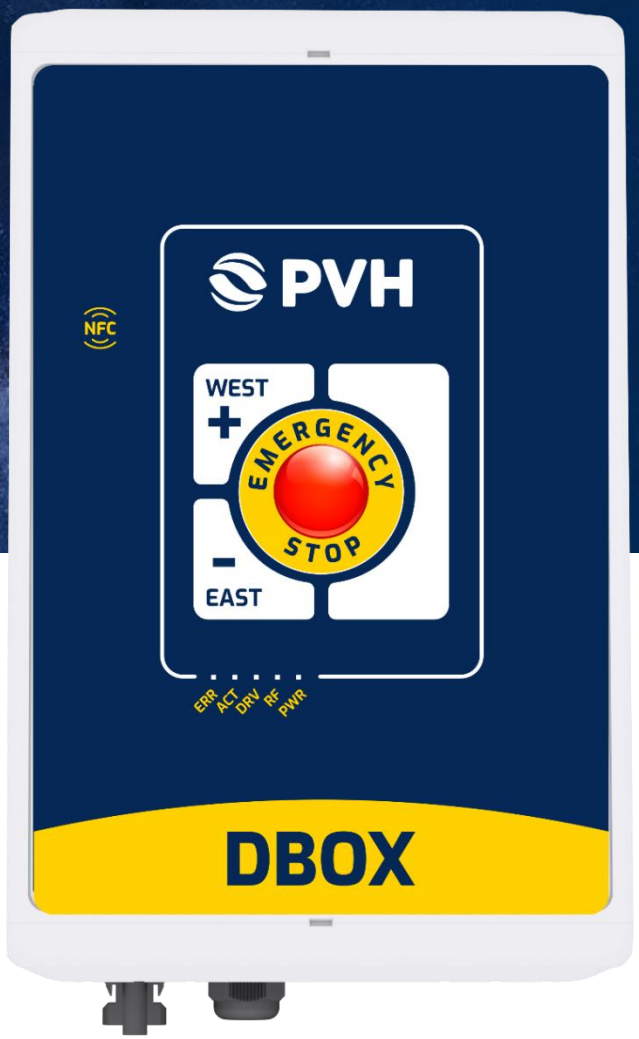
PVH SOLAR TRACKERS PRODUCT

# DBOX

User Manual




INTELLIGENCE
BEYOND STEEL

PVH-RD-PD-UMN-0004-01
Rev.: A1

# INDEX

***IMPORTANT:***

This document and the information in it are provided in confidence, for the sole purpose of exploring business opportunities between the disclosing party and the receiving party.

**Confidential document.**

It is not allowed to reproduce or disclose partial or totally the information contained in it, except by express written consent of PVH.

| BY/POR | *APPROVED/APROBADO* | *REV.* | *DATE/FECHA* | *REASON OF ISSUE/CAMBIOS* | |
|---|---|---|---|---|---|
| ER | OC | A1 | 03/2022 | First Edition | Primera Edición |

**IMPORTANT SAFETY INSTRUCTIONS**

**SAVE THESE INSTRUCTIONS** – This manual contains important instructions for DBox models DBox 4.0 DB-DB-SP-WL and DBox 4.0 DB-DB-AC-WL.

# 1. Introduction

The purpose of this manual is to describe the main characteristics and operation procedures for the Drive Box Tracker Controller. It is required that the user adheres to these instructions to ensure correct operation.

This document explains both DBox 4.0 versions:

- **DBox 4.0-DB-DB-SP-WL:** DBox 4.0 Wireless and Self-powered version.
- **DBox 4.0-DB-DB-AC-WL**: DBox 4.0 Wireless and AC powered version.

## 1.1. Glossary

| TERM | DESCRIPTION |
|---|---|
| **AC Input** | AC Input version |
| **DBoard, DB** | Electronic board which includes the NFC antenna, EEPROM memory and microcontroller which manages the tracker controller algorithms. It is enclosed in the DBOX. |
| **DBox** | PVH tracker controller. |
| **Emergency Stop** | Pushing button for emergencies situated in the case of the DBox. |
| **SCADA** | Control system architecture to interface and manage the photovoltaic plant. SCADA enables monitoring and issuing commands through the SCADA computer system. |
| **SP, DC Input** | Self-powered DC Input version |
| **TBox** | Technical name for the plant central controller. |
| **Tracker (or solar tracker)** | Tracking system considering the structure, photovoltaic panels, and the controller. |
| **Tracker Controller, Controller** | Box which manages the motor movement of the solar tracker. Power cables come into the box to feed the motor. |

## 1.2. Reference Documents

| CODE | DESCRIPTION |
|---|---|
| **PVH-OM-SYS-CONSOL-001** | Controller Solution |
| **PVH-EG-SYS-CONDET-XX.WL.XX-001** | Connection Details |
| **PVH-EG-DST-DBX40-XX.WL.DC-001** | Datasheet DBox 4.0 |
| **PVH-EG-DS-TB31-2313** | Datasheet TBox 3.1 |
| **PVH-OM-MAN-TBX31-001** | Operation and Maintenance Manual TBox 3.1 |
| **PVH-OM-MAN-APPDB31-8102** | Operation and Maintenance Manual<br>PVH Tracker Controller APP |

## 1.3. Regulatory Compliance

**IEC 61010-1: 2010 + AMD1: 2016 / UNE EN 61010-1: 2011 / EN 61010-1:2010 (*)**. Safety requirements for electrical equipment for measurement, control, and laboratory use.

**IEC 61326-1:2012 (*)**. Electrical equipment for measurement, control, and laboratory use.

**UL61010-1 / CSA-C22.2 No. 61010-1 (*)**. UL and CSA Standards for Safety Electrical Equipment for measurement.

**UL3703 (*).** UL Standard for solar trackers.

*__SGS__ Certified Standards.

800727

## 1.4. FCC/ISED Regulatory notices

### *1.4.1. Modification statement*

PVHARDWARE SOLUTIONS S.L. has not approved any changes or modifications to this device by the user. Any changes or modifications could void the user's authority to operate the equipment.

### *1.4.2. Interference Statement*

This device complies with Part 15 of the FCC Rules and Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

### 1.4.3. Wireless Notice

This equipment complies with FCC and ISED radiation exposure limits set forth for an uncontrolled environment. The antenna should be installed and operated with minimum distance of 20 cm between the radiator and your body. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

### 1.4.4. FCC Class B Digital Device Notice

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

### 1.4.5. CAN ICES-3 (B) / NMB-3 (B)

This Class B digital apparatus complies with Canadian ICES-003.

# 2. Safety information

## 2.1. Warnings, cautions and notes


**One *WARNING!* contains information which is essential for avoiding safety hazard.**


**One *CAUTION!* contains information which is necessary for avoiding risk of damage to the product or others.**

**NOTE**
**A NOTE contains information which helps to ensure correct operation of the product.**

## 2.2. Electrical Safety

The voltages used in the Solar Tracking Control System can cause electrical shock or burns and could be lethal. For this reason, precautions must always be taken to the extreme when working with, or adjacent to, the control system equipment. Specific warnings are given throughout this User Manual.

