PVH DBOX5 Solar Tracking System Instruction Manual

Contents

PVH

PVH DBOX5 Solar Tracking System

Power input

The DBox can be self-powered or externally powered.

Self-powered version
Self-powered version is powered via a PV panel. The PV panel(s) charge a battery which operates as backup in case the power provided by the PV panel is insufficient to move the tracker. The DBox becomes selfpowered with this system as Long as the power from the PV panels is adequate.

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.

NOTICE

- **Battery choice**
  PVH recommends a certain battery type considering the solar plant conditions and characteristics. Selecting the wrong battery type for the controllers could cause faults during charging tasks, which would prevent nominal solar tracking operation, especially in areas where the minimum temperature is under 0°C. PVH is not responsible of any issues resulting from the wrong choice of battery.
- **Battery info**
  Constant cloudiness could cause continuous transitions between diffuse irradiance position and nominal solar tracking positions, provoking thus battery discharge.

Optional kits

There are different optional kits with specific devices to enhance adaptation to certain weather conditions and improve the protection and the performance of the plant.

Flood kit

- This kit can be installed in any DBox operating as tracker controller.
- The flood sensors are installed on-site along with a DBox, whose Location must be designated by the customer. The defense involves monitoring the water Level on the ground, calibrating the Limits of the range of motion to avoid that the modules get immersed. Regarding the behavior, flood zones are independent from each other.

Figure 8. Flood sensor

NOTICE
Flood kit info
Refer to Controller Solution document, Flood kit manual and DBox installation drawings for further information.

Diffuse control kit
This kit can be installed in any DBox operating as a meteorological box. The Diffuse control kit periodically sends the area irradiance composition to the TBox. This kit must be installed on the tower where the □Box operating as a meteorological box is installed.
Diffuse control algorithm allows the system to optimize energy production when diffuse light predominates. It is a global plant control mechanism. This means that the optimal tilt calculated by the algorithm based on the light information received by the sensor will be commanded to every tracker on the plant.

Figure 9. Diffuse sensor

NOTICE
Diffuse control kit info
Refer to the Diffuse control kit manual and Diffuse control kit installation drawings for further information.

Functional description

The DBox 5 is a 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. The DBox 5 can also operate as a meteorological control unit, allowing to read the wind speed and direction in real time by requesting it to the anemometer. This allows the TBox to send the alarm.

Figure 10. DBox 5 on tracker

The DBox 5 is used for the following purposes

- Reading the wind information directly from the anemometer in real time.
- Managing alarms, such as the anemometer misconnection or a charger fault [SP version).
- 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
    - Flood 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's smartphone.
- Acting as the manual interface with the operator, allowing the movement with its capacitive buttons.
- Sending the tracker information up to the TBox.
- Managing the charge of the battery, and the discharge to the DBoard.

DBox 5 operation
As explained in Physical features, depending on its comm1ss1oning configuration and location on the structure, the DBox can operate as a tracker control unit or as a meteorological control unit.

- 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.

NOTICE

- **System info**

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 damage caused to the tracker if a wind or snow alarm is triggered during Local or remote maneuvers.

- **System info**

  Refer to PVH App user manual for information related to the use of the app.

Status description: Operation modes

System info

The operation mode depends on the DBox stage. SCADA will always show the information of the Last DBox message received by the TBox.

OPERATION MODE	DESCRIPTION
Defect: Not recognized	The DBox that is being consulted has not yet joined th e LoRa network, so the TBox does not have informatio n about it, since it has not been recognized in the syste m. The DBox is not in communication with the TBox, s o it will not respond to its orders, will not send its infor mation, or do solar tracking until it has joined the LoRa network. Refer to section Troubleshoo ting [►31].

OPERATION MODE	DESCRIPTION
Remote Control: Manual position	Remote manual mode allows to set the tracker in a us er-defined position. If the DBox is in remote manual, it is being remotely co ntrolled from SCADA. In this status, the DBox will be in a static position and will not move until it receives a ne w 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 tr acker locally in a user-defined position. In this status, t he DBox will be in a static position and will not move u ntil it receives a new NFC order or until the control is r eturned to the TBox.

