EOS OPERATING MANUAL

Thank you for choosing the EOS sensor from Sentinum. Please read the following user manual carefully to prevent damage to the sensor, to yourself, and to the environment.

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1. GENERAL WARNINGS AND SAFETY INSTRUCTIONS

⚠ DANGER	
	Immediate danger → **highly likely to** result in death or serious injury

⚠ WARNING	
	Dangerous situation → **may** cause serious injury.

⚠ CAUTION	
	Risk usually results in **minor injuries or property damage.**

NOTE	
	Tips and information.

NOTE	
	Please note: Follow the safety instructions and installation instructions in the manual and the installation checklist. Ensure that the installation environment complies with the specified operating range guidelines. Keep the temperature and other limit values at all times. The device may only be used within the ranges specified . The device may only be used for the intended purposes and in the specified environments . Safety and proper functioning can no longer be guaranteed if the device is modified or expanded. The sensor must not be mounted on ceilings or floors The sensor is approved for operation only up to a maximum altitude of 2,000 meters above sea level . • Due to human exposure regulations, a minimum distance of 20 cm must be maintained between the device and people. • Ensure that the installation environment complies with the prescribed guidelines for the intended application. Adhere to the temperature and other limit values at all times. • Ensure that the installation environment complies with the prescribed guidelines for the intended application. Adhere to the temperature and other limit values at all times. • Dispose of the device in accordance with national environmental regulations. • Repairs to the device may only be performed by the manufacturer. • Follow the specific safety instructions for batteries and lithium primary cells.

	If the device is installed **incorrectly**: It may not function properly. It could be permanently damaged. Please note: Improper handling, such as excessive mechanical stress (e.g., dropping the device), may result in damage. Using battery cells other than those recommended may negatively affect performance and product safety.

! CAUTION	
	If the device is installed **incorrectly**, it could pose a risk of injury.

! WARNING	
	Improper handling of lithium batteries (e.g., damage, incorrect charging, short circuits, or high temperatures) can lead to fire, explosion, or injury. Improper handling includes, in particular, mechanical damage, overcharging, deep discharge, short circuits, operation outside the specified temperature ranges, as well as misuse or improper disposal.

2. ADDITIONAL DOCUMENTATION

Please refer to the information and limit values in the technical data sheet.

The sensor-specific factory settings (Sentiface), as well as the keys and permissible values for the sensor, can be found in the NFC and downlink description. The Senticom and Sentivisor tables are included in the generic NFC and downlink documentation. The special functions for vandalism detection and opening detection are also generic.

Depending on the version, you can find instructions for configuring sensor communication in the respective generic LoRaWAN®, Mioty®, or Cellular (NB-IoT and LTE-M1) documentation.

All documents related to the generic documentation can be found at https://docs.sentinum.de/wichtig-produktübergreifende-dokumentation-für-sensoren.

3. INTENDED USE

The sensors of the EOS Radar Series are designed for non-contact level measurement of liquids, bulk materials, and solid goods using radar technology. They are intended for industrial applications, particularly in the field of tank and inventory monitoring (e.g., IBC containers).

The devices are designed for use in both outdoor and indoor environments and may be operated within the specified environmental and operating conditions. Installation is performed using suitable mechanical interfaces (e.g., 1.5" threads) in accordance with the respective installation instructions, or via other mounting methods such as screws, adhesives, or suitable brackets.

Data is transmitted wirelessly via supported IoT wireless standards for connection to higher-level systems, platforms, or cloud services. Additionally, integrated location functions (GPS) can be used for position determination.

Intended use refers exclusively to operation in accordance with the manufacturer’s technical specifications, connection requirements, and installation and operating instructions.

4. PRODUCT VERSIONS

Item Code	Battery	Model	Available	Configuration
S-EOS-LOEU-R-F	3xAA	**Flat**	✓	BLE
S-EOS-MIOTY-R-F	3xAA	**Flat**	✓	BLE
S-EOS-NBM1-R-F	3xAA	**Flat**	✓	BLE
S-EOS-LOEU-R-F-SMA	3xAA	**Flat**	✓	BLE
S-EOS-MIOTY-R-F-SMA	3xAA	**Flat**	✓	BLE
S-EOS-NBM1-R-F-SMA	3xAA	**Flat**	✓	BLE
S-EOS-LOEU-R-F-SMA-M12	3xAA	**Flat**	X	BLE
S-EOS-MIOTY-R-F-SMA-M12	3xAA	**Flat**	X	BLE
S-EOS-NBM1-R-F-SMA-M12	3xAA	**Flat**	X	BLE
S-EOS-LOEU-R-T	3xAA	1.5-inch thread	✓	BLE
S-EOS-MIOTY-R-T	3xAA	1.5-inch thread	✓	BLE
S-EOS-NBM1-R-T	3xAA	1.5-inch thread	✓	BLE
S-EOS-LOEU-R-T-SMA	3xAA	1.5-inch thread	✓	BLE
S-EOS-MIOTY-R-T-SMA	3xAA	1.5-inch thread	✓	BLE
S-EOS-NBM1-R-T-SMA	3xAA	1.5-inch thread	✓	BLE
S-EOS-LOEU-R-T-SMA-M12	3xAA	1.5-inch thread	X	BLE
S-EOS-MIOTY-R-T-SMA-M12	3xAA	1.5-inch thread	X	BLE
S-EOS-NBM1-R-T-SMA-M12	3xAA	1.5-inch thread	X	BLE

X: Upon request

Item Code	Battery	Model	Available	Configuration
S-EOS2C-LOEU-R-F	2xC	**Flat**	**X**	BLE
S-EOS2C-MIOTY-R-F	2xC	**Flat**	**X**	BLE
S-EOS2C-NBM1-R-F	2xC	**Flat**	**X**	BLE
S-EOS2C-LOEU-R-F-SMA	2xC	**Flat**	**X**	BLE
S-EOS2C-MIOTY-R-F-SMA	2xC	**Flat**	**X**	BLE
S-EOS2C-NBM1-R-F-SMA	2xC	**Flat**	**X**	BLE
S-EOS2C-LOEU-R-F-SMA-M12	2xC	**Flat**	**X**	BLE
S-EOS2C-MIOTY-R-F-SMA-M12	2xC	**Flat**	**X**	BLE
S-EOS2C-NBM1-R-F-SMA-M12	2xC	**Flat**	**X**	BLE
S-EOS2C-LOEU-R-T	2xC	1.5-inch thread	**X**	BLE
S-EOS2C-MIOTY-R-T	2xC	1.5-inch thread	**X**	BLE
S-EOS2C-NBM1-R-T	2xC	1.5-inch thread	**X**	BLE
S-EOS2C-LOEU-R-T-SMA	2xC	1.5-inch thread	**X**	BLE
S-EOS2C-MIOTY-R-T-SMA	2xC	1.5-inch thread	**X**	BLE
S-EOS2C-NBM1-R-T-SMA	2xC	1.5-inch thread	**X**	BLE
S-EOS2C-LOEU-R-T-SMA-M12	2xC	1.5-inch thread	**X**	BLE
S-EOS2C-MIOTY-R-T-SMA-M12	2xC	1.5-inch thread	**X**	BLE
S-EOS2C-NBM1-R-T-SMA-M12	2xC	1.5-inch thread	**X**	BLE

