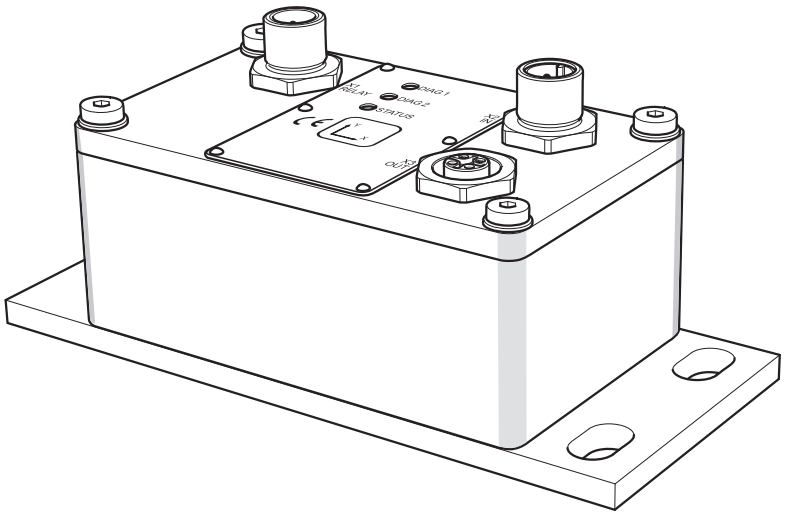
Tower oscillation monitor

for safety applications

Operating instructions



English

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1 General

1.1 About these Operating Instructions

These Operating Instructions are part of the product and describe how to use it safely.

- ▶ Please read the Operating Instructions carefully before you begin assembly.
- ▶ Keep the Operating Instructions for the entire service life of the product.
- ▶ Make sure that the Operating Instructions are available to personnel at all times.
- ▶ Pass the Operating Instructions on to each subsequent owner or user of the product.
- ▶ Insert all additions received from the manufacturer.
- ▶ To avoid property damage or malfunctions, read and observe the specifications provided in these Operating Instructions.

1.2 Validity

These Operating Instructions apply to the standard design of the product. This includes all types that are not marked with a **Y** behind the product number in the type code.

A product marked with Y is a customised design with a special assembly and/or modified technical specifications. Depending on the customised modification, additional or other documents may be valid.

1.3 Target group

These Operating Instructions are intended for electrical specialists and mechanics who are authorised to mount and electrically connect devices and systems, to put them into operation, and to label them under the terms of safety-related standards, as well as machinery operators and manufacturers.

1.4 Symbols used

- Notes on preventing malfunctions and damage
- Important information for understanding or optimising work processes
- ▶ Work step to be undertaken
- → Reference to another page in the document or to a separate document

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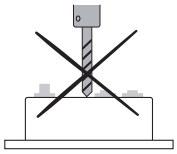
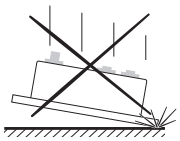
2 Safety

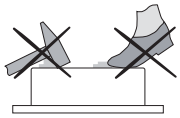
2.1 Safety instructions



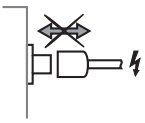
Do not drill holes in housing.



Do not bang or drop device.

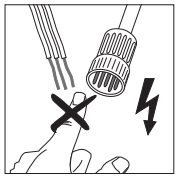


Do not hit or stand on the housing.

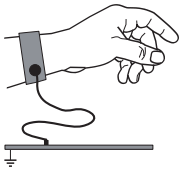


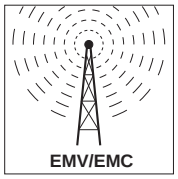
Only undo or make connections if electrically isolated. Ensure the supply voltage is free of interference due to contact bounce.

The tower oscillation monitor must always be **disconnected from the supply of electrical power** during installation and wiring.



Only touch connector pins and wires if you are suitably earthed (see EN 100015-1).





To improve the electromagnetic environment

- Use metallised connectors
- Connect screen to the connector
- Keep unscreened wires as short as possible
- Make short earth connections with a large cross-section
- Physically separate signal wires from power cables
- Lay equipotential bonding cables, if currents flow along the screens

It is imperative you comply with the technical data and the information on the connection conditions on the rating plate and in the related documentation.

