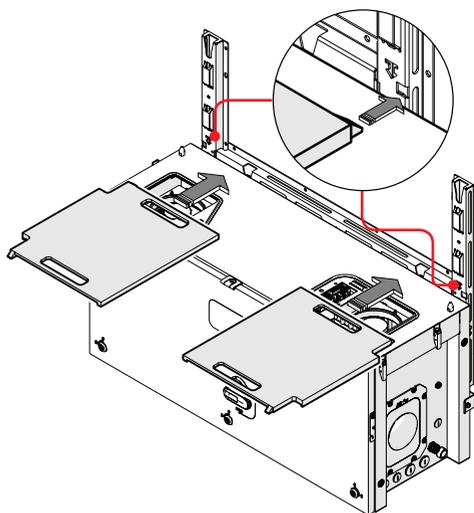
#### Assembly the inverter to the bracket

- Lift the wiring box **(02)** up to the bracket using the optional handles **(04)** or another appropriate lifting device.



**Risk of injury due to the heavy weight of the equipment.**

- Insert the heads of the two rear attachment pins **(14)** (placed on the rear part of the wiring box) into the two slots  on the bracket. Check that the pins **(14)** have been correctly inserted in the slots as shown in the picture before releasing the wiring box.

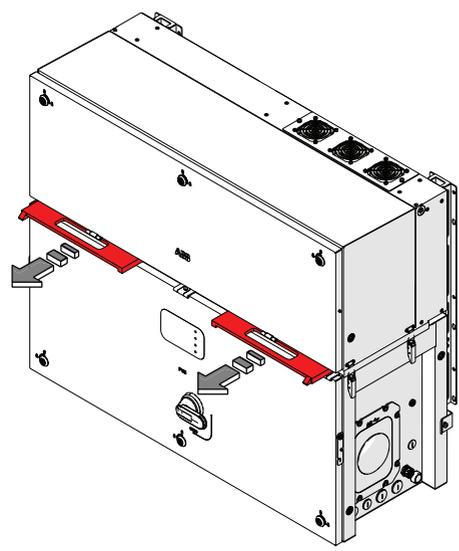
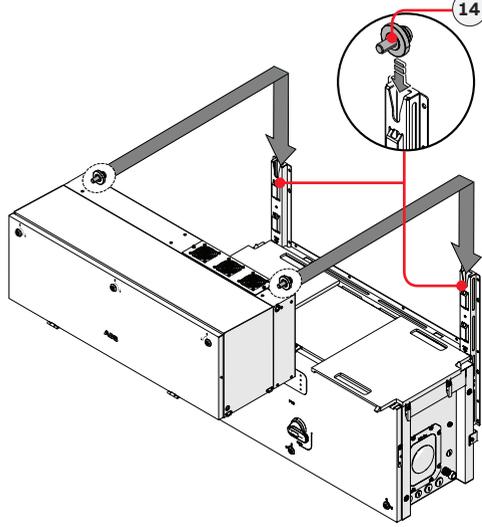


(Continue to next page)

- Lift the power module (01) up to the bracket and over the wiring box (02), using the handles (04) or another appropriate lifting device.

 **Risk of injury due to the heavy weight of the equipment.**

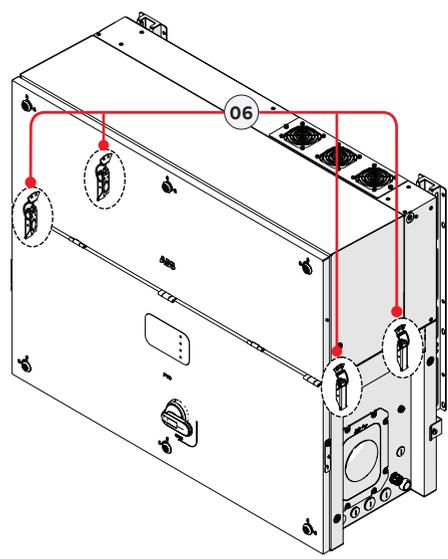
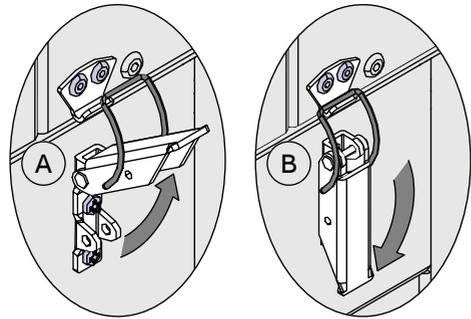
- Insert the heads of two rear attachment pins (14) (placed on the rear part of the power module) into the slots on the bracket. For horizontal mounting, the two markings on the bracket indicate the point where the edge of the power module have to be placed to allow the engagement of the rear attachment pins (14).



- Remove the previously installed gasket protective covers from the inverter by sliding it pulling from the handles.

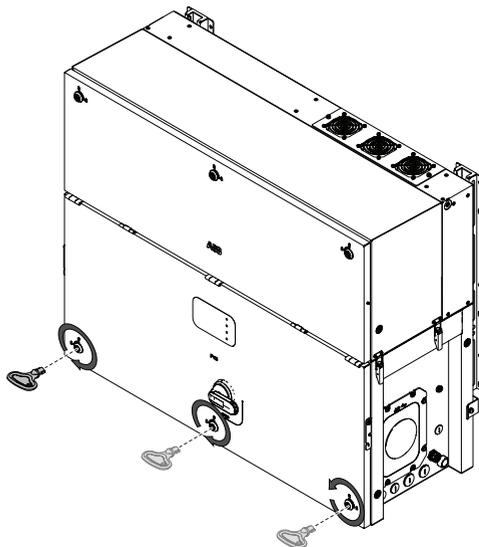
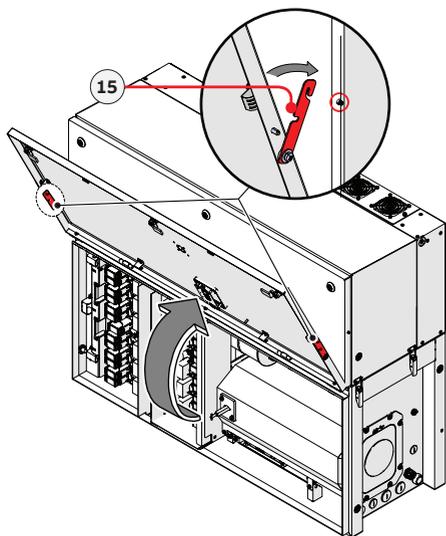
 **Gasket protective covers and handles can be reused for a new installation**

- Fasten all of the four side latches (06) as shown in the pictures.



### Opening the Wiring box cover

- Using the key tool (provided with the kit contained in the wiring box package), open the three cover quarter cam locks (05) following the proper rotation as shown in the related silkscreens on the Wiring box cover (07).
- Only for -SX2 version. Set the wiring box AC disconnect switch (09) to OFF position; otherwise it will not be possible to open the wiring box cover (07).



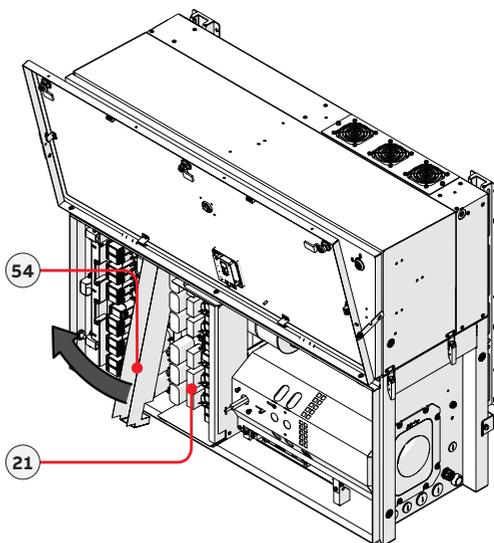
- Open the Wiring box cover (07) and use the cover support brackets (15) to lock the cover (07) in open position.



**Pay attention to properly secure the cover support brackets (15) in order to avoid damaging of the cover!**

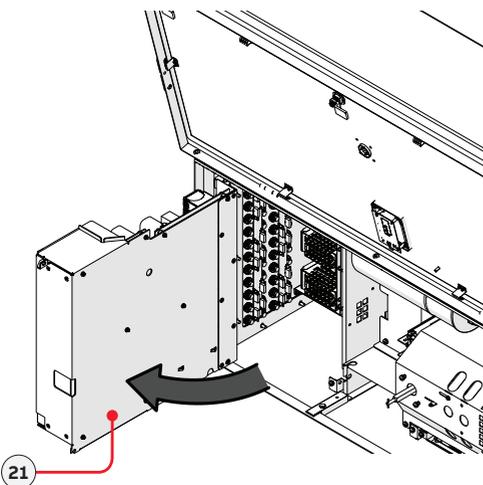
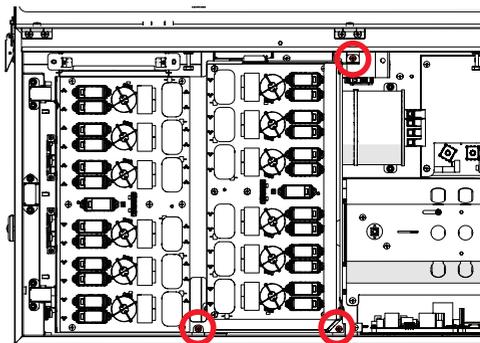
### Final fastening operations

- To reach the two junction screws (20) and complete the power module (01) and wiring box (02) mating, the DC surge arrester plate (21) have to be opened as follow:
- Remove the cable duct (54) from the DC surge arrester plate (21).