The user who is working with the device must always agree with this manual.

## 2.3. System Assembly and General Warning

The Control System is intended as an ensemble of components for professional incorporation into a complete solar tracking installation.

Close attention to the electrical installation and the system design is required to avoid hazards either in normal operation or in the event of equipment malfunction.

Installation, commissioning/start-up, and maintenance must be carried out by personnel who have the necessary training and experience. They must read this safety information and this User Manual carefully.

## 2.4. Installation Risks

Concerning errors during the installation of the equipment:

- If a mechanical or electrical component is damaged, do not use the product and contact your supplier.
- If the installation instructions are not followed correctly, some problems might arise, such as damage to the unit or physical harm.
- The work tools used to install the device should be approved for the job considering the voltage in the system.
- Once the installation has been carried out, the installed units and the cables should not be moved.
- The power cables from the panel to the DBox cannot be wrongly connected, the connectors are differentiated.

## 2.5. Radio Frequency (RF)

In relation to Safety due to the possibility of radio frequency (RF) interference, it is important that you follow all the special regulations that may apply regarding the use of radio equipment. Follow the safety advice given below.

Operating your device close to other electronic equipment may cause interference if the equipment is inadequately protected. Observe any warning signs and manufacturers' recommendations.

## 2.6. Interference with Pacemakers and Other Medical Devices

**Potential interference**

Radio frequency energy (RF) from cellular devices can interact with some electronic devices. This is electromagnetic interference (EMI). The FDA helped develop a detailed test method to measure EMI of implanted cardiac pacemakers and defibrillators from cellular devices. This test method is part of the Association for the Advancement of Medical Instrumentation (AAMI) standard. This standard allows manufacturers to ensure that cardiac pacemakers and defibrillators are safe from cellular device EMI.

The FDA continues to monitor cellular devices for interactions with other medical devices. If a harmful interference occurs, the FDA will assess the interference and work to resolve the problem.

### Precautions for pacemaker wearers

Based on current research, devices do not pose a significant health problem for most pacemaker users. However, people with pacemakers may want to take simple precautions to be sure that their device does not cause a problem. If EMI occurs, a pacemaker could be affected in one of the following three ways:

- Stop the pacemaker from delivering the stimulating pulses that regulate the heart rhythm.
- Cause the pacemaker to deliver the pulses irregularly.
- Cause the pacemaker to ignore the heart own rhythm and deliver pulses at a fixed rate.

Keep the device on the opposite side of the pacemaker to add extra distance between the pacemaker and the device.

Avoid placing a turned-on device next to the pacemaker.

### Device Maintenance

When maintaining your device:

- Do not attempt to disassemble the device. There are no user serviceable parts inside.
- Do not expose the DBox directly to any extreme environment where the temperature or humidity is high.
- Do not place the DBox alongside computer discs, credit or travel cards, or other magnetic media. The information contained on discs or cards may be affected by the device.
- Using accessories that PVH has not authorized, such as antennas, may invalidate the warranty. If the device is not working properly, contact PVH Technical Support.

# 3. Handling Conditions

When the product is received and before opening it, it must be verified that the packaging is in good condition. In case of damage, it should be notified in written form to the transport company or supplier.

When unpacking, it must be checked that everything is included and in perfect conditions.

If the unit is not immediately installed, it is convenient to keep it in its original packaging and situated in a ventilated and dry environment.

**WARNING!**

Never connect the fuse of the device until it is to be installed.

Prior to final installation of the device, the fuse must always be disconnected. Failure to do so will result in loss of warranty.

PVHardware will not be responsible for improper handling or installation of the devices. Installation should be only executed by trained and professional personnel. Any deviation of this manual may cause personal or device damages and loss of warranty.

Consider that some information in this manual might have changed, so it is important to be in contact with PVHardware Support.

**WARNING!**

Read and comply with product installation, operation, and maintenance manuals.

# 4. General description

DBox 4.0 is the first controller generation by PVH, designed to control and monitor the movement of the structure, improving solar tracking and power generation.

## 4.1. DBox general description

### *4.1.1. Technical Data*

| CHARACTERISTIC | VALUE | COMMENTS |
|---|---|---|
| **MAIN CHARACTERISTICS** | | |
| **IP rate** | IP67 Type Rating 3R | |
| **Output Voltage** | 24V DC | |
| **Communications** | LoRa with TBox | |
| | Modbus with external inclinometer | |
| **Size** | 270x170x120 | |
| **Emergency Stop** | Provided | |
| **Protections** | Fuse: 5x20mm, 16A, time delayed | SP-DC version |
| | Fuse: 5x20mm, 16A, time delayed | AC version |
| **Environment** | Exterior | |
| **Temperature operation range** | -20°C to 60°C [1] Battery Disclaimer | SP-DC version |
| | -40°C to 60°C | AC version |
| **Humidity rate** | 5% to 95% non-condensing | SP-DC version |
| | 10% to 95% non-condensing | AC version |
| **Maximum high of installation** | 3000 m | |
| **Overvoltage category** | OVC II | |
| **Pollution degree** | PD2 | |
| **Control Board Model** | DBoard | |
| **SELF-POWERED DC INPUT VERSION – (*Optional Double-panel available)** | | |
| **Input Voltage** | 37V (*per PV panel) | |
| **Maximum power Input (PV panel)** | 40W (*per PV panel) | |

| CHARACTERISTIC | VALUE | COMMENTS |
|---|---|---|
| **Battery Material** | LiFePO4 | |
| **Battery Normal Capacity** | 8Ah / 10Ah | |
| **Battery Typical Discharge Current** | 10A / 15A | |
| **AC POWER INPUT VERSION** | | |
| **Voltage Range** | 110 - 230 V AC 260VA | |
| **Frequency Range** | 50 - 60Hz | |
| **Efficiency** | 94 % | |
| **AC Current** | 1.1A/230V AC | |

[1] **Battery disclaimer**

Max working temperature in charge: 60°C; discharge: 60°C
Min working temperature in charge: 0°C; discharge: -20°C
The battery storage shall be in a clean, dry, and ventilated room, at room temperature, away from fire or heat and shall avoid corrosion elements. The batteries shall be charged every 3 months during storage, to about 30% to 50% of capacity. Both the stored cells in the process of the battery and the batteries in delivery shall be "first come, first use". The battery storage period is 12 months when in the warehouse. Expired batteries must be thoroughly checked.

### 4.1.2. Mechanical Characteristics

The DBox is equipped with two holders at the back of the cabinet. They are used to attach it to the corresponding structure as shown in the image below.

*Figure 1: Optional locations of the DBox*

The minimum and maximum dimensions between the predrilled holes to be considered during installation are indicated below.


| DIMENSIONS | |
|---|---|
| **A** | 293.8 mm |
| **B** | 126 mm |
| **C** | 188 mm |

*Figure 2: DBox dimensions*

### 4.1.3. Connection Diagrams

The DBox consists of an IP67 electric cabinet prepared for LoRa communications.