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2.2 Designated use

The tower oscillation monitor OM is used to monitor oscillations and vibration on installations and machines. It measures acceleration values in X, Y and Z direction. If a fixed limit range in the X/Y direction (horizontal plane) is exceeded, a relay output is switched and a corresponding message output via the fieldbus.

The primary application area is wind turbines for monitoring the oscillations that occur on the tower. However, the device can also be used in other sectors of industry with comparable tasks as a so-called oscillation monitor. The operating altitude is limited to 4000 m.

The tower oscillation monitor is designed as a **safety component** as part of a safety circuit in SIL systems and has the Performance Level **PLd** as per EN ISO 13849.

2.3 Safety requirements on the customer system

The higher level control, regulation and safe ty system must meet a number of requirements so that the specified function can be ensured. These are:

1. Ambient and operating conditions
   The device must be transported, stored, installed and operated within the ambient and operating conditions defined in the Technical Data.
2. Regular self-test
   At least once in an interval of 12 months, the higher level (safety) control system must trigger the device self-test via the fieldbus or by interrupting the supply of power for at least 10 seconds. In this way it is also possible to detect relay faults that would not be apparent in normal operation.
3. Re-start protection
   If previously defined limits are exceeded or a fault is detected, the safety circuit is opened by the device. Provided the limits are not exceeded again during the inhibit time (customer-specific) or the fault state has been left, the safety circuit is automatically closed again by the device.

   It is the task of the higher level control system to ensure the plant is not started again in such a case without prior diagnostics on the cause of the triggering. (Forexample this feature can be realised using an RS flipflop.)
4. Operating parameters
   Depending on the type of installation, various operating parameters have been set in the factory: limits, filters, trigger characteristic, mounting position, mounting orientation. As the manufacturer is not familiar with the physical model, the control parameters or the safety concept for the related type of installation, it is the responsibility of the customer to determine the operating parameters such that safe operation of the installation and reliable shutdown in undesirable operating states is ensured.

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5. Monitoring the safety circuit

   The higher level safety control system must be able to detect an opened safety circuit within 500 ms and to place the installation in a safe operating state in this case.

2.4 Non-designated use

The operation of the tower oscillation monitor is not allowed in the following situations:

- In potentially explosive atmospheres
- In environments with caustic and/or electrically conductive acids, bases, oils, vapours or dusts
- In environments with requirements on the protection class higher than those defined for this device
- In the household area

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3 Product identification

3.1 Scope of supply

The product is supplied in a cardboard box with foam insert. Included are:

- Tower oscillation monitor
- Technical descriptions and device description file on CD-ROM

Accessories

- Relay output mating connector
- Fieldbus cables of varying lengths and fieldbus mating connector

3.2 Rating plate

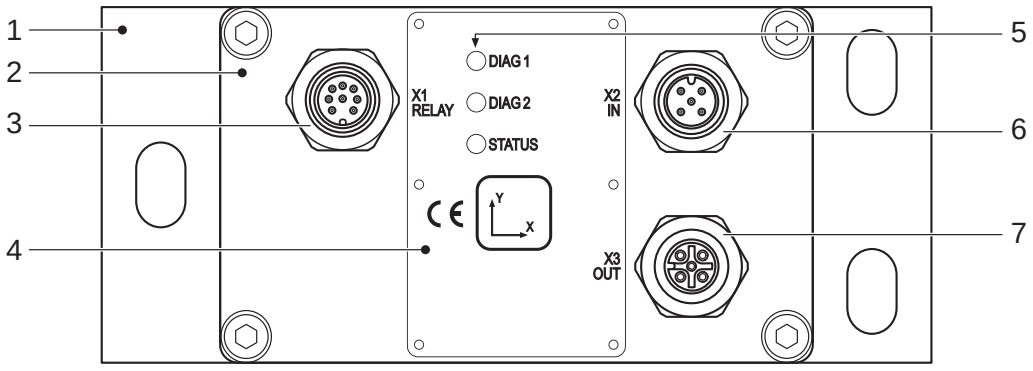
Type and serial number for the device are noted on the label plate on the front of the device (→ section 3.3.1 point 4).

