ROTOSCAN RS4-4

Laser Scanner for Personnel Protection and Measurement Tasks

Technical Description

50034330 - 08/2001 Subject to technical changes

TABLE OF CONTENTS

1 About This Technical Description

The technical description of the ROTOSCAN RS4-4 contains all information regarding proper use of the scanner as well as its engineering, mechanical and electrical installation, and startup. Additional information can be found in the operating instructions for the „RS4soft“ software package. Both of these sets of documentation, as well as the „RS4soft“ software, are supplied with every delivered system and are intended for use by the planners, operators and maintenance personnel of systems that are safeguarded by the ROTOSCAN RS4-4.

It is imperative that all information provided by both the technical description and the operating instructions, in particular the safety precautions, be strictly observed.

The technical description and the operating instructions must be kept in a safe place. They must also be easily accessible at all times during the entire service life of the scanner.

Safety precautions and warnings are designated by the symbol  .

Information on the safety of laser devices is designated by the symbol  .

Leuze lumiflex GmbH + Co. is not liable for damage resulting from improper use of its equipment.

Familiarity with this manual constitutes part of the knowledge required for proper use.

Version of the contents: V1.01

Leuze lumiflex GmbH + Co.
Ehrenbreitsteiner Str. 44
D-80993 Munich
Germany

2 Approvals and Certificates

2.1 Manufacturer Certification

2.2 Approval and Declaration of EC Conformity

EC prototype testing in accordance with
DIN EN 61496 - 1 and
IEC 61496 - 3

B I A
Berufsgenossenschaftliches Institut
für Arbeitssicherheit
(Trade Association Institute for Occupational Safety)
53757 Sankt Augustin
Germany

Prüf- und Zertifizierungsstelle
im BG-PRÜFZERT

European notified body
Identification number 0121

BIA
Berufsgenossenschaftliches
Institut für
Arbeitssicherheit

Hauptverband der gewerblichen
Berufsgenossenschaften

Translation

EC-Type Test Certificate

2001 1026
no. of certificate

Name and address of the holder of the certificate: (customer)	Leuze lumiflex GmbH & Co. Ehrenbreitsteiner Str. 44, 80993 München
Name and address of the manufacturer:	Leuze electronic GmbH & Co. In der Braike 1, 73277 Owen/Teck

Ref. of customer:	Ref. of Test and Certification Body:	Date of issue:
	PrüSch/ZI 1998 25009	20.04.2001

Product designation:	Electro-sensitive protective equipment Type 3 Laserscanner - Active opto-electronic protective device responsive to diffuse reflection (AOPDDR)
Type:	ROTOSCAN RS4-4
Intended purpose:	Area guarding for stationery and mobile applications for person detection (70 mm resolution).
Testing based on:	DIN EN 61496-1: 06.98 IEC 61496-3: 02.01 DIN V VDE 0801: 01.90 DIN V VDE 0801 A 1: 10.94 DIN 40839 Part 1: 10.92 DIN 40839 Part 3: 12.91 (Draft)
Remarks:	Meets Anforderungsklasse 4 according to DIN V VDE 0801 and is comparable to category 3 of DIN EN 954-1 in terms of safety. For further information on the software version and the hardware release see annex. In mobile applications only suitable for operation in systems with electrical motors.

The type tested complies with the provisions laid down in the directive 98/37/EC **(Machinery)**.

Further conditions are laid down in the Rules of Procedure for Testing and Certification of Oktober 1997.

Head of certification body

(Dr. S. Reinert)*

Certification officer

(Dr. M. Schaefer)

Postal address:
53754 Sankt Augustin

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Alte Heerstraße 111
53757 Sankt Augustin

Phone: 0 22 41/2 31-02
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EC-Declaration of Conformity

according to EC Machinery Directive 98/37/EU, Annex II C

We herewith declare,

Leuze lumiflex GmbH + Co.
Ehrenbreitsteiner Straße 44
D-80993 München

that the following described safety components in our delivered version complies with the appropriate basic safety and health requirements of the EC Machinery Directive 98/37/EU based on its design and type, as brought into circulation by us. In case of alteration of the safety components, not agreed upon by us, this declaration will lose its validity.

Description of the safety component:	**Laserscanner for safety at work and measurement**
Safety component Type:	**ROTOSCAN RS4-4**
Serial number:	see type plate
Safety category:	AOPDDR type 3
Safety function:	electronic sensitive protective device
Applicable directives and standards:	EC machinery directive (98/37/EU) EMC directive (89/336/EWG) DIN EN 60204-1 06.93 DIN EN 61496-1 06.98 IEC 61496-3 02.01 DIN EN 954-1 03.97 DIN V VDE 0801 01.90 and modification A1/10.94 EN 50082-2 02.96 EN 50081-2 03.94 DIN 40839 Teil 1 10.92 DIN 40839 Teil 2 12.91 draft
Notified body according to annex VII:	Berufsgenossenschaftliches Institut für Arbeitssicherheit (BIA) Alte Heerstraße 111 53757 Sankt Augustin
Charged to do:	EC - type examination Examination certificate no. **2001 1026**
CE-marking:	The compliance with the directives 73/23/EWG and 89/336/EWG is certified by the CE-mark.

Munich, April, 12, 2001

Beilke
(Managing Director)

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HRB 550. Geschäftsführer: Hans-Jochen Beilke, Michael Heyne
Vorsitzender des Verwaltungsrats: Meinert Hahnemann

2.3 Specialized Technical Terms and Abbreviations

AGV	Automatic guided vehicle
AOPD	Active optoelectronic protective device
AOPDDR	Active optoelectronic protective device responsive to diffuse reflection
BWS	See ESPE
ESPE	Electro-sensitive protecting equipment
FTF	See AGV
N.O.	Normal open contact
OSSD	Output signal switching device
PC	Personal computer
SF	Detection zone
Reset	Reset of the ROTOSCAN RS4-4
RS 232	RS 232 interface
RS 422	RS 422 interface
FP	Field pair (contains 1 x detection zone and 1 x warning field)
WF	Warning field

2.4 Guidelines and Standards

The following guidelines and standards are of critical importance for the implementation of laser scanners. Guidelines providing particularly relevant information for users of such systems are marked with an asterisk (*).

Guideline/Standard	Name	
European Guidelines		
98 / 37 / EG	Machine guideline	
73 / 23 / EWG	Low voltage guideline	
89 / 336 / EWG	EMC guideline	
A Standards		
DIN EN 292-1 und -2	Safety of machinery, basic concepts	
DIN EN 1050	Principles of risk assessment	*
B1 Standards		
DIN EN 294	Safety distances	*
DIN EN 954-1	Safety-related parts of controls	
DIN EN 999	Approach speeds of body parts	*
B2 Standards		
DIN EN 60204-1	Electrical equipment of machines	
DIN EN 60825-1	Safety of machines with laser components	
DIN EN 61496 -1	Electro-sensitive protecting equipment	*
IEC 61496-3	AOPDs responsive to diffuse reflection (AOPDDR)	*

Guideline/Standard	Name	
C Standards		
DIN EN 775	Industrial robots; safety	*
DIN EN 1525	Automatic guided vehicles (AGV) and their systems	*
DIN EN 12895	Automatic guided vehicles, electromagnetic compatibility	
National Standards		
DIN 15185-2	Warehousing systems using rail-guided aisle conveyance vehicles	*

This list does not claim to be complete. In certain cases, the concrete requirements of the application will necessitate the application of additional guidelines and standards! Copies of safety standards can be purchased from the Beuth Publishing Company in Berlin, Germany.

3 System Overview

3.1 Brief Description and Functional Principle of the ROTOSCAN RS4-4

The ROTOSCAN RS4-4 is an optical distance sensor that takes two-dimensional measurements. It could also be referred to as an optical area radar device. The sensor uses a rotating deflecting unit to periodically emit light pulses within a working range of 190°.

If these pulses strike a person or an obstacle, the reflected light is received and evaluated by the ROTOSCAN RS4-4. The scanner calculates the precise coordinates of the person or object based on the travel time of the reflected light and the current angle of the deflecting unit. If the person or obstacle is within the bounds of a previously defined area called a detection zone, a safety-oriented switching function is performed. This switching function causes the semiconductor outputs to be switched off. The safety-oriented switching function cannot be reset until the detection zone is clear. Depending on the operating mode, the reset can be initiated either automatically or manually.

SF = Detection zone, max. 4 m
WF = Warning field, max. 15 m
a = Maximum registration of measurement values, max. 50 m
b = Detection zone programmed in the ROTOSCAN RS4-4 (example)
c = Warning field programmed in the ROTOSCAN RS4-4 (example)
d = Configurable detection zone and warning field expansion (-5 °)
e = Configurable detection zone and warning field expansion (+5 °)
f = Object in the detection zone

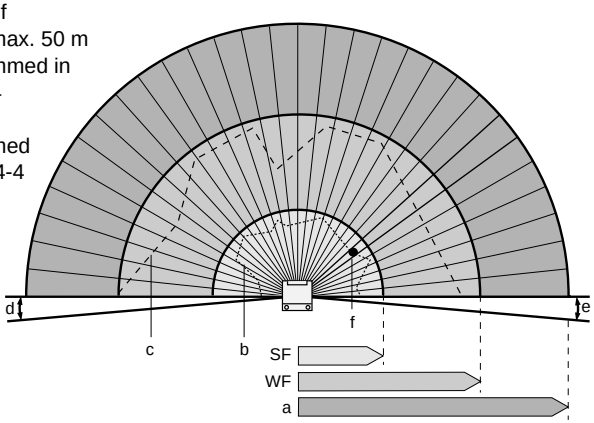


Fig. 1 The 190° angle range of the ROTOSCAN RS4-4 is divided into 0.36° angle segments.

A laser diode coupled with transmitter optics produces focused light pulses. These pulses are projected across the monitored surface by a rotating mirror in such a way that a light pulse is triggered in each of the angle segments within 40 ms (scanning rate: 25 scans/s).

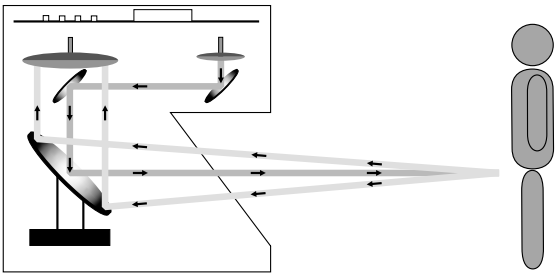


Fig. 2 Functional principle of the ROTOSCAN RS4-4

The ROTOSCAN RS4-4 can detect people up to a distance of 4.0 m (corresponds to the detection zone) – even if they are wearing very dark clothing or exhibit a low degree of reflectance. Dangerous movements are brought to a standstill by two failsafe semiconductor outputs.

Objects (min. 150 x 150 mm) are detected up to a distance of 15 m (corresponds to the warning field) and signaled by way of a non-safety-related semiconductor output.

Four programmable field pairs (each of which consists of one detection zone and one warning field) enable the scanner to be optimally adapted to the needs of each particular application.

The ROTOSCAN RS4-4 can be implemented not only on machines and systems (stationary safeguarding of danger zones), but also on vehicles (mobile safeguarding of transport vehicles).

Due to its wide range of measurement and its non-contact, electro-sensitive measurement principle, the ROTOSCAN RS4-4 can be effectively used as a protective device for virtually any application.

3.2 Special Features of the ROTOSCAN RS4-4

- Four freely programmable detection zones (up to a maximum of 4 m)
- Four freely programmable warning fields (up to a maximum of 15 m)
- Expanded monitoring range of up to 190 °
- Compact design (W x D x H: 140 mm x 135 mm x 155 mm)
- Low weight (2 kg)
- Low power requirements (300 mA, plus the load at the outputs [max. 25 W])
- Two types of interfaces at one Sub-D jack (RS232 and RS422)
- User-friendly software

4 Safety Precautions and Intended Use

4.1 General Safety Information

Leuze lumiflex products are developed and manufactured with careful attention to recognized codes of engineering practice. However, the protective function of the equipment can be impaired if the devices are used improperly or for any purpose other than the intended purpose. Such instances can jeopardize the health and lives of the personnel located in the area of the machine or system.

Caution: Laser radiation!
The ROTOSCAN RS4-4 is a laser device belonging to laser class 1. The valid legal and local regulations for operating laser systems must be complied with.

4.2 Operating Conditions and Proper Use

The relevant regulations for machine safety apply for the use of the ROTOSCAN RS4-4. The responsible authorities (e.g. trade associations, OSHA) are available to answer technical questions related to safety issues. In general, the following conditions for use must be complied with:

- If the scanner is enclosed in a protective housing, additional window material, such as plastic or glass must not be used as it may impair the detection.
- Avoid touching the scanner window and the six diffusing light screens.
- The ROTOSCAN RS4-4 is not suitable for use as a protective device:
  - if it is possible that dangerous fluids will be spewed out or objects will be ejected.
  - for machines with long braking times (max. depth of the detection zone: 4 m).

- For these cases, Leuze lumiflex offers suitable safety interlocking devices (safety switches) with and without guard locking.
- The ROTOSCAN RS4-4 corresponds to safety category 3 in accordance with EN 954-1. In order to maintain this level of safety, all elements in the safety chain, up to and including the stopping of the dangerous movement, must be selected and set up accordingly.
- Only electrical specialists are allowed to work on electrical systems.
- The 24 V DC power supply (+20 %, -30 %) must be provided by way of a safety transformer in accordance with IEC 742. The same requirements apply for all connected input and output circuits.
- The supply voltage must be provided to the scanner by way of a separate branch using a 1.25 A semi-delay fuse in the electronics cabinet.
- Guard operation is allowed only after the PC cable (X2) has been removed. The corresponding connector on the scanner must be protected with the provided dummy connector. This also applies for transport and storage.
- The safety output is equipped with double OSSDs. As a rule, both OSSDs must always be connected into the stop circuit of the machine so that each of the two is independently able to shut down the dangerous movement.
- Do not use the alarm output (pin 5 on X1) in order to switch safety-relevant signals.
- System tests (of the scanner, machine, control components and switch components) may only be performed when they do not result in potential hazards for people.
- Tampering with or making changes to the ROTOSCAN RS4-4 can result in the loss of the safety function.