X: Upon request

5. SCOPE OF DELIVERY AND VERSIONS

5.1. SCOPE OF DELIVERY AND OPTIONAL INSTALLATION ACCESSORIES

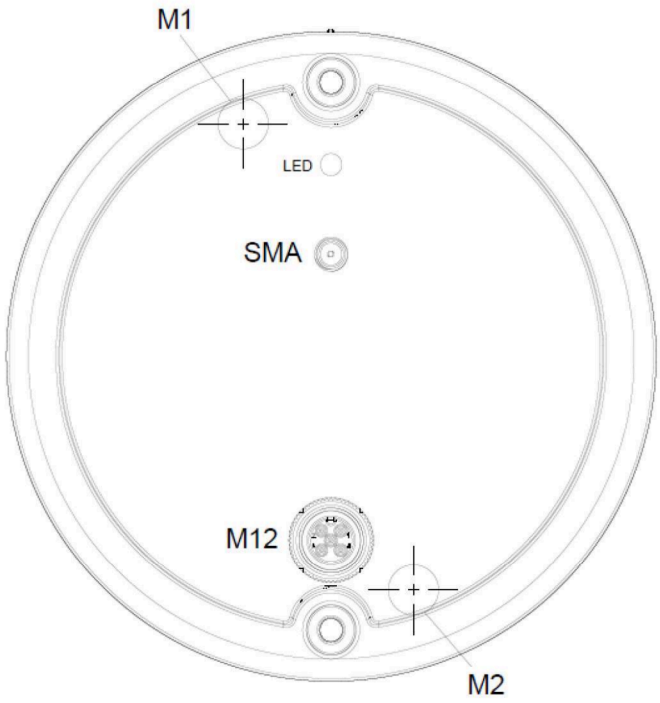
Part Number	Recommended Accessories
Z-EOS-MAG-NEO	APOQ Neodymium Magnet Set
Z-EOS-FLANGE-OI	4mm Stainless Steel Flange
Z-EOS-FLANGE-ROUND	Round Stainless Steel Flange, 4 mm
Z-EOS-GLUE-PAD	Adhesive pad for EOS-F versions (without threads)
Z-EOS-DSN	Sealing cord
Z-EOS-BLECH-U	U-shaped metal plate for ceiling mounting (SMA exposed)
Z-EOS-L	L-bracket for wall mounting
Z-EOS-SPX	Wood screws
Z-EOS-DIN912	DIN 912 Screws M4

Drilling templates can be found at the end of the operating manual

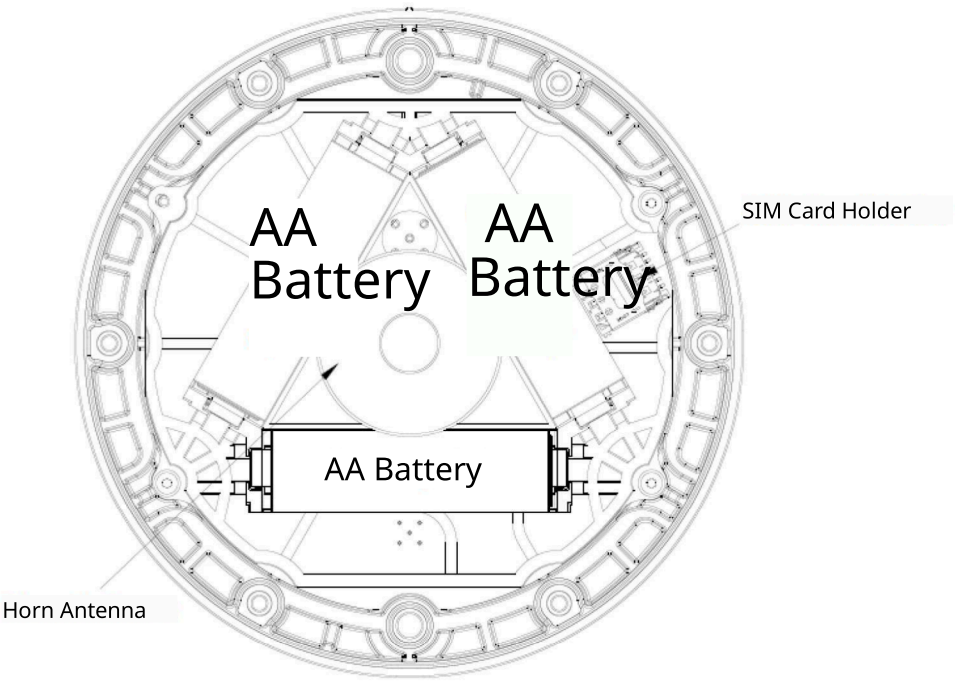
The package includes:

- 3 batteries (already installed)

6. IMPORTANT COMPONENTS



M1	Magnetic Switch 1
M2	Solenoid Switch 2
SMA	SMA connector for external antenna
LED	LED - visual feedback and indicator light
M12	M12 Top Connection


AA Battery
AA Battery
AA Battery
SIM Card Holder
Horn Antenna

7. TRACKING AND LOCATION

The EOS Radar Series features integrated GNSS functionality for global positioning. It processes signals from multiple satellite navigation systems, such as GPS, GLONASS, Galileo, and BeiDou, to enable reliable and precise positioning. Positioning is performed via a patch antenna integrated into the device, eliminating the need for an external antenna and ensuring a compact, rugged design. This allows for flexible use in mobile and stationary applications, such as tracking the location of containers, tanks, or moving assets—even under demanding environmental conditions.

8. EXTERNAL ANTENNA

The sensor features an **SMA connector and** is equipped with an automatic RF switching function. By default, the internal chip antenna is used. When a **specific** external antenna is connected, the system automatically switches to it, ensuring optimized radio performance. If no antennas listed in the following table are used, the switch must be made manually via BLE.

Manufacturer	Part Number
Poynting	OMNI-85
Poynting	OMNI-280

9. MOUNTING AND INSTALLATION

9.1. WARNINGS AND SAFETY INSTRUCTIONS FOR INSTALLATION

NOTE	
	If the sensor remains easily accessible after installation, install the sensor first and activate it after installation! If the sensor is no longer accessible after installation, activate the sensor first and then install it! Before proceeding with this type of installation, make sure that the surface to which the sensor is to be screwed is level; otherwise, the housing may be damaged.

Please note:

- Do not insert any objects or body parts into the sensor’s openings.
- Do not mount the sensor on the ceiling or floor.
- Do not install the sensor at heights exceeding two meters.
- Install the sensor only indoors on a wall in a standard room at a height of 1.50 m to 1.80 m.

The standard versions of the Eos sensor are designed for a wide range of industrial and logistics applications and feature robust housings with a high protection rating. The following points must be observed during installation:

- Select an installation location that falls within the specified ambient temperatures and conditions (see technical data).
- Do not cover the housing: Wireless communication (e.g., LoRaWAN, BLE) must not be obstructed by metallic objects, sealed housings, or materials that block radio waves.

NOTE	
	Ideally, mount the sensor with a clear line of sight to the sky. This ensures smooth operation of the wireless interfaces. The antennas are oriented toward the top of the device. For optimal wireless and GNSS performance, the antennas must not be obstructed. Maintain a minimum distance of 1 m from surrounding objects. Avoid installing the device in enclosed metal enclosures or in the immediate vicinity of large metal structures, as this can significantly impair signal quality. For the GNSS function, a clear line of sight to the sky is required to ensure reliable positioning.