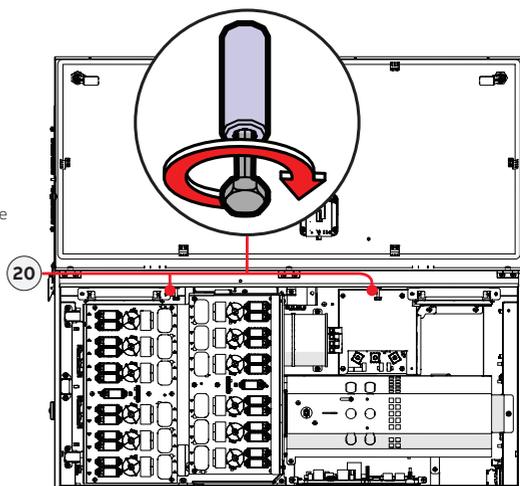
(Continue to next page)

- Remove the three M5 screws from the DC surge arrester plate.



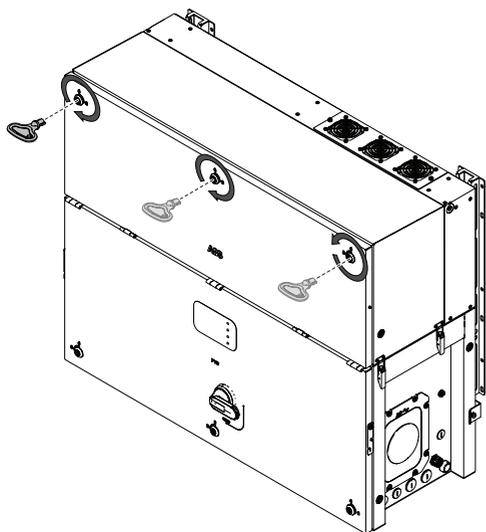
- Rotate the DC surge arrester plate.

- Tighten the two hexagonal junction screws (20) with a torque of 12Nm (8.85 ft-lb).

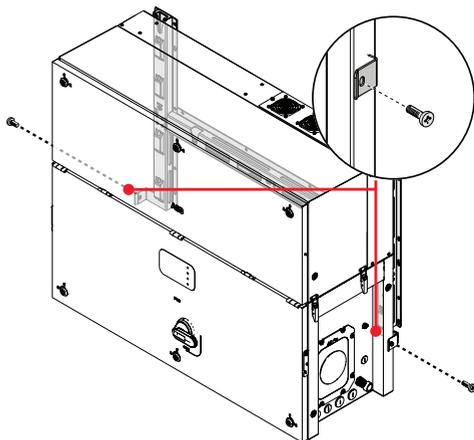


(Continue to next page)

- Close the DC surge arrester plate and install the three M5 screws previously removed.
- Install the cable duct (54) previously removed to the DC surge arrester plate (21).
- Tighten the two side screws (supplied) to torque of 5Nm (3.7 ft-lb), to avoid the tilting of the bottom part of the inverter.
- Close the Wiring box cover

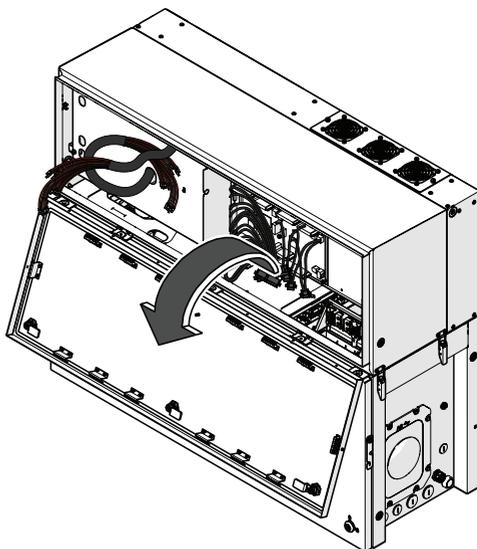


- Open the power module cover (50).



#### Opening the Power module cover

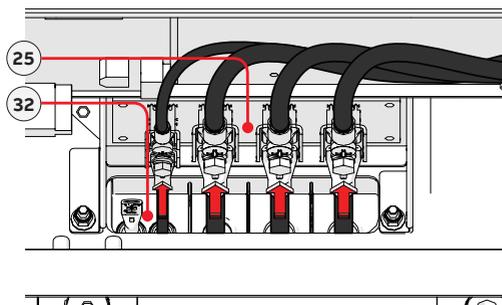
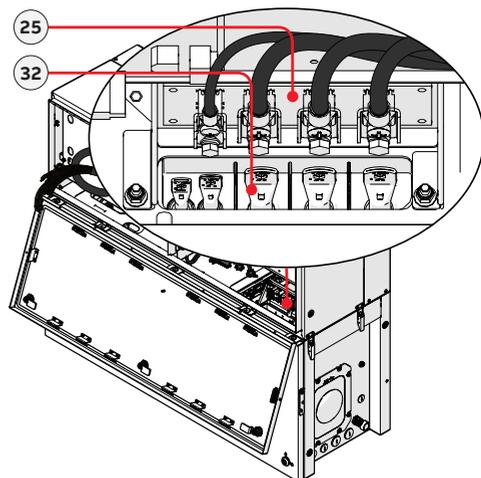
- Using the key tool (provided with the kit contained in the wiring box package), open the three cover quarter cam locks (05) following the proper rotation as shown in the related silkscreens on the power module cover (50).



(Continue to next page)

### Connection of the AC interface power cables (25)

The AC interface power cable (32) (RST phases, PE and MID BULK) are situated into the cable housing on the top side of wiring box (02).



- Install the R, S and T phases and MID BULK cable (coming from the wiring box) to the respective AC interface connection point (25) inside the power module, paying attention to the correspondence of the phases with the labels, using the M6 bolts (for phases) and the M5 bolt (for MID BULK) supplied in the power module installation kit:



**In case of a wrong phase sequence the inverter will not connect to the grid and it will provide an error state.**

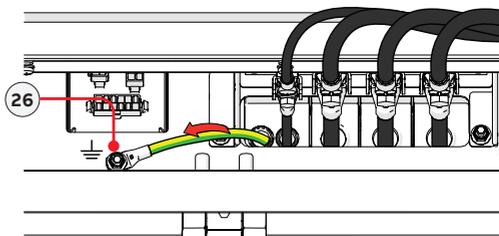
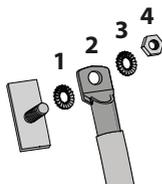


**The cable lugs must be installed with a recommended torque of:**

**M6 bolt (R,S,T phases) = 4Nm (3 ft-lb)**  
**M5 bolt (MID BULK) = 3Nm (2.2 ft-lb) .**

- Install the protective earth cable lug to the protection earth point interface cable (26) situated on the internal bottom side of power module (01), using the washers and bolt supplied in the power module installation kit, as shown in the following picture:

- 1 = toothed washer  
 2 = cable lug  
 3 = toothed washer  
 4 = M5 nut



**The cable lug must be installed with a recommended torque of 3Nm (2.2 ft-lb).**

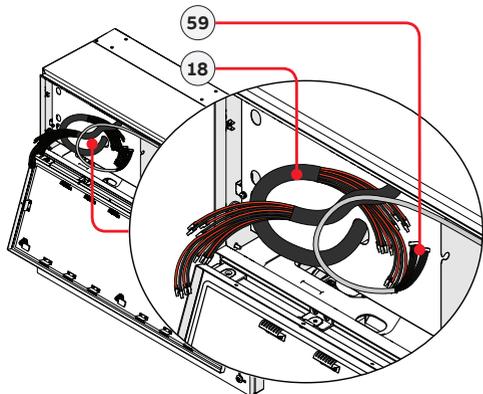
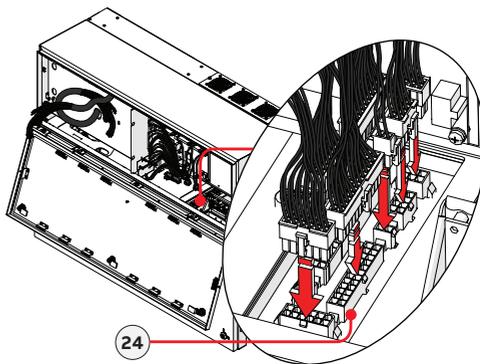


**Any failure of the inverter when it is not connected to earth through the appropriate connection point is not covered by the warranty.**

### Connection of the interface signal connectors

The interface signal cables (24) are situated into right side of power module (01) and they are composed by 8 connectors.

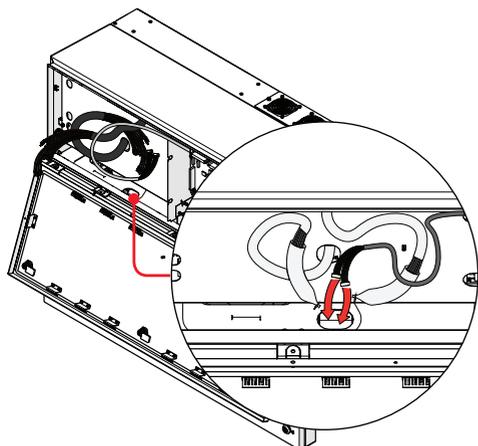
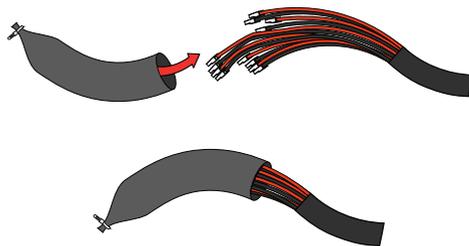
- Connect all the interface signal cables (24) (push the connector until you hear a locking "click"). All connectors have a different pin-out in order to avoid any connection error.



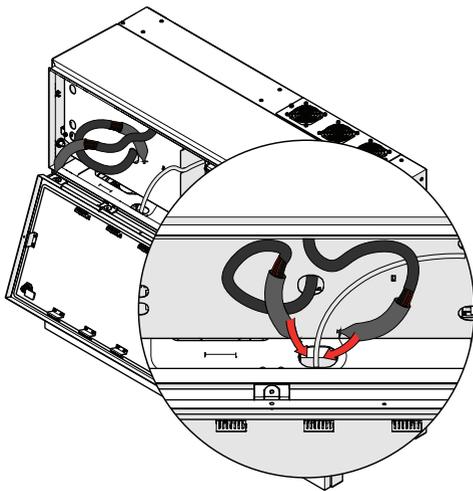
### Connection of the DC and AFD interface cables

The DC interface cables (18) and AFD interface cables (59) are situated into left side of Power module (01).