It has a pressure membrane that ensures the safety of the components inside the enclosure.

Externally there are two main components:


A) The Front Panel, situated on the cover of the DBox, can be vertically or horizontally oriented, depending on the location of the DBox. It is composed of:

1. Two capacitive buttons to allow the movement. (West and East).
2. An emergency stop button for an emergency stop. (Red button)
3. An NFC tag to connect with the Control App, that allows to transfer parameters and commands.
4. Five LED indicators that are ON when: ERR (ERROR: An error has occurred); ACT (ACTIVE: Normal operation), DRV (DRIVE: The motor is moving), RF (DBox communicating via LoRa); PWR (POWER: When the DBox is ON).

*Figure 3: DBox Front Panel*

B) The Connectors Panel of the DBox has 6 cable glands for the different cables that are used to connect the system:

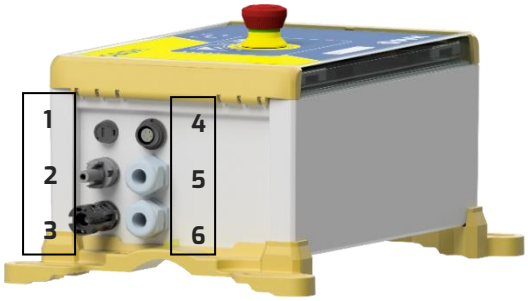



*Figure 4: DBox Connectors Panel*

| | Self-Powered DC Input version | AC Input version |
|---|---|---|
| 1 | Fuse | Fuse |
| 2 | Power (Negative pole) | N/A |
| 3 | Power (Positive Pole) | N/A |
| 4 | External Inclinometer | External Inclinometer |
| 5 | DC Motor | DC Motor |
| 6 | N/A | AC cable |

## 4.2. Power Input

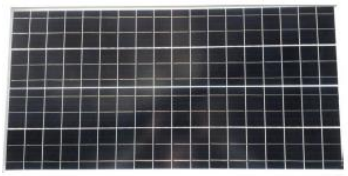
Working Cycle Note:

a) 8 cycles of 10 min powered at 60°C / 40 min off until the temperature reaches 50°C
b) 2 cycles of 5 min powered at 60°C / 20 min off until the temperature reaches between 50°C - 55°C

### *4.2.1. Self-powered: DC Input Voltage*

DC Input version is designed to power the DBox controller through the solar charge manager that is included inside the self-powered DBox. It is composed of one battery and one or two PV panels. This system makes the DBox self-powered.

Battery life preservation



The performance or "health" of batteries tends to deteriorate gradually during their lifetime due to irreversible physical and chemical changes taking place because of usage and age. Deep charges and discharges can reduce battery life, so the DBox tries to keep an average state of charge by monitoring the SoC (state of charge) of its battery, taking some decisions to maintain and preserve its lifetime.

The DBox sends its own SoC in every message to the Gateway in order to monitor its charge and discharge cycles. When the battery level is too low, the structure is moved to stow position and the system is turned off to preserve the battery health. Once the acceptable battery level is reached, the DBox turns on the system again.

### *4.2.2. AC Input Voltage*

Implemented ACDC power source allows to power the DBox with AC.

| INPUT REQUIREMENTS | |
|---|---|
| **Voltage Range** | 110 - 230V AC, 260VA |
| **Frequency Range** | 50 - 60Hz |
| **Efficiency** | 94 % |
| **AC Current** | 1.1A/230V AC |

## 4.3. Power output - Motor

To move the structure the DBox has to be connected to the motor placed on the structure. For this interaction to be done, the DBox has its motor power cable arranged with one quick connector to allow fast connection, and the motor must have the counterpart piece of this connector.

| DC MOTOR | |
|---|---|
| **Type** | DC |
| **Voltage** | 24V |
| **Max Motor current** | 10 A |

## 4.4. Angle measurement

Three types of angle sensors can be supplied:

### *4.4.1. Tilt position + String current measurement: SBox*

SBox measures the tilt position of the structure and monitors the current in the panel strings, bringing information of how much current the tracker is generating.


| TILT MONITORING PARAMETERS | |
|---|---|
| **Resolution** | 0.01° |
| **Accuracy** | +/-0.2 |
| **STRING MONITORING SYSTEM** | |
| **Voltage** | Compatible with up to 1500V DC string voltage |
| **Current** | 0-20A |

### *4.4.2. Tilt position External Inclinometer*

The tilt position external inclinometer measures the sun tracking angle of the structure. This type of inclinometers is recommended for high structures: the inclinometer must be attached to the torque tube, and the DBox must be anchored to the structure in a lower location.

| ITEM | CONDITIONS | 30° | 60° | 90° | UNIT |
|---|---|---|---|---|---|
| **Resolution** | - | 0.1 | 0.1 | 0.1 | ° |
| **Accuracy** | 25°C | +/- 0.2 | +/- 0.3 | +/- 0.5 | ° |

### *4.4.3. Tilt position Internal Inclinometer*

The tilt position internal inclinometer measures the sun tracking angle of the structure. It is included in the control board (DBoard) located inside the DBox, and, therefore, the DBox must be installed on the torque tube. This type of inclinometers should only be used in low structures, so that the emergency button, the capacitive buttons, and the NFC tag are fully accessible to the operator.

| ITEM | CONDITIONS | 30° | 60° | 90° | UNIT |
|---|---|---|---|---|---|
| **Resolution** | - | 0.1 | 0.1 | 0.1 | ° |
| **Accuracy** | 25°C | +/- 0.2 | +/- 0.3 | +/- 0.5 | ° |

## 4.5. Communications

### *4.5.1. Plant Communications: Wireless – LoRa Technology*

To establish plant communications as the solar setpoint or the wind alarm, the DBox can only interact with its partner, the TBox. These communications TBox-DBox are stablished through LoRa wireless technology, which offers a very compelling mix of wireless, long range, low power consumption and secure data transmission.

Every LoRa node (DBox) must have a network master (TBox). DBox devices must always be connected to one Gateway which gives them access to the LoRa Network. This LoRa network is installed in the TBox and expands its coverage with the several Gateways in plant.

This configuration uses the implemented drive board antenna to communicate between the LoRa Gateways of the TBox. The Gateway sends the status and the angle position to every DBox and they answer with another LoRa message when the new position is reached or any event happens.

**NOTE** → For more information about the typical network refer to the "*Connection Details*" document.

For more information about LoRa Gateway and TBox refer to the "*Controller Solution*" document and to the "*TBox*" installation, operation, and maintenance manual.

### *4.5.2. Angle sensor Communications*

To read the actual position of the tracker and compare it to the received setpoint, the DBox must be connected to one inclinometer. The communication with the inclinometer depends on the type of inclinometer provided with the DBox: Internal or External inclinometer.