- Only expert trained personnel is allowed to perform start-up, maintenance, parameter settings or detection zone configurations. Familiarity with the safety precautions in this Technical Description and in the operating instructions for the program „RS4soft“ constitutes part of this expert knowledge.
- The password required for configuring safety-relevant settings must be kept in a secure location by the safety official. Information about password levels can be found in the „RS4soft“ user manual.
- Using the scanner to control the passage of people through an area (vertical detection zone) in accordance with IEC 61496-3 is not admissible.

4.3 Restrictions for Use

- Glass, highly reflective materials such as mirrors (reflectance > 10,000 %), or objects that do not reflect any light back to the sensor can falsify the measurement result. For further information, refer to Chapter 6.3.5.
- Do not expose the ROTOSCAN RS4-4 to flying sparks (e.g. welding flash).
- Do not expose the ROTOSCAN RS4-4 to fog, rain or snow.
- Do not expose the ROTOSCAN RS4-4 to vapors, smoke or dust.
- Avoid extreme variations in temperature.
- Make sure that the following types of light sources are not present on the scanning plane:
  - Laser light from other scanners or sensors
  - Infrared light
  - Fluorescent light
  - Stroboscopic light

  Please see Chapter 6.2 for more information.

- The scanner may not be installed on vehicles with internal-combustion engines.
- The ROTOSCAN RS4-4 is conceived for use inside enclosed spaces and with the operating parameters listed in the technical specifications (temperature, humidity, shock, vibration, etc.). Please refer to the list of parameters in Chapter 15.
- Avoid having reflective surfaces (such as glass, mirrors, retro-reflectors, etc.) at fixed contours in the scanning plane. If this is not possible, a detection zone addition must be provided.

4.4 General Information On Defining the Contours of Detection Zones

- Shadow effects (e.g. surfaces or areas located behind stationary objects) must be considered.
  As a rule, insufficient safeguarding must be adequately supplemented by further safety measures such as barrier grids, light curtains, and the like!
- It must be impossible to step behind the detection zone in the direction of the danger zone.
- When setting the dimensions of the detection zone, you must comply with the formulas cited in Chapters 6.4.8 and 6.5.8! Be sure to comply with higher level machine standards (e.g. DIN EN 1525) if applicable.
  These contain individual specifications, for example, on points of access to the danger zone and, if applicable, detection zone additions that must be given special consideration.
  They also provide information on how to measure safety distances at machines.
- Detection zones with a radius smaller than 20 cm (at or close to the scanner) are not admissible. 20 cm is the preset minimum contour.
- When setting the dimensions of the detection zones, please comply with the maximum angle error stated in the technical specifications (Chapter 15.11).

- Pin-shaped detection zone contours are not admissible since they do not guarantee a protective function. For more detailed information, consult the „RS4soft“ user manual (Chapters 6.5.3 and 7.0).
- Due to possible measurement errors, every detection zone has an additions area in which detection is not guaranteed under all conditions. Please refer to Chapter 6.3.5.
  Read Chapters 6.4.6 and 6.5.6 for information on optimizing system availability.
- The required safety distances must be taken into account when making detection zone configurations. Safety distances are calculated according to formulas found in either the machine-specific C standards or the general B standards IEC 61496-3 in combination with DIN EN 999 (see Chapter 2.5). Tolerance fields and/or additions (see Chapters 6, 7 and 8) must be taken into account.
- After the detection zones have been set, make a printout of the following information:
  - Detection zone contour with the X and Y coordinates
  - Date
  - Serial number of the scanner
  - Name of the safety official
- When calculating the additions, be sure to consider whether the dust algorithm is deactivated or activated (see Chapter 6.3.5).
- When calculating the safety distances, be sure to consider all delay times, such as the response time of the scanner, response time of the control elements, and braking times and/or stopping times of the machine/system or AGV! Variations in delay time caused by factors such as reduced braking power must also be taken into consideration.
- The effectiveness of the switch-off function must be tested along the defined contour of the detection zone during the initial startup and subsequent to any changes made to a machine or system.

- The effectiveness of the switch-off function must be tested for the detection zone contours along the entire driving route during the initial startup and following any changes made to an AGV.
- In the event that there is insufficient room available to allow the full dimensions of a detection zone, additional safety measures (e.g. safety grids) must be installed.
- Following each definition of and change to the detection zones, the configuration must be checked to see whether the possibility of people standing in the danger zone as well as any barriers provided have been considered by an appropriate layout of the detection zone(s).

4.5 Additional Safety Precautions for Stationary Use

- If the danger zone can be accessed from the side, and if the detection zone cannot be extended sufficiently in this direction, additional safety measures (e.g. safety fences) must be installed.
- We recommended marking the contour of the detection zone on the floor by painting a colored line or applying colored adhesive tape.
- Check the mounting regularly (in particular, the angle of inclination) in order to guarantee the reliability of detection.

4.6 Additional Safety Precautions for Mobile Use

- There are additional requirements for the use of scanners on automatic guided vehicles (AGV) and transporter trolleys according to DIN EN 1525.
- If possible, (expanded detection zones to each side) should be provided in order to safeguard access from the side and directly in front of the vehicle.
- If is it not possible to completely safeguard the contour of the vehicle including its trailer and the dimensions of its load while making curves, additional protective devices such as switch strips must be attached to the side of the vehicle.
- A minimum safety distance S_{AB} of 500 mm to the side of the vehicle must be present on both sides. A one-sided minimum safety distance is admissible in certain exceptional cases. The specifications of DIN EN 1525 must be complied with.
- The basic value of the detection zone width for an AGV corresponds to the maximum vehicle width including the trailer and the dimensions of the load plus the detection zone additions Z_S. Furthermore, the greatest possible lateral shift of the AGV while making curves must be considered when defining detection zones.
- If the ROTOSCAN RS4-4 is mounted on vehicles, the mounting (especially the angle of inclination), the vehicles' braking power, and if applicable, play in the vehicle guidance (the difference between the optimum and actual line of guidance) must be regularly checked in order to guarantee the reliability of detection.

5 Applications for the ROTOSCAN RS4-4

Due to its continuous coverage of the area, its wide range, and the ability to select among four field pairs, the ROTOSCAN RS4-4 is able to handle even difficult applications.

5.1 Stationary Safeguarding of Danger Zones

The ROTOSCAN RS4-4 is used to safeguard dangerous working areas at machines and systems where both constant and variable demands are placed on the geometrical shape of the detection zone. The aim is to prevent people from entering the danger zone or reaching the danger point with their upper and/or lower extremities, at the same time without impeding the production process. The ROTOSCAN RS4-4 can be mounted directly at the machine table or on the side or in front of the machine.

SF1 = Detection zone 1, activated
SF2 = Detection zone 2, deactivated
WF1 = Warning field 1, activated
WF2 = Warning field 2, deactivated
a = Emergency stop and triggering of restart interlock
b = ROTOSCAN RS4-4

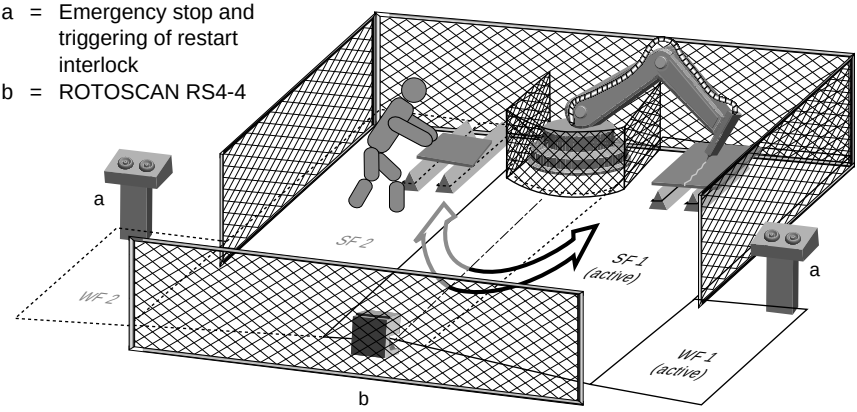


Fig. 3 Stationary danger zone monitoring of a robot with two alternating work areas (example)

An example for calculating the dimensions of the detection zone can be found in Chapter 6.4.8.

5.2 Mobile Safeguarding of Automatic Guided Vehicles

For this application, the ROTOSCAN RS4-4 is installed on automatic guided vehicles in order to monitor the vehicle path. The aim is to detect people or objects in the path of the vehicle and to automatically bring the vehicle to a halt. Safety systems available up to now, such as bumpers or safety bars, have allowed only very low driving speeds to be maintained. In contrast, using the ROTOSCAN RS4-4 as a non-contact „advance bumper“ results in the creation of a substantially larger safety zone. The vehicles can move faster, and down times are reduced to the necessary minimum.

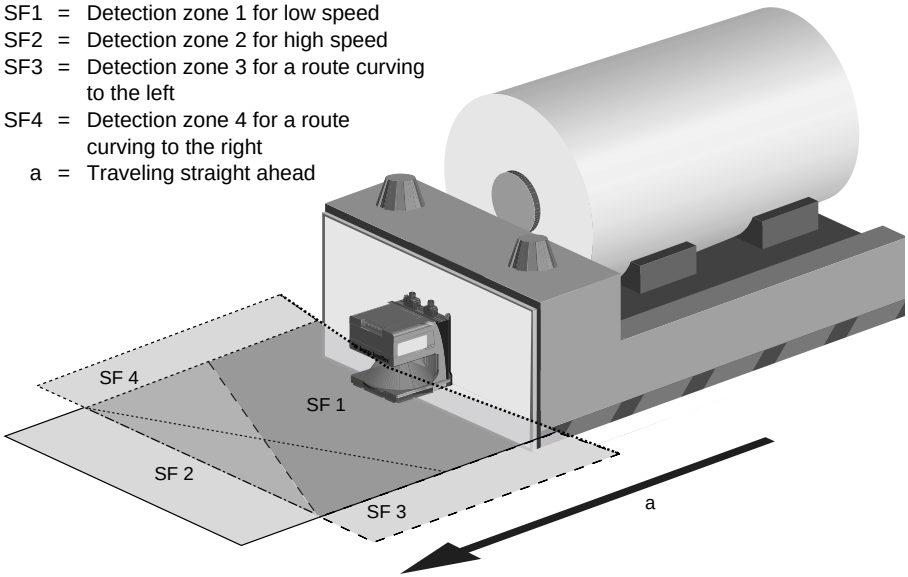


Fig. 4 Safeguarding an automatic guided vehicle (example)

An example for calculating the dimensions of the detection zone can be found in Chapter 8.

5.3 Protecting Transporter Trolleys against Collisions

Transporter trolleys are generally guided along a system of rails or grooves in the floor. Hence the vehicle paths are usually just slightly wider than the trolleys themselves. This represents an increased hazard for people, since it is impossible to get out of the way of the trolley. For this reason, transporter trolley are used in enclosed areas equipped with suitable access safeguarding.

SF1 = Detection zone 1 for slow speed
SF2 = Detection zone 2 for high speed
a = Emergency stop and triggering of restart interlock
b = Direction of travel
c = Undercut

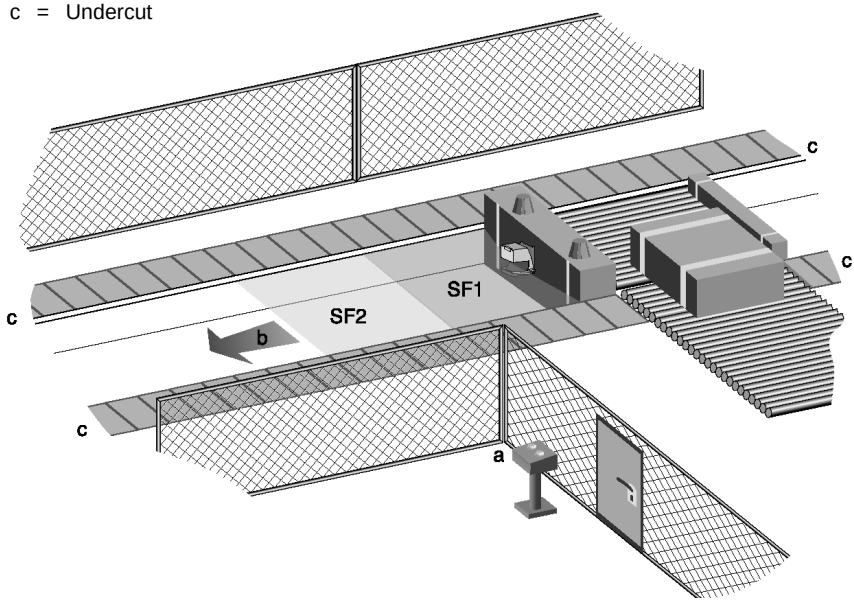


Fig. 5 Safeguarding a transporter trolley (example)

In these cases, the ROTOSCAN RS4-4 is used to detect people or objects in the vehicle path and then automatically bring the vehicle to a halt. The operating mode „with restart interlock" must be selected.

The demands placed on the geometrical shape of the detection zone are determined by the vehicle width, speed, stopping distance and response time. Here as well, factors such as additions in the direction of travel for tolerances in the measurement value and reduced braking power due to wear and tear must be taken into consideration.

5.4 Other Possible Applications

- Object and contour measurement
- Logistics (counting, measuring, controlling)
- Access control (detecting or counting people)
- Projection control (e.g. in fully automatic parking ramps or lots)
- Safeguarding or monitoring enclosed spaces
- and many more

6 Information for Planning and Mounting

It is essential that the following key points be complied with so that the ROTOSCAN RS4-4 can provide optimum performance:

- The ROTOSCAN RS4-4 must be placed so that areas of access to the danger zone being monitored are completely covered by the detection zone.
- The mounting position of the scanner should provide protection from humidity, dirt and extreme temperatures below 0° C or over 50° C.
- The mounting position must be selected in such a way as to minimize the possibility of mechanical damage. Additional protective cover panels or safety bars must be installed at exposed positions.
- Reinforcements, cover panels, mounting niches, and other machine elements may not in any way impair the field of view of the scanner.
- If there are areas of shadow caused by fixed obstacles that were defined as part of the detection zone boundary, these must be safeguarded (e.g. by safety grids) in order to prevent people standing in them from being able to suddenly enter the detection zone. This point must be taken into account in the hazard analysis of the machine or system.
- Be sure that there are no retro-reflectors or highly reflective surfaces made of metal or ceramic in the area of the detection zone and at the height of the scanning plane. Such objects can cause measurement errors.
- In order to ensure a consistent detection height at every point of the detection zone, the scanner – and hence the scanning plane – must be placed in a horizontal position.
- If the function „restart interlock“ is available, the restart button must be placed outside of the detection zone at a position from which the entire danger zone can be viewed.