- Wrap the DC interface cables (18) with the two cable sheaths supplied in the wiring box installation kit.

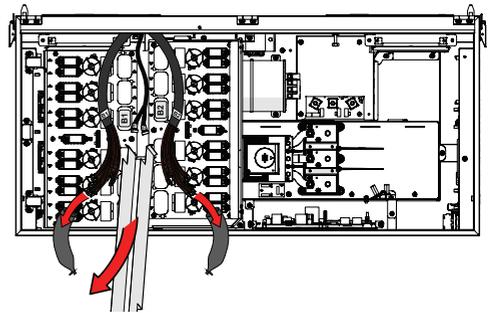


- Remove the cable tie from the AFD interface cables (59) and pass them into the wiring box using the dedicated opening for interface cables.



- Pass the DC interface cables (18) into the same dedicated opening used for the AFD interface cables.

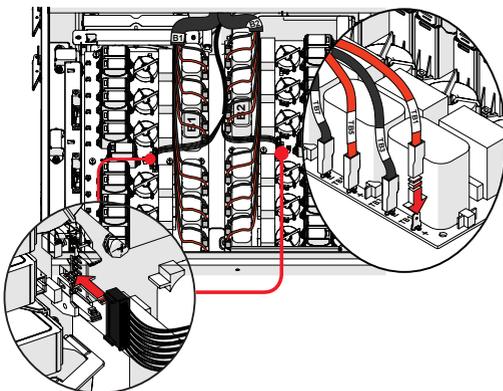
- Close the power module cover (50) and open the wiring box cover (07).
- Remove the cable sheathing from the DC interface cables (18) and the cable duct (54) from the DC surge arrester plate (21).



- Connect the two AFD interface cables to the related ARC fault connectors (19) located in the DC surge arrester plate.
- Connect all DC interface cables (18) to the related DC interface connection point connectors located in the DC surge arrester plate (21).  
The two cable groups are marked with an identification label "B1" and "B2" that correspond to the DSP board number label ("B1" and "B2").  
Each single cable DC is marked with a label corresponding to related DC interface faston connectors on the DSP boards (E.g. "TB1", "TB3"...).



**Polarity inversion can cause serious damage. Check polarity before connecting each cable! Always check correspondence of cables and board faston connectors identification!**



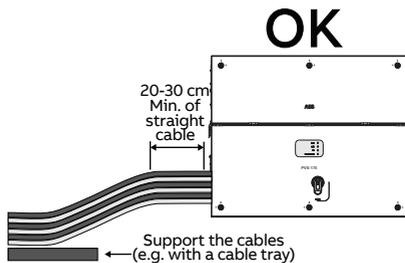
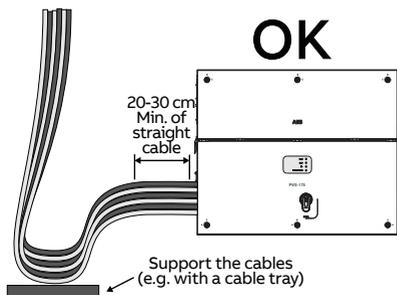
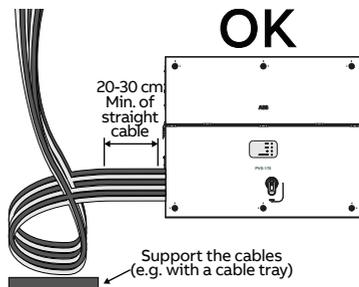
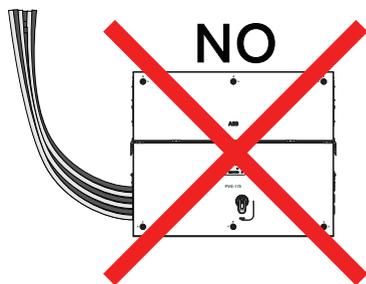
## Routing the cable to the inverter

Cables should be routed in a manner which prevents water from dripping on the DC input connectors (16).

Especially when coming from the top, the DC cables must be routed in order to create a loop: in this way the water that flows on the cables will be drained.

The DC conductors must be anchored or supported in order to prevent loading and mechanical stress on the cable glands and quick fit connectors causing potential damage on the DC plate.

Examples of improper and proper cable routing are shown in the figures:



## Installation planning

### Characteristics of the protective grounding cable



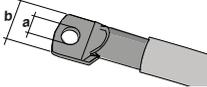
**Size the cable(s) in accordance with NEC and any local codes.**

**The wire must be large enough to handle the maximum ground fault current that the PV system might experience.**

**The warranty is void if the inverter isn't connected to ground through the appropriate terminals.**

Follow site wiring diagrams and grounding plans. At a minimum expect this to include:

- A PV array equipment ground conductor (EGC), to be landed on the EGC connection point (10) located on the external side of the inverter.
- A protective earth (PE) conductor, to be landed on the protective earth connection point (55).

|   | Protective earth point (ext.) (10)                     | Protective earth connection point (55)             |
|---|--|--|
| Cable lug dimensioning  | for M8 Bolt  | for M10 Stud                                       |
|  | a = 8.4 mm / 0.33" (min)<br>b = all dimension accepted | a = 10.5 mm / 0.42" (min)<br>b = 40mm / 1.57 (max) |

### Load protection breaker (AC disconnect switch) and differential protection downstream of the inverter

To reduce the risk of fire, connect only to a circuit provided with an overcurrent protection in accordance with the NEC (ANSI/NFPA 70). The inverter must be connected only to a dedicated branch circuit provided with the maximum branch overcurrent protection device (OCPD):

|                                    | PVS-166-TL-US  | PVS-175-TL-US |
|------------------------------------|--|---------------|
| Type                               | Automatic circuit breaker with thermal-magnetic protection |               |
| Nominal Voltage /Current           | 800 Vac / 150 A (*)  |               |
| Magnetic protection characteristic | Magnetic curve B/C   |               |
| Number of poles                    | 3  |               |

(\*): please consider thermal and other derating when selecting the current rating of the protection equipment for your application.

- It is installer's responsibility to provide external disconnect switches and OCPD as required by NEC and other prevailing regulations.
- The inverter is designed without an isolation transformer and must be installed per NFPA 70, 690.35 with an ungrounded PV array.

In case of installation of a residual current protection, the device shall meet the following characteristics in order to prevent nuisance tripping due to capacitive leakage current of photovoltaic modules:

|             | PVS-166-TL-US | PVS-175-TL-US |
|-------------|---------------|---------------|
| Type        |               | A / AC        |
| Sensitivity |               | 2.0 A         |

ABB declares that the ABB transformerless inverters, in terms of their construction, do not inject continuous earth fault currents and therefore there is no requirement that the differential protection installed downstream of the inverter be type B in accordance with IEC 60755 / A.2.

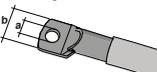
### Characteristics and sizing of the line cable

The cross-section of the AC line conductor cables must be sized in order to prevent unwanted disconnections of the inverter from the grid due to high impedance of the line that connects the inverter to the power supply; If the impedance is too high it causes an increase in the AC voltage which, on reaching the limit set by the standards in the country of installation, causes the inverter to switch off.



**The minimum required cross sectional area for the phases conductors is 50mm<sup>2</sup> / (1/0)AWG.**

The AC cables must be connected to the AC connection busbars (22) using a cable lug (not supplied) of a suitable size for installation on the M10 threaded studs used for securing the cable.

|   | Single core cable | Multi-core cable                                   |
|---|-------------------|--|
| Cable lug dimensioning  |                   | for M10 Stud                                       |
|  |                   | a = 10.5 mm / 0.42" (min)<br>b = 40mm / 1.57 (max) |



**The AC connection busbars (22) are in copper tin-plated; therefore if aluminum cables are used, the correct coupling with the copper bars must be guaranteed by using appropriate bi-metallic cable lug.**

## Grid output connection (AC side)



To avoid risks of electrical shock, all wiring operations must be carried out with the disconnect switch downstream of the inverter (grid side) opened and applying LOTO procedure on it. Be careful not to change round one of the phases with neutral!

**Caution! Connect the ground before starting the grid connections.**



Keep the resistance of the wires to a minimum between the OCPD and the AC terminals, to ensure the correct work of the protective devices.

**Size conductors per NEC Article 310 - use 90°C wire only; conductors must be sized according to operating temperature range and continuous current ratings.**

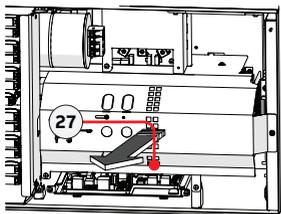
**AC output wire must be UL listed wire rated minimum 1000V.**

The inverter must be connected to a three-phase TN system with the center of the star connected to ground. To connect the inverter to the grid it is necessary to use a three-wire connection (3 phases) without neutral cable.

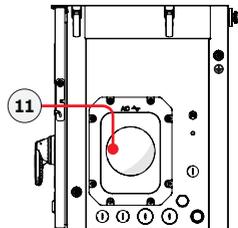
- Routing of the AC cables inside the inverter must be carried out through the AC opening (size 3 in conduit) (11) on the right side of the inverter.



**Use UL Listed reduction washers in case of smaller conduit used to maintain Type 4 enclosure integrity.**

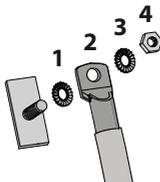


- Open the wiring box front cover (07).
- Remove the AC protective shield (27) by removing the M5 screw.



- Pass the protective earth cable through the AC opening (size 3" conduit) (11) on the AC panel.
- Attach the protective earth cable lug to the protection earth connection point (55) using the washers and bolt pre-installed on the M10 stud:

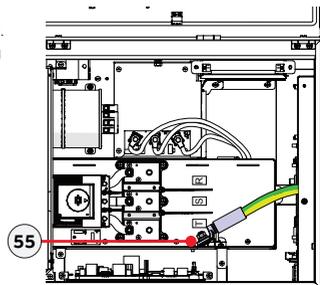
- 1 = toothed washer
- 2 = cable lug
- 3 = toothed washer
- 4 = M10 nut



- Torque to 21Nm (15.5ft-lb).

