

USER MANUAL AND OPERATION GUIDE

SunTracker-2000

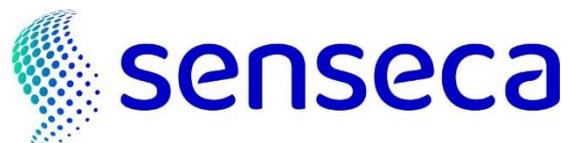
Solar Energy

Measurement System



EN

V1.0



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1 Introduction

The most important factors to consider when designing a new solar tracker are its Sun's path tracking accuracy, its operating reliability, and its robustness, which allow unattended operation of the system for long periods of time. More and more often this sort of equipment needs to be installed at remote and unsupervised sites with limited conditions or total lack of power supply that allows it to operate.

The main challenge that Senseca's SunTracker series meets is providing a system that is able to operate, completely unmanned, with just a small solar panel, and at the same time complying with strict accuracy, robustness and reliability requirements.

The SunTracker-2000 provides a new compact design to make transportation and installation easier with an optimized power supply.

2 Definitions

In order to help the reader understand this manual, the following list contains definitions and basic concepts related to the measuring process and the technology used. If you are familiar with the terminology used herein, you can skip this list and jump to the 'Operating Description' and 'Technical Features' sections.

If you have any doubt, please contact Senseca's Technical Support Service.

Solar Tracker:

This type of system contains the mechanical, logic, and electronic devices that provide for alignment with the Sun inside the celestial sphere for all of the sensors, shadow disks, etc. mounted on the mechanical system. The applications of this type of system range from studying direct and diffuse radiation for applications in photovoltaic or solar thermal energy generation plants to analysis of global warming, purely meteorological purposes, etc.

Orientation: Altitude and Azimuth:

In astronomical coordinate systems, altitude and azimuth are two concepts related to astronomy and coordinate systems used in this area. Different coordinate systems are used to locate stars in the sky, almost all of them spherical. This system uses angular measurements, not linear ones as is the case in more common systems, e.g. Cartesian.

Altitude and azimuth are used to describe locations in the astronomical coordinate system known as altazimuth or horizontal. This is because the system is relative to the horizon. The zero point or origin of coordinates lies on the observer's position. It is therefore a local system, because the measurements taken vary depending on the observer's geographical position.

The horizon forms a circumference around the observer (see image). The other feature of this coordinate system is the zenith, on the same vertical axis (Z axis) as the observer. It is directly above him, at a distance equal to the radius of the circumference formed by the horizon. These two elements and the Sun position define the circumferences on which altitude and azimuth are measured.

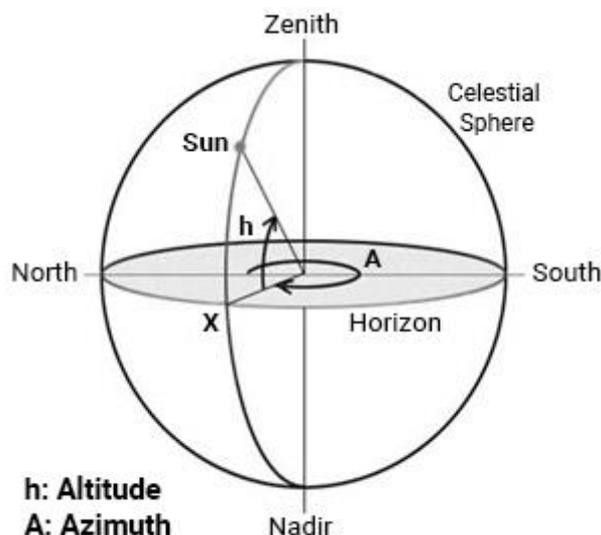


Fig. 2.1: Altitude and azimuth

A circumference centered on the observer position that goes through the zenith and the Sun cuts the horizon at point X (see image). The angle formed by the Sun position and point X on this circumference is known as altitude. The angle formed by Geographic North and point X, measured on the horizon circumference is the azimuth. The azimuth can range from 0° to 360° .

Direct and diffuse radiation:

The energy that comes from the Sun in the form of luminous radiation splits into three parts when it reaches the Earth's atmosphere. Part of it passes through the atmosphere without changing direction. Another part is dispersed, either due to reflection or refraction. The other part is absorbed by the air molecules in the atmosphere. Through the diffusion process, the radiation energy output is reduced, and part of it is redirected back outside the atmosphere. Meanwhile, during the absorption process, the radiated energy is trapped in the air molecules. In addition, the percentages of radiation that undergo these processes and the energy lost in them largely depends on weather conditions, the atmosphere composition and even the altitude of the Earth's surface and geographical location.

This distribution of energy results in the concepts of direct and diffuse radiation. Direct radiation is the irradiated energy that does not change direction when it comes from the Sun. The radiation diffused by the atmosphere and not escaping outside the atmosphere, together with the infrared radiation that the molecules produce after being heated due to the solar radiation absorption effect is known as diffuse radiation. The combination of both is called global radiation.

The global radiation and the direct/diffuse radiation percentage are important data to build solar facilities. On clear days, direct radiation is much stronger than diffuse radiation. However, on cloudy days there is virtually diffuse radiation only. Also, a surface needs to be positioned facing the Sun perpendicularly to receive all of the direct radiation because this radiation is focused in one direction. On the contrary, diffuse radiation is received from every direction and so a horizontal surface is more effective.

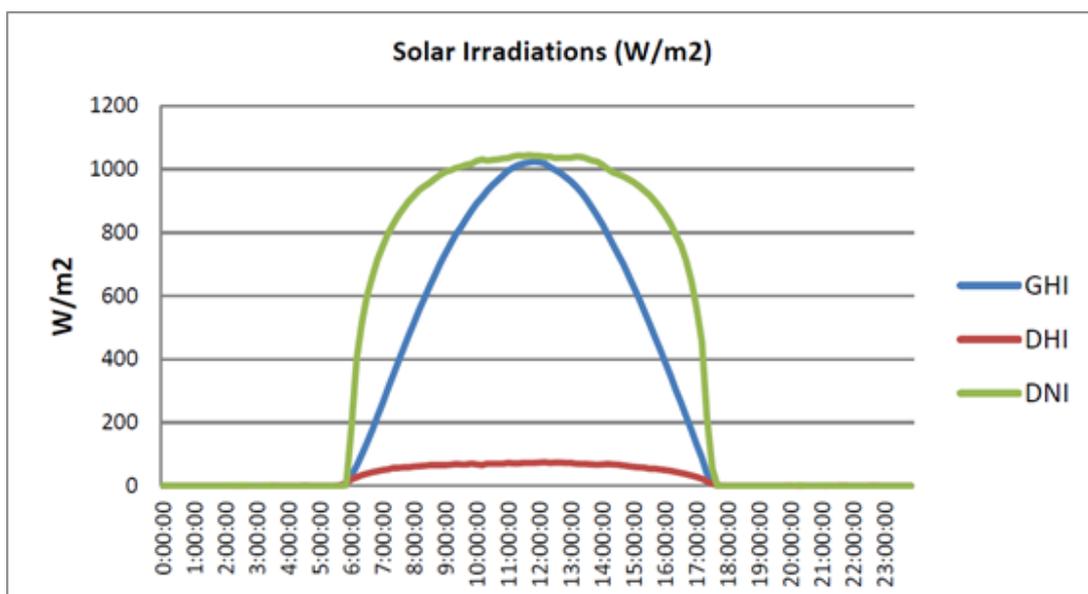


Fig. 2.2: Global (GHI), direct (DNI) and diffuse (DHI) on a clear day

Sensors: Pyrheliometer, pyranometer, shadow disk and Sun sensor:

Sensors used to measure radiated energy are based on converting heat into electrical power. The heat generated by the radiation is used upon being absorbed by a body, almost always with temperature compensated wound thermopiles.

Frequency response and visual field are used to differentiate between different types of sensors. The former defines the sensor reaction to light at different frequencies (ultra-violet, visible band, infrared, etc.). The latter characterizes the reaction to the position of the light source, referring to the angle formed by the normal and the plane of the sensor.

To measure radiated energy, whether global, direct or diffuse, broad spectrum sensors are used, because we want to know the total energy. However, the view angle varies in these measurements. A pyranometer is usually used to measure global radiation due to its large view angle (180°). In this case all radiation needs to be collected, and so the view angle needs to be large.

However, to measure direct radiation, the measurement needs to be focused on the radiation coming directly from the Sun direction. That is why a pyrheliometer is usually used, because of its narrower view angle (about 1°).

Measuring diffuse radiation requires a slightly more complex system. In this case, a wide view angle sensor also needs to be used, because diffuse radiation can come from any direction, but it must precisely cut out radiation being received from the Sun direction. For this measurement a system consisting of a pyranometer and a device known as a shadow disk or device is used. This is joined to the mechanical structure supporting the sensors. This shadow disk needs to be adjusted so that it is on the Sun's radiation path towards the pyranometer and when both rotate together it will always avoid direct radiation falling on it.

The SunTracker-2000 is designed with a very precise pointing system whose accuracy is 0.1° on both axis (altitude and azimuth). Optionally, the solar pointing accuracy factory default supplied can be increased including a Sun sensor¹ for active tracking in the system (with a positioning accuracy better than 0.01°). This device provides the incident angle of a Sun ray in two axes with high sensitivity, making it a suitable tool for Sun tracking and positioning.