A Y number after the product identifier – e. g. OM – identifies a customer specific version that may vary from the standard technical specification.
Then the additional documentation supplied has priority.

3.3 Parts named

3.3.1 Overview

The following view applies for the CANopen variant of the device.



1 Mounting plate
2 Tower oscillation monitor housing
3 Relay outputs connection (M12, 8 male)
4 Label and rating plate
Type: Type information as per order code (→ Technical information document)
Serial: Serial number, composed of (from the left) 2 places for the year of production (e.g. 14 ≙ 2014), 2 places for the week no. and 6 places with the current production number (uniquely assigned by production control)
5 LED displays for branch 1 (DIAG1) and branch 2 (DIAG2)
6 Bus connector M12, input (male); supply voltage feed
7 Bus connector M12, output (female)
If not used, seal using blanking plugs or bus terminating resistor.

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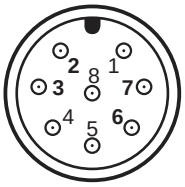
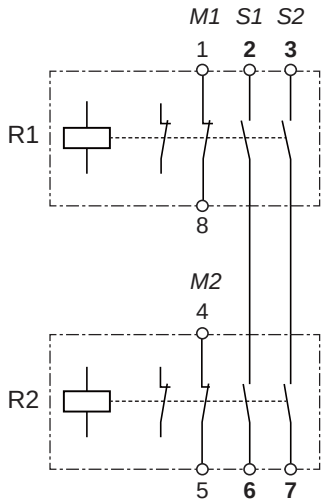
3.3.2 Connection elements

X1 – relay outputs





R1, R2 Relays (redundant)

M1, M2 Signalling contacts

S1, S2 Safety contacts (safety circuits 1 and 2)

X2/X3 – bus input/output

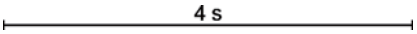
X2 IN
(male)

X3 OUT
(female)

1 Screen
2 Supply voltage $+U_B$
3 GND
4 CAN_H
5 CAN_L

3.3.3 Indicators

DIAG 1, DIAG 2 – switch states of relays R1 and R2 (1)



Limits exceeded, safety circuit open

Within the limits, but inhibit time active, safety circuit open

Normal operation, safety circuit closed

Hardware fault in the related branch, safety circuit open

Hardware fault in the redundant branch or communication error between the two branches, safety circuit open

STATUS – bus state

The function is dependent on the fieldbus interface: → related reference document.

(1) Representation on printing in black and white: ■ ≙ green, ■ ≙ red

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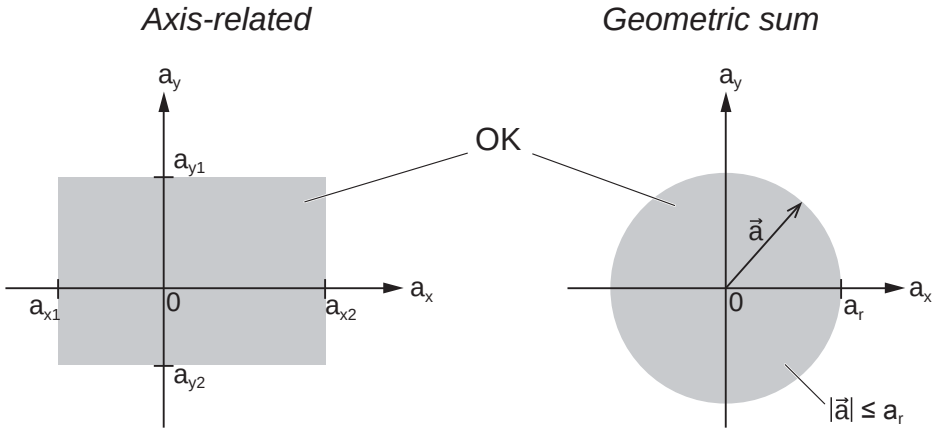
4 Function

The tower oscillation monitor measures the acceleration values on three axes (X, Y and Z direction) and signals if the factory-set limits are exceeded in the X/Y direction (horizontal plane) via a switched output (safety-related section). A trigger delay can be set in the factory (as standard 50 ms). The current acceleration values determined for all axes are output via a fieldbus interface (non-safety-related section).