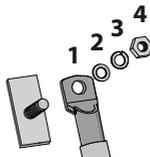


**Before connecting the inverter to AC sources use a suitable multimeter to test the conductivity of the earth connections between the protection earth connection point (55) and a handles thread (04) on the housing of power module (01).**

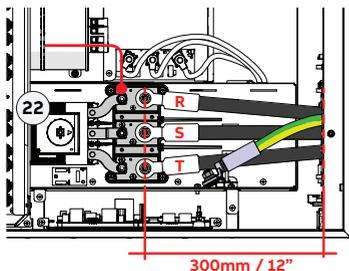


- Pass the AC cables trough the AC opening (size 3 in conduit) (11) on the AC panel. The length of phase cables on the internal side of wiring box needs to be about 300mm / 12" (cable lug included).
- Attach the R, S and T (phase R=L1, S=L2 and T=L3) cable lugs to the AC connection busbars (22), paying attention to the correspondence of the phases with the labels, using the washers and the M10 nuts pre-installed on the busbar:

- 1 = cable lug
- 2 = flat washer
- 3 = spring washer
- 4 = M10 nut



- Torque to 14Nm (10.3ft-lb).



**In case of a wrong phase sequence the inverter will not connect to the grid and it will provide an error state.**

- Give each wire a pull test to confirm the connection is secure.
- Conduit must be attached using EMT rain tight fittings to maintain Type 4 enclosure integrity.

## Checking the correct polarity of the strings and Input connection (DC)



Do not place objects of any kind on the inverter during operation!  
Do not touch the heatsink while the inverter is operating! Some parts may be very hot and cause burns.

To avoid risks of electrical shock, all wiring operations must be carried out with the DC disconnect switch internal and external (applying LOTO procedures on it) to OFF position and with the external AC disconnect switch to OFF position (applying LOTO procedures on it).



The DC disconnect switch disconnects the DC current from the PV panels in the "OFF" position. The inverter will stop producing power, but DOES NOT disconnect the AC from the grid.

In case of presence of internal DC disconnect switch only, there will be live parts internal to the inverter with a consequent risk of electrical shock.



Confirm the PV array's input polarity is correct.  
Confirm the PV array has no ground leakage current.



The transformerless design of the inverter requires that the PV array to be floating with respect to ground per NEC 690.35. Per NEC 690.35, wires from the PV array must be UL-listed, 1500V minimum rating, 90°C minimum temperature rating.

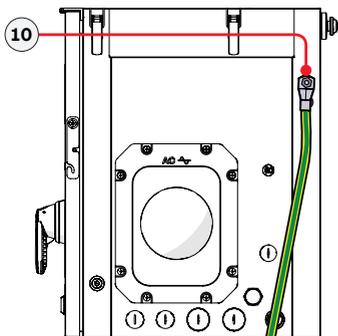
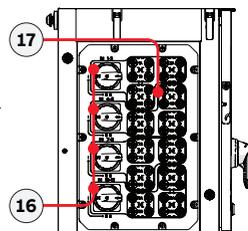
For the string connections it is necessary to use the DC input quick fit connectors (17) located on the left side of the wiring box (02).

| Type   | Manufacturer | Model         | P/N             | Conductor cross section                            | Ø cable gland             |
|--------|--------------|---------------|-----------------|--|---------------------------|
| Male   | Stäubli      | PV-KBT4-EVO 2 | 32.0087P0001-UR | 4mm <sup>2</sup> (11AWG) - 6mm <sup>2</sup> (9AWG) | 4.7-6.4 mm / 0.18-0.25"   |
|        |              |               | 32.0089P0001-UR | 4mm <sup>2</sup> (11AWG) - 6mm <sup>2</sup> (9AWG) | 6.4 - 8.4 mm / 0.25-0.33" |
|        |              |               | 32.0093P0001-UR | 10mm <sup>2</sup> (7AWG)                           | 6.4 - 8.4 mm / 0.25-0.33" |
| Female | Stäubli      | PV-KST4-EVO 2 | 32.0086P0001-UR | 4mm <sup>2</sup> (11AWG) - 6mm <sup>2</sup> (9AWG) | 4.7-6.4 mm / 0.18-0.25"   |
|        |              |               | 32.0088P0001-UR | 4mm <sup>2</sup> (11AWG) - 6mm <sup>2</sup> (9AWG) | 6.4 - 8.4 mm / 0.25-0.33" |
|        |              |               | 32.0092P0001-UR | 10mm <sup>2</sup> (7AWG)                           | 6.4 - 8.4 mm / 0.25-0.33" |



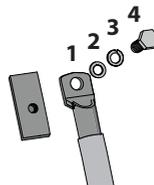
Using mating parts that are not compliant with the quick fit connector models on the inverter could cause serious damage to the unit and lead to invalidation of the warranty.

The input connectors are divided into 12 MPPTs consisting of 2 pairs of quick fit connectors (17). Each DC disconnect switch (16) disconnects a group of 3 MPPTs.



- Attach the DC side ground cable(s) to the equipment grounding conductor connection point (10) (this is the same thread for handles) using the washers and M8 bolt provided in the wiring box installation kit:

- 1 = cable lug
- 2 = flat washer
- 3 = spring washer
- 4 = M8 bolt

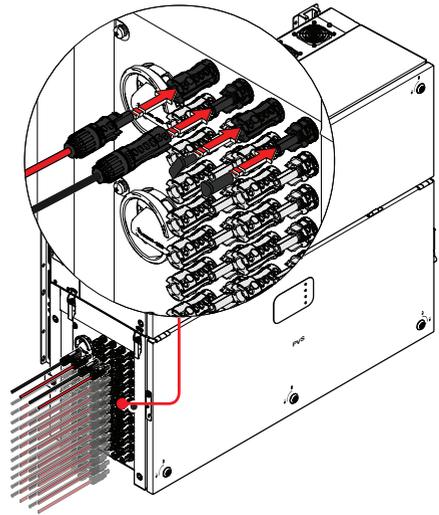


- Torque to 15.2 Nm (11.2ft-lb).



Before connecting the inverter to AC or DC sources use a suitable multimeter to test the conductivity of the earth connections between the equipment grounding conductor connection point (10) and a handles thread (04) on the housing of power module (01).

- Connect all the strings required by the system, always checking the seal of the connectors.



Make sure to connect at least one string per MPPTs to prevent unbalancing between input channels.



If any string inputs is not required check that protective caps are installed to the relative unused connectors. This is necessary for the inverter seal and to avoid any damage to the unused connectors which may be used at a later time.

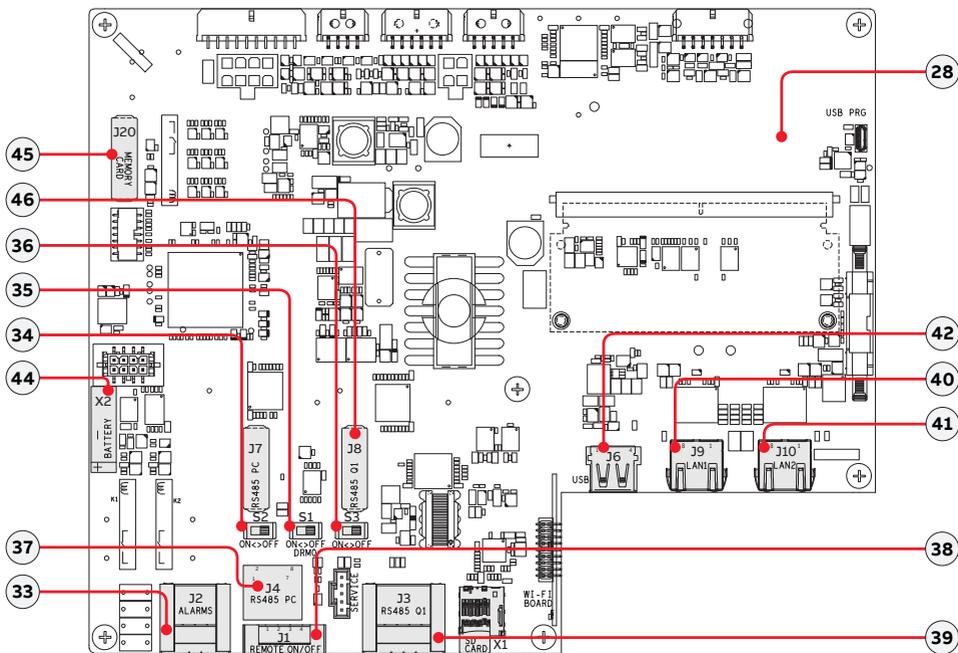


The connections can also be made with the wiring box (02) detached from the power module (01) that can be connected later for commissioning. When working with the wiring box (02) detached, pay particular attention to:

- presence of earth connection
- The top of wiring box must always be protected in outdoor installations with proper IP65 protection covers (optional accessory content in "PVS-175 INSTALLATION KIT", to be ordered separately). Refer to the dedicated chapter "Installation of IP65 protection covers for wiring box openings (long term installation)" for further information about the installation procedures.

## Connection of the communication and control signals

### Communication and control board (28) references



| Terminal name | Terminal reference | Description of communication and control board (28)                                |
|---------------|--------------------|--|
| J2            | 33                 | Multifunction relay connector (ALARM terminal block)                               |
| S2            | 34                 | RS485 ABB service 120Ohm termination resistance selector switch (ABB service only) |
| S1            | 35                 | DRM0 activation switch   |
| S3            | 36                 | RS485 line 120Ohm termination resistance selector switch                           |
| J4            | 37                 | ABB RS485 service RJ45 connector (service only)                                    |
| J1            | 38                 | Remote ON/OFF terminal block   |
| J3            | 39                 | RS485 line terminal block  |
| J9            | 40                 | Ethernet connector 1 (RJ45)  |
| J10           | 41                 | Ethernet connector 2 (RJ45)  |
| J6            | 42                 | USB connector  |
| X2            | 44                 | CR2032 Coin battery  |
| J20           | 45                 | Memory board   |
| J8            | 46                 | RS485 line communication board   |

(\*) The RS-485 connector (RJ45) (ABB Service only) **(37)** and the signal R1 on the Remote ON/OFF terminal block **(38)** are used to bring the signals on the external connector RS-485&Rem.ON/OFF (Service only) **(56)**.