Data Acquisition System

Data acquisition is the process of sampling signals that measure real-world physical conditions and convert the resulting samples into digital numeric values that can be manipulated by a computer. Data acquisition systems (abbreviated with the acronym DAS or DAQ) typically convert analog waveforms into digital values for data processing.

The ability of a data acquisition system to measure differing properties depends on whether it provides sensors that are suited to detect the various properties to be measured. DAQ systems also employ various signal conditioning techniques to adequately modify various different electrical signals into voltage that can then be digitized.

¹ Contact Geonica to know the availability.

For the specific case of the data acquisition system series METEODATA (models MTD-3000/2000), the system includes these additional functions:

1. Power supply unit chargeable through a solar panel
2. EMI / RFI /ESD input and output protection for all signals, power supplies and communication lines, etc.
3. Various communication options, GSM/GPRS Ethernet, Wi-Fi, Bluetooth, etc.
4. Large data storage capacity (128MB internal flash and 2GB SD memory card).
5. Low energy consumption, just 100mW.
6. Built-in GSM/GPRS/GPS communication MODEM.

For more information about the data acquisition system, please consult the Remote Data Measuring, Recording, and Transmission Station, Series 3000C manual.

Operation Description

The SunTracker-2000 is a two-axis chronological solar tracker based on altitude and azimuth. A system is said to be chronological when it is guided by an algorithm that calculates the Sun position, based on geographical location and the date and time. Two-axis systems allow more accuracy when placing the Sun inside the celestial sphere. This is because they track both the East-West axis and the Sun elevation. One-axis systems only track the first axis. Also, by being based on altitude and azimuth, these systems have a compact and simple mechanical structure with a reference to a local coordinates system. As a result, the device makes orientation and positioning easier and more accurate.

The complete system consists of two main elements: the solar tracker and the Data Acquisition System (DAS).

The mechanical structure of solar tracker supports the devices that need to be turned facing the Sun. Therefore, it must be able to move. The simplicity of the altitude and azimuth-based systems lies in the independence of these two movements. Firstly, a baseplate that can rotate on the vertical axis means that it can track the Sun East-West axis during the day. On this baseplate, a mounting arm with a horizontally-rotating axis allows the sensors to be turned to face the Sun elevation.

The control module is an internal component of the solar tracker. The control subsystem manages both the power supply to the mechanical structure and the operation of the stepper motors that generate both movements. It includes the motor drives and electrical protection devices. It also contains a connections network including both power lines to power the motors and the communications paths that let the digital information reach the drives so that the mechanical structure fulfils its function.

Finally, the data acquisition system supplies the necessary power and data to the control subsystem so that the whole system works properly. This includes the algorithm that calculates the Sun position. According to its output value the necessary data is sent to the motor driver. Optionally, a Sun sensor can be connected to the DAS for an active tracking, complementing the solar algorithm with information about small adjustments

to get a more accuracy pointing. The data acquisition system also performs a remote communication function. This communications port allows the complete system to provide status and position data and to be remotely reconfigured at any time.

The data collected by the sensors is sent to the DAS through some analog signals:

- Radiation 1: data coming from solar radiation sensor 1 - Temperature radiation 1
- Radiation 2: data coming from solar radiation sensor 2 - Temperature radiation 2
- Radiation 3: data coming from solar radiation sensor 3 - Temperature radiation 3

See Appendix A for more information about signals and connections between SunTracker-2000 and DAS.

3 Installation

One of the most decisive factors in achieving a precise solar radiation measurement is proper sensor positioning. Both the sensor position and direction are vital to the final measurement. Special care needs to be taken when choosing the right site for proper installation of the measuring system.

This section explains the features that must become visible in the location selected to install the SunTracker-2000 and the chronological steps to perform the required civil works and fix the tracker in this location:

- Select a location. Site and position.
- Civil works.
- SunTracker-2000 installation.

3.1 Select a location. Site and position.

Study and select an area to locate the system

A solar radiation accurate measurement must be independent from possible optical effects that could take place on the earth surface. The ideal site is an open area, so that the light hits the sensors from Sunrise until Sunset all year round. No elements that could cast a shadow or reflect the Sunlight and distort the measurement must be present. The system also needs to be facing the equator, South if it is located in the Northern Hemisphere and North if it is located in the Southern Hemisphere.

Compile Latitude and longitude data

The angle of incidence of solar radiation on the earth varies widely along with the coordinates. Over time it fluctuates considerably, both in the course of a day and over seasons. That is why reliable data about the coordinates for the site to be used is of utmost importance (recommended minimum precision 0.01°).

Compile accurate date and time

The date and time (UTC) are also essential for proper solar tracker installation.

3.2 Civil Works

Installation outline diagram

The following diagram shows a real example of a model installation with two towers:

- Tower No. 1 or SunTracker tower. It is intended to mount the Sun tracker and radiation sensors.
- Tower No. 2 or meteorological tower. METEODATA/HYDRODATA data acquisition system, meteorological sensors (wind speed and direction, relative humidity, temperature, etc.), solar panel or external power supply, etc. will be set on this tower.

The plane shown presents the following features:

In the Northern hemisphere, the meteorological tower (or tower 2) must be located on the north side of the fence and on the Southern hemisphere this tower must be located

on the south side of the fence. This layout must be maintained to prevent tower 2 from casting a shadow over the Sun tracker tower.

The baseplate where solar tracker is mounted (on top of the tower 1) must be at a higher height level than the installation fence in order to prevent unwanted shadows over the system.

You can see two triangles at 'plan view' on the diagram; they are oriented differently in the Northern hemisphere drawing and the Southern hemisphere drawing. These triangles represent the orientation of the tower in case of it being a triangular one. In case of square towers, you must ensure that one of the faces of the tower must be in the same position as the flat side of the triangle on the diagram (facing south in the Northern hemisphere and facing north in the Southern hemisphere).

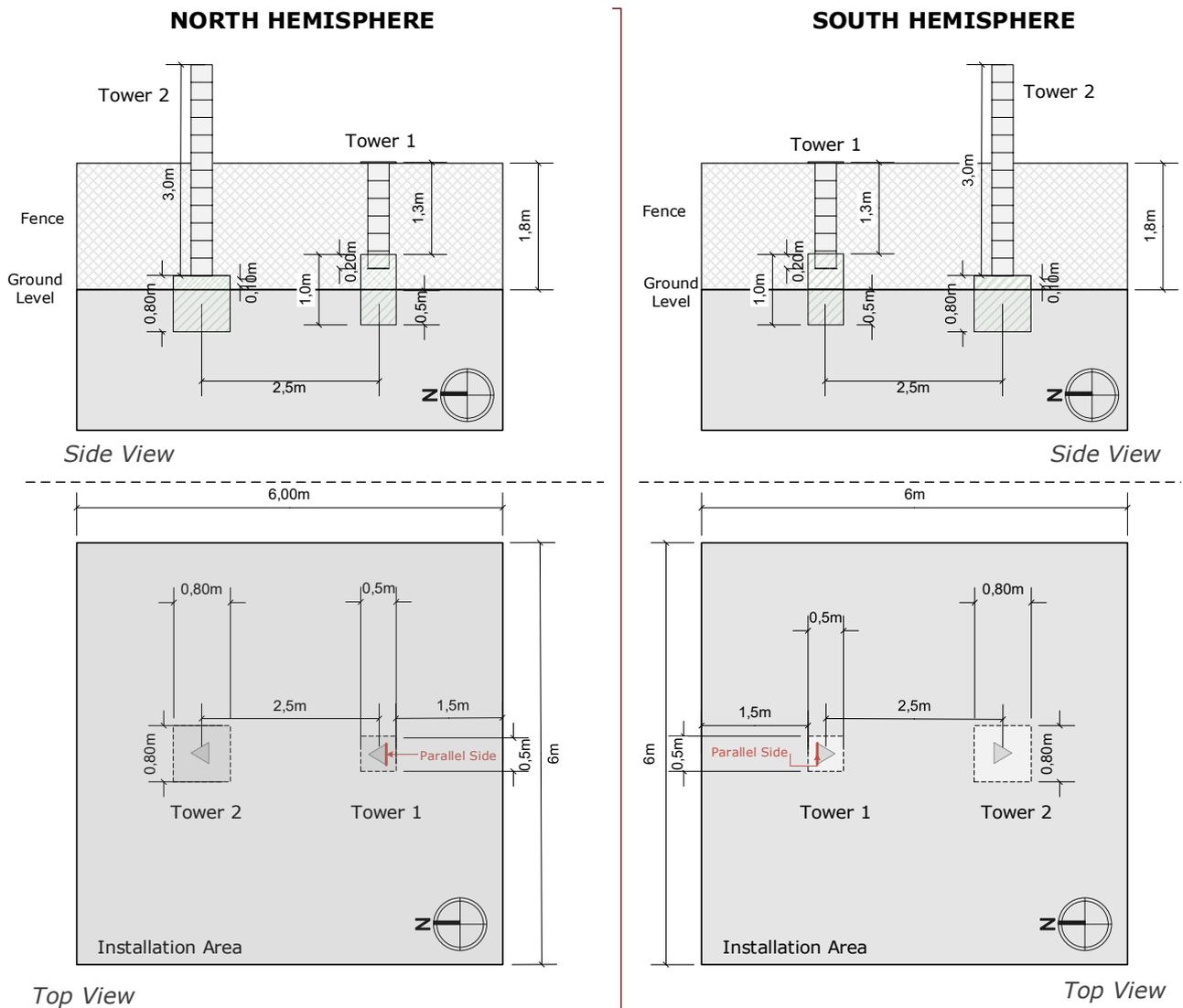


Fig. 3.1: Installation drawings²

² The North indication included in the planes of this manual is always referred to Geographic North.