The triggering behaviour corresponds to one of two possible criteria (pre-defined by the factory):
– axis-related acceleration values
– geometric sum of the acceleration values

The following illustration clarifies this issue.



a	Acceleration
a_{x1}, a_{x2}	Trigger values in negative and positive X direction
a_{y1}, a_{x2}	Trigger values in positive and negative Y direction
a_r	Trigger radius
Grey areas	No triggering

The acceleration values are pre-filtered using up to two digital signal filters and factory set parameters to remove undesirable frequency components. If the acceleration exceeds the limit – combined with the opening of the safety circuit – the restoration of normal operation is inhibited for a period of time also set in the factory (as standard 30 s), even if the acceleration then drops below the limit.

The architecture of the system is based on parallel redundancy with continuous monitoring.

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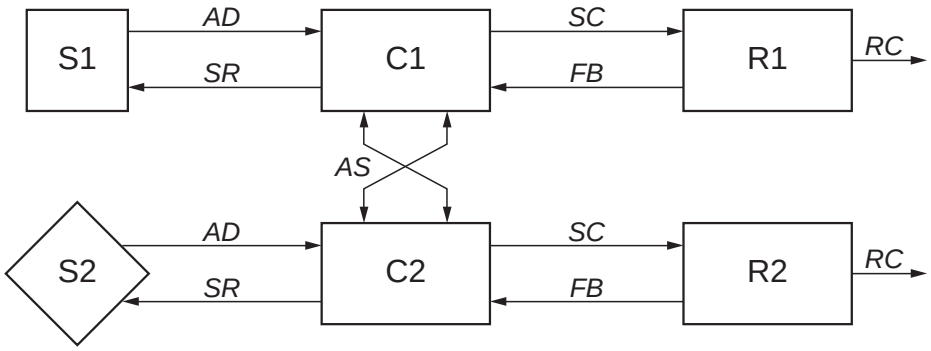
4.1 Safety-related section

4.1.1 Principle



S1 X/Y acceleration sensor
S2 Redundant X/Y acceleration sensor (rotated by 45°)
C1, C2 Filtering, evaluation, control
R1, R2 Relay
AD Acceleration data
SR Self-test request
AS Acceleration data comparison, state, mutual monitoring
SC Switching command
FB Feedback
RC Relay contacts: 2 normally open contacts (safety circuits), 1 normally closed contact (signalling circuit)

4.1.2 Configuration

The safety-related section is type approved. All function parameters are set in the device in the factory in accordance with customer requirements; it is not possible for the customer to change the settings.

General

Parameters	Standard	Setting
CANopen: LSS support	yes	
CANopen: Address {1 ... 126}	1	
Inhibit time after relay triggering	30 s	

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First filter

Parameters	Standard	Setting
Type {Default | Frequency-based low pass | Coefficient-based}	Default	
Default	Butterworth 2nd order, f_G = 10 Hz	
Frequency-based low pass • Cut-off frequency f_G (-3dB) • Characteristic {Bessel | Tschebycheff | Butterworth} • Filter order {1…6}	 10 Hz Butterworth 2	
Coefficient-based • Denominator • Numerator		

First trigger characteristic

Parameters	Standard	Setting
Type {Geometric sum | Axis-related}	Geometric sum	
Geometric sum • Mean value window • Trigger threshold	 0.005 s 2 ms^{-2}	
Axis-related • Trigger threshold X- • Trigger threshold X+ • Trigger threshold Y- • Trigger threshold Y+	 -2 ms^{-2} 2 ms^{-2} -2 ms^{-2} 2 ms^{-2}	
Trigger delay	50 ms	

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Second fillter

Parameters	Standard	Setting
Type {Default | Frequency-based low pass | Coefficient-based}	Default	
Default	Butterworth 2nd order, f_G = 10 Hz	
Frequency-based low pass • Cut-off frequency f_G (-3dB) • Characteristic {Bessel | Tschebycheff | Butterworth} • Filter order {1…6}	 10 Hz Butterworth 2	
Coefficient-based • Denominator • Numerator		