6.1 Attachment and Dimensions

For attaching the ROTOSCAN RS4-4, four drill holes are located at the back of the unit.

The mounting set RS4-MS is available as an accessory. It offers the following benefits to the user:

- Speeds up the mounting process by providing screws that are accessible from the front.
- Allows vertical inclinations of up to 9°, either up or down, infinitely adjustable within this range.
- Allows lateral tilting of up to approx. 9° to either side from the midpoint setting, infinitely adjustable within this range.
- Enables quick replacement of the scanner without requiring realignment.

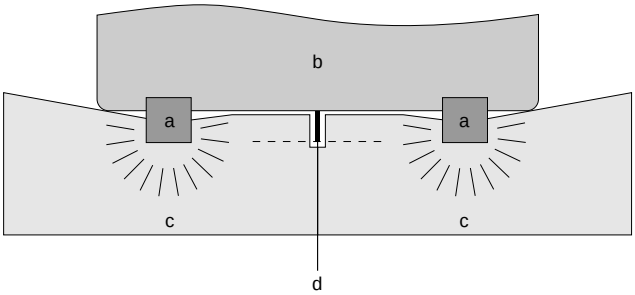
Please refer to the inside back cover to find out which parts and dimensions are required for mounting.

6.2 Mounting Adjacent Sensors

In order to prevent erroneous switch-offs caused by mutual influence between adjacent sensors, the following points must be taken into consideration:

6.2.1 Direct irradiation

To prevent the direct irradiation of outside light by a second sensor of the same type (laser light wavelength: 905 nm), a shield plate must be installed in the scanning plane. It is sufficient to place this shield at the height of the scanner window and flush with the front edge of the housing.



a = ROTOSCAN RS4-4
b = Machine (view from above)
c = Detection zones
d = Shield plate, flush with the housing

Fig. 6 Shielding to prevent direct irradiation

6.2.2 Indirect irradiation

If multiple laser-supported systems are in use, the mutual influence of beams reflected by objects in the area cannot be completely excluded. This effect can easily be prevented by staggering the levels at which the laser devices are mounted. A height differential of 100 mm, based on a distance of 4 m between objects, is sufficient.

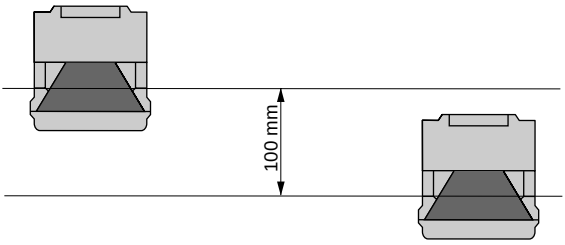


Fig. 7 Staggered mounting heights to prevent indirect irradiation

6.3 Information on Setting the Dimensions of Detection Zones

The hazards caused by machines and systems place a wide range of demands on safety distances and detection zones which must be appropriately defined.

6.3.1 Methods for configuring detection zones using the PC

With its user program „RS4soft“, the ROTOSCAN RS4-4 offers various methods for setting the configurations of detection zones.

Numerical input

A separate dialogue within the user program „RS4soft“ allows the right, left and front edges of the detection zone to be set using numerical values in mm.

Graphic input

A separate dialogue within the user program „RS4soft“ allows the basic contours of the detection zone to be entered. The contours can be adapted infinitely to the desired size of the detection zone. The following shapes are available:

- circle
- rectangle
- polygon

In addition, the contours can be infinitely varied by:

- changing
- limiting and
- deleting

partial segments as desired.

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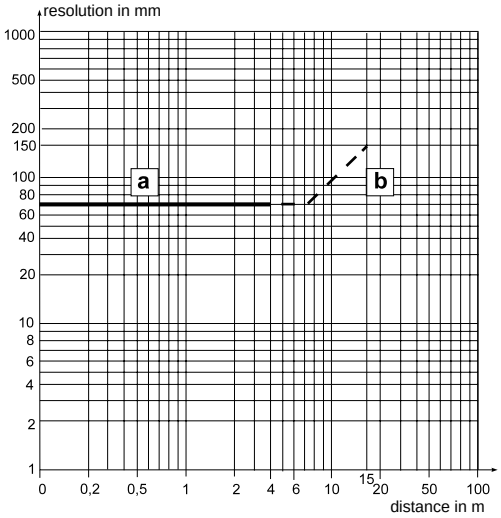
6.3.2 Range of the detection zone, resolution

The maximum range of the detection zone S_{MAX} may not exceed 4 m (including the additions) for an object with a diameter of 70 mm and a reflectance factor of 1.8 % (e.g. black corduroy).

6.3.3 Range of the warning field, resolution

A maximum range of 10 meters is available for an object with a diameter of 100 mm. The maximum available range for an object with a diameter of 150 mm is 15 meters. Both of these figures assume a reflectance factor of 20 %.



a = Detection zone
b = Warning field

Fig. 8 Detecting objects in the detection zone and in the warning field

6.3.4 Measurement field range

The maximum distance for contour measurement at a reflectance factor of 20 % is 50 m.

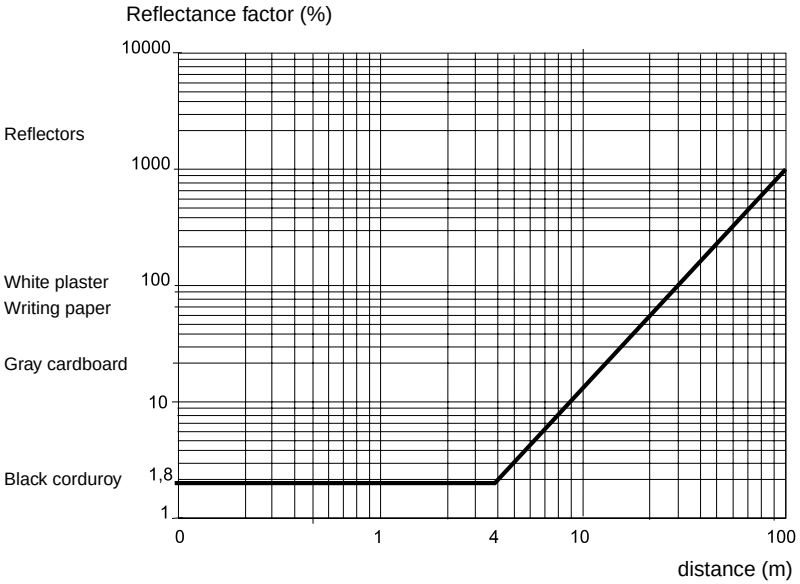


Fig. 9 Detection of objects depending on the reflectance factor

6.3.5 Required detection zone additions Z

The ROTOSCAN RS4-4 is equipped with a selectable dust algorithm to ensure optimum freedom from interference.

The following detection zone additions must be taken into account:

Addition Z_{SM} for deactivated dust suppression	81 mm
Addition Z_{SM} for activated dust suppression	81 mm (for a detection zone size < 3.5 m) 98 mm (for a detection zone size > 3.5 m)

Information on activating and deactivating this function is located in the „RS4soft“ user manual.

If retro-reflectors or very shiny surfaces, such as certain metals or ceramics, may be present in the scanning plane, the following table applies:

Addition Z_{REFL} if retro-reflectors or very shiny, surface-treated materials (e.g. metals and ceramics) are present in the scanning plane	0 mm for reflectors more than 1.2 m behind the detection zone line 110 mm for reflectors up to 1.2 m behind the detection zone line

$$\mathbf{Z = Z_{SM} + Z_{REFL}}$$

Z = Required detection zone addition, in mm
Z_{SM} = Measurement error of the scanner, in mm
Z_{REFL} = Addition for considering reflectors, in mm

6.4 Safeguarding Stationary Danger Zones

Please comply with the safety precautions in Chapter 4.

6.4.1 Purpose of safeguarding

- to protect people when entering a danger zone
- to protect people from reaching a danger point with their extremities
- to protect objects from the danger of collision due to variable machine or part movements.

6.4.2 Mounting position

The ROTOSCAN RS4-4 can be mounted either in a stationary position (e.g. on a wall or a machine) or on moving parts (e.g. machine table).

The qualified installer must ensure that the mounting position of the ROTOSCAN RS4-4 allows the danger zone to be monitored completely.

If a restart button is being used, make certain that the entire detection zone area can be viewed by the person pressing the button.

Refer to the safety precautions in Chapter 4.5 with regard to lateral access into the danger zone.

6.4.3 Mounting height

According to DIN EN 999, the lowest admissible height of the scanning plane for people, as measured from the base level, is calculated according to the following formula:

$$\mathbf{H_{MIN} = 15 * (d - 50\ mm)}$$

H_{MIN} = Lowest admissible scanning plane from the base level

d = Resolution of the scanner in mm (object size = 70 mm throughout the detection zone).

The admissible height range of the RS4-4 scanning plane lies between 300 and 1000 mm above the base level. If the application requires a scanning plane higher than 300 mm, or if children have access to the area, the analysis of the danger zone must consider the hazard caused by persons crawling below the scanning plane.

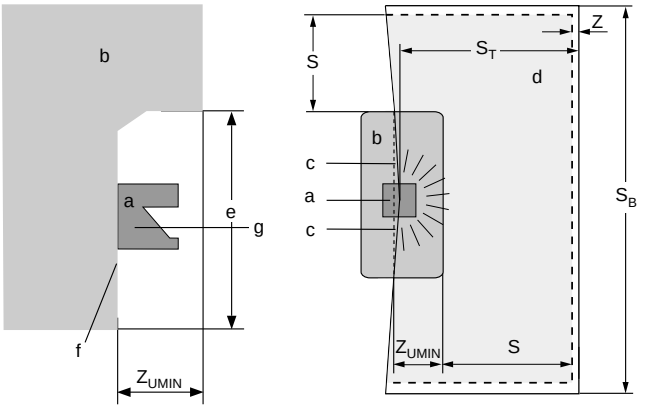
6.4.4 Mounting recommendations for preventing unmonitored zones

Unmonitored zones can result if the scanner is mounted onto a protruding attachment or if the contour of the machine/system is varied in depth.

6.4.4.1 Recessed installation (undercut) under the machine table

The undercut must be at least as deep as the zone not monitored by the detection zone lateral to and in front of the scanner. The minimum depth Z_{UMIN} is 135 mm. If is it possible to recess the scanner, this is allowed up to a maximum of 40 mm; the depth of the undercut is reduced by the depth value of the recess. If the mounting system is being used, the necessary dimensions of the undercut depth must be increased accordingly (see inside back cover). The height of the undercut must be limited to prevent people from being able to step beneath it.

Machine (side view) Machine (view from above)



a = ROTOSCAN RS4-4
b = Machine
c = Unmonitored zone
d = Detection zone
e = Height of the undercut
f = Mounting surface
g = Scanning plane

S = Safety distance
S_B = Entire width of the detection zone
S_T = Depth of the detection zone
Z = Detection zone additions
Z_{UMIN} = Depth of the undercut

Fig. 10 Recessed scanner installation with undercut

The additional safeguarding required for the particular application must be taken into account.

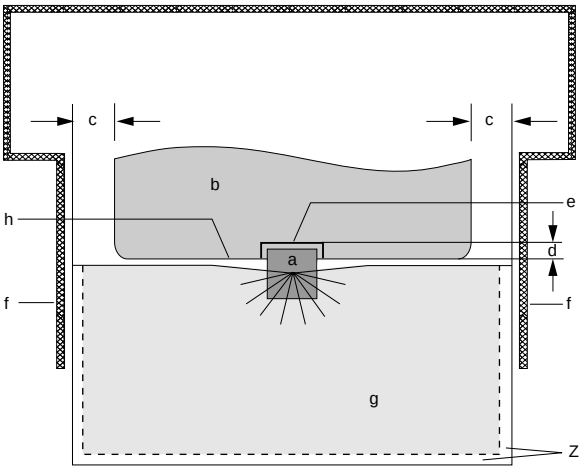
Please note that the undercut must cover any unmonitored zones.

6.4.4.2 Recessed installation within the machine contour

Furthermore, the scanner can be recessed into the contours of a machine. The recess can have a depth of up to 40 mm without the mounting system RS4-MS, or up to 65 mm with the mounting system RS4-MS. This is in reference to detection zones that cover an angle range of 180°. If it is not possible to comply with these values, or if unmonitored zones result due to the shape or movement of the machine, additional safety measures must be taken.

The effectiveness of the detection zones can be optimized by changing the depth at which the scanner is installed, or by adjusting the angle range (e.g. from 180° to 190°). If after such changes have been made the danger zone analysis indicates that the dead zone is covered by the detection zone, additional safeguarding measures need not be taken for this zone.

For information on how to configure the scanner in this way, please refer to the „RS4soft“ user manual.



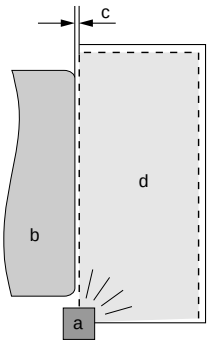
a = ROTOSCAN RS4-4
b = Machine
c = Lateral unmonitored zones
d = Maximum recessing (40 mm)
e = Installation niche
f = Lateral access safe guarding, if needed
g = Detection zone
h = Front machine edge
Z = Detection zone addition

Fig. 11 Recessed installation within the machine contour

Unmonitored zones require the use of restart interlock.