! Considerations regarding installation in different geographic areas!

Tower positioning (weather towers and Sun trackers) requires additional considerations when the system is installed in areas of the planet that lie between the Tropic of Cancer and the Tropic of Capricorn (latitudes between -23.5° and $+23.5^{\circ}$).

At these latitudes, the solar elevation can exceed the zenith position (90°), which means that the Sun tracker can start to point toward the part of the installation where the weather tower should be placed (see image below). Special care must be taken during siting to ensure that no shadows hit the Sun tracker components at any time of the year. The following website may help to determine the Sun path anywhere in the world and therefore, to identify any shadows that could hit the Sun tracker due to nearby items: <http://www.Sunearthtools.com/>.

Pedestal details

The pedestal supports the mechanical structure of the Sun tracker system. It must be rigid enough to withstand the pulling forces generated on the mechanical structure and those generated due to weather conditions, e. g. wind. This is extremely important because the slightest longitudinal variation could lead to a much greater angle difference. It is particularly important in sites where the extreme force of the wind could throw the mechanical structure off balance. There must be nothing in the surrounding area that could cast a shadow on this structure. The main components of the pedestal are the concrete platform, the turret, and the mounting plate.

The turret

The turret raises the installation preventing most of unwanted obstacles. It must be, at least, 1.5 m high. Most applications use a 360 mm intermediate section 1.5 m turret (ref. 3055) .

This is only an option; any turret (triangular or square) can be used if this condition is met: the turret base circle radius (R1) must be lower than the adjustment slots radius (R2) of the mounting plate. The adjustment slots, as explained below, are small drills for attaching the Sun tracker to the mounting plate allowing the most accurate operation.

The Mounting Plate

The mounting plate is the rigid support placed on top of the tower where the Sun tracker is mounted. It is a circular galvanized steel plate with a diameter of 500mm and 6 mm thick. Note this structure has three slots whose function is an alignment adjustment of the system and its subsequent anchorage.

The mounting plate is welded to the turret providing a secure fixation. Once it is welded, the pedestal must be painted using a UV resistant and corrosion resistant paint for optimal maintenance in wet environments or near the sea.

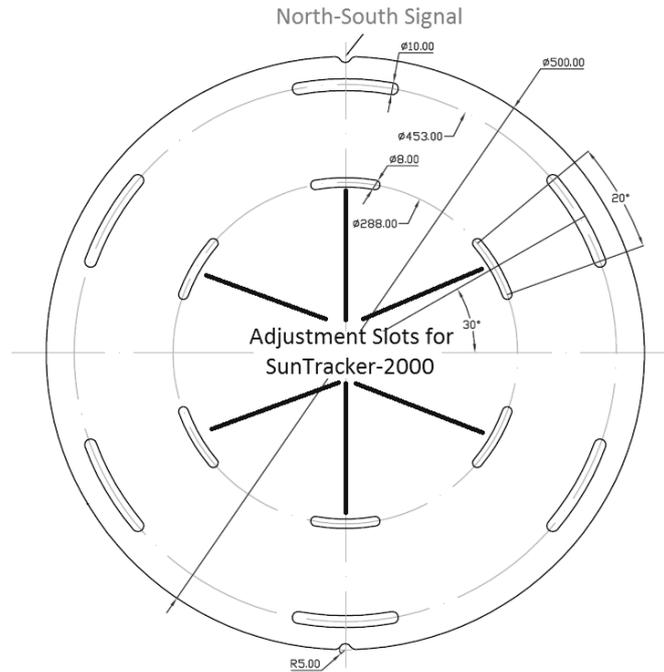


Fig. 3.2: Mounting plate

The complete pedestal

The turret and the mounting plate must be completely fastened to a concrete platform with a footprint of 0.5m x 0.5m and a minimum height of 0.5 m. At least 40 cm of this concrete platform must lie below ground level; the rest of the platform (10 cm in the figure below) may protrude above ground level.

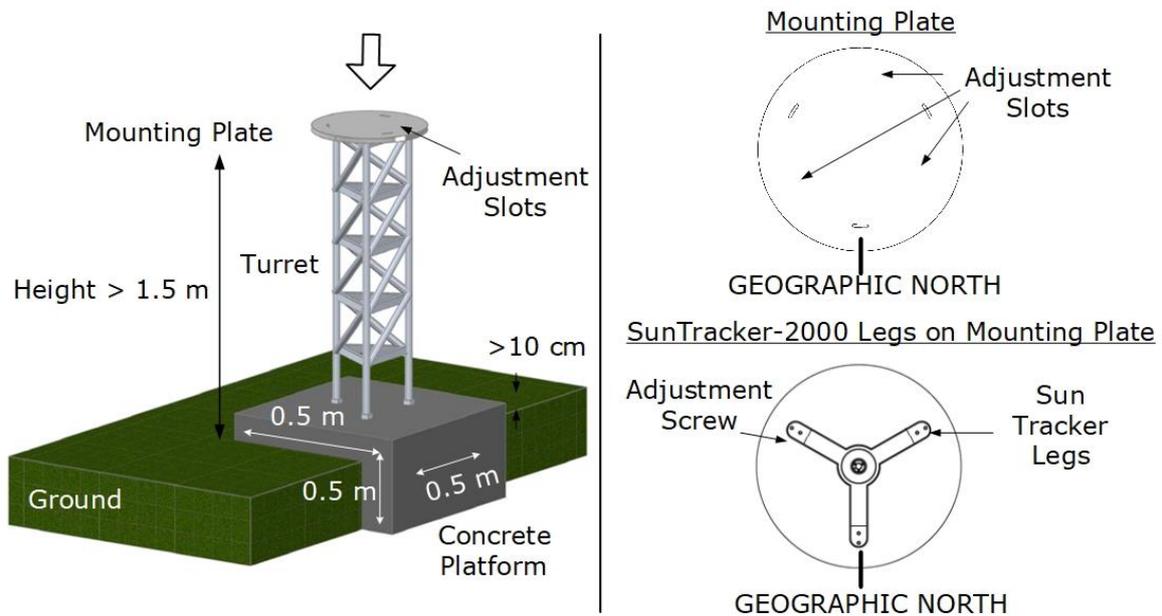


Fig. 3.3: Pedestal installation diagram³

³ In this figure you can see Geographic North marked. Note this point is Geographic North only in the Northern hemisphere. In locations in the Southern Hemisphere, this reference point must be facing Geographic South.

3.3 SunTracker-2000 site and position

SunTracker structure installation

Once the entire pedestal is installed, place the Sun Tracker on the mounting plate. Note that the inscribed reference ('N/S' or arrow) must be facing Geographic North (South if the selected location is in the Southern Hemisphere). Geographic North point is 0° in the solar orientation scale.

Mounting of the sensors

The sensors must be installed once the mechanical structure is in place.

The **pyrheliometers** are mounted on the clamps at the ends of the vertical axis (next Fig). The clamps are opened by removing the screws locking the bracket upper piece. The lower piece position must not be modified. Each clamp has some particular features related with the pyrheliometer mounted on it:

- Clamp for 'Pyrheliometer I': Located in the same axis end as the shadow arm.

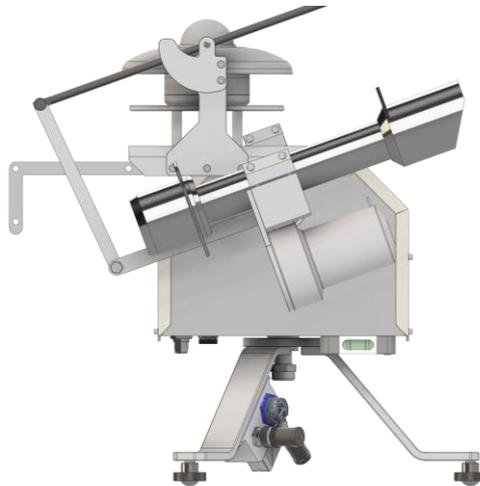


Fig. 3.4: Securing the pyrheliometer

- Adjustable clamp for 'Pyrheliometer II' or 'Calibration Pyrheliometer'. The adjustable clamp allows to regulate the pyrheliometer II pointing without moving the tracker position (that already was aligned for the 'Pyrheliometer I').

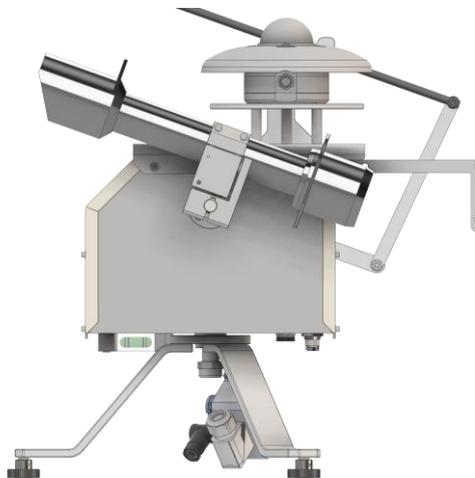


Fig. 3.5: Assembly for pyrheliometer II or calibration pyrheliometer

The **pyranometers** are mounted on a frame formed by a white board that is secured to the vertical axis as shown in the next Figure. Extension screws and hubcap tubes and/or a platform piece are installed on this structure.