The external inclinometer communication is carried out through Modbus RTU protocol, allowing the master-slave interaction to ask for inclinometer information. Two types of external angle sensors can be supplied; both use a non-contact principle to measure the tilt angle of the structure. The installation of both inclinometers is simple and convenient, and they only need to be fixed on the structure and connected to the DBox 4.0 through their own connector.

The internal inclinometer is included inside the DBox, specifically in the control board (DBoard) of the DBox. Therefore, the internal inclinometer communication is carried out internally, so there is no need for an additional communication protocol.

## 4.6. Front panel

The DBox is equipped with one NFC tag used as an interface with the user, to control and commission the device. It is also provided with two capacitive buttons to move the structure (EAST or WEST), and an emergency stop button in the midpoint of the front panel to stop the tracker in case of emergency. The front panel can be vertically or horizontally oriented depending on the inclinometer and the DBox final location on the structure. Always indicate the inclinometer model that is going to be installed.


← Horizontally oriented Front Panel:

- Usually installed on torque tube.
- Internal inclinometer.

Vertically oriented Front Panel: →

- Usually installed on actuator pile.
- External inclinometer.


*Figure 5: DBox orientation options*

## 4.7. Labelling

The device labels will look as follows:

- External Labels:


**DBox 4.0 SP**


**DBox 4.0 AC**

- Interior Label:


*Figure 6: DBox Labels*

# 5. Functional Description

The DBox 4.0 is the tracker controller based on the implementation of one drive board that allows a distributed control approach. Every tracker implements a position closed loop controller and implements security functions.

*Figure 7: DBox 4.0*

The DBox 4.0 is used for the following purposes:

- Receiving information from the plant central controller (PVH master box called TBox)
  - Angle setpoint which depends on the time of day:
    - Day-tracking
    - Backtracking
    - Night-time
  - Wind Alarm
  - Snow Alarm
  - Hail Alarm
- Controlling the DC motor of the tracker directly from its internal control board.
- Running the control algorithms reading the feedback from the inclinometer.
- Managing the tracker alarms.
- Acting as the NFC interface with the operator smartphone.
- Acting as the manual interface with the operator allowing the movement with its capacitive buttons.
- Sending the tracker information up to the TBox.

## 5.1. Operation

### *5.1.1. Safety features*

Emergency Stop Button

The Emergency Stop button halts the tracker operation and it can be activated by pressing it. This is the highest priority status. After releasing the Emergency Stop button the DBox passes through the *halt* status. There are three ways to leave this stage: pressing a capacitive button, sending one NFC command, or receiving a TBox message.

Communication timeout

In sun-tracking mode, if the DBox does not receive any downlink message during a time interval, the DBox sends the status "TBox communications lost" to the TBox and it moves the tracker to the position that best protects the tracker under current conditions. It will choose between *Stow position or Construction position*[1]. This mode overrides the Automatic status until a new TBox message is received or another command is sent from the local status (NFC or local manual). This ensures that the structure remains protected even in case of a network loss.

Wind Alarm[2]

If the tracker receives a wind alarm message, it should automatically go to the position that best protects the tracker under current wind conditions to keep the integrity of the structure: *Stow position or Construction position*[1]. „ Manual (local or remote) and NFC modes have higher priority than wind alarm status, so that when the tracker is in these modes, it will not change its position until it returns to Auto Mode.

Snow Alarm[2]

If the tracker receives a snow alarm message, it should automatically go to the most protective position under current snow conditions, which can be *Stow position or Construction position,* to keep the integrity of the structure. Manual (local or remote) and NFC modes have higher priority than wind alarm status, so that when the tracker is in these modes, it will not change its position until it returns to Auto Mode.

Soft start and stop (PWM)

To protect the tracker and save battery power, the internal control board has an integrated PWM (Pulse Width Modulation) system for a soft start and stop of the DC motor. This maneuver optimizes the start and stop sequence, saves battery, protects the motor extending its life and protects the DBox and the motor from current peaks.

Software limits

Software limits are configured to prevent the structure from leaving its nominal working region. These limits will stop the structure from exceeding the boundaries and will allow it to go back to the nominal region without triggering any alarms.

The *range of movement*[3] is programmable in the commissioning stage.

Low battery level (SP version)

As the DBox can read its battery level, some features have been implemented depending on it. When a low battery level is detected (< 40%) the DBox sends its status to the TBox and the DBox goes to the position that best protects the tracker under current conditions, which can be *Stow position or Construction position*[1], until the

battery is recovered (60%). This ensures the safety of the structure in case of wind or snow alarm during the fault.
After any reboot, and as a safety measure, the limits that apply are 60% (low level) and 80% (recovery level), until the battery charge reaches 100%.

[1] *Stow and construction positions* must be provided by the structure designer.

[2] For more information about wind and snow alarms, see the "*Controller Solution*" document.

[3] The *range of movement* of the structure must be provided by the structure designer.

### *5.1.2. Status description: Operation modes*

OperationMode → The operation mode depends on the stage in which the DBox is. SCADA will always show the information of the last DBox message received by the TBox.

- Defect: Not recognized: The DBox that is being consulted has not yet joined the LoRa network, so the TBox does not have information about it, since it has not been recognized in the system. The DBox is not in communication with the TBox, so it will not respond to its orders, will not send its information, or do solar tracking until it has joined the LoRa network.
- TBox Control: Auto: This is the nominal operating state. It is the mode with the lowest priority and can be surpassed by any other operating mode. Under nominal conditions, the tracker will use the setpoint sent by the TBox to follow the angle established by the solar algorithm.
  The solar tracking stage is made up of 3 sub-modes:
  - Day-Tracking: The TBox sends the setpoint for sun-tracking.
  - Backtracking: This function prevents shadows in the tracker in sunrise and sunset. During backtracking the setpoint is sent faster than in day-tracking.
  - Night-time: To save battery while the tracker is stopped at night, a static setpoint is sent if no alarm is active. The default setpoint at night is 0° but PVH can configure a different angle if required.

  Also, in the automatic mode, the stow position is sent when a wind or snow alarm is activated, which may be wind stow or construction stow position, depending on the situation.
  When the DBox is in automatic mode means that the TBox is remotely controlling it for solar tracking. If in this Auto state the wind alarm or snow alarm are triggered, the TBox would stop sending the solar angle and send the stow position that best protects the tracker at that moment, which can be wind stow or construction stow. See section *Use cases* to know the position that best protects the tracker in each situation.

**WARNING!**

Wind and snow alarms and the TBox communications lost mode will only move the tracker to stow position if the previous status of the tracker was Auto.

If the tracker is in any other status and an alarm is triggered, it will be ignored, and the tracker will remain in the current position.