- Secure the sensor firmly, ideally using the provided mounting holes. Low-vibration or solid surfaces are recommended.
- Orientation: The standard version does not require any special orientation and can therefore be mounted flat, vertically, or horizontally—depending on the application.
- Do not mount in the immediate vicinity of strong electromagnetic sources to avoid signal interference.

NOTE	
	Permanent magnets can generate strong magnetic fields that may be dangerous if handled improperly. Therefore, please observe the following warnings:

WARNING	
	• Protect your hands and fingers: Strong magnets can snap together suddenly and pinch your fingers or skin. This can lead to painful bruises and injuries. Always maintain a safe distance when handling permanent magnets and wear protective gloves if necessary. • Keep electronic devices away: Magnetic fields can damage electronic devices such as computers, smartphones, credit cards, pacemakers, and other sensitive electronics, or interfere with their operation. Therefore, always maintain a safe distance from such devices. • Be aware of the risk of breakage: Many permanent magnets are made of brittle materials (e.g., neodymium) that can break if subjected to sudden impacts or excessive stress. The shards can be sharp and cause injuries. Therefore, handle the magnets with care and avoid impacts or excessive loads. • Health risks: People with pacemakers or other implanted medical devices should avoid contact with strong magnets, as the magnetic fields can interfere with or deactivate these devices. If necessary, consult a doctor if necessary. • Store magnets safely: Keep magnets at a safe distance from each other and from other metallic objects. Sudden attraction can cause damage, injury, or cause objects to fly around uncontrollably. • Danger to children: Permanent magnets are not toys! Small magnets in particular can be life-threatening if swallowed or inhaled and can cause serious internal injuries. Therefore, always keep magnets out of the reach of children. • Avoid overheating: Permanent magnets lose their magnetic properties at temperatures above their maximum operating temperature (between 80 and 200 °C) permanently lose their magnetic strength. Therefore, do not expose magnets to direct heat or open flames.

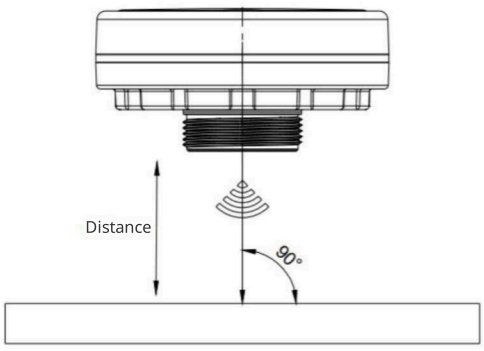
9.2. RECOMMENDED MOUNTING METHODS

Mounting Method	Description	Recommended Accessories
Screw connection	2 M4 or M5 screws	2x suitable countersunk screws, if necessary wood screws 4 mm – 5 mm
Magnets	2 M4 neodymium pot magnets, with internal threads	2 neodymium magnets (indoor) combined lifting capacity of 16–32 kg
Adhesives	Double-sided tape or mounting adhesive	Double-sided tape or mounting adhesive

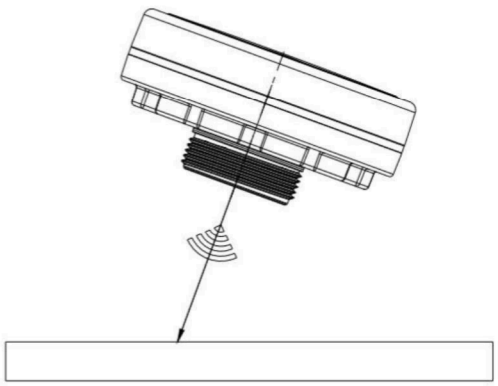
9.3. INSTALLATION ACCESSORIES

Installation method	Recommended Accessories
Screw fastening	DIN 912 machine screws with M4 nuts or wood screws
Magnets	2 neodymium pot magnets, holding force 16–32 kg, including 2 screws
Adhesives	Double-sided adhesive tape
Rivets	For rear panel mounting with M4 rivet nuts or front panel mounting with blind rivets
Spacer	See technical drawing for dimensions
Drilling templates	See the end of the operating instructions

9.4. GENERAL INSTALLATION INSTRUCTIONS



The sensor measures the distance to the object most accurately when it is aligned parallel to the object. For discrete or bulk materials, the sensor should be mounted parallel to the bottom of the container. Ideally, the sensor beam should strike the object to be measured at a 90° angle.



If the sensor is not mounted parallel to the object being measured, measurement performance may be impaired. If the sensor is not aligned horizontally, care must be taken to adjust the percentage calculation of the fill level.

9.5. IMPORTANT NOTE FOR DEVICES WITH AN EXTERNAL ANTENNA

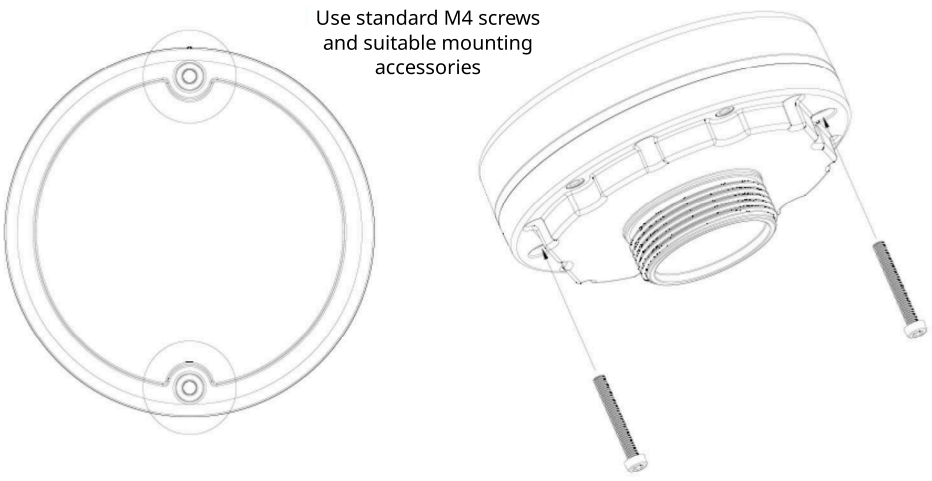
If you have ordered a device with an external antenna—which can be identified by the gold **SMA connector** —install the antenna first.

NOTE	
	External Antenna: Please note that the antenna should always be mounted vertically with the tip pointing toward the sky, if the application permits. The antenna should be at least 2 cm away from metal surfaces. Ensure that the antenna is not shielded by surrounding metal parts, provided the application allows it. Internal antenna: If your device has an internal antenna (no external antenna visible), the sensor should always be mounted vertically with the long side facing up, as this ensures the device achieves maximum signal strength. The antenna is located on the top (logo side) of the housing and should be at least 2 cm away from metal surfaces. Make sure the antenna is not shielded by surrounding metal parts, provided the application allows it.

9.6. WALL MOUNTING WITH SCREWS (WITHOUT SMA AND M12)

NOTE	
	This mounting method works only with versions without an SMA or M12 connector.