Halt: Waiting for acknowledge	The DBox is halted waiting for a new order to restart th e movement. This status happens when the emergenc y stop button has been pressed and released and no f urther action has been taken, such as moving the track er or returning the control to the TBox. Refer to section Troubleshooting [►31].
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 prote cts the tracker in that moment, which can be wind stow or construction stow position. When the battery is recovered (>60%) the tracker will r eturn to its previous status. As a safety feature, when t he device starts, these limits are established at 60% (l ow level) and 80% (recovery level) until the battery reaches 100%. Refer to section Alarm use cases [►28) to kno w the best position for each case, as well as section Troubleshooting[►31].
Defect: Fault Stop	There is a problem in the motor behavior or in the mov ement of the structure and the tracker is stopped until t he problem is solved. This behavior may have been ca used by a failure in the gearbox or the motor, among o ther cases. Refer to section Troubleshooting [►31) to check all the options.

OPERATION MODE	**DESCRIPTION**

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 angl e established by the solar algorithm. Wind and snow alarms and the TBox communications l ost mode will only move the tracker to stow position if t he previous status of the tracker was Auto. If the tracker is in any other status and an alarm is trig gered, it will be ignored, and the tracker will remain in t he current position. The solar tracking stage is composed by 3 sub modes: • **Day-Tracking:** The TBox sends the setpoint for sun -tracking. • **Backtracking:** This function prevents shadows in t he tracker in sunrise and sunset. During backtracking t he setpoint is sent faster than in day-tracking. • **Night- time:** To save battery while the tracker is sto pped at night, a static setpoint is sent if no alarm is acti ve. The default setpoint at night is 0° but PVH can conf igure 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 T Box 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. Refer to section Alarm use cases [►28] to know the position that best protects the tracker in each situation.

OPERATION MODE	DESCRIPTION
Local Control: Emergency Stop	The emergency stop button is pressed. This is the hig hest priority state, so the tracker will be stopped until th e button is released, and manual or local control is est ablished again. In case of releasing the emergency but ton and not carrying out any control, the DBox will rem ain in Halt state until it receives a movement command . Refer to section Troubleshooting[►31].
Remote Control: Manual Stop	The DBox is in remote emergency stop mode from SC ADA. The tracker will remain stopped until it receives a nother local or remote-control command or until the tra cker is returned to Auto mode.
Defect: TBox Communications Lost	The DBox has lost the TBox communications. In the e vent of this loss of communications, the tracker will aut omatically move to the stow position that best protects the tracker at that moment, which can be wind stow or construction stow position. Refer to section Alarm use cases [►28] to know the best position for each case, and section Troubleshooting [►31].
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.

System info
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 (refer to section Troubleshooting [► 31]). In all other cases Low battery mode takes priority and the tracker will move to stow position automatically.

Tracker control modes
Operation when functioning as a tracker control unit can be monitored and controlled manually through the capacitive buttons, the emergency stop button and PVH app (accessible via NFC) and remotely through SCADA.

System info
Refer to the TBox operating manual for more information about remote commands.

LOCAL MANUAL MODE

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

- PVH App for smartphone (NFC mode): The smartphone PVH app allows the user to interact 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 return the control to the TBox.
- 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

  System control info

  If the control is not returned 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 damage caused to the tracker if a wind or snow alarm is triggered during local maneuvers.

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. Then they will turn off. By touching one capacitive button, the tracker starts to move in the direction of the selected button (up or down). By pressing the capacitive button, the tracker starts its motion.

Figure 11. DBox 5 capacitive button

Figure 12. Moved trackers

To return to Remote mode so that the tracker control returns to the TBox, the technician must touch both buttons at the same time. This command returns the system to the last remote status saved in the memory of the □Box and cleans all the status (wind, manual, stop) set in local mode. However, the tracker will not move until it receives a new position message.

NOTICE

System control info

If the control is not returned 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 damage caused to the tracker if a wind or snow alarm is triggered during local maneuvers.