- Remote Control: Manual position: Remote manual mode allows to set the tracker in a user-defined position.
  If the DBox is in remote manual it is being remotely controlled from SCADA. In this status, the DBox will be in a static position and will not move until it receives a new manual order or until it is sent back to the Auto state for tracking.
- Local Control: PVH application: PVH application with NFC control allows to control the tracker with the PVH "Tracker Control" app to set the tracker locally in a user-defined position. In this status, the DBox will be in a static position and will not move until it receives a new NFC order or until the control is returned to the TBox.
- Halt: Waiting for acknowledge: The DBox is halted waiting for a new order to restart the movement. This status happens when the emergency stop button has been pressed and released and no further action has been taken, such as moving the tracker or returning the control to the TBox.
- Remote Control: Manual Wind Position: The DBox is in wind stow position in remote control.
- Remote Control: Manual Construction Position: The DBox is in construction position in remote control.
- Defect: Tracker protection status: The battery level is very low (<40%) to continue tracking the sun, so to protect the tracker, it will automatically move to the stow position that best protects the tracker in that moment, which can be wind stow or construction stow position. When the battery is recovered (>60%) the tracker will return to its previous status. As a safety feature, when the device starts, these limits are stablished at 60% (low level) and 80% (recovery level) until the battery reaches the 100%. See section *Use cases* to know the best position for each case.

**WARNING!**

Low battery mode has priority over all states except for Fault Stop, Local Emergency Stop and any of the alarms that stop the tracker automatically (see *Alarms and notifications*). In all other cases Low battery mode takes priority and the tracker will move to its stow position automatically.

- Defect: Fault Stop: There is a problem in the motor behavior or in the movement of the structure and the tracker is stopped until the problem is solved. This behavior may have been caused by a failure in the gearbox or the motor, among other cases.
- Local Control: Emergency Stop: The emergency stop button is pressed. This is the highest priority state, so the tracker will be stopped until the button is released, and manual or local control is established again. In case of releasing the emergency button and not carrying out any control, the DBox will remain in Halt state until it receives a movement command.
- Remote Control: Manual Stop: The DBox is in remote emergency stop mode from SCADA. The tracker will remain stopped until it receives another local or remote-control command or until the tracker is returned to Auto mode.
- Defect: TBox Communications Lost: The DBox has lost the TBox communications. In the event of this loss of communications, the tracker will automatically move to the stow position that best protects the tracker at that moment, which can be wind stow or construction stow position. See section *Use cases* to know the best position for each case.

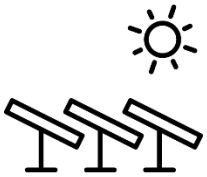
- Local Control: Buttons: The DBox is being controlled locally using the capacitive buttons. If a DBox is in local manual mode it will have a static position and will not move until it receives another manual command or until the control is returned to the TBox.

### *5.1.3. Alarms and notifications*

- Alarms → Each alarm is given a code number that depends on the type of fault concerning the tracker. Contact Technical Support to return the tracker to nominal operation.
- Emergency Stop: The emergency stop button on the DBox has been pressed. The tracker will remain stopped until the button is released. This alarm is associated with the status of Local emergency stop.
- Charger Fault (SP version): Communication failure between the DBoard and the solar charger. No value can be read. To protect the structure, the tracker will automatically move to the stow position that most protects it at that moment, which can be wind stow or construction stow position. See section *Use cases* to know the best position for each case.
- Inclinometer Fault: The inclinometer measurement is constantly reviewed to ensure correct operation. For safety reasons, if there is a fault in the inclinometer reading, the tracker will not move until the fault is corrected and until the inclinometer provides the correct angle.
- Overcurrent Fault: There is an overcurrent in the motor, so the tracker will be stopped to avoid damaging the controller, the motor, or the structure. The tracker will remain stopped until the problem is solved.
- Wrong direction movement: It is activated when the tracker is moving in the opposite direction than expected. The tracker will be stopped to avoid damages and it will remain stopped until the fault is corrected.
- Slow motor movement: It is activated when the motor is moving unusually slowly. The tracker will remain stopped until the fault is corrected. This alarm can be configured during the commissioning stage.
- High power consumption: It warns that the consumption of the DBox is greater than 10 A for over 1 second. The tracker will remain stopped until the fault is corrected to ensure the safety of the tracker. This alarm can be configured during the commissioning stage.
- Static inclinometer read: It is activated when the reading of the inclinometer is static, but the motor is consuming, or the tracker should be moving. The possible causes of this alarm may be an inclinometer fault or that the motor is disconnected.
- Out of boundaries: This alarm warns that the reading of the inclinometer is greater than ± 65°, so the tracker is out of boundaries, or the inclinometer has been released and it is hanging. The tracker will remain stopped until the fault is checked and corrected.
- Low battery: This alarm warns that a low battery level is detected (<40%). To ensure the safety of the structure in case of wind or snow alarm during the fault, the tracker is sent to Secure mode, and moved to Wind or Construction Stow position, depending on the wind conditions at that moment (refer to section 5.2.2.*Alarm use cases – Stow or construction position?)*, until the battery is recovered (>60%).
- Low temperature: The reading of temperature from the charger is too low. To ensure the safety of the structure in case of wind or snow alarm during the fault, the tracker is sent to Secure mode, and moved to Wind or Construction Stow position, depending on the

wind conditions at that moment (refer to section 5.2.2.*Alarm use cases – Stow or construction position?*), until the temperature is restored.

- High temperature: The reading of temperature from the charger is too high. To ensure the safety of the structure in case of wind or snow alarm during the fault, the tracker is sent to Secure mode, and moved to Wind or Construction Stow position, depending on the wind conditions at that moment (refer to section 5.2.2. *Alarm use cases – Stow or construction position?*), until the temperature is restored.
- PV panel fault: This alarm is activated when the reading of the voltage of the panel from the charger is 0.0 V during Day-tracking or Backtracking (never Night-time mode). The operation of the DBox continues normally.
- Fuse Fault: This alarm warns that a fuse failure has occurred because the remaining battery percentage is 0%. To ensure the safety of the structure in case of wind or snow alarm during the fault, the tracker is sent to Secure mode, and moved to Wind or Construction Stow position, depending on the wind conditions at that moment (refer to section 5.2.2. *Alarm use cases – Stow or construction position?*), until the fault is restored.



Notifications → Notifications are associated with a code that depends on the type of notification.

- Construction stow: The tracker is moving to Construction stow position, since the TBox is currently sending Construction stow position automatically or because this position has been sent manually from SCADA.
- Wind stow: The tracker is moving to Wind stow position, since the TBox is currently sending Wind stow position automatically or because this position has been sent manually from SCADA.
- Backtracking: The DBox is in Backtracking mode, since the TBox is currently sending a backtracking setpoint automatically. Check that the setpoint is correct and that it is within sunrise or sunset hours. The DBox will perform the backtracking when it is in automatic mode, since the backtracking is part of the solar tracking.
- Hail position: The TBox is currently sending a Hail position setpoint to keep the integrity of the structure. The command has been sent by an operator from SCADA.
- Snow position: Some snow has been detected by the snow sensor and the TBox is currently sending a Snow position setpoint, positioning the trackers at 0° to keep the integrity of the structure until the snow is removed. This will only happen when the DBox is in Automatic mode, so that when the snow is removed, the tracker automatically returns to the corresponding position.
- Diffuse: The TBox is currently sending a Diffuse position setpoint, positioning the trackers at 0° to capture as much diffuse light as possible on cloudy days. This will only happen when the DBox is in Automatic mode.
- Night position: The TBox is currently sending a Night position setpoint to save battery charge while no solar energy can be collected, and as long as no alarm is active. This will only happen when the DBox is in Automatic mode.

