OPERATING INSTRUCTIONS

TPS
Driver assistance system

EN

SICK
Sensor Intelligence.

Contents

Contents

1 About these operating instructions

Please read through this chapter carefully before you use the documentation and work with the TPS driver assistance system.

1.1 Function of this document

These operating instructions are designed to give **technical personnel** instructions on the safe mounting, configuration, electrical installation, commissioning, operation and maintenance of the **T**ruck **P**rotection **S**ystem TPS.

These operating instructions do **not** provide information on operating the vehicle into which the TPS is or will be integrated. For information about this instruction, refer to the vehicle's operating instructions.

1.2 Target group

These operating instructions are intended for people who install, connect, commission, operate, and maintain TPS.

Activities	Target group
Mounting, electrical installation, maintenance, and replacement of system components	Qualified personnel, such as service technicians or industrial electricians
Commissioning and configuration	Qualified personnel, such as technicians or engineers
Operating the system	Personnel qualified in running and operating the system (truck operators)

Tab. 1 Target group

1.3 Information depth

Note

These operating instructions contain information about the TPS driver assistance system on the following topics:

- Product description
- Mounting
- Electrical installation
- Commissioning and configuration
- Operation
- Maintenance and repairs
- Fault diagnosis and troubleshooting
- Technical data and dimensioned drawings

When planning and using the TPS driver assistance system, technical skills are required that are not covered by this document.

The official and legal regulations for operating the TPS must always be complied with.

Further information about the device components used in the TPS can be found in the accompanying operating instructions.

1.4 Abbreviations used

TPS	Truck Protection System = driver assistance system for haul trucks
LD-MRS	Ladar Digital (Laser Radar) Multi-Layer Range Scanner = 3D LiDAR sensor from SICK AG
LMS	Laser measurement sensor = 2D LiDAR sensor from SICK AG
RDW	Road Departure Warning = functionality against unintended road departure

1.5 Symbols used

Recommendation Recommendations are designed to assist you in the decision-making process with respect to the use of a certain function or technical measure.

Note Notes provide information about the features of a device, application tips, or other information that may come in useful.

1. / 2. ... Instructions that must be carried out in the described order are referred to as step-by-step instructions and are indicated by numbered lists. Carefully read and follow the instructions for action.

➢ Instructions for taking action are indicated by an arrow. Carefully read and follow the instructions for action.

● ☼ , ○ LED symbols describe the status of a diagnostics LED. Examples:
- ● The LED is illuminated continuously.
- ☼ The LED is flashing.
- ○ The LED is off.

Display symbols show the status of the 7-segment display:
- UU Constant display of characters, e. g., U
- 8 Flashing display of characters, e. g., 8
- L ⇄ 2 Alternating display of characters, e. g., L and 2

2 Safety

This chapter concerns your own safety and the safety of the system operator.

➢ Please read this chapter carefully **before** you begin working with TPS.

2.1 Qualified safety personnel

The TPS must only be mounted, commissioned, and maintained by adequately qualified personnel.

A qualified person

- has sufficient skills in the field of the respective equipment based on their technical training and experience **and**
- has been instructed by the manufacturer in system operation and all applicable safety guidelines **and**
- is familiar with all relevant country-specific occupational safety regulations, work safety regulations, guidelines, and generally accepted technical rules and standards (e. g., DIN standards, VDE regulations, country-specific rules) to such an extent that he/she is able to evaluate the safe condition of the power-operated equipment **and** if he/she
- has access to and has read the operating instructions.

2.2 Applications of the system

TPS is a driver assistance system for haul trucks in surface mining. It consists of three LiDAR sensors, a control cabinet, GPS and an interactive operator display.

The system warns the operator of **possible collisions**, **entering hazardous areas** (black spots) and **departure of the road** (RDW).

During the operation of the truck, the TPS will constantly monitor the surrounding of the vehicle for obstacles. If an obstacle is detected in one or more of the configured warning zones, the zone violation is reported to the operator **visually** and **audibly**.

When the truck enters a pre-defined black spot like a hazardous intersection, the crusher or workshop area, the system indicates this by a **visual** and **audible** alarm as well.

In case the truck comes to close or too far away from the bund wall the road departure warning function alerts the operator with an **visually** and **acoustically** alarm.

Note **TPS only detects objects which are visible in the measurement plane for the LiDAR sensor. Therefore, the LiDAR sensor must have a free view of the area to be monitored.**

Using TPS means that hazardous situations, such as vehicles, equipment, infrastructure, unintentional road departure, hazard areas or dangerous queuing up situations are detected in good time and that accidents during operating are avoided.

NOTE

TPS is a **driver assistance system**. This means that at all times the driver bears the full responsibility for safe operation, in particular for people who are in the hazardous zones of the vehicle.

2.3 Intended use

TPS may only be used as described in section **2.2 Applications of the system**. It may only be used by qualified personnel in the environment in which it was mounted and initially commissioned by qualified safety personnel in accordance with these operating instructions.

NOTE

TPS is not a safety device for human protection and it therefore does not comply with any safety standards. For safety applications, please contact SICK AG.

In the event of any other usage or of modification to the system – including in the context of mounting and installation – any claims against SICK AG under the warranty will be rendered void.

2.4 General safety notes and protective measures

2.4.1 Safety notes and symbols

The following safety and hazard symbols are used for your own safety, for the safety of third parties, and for the safety of the machine. You must therefore observe these symbols at all times.

HAZARD

Denotes an immediate hazard that may result in severe to fatal injuries.

The symbol shown on the left-hand side of the note refers to the type of hazard in question (the example here shows a risk of injury resulting from electrical current).

WARNING

Denotes a potentially dangerous situation that may result in severe to fatal injuries.

The symbol shown on the left-hand side of the note refers to the type of hazard in question (the example here shows a risk of damage to the eye by laser beams).

CAUTION

Denotes a potentially dangerous situation that may result in minor personal injury or possible material damage.

NOTE

Denotes a potential risk of damage or functional impairment to the device or the devices connected to it.

This symbol includes a reference to supplementary technical documentation.

2.4.2 General safety notes

TPS has been designed in a way that allows for safe operation. However, a certain level of risk will always remain.

Awareness of potential sources of danger in the system will help you to work in a safer manner and thus prevent accidents.

To avoid risks, please also observe the special warnings in each of the individual chapters.

⚠ *WARNING*

Safety notes

Observe the following to ensure the safe use of the system as intended.

- The notes in these operating instructions must be complied with.
- All official and statutory regulations governing the operation of the system must be complied with.
- The national and international legal specifications apply to the installation and use of the system, to its commissioning, and to recurring technical inspections, in particular:
  - The accident prevention regulations and work safety regulations
  - Any other relevant safety regulations
- The checks must be carried out by qualified safety personnel or specially qualified and authorized personnel, and must be recorded and documented to ensure that the tests can be reconstructed and retraced at any time.
- These operating instructions must be made available to the operator of the system. The system operator must be instructed by qualified safety personnel and must read the operating instructions.
- The driver must follow relevant instructions and conduct inspections in order to ensure that the screens of all LiDAR sensors are clean and undamaged
- The LiDAR sensors must have a free field of vision. The sensor head must not be covered by other objects, for example.
- SICK AG recommends carrying out a system check before commissioning the system.

⚠ *WARNING*

Risk resulting from improper operation

Improper installation and commissioning, damaged components, and unsuitable ambient conditions such as excessively cold or warm temperatures and high levels of dust, fog or spray, may cause faults and faulty alarms and may result in a complete system crash.

WARNING

System does not comply with safety standards

TPS is not suitable for the protection of humans within the meaning of the applicable safety standards for machines. The system therefore does not comply with safety standards.

TPS is a driver assistance system. It provides the driver with visual and acoustic warnings about objects outside of the truck, hazardous areas and departure of the road. At all times the driver bears the full responsibility for safe operation, in particular for people who are in the hazardous zones of the truck.

WARNING

Location of use

The system is intended exclusively for use in industrial environments.

2.4.3 Potential sources of danger

Laser protection

WARNING

Damage to the eye by laser beams

The LD-MRS 3D LiDAR senor used by TPS conform to laser class 1 (eye-safe) as per EN/IEC 60825-1 (see laser warning label on the device for publication date), 21 CFR 1040.10 and 21 CFR 1040.11.

The LMS151 2D LiDAR sensor used by TPS corresponds to laser class 1 (eye safe) as per EN/IEC 60825-1 (see laser warning label on the device for publication date).
This complies with 21 CFR 1040.10 with the exception of the deviations as per Laser Notice No. 50, June, 2007.

The laser operates at a wavelength γ = approx. 905 nm (invisible infrared light). The laser beam is not visible to the human eye.

The radiation emitted in normal operation is harmless to human skin and eyes.

CAUTION Improper use (e.g., opening the housing and stopping the motor) can result in dangerous exposure to radiation.

➢ Never open the LiDAR sensor housing. Opening the housing does not interrupt the operation of the laser beam.

➢ Observe the laser safety regulations as per IEC 60 825-1 (latest version).

Important

- No maintenance is required to ensure compliance with laser class 1.
- The laser output apertures are the optics cover on the LMS151 and LD-MRS LiDAR sensors.
- The laser warning is located on the right side of the LiDAR sensor.

Electrical current

HAZARD

Risk of injury and damage caused by electrical current

Improper handling of live devices may lead to severe personal injury or death by electric shock.

- Electrical installation and maintenance work must always be carried out by personnel authorized to do so.
- The voltage supply must be disconnected when attaching and detaching electrical connections.
- Select and implement wire cross-sections and their correct fuse protection in accordance with the applicable standards.
- Do not touch any live components.
- In the event of danger, immediately disconnect the system from the voltage supply.
- Always use original fuses with the specified current rating.
- Report any damaged cables to the maintenance team without delay.
- Observe the current safety regulations when working on electrical systems.

Commissioning/Operation/Maintenance

WARNING

Risk resulting from incorrect commissioning and configuration

Do not commission without testing by qualified safety personnel!

Before you operate the system or a device for the first time, you must have it checked and approved by qualified safety personnel.

NOTE

Claims under the warranty rendered void

Do not open the device housing. The devices are sealed.

If the device is opened, any warranty claims against SICK AG will be void.

WARNING

Risk resulting from faults

Cease operation if the cause of the malfunction has not been clearly identified.

A defect in the system may result in fatal accidents or damage to the system.

- Take the TPS out of operation if you cannot clearly identify the fault and if you cannot safely remedy the problem.

2.5 Protection of the environment

The system has been designed to minimize its impact on the environment. It consumes very little power.

Always act in an environmentally responsible manner at work. For this reason, please note the following information regarding disposal.

2.5.1 Power consumption

Including its components, the system typically consumes 40 W.

The peak power consumption when starting up or in the event of integrated sensor heating is 150 W.

2.5.2 Disposal after final decommissioning

- Always dispose of unusable or irreparable devices in an environmentally safe manner in accordance with the relevant national waste disposal regulations.
- Dispose of all electronic assemblies as hazardous waste. The electronic assemblies are easy to dismantle.

Note SICK AG does not take back devices that are unusable or irreparable.

3 Product description

This chapter provides information on the special properties of the TPS driver assistance system. It describes the design and operating principle of the system.

Note Always read this chapter **before** you mount, install and commission the system.

3.1 Scope of delivery

TPS consists of an LMS151 2D LiDAR sensor and two LD-MRS 3D LiDAR sensors, an interactive operator display, a control cabinet, mounting kits with shock mounts and connecting cables, GPS receiver, as well as a tone buzzer. Light signals can be optionally used.

Fig. 1: Scope of delivery for TPS

Thorough check for completeness

Important note

- ➢ It is recommended that you carefully check for and report transport damage of any kind as soon as possible after receiving the system.
- ➢ Also verify that the delivery includes all components listed on the delivery note.

3.2 System components

3D LiDAR sensor LD-MRS HD Front and Rear

The 3D LiDAR sensor LD-MRS HD mounted on the front and rear of the truck constantly monitors the area in front resp. behind the truck, in a radius of up to 200 m (max. value of warning zone of front LiDAR sensor).

The object detection is done with laser beams that the LD-MRS emits in four stacked planes. The device measures the distance and the direction (the angle to the LD-MRS) of the object.

The aperture angle is 100° for the front and back sensor.

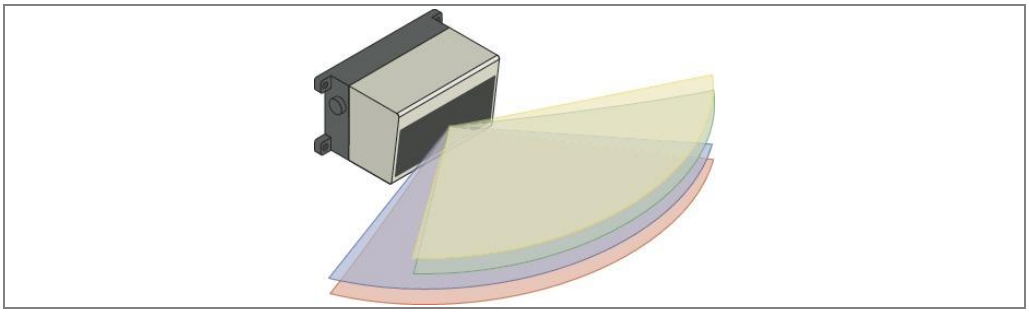


Fig. 2: Laser output aperture of the LD-MRS Front and Rear

2D LiDAR sensor LMS151 RDW

The 2D LiDAR sensor LMS151 RDW mounted on the front of the truck constantly monitors the area to the side of the truck.

The 2D LiDAR sensor scans its surroundings using a laser beam in a plane in the time-of-flight process. The maximum aperture angle is 180°. If the emitted laser beam is reflected by an object, the distance to the object is calculated.

Failure to install a suitable shock and vibration damper may result in a reduced system life cycle.

Fig. 3: Laser output aperture of the LMS151 RDW

The operator display

The interactive operator display is the central component of the system. It visualizes the outline of the truck and the warnings to the driver. Obstacles in the monitored area are identified, and therefore can be quickly localized.

The display has a touch screen (1), which allows the operator to make entries during initial commissioning and subsequent operation.

The operator display is attached to a mounting kit (2) with a swivel connector in the truck, within the operators's field of view.

Fig. 4: Operator display with mounting kit

Control cabinet

The control cabinet connects the LiDAR sensors with the operator display. It also process input signals and provides various output signals and power to the components.

Fig. 5: Control cabinet

To protect the control cabinet from shocks and vibration, damping measures must be installed. The control cabinet comes with shock absorber mounting brackets.

Tone buzzer

A tone buzzer supports the visual warning about an obstacle on the display with an acoustic warning.

Fig. 6: Tone buzzer

GPS receiver

A GPS receiver is used for ego localization in world coordinates, speed, heading and more information.

Fig. 7: GPS receiver

Mounting kits with shock mounts

The TPS comes with mounting brackets with build-in shock absorber for the LMS151 RDW and for both LD-MRS Rear and Front LiDAR sensors.

To protect the system components (sensors, control cabinet, operator display) from shocks and vibration, damping measures must be installed. SICK AG recommends using the included mounting kits with shock mounts that has built-in damper elements.

Note Failure to install a suitable shock and vibration damper may result in a reduced system life cycle.

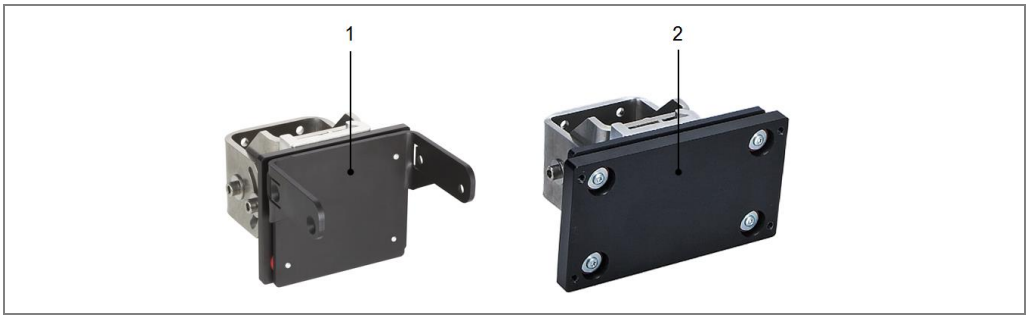


Fig. 8: Mounting kit for LMS151 RDW and LD-MRS Front and Rear

3.3 System functionality

The TPS is a driver assistance system for proximity detection and collision awareness for heavy mining trucks. The system warns the operator of possible collisions, entering hazardous areas (black spots) and departure of the road (RDW).

During the operation of the truck, the TPS will constantly monitor the surrounding of the vehicle for obstacles. If such an obstacle is detected in one or more of the configured warning zones, the zone violation is reported to the operator visually and audibly.

When the truck enters a predefined black spot like a hazardous intersection, the crusher or workshop area, the system indicates this by a visual and audible alarm as well.

In case the truck comes to close or too far away from the left bund wall the road departure warning function alerts the operator with an visually and acoustically alarm as well.

3.3.1 Front collision warning

The LD-MRS HD Front 3D LiDAR sensor monitors the area in front of the truck. It raises an alarm when an obstacle is violating one of the 3 warning zones (green, yellow, red).

The range of the frontal warning zones is adapted automatically to the current driving speed of the truck. Speed information is generated by the GPS receiver. In case GPS is currently not available TPS uses as fall back the so called “low speed warning zones”.

Fig. 9: Front collision warning

3.3.2 Rear End collision warning

The rear end collision warning supports the operator while he is driving in reverse gear with low speed like when parking, unloading and reversing to a shovel.

The area directly behind the truck is monitored by the rear sensor. The LD-MRS HD Rear 3D LiDAR sensor scans the area behind the wheels and watches for obstacles like walls, light or heavy vehicles or other mine site equipment that violate the light curtain by their height.

The rear surveillance is activated only while the truck is in reverse gear. The wheels are detected by the system and the measured points of the wheels are hidden.

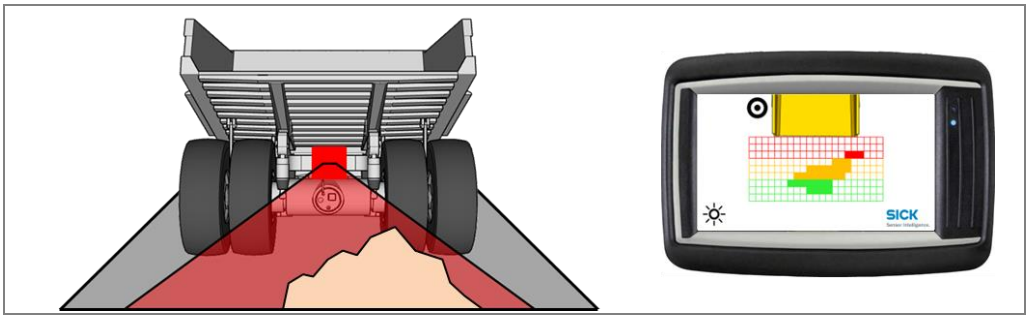


Fig. 10: Rear End collision warning

3.3.3 Road Departure Warning

The Road Departure Warning (RDW) function monitors the distance between the truck and the left roadside barrier, i.e. bund walls. If the truck violates the set safety distances to either side, a warning is issued to the driver. Broken bund wall or big rocks at the mine site are be filtered automatically by the system for a smooth operation. The road boarder is detected by the 2D LiDAR sensor LMS151 RDW.