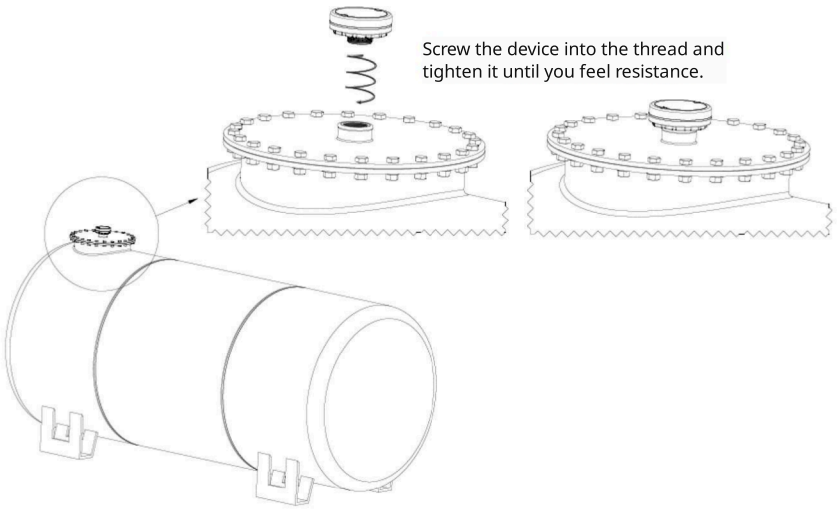
A drilling template can be found at the end of the operating instructions. This mounting method is typically used to attach the sensor to the ceiling. Insert the appropriate screws into the holes provided on the front panel. Alternatively, suitable wood or plastic screws can be used if the sensor is to be mounted on these materials. Use the included two-point mounting bracket for this purpose.



If the sensor is not mounted parallel to the object being measured, measurement accuracy may be compromised. If the sensor is not aligned horizontally, the level calculation must be adjusted accordingly.

9.7. MOUNTING THE SENSOR WITH A 1.5-INCH THREAD

The sensor has a 1.5-inch external thread and is designed for installation in corresponding 1.5-inch internal threads. To ensure a secure seal, use suitable sealing materials such as sealing cord or PTFE tape (Teflon tape). When screwing in the sensor, ensure that it is positioned straight and mounted without any tilting. Excessive resistance when screwing in indicates improper installation and can lead to damage to the thread. In this case, stop the installation process and inspect the sensor. If the thread sizes differ, use suitable and approved adapters. Perform the installation according to the instructions in the user manual. Improper installation of the sensor can lead to leaks, medium leakage, and damage to the thread. This can cause malfunctions or hazards during operation.

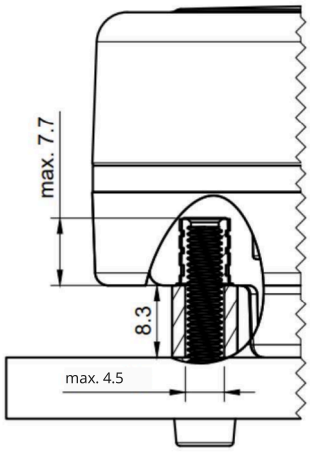


9.8. INSTALLATION USING THE M4 THREADED INSETS

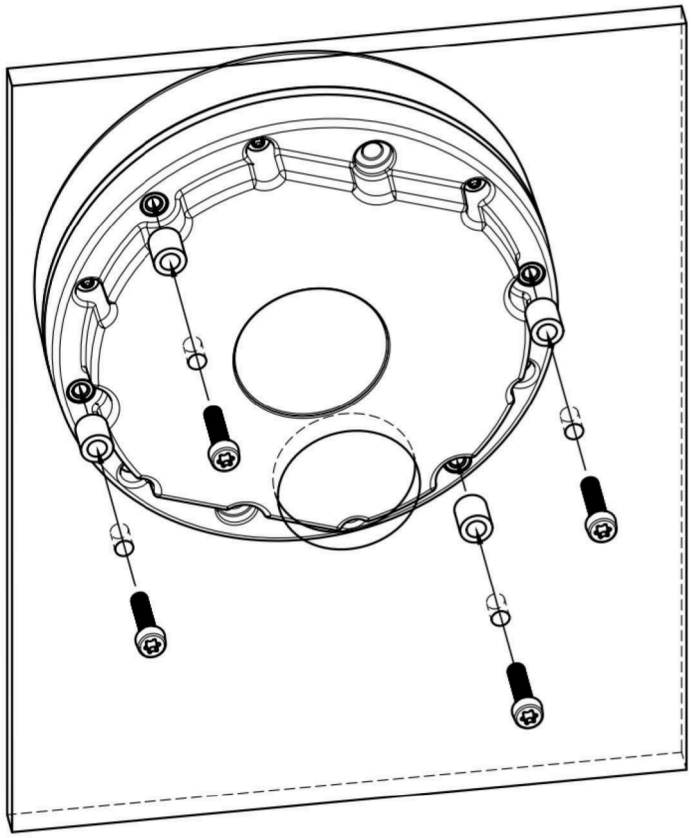
The sensor features four integrated M4 threaded inserts for mechanical fastening. Use standard M4 screws and suitable fasteners for installation.

The maximum permissible screw-in depth is 7.7 mm. Exceeding this depth may result in damage to the threaded inserts or internal components.

Installation must be performed evenly across all four mounting points to prevent stress in the housing. Screws must be tightened to the specified torque; do not overtighten. Ensure that the mounting surface is level and sufficiently load-bearing. If necessary, use suitable washers or mounting adapters. Installation must be performed in accordance with the instructions in the user manual.



Use standard M4 screws and suitable mounting accessories, such as spacer sleeves of the appropriate length, between the device and the mounting plate.



NOTE	
	The maximum torque with spacers is 2 Nm. Without suitable spacer sleeves, the torque is reduced to 0.8 Nm.

9.9. WALL MOUNTING WITH MAGNETS

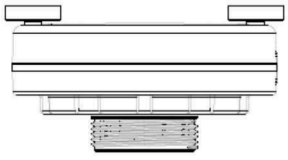
A drilling template can be found at the end of the operating instructions. The magnets shown below are neodymium magnets. Other versions may differ. Although neodymium magnets offer greater force per unit area, they are only suitable for outdoor use to a limited extent. Please contact us for advice if needed.

Insert the appropriate magnets into the designated holes on the back of the sensor. The magnets shown here are NEODYMIUM magnets. Alternatively, you can perform this step in the same way for FERRITE magnets.

Insert the screws into the holes on the opposite side and tighten the magnets by screwing them in.

Optional: Slide an anti-slip cover over the magnets. The anti-slip cover prevents the magnet from shifting if the object vibrates or changes position.

In addition to the rear-panel mounting shown, front-panel mounting is also possible. To do this, swap the positions of the magnets (magnets in the holes on the front, screws in the holes on the back).