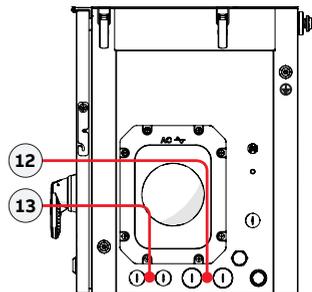
### Connections to the communication and control board

The communication and control signals are connected to the communication and control board inside the DC wiring box. To reach the board, on the right side of the DC wiring box, there are:

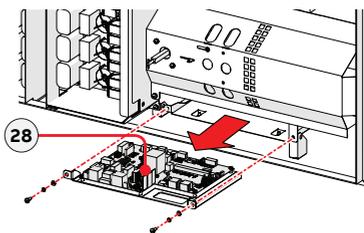
- 2x service opening (size 3/4" conduit) **(12)**
- 2x service opening (size 1/2" conduit) **(13)**



Use UL Listed reduction washers in case of smaller conduit used to maintain Type 4 enclosure integrity.



- To connect the signal and communication wirings, the communication and control board (28) have to be extracted by removing the two M5 screws.
- After the connections has been made, re-insert the communication and control board (28) in the board tray and fasten the two M5 screws previously removed.
- Give each wire a pull test to confirm the connection is secure.
- Conduit must be attached using EMT rain tight fittings to maintain Type 4 enclosure integrity.



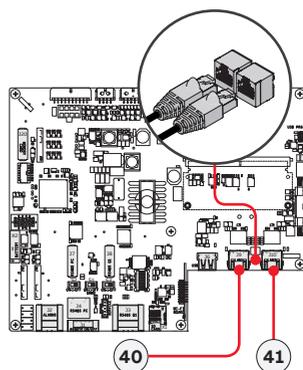
### Ethernet connection

The Ethernet connection allows a direct data transfer to the ABB server for monitoring purpose. When the inverter will be powered on, network parameters are automatically set and the inverter starts the transmission of telemetry data to the Aurora Vision® CLOUD platform.

The connection of the Ethernet communication cable must be made on the specific connectors (40)(41) located on the Communication and control board (28). The two RJ45 connectors LAN1 and LAN2 are equivalent to each other and can be used for the input or for the output of the line connecting multiple inverters in a daisy-chain.

The cable should be compliant to the following specification:

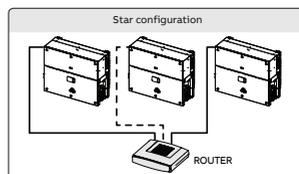
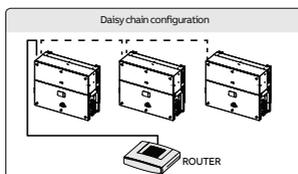
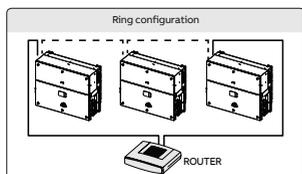
- Cable type: Patch or Cross type, 100BaseTx, CAT5e (or higher). For outdoor application and/or in presence of strong electromagnetic sources it is advisable to use shielded cables with metallic shielded RJ-45 plug.
- UV-resistant if used outdoors
- Type of plug: metallic shielded RJ45.
- The maximum length that can reach these cables is 100 meters, and it is always advisable not to let them pass by the power cords to avoid interference with data transmission.
- Maximum inverters number connected over one single daisy chain is 40.



**⚠ For outdoor application and/or in presence of adverse weather/strong electromagnetic events it is advisable to use additional overvoltage protective devices.**

**⚠ In order to avoid earth loop (that could create communication issues) the shield of any Ethernet cable must be connected to the RJ45 plug in only one side, the other side of the shield should be leaved floating. This could be guaranteed by crimping the shield or the screen of the ethernet cable to the RJ45 connectors only at one end of each cables.**

Three topologies of ethernet connection to the router are available:



The ring configuration is the preferred method to connect multiple units in order to allow reaching inverters also in case of single unit failures.

In case inverters are connected to the networking switch with a ring topology is recommended to enable SPT protocol on the switch (Spanning Tree Protocol SPT (IEEE 802.1D) is enabled by default on inverters).

**⚠ On each configuration the maximum length of the cable must be 100m between inverter – inverter and inverter – switch. No initial setup is required to start data transmission to Aurora Vision. Internet connection is required to use all the Aurora Vision remote functionalities.**

**📄 Please refer to Aurora Vision documents available on ABB website for further information how to get an Aurora Vision account for remotely monitoring and managing the installed solar assets.**

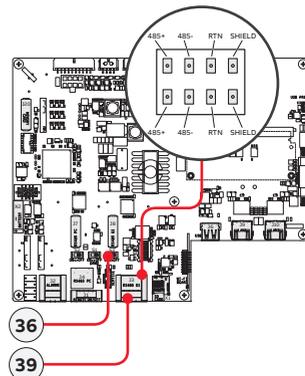
## Connection of RS-485 serial communication line



Please note that automatic settings of network parameters at turning on, embedded logging capability, automatic logger-free transferring of data to Aurora Vision Cloud and remote firmware update are provided over TCP/IP (Ethernet and/or Wi-fi) bus only.



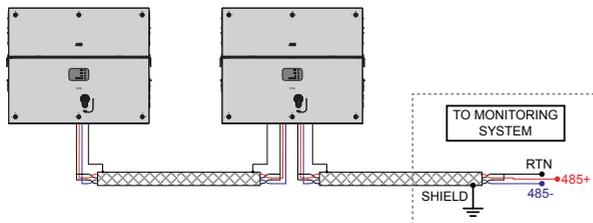
The use of the inverters over the RS485 line is recommended in case of monitoring and controlling by using third party RS485 control systems.



## Slave mode

By default the RS485 port is set as Slave mode. In case the port was set as "Master mode" it must be configured through the integrated Web User Interface (refer to chapter "Web User Interface") to use the RS485 as a serial communication line.

The RS-485 port can be used to set up a line of communication which, when connected to a monitoring device, enables the operation of the photovoltaic system to be kept under control. Depending on the device used monitoring can be local or remote.



RS485 line supports Modbus/RTU SUNSPEC compliant Modbus protocol.

The RS-485 serial communication line is available on the communication and control board (28) with two terminal blocks (39) for each serial line signal (+T/R, -T/R and RTN) so as to be able to make a daisy-chain connection ("in-out") of multiple inverters.

- Connection of the R485 communication line conductors is made using the terminal block connectors (39) (485+, 485-, RTN and SHIELD).
- When connecting a single inverter to the monitoring system, activate the communication line resistance terminal by setting the switch (36) (to the ON position). In case of multiple installation set the switch only on the last inverter of the chain.



For further information regarding the configuration and use of the RS-485 serial communication line, please refer to the user manual.

## Master mode

The RS485 port can either be used for connecting supported accessories (like weather station): in this case data from accessories will be logged and transferred to the cloud by inverter itself (master mode).

This will allow the inverter to serve as a logger for ABB accessories.

For more information on connecting the accessories to the RS485 terminal block, refer to the accessory product manual or contact ABB customer support.

The RS-485 serial communication line is available on the communication and control board (28) with two terminal blocks (39) for each serial line signal (+T/R, -T/R and RTN) so as to be able to make a daisy-chain connection ("in-out") of multiple inverters.

- Connection of the R485 communication line conductors is made using the terminal block connectors (39) (485+, 485-, RTN and SHIELD).
- Set the switch of the termination resistance (36) to "ON" position.
- When an accessory is connected it must be added and configured into the "Monitored device" list on the integrated Web User Interface.



For further information regarding the configuration and use of the RS-485 serial communication line, please refer to the user manual.

### Remote control connection

The connection and disconnection of the inverter to and from the grid can be controlled through an external control.

The function must be enabled via web server user interface. If the remote control function is disabled, the switching on of the inverter is dictated by the presence of the normal parameters that allow the inverter to connect to the grid.

If the remote control function is on, besides being dictated by the presence of the normal parameters that allow the inverter to connect to the grid, switching on the inverter also depends on the state of the R2 terminal compared to the RTN terminal present on the **(38)** terminal block of the communication and control board **(28)**. When the R2 signal is brought to the same potential as the RTN signal (i.e. by making a short circuit between the two terminals of the connector), this causes the inverter to disconnect from the grid.

Since this is a digital input, there are no requirements to be observed as regards cable cross-section (it only needs to comply with the sizing requirement for passing cables through the cable glands and the terminal connector).

The external switch used for Remote ON/OFF should be rated for DC low voltage, low current application (the minimum switching current capability should be 1mA or lower).

 **For further information regarding the configuration and use of the Remote control terminal block, please refer to the user manual.**

### Multifunction Relay connection (ALARM and AUX)

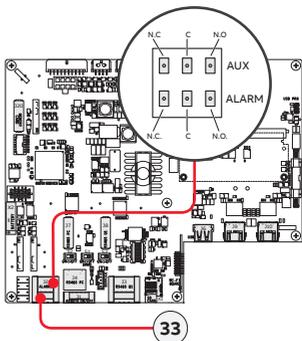
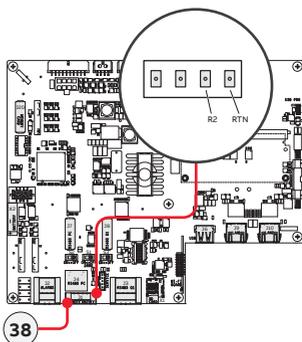
The inverter is equipped with 2 multifunction relays terminal blocks **(33)** with configurable activation. It can be connected with normally open contact (being connected between the NO terminal and the common contact C) and with normally closed contact (being connected between the NC terminal and the common contact C). This contact can be used in different operating configurations that can be selected by accessing the relevant section in the web user Interface "SETTINGS > Digital Outputs".