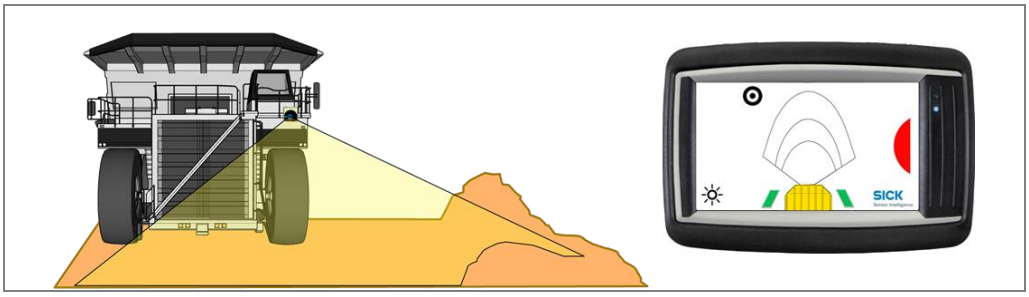


Fig. 11: Road Departure Warning Function with In-Lane Symbol

Note The 2D LiDAR sensor must identify the bund wall to activate this function. Two green blocks to the left and right of the truck on the display are indicating that the truck is in lane.

RDW Pause Signal

The system provides a pause signal input. The signal is muting the alarm unit for the following 30 seconds.

RDW Flash Lights (Optional)

Two relay outputs are provided on two 2-wire cables for connection to external RDW signal lights on the left and right front of the truck.

- If the truck is in lane, both RDW lights are illuminated continuously
- If the truck is moving unintentionally too close to the left bund wall, only the right light is illuminated. The left RDW light will not be illuminated anymore.
- In case of unintentional read departure to the right (center of the lane), only the left RDW light is illuminated. The right RDW light is not illuminated anymore. This informs truck drivers in the opposite direction that the truck is leaving the lane.

3.3.4 Black Spot Warning

TPS provides a function to mark mine site areas with GPS positions. Each GPS position defines a position in world coordinates with a circular area around it. This area is called “black spot” (1). This function can be used for two purposes:

- On mine site may be locations where the road departure warning system has no usable roadside barrier as a side reference. These locations may be crossroads, loading/unloading or construction areas. These areas may be marked by their positions, disabling the RDW function in their vicinity and thus suppressing false warnings.
- Also the position is used for “black spot” marking and identification. Black spots are hazardous areas like intersections, construction areas, crushers and workshops. TPS warns the operator when the truck is entering a black spot to raise operator’s attention.

If the black spot is activated for the area the truck is currently placed or driving, the GPS position is stored and a black spot with the radius of 80m (by default) is created and stored.

Inside black spot areas, the driver may also disable all acoustic warnings (2). Therefore, the speaker-icon is shown while the truck is inside the black spot area. Pressing this icon disables all sound output.

Note The sound output is automatically turned on again when leaving the black spot area. This function may be used to mute TPS while the truck is in maintenance in a workshop.

Note that for the correct function of black spots, GPS must be available.

Fig. 12: Black Spot Warning

3.4 Status indicators

2D LiDAR sensor

The 2D LiDAR sensor is fully automated in normal operation — no operator intervention is required. The LEDs (1) signal the operational status of the 2D LiDAR sensor. In addition, the 7-segment display (2) is also available for diagnostics when errors or faults occur (see chapter **9.2 Fault indicators of the LMS151**).

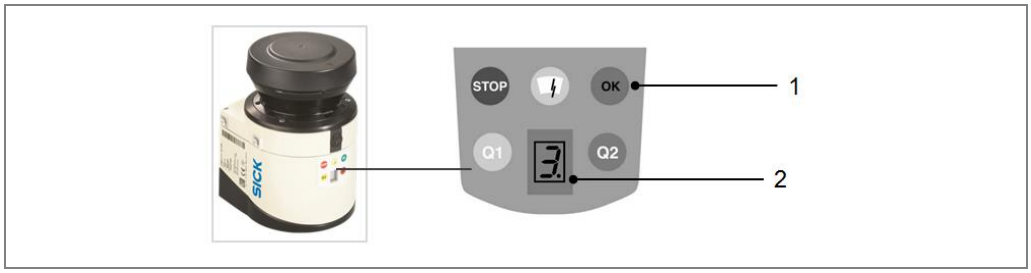


Fig. 13: Status indicators for the LMS511

Display	Meaning
OK	LMS151 measuring and no error reported
STOP	LMS151 is either not in measuring mode (stopped by the user) or it is running in measuring mode, but errors have occurred
	OFF: no contamination (optics cover) ON: contamination warning Blinking: contamination error
Q1	Not used
Q2	Not used

Tab. 2:Status indicators of the LMS151

Operator display

The operator display distinguishes between two operating modes. The system enters **configuration mode** when it is first started or following unlocking via the web interface. It contains assistants for the configuration of the LiDAR sensor, the vehicle dimensions and the supervisor setup.

In the **operating mode**, the display assists the operator with collision awareness, driver assistance and for setting black spot warnings.

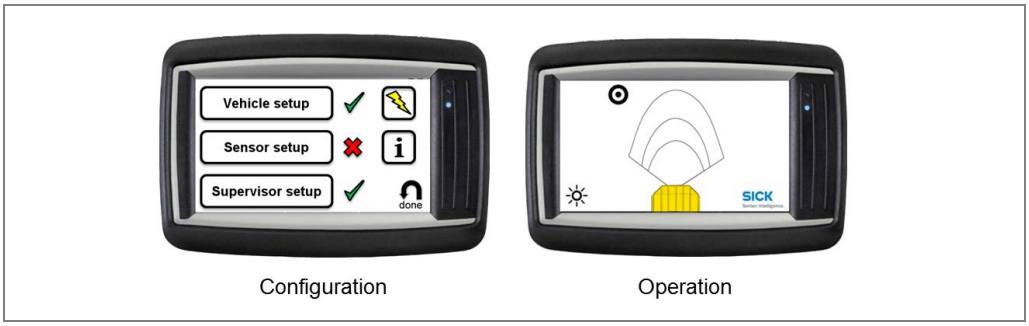


Fig. 14: The operator display in configuration and operating mode

Tone buzzer

The tone buzzer does not have any status indicators.

The DIP switch on the underneath of the housing can be used to set the tone selection (1) and the volume (2).

Recommended settings: OFF, ON, ON, OFF, ON (01101)

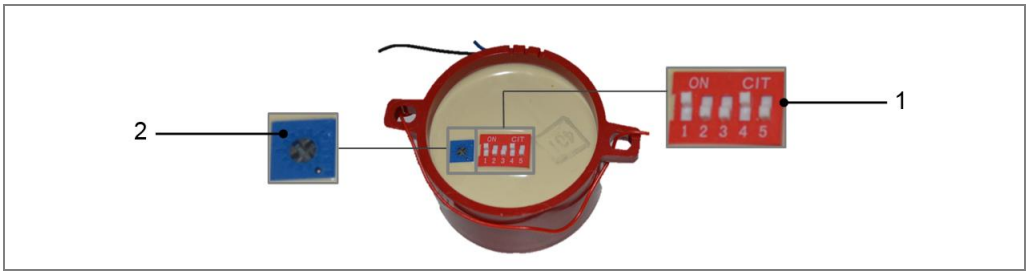


Fig. 15: DIP switch on the tone buzzer

Additional information on this can be found in the appendix in chapter **10.3 Tone selection for tone buzzer**.

4 Mounting

4.1 Function test before mounting

Before mounting the TPS components on the truck, it is recommended that the functional readiness of the devices should be checked.

1. Place the components on a table.
2. Connect the components according to the wiring diagram (see chapter **5.1 Wiring plan**).
3. Establish the supply voltage and check the general operational readiness of the components (see chapter **6.1 Launching the system**).

Important note It is recommended that the length of the cable should be checked in advance.

NOTE

The control cabinet is equipped with fuses both in the 24 V and ground voltage supply lines. If any of these fuses blow, disconnect from power immediately and check for the cause.

4.2 Mounting the LiDAR sensor

The reliable and problem-free operation of the system depends primarily on the proper mounting and alignment of the LiDAR sensor.

WARNING

Be sure to closely observe the following notes during mounting:

- Mount the LiDAR sensor so that it is protected from dirt and damage.
- Ensure that the field of vision of the entire optics cover is not restricted.
- Always mount the LiDAR sensors such that you are able to insert and remove the connectors.
- Avoid excessive shock and vibration loading on the LiDAR sensor.
- In the event of heavy vibration, prevent the fixing screws from accidentally coming loose using screw-locking devices.

The fine alignment is carried out later during the commissioning with the support of a setup assistant (see chapter **6.4 Configuring the LiDAR sensors**).

Note Make sure that the screws are easily accessible for fine alignment.

Mounting LD-MRS HD Front and Rear

Mounting is carried out using the supplied mounting kit with shock absorber (2) for the LD-MRS. For mounting the LD-MRS (1) safely at the mounting location, 4 M6 screws with washers and lock washers are required. The supply voltage of the LD-MRS must be switched off.

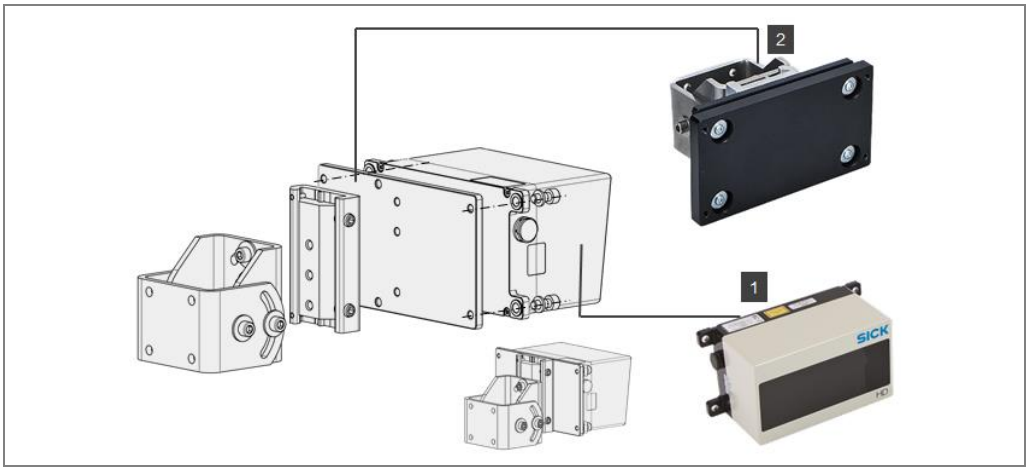


Fig. 16: Mounting the LD-MRS using mounting kit with shock absorber

Mounting LMS151 RDW

Mounting is carried out using the supplied mounting kit with shock absorber (2) for the LMS151 RDW. For mounting the LMS151 RDW (1) safely at the mounting location, 4 M5 screws with washers and lock washers are required. The supply voltage of the LMS151 RDW must be switched off.

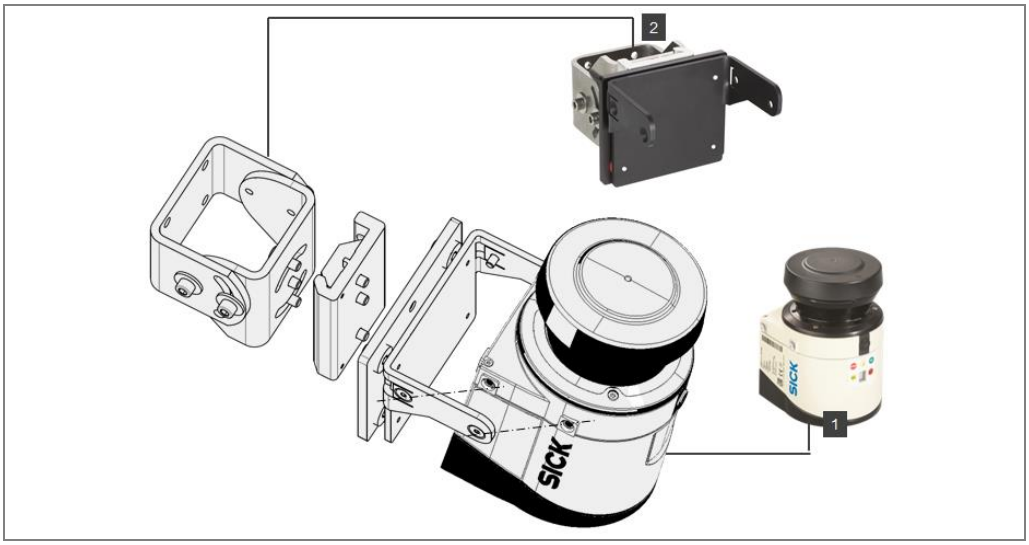


Fig. 17: Mounting the LMS151 RDW using mounting kit with shock absorber

Mounting LD-MRS HD Front to the vehicle

The frontal sensor must be mounted at the very front of the truck, with its area of view unobstructed in driving direction. The mounting height must be chosen so that relevant objects, such as pick-up trucks, are within the area of view.

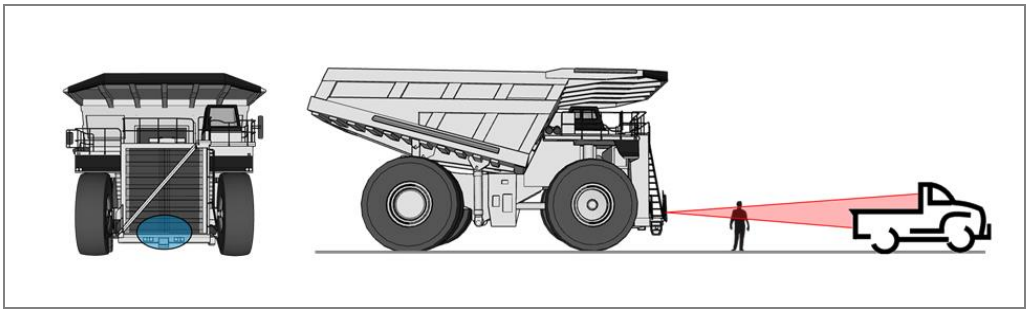


Fig. 18: Mounting position of the LD-MRS HD Front

For the best 3D LiDAR sensor coverage also of the very near proximity in front, the mounting position marked in blue should be considered.

Note Please avoid obstructions due to the ladder etc. Recommended mounting height is approx. 1.7 m. Additional protective measures for the scanner would be required for this mounting height (e.g. mud coverage etc.)

Mounting LD-MRS HD Rear to the vehicle

The rear collision protection system monitors the area directly behind the truck for obstacles. The 3D LiDAR sensor is typically mounted above the rear axle of the truck pointing downwards at an angle of about 45 degrees.

The scanner should be mounted close to the rear center of the truck.

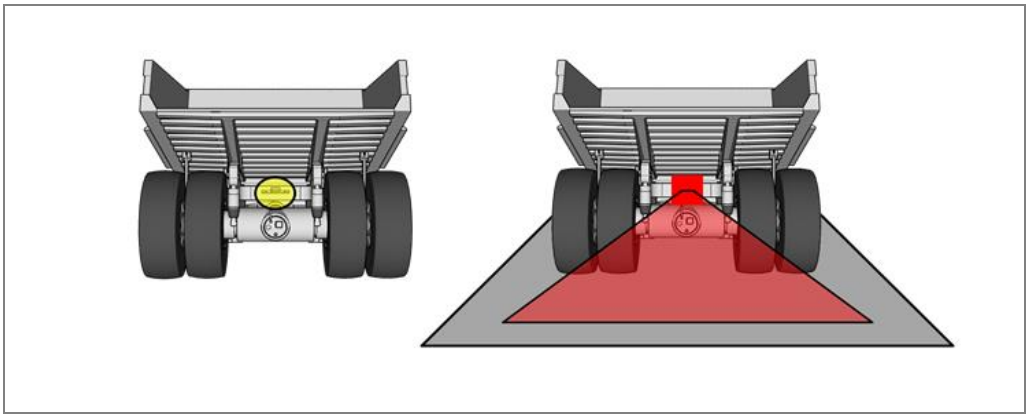


Fig. 19: Mounting position of the LD-MRS HD Rear

Note The exact angle is defined by its mounting height and will be adjusted during system setup. Please avoid unnecessary obstructions.

Mounting LMS151 RDW to the vehicle

The Road Departure Warning (RDW) LiDAR sensor must be mounted at the front of the truck, towards the left side. The sensor is mounted with a tilt angle of approximately 35 degrees downwards as its field of view must include the road surface in front of the truck as well as the left-side road barrier/ wall.

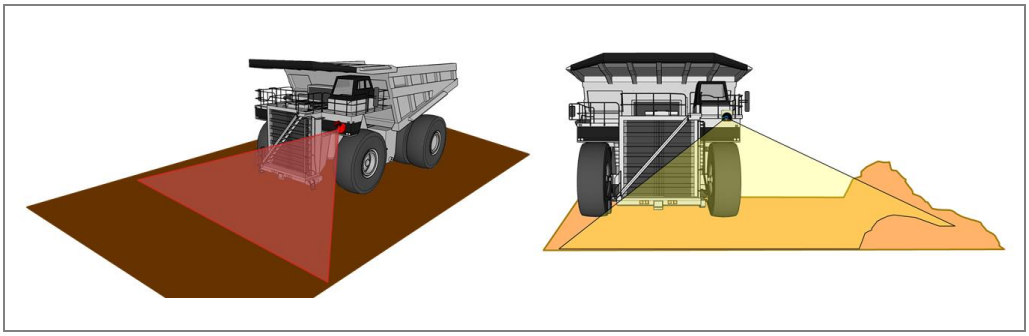


Fig. 20: Mounting position of the LMS151 RDW

Note The exact angle is defined by its mounting height and will be adjusted during system setup. Please avoid unnecessary obstructions.

4.3 Mounting the bracket for the operator display

The operator display is mounted in the truck cab. It must be clearly visible for the truck driver without them having to turn their head.

The operator display is mounted using the mounting kit included with delivery. This means that the display is additionally protected against mechanical shocks.

The mounting kit is made up of the bracket (1) and an adapter (2) to hold the operator display.