First trigger characteristic

Parameters	Standard	Setting
Type {Geometric sum | Axis-related}	Geometric sum	
Geometric sum • Mean value window • Trigger threshold	 0.005 s 2 ms^{-2}	
Axis-related • Trigger threshold X- • Trigger threshold X+ • Trigger threshold Y- • Trigger threshold Y+	 -2 ms^{-2} 2 ms^{-2} -2 ms^{-2} 2 ms^{-2}	
Trigger delay	50 ms	

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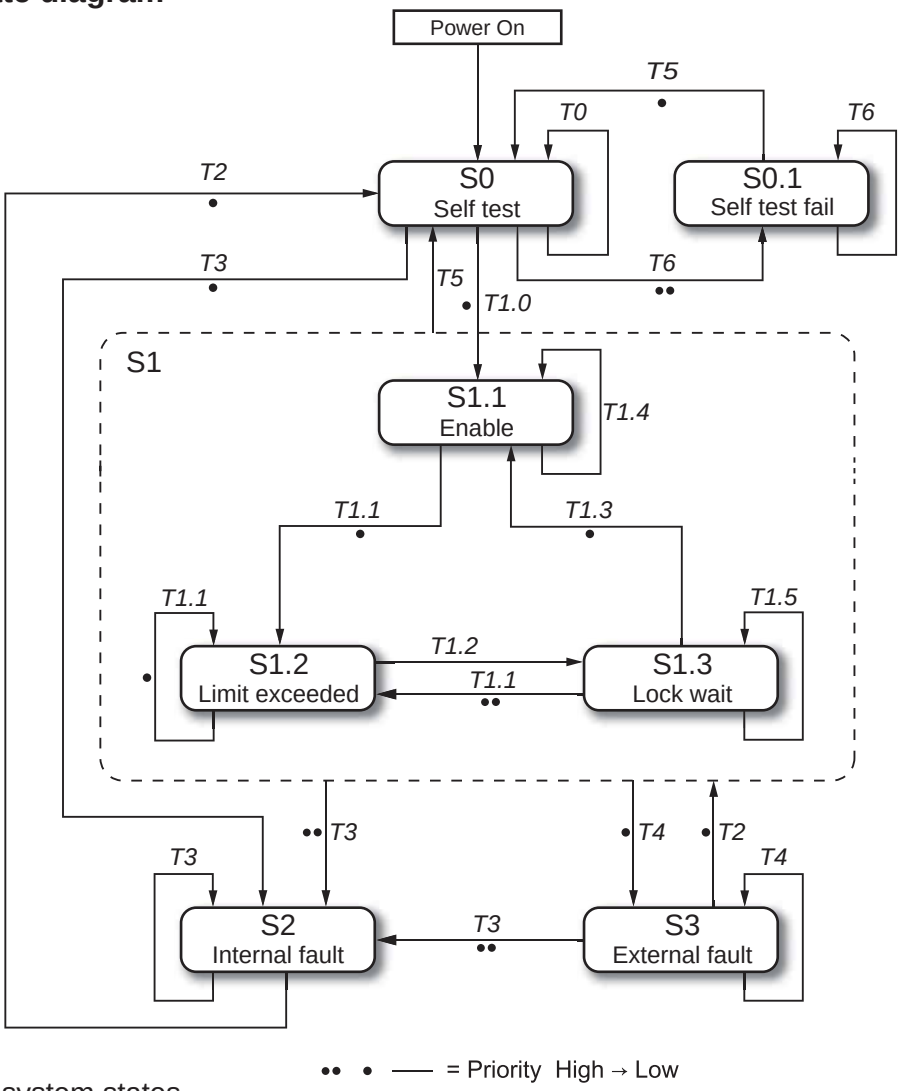
4.1.3 State diagram



S Control system states

C State transitions

State	Identifier	Explanation
S0	Self-test	Automatic self-test or self-test triggered via the fieldbus ⇒ Relay not energised
S0.1	Self-test fail	The fault is signalled via the fieldbus; the state remains active until a new self-test has been triggered via the fieldbus
S1	Operation	Normal operation: safe device state
S1.1	Enable	Acceleration values within the limits; monitoring active ⇒ Relay energised, DIAG LED: State 3
S1.2	Limit exceeded	At least one actual acceleration value is too high ⇒ Relay de-energised, DIAG LED: State 1
S1.3	Lock wait	Inhibit time active: Time since the last limit value was exceeded is less than the inhibit time (Customized preset (default: 30 s)) ⇒ Relay de-energised, DIAG LED: State 2