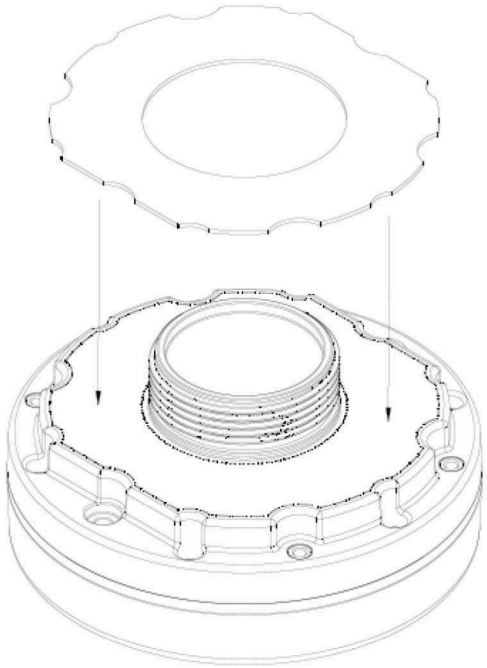


9.10. WALL MOUNTING WITH ADHESIVE STRIPS

Before using this mounting method, ensure that the surface is clean, dry, smooth, and suitable for adhesion, as an uneven or dusty surface can impair the adhesive strips' hold. Avoid mounting on rough, porous, or damp surfaces, as this can reduce the adhesive strength and cause the mount to come loose. After applying the mount, press it firmly for a few seconds to ensure optimal adhesion between the adhesive strips and the surface.

Apply the double-sided adhesive tape to the back of the sensor in the area shown. The tape should be large enough to ensure a secure hold. When mounting with adhesive strips, make sure the strips adhere completely and that no corners come loose.

This mounting option can be used for both the -T threaded version and the -F "flat version."



9.11. FRONT WALL MOUNTING WITH BLIND RIVET NUTS

A drilling template can be found at the end of the operating instructions. **Front-panel mounting** is used when you want to attach the front of the Apollon-Q sensor to the wall of the structure where the sensor is to be installed. The front side is the side with the opening in the center, where the logo is also visible. This mounting method is the **preferred option** because it allows for easy battery or SIM card replacement by simply loosening the screws (unlike front-panel mounting with blind rivets).

NOTE	
	Activate the sensor before beginning installation.

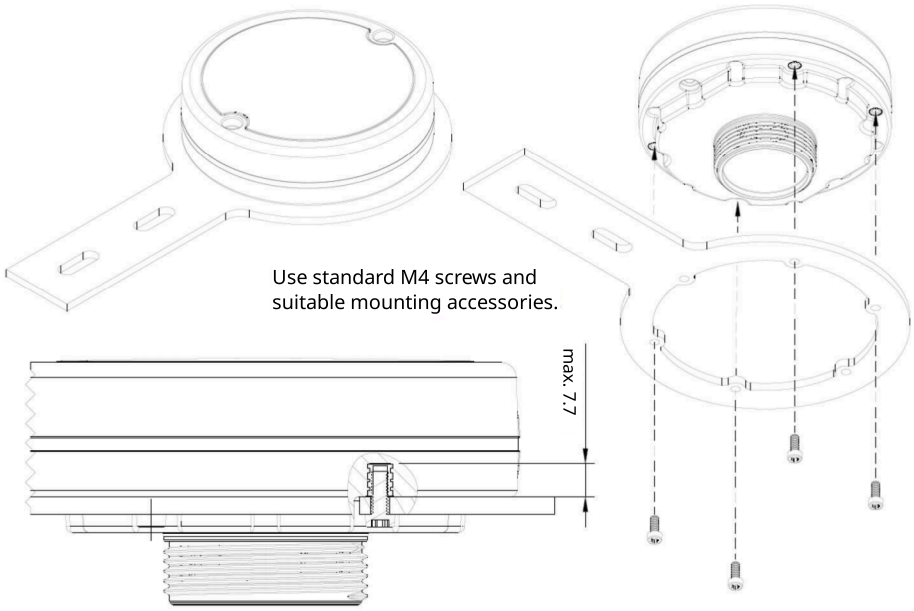
Step 1: Depending on the sensor type (radar and ToF only), drill the appropriate holes in the wall where you want to mount the sensor. Use the drilling template for this. The holes for the blind rivet nuts should have a diameter of 6.1 mm.

Step 2: Now secure the blind rivet nuts using a suitable tool. Use the spacer plate and insert the screws into the tabs as shown in the illustration. Tighten the screws to a maximum torque of 2 Nm. If continuous vibrations are expected during operation, we recommend using threadlocker.

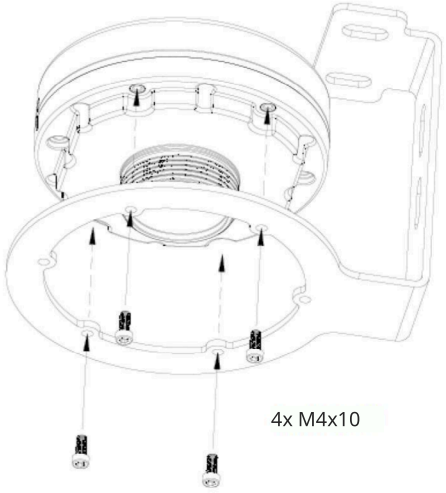
9.12. INSTALLATION WITH FLANGE

Use standard M4 screws for fastening. When screwing in the screws, be sure not to exceed a maximum insertion depth of 7.7 mm into the thread.

Screwing the screws in too deeply can damage the housing or the internal components. Select the screw length based on the installation conditions.



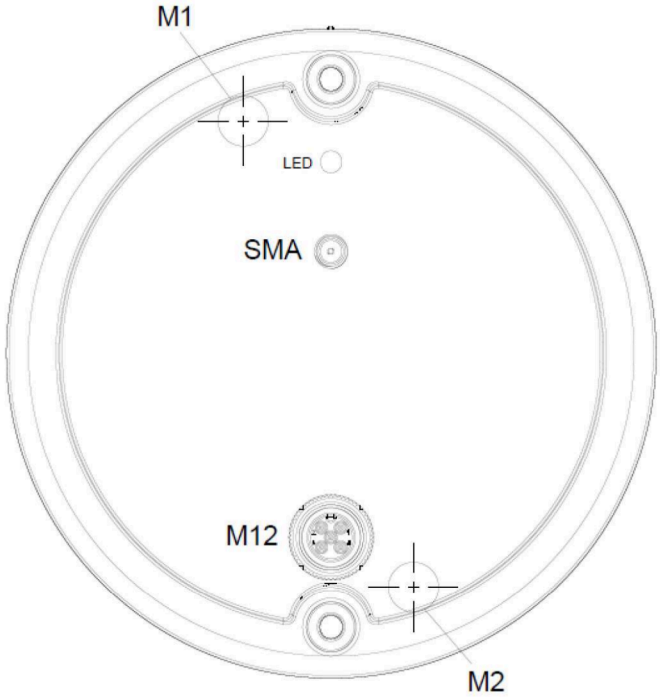
9.13. INSTALLATION WITH 90° STAINLESS STEEL BRACKET FOR WALL AND CEILING MOUNTING



Use standard M8 screws and suitable mounting accessories.

10. COMMISSIONING AND CONFIGURATION

NOTE	
	Please note that using knives or other sharp objects may damage the housing or electronics. There are two Hall sensors (magnetic field switches) on the sensor. The following diagram shows the location of the Hall sensors and the recommended placement of the Magnets.