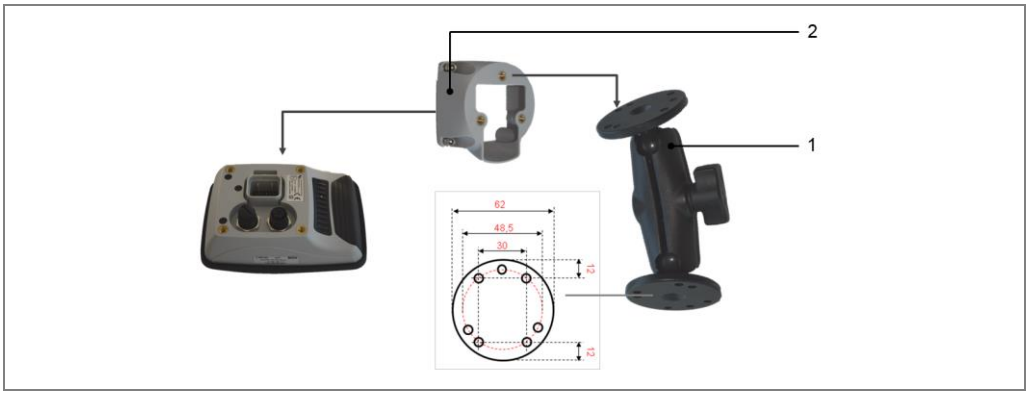
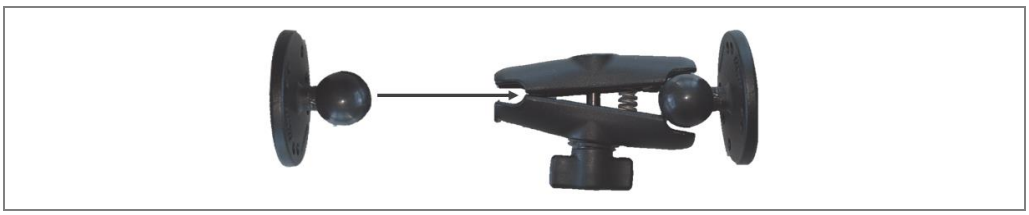


Fig. 21: Mounting the operator display

Assemble the bracket and mount in the driver's cab

1. Assemble the individual components of the bracket as shown in the figure.



2. Mount the bracket in the vehicle. In order to do this, screw the foot of the bracket tight in a suitable location in the truck cab.

Note The adapter and operator display are mounted during the electrical installation.
The connecting cables have to be inserted into the operator display in a later step. (see chapter **5.4 Connecting the operator display)**.

4.4 Mount the control cabinet

The control cabinet must be mounted in a dry and cool position in the inside of the truck e.g. inside the cabin behind the operator or passenger seat. It is not intended for outside mounting.

Note Before mounting the control cabinet, check that all components can be reached by the supplied cables.

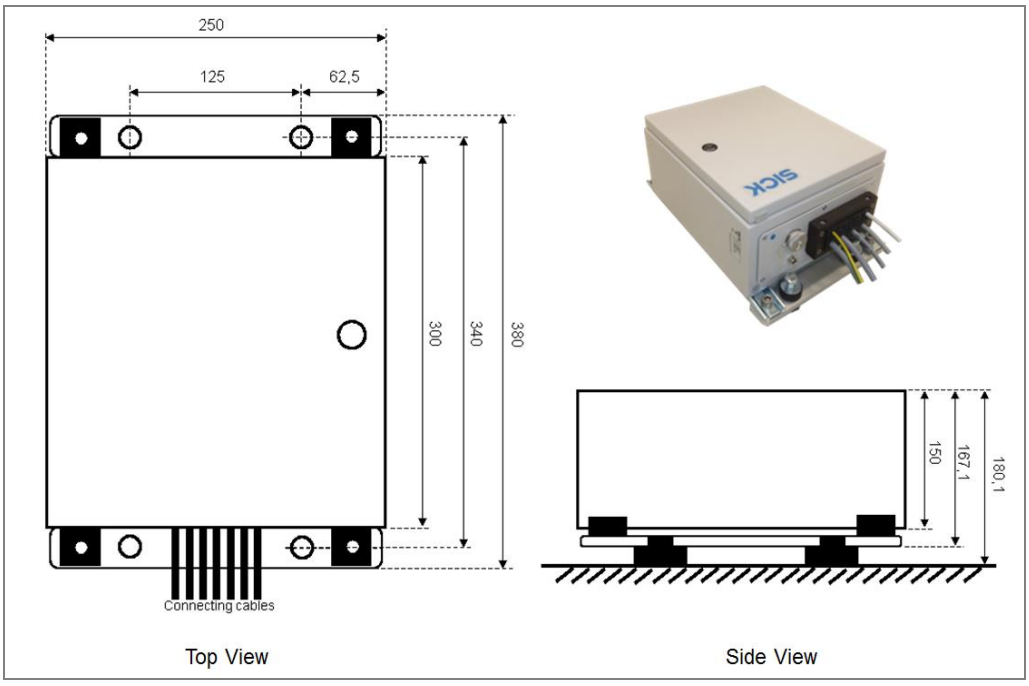


Fig. 22: Mounting the control cabinet

4.5 Mount the GPS receiver

The GPS receiver - with integrated antenna - must be mounted on the outside of the truck. It must be in possible best clear view of the sky, but protected from mechanical destruction like falling rocks. The recommended place is along the front railing of the truck.

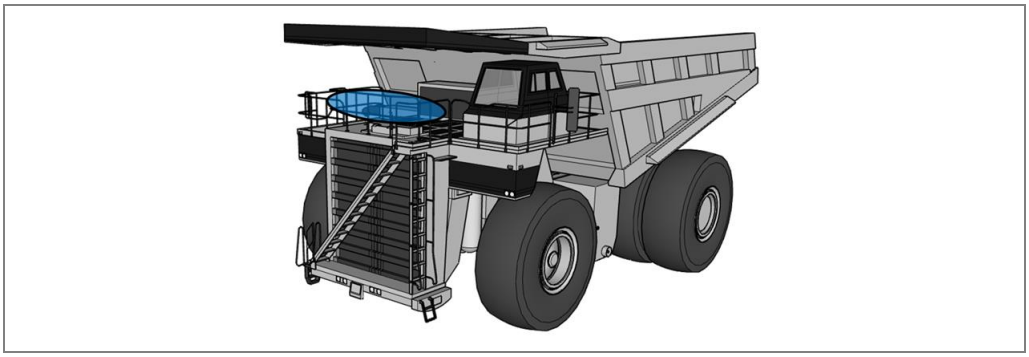


Fig. 23: Mounting the GPS receiver

4.6 Mounting the tone buzzer

Mount the tone buzzer in the operator cab behind the driver.

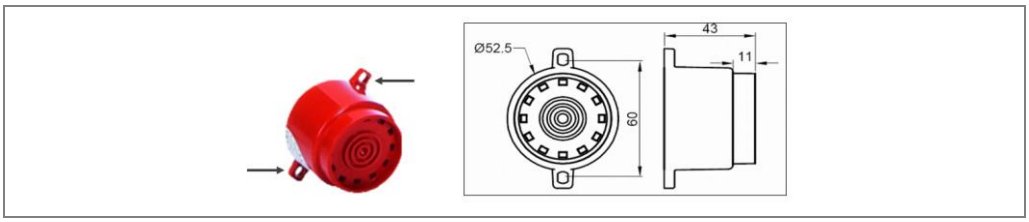


Fig. 24: Mounting the tone buzzer

5 Electrical installation

HAZARD

Disconnect the power to the system

- Make sure that all TPS components are disconnected from the voltage supply during electrical installation.

HAZARD

Risk of injury due to electrical current

- Standard safety requirements must be met when working on electrical systems.
- The voltage supply must be disconnected when attaching and detaching electrical connections.

5.1 Wiring plan

Establish the connections in accordance with the following wiring plan. Connect the components according the wiring connection overview inside the control cabinet.

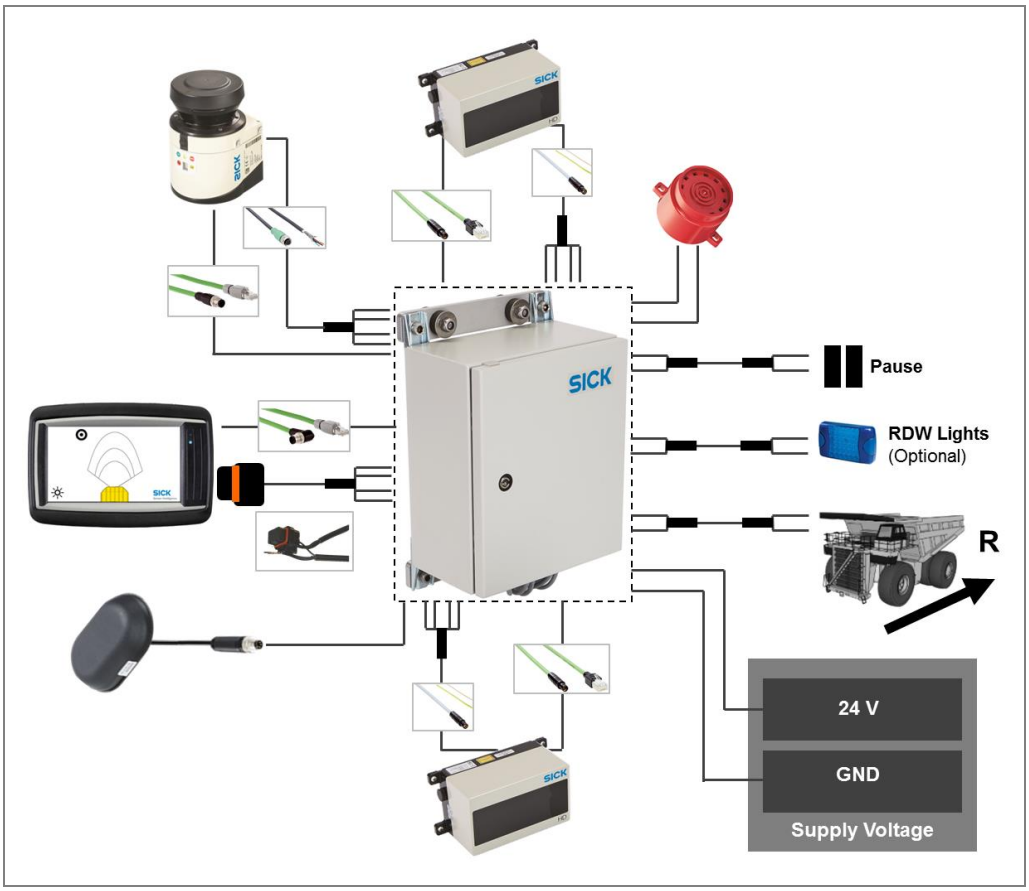
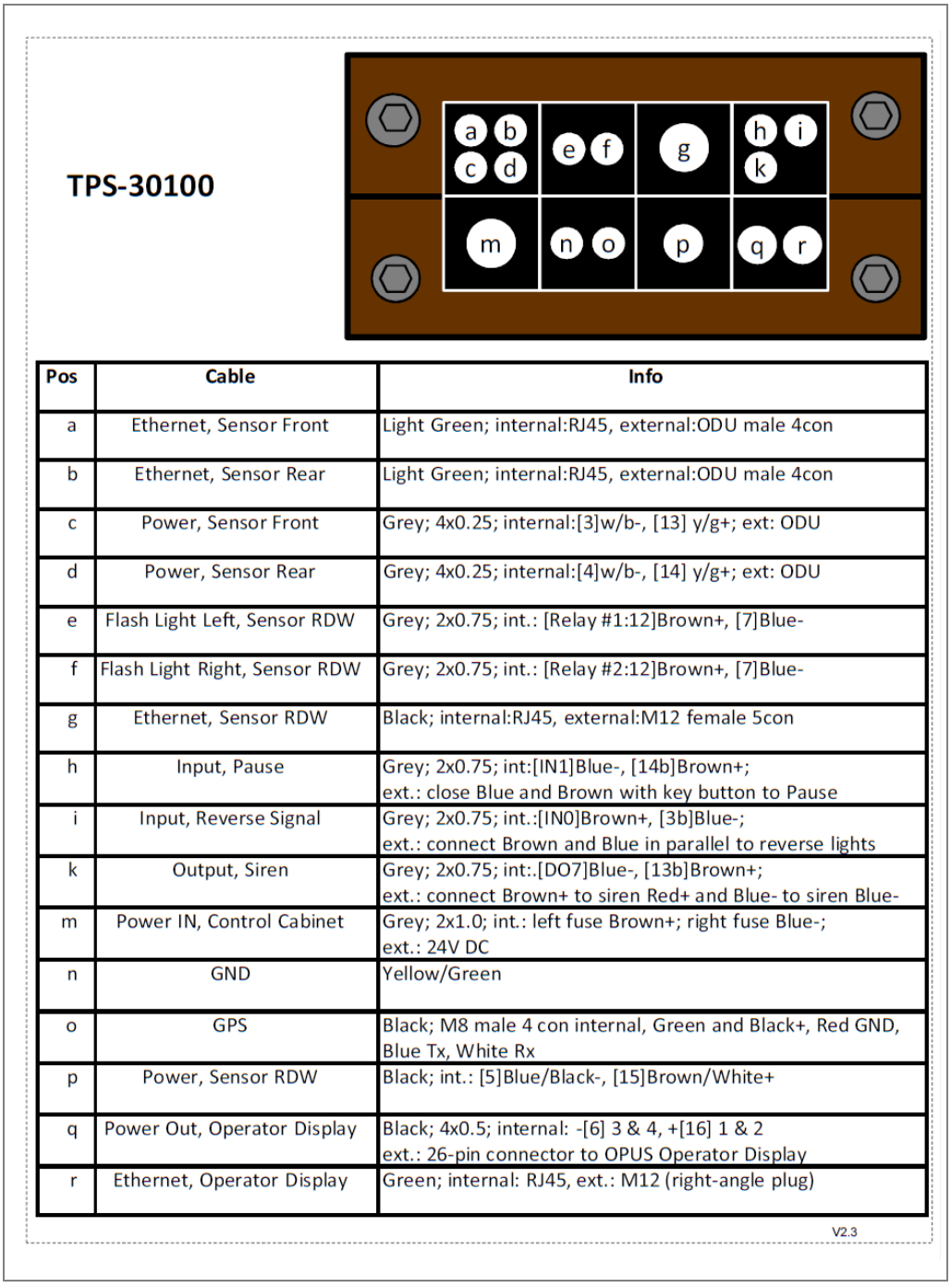


Fig. 25: TPS wiring plan



Pos	Cable	Info
a	Ethernet, Sensor Front	Light Green; internal:RJ45, external:ODU male 4con
b	Ethernet, Sensor Rear	Light Green; internal:RJ45, external:ODU male 4con
c	Power, Sensor Front	Grey; 4x0.25; internal:[3]w/b-, [13] y/g+; ext: ODU
d	Power, Sensor Rear	Grey; 4x0.25; internal:[4]w/b-, [14] y/g+; ext: ODU
e	Flash Light Left, Sensor RDW	Grey; 2x0.75; int.: [Relay #1:12]Brown+, [7]Blue-
f	Flash Light Right, Sensor RDW	Grey; 2x0.75; int.: [Relay #2:12]Brown+, [7]Blue-
g	Ethernet, Sensor RDW	Black; internal:RJ45, external:M12 female 5con
h	Input, Pause	Grey; 2x0.75; int:[IN1]Blue-, [14b]Brown+; ext.: close Blue and Brown with key button to Pause
i	Input, Reverse Signal	Grey; 2x0.75; int.:[IN0]Brown+, [3b]Blue-; ext.: connect Brown and Blue in parallel to reverse lights
k	Output, Siren	Grey; 2x0.75; int:.[DO7]Blue-, [13b]Brown+; ext.: connect Brown+ to siren Red+ and Blue- to siren Blue-
m	Power IN, Control Cabinet	Grey; 2x1.0; int.: left fuse Brown+; right fuse Blue-; ext.: 24V DC
n	GND	Yellow/Green
o	GPS	Black; M8 male 4 con internal, Green and Black+, Red GND, Blue Tx, White Rx
p	Power, Sensor RDW	Black; int.: [5]Blue/Black-, [15]Brown/White+
q	Power Out, Operator Display	Black; 4x0.5; internal: -[6] 3 & 4, +[16] 1 & 2 ext.: 26-pin connector to OPUS Operator Display
r	Ethernet, Operator Display	Green; internal: RJ45, ext.: M12 (right-angle plug)

V2.3

Fig. 26: TPS wiring connection overview (inside control cabinet)

5.2 Connecting the LD-MRS front and rear LiDAR sensor

The 3D LiDAR sensor LD-MRS Front and LD-MRS Rear mounted on the front resp. on the rear are connected to the control cabinet for power and the Ethernet connection.

The LD-MRS Front and Rear have the following connections:

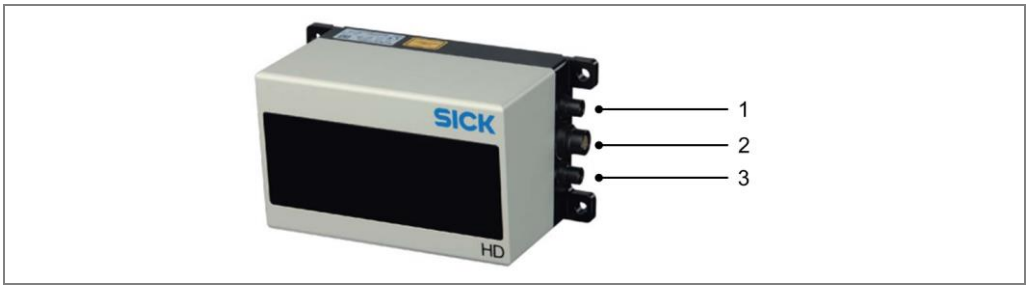


Fig. 27: LD-MRS connections

No.	Connection	Description
1	Ethernet	Ethernet connection to a control cabinet
2	Data interfaces/synchronization	Not assigned
3	Power	Connection to the control cabinet

Tab. 3:LD-MRS connections

Connection to voltage supply

The cable to connect the LD-MRS Front and Rear to the voltage supply has a round plug-in connector on one side. The other side has an open end.

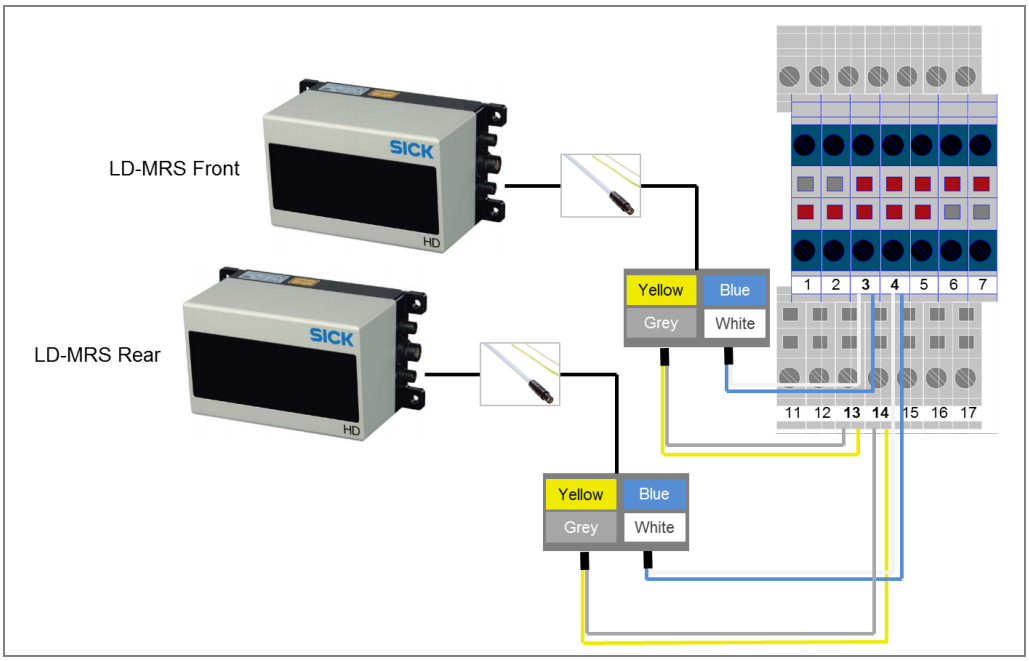


Fig. 28: Connecting the LD-MRS to the control cabinet

1. Connect the round plug-in connector the connecting cable on the LD-MRS to the **Power** female connector.
2. Run the connecting cable from the 3D LiDAR sensor to the control cabinet.
3. Connect the LD-MRS to the terminal block inside the control cabinet.