Different types of devices (light, sound, etc.) can be connected to the relay, provided they comply with the following requirements:

#### Alarm terminal block requirements

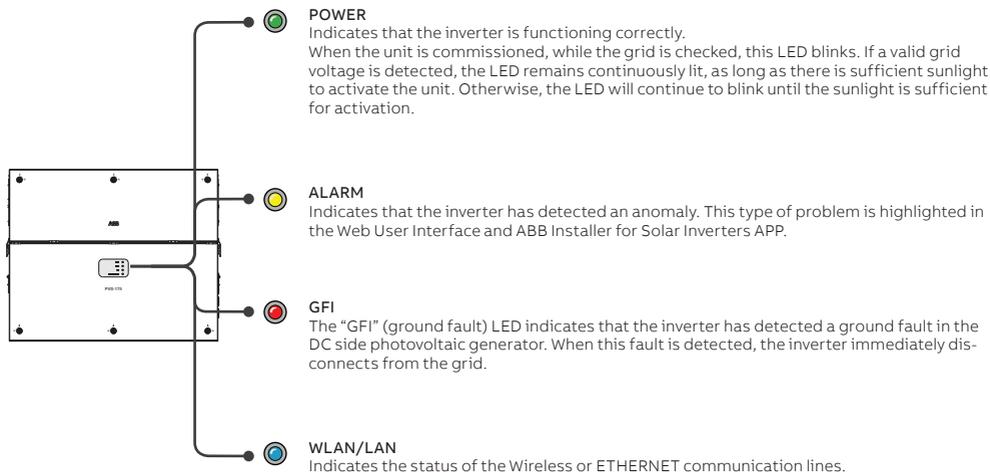
|                     |   |
|---------------------|---|
| Alternating current | Maximum Voltage: 160 Vac / Maximum Current: 6 A           |
| Direct current      | Maximum Voltage: 30 Vdc / Maximum Current: 3 A            |
| Cable requirements  | Conductor cross-section: from 0.08 to 1.3 mm <sup>2</sup> |

 **For further information regarding the configuration and use of the multifunction relay terminal blocks, please refer to the user manual.**



## Description of LED panel

### Description of the LED function



All possible LED activation combinations are shown in the following table. In particular, each LED could behave in one of the following ways:

- = LED on
- ⊗ = LED flashing slow (2 seconds on / 2 seconds off)
- ⊙ = LED flashing fast (0.2 seconds on / 0.2 seconds off)
- = LED off
- ⊕ = Any one of the conditions described above

The following table shows all the possible activation combinations of "Power" "Alarm" and "GFI" LEDs on the LED panel **(08)** according to the operating status of the inverter.

| LED status                      | Operating state  |
|---------------------------------|--|
| green: ⊗<br>yellow: ⊗<br>red: ⊗ | <b>Firmware programming</b><br>The inverter firmware is being programmed (never turn off the inverter during this phase).  |
| green: ○<br>yellow: ○<br>red: ○ | <b>Night mode (inverter automatically switches off)</b><br>The inverter is in night time switch-off mode (input voltage less than 70% of the set start-up voltage and AC grid is missing).   |
| green: ⊗<br>yellow: ○<br>red: ○ | <b>Inverter initialization / Waiting Sun</b><br>This is a transitional state due to verification of the operating conditions. During this stage the inverter checks that the conditions for connecting to the grid are met.  |
| green: ●<br>yellow: ○<br>red: ○ | <b>The inverter is connected and is feeding power into the grid</b><br>Normal operation. During this stage, the inverter automatically tracks and analyses the photovoltaic generator's maximum power point (MPP).   |
| green: ⊗<br>yellow: ●<br>red: ○ | <b>Missing grid</b><br>Indicates lack of grid voltage. This condition does not allow the inverter to connect to the grid.  |
| green: ⊕<br>yellow: ●<br>red: ○ | <b>Warning indication: (W message codes) or Error: (E message codes)</b><br>- Indicates that the inverter control system has detected a warning (W) or error (E). It is possible to identify the type of problem generated in the dedicated section of integrated Web User Interface ("Inverter Log" section). |
| green: ○<br>yellow: ●<br>red: ○ | <b>Temperature protection trip</b><br>Indicates that the trip relating to internal temperatures (insufficient or excessive temperature) may have been activated.   |

| LED status  | Operating state  |
|---|--|
| green: <br>yellow: <br>red:  | <p><b>Ventilation anomaly</b><br/>Indicates an anomaly in the operation of the internal ventilation system that could limit output power at high ambient temperatures.</p> <p><b>Overvoltage surge arresters triggered (where fitted)</b><br/>Indicates that any class II overvoltage surge arresters installed on the AC or DC side have been triggered</p> <p><b>Internal statistics memory anomaly</b><br/>Indicates an operating anomaly in the internal memory on which the inverter statistics are stored</p> <p><b>Buffer battery discharged</b><br/>The buffer battery is low and the inverter does not maintain the time setting</p>  |
| green: <br>yellow: <br>red:  | <p><b>Pre-commissioning phase (first start-up of inverter)</b><br/>The commissioning of the inverter must be completed through the Installation wizard steps (Web User Interface) or using the ABB Installer for Solar Inverters mobile APP</p> <p><b>Initial configuration failure</b><br/>The inverter is in locked state due to a failure in the initial configuration of the equipment, such as the standard network setting for the country of installation</p> <p><b>Incompatibility of the device firmware versions</b><br/>The firmware versions of the various devices comprising the equipment are incompatible and are being updated (this is an automatic operation)</p> <p><b>Temperature sensor anomaly detected</b></p> |
| green: <br>yellow: <br>red:  | <p><b>Remote OFF activated</b><br/>The Remote Off command has been activated.<br/>The unit will not connect to the network until the remote ON command has been activated</p>  |
| green: <br>yellow: <br>red:  | <p><b>Anomaly in the insulation system of the photovoltaic generator</b><br/>Indicates that a leakage to earth from the PV generator has been detected, causing the inverter to disconnect from the grid.</p>  |
| green: <br>yellow: <br>red:  | <p><b>DC arc fault detected during operation</b><br/>If a DC arc fault is detected during operation, the inverter disconnects from AC grid (the error code is readable through internal Webserver).</p>  |
| green: <br>yellow: <br>red:  | <p><b>AFD board self test failure</b><br/>Potential problem on the AFD board detected during self test phase</p>   |

The following table shows all the possible status of "WLAN/LAN" LED on the LED panel **(08)** according to the operating status of the wireless or ethernet communication lines.

| LED status  | Operating state   |
|---|---|
| Blue:  | Wireless not configured or/and ethernet cable not connected.                          |
| Blue:  | Scanning for available wireless networks.   |
| Blue:  | Trying to connect to a wireless network.  |
| Blue:  | Wireless or ethernet network is connected to the inverter and IP address is obtained. |

## Commissioning



Do not place objects of any kind on the inverter during operation! Do not touch the heat sink while the inverter is operating! Some parts may be very hot and could cause burns.

Before proceeding with commissioning, make sure you have carried out all the following checks:

- Ensure that all the checks indicated in the previous sections of this Quick Installation Guide have been correctly performed
- Ensure that the front door have been correctly closed.
- Check the correct connection and polarity of the DC inputs, and the correct connection of the AC output and earth cables.
- Check the sealing barrier of the cable ducts and installed quick-fit connectors to prevent accidental disconnections and/or avoid compromising the NEMA4 environmental protection rating.



The inverter can be powered with DC sources only; make sure that irradiation is stable and adequate for the inverter commissioning procedure to be completed.



At the first activation of the inverter the firmware version could synchronized between power module and wiring box. During this phase the LEDs “Power” “Alarm” and “GFI” blinks together every 1 second. This process is absolutely normal and must be completed without interruption. A switch-off of the system during this process could cause serious damage to the inverter.



Commissioning could be carried out in two different ways:

- Via ABB Installer for Solar Inverters APP (mobile APP for commissioning a single inverter as well as a multi-inverter solar plant)
- Via Web UI (Integrated Web User Interface enabling setting parameters and performing commissioning of a single inverter).

ABB Installer for Solar Inverters APP is the recommended method to commission the inverters.

### Commissioning via ABB Installer for Solar Inverters mobile APP

ABB Installer for Solar Inverters APP is available for Android mobile devices with an Android version of 6.0.1 or greater (for iOS mobile devices will be implemented soon) and could be downloaded and installed from Play Store.

The requirements to complete the procedures are listed below:

- ABB Installer for Solar Inverters APP installed on mobile device.
- Enabled installer account for ABB Installer for Solar Inverters APP (The account could be created in the mobile app directly following the dedicated wizard procedure).
- Manual claiming of the inverters to be commissioned.

The claiming process consists of indicating which inverters are to be commissioned.

Claiming process can be performed by:

- taking pictures of the QR codes (A) of single inverter units (printed on the Communication identification label) (recommended).
- manual insertion of the MAC address (B) and related product keys (C) (printed on the Communication identification label) of all the inverters that shall be commissioned.



- scanning and selecting of SSIDs associated to the Wi-Fi networks generated by each inverter to commission.