If it is not possible to mount the ROTOSCAN RS4-4 directly onto the machine, it can also be positioned lateral to or across from the machine.

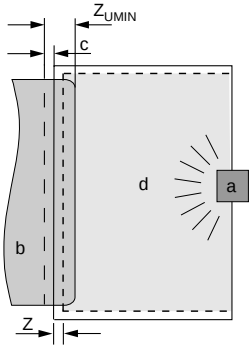
6.4.4.3 External mounting lateral to or across from the machine



a = ROTOSCAN RS4-4
b = Machine
c = Distance, max. 35 mm
d = Detection zone

Fig. 12 Lateral external scanner mounting without an undercut

If the machine contour runs parallel to the 90° beam of the laterally placed RS4-4, the distance between the detection zone boundary and the machine may not exceed 35 mm.



a = ROTOSCAN RS4-4
b = Machine
c = Minimum distance from the environment
d = Detection zone
Z = Required detection zone additions
Z_{UMIN} = Minimum depth of the undercut

Fig. 13 Mounting the scanner across from the machine with an undercut

6.4.5 Additions

The axis of the rotating mirror (midpoint of the scanner) is of critical importance when configuring the detection zones. This axis is assigned a value of 67 mm from the front edge of the scanner when calculating detection zones.

Add **81 mm** or **98 mm** for the maximum radial measurement error as described in Chapter 6.3.5.

Add an addition Z_{REFL} as described in Chapter 6.3.5 if reflectors could be present in the area.

Please note that safety additions must principally be added to the safety distance throughout the entire detection zone. In other words, additions may not be added to just one side or only to certain sections.

Please consult the operating instructions provided by the machine or system manufacturer.

6.4.6 System availability

There must be a buffer distance of 81 mm between the surrounding contour and the detection zone contour (including the additions). This distance increases the up-time of the machine or system since it prevents the surrounding contour from being detected as relevant for generating a switch-off signal. If there is an undercut across from the scanner that is impossible for a person to step beneath (see Fig. 13), the depth of the undercut can be calculated according to the following formula:

$$\mathbf{Z_{UMIN} = Z + 81\ mm - d}$$

Z_{UMIN} = Depth of the undercut, in mm
Z = Required detection zone additions, in mm
d = Resolution of the scanner (d = 70 mm)

This is possible since it is absolutely certain that a person in front of the undercut will be detected.

Furthermore, the dust algorithm of the RS4-4 can be implemented if floating particles may be present in the area. This algorithm, which can be activated in the user program „RS4soft“, prevents the machine or system from being switched off unintentionally. Please refer to Chapter 6.3.5.

If the danger zone analysis allows a multiple evaluation, detection errors caused by floating particles can be decreased. The number of evaluations that is decisive for the response time of the scanner (T_{SCAN}), and thus also requires a larger detection zone, can be set in the user program „RS4soft“.

6.4.7 Restart interlock

The ROTOSCAN RS4-4 is equipped with a restart interlock function. This function, which can be selected or unselected, links the restart of the machine to a manual approval if it is possible to leave the detection zone in the direction of the danger point. For information on how to set the scanner appropriately, please refer to „RS4soft“ user manual (Chapter 6.5.3).

The restart button must be mounted so that

- the entire danger zone (or detection zone area) can be viewed from the operating position.
- it is not possible to directly step or reach into the danger zone or danger point from the operating position.

6.4.8 Calculating the detection zone dimensions for safeguarding an area

According to **IEC 61496-3** and **DIN EN 999**, the following formulas apply for calculating the safety distance and the minimum depth of the detection zone when the direction of approach runs parallel to the detection zone:

S = (K x T) + C
C = 1200 mm – 0,4 H

C_{MIN} = 850 mm
H_{MIN} = 15 (d – 50 mm)
H_{MAX} = 1000 mm

S = Safety distance, minimum distance from the danger zone to the point of detection, to the plane of detection, or to the detection zone, in mm
K = Approach speed of a person or one of their body parts (1600 mm/s), in mm/s
T = Lag time of the entire system (response time and braking time until standstill), in s
C = Safety-related constant to consider entry into the danger zone before the protective device is triggered, in mm
C_{MIN} = Minimum value of the safety-related constant (850 mm), in mm
H = Height of the scanning plane from the reference point, in mm
H_{MIN} = Minimum height of the scanning plane from the reference plane, in mm
H_{MAX} = Maximum height of the scanning plane from the reference plane, in mm
d = Resolution of the scanner (70 mm throughout the detection zone), in mm

6.4.8.1 Additions and minimum depth of the detection zone

The sum of the system-specific and application-specific detection zone additions (see Chapter 6.3.5) is calculated according to the following formula:

$$\mathbf{Z_{GES} = Z_{SM} + Z_{REFL} + Z_{AU}}$$

Z_{GES} = Sum of the system-specific and application-specific detection zone additions, in mm
Z_{SM} = Measurement error of the scanner, in mm
Z_{REFL} = Addition for considering reflectors, in mm

Z_{AU} = Addition for application-specific undercut, in mm

The depth of the detection zone, with reference to the direct distance between the danger zone and the detection point or line, is calculated according to the following formula:

$$\mathbf{S_T = (K \times (T_{SCAN} + T_{MASCH} + (T_{NACHLAUF} \times L_{NACHLAUF}))) + C + Z_{GES}}$$

S_T = Depth of the detection zone, distance from the danger zone to the point or line of detection, including the system- and application-specific additions, in mm
K = Approach speed of a person or one of their body parts (1600 mm/s), in mm/s
T_{SCAN} = Response time of the scanner, in s
T_{MASCH} = Response time of the machine or system, in s
$T_{NACHLAUF}$ = Lag time of the entire system, in s
$L_{NACHLAUF}$ = Factor for increases in lag time
C = Safety-related constant, in mm

6.4.8.2 Maximum range of the detection zone

$$S_{MAX} = \sqrt{S_T^2 + S_{BDIFF}^2}$$

$$S_{BDIFF} = G_{BDIFF} + S + Z$$

S_{MAX} = Maximum range of the detection zone considering the diagonals, in mm

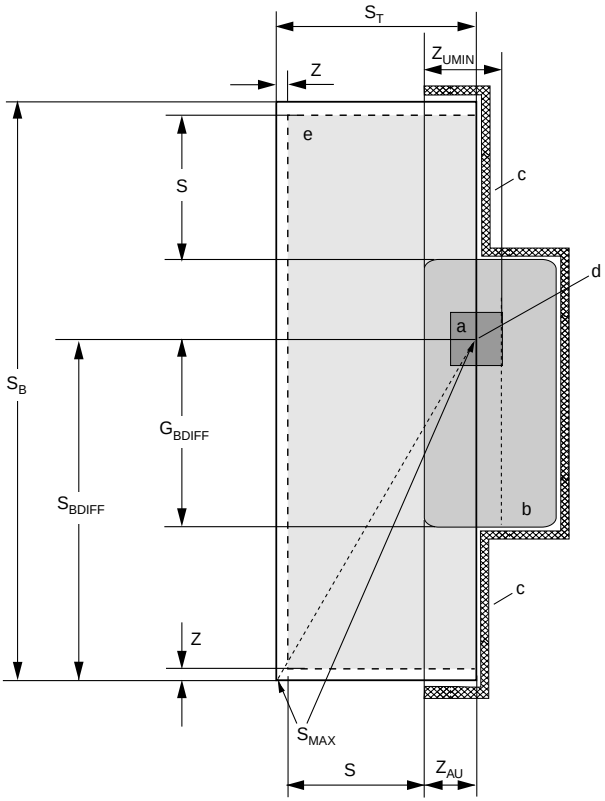
S_T = Depth of the detection zone, in mm

S_{BDIFF} = Largest width of the detection zone between the axis of the rotating mirror and the outer edge of the detection zone, in mm

G_{BDIFF} = Largest width of the danger zone between the axis of the rotating mirror and the boundary of the danger zone, in mm

S = Safety distance, minimum distance from the danger zone to the point of detection, to the plane of detection, or to the detection zone, in mm

Z = Required detection zone additions, in mm



a = ROTOSCAN RS4-4
b = Dangerous machine/danger zone
c = Safety fence to prevent stepping behind
d = Axis of the rotating mirror
e = Detection zone
G_{BDIFF} = Largest width of the danger zone
S = Safety distance
S_B = Entire width of the detection zone
S_{BDIFF} = Largest width of the detection zone
S_{MAX} = Geometrical maximum distance
S_T = Depth of the detection zone
Z_{AU} = Detection zone addition, application-specific
Z = Detection zone additions
Z_{UMIN} = Undercut

Fig. 14 Considering the maximum measurement distance when safeguarding an area

6.4.8.3 Example for calculating the depth of a detection zone

This example is based on the following application data (see Fig. 14):

Largest width between the axis of the rotating mirror and the boundary of the danger zone	G_{BDIFF}	700 mm
Access speed	K	1600 mm/s (constant)
Response time of the RS4-4 (adjustable)	T_{SCAN}	0.08 s
Response time of the machine or system	T_{MASCH}	0.1 s
Stopping time or lag time of the machine or system	$T_{NACHLAUF}$	0.5 s (time for braking the dangerous movement until standstill)
Factor for increase in lag time	$L_{NACHLAUF}$	1.1 (fixed addition to account for increased lag time)
Addition for system-specific measurement error	Z_{SM}	81 mm (when dust algorithm is switched off)
Addition caused by the mounting position	Z_{AU}	125 mm (distance between the front edge of the undercut to the beam axis of the scanner)
Height of the sensor scanning plane	H	300 mm
Safety-related constant	C	1200 mm - 0,4 * Height H = 1080 mm

The formula
$S = (K \times (T_{SCAN} + T_{MASCH} + (T_{NACHLAUF} \times L_{NACHLAUF}))) + C$

results in the safety distance:

$S = (1600\ mm/s * (0{,}08\ s + 0{,}1\ s + (0{,}5\ s * 1{,}1))) + 1080\ mm = 2248\ mm$

The formula
$S_T = S + Z_{SM} + Z_{AU}$

results in the detection zone depth:

$S_T = 2248\ mm + 81\ mm + 125\ mm = 2454\ mm$

6.4.8.4 Example for calculating maximum detection zone range

The formula:

$$_{MAX} = \sqrt{S_T^2 + S_{BDIFF}^2}$$

$S_{BDIFF} = G_{BDIFF} + S + Z_{SM}$

including the width of the danger zone, results in the maximum distance to be monitored:

$$S_{MAX} = \sqrt{2454\,mm^2 + 3029\,mm^2}$$

$S_{BDIFF} = 700\ mm + 2248\ mm + 81\ mm = 3029\ mm$

$S_{MAX} = 3899\ mm$

6.4.8.5 Example for calculating an undercut

This example is based on the following application data. If the scanner is mounted across from the machine (see Fig. 13), the undercut dimension can be reduced by d = 70 mm.

The formula
$Z_{UMIN} = Z + 81\ mm - d$

results in a minimum undercut:

$Z_{UMIN} = 81\ mm + 81\ mm - 70\ mm = 92\ mm$

It is not allowed for a person to be able to step beneath the undercut.

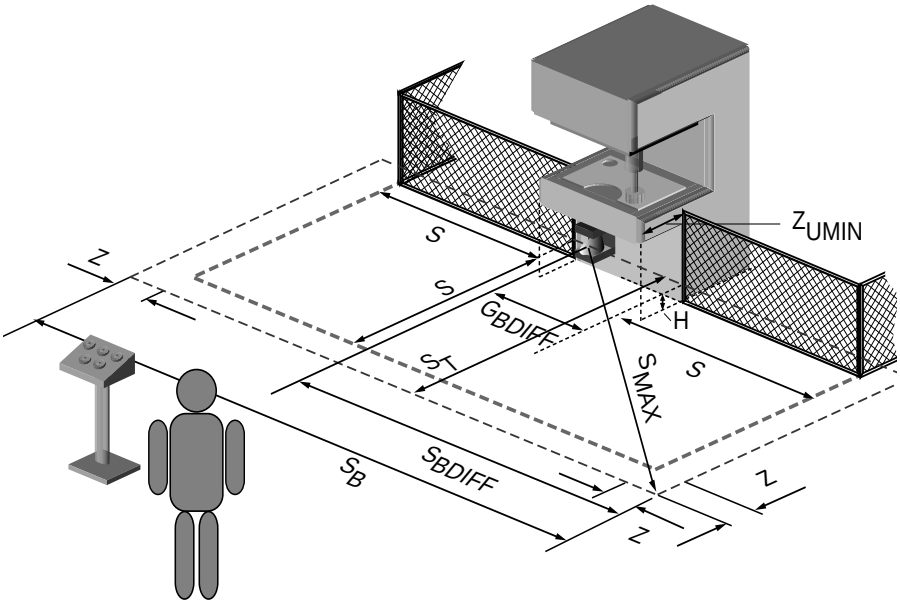


Fig. 15 The undercut

6.5 Safeguarding Mobile Machines

Please comply with the safety precautions in Chapter 4.

6.5.1 Purpose of safeguarding

- to protect people when entering variable danger zones
- to protect objects located in the vehicle path
- to protect the automatic guided vehicle and its load

6.5.2 Mounting position

For the purpose of safeguarding the path of a vehicle, the ROTOSCAN RS4-4 is mounted on the front of a vehicle (in each direction of travel), preferably in the center.

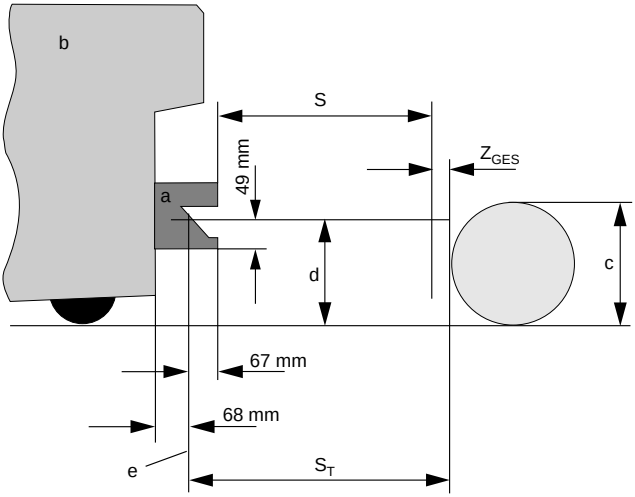
The scanner, and hence the beam axis, must be aligned horizontally in order to achieve a consistent scanning height.