Safety features

- **Emergency Stop Button**
  The Emergency Stop button located on the DBox can be activated by pressing it. It halts the tracker operation. After releasing the Emergency Stop button, the DBox is set on halt status. It is the highest priority 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 moves the tracker to the position that best protects the tracker under current conditions: Stow position or Construction position1. 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**
  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. 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/Hail Alarm**
  If the tracker receives a snow or hail 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.
- **Safe defense position for interior and exterior trackers**
  Differentiated positions for a safe defense against wind are established in the commissioning stage of the plant to protect the different trackers in the field, depending on the different layouts. Exterior and perimetral trackers have a more inclined position than the internal rows to shield the rest of the plant.
- **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 operating limits**
  Software limits automatically stop the tracker if its position reaches an angle greater or equal than the operative range3 of the structure. This range of movement can be modified in the commissioning of the device. The tracker position is detected by the inclinometer, which determines the actual angle of the PV panels.
- **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 □Box sends its status to the TBox and the □Box goes to the position that best protects the tracker under current conditions, which can be Stow position or Construction position1. 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, as a safety measure, the limits that apply are 60% (low level) and BO% (recovery level), until the battery charge reaches 100%.

Alarms and notifications

DBox 5 operating as a tracker control unit: Alarms

ALARM	DESCRIPTION
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.
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. Refer to section Troubleshooting [►31].

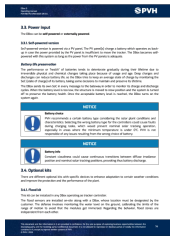
ALARM	DESCRIPTION
Overcurrent fault	There is an overcurrent in the motor, so the tracker will be stopped to avoid damaging the controller, the motor, or the structure. The tracker will remain stopped until the problem is solved. Refer to section Troubleshooting (►31) to check what may have caused the failure.
Wrong direction movement	It is activated when the tracker is moving in the opposite direction than expected. The tracker will be stopped to avoid damage and it will remain stopped until the fault is corrected. Refer to section Troubleshooting(►31).
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. Refer to section Troubleshooting(►31].

High power consumption	It warns that the consumption of the DBox is greater th an 10 A for over 1 second. The tracker will remain stop ped until the fault is corrected to ensure the safety of t he tracker. This alarm can be configured during the commissioning stage. Refer to section Troubleshooting [►31].
Static inclinometer read	It is activated when the reading of the inclinometer is st atic, 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. Refer to section Troubleshooting (►31).
Out of boundaries	This alarm warns that the reading of the inclinometer i s 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. Refer to section Troubleshooting (►31].
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 t o Secure mode, and moved to Wind or Construction St ow position, depending on the wind conditions at that moment (refer to section Alarm use cases – Stow or c onstruction position?), until the battery is recovered (>60%).

ALARM	DESCRIPTION
Low temperature	The reading of temperature from the charger is too low . To ensure the safety of the structure in case of wind o r snow alarm during the fault, the tracker is sent to Sec ure mode, and moved to Wind or Construction Stow p osition, depending on the wind conditions at that mom ent (refer to section Alarm use cases – Stow or construction position?), until the temperature is restored. Refer to section Troubleshooting [►31].
High temperature	The reading of temperature from the charger is too hig h. To ensure the safety of the structure in case of wind or snow alarm during the fault, the tracker is sent to Se cure mode, and moved to Wind or Construction Stow position, depending on the wind conditions at that mo ment (refer to section Alarm use cases – Stow or const ruction position?), until the temperature is restored. Refer to section Troubleshooting [►31].
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 beca use the remaining battery percentage is 0%. To ensure the safety of the structure in case of wind or snow alar m during the fault, the tracker is sent to Secure mode, and moved to Wind or Construction Stow position, dep ending on the wind conditions at that moment (refer to section Alarm use cases – Stow or construction position?), until the fault is restored. Refer to section Tr oubleshooting[►31].
Charger fault (SP version)	Communication failure between the □Board and the solar charger. No value can be read. To protect the structure, the tracker will automatically move to the sto w position that best protects it at that moment, which c an be wind stow or construction stow position. Refer to section Alarm use cases [►28] to know the best position for each case, as well as section Troubleshooti ng [►31].

NOTIFICATION	DESCRIPTION
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	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	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. This will only happen when the DBox is in Automatic mode.
Night	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.

Documents / Resources

	PVH DBOX5 Solar Tracking System [pdf] Instruction Manual DBOX5, DBOX5 Solar Tracking System, Solar Tracking System, Tracking System, System

References

- User Manual