	Description	Function
M1	Magnetic Switch 1	• When the sensor is off, placing the magnet between 2 and 8 seconds causes the sensor to start up and begin BLE advertising • When the sensor is on, the following functions are active: • Magnet is in contact for 0–2 sec.: BLE advertising • Magnet is in contact for 2–8 sec.: Transmission is triggered and • Magnet is in contact for >8 sec.: Reboot Device
M2	Magnetic Switch 2	Custom functions can be implemented

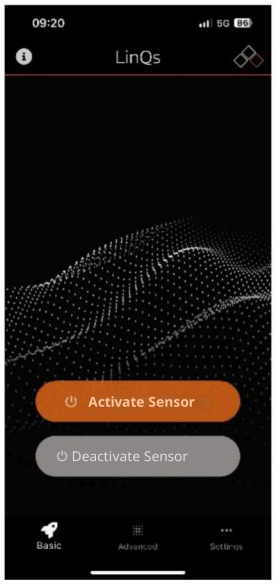
10.1. COMMISSIONING AND CONFIGURATION OF THE SENSOR VIA BLE

1. All Eos models can be activated via BLE using a smartphone. To do so, simply use our LinQs app from Sentinum GmbH, which you can find in the App Store and Google Play Store.

2. Activate the sensor by briefly triggering the lower-left Hall sensor (M1) with a magnet for at least 2 seconds. The sensor should now emit a series of beeps. Advertising mode will then start automatically.

3. You can now conveniently control the sensor via BLE from your device. Make sure Bluetooth is turned on on your smartphone and that you are within range of the sensor to be able to connect to and control it.

Enable BLE Advertising

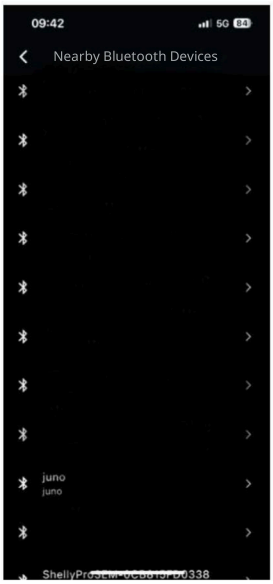


BLE advertising mode can be activated using the magnets or after activating the sensor.

Search for BLE device

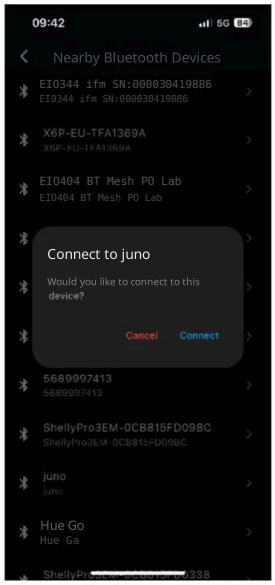
Use the "Search" button to search for the sensor via BLE.

Connect to the sensor via BLE Search for



Select the correct sensor and confirm by clicking “Eos.”

Connecting to the sensor via BLE

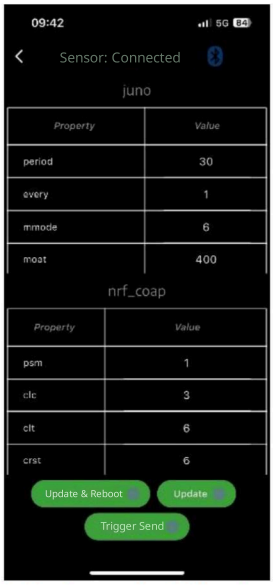


Click the "Connect" button

Configuring the sensor via BLE

Now use the “Configure” button to set parameters.

Configure the sensor via BLE



Use the “Trigger Send” button to initiate a transmission. Tap the desired table entry and change the values. Confirm by clicking the “Update & Reboot” or “Update” button at the bottom. “Update & Reboot” forces a reboot in addition to applying the changes; “Update” applies the changes during the next measurement or transmission.

10.2. AUDIBLE SIGNAL AND FLASHING PATTERN

- When the device is turned on, an audible signal consisting of several rising tones sounds. This tone sequence indicates that the sensor has been successfully activated.
- When the device is turned off, several descending tones are played to acoustically confirm that the device is shutting down.
- When establishing or disconnecting a Bluetooth (BLE) connection, the sensor also emits an audible signal confirming the connection status.
- There are also flashing codes described in the following table

11. FLAP OPENING DETECTION USING AN ACCELEROMETER AND TILT DETECTION

The Apollon sensor is equipped with an integrated 3-axis accelerometer of the type used for the reliable detection of changes in motion and position. One of the key functions of this sensor is the detection of the opening of flaps, lids, or housings, as typically found in industrial applications.

1. Position Detection in the Resting State:
    - When the flap is closed, the sensor is in a defined, stable position.
    - The LIS2DTW12 continuously measures acceleration along the X, Y, and Z axes.
    - The absolute position of the flap can be uniquely determined based on what is known as static acceleration (primarily caused by Earth's gravity).

2. Change in orientation or movement:
    - When the flap is opened or moved, the sensor's orientation in space changes.
    - The sensor detects this change through a significant deviation in the measured acceleration values on at least one axis.
    - This change is interpreted as a trigger event.
3. Threshold-based detection:
    - In the Apollon's firmware setup, a tilt angle or motion threshold can be defined (e.g., a change of 15, not in ultra-low-power mode)
    - As soon as the measured values exceed this threshold, a flap opening event is registered.

NOTE	
	Of course, the sensor can continue to operate very energy-efficiently by setting the angle measurement frequency to a correspondingly high value, e.g., 5 minutes. In this case, the measurement is negligible compared to the rest of the power consumption.

4. Optional: Interrupt-controlled operation:
    - The sensor supports low-power modes triggered by interrupts.
    - This means that the sensor remains in a power-saving state and only triggers an interrupt to the microcontroller when motion is detected—ideal for extending battery life.
    - **Disadvantage: The angle cannot be adjusted and is fixed at 65°**
5. Event processing and data transmission:
    - After an opening is detected, the event is logged in the internal memory.
    - Depending on the configuration, a data packet can be sent immediately via LoRaWAN, BLE, or another network protocol to report the event.

Advantages of this method

- No mechanical components required (compared to reed or magnetic switches)
- Insensitive to magnetic field interference
- Easy retrofitting or customization via software

12. COMMUNICATION WITH THE INTERFACE

Depending on the version, detailed information on configuring sensor communication and join behavior can be found in the respective generic LoRaWAN®, Mioty®, or Cellular (NB-IoT and LTE-M1) documentation.

Furthermore, all documents related to the generic documentation can be found at https://docs.sentinum.de/wichtig-produktübergreifende-dokumentation-für-sensoren.

12.1. LoRaWAN Join Behavior

Before telemetry data can be transmitted via LoRaWAN, the device must establish a connection to the network. To do this, the device sends join requests until a join accept is successfully received. As a compromise between power consumption and a quick join, the transmission intervals between join requests gradually increase. In addition, the data rate is varied (starting with a high data rate or low spread factor, then decreasing to a lower data rate or higher spread factor). The join behavior strictly adheres to the requirements and recommendations of the LoRa Alliance specification. Sentinum sensors implement these requirements using so-called join bursts, the intervals between which increase.

A join burst consists of a maximum of 6 join requests with a decreasing data rate (DR5–DR0) or an increasing spread factor (SF7–SF12). The intervals between requests increase quadratically to avoid violating the LoRa Alliance's specific duty cycle guidelines. The LoRa Alliance mandates a decreasing duty cycle for join requests according to the following table: Time Duty Cycle <1h 1% <11h 0.1%

This means that in the first phase (<1h), exactly as much transmission budget is available as in the second phase (<11h), even though only one-tenth of the time is available. To maximize the use of the budget, the intervals between join bursts (consisting of a maximum of 6 join requests) are initially short and then become longer. Specifically, 2 bursts are performed in Phase 1. In Phase 2, 2 additional bursts are performed; starting in Phase 3, 1 burst is performed per day. The duration of the bursts increases from approximately 10 minutes in Phase 1, to approximately 100 minutes in Phase 2, up to 16 hours in Phase 3.