Follow the procedure below to commission the inverter:

- Close the DC disconnect switches (16) to supply the inverter with input voltage from the photovoltaic generator. In the pre-commissioning phase the “Alarm” LED keeps quickly flashing, “Power” and “GFI” LEDs are OFF.
- Perform the installation wizard steps with ABB Installer for Solar Inverters APP enabling the transferring the settings to all the claimed inverters.
- After the commissioning via ABB Installer for Solar Inverters APP is completed, the inverter changes the behavior of the “Power” and “Alarm” LEDs (08), in relation of the input voltage value:

| Input voltage        | LED Status                      | Description   |
|----------------------|---------------------------------|---|
| $V_{in} < V_{start}$ | Power = Flashing<br>Alarm = OFF | The input voltage is not sufficient to enable connection to the grid.   |
| $V_{in} > V_{start}$ | Power = Flashing<br>Alarm = ON  | The input voltage is sufficient to enable connection to the grid: the inverter waits for the grid voltage to be present to make the connection to the grid. |

- Close the AC disconnect switch downstream of the inverter (and AC disconnect switch (09) for the -SX2 wiring box version).
- When the input voltage is sufficient to allow the connection to the grid, the inverter will check the grid voltage, measure the isolation resistance of the photovoltaic field with respect to earth and performs other auto-diagnostic checks. During the preliminary checks on the parallel connection with the grid, the “Power” LED keeps flashing, the “Alarm” and “GFI” LEDs are OFF. The inverter will ONLY connect to the grid if all parameters fall within the ranges foreseen by current regulations.
- If the outcome of the preliminary checks to grid synchronization are positive, the inverter connects and starts to export power to the grid. The “Power” LED remains fixed on while the “Alarm” and “GFI” LEDs are OFF.



For more details about commissioning and any other functionalities of the Installer for Solar Inverters mobile APP please contact ABB customer support. For any other specific settings of parameters of single inverters please refer to “Description of the Web User Interface” chapter on the product manual.

## Commissioning via Web User Interface

Commissioning could be carried out via wireless connection to the inverter's Web User Interface. Initial setup of the system must therefore be carried out via a tablet, notebook or smartphone with a wireless connection.

- Close the DC disconnect switches **(16)** to supply the inverter with input voltage from the photovoltaic generator. In the pre-commissioning phase the "Alarm" LED keeps quickly flashing, "Power" and "GFI" LEDs are OFF.
- Once powered, the inverter will automatically create a wireless network (approx. 60 seconds after switching-on).
- Enable the wireless connection on the device which is being used for the board setup (tablet, smartphone or PC) and connect it to the Access Point created by the inverter system; the name of the wireless network created by the system that the connection should be established with, will be: ABB-XX-XX-XX-XX-XX where "X" is a hex digit of the wireless MAC address **(B)** (MAC address can be found on the "Communication Identification Label" placed on the side of the inverter).
- When required enter the PRODUCT KEY **(C)** (printed on the "Communication Identification label" and applied during the commissioning phase to the plant documentation) as access point password (Note that it's required to digit also the dash "-" characters of the Product Key in the password field).
- Open an internet browser (recommended browser: Chrome versions from v.55, Firefox versions from v.50) and enter the pre-set IP address 192.168.117.1 to access the Web User Interface.
- Follow the step-by-step commissioning wizard to complete the commission of the inverter. After the settings are confirmed, the inverter restarts.



**From the moment the grid standard is selected, there will be 24 hours available to make any changes to the grid standard; after this, the "Country Select" feature is blocked and you can make further changes only by resetting the remaining-time timer.**

**For further information regarding the commissioning procedure via Web User Interface, please refer to the product manual.**

- After the commissioning via Web User Interface is completed, the inverter changes the behaviour of the "Power" and "Alarm" LEDs **(08)**, in relation of the input voltage value:

| Input voltage        | LED Status                      | Description   |
|----------------------|---------------------------------|---|
| $V_{in} < V_{start}$ | Power = Flashing<br>Alarm = OFF | The input voltage is not sufficient to enable connection to the grid.   |
| $V_{in} > V_{start}$ | Power = Flashing<br>Alarm = ON  | The input voltage is sufficient to enable connection to the grid: the inverter waits for the grid voltage to be present to make the connection to the grid. |

- Close the AC switch downstream of the inverter (and AC disconnect switch **(09)** for the -SX2 wiring box version).
- When the input voltage is sufficient to allow the connection to the grid, the inverter will check the grid voltage, measure the isolation resistance of the photovoltaic field with respect to earth and performs other auto-diagnostic checks. During the preliminary checks on the parallel connection with the grid, the "Power" LED keeps flashing, the "Alarm" and "GFI" LEDs are OFF. The inverter will ONLY connect to the grid if all parameters fall within the ranges foreseen by current regulations.
- If the outcome of the preliminary checks to grid synchronization are positive, the inverter connects and starts to export power to the grid. The "Power" LED remains fixed on while the "Alarm" and "GFI" LEDs are OFF.

**For more details about commissioning and any other functionalities of the Installer for Solar Inverters mobile APP please contact ABB customer support. For any other specific settings of parameters of single inverters please refer to "Description of the Web User Interface" chapter on the product manual.**

**According to CEC requirements the inverter display measured net generated energy and measured instantaneous power using a remote device like a smartphone, tablet or PC. Access it by connection to the inverter internal Webserver (please see the beginning of this paragraph on how to access to the internal webserver). In addition it is possible to use the mobile App 'ABB ability Energy Viewer for solar plants' and the ABB Web portal Aurora Vision (please refer to product manual for further details) to monitor all production data.**

## Arc fault detection

The Arc Fault Circuit Protection required by NFPA 70 Article 690.11 is provided by the inverter.

The AFD performs a self-test when the system is started:

- If the self-test results are OK, the inverter will continue to AC grid connection.
  - If a potential problem on the AFD board is detected, the self test will result in error E053.
- During normal operation the input current is continually measured and analyzed. If a DC arc fault is detected during operation, the inverter disconnects from AC grid and generates an E050 error code (readable through internal Webserver).

Based on the above conditions, the Leds behaviour is described in the table below:

|                   | POWER | ALARM | GFI                     |
|-------------------|-------|-------|-------------------------|
| Arc Fault pending | OFF   | ON    | ON                      |
| Self Test Failed  | OFF   | ON    | Blinking (200ms period) |

Press and hold the AFD reset button **(57)** on the right side of the DC wiring box for 3 seconds. This will clear the E050 error and restart the self test. If self-test results are OK, the inverter will reconnect to the AC grid; if the DC arc fault is still present, the inverter will result in error E050.

**Refer to the product manual (downloadable on [www.abb.com/solarinverters](http://www.abb.com/solarinverters)) for troubleshooting suggestions.**

The AFD self-test can be manually started anytime using the following procedure:

1. Turn off the inverter (switching off both DC and AC switches),
2. Turn on both the DC and AC switches and wait for self-test result.

If the AFD trips frequently, it means arcs are occurring. Turn the inverter OFF and request service to do complete check of the system wiring, including all connections and junction boxes, to locate the problem.

## Grid support functions and Voltage & Frequency trip limits

The inverter is equipped with advanced grid support functionality that is useful to support reactive loads and also assist in reliable operation of the utility grid in the presence of a large number of distributed energy generation sources. The grid support functions that are equipped on this inverter are described in the following sections.

The internal Webserver can be used to adjust grid parameters. A Wi-Fi connection to the inverter is required to modify settings using the internal Webserver.

This QIG provides an overview of the available grid support functions. For complete details, refer to the product manual at [www.abb.com/solarinverters](http://www.abb.com/solarinverters).

### 1. Voltage ride-through

This inverter provides parameters to respond to undervoltage and overvoltage events. The inverter is designed to operate normally within the specified operating range. If voltage excursions occur, the inverter is designed to continue operating normally or cease to export power for a specified delay. Beyond this programmed delay, the inverter disconnects from the grid in the event of an abnormal voltage condition.

### 2. Frequency ride-through

This inverter provides parameters to respond to underfrequency and overfrequency events. If frequency excursions occur, the inverter is designed to continue operating normally for a specified delay. Beyond this programmed delay, the inverter disconnects from the grid in the event of an abnormal voltage condition.

### 3. Reactive power control

The inverter provides several modes of operation for reactive power control and are described below:

- Disable: This is the default setting. Under this setting, the inverter exports with a power factor of 1.0.
- Fixed power factor control (Cos $\phi$  set): In this mode, the operator can set the output power factor to a fixed value. When enabled, a new value will be set in the inverter.
- Q Fixed (Q Set): Sets the reactive power to a fixed value. When enabled, a new value will be set in the inverter.
- Power factor as function of output power (Watt/Cos $\phi$  Settings: Cos $\phi$ (P)): In this mode, the inverter reduces the power factor (cos-phi) as a function of the output power at a given operating point. The 4 points of the default curve, where you can set the % of Pmax values and related cos-phi, can be modified using the internal Webserver. When enabled, the curve will be set in the inverter.
- Dynamic Volt/VAR control (Volt/VAR Settings: Q(V)): Under this mode, the level of reactive power exported by the inverter is a function of the operating grid voltage, also known as a Volt/VAR curve. The 4 points of the default curve, where you can set the % of Vnom values and related % of Smax, can be modified using the internal Webserver. When enabled, the curve will be set in the inverter.

### 4. Active Power Control

This inverter offers several modes for active power reduction.

- Active Power Curtailment: Sets a new value of active power as % of Pmax. When enabled, a new value will be set in the inverter.
- CEI Average VGrid Derating (only Italian grid standard): Sets, after a specific threshold, an active power derating based on the average of Vac on 10 minutes as per CEI-021 Italian grid standard.
- Volt/Watt settings: P(V). Under this mode, the level of active power exported by the inverter is a function of the operating grid voltage, also known as a Volt/Watt curve. The 4 points of the default curve, where you can set the % of Vnom values and related % of Pmax, can be modified using the internal Webserver. When enabled, the curve will be set in the inverter.
- Frequency/Watt function (Frequency Control: P(f)): In this mode, the inverter limits the active power as a function of the grid frequency.

### 5. Ramp control

The inverter is designed to control the rate at which output power is increased, either at startup, or after a temporary low power condition on the PV array (such as fast shading). The following ramp controls are provided on this inverter.

- Normal ramp: The normal ramp defines the maximum rate at which the inverter can increase the output power under normal operation. The normal ramp control limits the fluctuations in the output power in order to prevent instabilities on the utility grid.
- Soft start: The soft-start ramp defines the maximum rate at which the inverter can increase the output power when the inverter is first starting up. This startup may occur on a daily basis or when the inverter restarts after an abnormal grid event has ended.