## 5.2. Use cases

### *5.2.1. Status priorities: local and manual controls*

- ➔ *Local maneuver* is a concept composed of the NFC interface control (manual, wind, clean, etc.), local capacitive buttons control or pressing the emergency stop button.
- ➔ *Remote maneuver* is a concept composed of remote manual, remote stop, and remote cleaning.

**WARNING!**

Local or remote operations that the O&M technician performs in the tracker, such as manual movements or stop, have priority over the automatic operations that the TBox sends, such as sun-tracking or wind and snow alarms.

Local maneuvers take priority over remote maneuvers.

This means that, if the tracker is not in AUTO MODE, it will not track the sun or go to stow position in case of storm or snow. PVH is not responsible for any damages caused to the tracker if a wind or snow alarm is triggered during local or remote maneuvres.

**NOTE** → For more information about local and manual control refer to section *6. Interfaces.*

### *5.2.2. Alarm use cases – Stow or construction position?*

After having explained each situation separately, it is important to know that more than one alarm can occur simultaneously. Therefore, the table below has been created to clarify the behavior of the system.

**WARNING!**

**The table below shows transitions between positions, not between stages.**
**Transitions explained in table WILL ONLY WORK when the tracker is in AUTO MODE.**
As snow alarm, wind alarm and TBox communications alarm only work in AUTO MODE, if the tracker is in any other status (manual remote or local, emergency stop remote or local, NFC or Fault Stop) these transitions won't work.

| Previous tracker position | Wind speed | Snow Alarm (High level) | Low Battery | Comm Loss | Final Tracker position |
|---|---|---|---|---|---|
| Tracking | <***a*** m/s | OFF | OFF | OFF | Tracking |
| Tracking | >***a*** m/s | X | X | X | Wind stow |
| Tracking | >***c*** m/s | **ON** | OFF | OFF | Wind stow |
| Tracking | <***c*** m/s | **ON** | OFF | OFF | Construction |
| Tracking | >***c*** m/s | OFF | **ON** | OFF | Wind stow |
| Tracking | <***c*** m/s | OFF | **ON** | OFF | Construction |
| Tracking | >***c*** m/s | OFF | OFF | **ON** | Wind stow |
| Tracking | <***c*** m/s | OFF | OFF | **ON** | Construction |
| Construction | WIND Alarm active | X | X | X | Construction |
| Construction | No WIND Alarm | **ON** | OFF | OFF | Construction |
| Construction | No WIND Alarm | OFF | **ON** | OFF | Construction |
| Construction | No WIND Alarm | OFF | OFF | **ON** | Construction |
| Construction | No WIND Alarm | OFF | OFF | OFF | Tracking |
| Wind stow | WIND Alarm active | X | X | X | Wind stow |
| Wind stow | <***b*** m/s (t>10') | OFF | OFF | OFF | Tracking |
| Wind stow | <***b*** m/s (t<10') | OFF | OFF | OFF | Wind stow |
| Wind stow | <***b*** m/s (t>10') & <***c*** m/s | **ON** | OFF | OFF | Construction |
| Wind stow | <***b*** m/s (t>10') & >***c*** m/s | **ON** | OFF | OFF | Wind stow |
| Wind stow | <***b*** m/s (t<10') | **ON** | OFF | OFF | Wind stow |
| Wind stow | <***b*** m/s (t>10') & <***c*** m/s | OFF | **ON** | OFF | Construction |
| Wind stow | <***b*** m/s (t>10') & >***c*** m/s | OFF | **ON** | OFF | Wind stow |
| Wind stow | <***b*** m/s (t<10') | OFF | **ON** | OFF | Wind stow |
| Wind stow | <***b*** m/s (t>10') & <***c*** m/s | OFF | OFF | **ON** | Construction |
| Wind stow | <***b*** m/s (t>10') & >***c*** m/s | OFF | OFF | **ON** | Wind stow |
| Wind stow | <***b*** m/s (t<10') | OFF | OFF | **ON** | Wind stow |

**KEY**

**a** = maximum threshold
**b** = minimum threshold
**c** = security threshold

**Note about the transitions above**

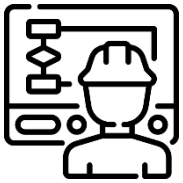
The transitions shown in the table above must be used for refence only. The values will depend on the type of structure and project.

# 6. Interfaces

## 6.1. Introduction

The tracker has two different modes to be controlled: local and remote.

REMOTE MANUAL MODE



If your SCADA allows the control of the plant, Remote Manual Mode allows to send the manual angle from SCADA by connecting to the TBox.

**NOTE** → For more information about remote commands see the "TBox" O&M Manual.

**Note about remote movement**

Remote movement is only available if your SCADA system allows the remote control of the plant.

If the tracker must be fixed in a remote position, move it by sending a manual position through the SCADA control. When the required tasks are finished, send the DBox back to the TBox control for suntracking.

If the control is not given back to the TBox when the tasks are finished, the tracker will remain in remote manual mode until receiving a command. PVH is not responsible for any damages caused to the tracker if a wind or snow alarm is triggered during remote maneuvers.

LOCAL MANUAL MODE

Local Manual Mode and NFC Mode allow to send the tracker manual angle from the App "Tracker Commissioning" or by using the capacitive buttons.

- App "Tracker Commissioning" for smartphone (NFC mode)→ The smartphone app "PVH Tracker Controller" allows the user to interface with the DBox by selecting the command and placing it on the NFC tag to transfer the order to the DBoard. The app can send 3 different modes: Manual Mode, Clean and Wind. The fourth command "TBox control" is designed to get back the control to the TBox.
  For information about the use of the PVH Tracker Commissioning APP, see the "*PVH Tracker Controller APP*" manual.

- Capacitive buttons (Local Manual Mode) → The capacitive buttons allow to send the tracker towards the east or the west. When the NFC App is not available to return the system to the tracking mode, the command can be sent by touching both capacitive buttons at the same time for 3 seconds. This operation clears the status and returns the tracker to the tracking mode as long as no higher priority command is activated.

**Note about local movement**

If the tracker must be fixed in a local position, move it with the capacitive buttons or an NFC command, and then, press the emergency stop button to set a secure fixed position.

When the required tasks are finished, release the emergency stop button and give back the control to the TBox using the smartphone app or the capacitive buttons.