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State	Identifier	Explanation
S2	Internal fault	Self-tested hardware faulty ⇒ Relay de-energised, DIAG LED: State 4 (other DIAG LED: state 5)
S3	External fault	Externally controlled hardware faulty (redundant branch) ⇒ Relay de-energised, DIAG LED: State 5 (other DIAG LED: State 4)

Transition	Identifier	Condition/function
T0	Self-test	Self-test active
T1.0	Start operation	Self-test successfully completed
T1.1	Limit exceeded	Acceleration measured exceeds the limit for longer than the trigger delay set
T1.2	Limit no longer exceeded	Acceleration measured within the limits
T1.3	Inhibit time elapsed	Measured accelerations below the limits set for the duration of the inhibit time
T1.4	Enable	Normal operation: Measured acceleration within the limits
T1.5	Inhibit time active	Inhibit time not yet elapsed
T2	Operating time	Fault no longer present
T3, T4	Fault present	Sensor or relay fault occurred
T5	Self-test request	Self-test triggered via the fieldbus
T6	Self-test fault	Self-test fault occurred

4.2 Self-test

After switching on, a self-test is run automatically on the acceleration sensors and relays. Readiness is signalled via the DIAG LEDs and to the installation control system via the bus interface.

Continuous monitoring ensures the function of both acceleration sensors is tested in operation. In this way a defective sensor is reliably detected; the device then signals the failure of the sensor via the fieldbus and opens the safety circuit.

The self-test can be also triggered by the installation control system in accordance with the fieldbus protocol. During this process the acceleration sensors are subjected to a function test and each relay switched once, as a result the safety circuit is opened. The safety function is then re-started afterwards.

To ensure the safety circuit is not interrupted, two tower oscillation monitors must be connected in parallel; these sensors are then not allowed to be subjected to a self-test**simultaneously**. This is the only function from the non-safety-related section of the tower oscillation monitor (fieldbus communication) that affects the safety-related section.

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5 Handling

5.1 Transport

- Only transport the tower oscillation monitor in the manufacturer's original packaging, which is suitable for recycling (cardboard box with foam insert).
- Observe the storage temperature range specified.
- Avoid hard knocks.
- The tower oscillation monitor contains components that are susceptible to electrostatic and that could be damaged by incorrect handling. Pay attention to the information related to electrostatic discharge.
- If the packaging is damaged, check the device for visible damage. Inform the freight carrier and if necessary the manufacturer.

5.2 Storage

- Observe the temperature range specified.
- Only store the tower oscillation monitor in the manufacturer's original packaging, which is suitable for recycling.

5.3 Maintenance / cleaning

The tower oscillation monitor is maintenance-free in electrical terms.

Only have any repairs necessary undertaken by LENORD+BAUER or an authorised service centre.

If the tower oscillation monitor's housing is opened the warranty will be rendered void.

5.4 Disposal

- Dispose of the packaging material in accordance with the local regulations.
- The tower oscillation monitor contains electronic components. For this reason dispose of it in accordance with regional regulations for electrical and electronic devices.