This inverter has been factory programmed to automatically disconnect from the utility distribution system in compliance with UL 1741 and IEEE 1547-2003 specifications. Default voltage and frequency trip limit and trip time settings to comply with these standards are shown in table below. The internal Webserver can be used to adjust Voltage and Frequency Trip Limit and Trip Time Parameters according to Grid requirements of installation country.

| Condition | Utility source Voltage (V)       | Utility source Frequency (Hz)               | Max. time (sec) at 60Hz before cessation of current |
|-----------|----------------------------------|---|---|
| A         | < 0.50 Vnom (Fixed)              | Rated (60Hz)                                | 0.16 (default) Adj. Set Points 0.16 to 50s          |
| B         | 0.50 Vnom ≤ V < 0.88 Vnom (Adj.) | Rated (60Hz)                                | 2 (Default) Adj. Set Points 0.16 to 100 s           |
| C         | 1.10 Vnom < V ≤ 1.2 Vnom (Adj.)  | Rated (60Hz)                                | 1 (Default) Adj. Set Points 0.16 to 100 s           |
| D         | 1.2 Vnom ≤ V (Fixed)             | Rated (60Hz)                                | 0.16 (Adj. 0.001 to 0.16s)                          |
| E         | Rated                            | f > 60.5Hz (Default) Adj. 60.1 to 66.0 Hz   | 0.16 (Default) Adj. Set Points 0.16 to 1000 s       |
| F         | Rated                            | f < 59.3 Hz (Default) Adj. 50.0 to 59.9 Hz  | 0.16 (Default) Adj. Set Points 0.16 to 1000 s       |
| G         | Rated                            | f << 57.0 Hz (Default) Adj. 50.0 to 59.9 Hz | 0.16 (Default) Adj. Set Points 0.16 to 1000 s       |
| H         | Rated                            | f >> 63.0 Hz (Default) Adj. 60.1 to 66.0 Hz | 0.16 (Default) Adj. Set Points 0.16 to 1000 s       |

Reconnection 300s (Default) (Adjustable 20s to 1000s)

## Technical data table

|  | PVS-166-TL US  | PVS-175-TL US                       |
|--|--|-------------------------------------|
| <b>Input side</b>  |  |                                     |
| Absolute maximum DC input voltage ( $V_{max,abs}$ )                      | 1500 V   |                                     |
| Start-up DC input voltage ( $V_{start}$ )                                | 750 V (650...1000 V)   |                                     |
| Operating DC input voltage range ( $V_{dcmin...V_{dcmax}}$ )             | 0.7 x Vstart...1500 V (min 600 V)  |                                     |
| Rated DC input voltage ( $V_{dcr}$ )                                     | 1100 V   |                                     |
| Rated DC input power ( $P_{dcr}$ )                                       | 169 000 W @ 40°C   | 188 000 W @ 30°C<br>(177 kW @ 40°C) |
| Number of independent MPPT   | 12   |                                     |
| MPPT input DC voltage range ( $V_{MPPTmin...V_{MPPTmax}}$ ) at $P_{acr}$ | 850...1350 V   |                                     |
| Maximum DC input current for each MPPT ( $I_{MPPTmax}$ )                 | 22 A   |                                     |
| Maximum input short circuit current for each MPPT ( $I_{SCmax}$ )        | 30 A   |                                     |
| Number of DC input pairs for each MPPT                                   | 2 DC inputs per MPPT   |                                     |
| DC connection type   | PV quick fit connector <sup>1)</sup>   |                                     |
| <b>Input protection</b>  |  |                                     |
| DC Series Arc Fault Circuit Interrupter                                  | Type I acc. to UL 1699B with single-MPPT sensing capability  |                                     |
| Reverse polarity protection  | Yes, from limited current source   |                                     |
| Input over voltage protection for each MPPT - replaceable surge arrester | Type 2 with monitoring   |                                     |
| Photovoltaic array isolation control (Insulation Resistance, R-iso)      | Yes (pre start-up R-iso measurement)   |                                     |
| Residual Current Monitoring Unit (leakage current protection)            | Yes (dynamic GFDI)   |                                     |
| DC Load Breaking Disconnect Switch (rating for each MPPT)                | 30A/1500V ; 50A/1000V  |                                     |
| Fuse rating  | N/A, No fuses required   |                                     |
| String current monitoring  | MPPT-level current sense   |                                     |
| <b>Output side</b>   |  |                                     |
| AC Grid connection type  | Three phase 3W+PE  |                                     |
| Rated AC power ( $P_{acr}$ @ $\cos\phi=1$ )                              | 166 500 W @ 40°C   | 175 000 W @ 40°C                    |
| Maximum AC output power ( $P_{acmax}$ @ $\cos\phi=1$ )                   | 166 500 W @ 40°C   | 185 000 W @ $\leq 30^\circ\text{C}$ |
| Maximum apparent power ( $S_{max}$ )                                     | 166 500 VA   | 185 000 VA                          |
| Rated AC grid voltage ( $V_{ac,r}$ )                                     | 800 V  |                                     |
| AC voltage range   | 552...960 <sup>2)</sup>  |                                     |
| Maximum AC output current ( $I_{ac,max}$ )                               | 134 A  |                                     |
| Rated output frequency ( $f_o$ )   | 50 Hz / 60 Hz  |                                     |
| Output frequency range ( $f_{min...fmax}$ )                              | 45...55 Hz / 55...65 Hz <sup>2)</sup>  |                                     |
| Nominal power factor / adjustable range at $S_{max}$                     | > 0.995<br>0.75 Lead...0.75 Lag  | > 0.995<br>0.8 Lead...0.8 Lag       |
| Total current harmonic distortion  | < 3%   |                                     |
| Max DC current injection (% of $I_n$ )                                   | < 0.5%* $I_n$  |                                     |
| AC wire range  | 4x1x2/0 AWG to 4x1x400 kcmil, Cu/Al <sup>3)</sup>  |                                     |
| AC plate   | Opening for Trade size 3 conduit   |                                     |
| AC connection type   | Copper Busbar for ring terminal lug connections with M10 stud type terminal block (bolts included) |                                     |
| <b>Output protection</b>   |  |                                     |
| Anti-islanding protection  | Meets UL1741 / IEEE1547 requirements   |                                     |
| Output overvoltage protection - replaceable surge protection device      | Type 2 with monitoring   |                                     |

(Continue to next page)

|   | PVS-166-TL US  | PVS-175-TL US |
|---|--|---------------|
| <b>Operating performance</b>                |  |               |
| Maximum efficiency ( $\eta_{max}$ )         | 98.6 %   |               |
| Weighted CEC efficiency ( $\eta_{CEC}$ )    | 98.4 %   |               |
| <b>Communication</b>                        |  |               |
| Embedded communication interfaces           | Dual port Ethernet, WLAN <sup>4</sup> , RS-485   |               |
| User interface                              | 4 LEDs, Web User Interface, Mobile APP   |               |
| Communication protocol                      | Modbus RTU/TCP (SunSpec compliant)   |               |
| Commissioning tool                          | Web User Interface, Mobile APP   |               |
| Monitoring                                  | Plant Portfolio Manager, Plant Viewer  |               |
| FW update                                   | Remote inverter FW upgrade via Ethernet/WLAN interface locally/remotely                                    |               |
| Parameter upgrade                           | Remote inverter parameter upgrade via Ethernet/WLAN according to SunSpec Modbus protocol                   |               |
| <b>Environmental</b>                        |  |               |
| Operating ambient temperature range         | -13...+140°F (-25...+60°C)<br>with derating above 104°F (40°C)   |               |
| Relative humidity                           | 0...100% condensing  |               |
| Sound pressure level, typical               | <65 dB(A)@1m   |               |
| Maximum operating altitude without derating | 2000 m / 6560 ft   |               |
| <b>Physical</b>                             |  |               |
| Environmental protection rating             | Cert. to UL 50E Type 4X – meets or exceeds NEMA 4X   |               |
| Cooling                                     | Forced air cooling with variable speed cooling fan   |               |
| Dimension (H x W x D)                       | 34.2x42.7x16.5" (867 x 1086 x 419 mm) / -SX model<br>34.2x42.7x18" (867 x 1086 x 458 mm) / -SX2 model      |               |
| Weight                                      | ~76.5kg / 168 lbs for power module<br>~76.8kg / 169 lbs for wiring box<br>Overall max 153 kg / 338 lbs     |               |
| Mounting system                             | Bracket (included, vertical mounting only)   |               |
| <b>Safety</b>                               |  |               |
| Isolation level                             | Transformer-less (floating array)  |               |
| Marking                                     | cTUVus   |               |
| Safety and EMC standard                     | UL1741, IEEE1547, IEEE1547.1, CSA-C22.2 No. 107.1-01, UL1998, UL 1699B, FCC 47 CFR Part 15B Class A Limits |               |
| Grid standard                               | UL 1741 SA, IEEE1547, IEEE 1547a, Rule 21, Rule 14 (HI)  |               |
| <b>Optional available</b>                   |  |               |
| DC link recharge circuit                    | Night time operation with restart capability   |               |
| Anti-PID <sup>5)</sup>                      | Based on night time polarization of the array  |               |

1. Multicontact MC4-Evo2. Cable couplers may accept up to 10mm<sup>2</sup> (AWG8)
2. The AC voltage and frequency range may vary depending on specific country grid standard
3. Aluminum cable requires bi-metallic compression lug or bi-metallic adapter
4. as per IEEE 802.11 b/g/n standard, 2.4 GHz
5. Cannot operate simultaneously when installed in conjunction with the DC link recharge circuit







—  
[www.abb.com/solarinverters](http://www.abb.com/solarinverters)  
[www.abb.com](http://www.abb.com)

#### **Additional information**

Data and images are not binding. Depending on technical development and the products, we reserve the right to modify the content of this document without notice.

With regard to purchase orders, the agreed particulars shall prevail. ABB AG does not accept any responsibility whatsoever for potential errors or possible lack of information in this document.

We reserve all rights in this document and in the subject matter and illustrations contained therein. Any reproduction, disclosure to third parties or utilization of its contents – in whole or in parts – is forbidden without prior written consent of ABB AG.