Please comply with the safety precautions in Chapter 4.6.

6.5.3 Mounting height

As a rule, the scanner should be mounted as low as possible in order to prevent people from crawling beneath the detection zone. This specification is limited due to such factors as uneven floors or the deflection of the springs in the AGV.

The maximum mounting height must be selected so that an object (cylinder with a diameter of 200 mm in the prone position) is reliably detected (see DIN EN 1525). The detection must be tested at the position of maximum depth within the detection zone. For AGV applications, sufficient resolution of detection is achieved when an object (upright cylinder) with a diameter of 70 mm can be detected throughout the detection zone.



a = ROTOSCAN RS4-4
b = AGV
c = Height of the test piece, max. 200 mm
d = Recommended maximum height of the scanning plane: 150 mm
e = Axis of the rotating mirror
S = Safety distance
S_T = Depth of the detection zone
Z_{GES} = Detection zone additions in the direction of travel

Fig. 16 Mounting height on an AGV

Depending on the application, further additions may be necessary. Consult Chapter 6.5.5 for more information.

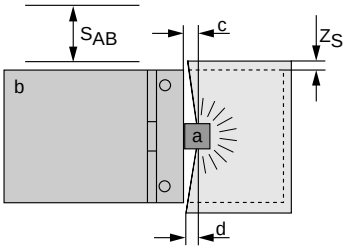
6.5.4 Recommendations for mounting in order to prevent unmonitored zones

The creation of unmonitored zones is dependent upon the following factors:

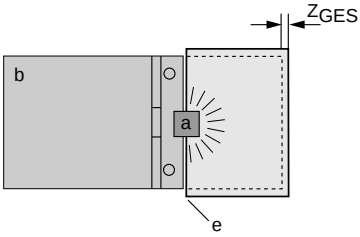
- the vehicle width
- the design of the vehicle (e.g. attachments, shape)
- the position of the scanner
- the installation depth
- the selected angle range.

If the detection zone of a ROTOSCAN RS4-4 mounted on an AGV does not cover the entire front of the vehicle, you can prevent the creation of unmonitored zones by changing the installation depth of the scanner or by adjusting the angle range (from 180° to 190°).

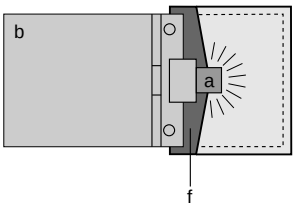
If this is not possible due to constructional limitations, additional safety measures such as mechanical cover panels, switch strips or bumpers must be implemented. Please refer to the safety precautions in Chapter 4.6.



ROTOSCAN RS4-4 mounted on the front of a vehicle



ROTOSCAN RS4-4 recessed into the front of a vehicle



ROTOSCAN RS4-4 mounted on a protruding vehicle attachment

a = ROTOSCAN RS4-4
b = Automatic guided vehicle
c = The distance from the back wall of the scanner to the axis of the rotating mirror is 68 mm.
d = The 190° detection zone enables an expanded monitored range.
e = The detection zone is limited by the scanner recess at the front of the vehicle (180°).
f = The protruding attachment results in the creation of unmonitored zones.
S_{AB} = Lateral safety distance (between the edge of the roadway and the boundary of the detection zone).
Z_{GES} = Sum of the system- and application-specific additions in the direction of travel
Z_S = Sum of the system- and application-specific additions to the side

Fig. 17 Three possibilities for mounting the ROTOSCAN RS4-4 onto an AGV

6.5.5 Additions

The axis of the rotating mirror (midpoint of the scanner) is of critical importance when configuring the detection zones. This axis is assigned a value of 67 mm from the front edge of the scanner when calculating detection zones.

Add **81 mm** or **98 mm** for the maximum radial measurement error as described in Chapter 6.3.5.

Add an addition Z_{REFL} as described in Chapter 6.3.5 if reflectors could be present in the area.

Without information from the AGV manufacturer, take into account the wear and tear on the brakes by adding an addition L_{ANHALT} of at least 10 % of the braking distance, as long as this is not already included in the braking distance S_{ANHALT}.

If there is a very small distance between the bottom of the AGV and the floor, the detection difference between the leg and the toes must be considered in the calculation. For AGVs with a floor clearance of less than 120 mm, an addition Z_{AFUSS} must be added (as shown in the following diagram) for the direction of travel only.

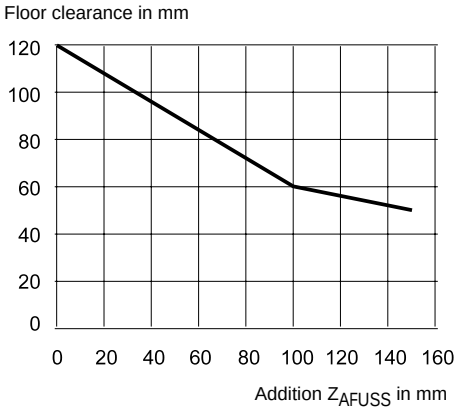


Fig. 18 Diagram for calculating the addition to compensate for inadequate AGV floor clearance

6.5.6 System availability

There must be a buffer distance of 81 mm between the surrounding contour and the detection zone contour (including the additions). This distance increases the up-time of the AGV, since it prevents the surrounding contour from being detected as relevant for generating a switch-off signal due to a measurement error.

Furthermore, the dust algorithm of the RS4-4 can be implemented if floating particles may be present in the area. This algorithm can be activated in the user program „RS4soft“ and prevents the AGV from being switched off unintentionally. Please refer to Chapter 6.3.5.

If the danger zone analysis allows a multiple evaluation, detection errors caused by floating particles can be decreased. The number of evaluations that is decisive for the response time of the scanner (T_{SCAN}), and thus also requires a larger detection zone, can be set in the user program „RS4soft“.

6.5.7 Restart

At least 2 seconds must elapse following the release of a violated detection zone before the AGV is allowed to start up again (in accordance with DIN EN 1525). The restart can be initiated either manually or automatically. In case of automatic restart, the delay time of up to 10 s can be set in advance using the program „RS4soft“. If a restart button is provided, it must be mounted outside the danger zone at a position from which the entire danger zone can be viewed.

6.5.8 Calculating the dimensions of the detection zone for an AGV Application

Following are the specifications and calculation examples for the mobile safeguarding of automatic guided vehicles.

According to **IEC 61496-3**, the following formulas apply for calculating the safety distance:

$$\mathbf{S = (V_{MAX} \times T) + S_{ANHALT}}$$

V_{MAXFTF} = Maximum speed of the AGV, in mm/s
T = Response time of the scanner and the AGV, in s
S_{ANHALT} = Braking distance of the AGV until standstill, in mm

6.5.8.1 Direction-related minimum depth of the detection zone and additions

The depth of the detection zone in the direction of travel, with respect to the distance between the edge of the roadway and the boundary of the detection zone, is calculated according to the following formula:

$$S_T = V_{MAXFTF} \times (T_{SCAN} + T_{FTF}) + (S_{ANHALT} \times L_{ANHALT}) + Z_{GES}$$

S_T = Depth of the detection zone in the direction of travel, in mm
V_{MAXFTF} = Maximum speed of the AGV, in mm/s
T_{SCAN} = Response time of the scanner, in s
T_{FTF} = Response time of the AGV, in s
L_{ANHALT} = Factor for wear and tear on the brakes
Z_{GES} = Sum of the system-specific and application-specific additions, in mm

$$Z_{GES} = Z_{SM} + Z_{REFL} + Z_{AFUSS} + Z_{AU}$$

Z_{SM} = Measurement error of the scanner, in mm
Z_{REFL} = Addition for considering reflectors, in mm
Z_{AFUSS} = Addition for inadequate floor clearance by the AGV, in mm
Z_{AU} = Application-specific addition, in mm

6.5.8.2 Maximum range of the detection zone

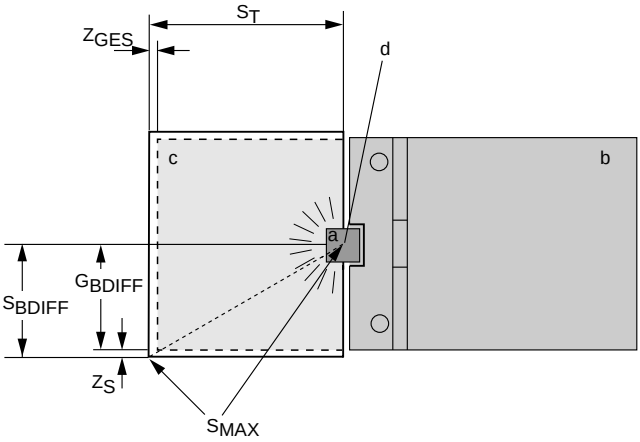
$$MAX = \sqrt{S_T^2 + S_{BDIFF}^2}$$

$$S_{BDIFF} = G_{BDIFF} + Z_S$$

S_{MAX} = Maximum range of the detection zone, in mm
S_T = Depth of the detection zone in the direction of travel, in mm
S_{BDIFF} = Largest width of the detection zone, in mm
G_{BDIFF} = Largest width of the danger zone, in mm
Z_S = Sum of the system-specific and application-specific additions to the side, in mm

$$Z_S = Z_{SM} + Z_{REFL} + Z_{AU}$$

Z_{SM} = Measurement error of the scanner, in mm
Z_{REFL} = Addition to consider reflectors, in mm (see Chapter 6.3.5)
Z_{AU} = Application-specific addition, in mm



b = AGV
c = Detection zone
d = Axis of the rotating mirror
G_{BDIFF} = Largest width of the danger zone
S_{BDIFF} = Largest width of the detection zone
S_{MAX} = Geometrical maximum distances
S_T = Depth of the detection zone
Z_{GES} = Sum of the additions in the direction of travel
Z_S = Sum of the additions to the side

Fig. 19 Considering the maximum measurement distance for safeguarding AGVs

In accordance with DIN EN 1525, a minimum safety distance of 0.5 m width between the vehicle and its environment must be maintained.

6.5.8.3 Example for calculating the depth of a detection zone

This example is based on the following typical application data (without access against the direction of travel and without retro-reflectors):

Largest width of the danger zone from the axis of the rotating mirror = G_{BDIFF}	1400 mm
Maximum speed = V_{MAXFTF}	1800 mm/s
Response time RS4-4 (selectable) = T_{SCAN}	0,08 s
Response time AGV controls = T_{FTF}	0,1 s
Braking distance = S_{ANHALT}	1900 mm
Factor for wear and tear on the brakes = L_{ANHALT}	1.1 (fixed addition to account for wear and tear on the brakes)
Measurement error = Z_{SM}	81 mm
Distance between AGV and floor = Z_{AFUSS}	90 mm (results in an addition of 50 mm according to Fig. 18 for calculating the addition for inadequate floor clearance)

The formula
$S = V_{MAXFTF} \times (T_{SCAN} + T_{FTF}) + (S_{ANHALT} \times L_{ANHALT})$

results in a safety distance of:

$S = 1800\ mm/s * (0,08\ s + 0,1\ s) + (1900\ mm * 1,1)$
$= 2414\ mm$

The formula
$S_T = S + Z_{SM} + Z_{REFL} + Z_{AFUSS} + Z_{AU}$

results in the following required depth of the detection zone in the direction of travel:

$S_T = 2414\ mm + 81\ mm + 0\ mm + 50\ mm + 0\ mm = 2545\ mm$

6.5.8.4 Example for calculating the maximum range of a detection zone

The formula

$$S_{MAX} = \sqrt{S_T^2 + S_{BDIFF}^2}$$

$$S_{BDIFF} = G_{BDIFF} + Z_S$$

under consideration of the width of the danger zone results in the maximum distance to be monitored:

$$S_{MAX} = \sqrt{2545mm^2 + 1481mm^2}$$

$$S_{BDIFF} = 1400 \text{ mm} + 81 \text{ mm} = 1481 \text{ mm}$$

$$S_{MAX} = 2945 \text{ mm}$$

7 Information on Detection Zone and Warning Field Changeovers

In the course of using machines to their optimum capacity, alternating cycles of material insertion and processing often necessitate the creation of variable danger zones. Due to their very nature, AGV applications also necessarily comprise various danger zones. If it is possible for a person to gain access to these hazardous areas, it is necessary to implement a safeguarding system that adapts to the changing conditions. For this purpose, the ROTOSCAN RS4-4 provides four field pairs, each consisting of one detection zone and one warning field, which the user can select among and freely configure. This feature allows the ROTOSCAN RS4-4 to fulfill the diverse safeguarding demands of an extremely wide range of applications.

The necessary contours of the field pair can be set in the user-friendly software program „RS4soft“.

To activate the field pairs, apply 24 V to the corresponding inputs provided at connector X1 on the scanner. Please refer to Chapters 8.2 and 10 for more detailed information on wiring the scanner.

Note the following points if the ROTOSCAN RS4-4 is going to be started up again or if you are going to switch among different field pairs:

- When selecting the field pair for the startup, pay careful attention to the danger zones that are valid at the moment of startup.
- Always switch on the second field pair before switching off the first field pair.
- The changeover must take place within 1 s.
- At no time during the switching process may all of the field pairs be deactivated simultaneously.
- Only one field pair may be active at any one time, except during the changeover process.
- The sequence of the activated monitoring fields must ensure that the application-specific minimum detection zone size is met at all times.

- It must be impossible for changeover signals to change simultaneously as the result of a systematic error. This is achieved by using independent circuits (e.g. separately actuated binary switches) under consideration of the switching behavior described in this chapter.

Please see the assignments of connections and/or interfaces in Chapter 10.5.

7.1 Sequence of a Field Pair Changeover from FP 2 to FP 4 (Example)

- Field pair 2 (X1-6) is the active field pair.
- Field pair 4 (X1-8) is then activated in addition.
- In this state, both field pair monitors are switched on.
- Field pair 2 (X1-6) must be switched off within one second.
- Field pair 4 (X1-8) is now active.