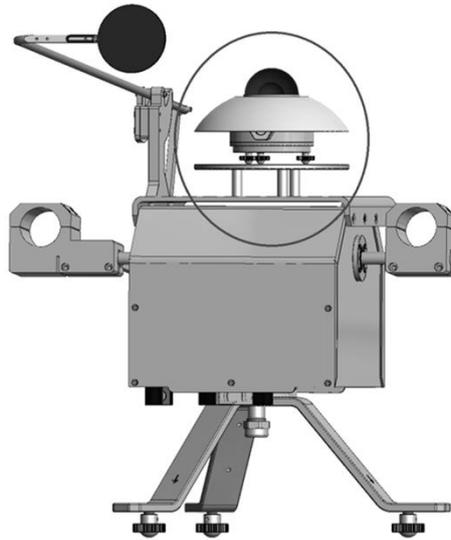


Fig. 3.6: Mounting the pyranometer

If a **shadow disk** is required, this will also be installed on the structure, ensuring that it moves together with the pyranometers.

The shadow disk must be adjusted until its shadow covers the pyranometer cupola.

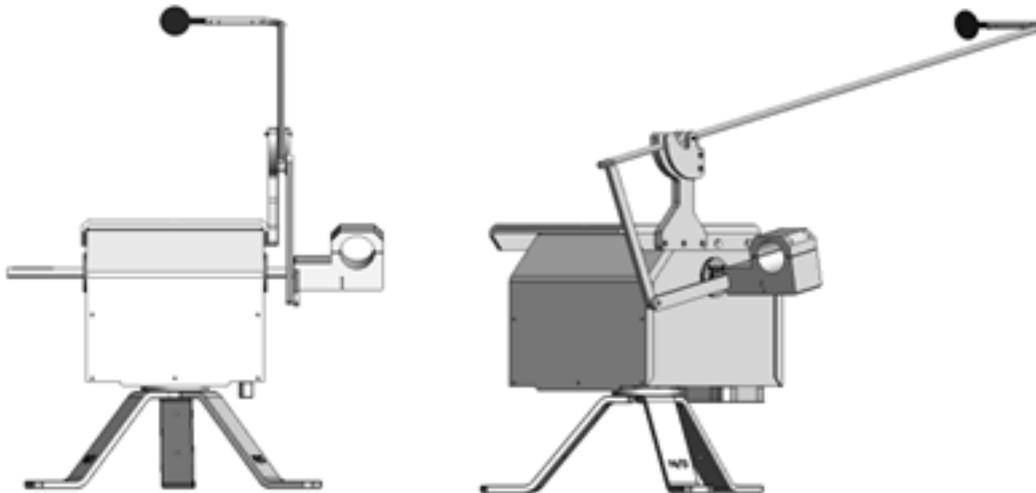


Fig. 3.7: Shadow disk

If the optional **Sun sensor** is installed in the system, it will be fastened to the pyrhelio-meter clamp through an aluminum platen. Read the Appendix B to know more details about this assembly.

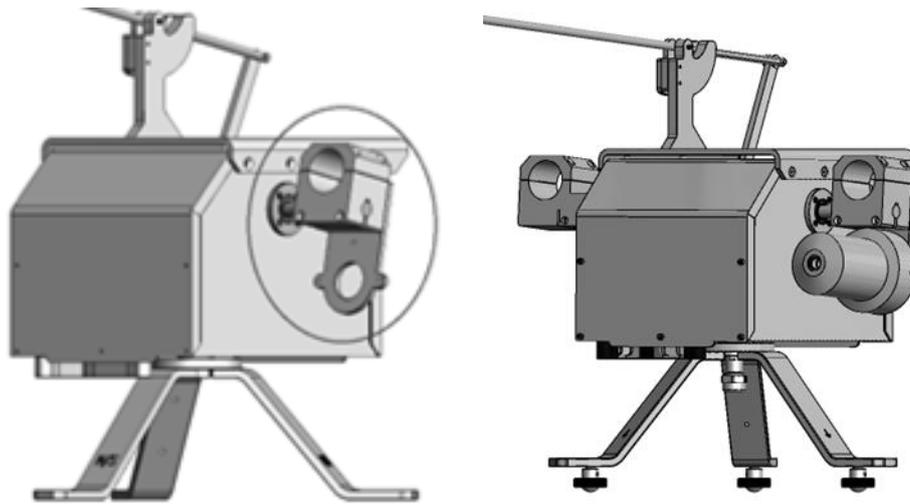


Fig. 3.8: Active solar tracking sensor

! Attention!

With the sensors already installed, make sure that no object prevents the solar tracker mechanical movements.

If the project includes any of the **spectral sensors** (SolarSIM-D2 or SolarSIM-G/G1), they will be mounted on the tracker using an adapted support (contact info.madrid@senseca.com for more information).

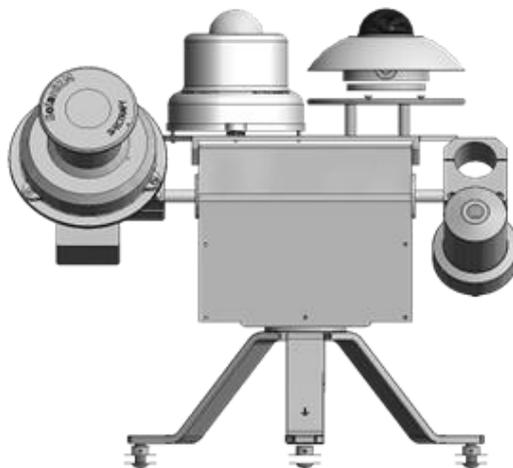


Fig. 3.9: Spectral sensors mounted on SunTracker-2000

Levelling

Once the Sun Tracker is roughly oriented, proceed to level the mechanical structure. Use the level rods, and the level sensors mounted on the mechanical structure.

DAS Mounting

Fix the DAS model METEODATA/HYDRODATA to the tower using the mechanical kit provided by Senseca.

4 Configuration and start-up

After following the steps described in this section the system will be working in an autonomous mode. The phases contemplated in the 'Configuration and start up' process are.

1. DAS Configuration
2. Connections
3. Start Up
4. Alignment
5. Additional Adjustments
6. Tests

4.1 DAS Configuration

The acquisition system samples and stores the data captured by the sensors. It processes and transmits data so that it is available wherever necessary. These processes are possible only if the device is configured properly. Make sure that the right data is managed and the necessary devices are ready for this purpose.

1. Configure MTD. Connect a PC to the DAS serial port (RS232) and start the Teletrans application, which is part of the GEO-DataView supplied with the station.
2. Station Window. Once you have logged into the program, after specifying your username, password, and the database that will contain your station data, you will see a series of windows. In the 'Stations' window search for the name of the system to be configured and double click on it.
3. Edit Coordinates. A new window that allows you to interact with the station will appear. By clicking on 'Edit', in the top-left corner, you will access the 'Station configuration' window. Clicking on the 'Configuration' tab you will see a list of options. Click on 'Location (Coordinates)' to fill the coordinates form.
Latitude and longitude data must be entered in degrees with a minimum precision of 4 decimal places and height must be entered in meters. This data must be completely correct. Together with the date and time it is the basis to calculate the SOL-POS algorithm that determines the Sun position.
This data (latitude, longitude, and height) will be measured from an external GPS. This GPS will perform the measurements in the exact location of the installation. The following figure shows an example of a GPS that can be used to measure the installation coordinates.

Attention!

The geographical coordinates always must be configured using Teletrans software, even if a GPS is connected to the station.

Example!

A Sun Tracker System is installed in a solar plant, in the following specific coordinates:

Latitude: 40° 12' 50" N

Longitude: 3° 25' 32" W

Height: 731.545 m

We must enter this data in the Teletrans application using a 4-decimal-place format. The following calculations are needed:

Latitude (4-decimal-place format) = $40 + 12/60 + 50/(60 \cdot 60) = 40.2139^\circ$

Longitude (4-decimal-place format) = $-(3 + 25/60 + 32/(60 \cdot 60)) = -3.4256^\circ$

Height (meters) = 731.545m

4. Date and time. The date and time must be as accurate as possible. Both, solar time and official time are compatible with the system:

- Solar Time: UTC time adapted to the time zone where the tracker is installed.
- Official time: time used as reference set by the Government for the area where the station is located. When the DAS works with this time configuration, the DST changes due to winter/summer time are not considered.

In most of places, there is a difference between the official time and the solar time. The solar time is determined from the Sun position while the official time is set by the Government for the entire region.

Example!

A Sun Tracker System is installed in Sevilla (Spain). In that instant, the UTC time (Universal Time Coordinated) was 13:50.

The official time, according to the Spanish Government regulations (without DST), would be UTC+1.

Official time at Sevilla: $13:50 + 1 = 14:50$

The solar time should be given by the 'Longitude' coordinate of the installation (05°59'13"W) This value would be inside the thresholds of Greenwich meridian ($0 \pm 7.5^\circ$), that is TimeZone = 0.

Solar time at Sevilla: $13:50 + 0$ (TimeZone Longitude 5°59') = 13:50

Warning!

It is required to setup a correct time value in the station METEODATA to get a proper operation. The time must be particularly calculated according to the time selected (solar time or official time). The station will have a specific configuration for each time option, whose details can be found in the configuration sheet.

5. Optional GPS. Frequently, external GPSs provide user UTC time data. Check the time format that provides your GPS. With this data, calculate the time to be entered in the system as explained in above section. Set the DAS time using its keyboard. Press the 'Time' key and enter the time data calculated.