If the control is not given back to the TBox when the tasks are finished, the tracker will remain in local manual mode until receiving a command. PVH is not responsible for any damages caused to the tracker if a wind or snow alarm is triggered during local maneuvers.

## 6.2. NFC Phone App

The PVH smartphone app "PVH Tracker Controller" is designed to control the tracker in local mode and to be able to get back the control to the central controller, the TBox, to allow it to continue tracking the sun.

This application also reads the tracker and the DBox information, such as the status, the setpoint, the motor current, etc., and it is displayed on the smartphone screen.

In addition, to assist with maintenance tasks, the PVH smartphone app includes a Maintenance tab that allows to reset the DBox or swap the memory of one DBox to another in case of replacement.

*Figure 8: Main Screen*

The main screen displays three options:

- Tracker Control → to send the tracker to different positions.
- Tracker Info → to see the tracker information by reading its NFC memory.
- Advanced → to carry out commissioning and maintenance processes of the tracker.

### 6.2.1. Tracker Control

- Manual Setpoint: The Manual mode allows the user to send the tracker to a configurable angle. The angle value can be entered by moving the slider or directly typing the number.
- Clean: Clean command sends the tracker to the pre-defined cleaning position. This position is defined in the commissioning status of the plant.
- Wind: Wind alarm command sends the tracker to stow position and overrides any TBox movement until it has been cleared.
- TBox Control: This command returns the DBox to the TBox remote mode. The DBox will not move until it receives a new message with current information from the TBox.

**WARNING!**

Local operations that the O&M technician performs in the tracker, such as manual movement, clean or wind position and pressing the stop button have priority over the automatic operations that the TBox sends, as sun-tracking or wind and snow alarms.


*Figure 9: NFC APP – Tracker Control*

**NOTE** → For more information about the PVH smartphone control App see "*PVH Tracker Controller APP*" O&M Manual.

### 6.2.2. Tracker Info

The Tracker info tab shows the information written on the NFC memory of the DBox when the commissioning process has been done. By selecting "Read info" the phone starts a countdown to place the phone close to the NFC tag.

| Parameter | Options | Description |
|---|---|---|
| **Block & Tracker** | **-** | Block and tracker parameters set. |
| **Firmware version** | **-** | DBox firmware version. |
| **LoRaWAN Region** | **EU868, AU915, US915, AS923** | Region where the antenna is configured. |
| **Operation mode** | **Defect: Not recognized** | DBox is not commissioned. |
| | **Defect: Secure position** | The tracker has been moved to Wind Stow or Construction Stow position due to an associated alarm.<br>See specific alarms in section *Alarms and notifications.* |
| | **Defect: Fault stop** | There is a fault in the motor behavior with an associated alarm. |
| | **Defect: TBox communications lost** | The tracker has lost the TBox communications. |
| | **TBox Control: Auto** | DBox is in automatic mode. |
| | **Remote Control: Manual Position** | DBox is in Remote manual mode. |
| | **Remote Control: Manual Wind Position** | DBox is in Wind-Stow position in remote control. |
| | **Remote Control: Manual stop** | DBox is in Emergency stop in remote control. |
| | **Remote Control: Manual Construction Position** | DBox is in Construction position in remote control. |
| | **Local Control: PVH application** | DBox is in local NFC status (PVH Tracker Controller App managed). |
| | **Local Control: Emergency stop** | Emergency stop has been pressed locally. |
| | **Local Control: Buttons** | DBox is in local control with capacitive buttons. |
| | **Halt: Waiting for acknowledge** | The tracker is halted waiting for order. |
| **Alarms** | **Emergency Stop button** | Emergency stop has been pressed. |
| | **Charger fault** | Communication failure between the DBoard and the solar charger. No value can be read. The tracker moves to a Stow position. |
| | **Inclinometer fault** | There is a fault in the inclinometer and the tracker is stopped. |
| | **Overcurrent fault** | Motor overcurrent. |

| Parameter | Options | Description |
|---|---|---|
| | **Fuse fault** | Battery disconnected due to a fuse fault, but the solar panel keeps the DBox ON if it is daytime. |
| | **PV Panel Fault** | Panel voltage reading = 0.0 V during daytime. |
| | **High temperature** | The reading of temperature is too high. |
| | **Low temperature** | The reading of temperature is too low. |
| | **Low battery** | DBox battery level below the level that allows its movement. See Battery disclaimer in section *Technical Data.* |
| | **Out of boundaries** | The reading of the inclinometer > ± 65°. |
| | **Static inclinometer read** | The reading of the inclinometer is static, but the motor is consuming, or the tracker should be moving. |
| | **High power consumption** | DBox consumption > 10 A for over 1 second. |
| | **Slow motor movement** | The motor is moving unusually slowly. |
| | **Wrong direction movement** | The tracker is moving in the opposite direction than expected. |
| **Notifications** | **Construction Stow** | The tracker is moving to Construction stow position, since the TBox is currently sending Construction stow position automatically or because this position has been sent manually from SCADA. |
| | **Wind Stow** | The tracker is moving to Wind stow position, since the TBox is currently sending Wind stow position automatically or because this position has been sent manually from SCADA. |
| | **Backtracking** | The TBox is currently sending a backtracking setpoint automatically. Check that the setpoint is correct and within sunrise or sunset hours. The DBox will perform the backtracking when it is in automatic mode. |
| | **Hail position** | The TBox is currently sending a Hail position setpoint to keep the integrity of the structure. The command has been sent by an operator from Scada |
| | **Snow Position** | The TBox is currently sending a Snow position setpoint (0°). Only in Automatic mode. When the snow is removed, the tracker automatically returns to the corresponding position. |
| | **Diffuse** | The TBox is currently sending a Diffuse position setpoint (0°) to capture as much diffuse light as possible on cloudy days. Only in Automatic mode. |

| Parameter | Options | Description |
|---|---|---|
| | **Night Position** | The TBox is currently sending a Night position setpoint to save battery charge while no solar energy can be collected, and as long as no alarm is active. Only in Automatic mode. |
| **Setpoint** | - | Angle of movement remotely or locally received. |
| **Tilt** | - | Real angle of the tracker in that moment. |
| **Power mode** | **AC, SP** | AC for DBox AC version, SP for DBox Self powered version |
| **Battery level (SP)** | - | Battery level in percentage. |
| **Motor max current** | - | Maximum motor current registered. |
| **PV Panel voltage (SP)** | - | Voltage in the PV panel. Irradiance. |
| **Current 1** | - | Only if SBox is installed. String 1 current. |
| **Current 2** | - | Only if SBox is installed. String 2 current. |
| **Current 3** | - | Only if SBox is installed. String 3 current. |
| **Current 4** | - | Only if SBox 4S model is installed. String 4 current. |
| **Min Angle** | - | Minimum angle of movement (negative angle) |
| **Max angle** | - | Maximum angle of movement (positive angle) |
| **Construction angle** | - | Construction angle of the tracker |
| **Stow angle** | - | Wind stow angle of the tracker. |
| **DBoard temp** | - | Temperature of the control board, degrees. |
| **Solar charger temp** | - | Temperature of the solar charger, degrees |
| **LoRa Device EUI** | - | LoRa device parameters |
| **LoRa Multicast EUI** | - | LoRa device parameters |
| **Latitude** | - | Tracker location latitude. |
| **Longitude** | - | Tracker location longitude. |

### 6.2.3. Advanced

The commissioning and maintenance tasks of the controller are also carried out through the "Advanced" button.