Place the wires in the control cabinet as follows.

Wire color	Connection Terminal Block		Voltage supply
	LD-MRS Front	LD-MRS Rear	
Yellow	13	14	+24 V (Voltage)
Gray	13	14	+24 V (Voltage)
White	3	4	0 V (Ground)
Blue	3	4	0 V (Ground)

Tab. 4: Connecting the LD-MRS Front and Rear to the voltage supply

Connection to Ethernet switch

Connect the 3D LiDAR sensor Front and Rear with the Ethernet switch inside the control cabinet. Use the connecting cable with the round plug-in and the RJ45 connector.

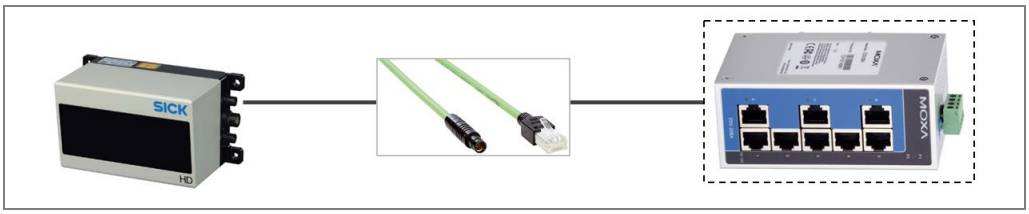


Fig. 29: Connecting the LMS511 to the Ethernet switch

1. Connect the round plug-in connector into the female Ethernet connector of the 3D LiDAR sensor.
2. Run the Ethernet cable from the 3D LiDAR sensor to the control cabinet.
3. Connect the RJ45 connector into a free port on the Ethernet switch.

5.3 Connecting the LMS151 RDW LiDAR sensor

The 2D LiDAR sensor LMS151 RDW mounted on the front for road departure warning is connected to the control cabinet for power and the Ethernet connection.

The LMS151 RDW has the following connections:

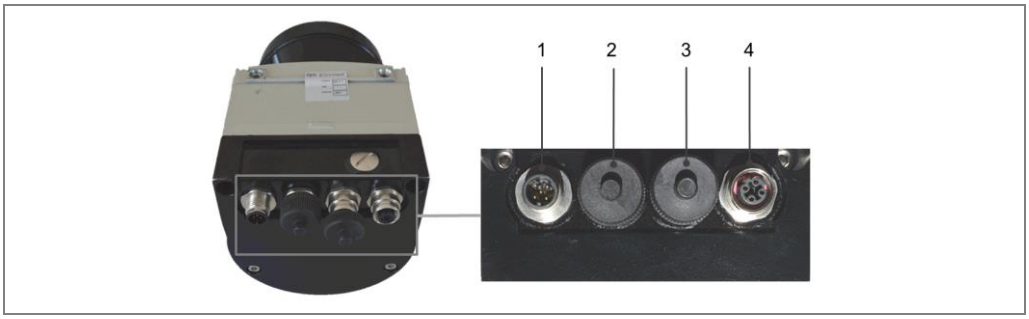


Fig. 30: LMS151 connections

No.	Connection	Description
1	Power	Connection to the voltage supply
2	Data	Not assigned
3	I/O	Not assigned
4	Ethernet	Connection to the network

Tab. 5:LMS151 connections

Connection to voltage supply

The cable to connect the LMS151 RDW to the voltage supply has an M12 plug connector on one side. The other side has an open end with a shield.

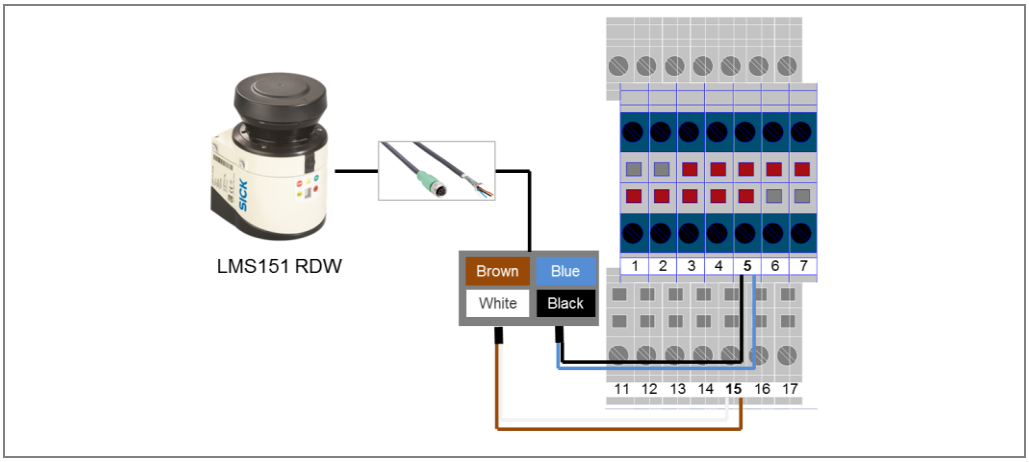


Fig. 31: Connecting the LD-MRS to the control cabinet

1. Screw the M12 round connector of the connecting cable on the LMS151 to the **Power** female connector.
2. Run the connecting cable from the 2D LiDAR sensor to the control cabinet.

Note It is recommended that cable shielding should be used for bundled and safe installation of the cables.

3. Connect the LD-MRS to the terminal block inside the control cabinet.

Place the wires in the control cabinet as follows.

Wire color	Connection Terminal Block	Voltage supply
Brown	15	+24 V (Voltage)
White	15	+24 V (Voltage)
Blue	5	0 V (Ground)
Black	5	0 V (Ground)

Tab. 6: Connecting the LMS151 RDW to the voltage supply

Connection to Ethernet switch

Connect the 2D LiDAR sensor RDW with the Ethernet switch inside the control cabinet. Use the connecting cable with the M12 plug connector and the RJ45 connector.

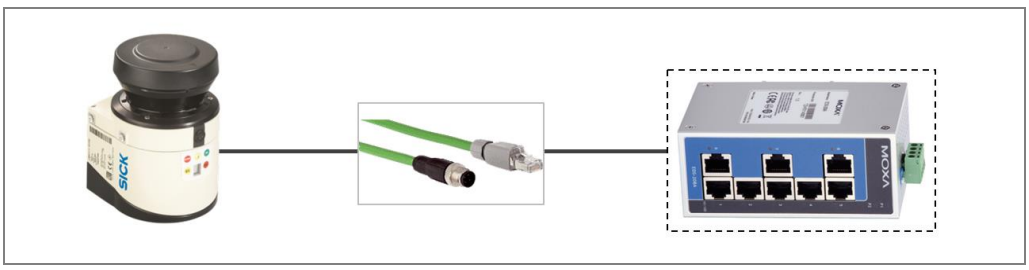


Fig. 32: Connecting the LMS511 to the Ethernet switch

1. Screw the M12 round connector into the female Ethernet connector of the 2D LiDAR sensor.
2. Run the Ethernet cable from the 2D LiDAR sensor to the control cabinet.
3. Connect the RJ45 connector into a free port on the Ethernet switch.

5.4 Connecting the operator display

The operator display mounted in the operator's cab is connected to the voltage supply and the Ethernet switch inside the control cabinet.

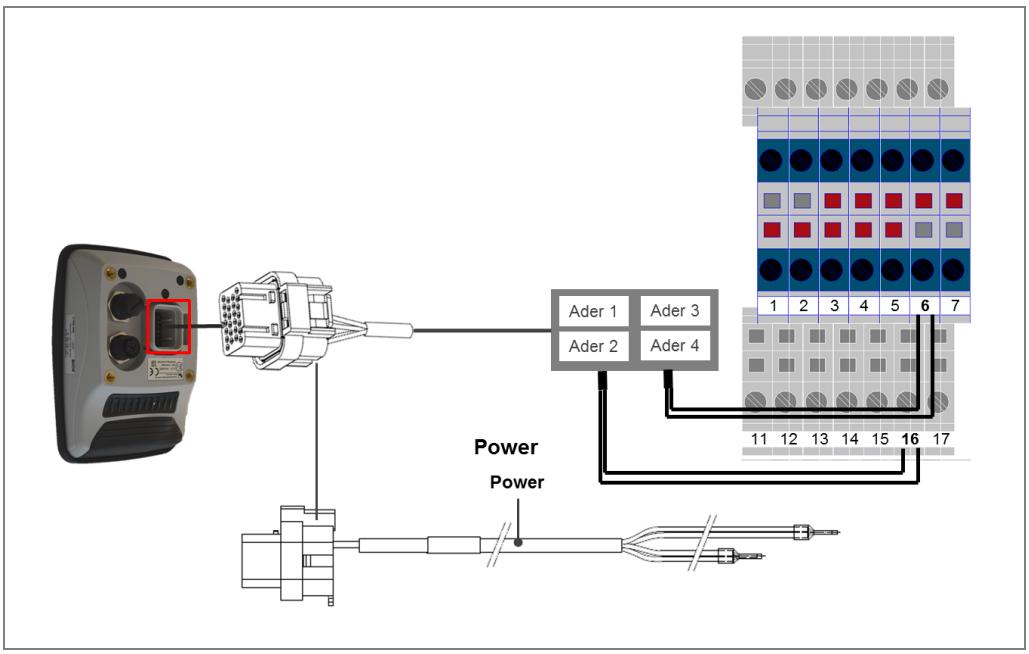
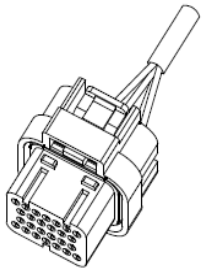


Fig. 33: Connecting the operator display

Pin assignment



Pin	Wire no.	Description
POWER		
1	1	24 V
2	2	24 V
3	3	GND
4	4	GND

Tab. 7: Operator display – pin allocation of the connecting cable

Ethernet connecting cable

The Ethernet cable for connecting the display and control cabinet has an angled M12 male connector (for connection on the display side) and a RJ45 connector (for connection on the control cabinet).

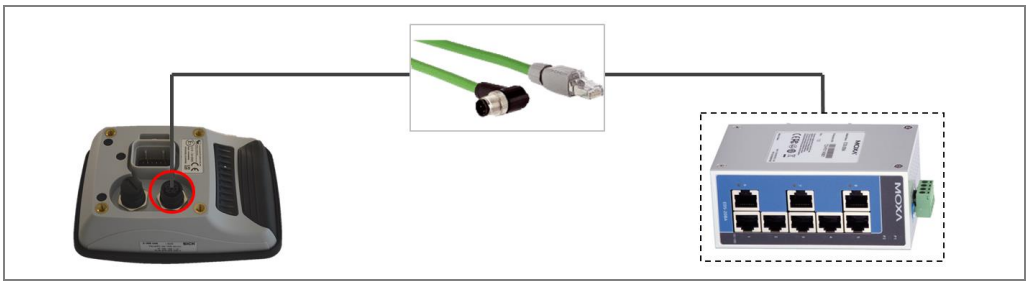


Fig. 34: Connecting the operator display to the control cabinet

Inserting cables on the operator display

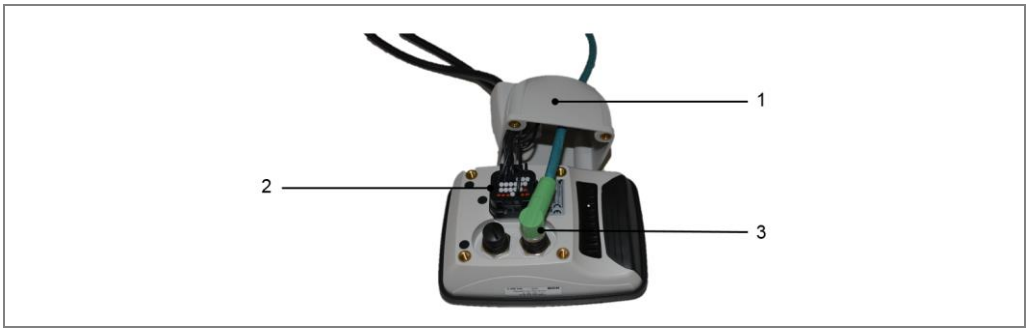


Fig. 35: Inserting connecting cables on the operator display

1. Run the two connectors through the opening of the adapter.
2. Connect the female connector of the connecting cable into the male connector of the operator display. Check that the plug connector is securely attached.
3. Insert the angled male connector of the connecting cable into the female connector of the operator display and screw together the plug connector.

Mounting the adapter

After the cabling, mount the adapter on the operator display.

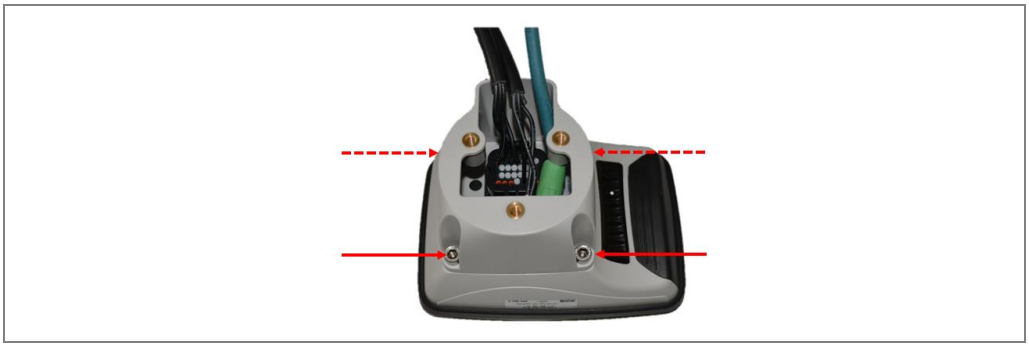


Fig. 36: Mounting the adapter on the operator display

1. Place the adapter on the reverse of the operator display.
2. Secure the adapter to the operator display using the four supplied screws.

Mounting the operator display on the bracket

Now mount the adapter with the operator display on the bracket.

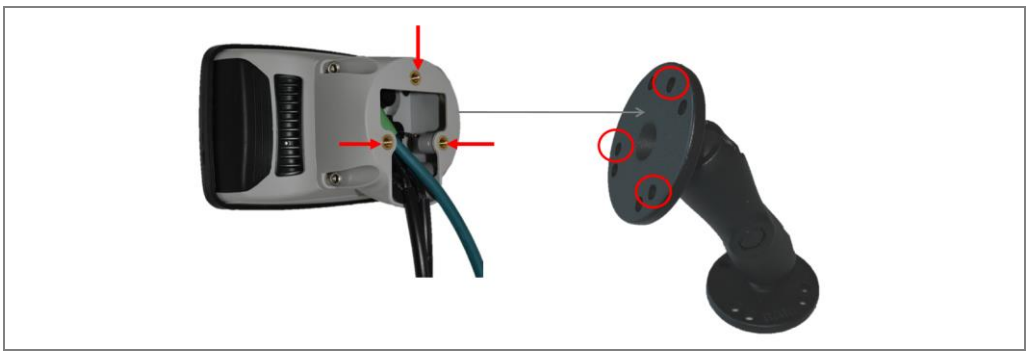


Fig. 37: Mounting the adapter with the operator display on the bracket

1. Turn the bracket for mounting the operator display into a suitable position.
2. Place the adapter on the support plate of the bracket
3. Secure the adapter using the three supplied screws.

Connection to voltage supply

1. Run the power cable from the display to the control cabinet.

Note It is recommended that cable shielding should be used for bundled and safe installation of the cables.

2. Connect the power cable to the voltage supply. Place the wires in the control cabinet as follows.

Wire no.	Connection Terminal Block	Voltage supply
1	16	+24 V (Voltage)
2	16	+24 V (Voltage)
3	6	0 V (Ground)
4	6	0 V (Ground)

Tab. 8: Connecting the operator display to the voltage supply

Connecting the Ethernet cable to the Ethernet switch

1. Run the Ethernet cable from the operator display to the Ethernet switch inside the control cabinet.

Note It is recommended that cable shielding should be used for bundled and safe installation of the cables.

2. Connect the RJ45 connector into a free port on the Ethernet switch.

5.5 Connecting the GPS receiver

The GPS receiver mounted on the outside of the truck is connected to the GPS M8 connector inside the control cabinet.

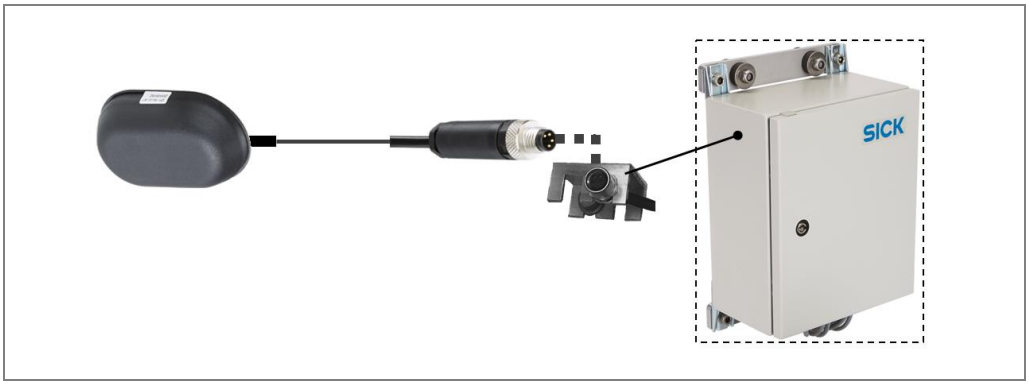


Fig. 38: Connecting the operator display

1. Run the GPS receiver cable from the GPS receiver to the control cabinet.
2. Screw the M8 round connector into the female M8 connector in the control cabinet.

5.6 Connecting the tone buzzer

The tone buzzer is connected to the output siren cable from the control cabinet.