Warning!

The geographical coordinates always must be configured using Teletrans (Step 3: Edit coordinates), even if a GPS is connected to the station.

6. Complete DAS channels configuration. On the Teletrans application, go back to the configuration window and click on 'Edit' to configure the necessary system resources. Set 'Channels', 'Special functions', 'Parameters', etc. as explained in the following setup table. Make sure you transfer all these settings to the logger internal flash configuration memory.

Warning!

The DAS model METEODATA is always provided with the specific configuration adapted to each specific project requirements. Often it will be not required configuring the datalogger again during the start-up process.

4.2 Connections

Once you have made sure that the DAS has been properly configured, switch it off and connect the SunTracker-2000 and the sensors using the supplied cables.

Warning!

Do not connect or disconnect the cables between SunTracker-2000 and DAS during operation. Always switch the power supply off before connecting or disconnecting the SunTracker to the DAS. On the contrary, the motor driver can be damaged.

The first step is to connect the input devices to the DAS. Ensure that the acquisition system power supply is OFF.

- a. Connect the solar tracker structure to the DAS. The connectors between the SunTracker-2000 and the DAS need special attention. They are IP67. In order to check they are properly connected they have slots and pins. Turn them until they are completely fit together.
- b. Connect the optional GPS to the METEODATA (Optional).
- c. Then, connect the sensors (pyrheliometers, pyranometers, and optional active positioning sensor) to the solar tracker mechanical structure. Over the tracker connectors, there is a sticker signaling the proper sensor to connect:
 1. Active tracking sensor (optional)
 2. Pyrheliometer II or calibration pyrheliometer
 3. Pyranometer
 4. Pyrheliometer I

Code:

Serial No.:

Cal. Angle:

 **senseca**
SunTracker-2000



Fig. 4.1: Sensor connections to SunTracker-2000

4.3 Start-Up

Step 1. Switch the DAS ON after all the connections have been made. For this purpose, open the DAS case, unscrew the front panel and turn the switch on.

Step 2. Reset the DAS using the keyboard. Press the 'TEST' button and then press the '->' button twice. 'Reinitialize datalogger' option appears on the display. Press the 'Yes' and 'Enter' buttons.

While DAS is reinitializing the mechanical structure will move following these steps:

- First, the SunTracker-2000 hands will fall up to find vertical axis end.
- Then, the mechanical structure will look for the mechanical North.
- At the end, the mechanical structure will rotate to the Sun beam orientation.

If after this process the solar tracker does not face the Sun, review the previous steps, especially METEODATA date/ time and coordinates configuration.

4.4 Alignment

Once the start-up steps have been completed, the solar tracker must be facing the Sun position. This is time to perform small adjustments in order to optimize the alignment to the Sun.

Pyrheliometer alignment

The pyrheliometer sensors include a simple optical device that allows the alignment to the Sun to be completed. Therefore, it is recommended that you complete the alignment on a Sunny day. The device consists of a small hole on the front fin of the pyrheliometers and a small target on its rear. When the pyrheliometer is perfectly aligned to the Sun, the ray of light that passes through the hole lights up the center of the target. As long as the ray of light is inside the target, manufacturers guarantee that the orientation differs by a maximum of 1° from the correct orientation.

When the pyrheliometer I is mounted, a standard clamp is used. In this case, the alignment required to pass the ray of light through the hole must be performed with an adjustment in the tracker azimuth position over the adjustment slots drilled in the mounting plate. For this purpose, follow the instructions described in the next section ('Structure rotation').

If two pyrheliometers are mounted on the same tracker, first you must mount and align the pyrheliometer I. Then, the pyrheliometer II (or calibration pyrheliometer) will be mounted on an adjustable clamp.

In order to align the second pyrheliometer (or calibration pyrheliometer), the clamp has some internal springs and some fixation screws. Once the pyrheliometer II is mounted, it will be aligned using the three adjustment screws located at the back of the clamp (see the image) up to make that the ray of light passes through the hole. Then, fix this position using the two fixation screws:

- Adjustment screw 1: When the screw 1 is tightened, the pyrheliometer elevation angle is decreased. When the screw 1 is loosened, the pyrheliometer elevation angle is increased.
- Adjustment screw 2: When the screw 2 is tightened, the pyrheliometer turns left. When the screw 2 is loosened, the pyrheliometer turns right.

- Adjustment screw 3: When the screw 3 is tightened, the pyrhelimeter turns right. When the screw 3 is loosened, the pyrhelimeter turns left.

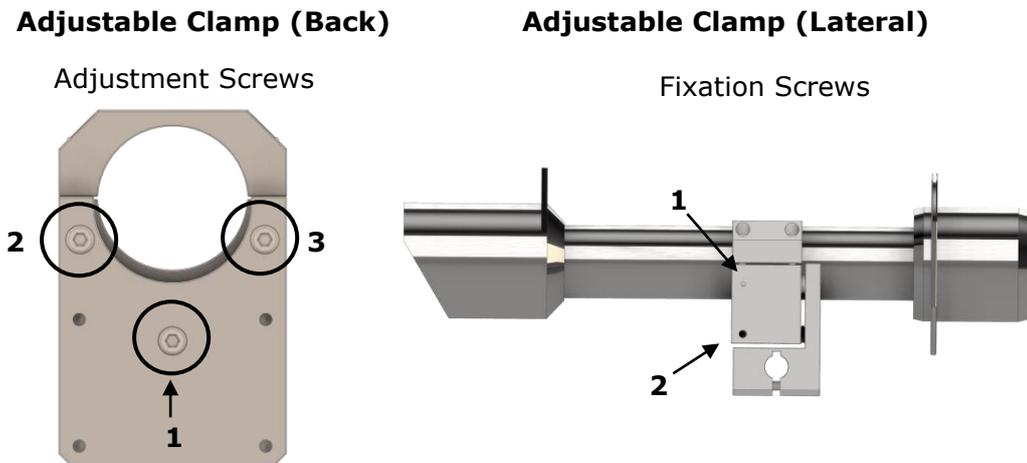


Fig. 4.2: Pyrhelimeter II on adjustable clamp

In the case of the pyranometer, no adjustments need to be made because its position should be perfectly horizontal. If the part joined to the mechanical structure is leveled, the pyranometer will be too. In any case, check the pyranometer level to ensure that it is mounted properly and that the fasteners have been fully tightened

Azimuth adjustment slots

Any solar orientation error can then be corrected by rotating the tracker structure manually and checking the ray of light on the target on the pyrhelimeter I. You can use de mounting plate adjustment slots to readjust the system after installing the tracker for the first time. This might upset the structure. Check the levels and readjust the tripod if necessary. If the solar elevation is not correct, check that the pyrhelimeter is properly fitted in the clamp. If after several attempts you still cannot adjust the pyrhelimeter position, check that the longitude, latitude, altitude, date and time data entered is correct. Any error in this data could prevent the pyrhelimeter from being aligned.

Fixing the complete system

Once you have properly adjusted the structure and the sensors, you will have a sufficiently accurate measurement of the tracker orientation. Mount fastening screws to fix the complete system. At this point, it is strongly recommended to reset the system and check that when it reboots the tracker aligns itself correctly to the Sun. If you notice any deviations after the leveling and adjustment are completed, loosen the screws slightly and restart the sensor orientation, leveling, and adjustment process.

4.5 Additional recommendations

Time for azimuth adjustment.

Sometimes users intuitively make the solar tracker azimuth adjustment at midday. At midday, when the Sun is at its highest position in the sky, it is very difficult to adjust the tracker azimuth with enough accuracy. This adjustment may imply some measurement errors because it is possible to rotate the tracker a few degrees without a strong

impact on the way the Sun beam light incidences into the pyrliometer target. These few degrees of inaccuracy have an enormous impact in the tracker ability to point to the Sun during the rest of the day. In order to avoid this problem, the Sun tracker must always be adjusted in the morning (at least 3 or 4 hours before the Sun reaches its highest position in the sky) and the adjustment must be tested in the afternoon (3 or 4 hours after the highest Sun position in the sky).

Pyrliometers pigtail

Make sure the pyrliometer pigtail position and its rear connector do not cause that the cable rolls on the leveling legs. If so, loosen the Sun tracker pyrliometer clamp and slide the pyrliometer in the opposite direction to avoid friction and cable rolling again.

Pyrliometers clamp

Make sure the pyrliometer clamp is not frictioning with the tracker upper cell vertical wall or the bearings protection etc. If so, loosen the Sun tracker pyrliometer clamp and slide it away from the bearings and vertical wall.

In order to ensure that you mount the pyrliometer in a correct position, Senseca will supply the pyrliometer marked with the recommended mounting position. These marks correspond with the position of the pyrliometer on the tracker clamp.

Connector caps

Often the tracker is supplied with some protection caps mounted on the tracker connectors. Once the SunTracker installation is completed, these connector caps must be removed. On the contrary, the caps may block the free SunTracker movement.

4.6 Operating tests

Before the solar tracker works standalone, Senseca recommends checking the following points to ensure proper future operation:

Check-Point 1. Elevation and azimuth

As soon as you have started the system, check that it calculates a solar azimuth and elevation. If the elevation is over -0.5° , check that the control module and mechanical structure start moving from an indefinite position. To do so, browse through the station menu until you get elevation channel readings. Then restart the acquisition system to make sure that the tracker is working properly. Use the TEST key as specified in the METEODATA Series 3000 manual. When the system restarts, check that it runs an axis calibration and moves into a position determined by the system date and time. If the date and time are correct, it will align itself to the Sun.