12.2. MIOTY JOIN BEHAVIOR

Before telemetry data can be sent via mioty, the device must establish an initial communication link with the base station. An explicit join process, as required by LoRaWAN, is not necessary. Instead, the device immediately begins transmitting so-called telegrams, which consist of 512-bit data packets that are fragmented into up to 12 subpackets and distributed across different frequencies and time slots (telegram splitting). The first successful delivery of a telegram with a valid device ID is interpreted by the backend as network joining. The device's configuration (e.g., device ID, application key) is predefined and must match that of the backend.

If no confirmation is registered in the backend (e.g., due to missing reception timestamps or missing evaluation results), the device begins retrying the transmission. These retries occur in so-called mioty transmission cycles. The cycle duration increases progressively from an initial 5 minutes (after the

first attempt), through 30 minutes, up to 12 hours, in order to comply with duty cycle specifications (<1%) while simultaneously minimizing energy consumption.

The transmission frequencies (868.0–868.6 MHz in Europe) and channels are cyclically switched to avoid multiple collisions. The device does not actively change the data rate, as this is specified by the protocol (15.625 kbit/s for the uplink, optionally 4.882 kbit/s for the downlink). The telegrams are robust against interference, as only 3 out of 12 subpackets need to be received correctly upon reception (Forward Error Correction).

A complete transmission attempt consists of a telegram with 12 subpackets over a duration of approximately 1.2 seconds (including guard time). Upon successful registration, the device switches to a regular operating mode with fixed transmission intervals. If no reception occurs after several transmission cycles (typically 10–12), the device pauses for 24 hours before initiating a new initialization attempt.

12.3. CELLULAR JOIN BEHAVIOR (NB-IoT AND LTE-M1)

Before telemetry data can be transmitted via cellular (NB-IoT or LTE-M1), the device must perform the standardized network attachment procedure according to 3GPP (Release 13 and later). To do this, the device first scans the LTE frequency range (e.g., Band 8 or Band 20 for Europe) and searches for available cells. After successful synchronization (PSS/SSS) and decoding of the System Information Block (SIB), the device initiates the attach process. This process includes an RRC Connection Request, NAS Authentication, Security Setup, and the establishment of a PDP or PDU context (APN, IP address).

If the first attempt to join the network fails (e.g., due to no reception, rejected authentication, or no PDU context), a retry cycle begins. The retry cycles follow an exponential backoff: After the first failure, the next attempt occurs after approximately 15 seconds, then 60 seconds, 5 minutes, and so on up to 6 hours. The maximum number of join attempts per day is limited by the carrier, e.g., to 6 or 8 attempts. The cellular modems strictly adhere to the 3GPP and GSMA guidelines for network access control (Access Control Mechanism).

Both NB-IoT and LTE-M1 use Coverage Enhancement Levels (CE Levels 0–2) to ensure successful connection even in areas with poor reception. At CE Level 2, a message can be transmitted with up to 2,048 repetitions. Data rates vary significantly: NB-IoT typically operates at up to 250 kbit/s in the uplink and 26 kbps in the downlink, while LTE-M1 achieves uplink rates of up to 1 Mbit/s. The connection duration depends on the network status and, in the worst-case scenario (CE Level 2 + backoff), can last several hours.

To reduce energy consumption, cellular devices employ power-saving mechanisms after a successful join:

- PSM (Power Saving Mode): The device remains in power-saving sleep mode for several hours or days and does not re-register until the next scheduled transmission.

- eDRX (Extended Discontinuous Reception): The device checks for downlink messages only at specified intervals (e.g., every 20 minutes to 3 hours).

If no network is found, the device stops its search after 60 minutes at the latest and enters a deep sleep mode for several hours. Only then does a new network search and join cycle begin. This behavior has been optimized by the manufacturer and is based on recommendations from network operators as well as requirements for high energy efficiency in mass IoT deployment.

13. MAINTENANCE AND CLEANING

To ensure that the sensor functions reliably and has a long service life, it should be maintained regularly. Please observe the following instructions:

- Clean the housing, especially the sensor's ventilation slots, with a dry or slightly damp microfiber cloth. Make sure no moisture enters the device.
- Clean the sensor regularly, especially in dusty or pollen-rich environments, to ensure its long-term functionality.
- Do not use cleaning agents containing alcohol or solvents, as these can damage the sensor's surface.
- Do not use compressed air or other aggressive cleaning methods, as these can damage sensitive sensor components.
- Hard deposits (e.g., limescale, oil, or grease) can impair measurement accuracy. If necessary, clean them promptly with a soft, damp cloth and a mild cleaning agent.
- For optical or radar-based sensors, the lenses or antenna surfaces should be checked regularly for dirt or scratches.
- Regularly check that the sensor and its mounting are securely fastened.

14. BATTERY REPLACEMENT AND SIM CARD REPLACEMENT

NOTE	
	Please familiarize yourself with the general safety guidelines for the lithium batteries used. These can be found at docs.sentinum.de.

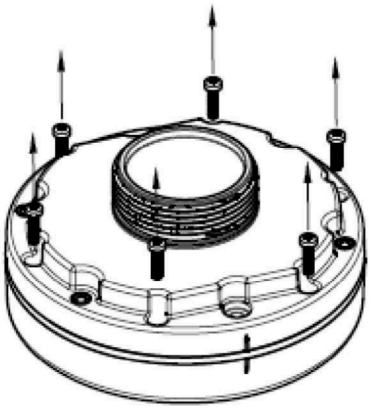
⚠ WARNING	
	Improper handling of lithium batteries (e.g., damage, incorrect charging, short circuits, or high temperatures) can lead to fire, explosion, or injury. Improper handling specifically includes mechanical damage, overcharging, deep discharge, short circuits, operation outside the specified temperature ranges, as well as misuse or disposal.

Communication Standard	Approved Batteries
LoRaWAN® and mioty®	• AA $LiSOCl_2$ cell, see SAFT LS14500 • Energizer® Ultimate Lithium Batteries - AA
S-EOS2C-XXX	• C LiSOCL2 spiral cell • C $LiMnO_2$ spiral cell, see SAFT LM26500

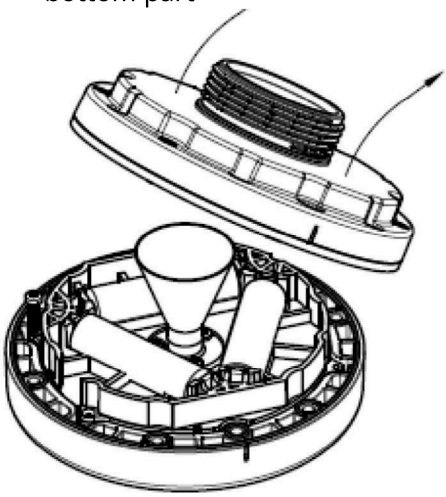
Parameters	Value
Torque	1.5 Nm maximum
SIM Card Format	Nano SIM 4FF

NOTE	
	Lithium batteries must **not be disposed of with household waste**. They contain valuable raw materials as well as potentially hazardous substances and are therefore subject to legal take-back obligations. Please dispose of used or defective batteries exclusively at appropriate collection points (e.g., recycling centers or retailers). Be sure to protect the battery from short circuits before disposal (e.g., by taping over the terminals). Damaged, swollen, or leaking batteries must be handled with special care and disposed of separately. Do not throw batteries into a fire, and avoid mechanical damage. Proper disposal helps protect the environment and public health.