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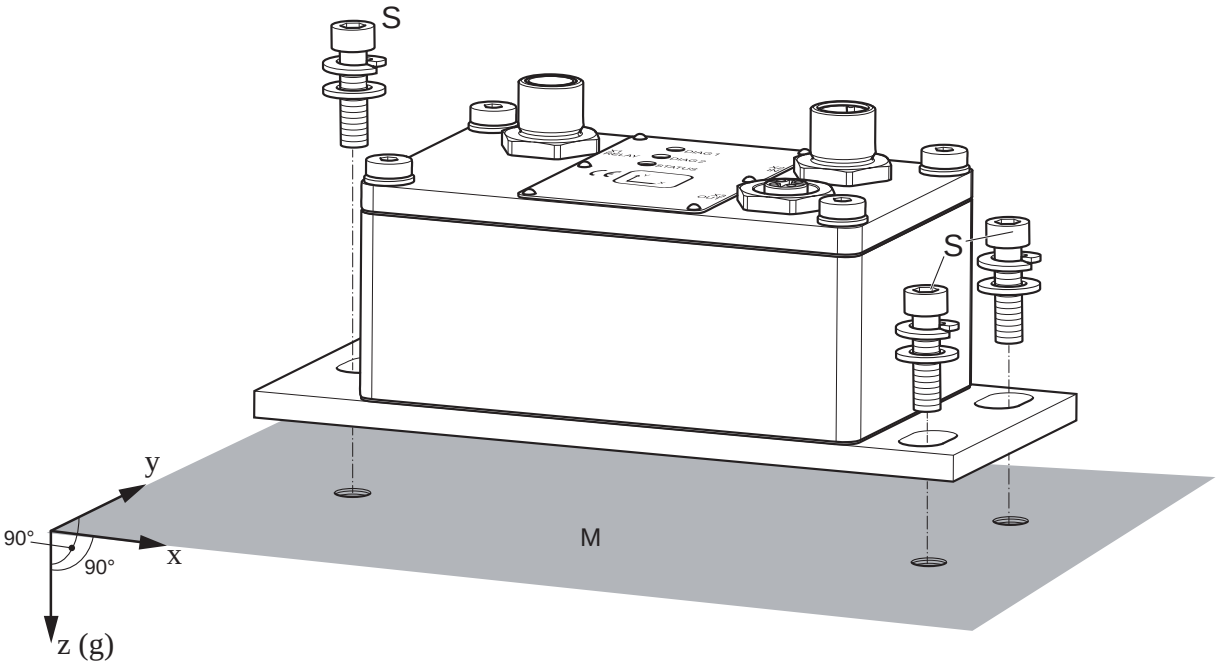
6 Assembly

- ▶ Only install and wire the tower oscillation monitor if it is **disconnected from the supply of electrical power**.
- ▶ On mounting the tower oscillation monitor ensure there is an electrically conductive connection with as large a surface area as possible between the mounting plate and the attachment surface.

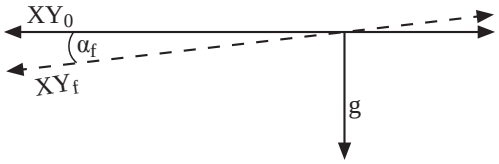


S Hexagon socket head cap screw M8×20 DIN 912 V2A with spring washer and washer (Lenord+Bauer order numbers VS 1221, VS 1228, VS 1219); tightening torque: 24 Nm

M Mounting surface, horizontal

g Acceleration due to gravity, vertical

Mounting error (measurement uncertainty)



XY_0 Correct horizontal mounting position

XY_f Incorrect mounting position

α_f Error angle

The sensor's offset error is dependent on the mounting error and is on average 0.17 m/s^2 per degree deviation from the horizontal in X and Y direction (α_f). At error angle e.g. α_f = 2° in the X direction there would be a measuring accuracy of 0.35 m/s^2.

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7 Technical data

7.1 Specifications

General	
Measuring axes	3 (X, Y, Z); X and Y monitored
Measuring range	± 15 ms^{-2} (approx. 1.5g)
Resolution	± 0.01 ms^{-2}
Accuracy (X, Y)	± 0.05 ms^{-2} at 25 °C ± 0.25 ms^{-2} at -40 °C to +85 °C
Temperature dependency	± 0.004 $ms^{-2}K^{-1}$
Safety level	PLd according to EN ISO 13849
Electrical data	
Operating voltage	24 VDC ± 10 %
Power consumption	Approx. 2.4 W
Scanning rate	5 ms
Digital interfaces	CANopen
Switched output	
Relay	2, each 2 NC and 2 NO, 24 VDC / 0.5 A, positively driven, floating, position in the de-energised state and in case of error: open
Release criteria (alternatively)	Axis related (X, Y) or geometric sum (radius)
Trigger limits in X direction (+/-)	Customized preset
Trigger limits in Y direction (+/-)	Customized preset
Trigger limit radial	Customized preset
Trigger delay	Customized preset (default: 0.05 s)
Inhibit time after relay triggering	Customized preset (default: 30 s)
Filter	1. Customized preset (default: Butterworth 2nd order low-pass filter, f_C = 10 Hz); 2. Optional additional filter with customized characteristics
Mechanical data	
Housing material	Aluminium
Weight	Approx. 625 g
Dimensions (W×D×H)	140 × 60 × 45 mm
Environmental conditions	
Assured operating temperature range	-40 °C to +85 °C
Storage temperature range	-40 °C to +85 °C