7.2 Practical AGV Application (Example)

The following example shows the sequence of field pair changeovers for an efficiently implemented AGV under consideration of the ambient conditions. Please observe the particular danger zone analysis for each detection zone in combination with the corresponding route segments. Also note the safe sequences of changeovers and starts. For information on programming the startup detection zones (detection zones enabled for starting up the scanner) and on determining the sequence in which the detection zones are to be activated, please see the „RS4soft“ user manual.

Activat-ing an FP	AGV Position	Deacti-vating an FP	AGV Steering Position
FP1	Straight section		High speed
FP2	2 m before the curve	FP1	Low speed
FP3	Beginning of the curve	FP2	Steering lock - curve
FP1	Straight section	FP3	Steering lock - straight

FP = 1 x detection zone + 1 x warning field

If the AGV is controlled by a PLC, for instance, which corresponds to Cat. 3 or higher according to DIN EN 954-1, the previous field pair (FP) can be deactivated immediately after the next field pair has been activated, with no time delay. This results in a faster switching sequence.

The applicable safety guidelines and standards as well as the operating instructions for the systems must be strictly complied with.

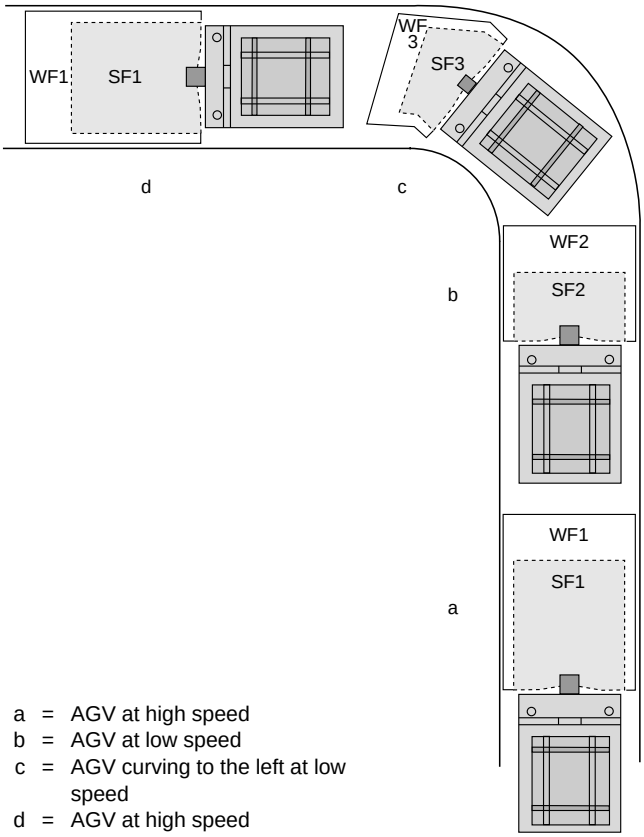


Fig. 20 Example of a field pair changeover for an AGV on a curved route

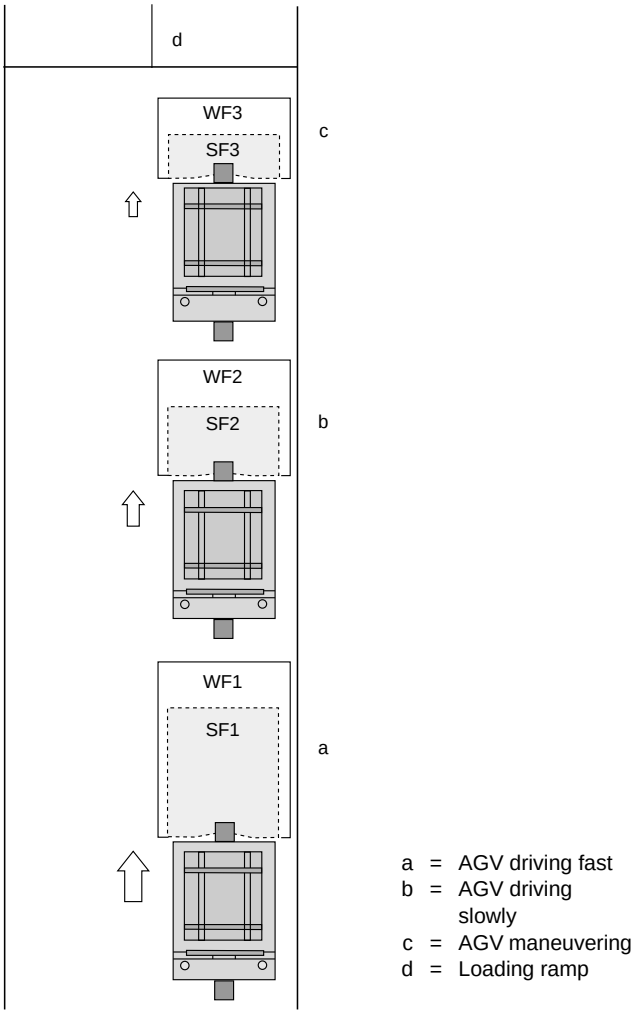


Fig. 21 Example of a field pair changeover an AGV reducing its speed

8 Functions of the ROTOSCAN RS4-4

The ROTOSCAN RS4-4 is equipped with the interfaces X1 and X2, which provide the following functions:

8.1 Restart

Depending on the operating state, the restart input X1-2 has several functions:

- Enables the restart interlock following the interruption of a detection zone
- Enables the start interlock following a system start
- Restarts after a device error has been eliminated
- Recognizes a defined enable signal
  - after a device error
  - after a detection zone interruption for enabling the restart interlock

To activate the functions, apply 24 V to input X1-2. In the meantime, the safety outputs OSSD 1 and OSSD 2 are switched off; the indicator at the scanner (LED 3) is lit up red. The duration of the signal must be between 2 s and 4 s.

The restart input X1-2 must be connected with an external, permanently installed button. It may not be connected with the remaining controls in order to prevent an unintended release. Please see Chapters 6 (Information for Planning and Mounting) and 10.1 (Electrical Power Supply).

8.2 Channels for Field Pair Changeovers, FP 1 to FP 4

To activate the field pairs, apply +24 V (see Chapter 10.1) to the following inputs:

- X1-4 (FP1)
- X1-6 (FP2)
- X1-7 (FP3)
- X1-8 (FP4)

When changing over the field pairs, please note that the new field pair must be switched on before the previous pair is switched off. This procedure is allowed to last a maximum of 1 s. If this time period is exceeded, or if the previous field pair is switched off too soon, the ROTOSCAN RS4-4 reports an error by switching off the two OSSDs and the alarm output. In addition, this state is shown in the indicator field on the scanner; LED 3 (middle) and LED 5 (right) will both be lit up and flashing quickly at approx. 4 Hz.

8.3 Alarm (X1-5)

As long as the output X1-5 is switched on, the system signals trouble-free operation. If it is switched off, the following states are reported:

- Interruption of the warning field is shown by the continuously lit LED 2 in the indicator field of the scanner.
- Warning state:
  For instance, the system may detect a slight dirt buildup on the window. To signal this state, LED 5 on the scanner flashes (0.25 Hz). The user should clean the window before it gets dirtier; waiting too long will cause a device error to be reported and the outputs OSSD 1 and OSSD 2 to be switched off.
- Device error:
  Such as an erroneous reference measurement or extreme dirt buildup on the window. This state is signaled by LED 5 flashing quickly (4 Hz).

Both the reporting of a warning field interruption and the signalling of the warning and error state can be selected either separately or in combination. This procedure is described in the user manual for the program „RS4soft“.

Output X1-5 is equipped with an internal electronic current limit to protect it against damage from overload.

8.4 OSSD 1 (X1-12) and OSSD 2 (X1-11)

When the detection zone is interrupted, the two semiconductor outputs switch off and, by way of elements such as positively guided relays, cause the monitored machine(s) to shut down. It is not admissible to control different safety circuits with a single OSSD. Connected loads must exhibit a low-pass behavior in accordance with the plausibility control conducted by the scanner ($f_g \leq 1$ kHz, $C_L \leq 100$ nF). The OSSDs are equipped with an internal electronic current limit to protect them against damage from overload.

For connection examples, see Chapter 9.

8.5 Data Communication

The interface X2 allows the ROTOSCAN RS4-4 to support two types of connections to the PC or laptop.

Communication via the X2 connector in RS232 mode does not require any further bridging. To enable data transfer in RS 422 mode, connect pin 5 with pin 6. This scanner automatically adjusts itself to the appropriate transfer type and baud rate.

The interface (X2) is used for

- configuring and setting parameters for the ROTOSCAN RS4-4
- transferring the measurement data
- evaluating the coordinates during parameter setting (e.g. for AGV applications)
- diagnosing and/or localizing faults.

The interface X2 may not be used during guard operation. It is intended solely for use in configuring and setting parameters for the ROTOSCAN RS4-4, which in turn stores the data received from the PC until the next change. After configuring the scanner, remove the interface cable, slip on the provided dummy cap at position X2, and screw it tight.

Please note the pin assignments specified in Chapter 10.5. For additional information on using the X2 interface, refer to the user manual for the program „RS4soft“.

9 Integrating the ROTOSCAN RS4-4 into Machine Controls

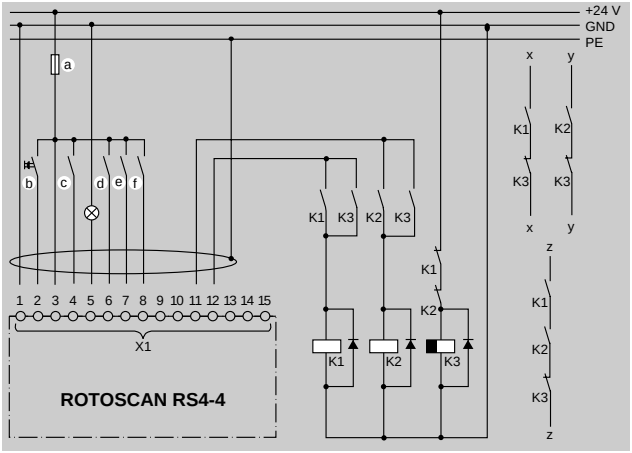
The following examples illustrate possibilities for integrating the ROTOSCAN RS4-4 into machine controls.

Once the operating voltage pin X1-3 (+UB) has been connected to pin X1-1 (GND) and a detection zone has been activated (X1-4, X1-6, X1-7 or X1-8), the unit is ready for operation.

Please see the point „Start detection zone” in the user manual for the program „RS4soft“.

9.1 Integrating the ROTOSCAN RS4-4 with External Wiring with Relays and Quadruple Field Pair Changeover

In this connection example, the restart interlock function is provided by the connected command unit „WA”, which applies the voltage of 24 V to the input RESTART X1-2. The ROTOSCAN RS4-4 itself must be configured using the „RS4soft“ user software so that the operating mode „with restart interlock” is active.



a = Fuse 1.25 A, semi time-lag
b = Restart button
c = SF 1/WF 1
d = SF 2/WF 2
e = SF 3/WF 3
f = SF 4/WF 4

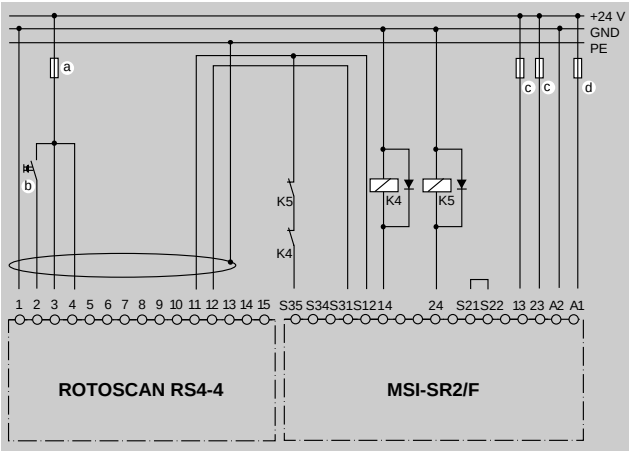
Fig. 22 Wiring the ROTOSCAN RS4-4 with evaluation of the OSSDs, field pair changeover and restart interlock (example)

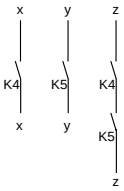
The relays K1 and K2 must have positively guided contacts. They are operated directly at the two failsafe semiconductor outputs OSSD 1 (X1-12) and OSSD 2 (X1-11). The relay K3 is drop-out delayed. A suitable arc suppressor is required. Please note that this results in an increase of the switching times.

According to DIN EN 954-1, channels „x“ and „y“ must be integrated for Categories 3 and 4. A single-channel integration comprising „z“ is only admissible for a single-channel control and under consideration of the results of a risk analysis.

Serial machine controls are admissible only insofar the valid regulations allow.

9.2 Connecting the ROTOSCAN RS4-4 to a Safety Sequential Circuit with Manual Restart Interlock and Relay Monitoring, and without Field Pair Changeover





a = Fuse 1.25 A, semi time-lag
b = Restart button
c = Fuse 4 A, delay-action
d = Fuse 1 A, delay-action

Fig. 23 Wiring the ROTOSCAN RS4-4 with external restart interlock and relay monitoring, and without field pair changeover

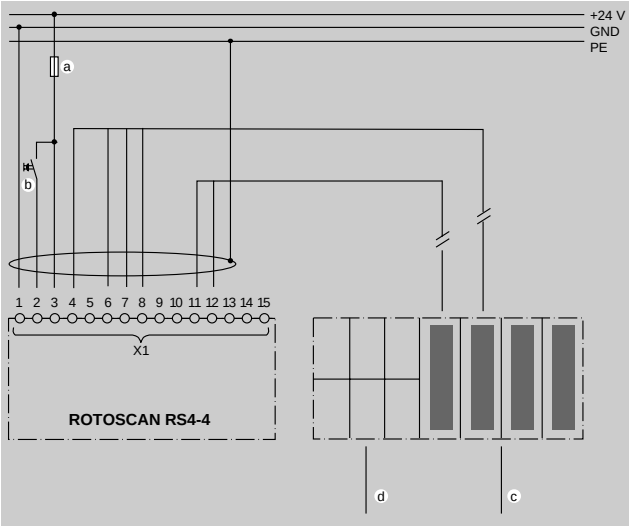
In this example, the relay monitoring is performed by an external safety module (e.g. MSI-SR2/F). Relays K4 and K5 must be equipped with positively guided contacts. A suitable arc suppressor is required. Please note that this results in an increase of the switching times.