- The "Commissioning" button is only allowed to be carried out by PVH commissioning technicians, who must enter a password to carry out the start-up procedure of the controller.
- The "Maintenance" button is used to:
    - SWAP: "SWAP" option is used in the replacement procedure of a DBox. The O&M technician must select "DUMP MEMORY" to dump the old DBox memory on the phone, and then select "FILL MEMORY" to fill the new DBox memory with the old DBox information.
    - RESET: is used to reset a DBox without disconnecting any cable. A confirmation is requested before the reset to verify the order.

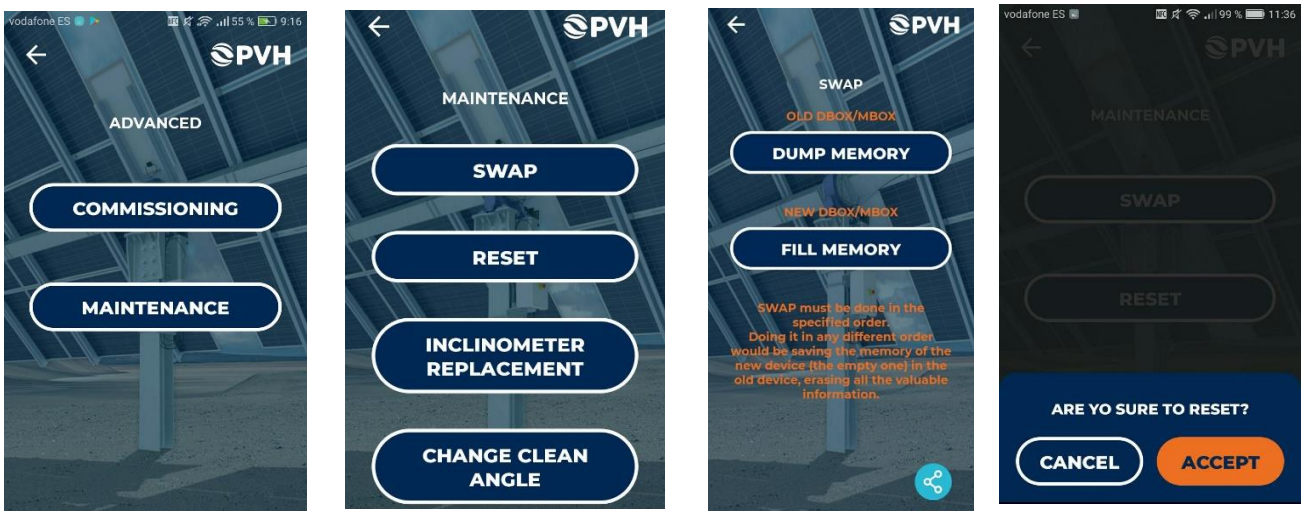



*Figure 10: NFC APP - Advanced*

**NOTE** → For more information about the use of PVH smartphone control App refer to the "*PVH Tracker Controller APP*" O&M Manual.

## 6.3. Buttons actions

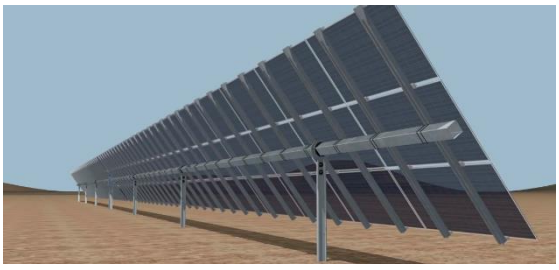
To activate the buttons, the emergency stop button must be pressed and released. After doing the release, the buttons will be active for 10 minutes and then they will turn off.

By touching one capacitive button, the tracker starts to move in the direction of the selected button (east or west).

To return to Remote mode, the technician must touch both buttons at the same time. This movement returns the system to the last remote status saved in the memory of the DBox, but the tracker will not move until it receives a new position message.

### *6.3.1. West Button*


By pressing the “West” button, the tracker starts its motion to the west.



### *6.3.2. East Button*


By pressing the “East” button the tracker starts its motion to the east.

### *6.3.3. Both buttons*


By pressing both buttons at the same time, the tracker control returns to the TBox and all the status (wind, manual, stop) set in local mode are cleaned.

This command returns the tracker to the last mode received from the TBox remote control, but the tracker will not move until it receives a new position message.

# 7. Exclusion of liability

PVH accepts no liability for erroneous handling or damage to product from PVH or third-party product resulting from disregard of information contained in this documentation.

PVH reserves the right to alter, correct, and/or improve the technical documentation and the products described in this documentation at any time and without giving prior notice, insofar as this is reasonable for the user. The same applies to any technical changes that serve the purpose of technical progress.

The receipt of technical documentation (data sheets, assembly manuals, O&M manuals, etc.) does not constitute any further duty on the part of PVH to furnish information on alterations to products and/or technical documentation. Any other agreement shall only apply if expressly confirmed in writing by PVH.

Please note that the supplied documentation is intended to serve as product-specific documentation only and that you are responsible for checking the suitability and intended use of the products in your specific application, in particular with regard to observing the applicable standards and directives. Although PVH makes every effort to ensure that the information and content is accurate and up-to-date, technical inaccuracies and/or printing errors in the information cannot be ruled out. PVH does not offer any guarantees as to the reliability, accuracy, or completeness of the information. All information made available in the technical documentation is supplied without any accompanying guarantee, whether expressly mentioned, implied, or tacitly assumed.

PVH accepts no liability or responsibility for errors or omissions in the content of the technical documentation (data sheets, assembly manuals, O&M manuals, etc.).

PVH is not responsible in any way for:

- Damage caused by the erroneous or unnecessary use of the equipment.
- Equipment damaged, dismounted, or manipulated by unauthorized technical service.
- Constant use of loads above the defined in the installation section.
- Damage produced by exceptional temperatures above or below the devices working operating temperatures.
- Lightning, accidents, water, fire, or other situations outside the control of PVH.

# 8. Support

Once the DBox is installed on field, PVHardware provides support for the issues that happen in the plant.

The customer will sign the reception of the plant and the agent assigned to the project will contact the customer via email. The customer will be registered on the support portal and will be trained on how to use it.

The Aftersales team can be contacted on: aftersales@pvhardware.es.

Avenida de la Transición Española 32
Parque Empresarial Omega Edif A 3ª
28108 Alcobendas (Madrid) Spain

(+34) 960 918 522 | contact@pvhardware.es