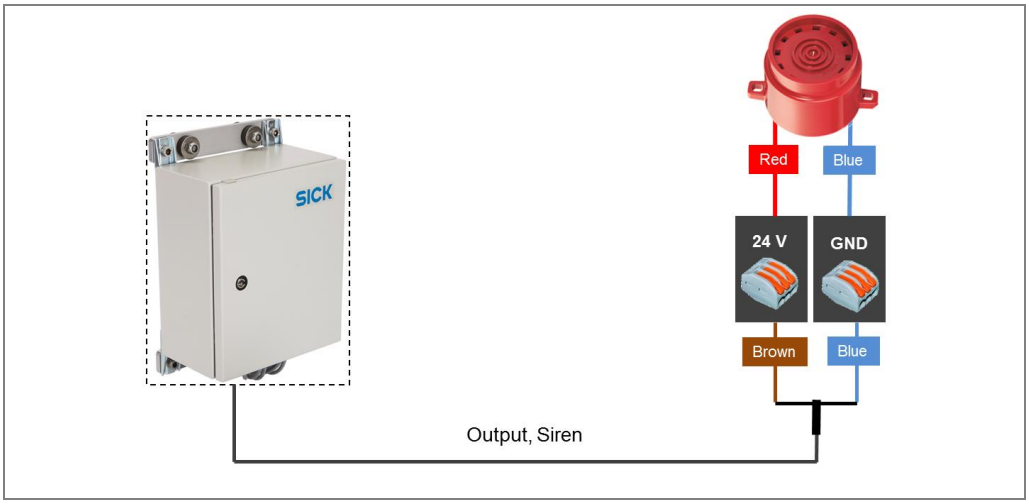


Fig. 39: Connecting the tone buzzer

For the connection, the tone buzzer is produced in the factory with three wires coming out of it:

- The connection to the **24 V** supply voltage is carried out via the **red** wire. The wire is extended using a conductor and run to the **brown** cable wire from the control cabinet.
- The **GND** connection is carried out via the **blue** wire. This is connected to the **blue** cable wire from the control cabinet.
- The black wire is not connected.

Accessories

The following accessories are required for connecting the tone buzzer:

- Cable stripping knife
- Wire stripper
- 2 connectors
- Flat-head screwdriver

5.7 Connecting the control cabinet

Connect the control cabinet to the truck voltage supply. The connecting cable (Power IN, Control cabinet) is connected to the control cabinet on one side. The other side has an open end.

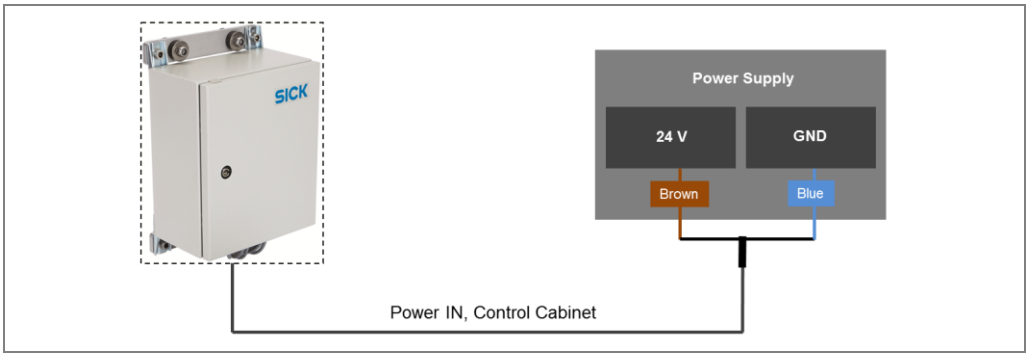


Fig. 40: Connecting the control cabinet to the voltage supply of the truck

1. Run the connecting cable from the control cabinet to the voltage supply of the truck.
2. Connect the control cabinet to the voltage supply.

Place the wires to the voltage supply as follows.

Wire color	Connection	Voltage supply
Brown	Voltage	+24 V
Blue	Ground	0 V

Tab. 9: Connecting the control cabinet to the voltage supply

5.8 Connecting the reverse signal (optional)

Connect the control cabinet to the truck reverse gear signal. The connecting cable (Input, Reverse signal) is connected to the control cabinet on one side. The other side has an open end.

To activate the input signal, apply 24 V to this signal, ground reference is the GND of the control cabinet voltage supply. Leave the signal input open to deactivate the signal.

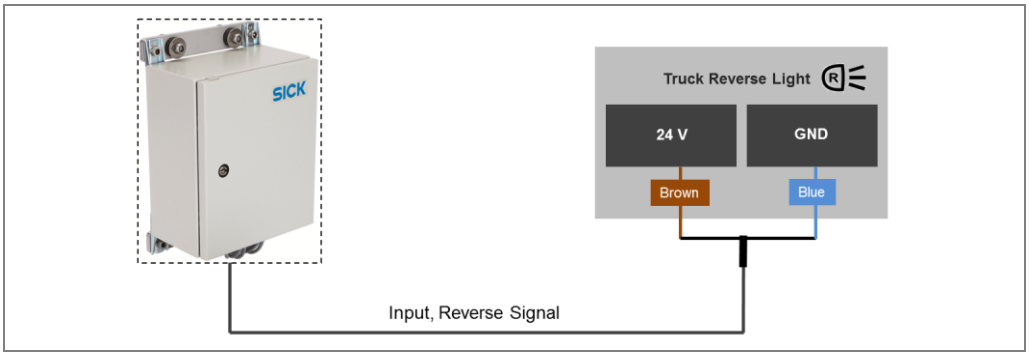


Fig. 41: Connecting the control cabinet to the voltage supply of the truck

1. Run the connecting cable from the control cabinet to the reverse light cable of the truck.
2. Connect the control cabinet to the reverse light or reverse gear of the truck in parallel.

Place the wires to the voltage supply as follows.

Wire color	Connection	Voltage supply
Brown	Voltage	+24 V
Blue	Ground	0 V

Tab. 10: Connecting the control cabinet to the truck reverse light

5.9 Connecting the pause signal

Connect the control cabinet to any switch for the pause signal. The connecting cable (Input, Pause) is connected to the control cabinet on one side. The other side has an open end.

To activate the input signal close the wire with a key button or any switch. Leave the signal input open to deactivate the signal.

1. Run the connecting cable from the control cabinet to a switch or key button.
2. Connect the wire to the switch or key button.
3. Close the brown and blue wire to active the pause signal.

Place the wires to the voltage supply as follows.

Wire color	Connection	Voltage supply
Brown	Voltage	+24 V
Blue	Ground	0 V

Tab. 11: Connecting the control cabinet to the voltage supply

5.10 Connecting the RDW lights (optional)

Connect control cabinet to the RDW lights (optional) at the front of the truck. The connecting cable for the left RDW signal lights (Flash Light Left, Sensor RDW) and the right RDW signal lights (Flash Light Right, Sensor RDW) are connected to the control cabinet on one side. The other sides have open ends.

1. Run the connecting cable from the control cabinet to the RDW lights.
2. Connect the wire to flash lights.

Place the wires to the voltage supply as follows.

Wire color	Connection	Voltage supply
Brown	Voltage	+24 V
Blue	Ground	0 V

Tab. 12: Connecting the control cabinet to the RDW lights

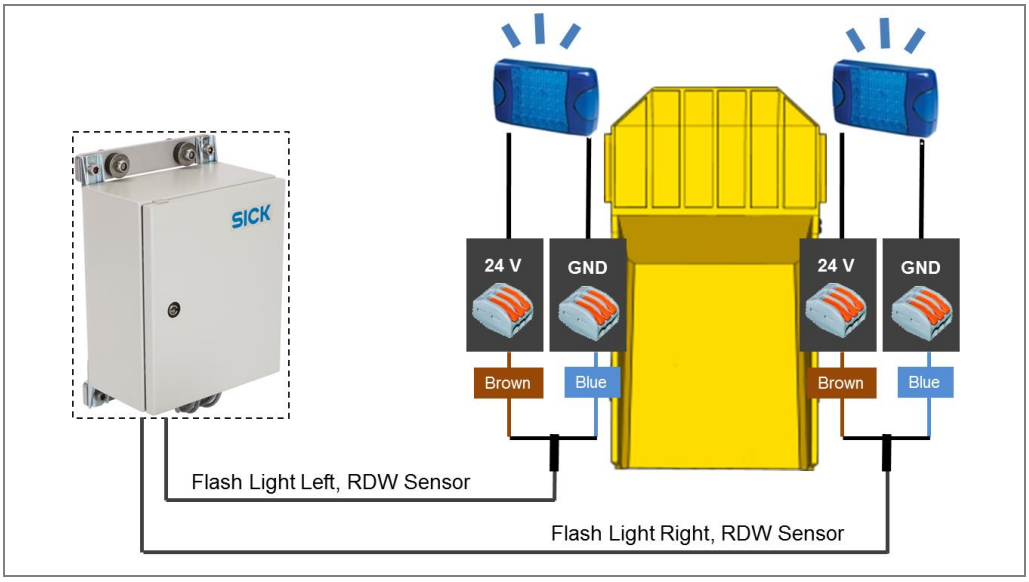


Fig. 42: Connecting the control cabinet to the RDW lights (optional)

6 Commissioning

No PC is required for initial commissioning.

⚠ WARNING

Do not commission without testing by qualified safety personnel

Before you commission the system for the first time, you must have it checked and approved by qualified safety personnel. Observe the notes provided in Chapter **2 Safety**.

6.1 Launching the system

All system components are automatically launched when starting the truck and checked in a self-test.

Fig. 43: Self-test of the system on the operator display

The system is ready for operation after approx. 60 seconds. A notification appears informing you that the system has not yet been (completely) configured.

Fig. 44: Information about incomplete configuration

Note Warnings (optical and acoustical) may occur as the system setup is yet to be done. This is no malfunction and can be ignored.

Start configuration

➢ Press **OK** to confirm you have seen the notification.

TPS is started in the configuration mode. An overview page with the individual setup steps is automatically displayed on the operator display.

Fig. 45: Configuration mode after launching for the first time

Display of the operational readiness of the devices

The LMS151 2D LiDAR sensor visualizes operational readiness via the green **OK** LED (1). The 7-segment display is blank.

The operation LED (3) must illuminate on the operator display.

The LD-MRS 3D LiDAR sensor has no readiness visualization.

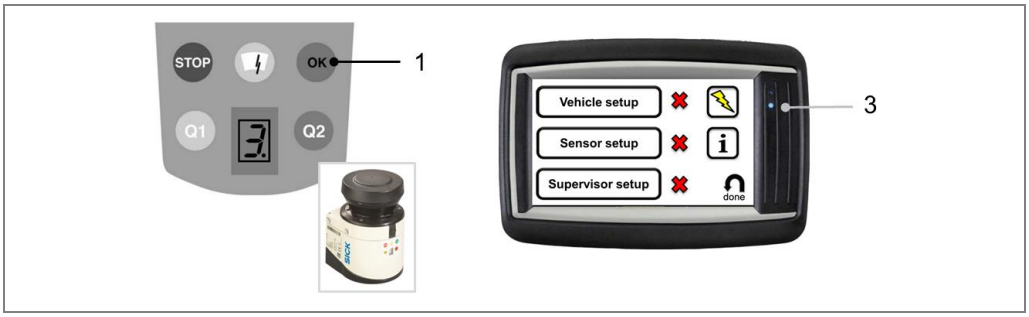
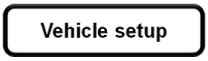


Fig. 46: Testing operational readiness of the devices

6.2 The operator display in configuration mode

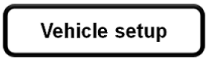
The following functions are available in configuration mode:

Function/symbol	Meaning
	**Vehicle setup** Opens the assistant for the configuration of the vehicle size. In addition, it is possible to set a vehicle ID.
	**Sensor setup** Opens the assistant for the configuration of the LD-MRS Front, Rear and LMS151 RDW LiDAR sensors.
	**Zone setup** Opens the assistant for the configuration of the warning zones.
	**Not OK** Indicates that the relevant setup step has not yet been completed or has not been completed successfully.
	**OK** Indicates that the relevant setup step has been completed successfully. The parameters are permanently saved.
	**Reset** Resets all parameters to their factory settings.
	**Info** Shows, among other things, the version of the software and the current system status. In addition, it is possible to test the output and input signals.
	Quits the configuration mode and switches into the operating mode for the person carrying out commissioning. It is only possible for the person carrying out commissioning to switch to the operating mode if **all** setup steps have been successfully completed and marked with a green check mark.

Tab. 13: Functions in the configuration mode

6.3 Making vehicle setup settings

Make the vehicle setup settings in the first step.



➢ Click on the **Vehicle setup** icon. The **Entering truck size setup** page is opened.

Navigation

As soon as the entries have been completed on one assistant page, use the **next** icon to navigate to the following page.

When changing the assistant page, the settings and information that have been provided are temporarily saved.

Important Note

Changing the truck size parameter on the following page will affect sensor mounting positions. Truck size must be configured before sensor setup.

If truck size setup must be changed when sensors where already configured, all sensor parameters must be checked afterwards.

Input the vehicle ID

The vehicle ID is usually a unique number for each vehicle within the mine site. This number is displayed in the operator screen and written in the event log for identification. The number is limited to 4 digits (0..9999).

➢ Click on the plus or minus icon to set the desired number. The value displayed increases or decreases by 1 with each click.

➢ If you click and hold on the icon, the value automatically goes up or down in increments of 1 (auto repeat).

Input truck size

Enter the truck dimensions in the appropriate places. Please use image shown on the screen for reference.

The TPS is scalable and adjustable to different truck sizes and types. Therefore the individual measures of the vehicle have to be configured.

Saving settings

➢ Click on the **done** icon. The settings are permanently saved in the system.

You will then be taken back to the overview page with the individual setup steps.
The setup step **Vehicle setup** now has a green check mark.

6.4 Configuring the LiDAR sensors

6.4.1 Starting sensor setup

When setting up the parameters for the LiDAR sensors, an assistant provides support for all LiDAR sensors.

➢ Click on the **Sensor setup** icon.

Sensor setup is done in a separate screen, showing all available sensors, a green check mark or red not ok mark indicator is shown at each of them.

After the successful completion of any sensor setup, the indicator that was initially a red not ok mark will turn to a green check mark.

Note The result of the sensor setup, displayed in the main setup page, will not turn to a green check mark until all of the individual sensors have been successfully configured.

Navigation

As soon as the entries have been completed on one assistant page, use the **next** icon to navigate to the following page.

When changing the assistant page, the settings and information that have been provided are temporarily saved.

6.4.2 Front sensor set up

In order to detect different vehicle sizes from haul truck up to small service and utility vehicles, the front 3D LiDAR sensor has to be adjusted to cover a large observation zone dependent on the individual mounting position. The setup procedure assists the installing personal accordingly.

➢ Click on the **Front** icon.

In the front sensor setup, only position measurements of the sensor position are required. Enter the appropriate values and complete setup.

Sensor Front: Mounting position

The system setup firstly requires the designation of the front scanner mounting position.

➢ Click on the plus or minus icon to set the distances. The value displayed increases or decreases by 5 cm with each click.

➢ If you click and hold on the icon, the value automatically goes up or down in increments of 5 (auto repeat).

Sensor Front: Adjustment

The system setup requires the adjustment of the front sensor.

Note Although it is not verified here, angular adjustment of the frontal sensor is critical to achieve the desired range and accuracy of the warning zones. Please use care to manually verify the mounting of the sensor.

Front Sensor: Pitch angle adjustment

For a high mounting position (e.g. above the air intake) apply a pitch angle (parallel to the ground) up to 1 degree. The tilt angle should be about 1 degree.

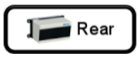
Saving settings

➢ Click on the **done** icon. The settings are permanently saved in the system.

You will then be taken back to the sensor setup page with the individual setup steps for the LiDAR sensors.
The setup step **Front** now has a green check mark.

6.4.3 Rear sensor set up

In order to assist the operator in reversing e.g. against walls and crushers and to be able to deliver an effective aid to the driver, the rear 3D LiDAR sensor has to be adjusted to cover the area behind the tires according to the mounting position.



➢ Click on the **Rear** icon.

The setup procedure therefore assists the installer. The rear sensor setup comprises 3 steps:

- **Position setup:** In this step, the mounting position of the sensor is defined.
- **Pitch angle setup:** In this step, the pitch angle (downward tilt) of the scanner is verified and must be tuned to match the required setting. This includes the mechanical adjustment of the sensor pitch angle. Adjust the sensor as indicated until the green signal is reached.
- **Aperture angle setup:** The aperture angle of the rear sensor may be limited by the rear wheels of the truck. During this setup step, the wheels are automatically detected and removed from the sensors detection area. To begin the processing, press Start on the setup page.

Rear Sensor Setup:

The system setup requires the designation of the rear scanner mounting position.

- Click on the plus or minus icon to set the distances. The value displayed increases or decreases by 5 cm with each click.
- If you click and hold on the icon, the value automatically goes up or down in increments of 5 (auto repeat).

Rear sensor: Adjustment preparation

Place the vehicle on flat ground. Make sure no person or object is standing behind the vehicle.

Rear sensor: Pitch angle

The system further assists the installer in guiding through the pitch angle calibration procedure.

- Indicates that the pitch angle is too small. Increase the pitch angle of the rear 3D LiDAR sensor downwards until the level indicator is green.

- Indicates that the pitch angle is too large. Decrease the pitch angle of the rear 3D LiDAR sensor upwards until the level indicator is green.

Note Failure to reach a green indicator will result in the overall setup to fail.

Rear sensor: View area adjustment

Start

Press start to detect the limits (wheels) and to set the sensor angles. Make sure no person or object is located behind the vehicle. The final result (status) needs to be **Success** in order for the overall setup to be successful.

Saving settings

done

➢ Click on the **done** icon. The settings are permanently saved in the system.

You will then be taken back to the sensor setup page with the individual setup steps for the LiDAR sensors.
The setup step **Rear** now has a green check mark.

6.4.4 RDW sensor set up

RDW

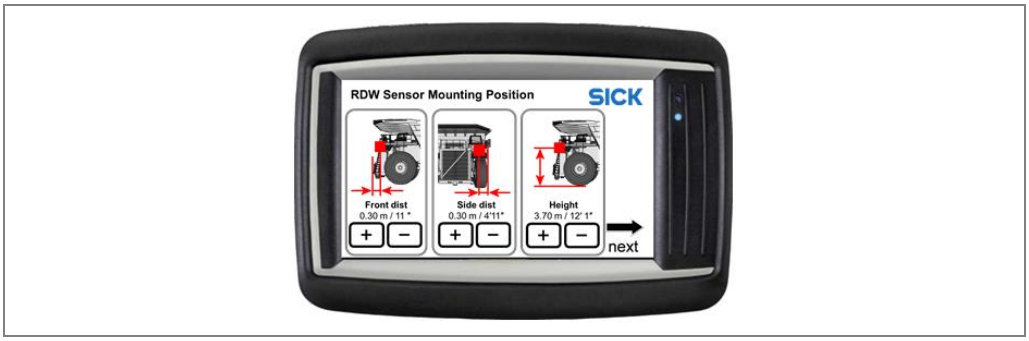
➢ Click on the **RDW** icon.

The 2D LiDAR sensor setup for the RDW comprises 2 steps:

- **Position setup:** This step requires the designation of the RDW scanner mounting position.
- **Pitch angle setup:** This step assists the installing personal in offering an adjustment check as an assistance function.

RDW Sensor Mounting position

The system setup requires the designation of the LMS151 RDW 2D LiDAR sensor mounting position.



+ −

➢ Click on the plus or minus icon to set the distances. The value displayed increases or decreases by 5 cm with each click.