Please refer to the operating instructions for the components.

According to DIN EN 954-1, channels „x“ and „y“ must be integrated for Categories 3 and 4. A single-channel integration comprising „z“ is only admissible for a single-channel control and under consideration of the results of a risk analysis.

Serial machine controls are admissible only insofar the valid regulations allow.

9.3 Connecting the ROTOSCAN RS4-4 to a PLC with Corresponding Safety Level (Cat. 3 or higher, EN 954) and Field Pair Changeover



a = Fuse 1.25 A
b = Restart button
c = Decentralized peripherals, e.g. ET200M with failsafe signal subassembly
d = Further processing by a failsafe PLC, e.g. SIMATIC S7-400F

Fig. 24 Connecting the ROTOSCAN RS4-4 to a failsafe PLC with a safety level (at least Cat. 3, EN 954) and field pair changeover (example)

In this connection example, all of the switching functions are controlled directly by the PLC.

The changeover of 4 field pairs is achieved by way of the inputs X1-4 (FP1), X1-6 (FP2), X1-7 (FP3) and X1-8 (FP4).

For applications in which the scanner must be separately enabled for its detection zone, the signal can be given either by the machine controls or by connecting a command unit for restart interlock. The ROTOSCAN RS4-4 itself must be configured using the „RS4soft“ program so that the operating mode „with restart interlock“ is active.

10 Electrical Connection

10.1 Electrical Power Supply

The ROTOSCAN RS4-4 requires a direct voltage of 24 V and 8 W of power plus the load at the outputs (max. 25 W).

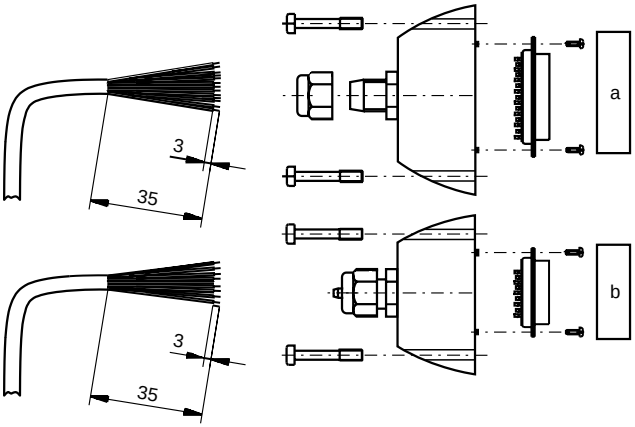
The power must be supplied by way of an external 1.25 A, semi time-lag fuse (e.g. in an electronics cabinet). In addition, a permanent current of 2.5 A must be ensured before safeguarding begins in order to guarantee that the fuse will be triggered in case of a fault.

In keeping with electrical safety requirements, the power to the ROTOSCAN RS4-4 and all connected input and output circuits must be provided by a power supply unit with protective isolation from a safety transformer according to IEC 742 or comparable (this also applies for the use of battery chargers for AGV applications).

10.2 Connecting the PC and Control Cables to the Scanner

Three connector adapters with cable screw coupling are supplied with the ROTOSCAN RS4-4. Two of these are needed to accommodate the 9-pin Sub-D connector and the 15-pin Sub-D jack (PC cable and control cable). One adapter is intended to protect the interface X2 when the PC cable has been removed (in accordance with enclosure rating IP 65).

The cable screw couplings can accommodate cable diameters from 6.5 mm to 10.5 mm.



a = Jack X1
b = Connector X2

Fig. 25 Preparing the connectors

The connector adapter of control cable X1 must be connected with interface X1 and screwed tightly to the ROTOSCAN RS4-4. The connector adapter of cable X2, or else the X2 dummy cap (without a cable), must also be screwed tightly to the ROTOSCAN RS4-4. Threaded drill holes are located on the top of the scanner housing for this purpose. Both of the connector adapters must be attached in order for the ROTOSCAN RS4-4 to comply with the enclosure rating IP 65. Please refer to the inside front cover of this technical description to see the layout of the connectors.

10.3 Connector Assembly

Every connector adapter consists of the following individual parts:

- Adapter with sealing ring and Phillips mounting screws
- Cable screw coupling (M16) with dummy plugs
- Sub-D9 connector and/or Sub-D15 connector, each with a solder connection

10.4 Points to Consider When Preparing and Laying the Cables

- The cross-section of cable X1 must be at least 0.5 mm^2.
- The outer diameter of the cable must be between 6.5 mm and 10 mm.
- The maximum cable length for X1 is 50 m.
- The maximum cable length for X2 is 10 m (for RS232).
- The maximum cable length for X2 is 50 m (for RS422, twisted pair).
- Use shielded cables.
- Connect the cable shielding with PE to the electronics cabinet only.
- The cables may not be laid loose.

Scanner control cables may not be laid in a stand parallel to power supply cables for machines. This minimizes the effects of inductive interference factors from motors carrying high current. In addition, the cables should be laid so that they cannot be damaged (e.g. by being crushed or pinched).

Cabling prepared for connection to the scanner is available as an optional accessory in various lengths and for both interfaces. For further information, see Chapter 14.

10.5 Interface Pin Assignments

Pin Assignments for Connector X1

Pin	Signal	Description
1	GND	Ground for the supply voltage
2	Restart	Input, scanner reset, and connecting the restart button
3	UB	Supply voltage +24 VDC
4	FP 1	Changeover to field pair 1
5	Alarm	Semiconductor output that switches off when the warning field is violated as well as for warning messages such as „window slightly dirty“, error messages such as „window very dirty“, and for internal errors (the functions can also be selected in combination).
6	FP 2	Changeover to field pair 2
7	FP 3	Changeover to field pair 3
8	FP 4	Changeover to field pair 4
9	NC	Not connected
10	NC	Not connected
11	OSSD 1	Semiconductor output, switches off when the detection zone is violated, Channel 1
12	OSSD 2	Semiconductor output, switches off when the detection zone is violated, Channel 2
13	NC	Not connected
14	NC	Not connected
15	Re-served	Reserved for testing purposes, no wiring

Pin Assignments for Connector X2 used as an RS 232 Port

Pin	Signal	Description
1	- - -	Not connected
2	TxD	Data communication, transmit
3	RxD	Data communication, receive
4	- - -	Not connected
5	GND / shield	Ground / shield
6	RS 232	Not connected
7	NC	Not connected
8	NC	Not connected
9	Re-served	Reserved for testing purposes, no wiring

Pin Assignments for Connector X2 used as an RS 422 Port

Pin	Signal	Description
1	TxD-	Data communication, receive
2	TxD+	Data communication, receive
3	RxD+	Data communication, transmit
4	RxD-	Data communication, transmit
5	GND / shield	Ground / shield
6	RS 422	Select RS422 interface by connecting a bridge to pin 5
7	NC	Not connected
8	NC	Not connected
9	Re-served	Reserved for testing purposes, no wiring

Please refer to the inside front cover of this technical description to see the pin assignments.

11 Start-up

Communication with the PC or laptop needs to be established so that the ROTOSCAN RS4-4 can be configured and the detection zones and warning fields can be programmed. This is also necessary for displaying the measurement contours and for the system check.

The program „RS4soft“, which is included with delivery, makes this easy and convenient to do. Refer to the software user manual to find additional important information and helpful explanations. In addition, we recommend that you consider the following points:

11.1 Hardware and Software Requirements

The following components are required for the initial startup:

- ROTOSCAN RS4-4
- RS232 interface cable (1:1, without cross-connection) or RS422 interface cable
- Shielded control cable for the power supply and for activating a field pair
- Power supply that meets the requirements specified in Chapter 10.1
- PC or laptop, color monitor
- „RS4soft“ program

The PC should fulfill the following requirements:

- Intel® processor, Pentium® class or higher (or compatible models such as AMD® or Cyrix®)
- At least 16 MB RAM
- 3 1/2” disk drive or CD-ROM drive
- Hard drive with at least 8 MB of free memory (more if detection zone data and/or configuration data are going to be stored)
- Mouse

- RS 232 serial interface, or alternatively, RS 422 interface
- Microsoft® Windows 95/98/NT®/2000

11.2 Installing „RS4soft“ and Starting Up the ROTOSCAN RS4-4

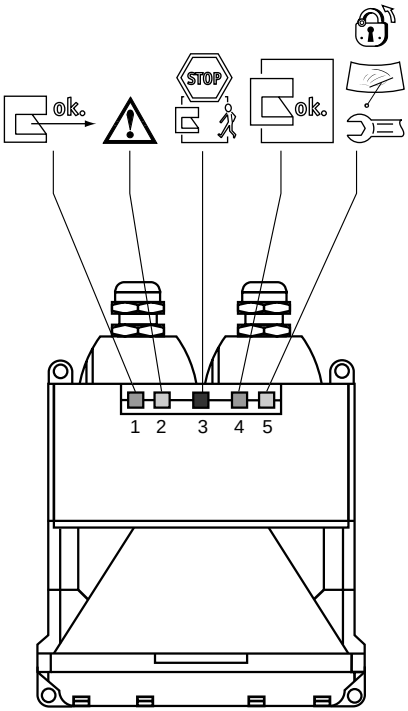
- First, run the installation program „Setup.exe“ in order to install the program on the PC.
- Start the software by calling up the program.
- Connect the control cable and the PC cable.
- Then apply the supply voltage to the ROTOSCAN RS4-4. The scanner will now attempt to communicate with the PC; this process is displayed on the screen.
- If the connection between the ROTOSCAN RS4-4 and the PC was successful, you can enter the appropriate password and then change the parameters and field pairs of the ROTOSCAN RS4-4 to meet the needs of the particular application.
  The standard password to be entered in the authorized level „Authorized Customer“ of the ROTOSCAN RS4-4 is „RS4LEUZE“.
  Please note that the password must be changed following the initial configuration of the scanner, and that the data carrier must be kept locked up in a secure location.
- The ROTOSCAN RS4-4 is ready for operation once the scanner settings and detection zone configurations have been transferred.

Every ROTOSCAN RS4-4 is factory-equipped with the maximum safety parameters. For this reason, first the device settings and then the detection zones must be adapted to the requirements of the application before the scanner is put into operation. After configuring the scanner, remove the PC interface cable from position X2, slip on the dummy cap provided with delivery, and screw it tight.

For a list of parameters, please see the instructions for the user software „RS4soft“.

11.3 ROTOSCAN RS4-4 Status Indicator

There are five LEDs located on the front of the scanner behind the cover with the matte finish. These LEDs indicate the status of the ROTOSCAN RS4-4.



Association to function:

Easy-to-interpret pictographs on the ROTOSCAN RS4-4 explain the meaning of each of the LEDs.

1 = Green
2 = Yellow
3 = Red
4 = Green
5 = Yellow

Fig. 26 The ROTOSCAN RS4-4 status indicator

Meaning of the individual LEDs

LED	Color	Function / Meaning	Picto-graph
1	green	Sensor function is active, active detection zone is clear	
2	yellow	Warning field is occupied	
3	red	OSSD outputs are switched off	
4	green	OSSD outputs are switched on	
5	yellow	• constantly lit: restart interlock • flashing slowly (1): warning message (approx. 0.25 Hz) • flashing quickly (((1))): error message (approx. 4 Hz)	  

11.4 Status information for the ROTOSCAN RS4-4

Scanner-Display LED Numbers 1 2 3 4 5	Indicator	Status
– – 1 0 –	LED 3	The OSSD outputs are switched off (e.g. during booting).
1 0 0 1 0	LED 1 LED 4	The sensor function is active (measurement operation without a violation of the activated field pair). The OSSDs are switched „active high“.
1 1 0 1 0	LED 1 LED 2 LED 4	The sensor function is active (measurement operation without a violation of the activated detection zone). Violation of the activated warning field. The OSSDs are switched „active high”.
0 1 1 0 –	LED 2 LED 3	Violation of the warning field. Violation of the detection zone. The OSSDs are switched off.
1 0 0 1 (1)	LED 1 LED 4 LED 5	The sensor function is active (measurement operation without a violation of the activated detection zone). The OSSDs are switched ”active high”. Warning message signaled by slow flashing at approx. 0.25 Hz (e.g.)

0 0 1 0 (((1)))	LED 3 LED 5	The OSSDs are switched off. Error message signaled by fast flashing at approx. 4 Hz (e.g. for a defect or a safety-relevant fault)
1 0 1 0 1	LED 1 LED 3 LED 5	The sensor function is active (measurement operation without an interruption of the activated field pair). The OSSDs are switched off. Restart interlock is active.
0 1 1 0 1	LED 3 LED 5	Interruption of the field pair. The OSSDs are switched off. Restart interlock is active.

1 = LED is lit up
0 = LED is dark
– = undefined

Upon delivery, the ROTOSCAN RS4-4 is programmed with the largest possible detection zone and with activated restart interlock. For this reason, LED 5 is constantly lit up when the scanner is switched on. When starting up your ROTOSCAN RS4-4, please modify the parameters to meet the specific needs of your application.

12 Maintenance and Testing

The faultless function of the scanner must be tested by trained personnel after longer periods of standstill, after repairs have been made, and in any case, at least once per year. If there is any doubt as to the proper function of the system, or if parameters relevant to the detection zones have changed, it is not allowed to use stopgap measures or quick fixes.

Following each definition of and change to the detection zones, the configuration must be checked to see whether the possibility of people standing in the danger zone as well as any barriers provided have been considered by an appropriate layout of the detection zone(s).

The scanner window and the six diffusing screens above it should be cleaned at regular intervals (depending on the application). Do not use any cleaning substances that contain caustic solvents or scouring particles. Doing so can result in the plastic being clouded. We recommend

- cleaning the scanner window with a soft cloth dampened with water and a small amount of dishwashing liquid
- drying the window with an absorbent, lint-free soft cloth.