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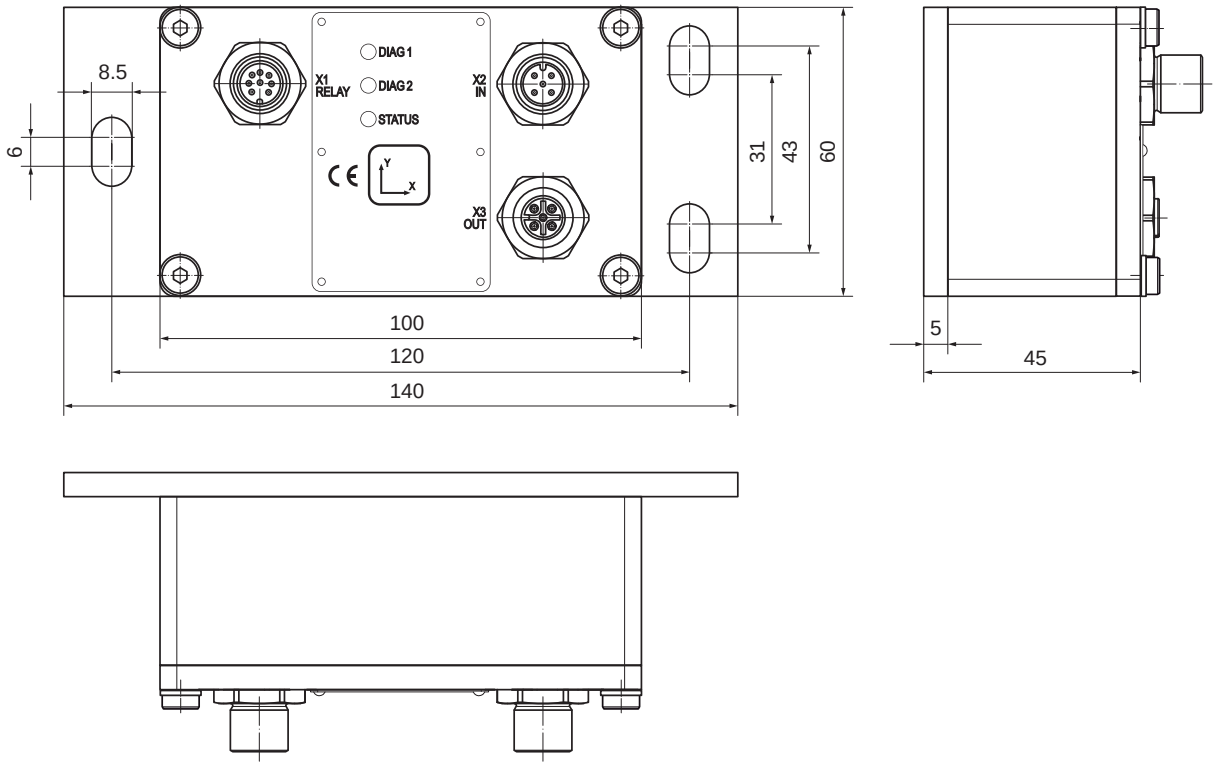
Environmental conditions	
Max. installation altitude	4000 m
Protection class in accordance with DIN 60529	IP 67
Vibration resistance (EN 60068-2-6)	100 ms^{-2} (approx. 10g), 10 to 100 Hz
Shock resistance (EN 60068-2-27)	1000 ms^{-2}, 11 ms (transport only)
EMC	EN 61000-6-1 to 4
Insulation strength	Ri > 1 MΩ, at a test voltage of 500 VAC
Max. relative humidity of air	99 % (annual average < 75 %)
Condensation permitted	Yes

7.2 **Dimensions** (in mm)



English

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