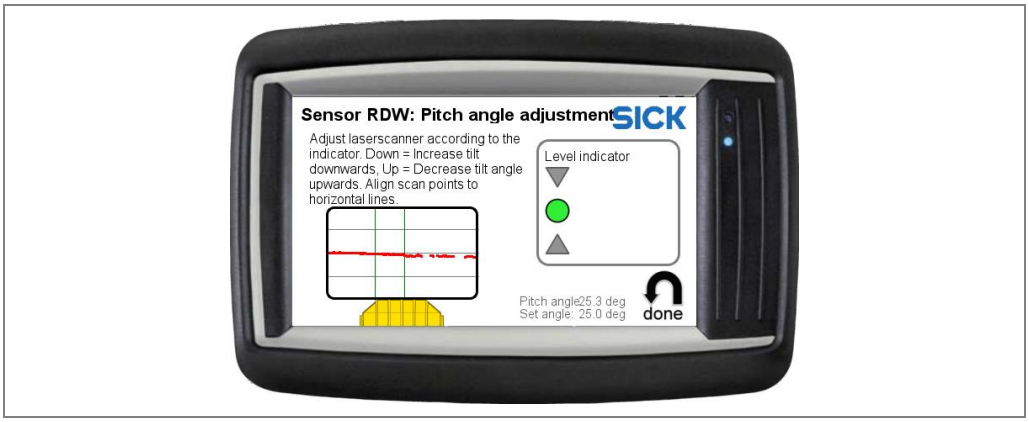
➢ If you click and hold on the icon, the value automatically goes up or down in increments of 5 (auto repeat).

Sensor RDW: Adjustment preparation

Place the vehicle on flat ground. Make sure no person or object is standing behind the vehicle.

Sensor RDW: Pitch angle adjustment

The system further assists the installer in guiding through the pitch angle calibration procedure.



1. Pitch angle (downward tilt) of the scanner is verified and must be tuned to match the required setting. This includes the mechanical adjustment of the sensor pitch angle. Adjust the sensor as indicated until the green signal is reached.

Note Failure to reach a green indicator will result in the overall setup to fail.

➢ Indicates that the pitch angle is too small. Increase the pitch angle of the LMS151 RDW 2D LiDAR sensor downwards until the level indicator is green.

➢ Indicates that the pitch angle is too large. Decrease the pitch angle of the LMS151 RDW 2D LiDAR sensor upwards until the level indicator is green.

2. Roll angle alignment is displayed as a line of distance measurement points relative to the ground (earth). The roll angle setup has been successful when the display shows a parallel horizontal line on the screen.

Saving settings

➢ Click on the **done** icon. The settings are permanently saved in the system.

You will then be taken back to the sensor setup page with the individual setup steps for the LiDAR sensors.

The setup step **RDW** now has a green check mark.

6.4.5 Saving sensor setup settings

All LiDAR sensors have now a green check mark.

➢ Click on the **done** icon. The settings are permanently saved in the system.

You will then be taken back to the overview page with the individual setup steps.
The setup step **Sensor setup** now has a green check mark.

6.5 Making Supervisor setup settings

In this warning zones setup, the behavior of the warning zones for "Front" and "RDW" can be configured.

The configuration of the warning zone sizes determines the warning strategies. The evaluation of warning zones allow the mine supervisor to adjust the warning levels according to the individual mine operation safety process. Improper adjustment could introduce a lack of performance.

➢ Click on the **Supervisor setup** icon. The **Supervisor setup** page is opened.

Supervisor setup is done in a separate screen, showing all available warning zones, a green check mark or red not ok mark indicator is shown at each of them.

After the successful completion of any warning zone setup, the indicator that was initially a red not ok mark will turn to a green check mark.

Navigation

As soon as the entries have been completed on one assistant page, use the **next** icon to navigate to the following page.

When changing the assistant page, the settings and information that have been provided are temporarily saved.

6.5.1 Front zones set up

The frontal collision warning uses three warning zones, colored green, yellow and red. The overall logic follows the traffic light: The green zone is the “obstacle monitoring zone”. This area is meant to deliver information to the operator about the vehicle surrounding obstacles. The yellow zone constitutes the “Pre Alarm” – the operator must prepare to stop. A red zone violation raises the “urgent alarm” – operator must stop

However, the length of each warning zone can be configured in this setup step, so that adaption to the individual situation can be made

➢ Click on the **Front zones** icon.

➢

Setup: Low-speed warning zones

The size of the warning zones is adapted to the vehicle speed, but limited by the Min/Max settings:

Vehicle speed	Warning zone
0 ... 15 km/h	Minimum warning zone size
15 ... 60 km/h	Zones are scaled linearly from min to max size
> 60 km/h	Maximum warning zone size

Tab. 14: Warning zones in relation to vehicle speed

The size of the warning zones is adjusted linearly between the minimum value (the smallest possible size of the “low speed warning zones”, intended for a stationary and low speed driving truck) and maximum values (the largest possible size of the so called “high speed warning zone”, intended for fast driving).

Both range limits (min and max) of the frontal warning zones can be individually configured.

1. Adjust the warning zone for low-speed accordingly using the plus/minus icon for the green, yellow and red warning zones.

2. Confirm the adjusted warning zone using the **next** icon.
3. Adjust the warning zone for **high-speed** accordingly using the plus/minus icon for the green, yellow and red warning zones.

4. Confirm the adjusted warning zone using the **done** icon. The parameters are permanently saved in the system.

You will then be taken back to the supervisor setup page with the individual setup steps for the warning zones.
The setup step **Front zone** now has a green check mark.

6.5.2 RDW setup

The RDW warning zones are defined relatively to the left road limitation

➢ Click on the **RDW** icon.

1. Choose the bunt wall type according to individual mine site situation.

2. Confirm the adjusted warning zone using the **next** icon.

3. Adjust the warning zones for **RDW** accordingly using the plus/minus icon for the yellow and red warning zones.

4. Confirm the adjusted warning zone using the **done** icon. The parameters are permanently saved in the system.

You will then be taken back to the supervisor setup page with the individual setup steps for the warning zones.

6.5.3 Saving sensor setup settings

All setups for the warning zones have now a green check mark.

➢ Click on the **done** icon. The settings are permanently saved in the system.

You will then be taken back to the overview page with the individual setup steps.
The setup step **Supervisor setup** now has a green check mark.

6.6 Reverse Gear and components connection check

➢ Click on the **information** icon.

The status of the gear shift is read from the signal supplied to the control cabinet. The status shows here either **Active** or **Not active**. Once power (24 V) is applied to the reverse signal line, the shown state should be **Active**. If this is not the case, please refer to the troubleshooting chapter for solutions.

Note Make sure that truck ignition is on so that there is actually a signal on the reverse gear input line when testing.

The info page gives also an overview of the functional state of system components. Additionally the TPS output (control lights and siren) can be manually activated to check the functionality and proper wiring.

This function is helpful to verify the cabling after installation.

6.7 Switch to the operating mode

6.7.1 Quit configuration mode

As soon as all setup steps have been successfully completed and have a green check mark on the overview page, you can leave the configuration mode and switch to the operating mode for the person carrying out commissioning.

➢ Click the **done** icon on the overview page.

This quits configuration mode.

You are now in the operating mode for the person carrying out commissioning.

6.7.2 Operating mode for person carrying out commissioning

In the operating mode for the person carrying out commissioning, the user interface provides five functions accessible by symbols.

The following three functions are only available to the person carrying out commissioning:

Function/symbol	Meaning
	**Switching to configuration mode** Allows you to switch back to the configuration mode. The icon is only visible if TPS has been enabled for commissioning via the web interface (see also chapter **8.4.2 Enable configuration mode on the display**).
	**Switching the tone buzzer on/off** Switches the tone buzzer on and off. The tone buzzer is switched on when the system first starts. If there are obstacles in the monitored area, then there is an acoustic warning in addition to the visual indication on the display. The system saves the setting that has been made. The icon is only visible if TPS has been enabled for commissioning via the web interface (see also chapter **8.4.2 Enable configuration mode on the display**).
SICK Sensor Intelligence.	**Show measuring points on display** Displays the measuring points currently recorded by the LiDAR sensors. The display can be used as part of fault analysis. The logo has no function in the operating mode for the truck operators.

Tab. 15: Functions in the operating mode for person carrying out commissioning

The other icons are also available in the operating mode for truck operators. They are described in detail in chapter **7 Operation**.

6.7.3 Enable operating mode for truck operators

Quit the commissioning and then enable the operating mode for truck drivers.

1. Switch off the truck. All TPS components are shut down.
2. Switch the truck on. All TPS components are restarted.

The operator display has two icons. The operator is not able to switch to configuration mode or switch the tone buzzer on/off. The corresponding icons are hidden. It is also not possible to display the measuring points via the SICK logo. The logo functions are disabled.

Note After enabling the operating mode for truck operators, configuration mode can only be enabled on the operator display again via a web interface using a PC (see chapter **8.4.2 Enable configuration mode on the display**).

It is also possible to enable the operating mode for truck operators (as an alternative to the described procedure of starting up the system again) via the web interface (see chapter **8.4.3 Activating operating mode for truck operators via the web interface**).

7 Operation

⚠ WARNING

You are responsible!

Even when using TPS, the following rules apply for you as a driver:

1. Always drive the truck on the lines intended for this purpose.
2. Always keep an eye on the surroundings of the truck.

Note

TPS only has a **supporting role**:

- It helps you as the driver to monitor the surroundings and warns you in good time if obstacles appear in the hazardous area.
- It is intended to relieve pressure on you as the driver and ensure a greater level of safety when driving the truck.
- At all times you, as the driver, bear the full responsibility for safe operation, in particular for people who are in the hazardous zones of the truck.

⚠ WARNING

Personnel requirements

All activities may only be carried out by trained and authorized personnel.

7.1 Start the truck and system

All system components are automatically launched when starting the truck. The devices are ready for operation after approx. 60 seconds.

7.1.1 The operator display in the operating mode for truck drivers

The following functions are available in the operating mode for truck drivers:

Function/symbol	Meaning
 	**Black Spot Target Icon** In order to set or remove a black spot target at the current area. Inside black spot areas, the driver may also disable all acoustic warnings. Therefore, the speaker-icon is shown while the truck is inside the black spot area. Also see chapter **8.4.4 Up- and downloading of GPS black spots** for the description of setting and removing black spots via the web interface.
	**Day/night mode switching** Swaps (inverts) the screen colors: Black becomes white and white becomes black. This adjusts the display to the current light conditions. When the system starts, the inverted display (white on black) is always preset.
SICK Sensor Intelligence.	It has no function in the operating mode for the truck driver.

Tab. 16: Functions in the operating mode for truck drivers

7.2 Forward Driving

While the gear selector is in neutral “N” or one of the forward gear positions, the main operator display shows the truck with configured warning zones in bird’s eye view. In this view, zone violations are shown with a colored warning zone (green, yellow or red) and a pulsating red dot at the position of the violation.

Two green blocks to the left and right of the truck on the display are indicating that the truck is in lane.

Note In order to be in lane and active the road departure warning, the truck needs to detect the bund wall for a certain time and speed.

7.2.1 Black spot warning

Black spots are hazardous areas on mine site like intersections, construction areas, crushers and workshops.

TPS warns the operator when the vehicle is entering a black spot by a short double-beep sequence to raise operator's attention.

Inside a black spot the operator is allowed to mute all alarms (e.g. when the truck is in workshop for maintenance) and no RDW warnings will be made.

Note For the correct function of black spots, GPS must be available.

➢ Click the **black spot target** icon on the display.

When a black spot was set successfully the "target"-icon turns into an "exclamation-mark" icon.

➢ Click the **speaker** icon on the display.

This will enable/disable sound output for this black spot area.

➢ Click on the "exclamation-mark" to remove the black spot.

7.3 Reverse Driving

When the truck is in reverse gear, there are two different views:

- **Standard reverse view:** Default view in reverse gear. Only the rear end of the truck is shown, with a red/yellow/green grid behind the vehicle. Objects behind the truck are shown as colored grid areas. This view is used as long as only reverse warnings are present.

- **Standard truck view:** This view is used whenever warnings from other sensors other than the reverse sensor are present, in order to indicate the origin of the warning. E.g., during an active frontal warning, this view is used.

NOTE

The range of the reverse warning is very limited in comparison to the forward warning zones. Therefore, the reverse driving speed should be limited.

7.4 Operate the system

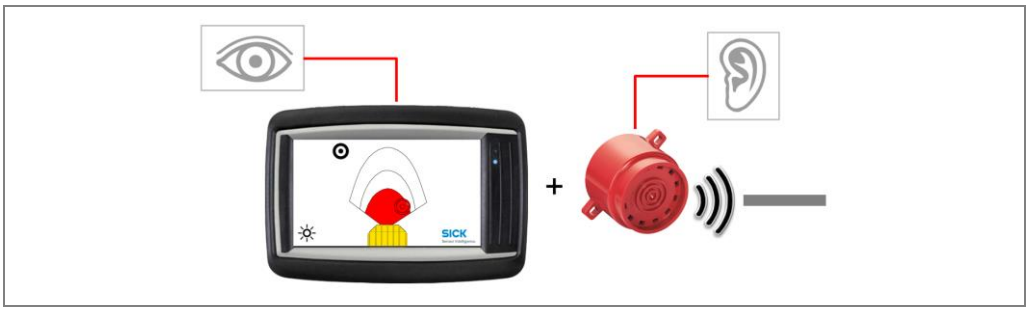
7.4.1 Switching between day/night mode

You can switch between day/night mode to adjust the display on the screen to the current light conditions. Particularly at night, the white day display may be extremely bright.

➢ Click the sun icon on the display. The display is inverted. This means that the colors on the screen are swapped. Black becomes white and white becomes black. In the following figure, the truck is shown in brown on a black background.

7.4.2 Collision warning in the event of obstacles in the warning zone

As soon as an obstacle appears in one of the three configured warning zones of the truck, a visual warning is shown at the location of the obstacle. This means that the danger for the truck can be quickly located.



If the tone buzzer is connected and switched on, there is also an acoustic signal depending on the warn zone infringed for the front, rear and road departure warning.

Active warning zone	Acoustic signal	Tone interval
Green	No acoustic signal	
Yellow	Interval tone	
Red	Continuous tone	

Tab. 17: Acoustic signal

How is the risk visualized?

- ❑ On the display, the relevant **object** that is closest to the truck is marked in **red**. The measuring point is given a **red circle**.
- ❑ If the obstacle is in the front of the truck, the relevant **warning zone is displayed in color**.

- ❑ If the truck is in reverse, objects behind the truck are **shown as colored grid areas**.

❑ If the truck is in reverse and objects are appearing at the front of the truck, the front collision warning function is activating automatically in addition. The relevant object that is closest to the truck is marked in **red**.

7.4.3 Collision warning in the event of unintentional road departure

How is it visualized?

❑ If the truck operator is coming unintentionally to close to the left bund wall, the **left side RDW mark is displayed**. Deepening on the warning zone setup, the mark is highlighted in yellow first and will turn into red, if the driver is getting closer to the bund wall.

Note TPS needs to be in lane first, in order to active the RDW function.

❑ If the truck operator is leaving unintentionally the lane to the right side, the **right side RDW mark is displayed**. Deepening on the warning zone setup, the mark is highlighted in yellow first and will turn into red, if the driver is getting closer to the bund wall.

7.4.4 React to collision awareness

If it is reported that there is a danger in the warning zone, as the driver of the truck, you must react **appropriately**.

Note

- TPS does not actively intervene in the operating or steering process even in hazardous situations.
- As the driver, you continue to be responsible for the safe driving of the truck.

8 Maintenance

8.1 Overview of maintenance tasks

The following maintenance work must be carried out at the specified time intervals:

Device	Maintenance task	Interval	Completed by
LiDAR sensor LD-MRS and LMS151	Cleaning the front screen	at the start of a shift	Trained personnel
General	Optical inspection of the LiDAR sensor for mechanical stability of the mounting brackets	weekly	Trained personnel
	Visual inspection of the electrical wiring for damage	2x / year	Trained personnel

Tab. 18:Maintenance intervals

8.2 Maintenance during operation

8.2.1 Cleaning the LiDAR sensor

The LiDAR sensors are maintenance-free. Maintenance is not necessary to ensure compliance with laser class 1.

To achieve the full optical output of the LiDAR sensors, the front screen must be regularly checked for contamination.

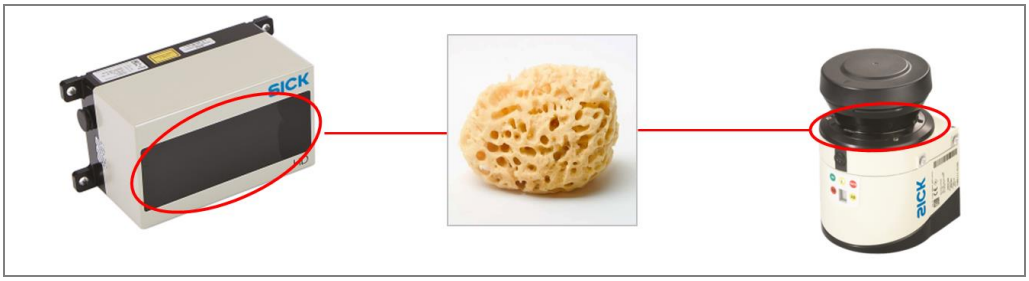


Fig. 47: Cleaning the LiDAR sensor

Clean the front screen

- ➢ Switch off the device during cleaning.
- ➢ Get rid of any contamination on the optics cover to avoid incorrect measurements.
- ➢ Wipe the optics cover with a soft, wet sponge.
- ➢ Then dry the optics cover with a clean cloth.

WARNING

Damage to the optics cover

The optics cover is made of polycarbonate. The optical output is weakened by scratches and streaks on the optics cover.

- ➢ Do not use aggressive cleaning agents.
- ➢ Do not use abrasive cleaning agents.
- ➢ Avoid scratching and chafing motion on the optics cover.

8.2.2 Visual inspection of the cables

Regularly check the electrical installation. Check that all cable connections are securely attached.

WARNING

Loose connections or scorched cables

- ➢ Deficiencies such as loose connections or scorched cables must be rectified immediately.

HAZARD

Damaged cable insulation

There is a risk of electrocution if the insulation of the connecting cables is damaged.

8.3 Replacing components

Faulty or damaged components must be dismantled and replaced with new or repaired components.

HAZARD

Disconnect the power to the system

- ➢ Make sure the voltage supply for the entire system is disconnected while you are carrying out maintenance and repair work.

HAZARD

Risk of injury due to electrical current

Only a qualified electrician or trained person working under the guidance and supervision of a qualified electrician is permitted to work on electrical systems or equipment and they must comply with the electrical regulations.

8.3.1 Replacing a LiDAR sensor

As all external cable connections terminate in the system plug or the connectors, there is no need to repeat the electrical installation when the device is replaced. The replacement device can simply be connected.

NOTE

Claims under the warranty rendered void

The housing screws on the LiDAR sensors are sealed.

Any claims against SICK AG under the warranty will be rendered void if the seals are damaged or if the device is opened.

The housing must only be opened by authorized SICK service personnel.

Replace the device.

1. Loosen the connectors on the LiDAR sensor and remove the connecting cables from the LiDAR sensor.
2. Dismantle the defective LiDAR sensor from the mounting.
3. Mount the replacement device.
4. Connect the cables to the new LiDAR sensor and screw the connectors together.