Check-Point 2. SunTracker-2000 autonomous movement

If the solar elevation value is over -0.5° when the system is started, check that the mechanical structure starts to move the axes alternately, one each second.

Check-Point 3. Time

Change the time such that the elevation remains above -0.5° . Check that the system moves to face a new direction. Then, change the time such that the elevation falls below

-0.5°. Check that the control module changes to night standby mode and switches off (for more information, please see 'Ultra-low power consumption smart mode'). This also guarantees that when it returns to day time (solar elevation above -0.5°) the system will recalibrate the axes.

Check-Point 4. Axis recalibration

To force a manual axis recalibration, restart the data acquisition system and try to prevent the elevation axis from moving. Check that for the first two seconds the motor is running at full torque and emits a loud noise, and that, afterwards, the stop detector is activated and the motor changes to standby mode. This test ensures that the limit switch stops properly. Finally, restart the acquisition system to restore the functional status.

Check-Point 5. Night standby status check

Enter a night time and try to force an axis recalibration by restarting the acquisition system. Check that the night standby mode prevails and that the system does not move once it is restarted.

Check-Point 6. Configuration check

At Teletrans, enter the site longitude and latitude data and ensure that the date and time (UTC) are correct. Also check that the status channel offset constant in the acquisition system matches the one shown on the mechanical structure label ('Degrees: X,XXXX'). With the system aligned to the Sun, finally check that the solar elevation value displayed by the acquisition system matches the one on the SunTracker. Take the parallax and assessment error into account.

5 Technical specifications

The main features of the SunTracker-2000 are described below.

SunTracker-2000. Internal control module

This module, which is an interface between the data acquisition system and the moving mechanical structure, has the following features.

Power	12 Vdc in accordance with annual average power consumption (2.8 W)
Activation	The power is controlled by a digital line. This cuts off the current to the motor controllers through an opto-relay at the power line output.
Communication	RS485 communications port to receive instructions from the data acquisition system and send the tracker status. The communication is set to 9600 baud and half duplex mode.
Controllers	Each motor is activated by a series-programmable high-resolution controller. This can give 64 different positions per step, defining axis rotations of 0.0003°. The axis position refresh time is set to one second. This makes it a real-time positioning system.
Resolution	High resolution positioning control module, 12800 micro-steps for 360° resulting in a 0,00058° resolution for each axis.
Protection	<p>The control subsystem is protected against EMI interference and type 2 and 3 ESD electrostatic discharges. The protection devices are:</p> <p>Power lines: Protected against currents by a quick-acting fuse, against surges by a transorb diode and against voltage peaks by a varistor along with a choke working as an inductive filter against ripple conditions. Finally, a solid-state relay, controlled by the activation line, provides 4000 V galvanic isolation.</p> <p>Activation line: Protected against voltage peaks by a transorb diode.</p> <p>Communication lines: Protected against voltage peaks by a transorb and a magnetic noise suppression filter</p>

SunTracker-2000. Mechanical structure

The moving mechanical structure has the following features:

Material	Made of machined aluminum, AISI 316 stainless steel for worm and other mechanical components and bronze for the gear.
Finish	Painted with UV protection, anodized and electrogalvanized.
Securing	It is supported on an adjustable tripod and has two spirit levels for adjustment
Resistance	It is designed to withstand extreme temperature situations (heater not necessary): -30°C to 60°C (working according Senseca operation specifications). Humidity: 0% - 100% and wind speed (up to 30m/s without affecting the alignment).
Accessories	Factory default: Brackets for two pyrhelimeters and support for one pyranometer.

	Optional: A shadow disk can also be added to measure diffuse radiation.
Drive	It is driven by two stepping motors, with 18.8 °/s speed and 12 Nm torque.
Transmission	Between each motor and the relevant axis there is a 48:1 ratio machined worm and gear set that provides special rotation sensitivity (0.00058°/micro-step).
Alignment accuracy	±0.1° for both axes. The alignment can be adjusted installing a Sun sensor for active tracking with an accuracy better than ±0.01°.
Repeatability	±0.1 ° for both axes
Leveling	The mechanical kit can be leveled by means of a couple of bubble level sensors attached to the system and by adjusting the tripod base
Weight	8 Kg
Size	Height (300mm), Width (370mm) and depth (290mm)

SunTracker-2000. External Control Unit (METEODATA-3000)

The data acquisition system model METEODATA-3000 supplies energy and information to the rest of the system. Apart from the general product specifications, it also has the following features specific to the solar tracking application:

Power Supply	Capacity to supply up to 3W@12Vdc to power the electronics and the motors. The batteries can be recharged from the power supply or using a 50 to 75W panel (for latitudes of around 1 sph).
Astronomical Algorithm	The astronomical algorithm, from the 'National Renewable Energy Laboratory' agency. This determines the Sun position with a maximum error of 0.01 degrees. This must provide the subsystem with the Sun elevation and orientation (azimuth) each second. The input data needed is the location of the tracker, longitude, latitude and altitude, and the date and time.
Consumption Saving	Algorithm to manage the tracker switching on and off procedures. This means an energy saving of around 67% in the winter and 33% in the summer. Also, it can switch to ultra-low power consumption smart mode in critical situations by just activating the battery reading.
Ports	A RS485 series communication port that runs in half duplex mode to send the required motor status to the control subsystem. An opto-coupled digital output for the acquisition system to switch the rest of the system on and off. A communications port (GSM, GPRS, 3G, WiFi, WiMax, etc.) that allows the unit to be reconfigured remotely, such as sending alarms via SMS if the battery levels drop significantly low or any alarm is generated.
Optional GPS	Optionally, a communications port to connect a GPS system. This option entails higher consumption, and so there must be enough power (mains supply or a solar panel of higher capacity).
Channels	Four logic channels in the calculation system for the following parameters:

	<p>Power supply control: This channel implements the solar tracker energy activation control algorithm. The unit internal battery reading must be activated.</p> <p>Solar elevation: Optionally, this channel can be activated to provide data about the Sun position.</p> <p>Solar orientation (azimuth): Optionally, this channel can be activated to provide data about the Sun position.</p> <p>Tracker status: Provides diagnostic information about the operating mode of both axes. The information is provided in a 16-bit word where each bit has a different operation mode definition according :</p> <table border="1" data-bbox="435 638 1439 1279"> <thead> <tr> <th>Value</th> <th>Hex</th> <th>Message</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>0x0001</td> <td>Elevation communication error</td> </tr> <tr> <td>2</td> <td>0x0002</td> <td>Azimuth communication error</td> </tr> <tr> <td>4</td> <td>0x0004</td> <td>Communication error with Sun Sensor</td> </tr> <tr> <td>8</td> <td>0x0008</td> <td>Active tracking</td> </tr> <tr> <td>16</td> <td>0x0010</td> <td>Elevation reset</td> </tr> <tr> <td>32</td> <td>0x0020</td> <td>Elevation failure due to 'StallGuard' detection</td> </tr> <tr> <td>64</td> <td>0x0040</td> <td>Elevation axis position is not correct. Difference > 0.2° </td> </tr> <tr> <td>128</td> <td>0x0080</td> <td>Elevation axis position is not correct. Difference > 0.2° </td> </tr> <tr> <td>256</td> <td>0x0100</td> <td>Azimuth reset</td> </tr> <tr> <td>512</td> <td>0x0200</td> <td>Azimuth failure due to 'StallGuard' detection</td> </tr> <tr> <td>1024</td> <td>0x0400</td> <td>Azimuth axis position is not correct. Difference > 0.2° </td> </tr> <tr> <td>2048</td> <td>0x0800</td> <td>Azimuth axis position is not correct. Difference > 0.2° </td> </tr> <tr> <td>4096</td> <td>0x1000</td> <td>Calibration error on elevation</td> </tr> <tr> <td>8192</td> <td>0x2000</td> <td>Calibration error on azimuth</td> </tr> </tbody> </table>	Value	Hex	Message	1	0x0001	Elevation communication error	2	0x0002	Azimuth communication error	4	0x0004	Communication error with Sun Sensor	8	0x0008	Active tracking	16	0x0010	Elevation reset	32	0x0020	Elevation failure due to 'StallGuard' detection	64	0x0040	Elevation axis position is not correct. Difference > 0.2°	128	0x0080	Elevation axis position is not correct. Difference > 0.2°	256	0x0100	Azimuth reset	512	0x0200	Azimuth failure due to 'StallGuard' detection	1024	0x0400	Azimuth axis position is not correct. Difference > 0.2°	2048	0x0800	Azimuth axis position is not correct. Difference > 0.2°	4096	0x1000	Calibration error on elevation	8192	0x2000	Calibration error on azimuth
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Motor torque control	<p>When the system needs to move to the new Sun position calculated each second, each of the axes is activated with the maximum motor torque or rotating torque (maximum power consumption). The new position is attained in 100ms and after this time the motor torque is reduced to holding torque of up to 10% of the rotating torque. This results in a reduction of approximately 80% in power consumption</p>																																													
Night standby	<p>Solar tracking only makes sense when the Sun is above the horizon, and so for the rest of the time the system can remain on standby with 0 power consumption. Due to disconnection during the night, when the Sun reappears above the horizon the system runs a mechanical calibration before permanently aligning to the Sun</p>																																													
Critical power mode	<p>The versatility of the MTD-3000 system allows it to detect the internal battery charge level at any time. If the solar panel breaks down, is stolen or there is low solar radiation for a long period of time, the system will detect a critical power situation. In this case, the tracking will be activated at intermittent intervals until the incident is solved. It even stops completely if necessary. If SMS alarm sending is activated, the user will be notified about the critical power mode to anticipate the complete deactivation of the tracker with the consequent loss of data.</p>																																													