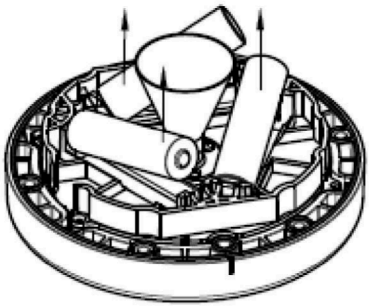
Step 1 - Remove the screws



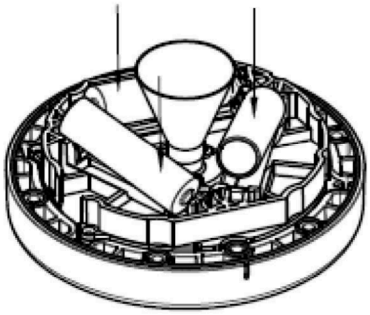
Step 2 - Remove the bottom part



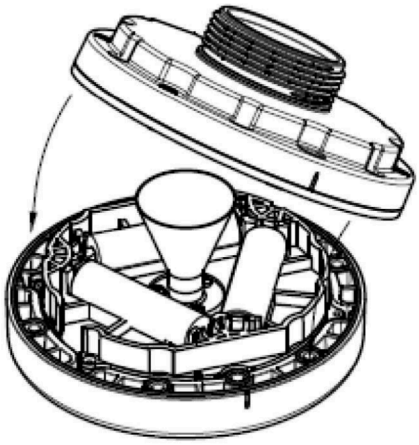
Step 3 - remove old batteries



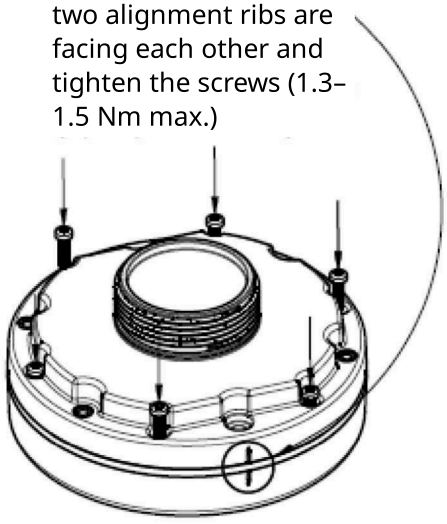
Step 4 - Reinsert new batteries



Step 5 - put the bottom part back on

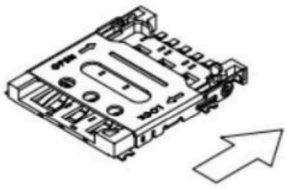


Step 6 - Make sure the two alignment ribs are facing each other and tighten the screws (1.3–1.5 Nm max.)

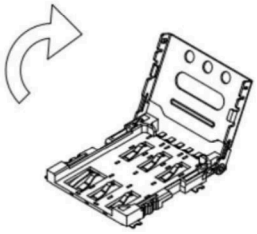


15. INSERTING SIM CARDS

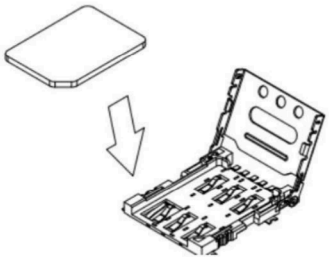
Applies to all S-EOS-NBM1-XXXX or S-EOS2C-NBM1-XXXX models.



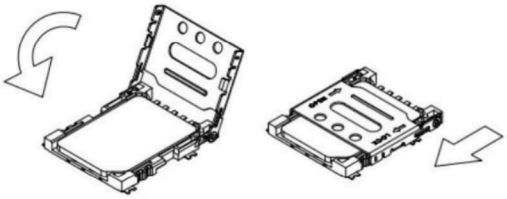
Unlock the metal cover by sliding it upward.



Open the cover to insert the nano SIM card.



Now place your SIM card in the designated holder.



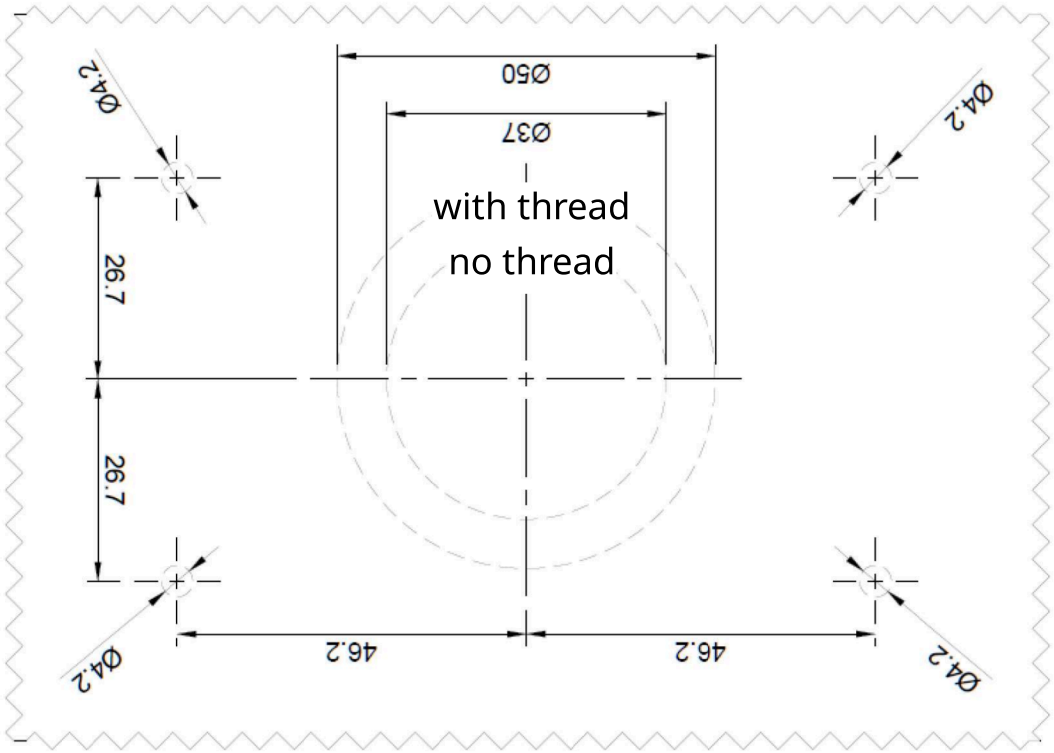
Close the compartment and lock it again by sliding the metal cover downward.

16. MARKING AND CERTIFICATION

Approval documents and certifications, as well as the CE EU Declaration of Conformity, can be found at https://docs.sentinum.de/sensoren-und-produktreihen.

17. DRILLING TEMPLATES FOR INSTALLATION

Sheet - DIN A4



Scale 1:1