Configuring the replacement device

1. The replacement device is configured via the configuration interface of the display (see chapter **6.4 Configuring the LiDAR sensors**).
2. The configuration interface must previously be enabled via the web interface. The procedure for doing this is described in chapter **8.4 Activities on the web interface**.

8.3.2 Replacing the operator display

1. Turn the display on the ball joint so that you can easily access the reverse.
2. Undo the three fixing screws that connect the operator display to the bracket.

Fig. 48: Removing the operator display from the bracket

3. Remove the defective display from the bracket.
4. Undo the four cover screws and remove the adapter from the housing of the operator display.

Fig. 49: Removing the adapter from the operator display

5. Unplug the connectors of the connecting cables.
6. Put the connecting cables into the new display.
7. Screw the adapter to the housing and mount the display in the bracket.
8. Turn the device until the driver has a good view of the screen.

8.4 Activities on the web interface

TPS features a web interface. This interface can be called up in a web browser using a PC connected via Ethernet.

You need the web interface in order, for example, to activate configuration mode on the display. You can also use the web interface to install a software update, call up current system information or define the logging level.

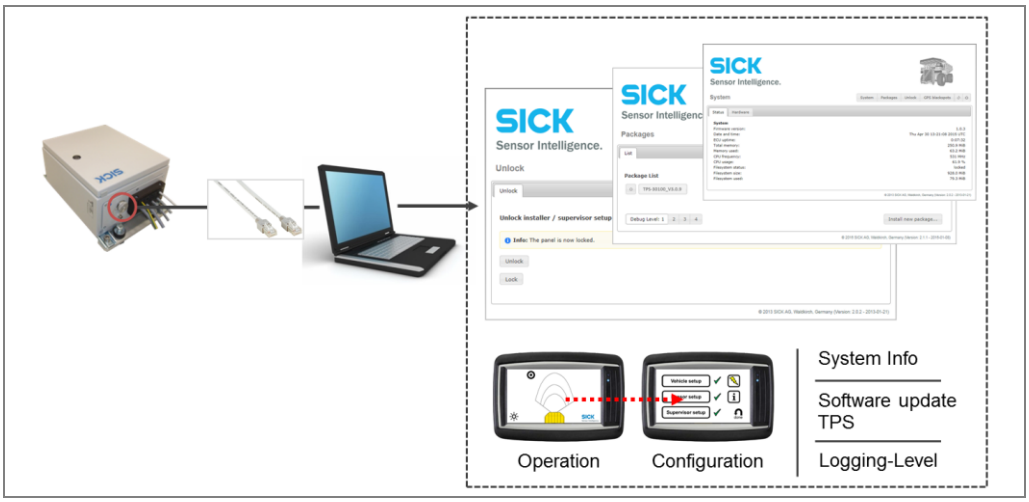


Fig. 50: The web interface

Note You need a cable with RJ-45 male connectors for connecting the PC to the control cabinet.

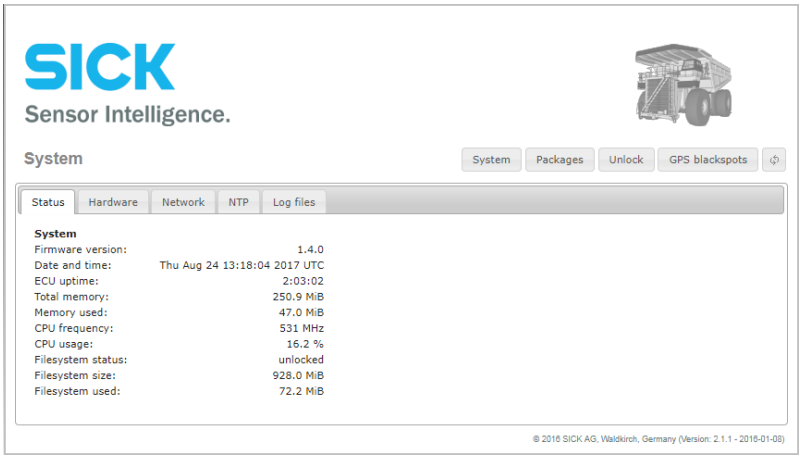
8.4.1 Calling up the web interface

Proceed as follows to call up the TPS web interface:

Prerequisites

- The PC may need to be switched from DHCP to a fixed IP address, such as 192.168.1.50. Subnet mask 255.255.255.0 must be used.
- If a proxy server is configured on the PC, it may be necessary to deactivate it.

1. Connect the PC with the control cabinet via the network connection.
2. On the PC, open the address **http://192.168.1.10** with a web browser.



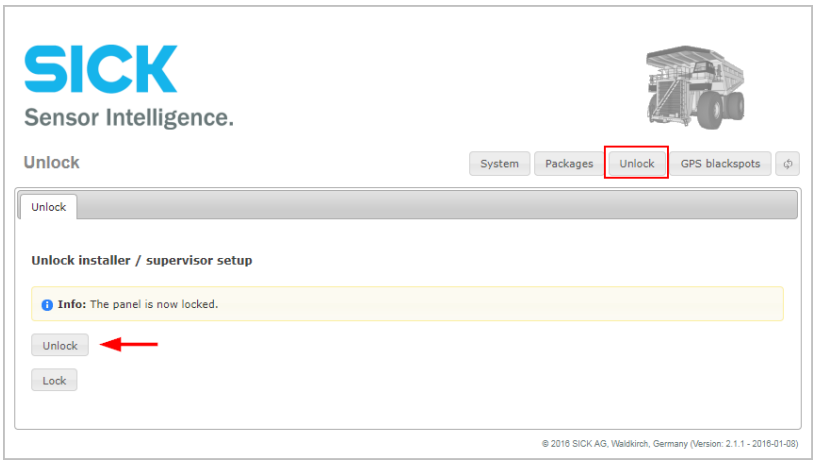
The web interface starts up with the **System** tab.

3. Use this to find the system status, e.g. the current firmware, to help with remote support.

8.4.2 Enable configuration mode on the display

Enable configuration mode on the operator display. This is required, e.g., to configure the replacement device after the replacement of a defective LiDAR sensor or in order to correct the field of vision of the LiDAR sensor after modifications to the truck.

1. Switch to the **Unlock** tab. You will receive a notification there informing you that the operator display is currently locked.



2. Click on the **Unlock** button.
3. If release has been successful, then the message **Success! The panel is now unlocked** will be displayed. You are taken to the operating mode for the person carrying out commissioning.

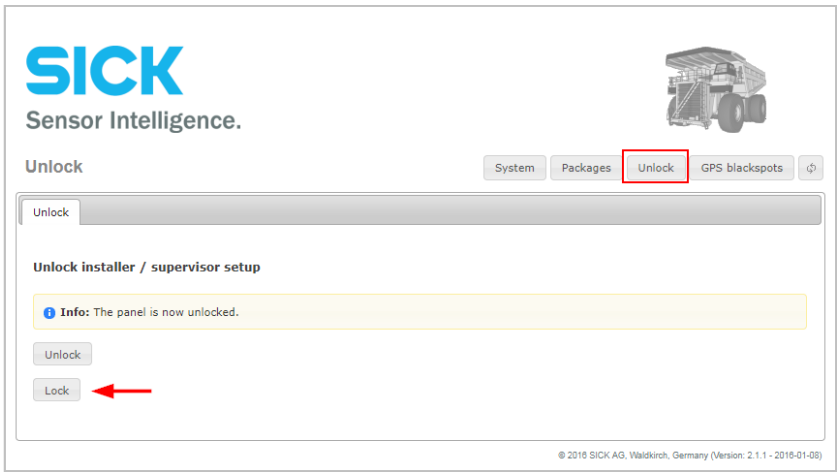
4. Click the tool icon on the operator display. The overview page for configuration mode is displayed.

Note Further information on configuration mode can be found in chapter **6.2 The operator display in configuration mode**.

8.4.3 Activating operating mode for truck operators via the web interface

The web interface allows you to easily switch between the operating mode for the person carrying out commissioning and the operating mode for truck drivers. You do not need to restart the system in order to do this (see chapter **6.7.3 Enable operating mode for truck operators**).

1. Switch to the **Unlock** tab in the web interface.



2. Click on the **Lock** button.

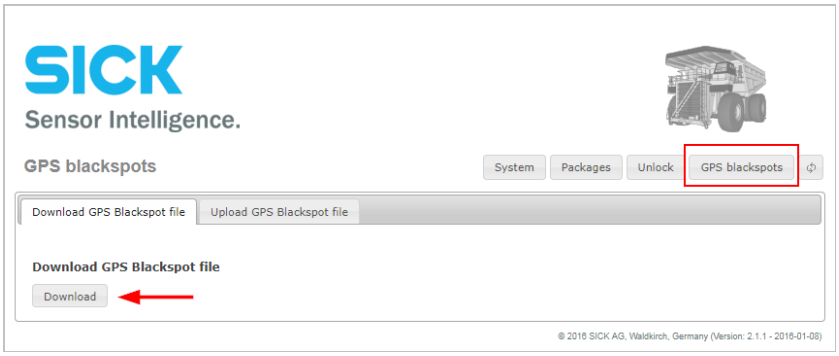
   You will receive a notification informing you that the operator display is now locked. The operating mode for truck operators is displayed on the operator display.

8.4.4 Up- and downloading of GPS black spots

The complete set of black spots can be transferred to other trucks by downloading and uploading via the web interface.

Download GPS black spots

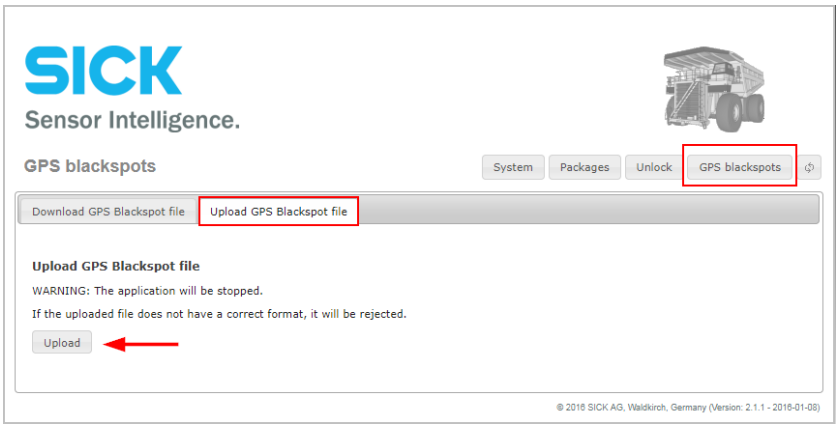
1. Switch to the **GPS blackspots** tab in the web interface.



2. Click on the **Download** button and save the blackspot.ini file on your computer

Upload GPS black spots

1. Switch to the **GPS blackspots** tab in the web interface.
2. Switch to the **Upload GPS Blackspot file** tab in the web interface.



3. Click on the **Upload** button and upload a blackspot.ini file from your computer.

Note The application will be stopped. If the uploaded file does not have a correct format, it will be rejected.

8.4.5 Updating TPS software

The TPS software is updated via the web interface.

1. Switch to the **Packages** tab.

   The current version status is listed under **Package List**.

2. If one or more packages are already installed, check the box to the left of the package from which you wish to transfer the configuration. This renders configuration unnecessary.

   If you do not wish to transfer anything, do not select any of the packages. Following package installation, the system will need to be completely re-commissioned.

3. Click on the **Install new package** button and select the package file with the current software update.

   The file can be obtained directly from SICK support or via the homepage of your local SICK sales office.

9 Fault diagnosis

This chapter describes how to identify and remedy fault situations.

9.1 Response to faults

⚠ WARNING

Risk resulting from faults

Cease operation if the cause of the malfunction has not been clearly identified.

A defect in the system may result in fatal accidents or damage to the system.

➢ Take the TPS out of operation if you cannot clearly identify the fault and if you cannot safely remedy the problem.

9.2 Fault indicators of the LMS151

You can discern the following information from the LEDs:

Display	Possible cause	Remedy
OK and STOP off	No operating voltage, or voltage too low	➢ Check the voltage supply and activate, if necessary
lights up	Optics cover contaminated, still in operation	➢ Clean the optics cover.
flashes at 1 Hz	Optics cover contaminated, no operation	➢ Clean the optics cover.
flashes at 4 Hz	System error	➢ Pay attention to the error display of the 7-segment display or carry out a diagnostics with the aid of SOPAS ET. ➢ Switch the device off and back on again.

Tab. 19: LED display in the case of an error for the LMS151 2D LiDAR sensor

The 7-segment display provides the following information:

Display	Possible cause	Remedy
, , ...	No fault.	Device is in measuring mode
	Idle mode, outputs are in the OFF state, laser is switched off.	No fault. If the criteria for IDLE mode are withdrawn, operational readiness is restored.
	Motor starts	No fault.
E.	Error in the 2D LiDAR sensor	➢ Send the 2D LiDAR sensor to the manufacturer for repair.
	Temperature is too low	➢ The ambient temperature is too low for the measuring mode.

Tab. 20: 7-segment display for the LMS511/LMS111 2D LiDAR sensor

9.3 Typical fault situations during commissioning

9.3.1 Configuration incomplete or incorrect

Fault situation

The following error message is shown on the display screen after the system is started up:

Possible cause

- Not all setup steps have been carried out yet.
- The configuration is incorrect. This may have been changed.

Remedy

➢ Carry out all setup steps as described in chapter **6 Commissioning**.

9.3.2 LiDAR sensor not available

Fault situation

The display is not receiving any measured data from the LiDAR sensor.

The following error message appears on the operator display:

Possible cause

- The LiDAR sensor is not connected to the control cabinet voltage supply or is defective.
- The control cabinet is not connected to the supply voltage or is defective.
- The supply voltage is too high or too low.
- The Ethernet connection between the LiDAR sensor, control cabinet, and operator display has been interrupted.
- The Ethernet cable or the connecting cable for the voltage supply is defective.

Remedy

1. Check the cabling and close all components according to the wiring plan. On this matter, refer to chapter **5 Electrical installation**.
2. Check the voltage supply to the system. The voltage must be 24 V. Switch on the correct voltage supply.

9.4 Typical fault situations during operation

9.4.1 Viewing window of the LiDAR sensor contaminated

Fault situation

The following error message appears on the operator display:

Possible cause

The system has integrated contamination detection.

The LiDAR sensor has reached a critical level of contamination. The detection performance of the LiDAR sensor is severely restricted. Reliable operation is no longer guaranteed. The display informs you of this.

Remedy

1. Clean the optics cover on the LiDAR sensor. Read the notes provided in Chapter **8.2.1 Cleaning the LiDAR sensor**.
2. The message disappears once the optics cover of the LiDAR sensor has been cleaned.

Note Acknowledge the message with **OK**. By doing so, the driver acknowledges that he/she has accepted the restriction in function and is currently continuing to drive with reduced system performance.

9.4.2 LiDAR sensor not available

Fault situation

The display is not receiving any measured data from the LiDAR sensor.

The following error message appears on the operator display:

Possible cause

- The LiDAR sensor is not connected to the supply voltage or is defective.
- The control cabinet is not connected to the supply voltage or is defective.
- The supply voltage is too high or too low.
- The Ethernet connection between the LiDAR sensor, control cabinet, and operator display has been interrupted.
- The Ethernet cable or the connecting cable for the voltage supply is defective.

Remedy

1. Check the cabling and close all components according to the wiring plan. On this matter, refer to chapter **5 Electrical installation**.
2. Check the voltage supply to the system. The voltage must be 24 V. Switch on the correct voltage supply.

9.4.3 No image on display

Fault situation

There is no image on the display after starting the truck.

Possible cause

- The operator display is not connected to the supply voltage of the control cabinet.
- TPS does not have any supply voltage, or the supply voltage is insufficient.
- The operator display is defective.
- Control cabinet fuse is blown.

Remedy

1. Check the mains connection to the operator display and establish the correct connection to the voltage supply of the control cabinet. Read the notes provided in Chapter **8.2.2 Visual inspection of the cables**.
2. Check the voltage supply to the system. The voltage must be 24 V. Switch on the correct voltage supply.
3. If voltage is being supplied to the system, and at least the operation LED is illuminated, but no image appears, then the display may be defective. If possible, carry out a cross-check with another display.
4. If power goes into the system, but does not reach the components, one or both of the internal fuses may be blown. Replace the fuses inside the control cabinet.

Note If the display is defective, you will need to replace it with a replacement device. On this matter, refer to chapter **8.3.2 Replacing the operator display**.

9.5 SICK support

If you cannot remedy the error with the help of the information provided in this chapter, please contact your respective SICK subsidiary.