SunTracker-2000. General technical features

The complete system includes a datalogger, a motor control unit and a mechanical kit. The general characteristics as a complete system are:

Remote control	Positioning and alignment control by Senseca station model MTD3000. It allows remote supervision and control of the whole system through GSM, GPRS, 3G, Wi-Fi, WiMax etc.
Power Features	Switched power supply allowing disconnection by means of a 4000V-isolation solid-state relay.
Power Consumption	Low power consumption: 2.8 W (only the Sun tracker). 3.7 W (the entire system including logger, GPS controller, Ethernet, etc.).
Power Supply	The system is powered through a 12V, 18 Ah battery. It can be charged by a small size 75W solar panel in locations with just 1 Sun peak hour of solar radiation. With this solar power supply there is no need to connect the system to the mains.
Remote Alarms	SMS alarm system warning about power failures, missing solar panel etc. This allows the user to be aware of the problem before the local battery is depleted. This is available only when the GSM/GPRS communication option is configured
Environmental Conditions	Operating temperature (heater not necessary): -30°C to 60°C (working according Senseca operation specifications). Relative humidity (0 a 100%); Wind speed (0 to 30 m/s with no positioning error).
Maintenance	Completely automatic and unattended system. Once it is installed, it can operate for long periods of time without human intervention
EMI / ESD	Both motor control module and the associated logger (MTD-3000/2000) are completely EMI and ESD protected

ADAS-3000

Today solar radiation data acquisition systems like Senseca's Solar Energy Measurement Systems (SEMS) are widely used for many applications, such as solar power plants, standard meteorological stations, solar energy assessment etc. that demand high levels of data quality.

Although nowadays the Solar Energy Measurement Systems and related sensor state-of-the-art technology has reached very high levels of quality and performance, there are still many issues that need to be overcome to meet these demanded levels of reliability.

Despite all these tight requirements, the Solar Energy Measurement Systems are often installed in remote unattended areas where they are exposed to all kind of meteorological conditions like rain, ice, snow, dusty winds etc. Dust along with ice and snow are certainly the major contributors affecting the quality of the solar systems radiation data.

Any radiation sensor whose dome or lens is covered by dust or ice will experience remarkable signal drops that must be detected and corrected as soon as possible to maximize the acquired data quality. Because of this, after many years of field experience, Senseca has carefully studied this issue and has proposed a solution called ADAS-3000.

ADAS-3000 is a firmware program run by Senseca's METEODATA-3000 series of loggers that monitors on a real-time basis the readings coming from the three solar radiation sensors (GHI, DNI and DHI) connected to the system. As a result of this, ADAS-3000 can automatically generate warning SMS alarms that are automatically sent to the users whenever any solar radiation data incoherence is detected. This incoherence alarm means that any of the sensor readings is not coherent with the other ones and so any of them is not working under optimal conditions and may need some maintenance or calibration.

Part of ADAS-3000 algorithms is based on Global Horizontal Radiation -GHI- and Dif-fused Horizontal Radiation -DHI- components data processing following WMO recommendations. In addition, the ADAS-3000 firmware module allows to adapt the algorithm to any site, with small or medium obstacles in the surroundings or without them, by configuring an elevation filter. This filter ensures that the shadows occurred during Sunrise and Sunset will not interfere in the algorithm proper operation.

The ADAS-3000 firmware module can optionally be included in Senseca's METEODATA-3000 series supplied loggers.

6 Maintenance

The SunTracker-2000 system is designed to work in unattended mode in worldwide environments.

In order to improve the current operation, Senseca recommends keeping the sensors and solar panel clean. When cleaning the sensors a damp cloth or a brush must be used ensuring that the sensor is not scratched or damaged during cleaning.

The following table shows the recommended maintenance and cleaning intervals depending on the environment:

Equipment	Environment		
	Standard	Aggressive	Very Aggressive
Datalogger	Every 3 months	Every month and a half	Once a month
Pyranometer	Every 3 months	Every month and a half	Once a month
Solar Panel	Every 3 months	Every month and a half	Once a month

Senseca also recommends when visiting the installation:

1. Perform a general visual inspection of the system conditions, including foundations and fence. Inspect carefully the mechanical components looking for the existence of rust or damage in the paint. It is unusual to find rust because the pieces are made of aluminium and stainless steel.
2. Ensure tower and brackets are well anchored and perfectly clean.
3. Verify that all connections and connectors are in good conditions and check the interconnection cables don't show damages or damp.
The connectors between the SunTracker-2000 and the DAS need special attention. They are IP67. In order to check they are properly connected they have slots and pins. Turn them until they are completely fit together.
4. Verify that the shadow disk casts a shadow over the pyranometer dome.
5. Check the shading arm does not have friction excess on the connecting axis that joins it with the aluminum guide. In any case (rubbing or not) it is recommended to apply penetrating oil (type '3 in One' or similar) between the arm and the guide piece. Then, remove the surplus oil with a cloth to prevent the adhesion of any particle.
6. Verify the SunTracker-2000 structure and the sensors are properly leveled. The SunTracker-2000 includes a level on its mechanics. The pyranometers normally also includes an internal level; in order to access to it, first remove the protective piece following the manufacturer instructions.
7. The system must be fixed well enough to withstand natural phenomena such as wind, etc. Try to move the structure and check its stability against vibration.
8. Check the azimuth and elevation of the SunTracker-2000. Restart the DAS and check the movement of the solar tracker. The tracker will move its azimuth and elevation axis. Check that both movements are correctly done. After a few minutes, the tracker will be pointing at the Sun again. Verify the appointment is correct.

7 Packing procedure

Senseca supplies the SunTracker-2000 unit inside a specifically designed package that protects the unit during its transportation.

Warning!

It is recommended to preserve the original packing elements, mainly if you plan to move the SunTracker-2000 from one area to another.

In order to insert the SunTracker-2000 inside the packing box, identify the tracker plane under which the connectors are (it has the connectors' legend). This plane must be oriented to the mechanical reference with 'N'/^S' indication. If you use the factory-default packing elements, you should follow these steps:

1. Modify the date at the DAS until the SunTracker-2000 will be oriented as described above. For this purpose, press the button '7/Date/Fecha' at the DAS display and enter the new value.
2. When the SunTracker-2000 will be properly oriented, switch the station off. The SunTracker-2000 will be ready to be packed.

Warning!

Remember to set up the DAS with the proper date and time before the SunTracker-2000 unit is installed again.

8 Appendix A: Internal connection details

Standard SunTracker-2000 sensors configuration: sun sensor + 3 irradiance sensors:

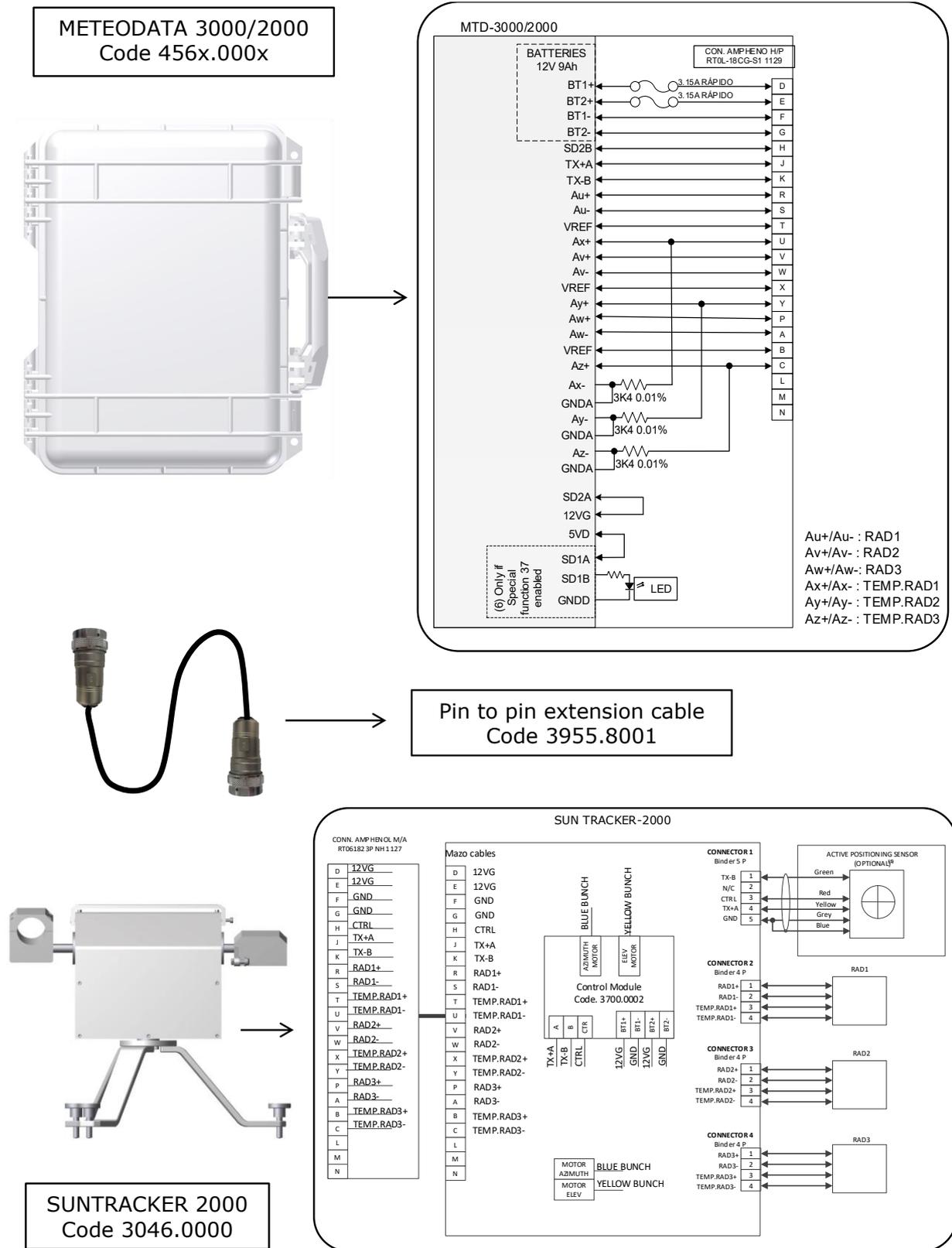


Fig. 8.1: Standard SunTracker connections

9 Appendix B: Sun Sensor for active tracking

The Sun sensor for the active tracking provides the solar beam incidence angle on two axes with a high accuracy (better than 0.01°). This data collected by the Sun sensor is sent to the SunTracker-2000 to adjust its pointing at the Sun.

Sensor type	Two orthogonal axes Sun sensor
Field of View	$5^\circ (\pm 2.5^\circ)$
Power Consumption	33 mA active mode (5 mA sleep mode)
Power Supply	5 - 12V
Temperature Range	Industrial: -40° to $+85^\circ$
Power Protections	Reverse polarity protection
Accuracy	$<0.01^\circ$
Resolution	0.001°
Sampling Frequency	50Hz
Bandwidth	0.4Hz
Estimated Lifetime	>10 years
Material	Machined aluminum
Treatment	Natural anodizing
Screws	AISI 316 stainless steel
Sealed	O-ring
Moisture desiccant	10g silica gel
Optical Window	Fused silica glass of high transmittance
Optical Set	Diaphragm and collimator
Weight	700g
External size	105mm long x \varnothing 80mm

Important Considerations

Before installing the Sun sensor for active tracking in the system, it is strongly recommended to look for a location without any shadow during the entire day. Take special attention to trees or other obstacles set in the surroundings.

Warning!

The Sun sensor for active tracking is strongly affected by:

- Shadows.
- Water droplets on the sensor lens.

It is absolutely recommended to keep the Sun sensor clean and dry to optimize the system performance. The Data Acquisition System (DAS) will perform an external and internal evaluation to allow active tracking only under appropriate conditions. Under unfavorable conditions for the Sun sensor, the system will operate with the traditional passive tracking managed by a solar algorithm.

Assembly and connection instructions

Once the tracker is mounted and all the sensors (pyrheliometers and pyranometer) and the shadow disk are assembled, it is time to mount the Sun sensor for active tracking.

Senseca supplies an adaptor to fix the sensor on the clamp. The recommended steps to mount the Sun sensor are:

1. Fix the adaptor to the Sun sensor for active tracking using three screws.
2. Fix the adaptor to the tracker clamp using four screws.
3. Connect the Sun sensor to the SunTracker-2000 in the position reserved for this purpose.

Warning!

Ensure that the cable linking the Sun sensor to the SunTracker-2000 does not interfere with the movement of any element.

It is recommended to keep cables in good order, using, for example, spirals or similar elements.

Instructions for Sun sensor calibration

Once the assembly is completed, a Sun sensor calibration is required in order to set a mechanical reference for its operation.

Warning!

The Sun sensor calibration must be performed only under the following conditions:

- Clear sky condition at the calibration time.
- The Sun sensor lens must be clean and water/shadows free.
- The direct radiation detected by the Sun Sensor must exceed 400 W/m².
- The tracker must be pointing at the Sun with a deviation below 1°.
- The solar elevation must exceed the value defined in the function configured at the station. There are different functions designed to set a minimum elevation threshold from which active tracking and Sun sensor calibration are allowed.

89 - Elevation threshold 0°

90 - Elevation threshold 5°

91 - Elevation threshold 10°

92 - Elevation threshold 15°

93 - Elevation threshold 20°

94 - Elevation threshold 25°

Attention!

The selection of one of the functions available for the active tracking depends on the surrounding conditions. There must not be any shadows falling over the sensor. Shadows are mostly cast early in the morning or before sunset. They can be rejected if a minimum elevation is considered to start the active tracking. The available options are:

89 - Elevation threshold 0°

- 90 – Elevation threshold 5°
- 91 – Elevation threshold 10°
- 92 – Elevation threshold 15°
- 93 – Elevation threshold 20°
- 94 – Elevation threshold 25°

Select functions 89 or 90 in environments without any obstacles in the surroundings that can cast a shadow over the sensor. Select 93 or 94 in locations where shadows caused by trees and other obstacles are likely to occur. For general purposes, select functions 91 or 92.

Warning!

Note the Sun sensor is very sensitive to the dirt, the water drops and the shadows. The METEODATA-3000 internal program has been designed with the purpose of ensuring that the Sun tracking will be performed with the best achievable accuracy. For this purpose, some firmware security measures (e.g. elevation threshold and maximum deviation) have been implemented in the logger to prevent Sun sensor corrections under unfavorable conditions.

If any element of the system is relocated or its position is modified, you should perform a Sun sensor re-calibration. For this purpose, you should perform two steps:

1. Delete the Sun sensor calibration data. Press the '4-CALIB.' key and then, press the 'ENTER' key. The following message will appear on the display ('Sun-Sensor already calibrated. Press enter to clear current calib. Data'). Press the 'ENTER' key again to delete the latest calibration data. At the end of this step, the Sun sensor reference data will be cleared.
2. Perform a Sun sensor calibration again to collect the reference data adequate for the new position of the system. For this purpose, follow steps from 1 to 4 included in this section

Warning!

If the calibration constants are cleared (when the Sun Sensor is not calibrated yet or the Sun Sensor calibration is manually deleted) the active tracking mode will not be used by the tracker.

Operation considerations

The SunTracker-2000 will operate in active tracking mode when the system will work under the following conditions:

- Irradiance threshold. The Sun sensor must be measuring a direct irradiance of at least 400 W/m².
- Elevation angle. The elevation angle recorded by the DAS must be at least the value configured by the selected tracking function.
 - 89 – ST2K/ST3K Active Tracking Elevation Threshold 0°
 - 90 – ST2K/ST3K Active Tracking Elevation Threshold 5°
 - 91 – ST2K/ST3K Active Tracking Elevation Threshold 10°
 - 92 – ST2K/ST3K Active Tracking Elevation Threshold 15°
 - 93 – ST2K/ST3K Active Tracking Elevation Threshold 20°
 - 94 – ST2K/ST3K Active Tracking Elevation Threshold 25°

- Deviation angle. The deviation angle indicated by the Sun sensor must be below $\pm 2^\circ$

If any of the previous conditions is not met in the location, the SunTracker-2000 will be positioned under the indications provided by the SOLAR algorithm.

Remote activation / deactivation of the active tracking

In order to disable the active tracking performed by the SunTracker-2000, access to the DAS configuration using Teletrans and disable the 'Special function' 89/90/91/92/93/94. For this purpose, follow the sequence: Select the station at Teletrans' station manager window and click on 'Edit' -> 'Configuration' -> 'General' -> 'Special Functions' and disable the function 'NN: ST2K/ST3K Active Tracking...'

NOTES

NOTES

WARRANTY

The manufacturer is required to respond to the "factory warranty" only in those cases provided by Legislative Decree 6 September 2005 - n. 206. Each instrument is sold after rigorous inspections; if any manufacturing defect is found, it is necessary to contact the distributor where the instrument was purchased from. During the warranty period (24 months from the date of invoice) any manufacturing defects found will be repaired free of charge. Misuse, wear, neglect, lack or inefficient maintenance as well as theft and damage during transport are excluded. Warranty does not apply if changes, tampering or unauthorized repairs are made on the product. Solutions, probes, electrodes and microphones are not guaranteed as the improper use, even for a few minutes, may cause irreparable damages.

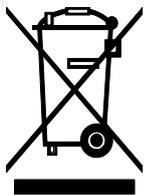
The manufacturer repairs the products that show defects of construction in accordance with the terms and conditions of warranty included in the manual of the product. For any dispute, the competent court is the Court of Padua. The Italian law and the "Convention on Contracts for the International Sales of Goods" apply.

TECHNICAL INFORMATION

The quality level of our instruments is the result of the continuous product development. This may lead to differences between the information reported in the manual and the instrument you have purchased.

We reserve the right to change technical specifications and dimensions to fit the product requirements without prior notice.

DISPOSAL INFORMATION



Electrical and electronic equipment marked with specific symbol in compliance with 2012/19/EU Directive must be disposed of separately from household waste. European users can hand them over to the dealer or to the manufacturer when purchasing a new electrical and electronic equipment, or to a WEEE collection point designated by local authorities. Illegal disposal is punished by law.

Disposing of electrical and electronic equipment separately from normal waste helps to preserve natural resources and allows materials to be recycled in an environmentally friendly way without risks to human health.



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