10 Annex

10.1 Technical data

Features	
Field of application	Mining
Vehicle	Haul trucks
Laser class	1 (IEC 60825-1:2014)
Performance	
Display	4.3" touch display
Functions	Audible and visual collision warning Front-end collision warning Reverse assist Road departure warning system Black spot warning (geo-fencing) for hazardous areas Event logging
Number of LiDAR sensors	3
Monitored area	Vehicle front end Vehicle rear end Road profile
Warning zones	3 2 (RDW)
GPS	✓
Self-diagnosis	✓
Web interface	Software updates
Interfaces	
Ethernet	✓
Function	Software updates Event Log
Digital I/O	✓
Operator interface	Touch display
Mechanics/electronics	
Supply voltage	24 V DC, 19.2 V DC …27 V DC
Power consumption	40W 150 W, With heating
Weight	
LD-MRS	1 kg, without mounting kit
LMS151	1.1 kg, without mounting kit
Display	360 g, 600 g with mounting
Control cabinet	8 kg
Dimensions (L x W x H)	
Display	142 mm x 44 mm x 98 mm
LMS511	(with bracket 130 mm depth) 160 mm x 155 mm x 185 mm
Mounting position	
Display	142 mm x 44 mm x 98 mm (with mounting 130 mm depth)
Ambient data	
Ambient temperature, operation	–20 °C ... +50 °C
Ambient temperature, storage	–30 °C ... +80 °C

Tab. 21: TPS data sheet

10.2 Dimensional drawings

10.2.1 Dimensional drawing of the 3D LiDAR sensor LD-MRS

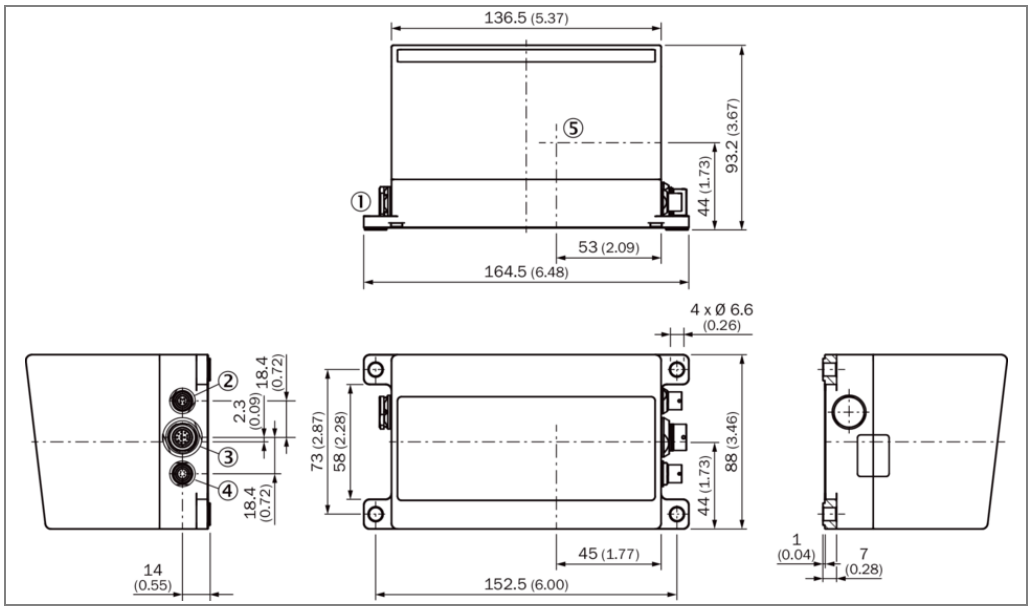


Fig. 51: Dimensional drawings of the LD-MRS 3D LiDAR sensor

10.2.2 Dimensional drawing of the 2D LiDAR sensor LMS151

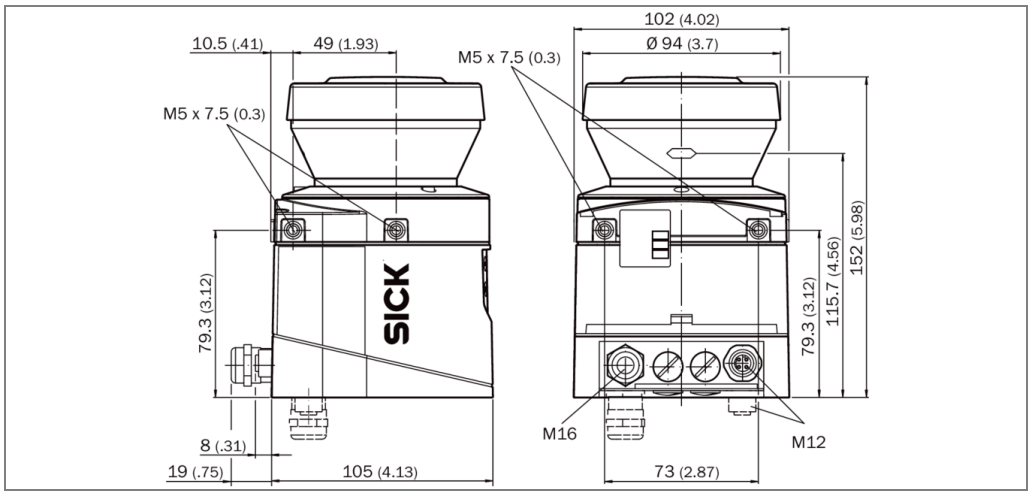


Fig. 52: Dimensional drawings of the LMS151 2D LiDAR sensor

10.2.3 Display dimensional drawing

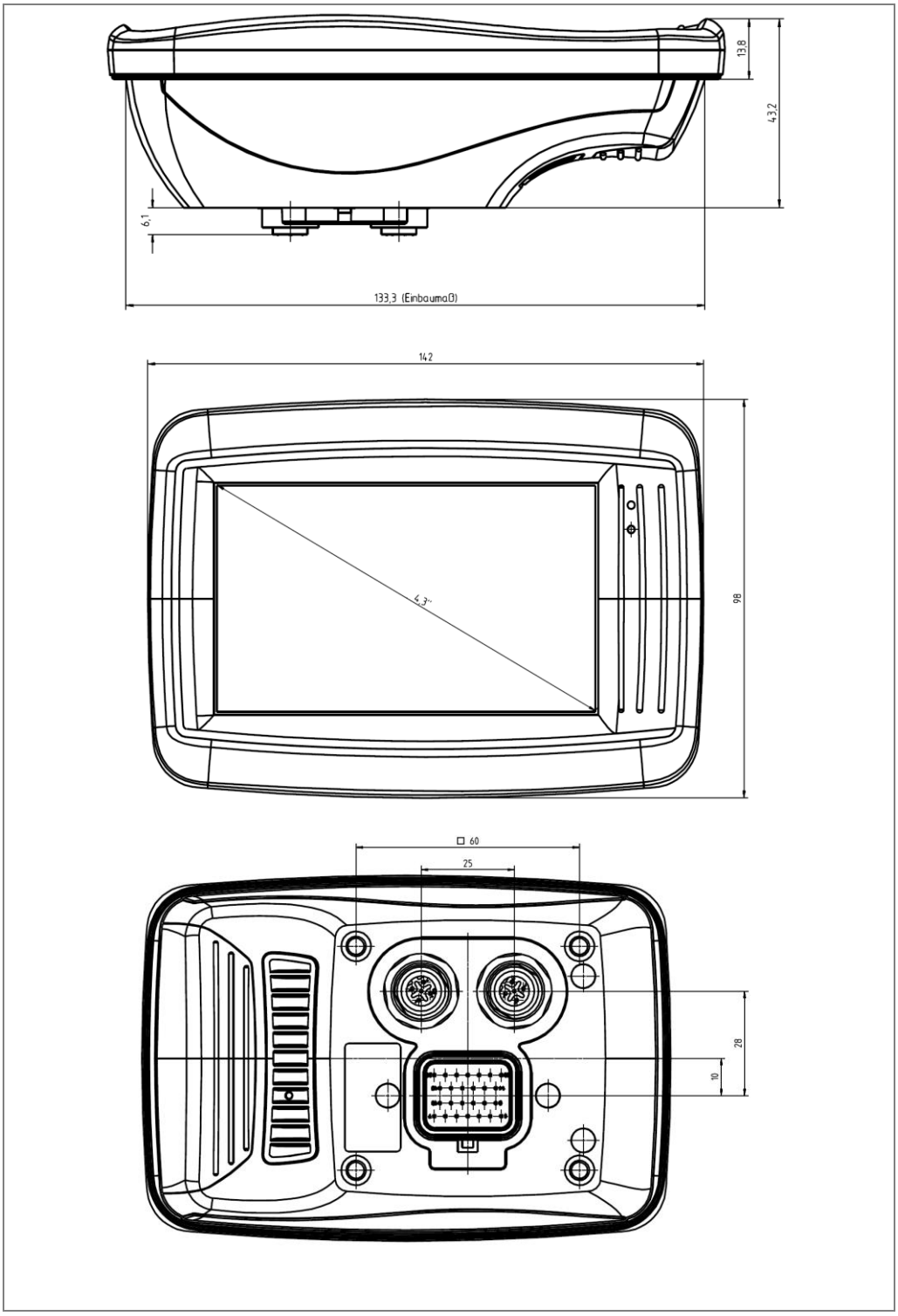


Fig. 53: Dimensional drawings of the operator display

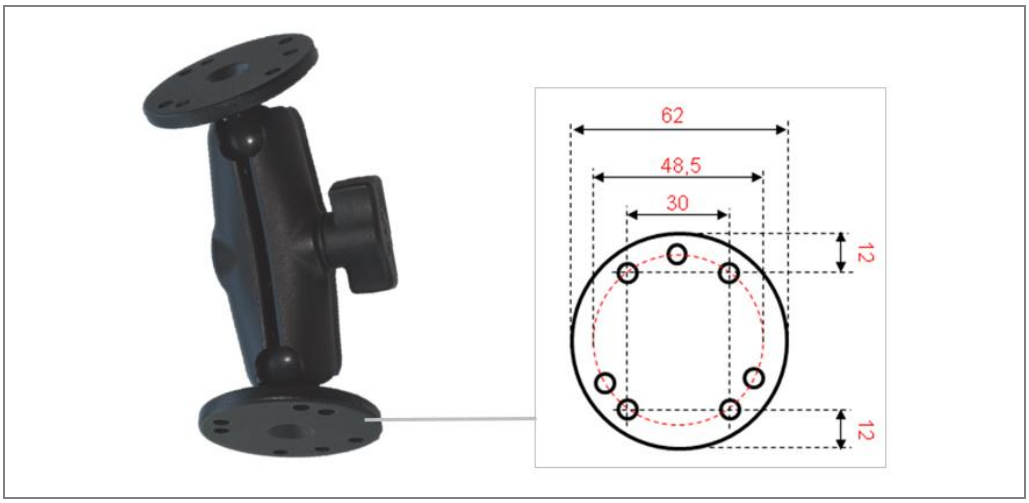


Fig. 54: Dimensional drawings of the mounting kit for the operator display

10.2.4 Control cabinet dimensional drawing

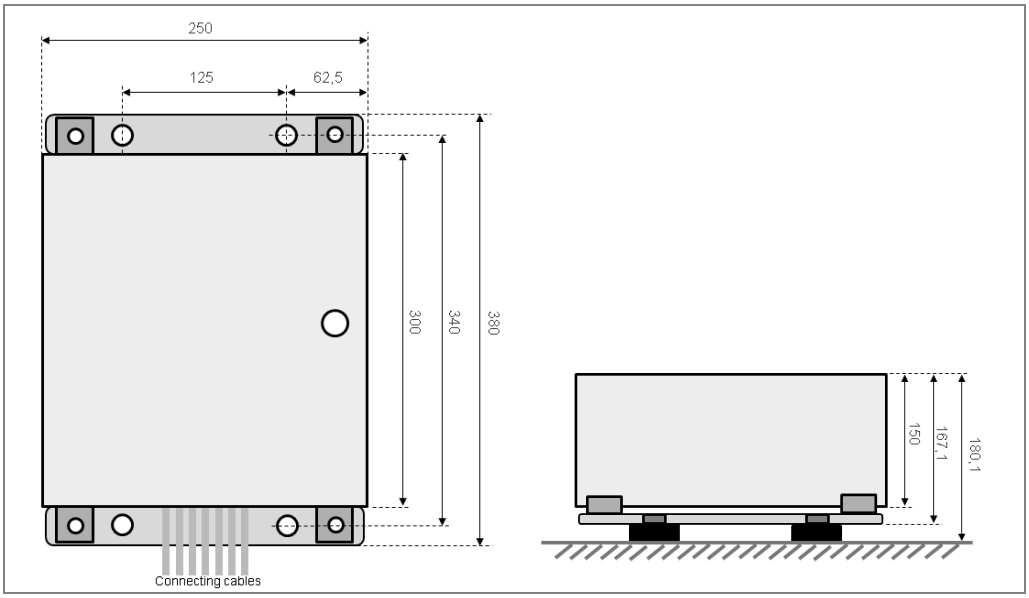


Fig. 55: Dimensional drawings of control cabinet

10.2.5 Tone buzzer dimensional drawing

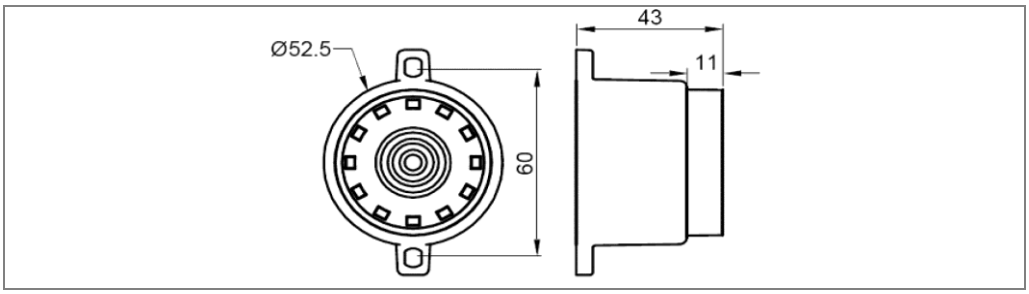
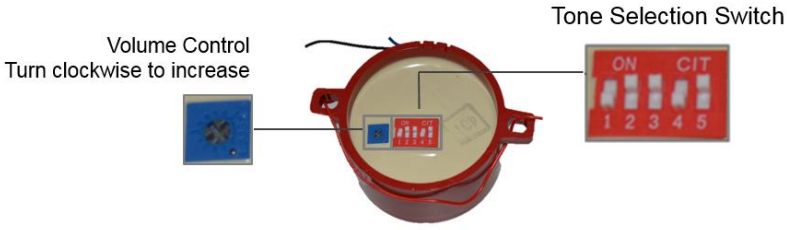


Fig. 56: Dimensional drawing of the tone buzzer

10.3 Tone selection for tone buzzer

Recommended settings when using the **red** and **blue** cable:
OFF, ON, ON, OFF, ON (01101)



The cable connections are as follows:
- Red cable is for +Vdc
- Black cable is the –V for tone stage 1
- Blue cable is the –V für tone stage 2

Fig. 57: Tone selection for tone buzzer

Tone selection table

No.	Tone		2nd Tone	Code 12345	Description	Typ current (avg mA)		Typ S.P.L ±2dBA at 1m	
						12V	24V	12V	24V
1	Alternating	800/970Hz at 2Hz	14	11111	BS5839 Part 1 1988	10	18	91	95
2	Sweeping	800/970Hz at 7Hz	14	11110	Fast sweep (LF) BS5839 Part 1 1988	10	18	94	97
3	Sweeping	800/970Hz at 1Hz	14	11101	Medium sweep (LF) BS5839 Part 1 1988	10	18	94	97
4	Continuous	2850Hz	14	11100		16	32	102	105
5	Sweeping	2400-2850Hz at 7Hz	4	11011	Fast sweep	18	30	101	106
6	Sweeping	2400-2850Hz at 1Hz	4	11010		17	30	101	106
7	Slow Whoop		14	11001	Slow whoop	12	20	92	96
8	Sweep	Sweep 1200-500Hz at 1Hz	14	11000	Din tone	9	16	91	95
9	Alternating	2400/2850Hz at 2Hz	4	10111		19	30	100	105
10	Intermittent	970Hz at 1Hz	14	10110	Back-up Alarm (LF) BS5839 Part 1 1988	9	12	89	93
11	Alternating	800/970Hz at 1Hz	14	10101	BS5839 Part 1 1988	10	18	90	95
12	Intermittent	2850Hz at 1Hz	4	10100	Back-up Alarm (HF)	14	24	101	105
13	Intermittent	970Hz at ½S on 1S off	14	10011	BS5839 Part 1 1988	5	8	85	90
14	Continuous	970Hz	14	10010	BS5839 Part 1 1988	11	20	90	94
15	Alternating	554Hz for 100mS and 440Hz for 400mS	14	10001	French Fire sound	7	12	86	91
16	Intermittent	660Hz 150mS On/150mS Off	16	10000	Swedish Alarm tone	6	9	83	88
17	Intermittent	660Hz for 1.8S On/1.8S Off	17	01111	Swedish Alarm tone	7	12	85	90
18	Intermittent	660Hz for 6.5S On/13S Off	18	01110	Swedish Alarm tone	8	14	86	91
19	Continuous	660Hz	19	01101	Swedish Alarm tone	8	14	86	91
20	Alternating	554/440Hz at 1Hz	20	01100	Swedish Alarm tone	7	13	86	91
21	Intermittent	660Hz at 1Hz	21	01011	Swedish Alarm tone	6	10	84	89
22	Intermittent	2850Hz 150mS On/100mS Off	14	01010	Pelican Crossing	13	22	100	105
23	Sweep	800-970Hz at 50Hz	14	01001	Low Frequency Buzz BS5839 Part 1 1988	10	18	92	96
24	Sweep	2400-2850Hz at 50Hz	4	01000	High Frequency Buzz	14	25	100	106
25	Intermittent	970Hz 500mS On/500mS Off	25	00111	ISO 8201 Low Frequency BS5839 Part 1 1988	9	14	88	92
26	Intermittent	2850Hz 500mS On/500mS Off	26	00110	ISO 8201 High Frequency	12	20	100	104
27	Continuous	4kHz	27	00101		18	35	97	101
28	Alternating	800/970 at 2Hz	10	00100	FP1063.1 - Telcom	10	17	91	95
29	Alternating	988/645 at 2Hz	988Hz	00011	Symphoni tones	8	17	90	97
30	Alternating	510/610 at 2Hz	510Hz	00010	Squashni Micro	6	12	91	98
31	Sweeping	300-1200 at 1Hz	31	00001		6	13	89	96
32	Continuous	4kHz	32	00000		18	35	97	101

Tab. 22: Tone selection table

11 Figures and tables

11.1 List of tables

11.2 List of figures

11.3 Keywords index

Australia
Phone +61 3 9457 0600
1800 334 802 – tollfree
E-Mail sales@sick.com.au

Belgium/Luxembourg
Phone +32 (0)2 466 55 66
E-Mail info@sick.be

Brasil
Phone +55 11 3215-4900
E-Mail sac@sick.com.br

Canada
Phone +1 905 771 14 44
E-Mail information@sick.com

Ceská Republika
Phone +420 2 57 91 18 50
E-Mail sick@sick.cz

China
Phone +86 4000 121 000
E-Mail info.china@sick.net.cn
Phone +852-2153 6300
E-Mail ghk@sick.com.hk

Danmark
Phone +45 45 82 64 00
E-Mail sick@sick.dk

Deutschland
Phone +49 211 5301-301
E-Mail kundenservice@sick.de

España
Phone +34 93 480 31 00
E-Mail info@sick.es

France
Phone +33 1 64 62 35 00
E-Mail info@sick.fr

Great Britain
Phone +44 (0)1727 831121
E-Mail info@sick.co.uk

India
Phone +91–22–4033 8333
E-Mail info@sick-india.com

Israel
Phone +972-4-6881000
E-Mail info@sick-sensors.com

Italia
Phone +39 02 27 43 41
E-Mail info@sick.it

Japan
Phone +81 (0)3 3358 1341
E-Mail support@sick.jp

Magyarország
Phone +36 1 371 2680
E-Mail office@sick.hu

Nederlands
Phone +31 (0)30 229 25 44
E-Mail info@sick.nl

Norge
Phone +47 67 81 50 00
E-Mail austefjord@sick.no

Österreich
Phone +43 (0)22 36 62 28 8-0
E-Mail office@sick.at

Polska
Phone +48 22 837 40 50
E-Mail info@sick.pl

România
Phone +40 356 171 120
E-Mail office@sick.ro

Russia
Phone +7-495-775-05-30
E-Mail info@sick.ru

Schweiz
Phone +41 41 619 29 39
E-Mail contact@sick.ch

Singapore
Phone +65 6744 3732
E-Mail admin@sicksgp.com.sg

Slovenija
Phone +386 (0)1-47 69 990
E-Mail office@sick.si

South Africa
Phone +27 11 472 3733
E-Mail info@sickautomation.co.za

South Korea
Phone +82 2 786 6321/4
E-Mail info@sickkorea.net

Suomi
Phone +358-9-25 15 800
E-Mail sick@sick.fi

Sverige
Phone +46 10 110 10 00
E-Mail info@sick.se

Taiwan
Phone +886 2 2375-6288
E-Mail sales@sick.com.tw

Türkiye
Phone +90 (216) 528 50 00
E-Mail info@sick.com.tr

United Arab Emirates
Phone +971 (0) 4 88 65 878
E-Mail info@sick.ae

USA/México
Phone +1(952) 941-6780
1 (800) 325-7425 – tollfree
E-Mail info@sickusa.com

More representatives and agencies
at **www.sick.com**

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