If the window monitoring reports dirt buildup on the window even after cleaning, the window glass must be replaced. Disconnect the ROTOSCAN RS4-4 from its power supply before beginning with the replacement. The exchange may be made only by trained specialist personnel in a clean environment (preferably by the manufacturer or persons authorized by the manufacturer). After the window has been replaced, the window sensors must be adjusted using the RS4 configuration software „RS4soft“.

Because of the maintenance-free technology of the ROTOSCAN RS4-4, it is not allowed to tamper with or make changes to the system. Repairs may be made only by the manufacturer.

If the scanner signals an error at LED 5, helpful information can be queried from the user program. A list of possible errors can be called up from the menu „RS4 Diagnostics“. For further information, please see Chapter 16. If the scanner needs

to be sent back to us for repairs, be sure that the connectors are screwed on or that the interfaces are adequately protected. Please enclose a detailed description of the problem with the shipment.

12.1 List of Test Points

- Check the front screen for dirt buildup, clean if necessary.
- Check the front screen for damage or scratches, replace if necessary.
- Make sure that the connector caps are firmly in place.
- Make sure that the scanner mounting screws are firmly in place.
- Make sure that the mounting system screws are firmly in place.
- Check that the scanner is in the correct mounting position and aligned properly.

12.2 Service

Your partner in all matters of occupational safety, Leuze lumiflex GmbH + Co offers additional services:

- Annual maintenance of the ROTOSCAN RS4-4 laser scanner
- Training seminars on the topic „Safety at Work”
- Training seminars on the topic „Information about Laser Scanners”

Our customer service department is available to answer any questions you may have. You can reach them by calling ++49-89/143 65-122.

12.3 Disposal

Laser scanners that are no longer in use must be disposed of in an appropriate manner.

13 Delivery Package

The basic unit consists of:

- ROTOSCAN RS4-4
- RS4-4 connector, complete, 15-pin, interface X1
- RS4-4 connector, complete, 9-pin, interface X2
- 1 protective cover, interface X2
- User program „RS4soft“ on four diskettes
- Technical description of the ROTOSCAN RS4-4
- User manual for „RS4soft“

14 Accessories

Description	Abbreviation	Order No.
RS4-4 mounting system for attaching and aligning the RS4-4	RS4-MS	50033346
RS4-4 scanner adapter plate for existing mounting systems	RS4-Adap-P	50035814
RS4-4 scanner window with seal	RS4-Win	50035816
RS4-4 picto-foil >LEDs<	RS4-Foil-PIC	50035855
RS4-4 connector, complete, 15-pin, interface X1	RS4-MG-X1-Set	50035735
RS4-4 connector, complete, 9-pin, interface X2	RS4-MG-X2-Set	50035768
RS4-4 control cable, prepared for connection to the scanner, 5 m	RS4-CB-X1-5	50035736
RS4-4 control cable prepared for connection to the scanner, 10 m	RS4-CB-X1-10	50035737
RS4-4 control cable, prepared for connection to the scanner, 20 m	RS4-CB-X1-20	50035849
RS4 control cable, prepared for connection to the scanner, 35 m	RS4-CB-X1-35	50035850
RS4 control cable, prepared for connection to the scanner, 50 m	RS4-CB-X1-50	50035851
RS4 PC cable, prepared for connection to the scanner, 3 m	RS4-CB-X2-3	50035863

Description	Abbreviation	Order No.
RS4 PC cable, prepared for connection to the scanner, 5 m	RS4-CB-X2-5	50035865
RS4 PC cable, prepared for connection to the scanner, 10 m	RS4-CB-X2-10	50035867
User program „RS4soft“ on diskette and „RS4soft“ manual, German/English	RS4-SWD-MSW-DE-Set	970070
User program „RS4soft“ on diskette and „RS4soft“ manual, French	RS4-SWD-MSW-F-Set	970078
ROTOSCAN RS4-4 user manual, German/English	RS4-MHW-DE	50034330
ROTOSCAN RS4-4 user manual, French	RS4-MHW-F	50037316
Test piece, cylinder, 500 mm in length, 70 mm in diameter, reflectance factor approx. 1.8 %	RS4-TB-70-500	50036433
Test piece, cylinder, 1000 mm in length, 200 mm in diameter, reflectance factor approx. 1.8 %	RS4-TB-200-1000	50036434

14.1 Coding of the Control Cable X1

The following table defines the pin assignments for the 12-pin connector cable

Pin No.	Color Code	Meaning
1	blk	GND
2	blu	Restart
3	rd	UB
4	or	FP 1
5	ye	Alarm
6	grn	FP 2
7	vio	FP 3
8	gray	FP 4
9	n.c.	
10	n.c.	
11	wh	OSSD 1
12	wh-blk	OSSD 2
13	n.c.	
14	wh-br	
15	br	

15 Technical Specifications

15.1 Test Pieces

The following test pieces are defined for the purpose of controlling the effectiveness of the monitoring function by the detection zones:

- Cylinder, 500 mm in length, 70 mm in diameter, reflectance factor 1.8 % ± 0.2 %, for use in an upright position
- Cylinder, 1000 mm in length, 200 mm in diameter, reflectance factor 1.8 % ± 0.2 %, for use in a prone position (e.g. for AGV applications).

15.2 Detection Zone

Detection range	0 - 4 m
Reflectance factor	min. 1,8 %
Object size (diameter)	70 mm (cylindrical test piece)
Response time	Double evaluation: 80 ms (corresponds to 2 scans), up to 16 scans can be selected (640 ms)
Number of detection zones	4 (changeover via switch inputs)
Output	2 failsafe PNP transistor outputs, 24 V/250 mA
Safety category	Specification class 4 in accordance with DIN V 19250, single-fault proof, Category 3 according to EN 954-1, Type 3 according to DIN EN 61496-1, IEC 61496-3
Start	The startup testing and the start interlock can be set separately.
Restart	Adjustable from 160 ms to 10 s, or manual

15.3 Detection Zone Additions

Addition for deactivated dust suppression	81 mm
Addition for activated dust suppression	81 mm (for a detection zone size < 3.5 m) 98 mm (for a detection zone size > 3.5 m)
Addition if retro-reflectors or very shiny surfaces such as certain metals or ceramics are present in the scanning plane	0 mm (more than 1.2 m behind the detection zone line) 110 mm (in the detection zone or up to 1.2 m behind detection zone line)

15.4 Warning Field

Detection range	0 -15 m
Reflectance factor	min. 20 %
Object size	150 x 150 mm
Response time	Double evaluation: 80 ms (corre-sponds to 2 scans), up to 16 scans can be selected (640 ms)
Number of warning fields	4 (selectable via switch inputs)
Output	PNP transistor output, max. 100 mA

15.5 Contour Measurement

Measurement range	0 - 50 m for RS4-4
Reflectance factor	min. 20 %
Object size	- - -
Output	Serial interface RS 232 (10 m), RS 422 (50 m)
Radial resolution	5 mm
Lateral resolution	0,36 °

15.6 Electrical Power Supply

Supply voltage	+24 VDC +20 % / -30 %, supply according to IEC 742 with safety transformer or comparable for DC/DC converters
Overload protection	Provide by 1.25 A semi-delay fuse in the electronics cabinet
Current consumption	approx. 300 mA (use a power supply with 2.5 A)
Power consumption	8 W at 24 V, plus the output load
Excess voltage protection	Over-voltage protection with safe end cut-off
Voltage drops	In accordance with DIN EN 61496-1
Non-fused earth conductor	Connection not allowed

15.7 Inputs

Restart/Reset	For connecting a command device for operating mode „with restart interlock“ and/or device reset, dynamically monitored, 24 VDC, optically isolated
Field pair changeover	For selecting among 4 field pairs via 4 control cables with internal monitoring (field pair = 1 detection zone and 1 warning field), 24 VDC, optically isolated
Signal definition High / logical 1 Low / logical 0	 16 ... 30 V < 3 V

15.8 Outputs

Detection zone	2x failsafe semiconductor output, PNP, max. 250 mA, short-circuit monitored, overload protected
Warning field/ contamination/ error	PNP transistor output, max. 100 mA
Load characteristics, maximum	Low-pass behavior, frequency f_g = < 1 kHz, C_{Load} ≤100 nF
Level high (OSSD active) Level low (OSSD inactive) Level high (alarm active) Level low (alarm inactive)	 U_B - 3,2 V < 2,0 V U_B - 4 V < 2,0 V

15.9 Software

User software	Communication and parameter-setting software for Windows 95/ 98/2000/NT with safe protocol for programming

15.10 Interfaces

RS 232, RS 422	For setting device parameters and defining detection zones and warning fields

15.11 Optics

Angle range	max. 190 °
Angle resolution	0,36 °
Lateral tolerance without mounting system with mounting system	 ± 0.18 ° (with respect to the back wall of the housing) ± 0.22 ° (with respect to the mounting surface)
Scanning rate	25 scans/s or 40 ms/scan
Laser protection class	Class 1 (safe for the eyes) in accordance with DIN EN 60825-1 Wavelength = 905 nm Beam divergence = 2 mrad Time basis = 100 s

15.12 Environment and Material

Enclosure rating	IP 65 in accordance with IEC 60529
Shock protection	Protection class 2
Operating temperature	0 ... + 50 °C
Storage temperature	-20 °C ... + 60 °C
Humidity	DIN 40040 Table 10, Identification letter E (moderately dry)
Dimensions	140 x 155 x 135 (W x H x D) in mm
Distance from the middle of the scanning plane to the bottom edge of the housing	48.75 mm
Distance from back edge of the housing to the axis of the rotating mirror	68 mm
Connection	2 connectors (plugged in from above, solder connection)
Control cable length X1	Max. 50 m at a cable cross-section of 0.5 mm^2, shielded Connect shield with PE to the electronics cabinet only
Data cable length X2 RS 232	Max. 10 m
Data cable length X2 RS 422	Max. 50 m (twisted pair)
Transmitter	Infrared laser diode (λ = 905 nm)
Housing	Die-cast aluminum, plastic
Weight	Approx. 2 kg
Dynamic stress across 3 axes	In accordance with IEC 60068 Part 2 - 6, 10 – 150 Hz, max. 5 G

Continuous shock across 3 axes	In accordance with IEC 60068 Part 2 - 29, 10 G, 16 ms
Interference immunity	In accordance with DIN EN 61496-1 (corresponding to the requirements for Type 4); in addition, in accordance with DIN 40839-1/3 Test pulses 1, 2, 3a, 3b and 5 (not for use for vehicles with internal-combustion engines)
Rotating mirror drive	Brushless direct-current motor
Rotating mirror bearing	Maintenance-free ball bearing

16 Error Codes and Causes

Location	Description	No.	Description
102	Processing of commands, processing of messages	2	Invalid command received
103	Control of command processing	2	Invalid command received
104	Processing of commands, processing of configuration	2	Invalid command received
105	Processing of commands, generation of output messages	6	Command not allowed at current level of authorization
201	Processing of the receive protocol	4	Data overflow, message overwritten by new message
302	Processing of the transmit protocol	2	Timeout while waiting for verification of transmitted message
306	Output of measurement values	5	Previous message not yet completely output
801	Error processing	2	Error memory cannot be read
805	Processing of the commands to the error memory	6	Error memory cannot be transferred
1002	Motor control during initialization	1	Motor does not achieve rated speed
1002	Motor control during initialization	2	Engine revolutions not constant
1110	Test of the switch outputs	4	State of switch outputs inconsistent with that shown by the internal memory

Location	Description	No.	Description
1110	Test of the switch outputs	5	Switch output cannot be switched off
1110	Test of the switch outputs	6	Switch output cannot be switched on
1111	Short circuit test of the switch outputs	7	Short circuit of a switch output with ground
1111	Short circuit test of the switch outputs	8	Short circuit of a switch output with Vcc
1606	Motor speed monitoring	4	Motor speed error, zero pulse not detected properly
1607	Monitoring the duration of a scan	5	Motor speed error, motor not at rated speed
1705	Processing of field monitoring light barrier data	1	Signal of a field monitoring light barrier below lower limit
1705	Processing of field monitoring light barrier data	2	Signal of a field monitoring light barrier above upper limit
1906	Test of the external watchdog	1	Watchdog not enabling the OSSDs
1906	Test of the external watchdog	2	Watchdog not switching off the OSSDs
1906	Test of the external watchdog	5	State of switch outputs inconsistent with that shown by the internal memory
1906	Test of the external watchdog	6	Watchdog not switching the cutoff path for the laser

Location	Description	No.	Description
1907	Test of the external watchdog	4	Fault detected by watchdog, watchdog switched off (motor speed error)
1907	Test of the external watchdog	7	Fault detected by watchdog, watchdog switched off (motor speed error)
2002	Processing of the parameter commands	12	Timeout while transmitting the configuration data
2007	Test of received parameter data	18	Date of the currently transmitted detection zone is older than the date of the detection zone in the scanner
2201	Area monitoring	5	Number of measurements in the scan too small due to motor speed error or switch-off of the watchdog
2401	Reference measurement on the dark reference element	10	No distance value calculable for reference measurement; glare from another light source or motor speed error
2402	Reference measurement on the light reference element	10	No distance value calculable for reference measurement; glare from another light source or motor speed error
2701	Processing of messages for system diagnostics	1	Invalid diagnostics command received

Location	Description	No.	Description
2702	Processing of Requests for diagnostics data	3	Invalid diagnostics value requested
2800	Processing of inputs for detection zone changeover	2	2 detection zones active longer than 1 s
2800	Processing of inputs for detection zone changeover	3	Changeover to new detection zone after parameter-setting not allowed
2800	Processing of inputs for detection zone changeover	4	Invalid number of detection zones during operation selected
2800	Processing of inputs for detection zone changeover	6	No valid detection zone info could be gained from the data from the input cables
2801	Test of inputs for detection zone changeover	1	Error during testing of inputs for detection zone changeover
2802	Initialization of detection zone changeover	3	Selected detection zone not allowed during start after parameter-setting
2802	Initialization of detection zone changeover	4	Invalid number of detection zones selected during Power-On
2802	Initialization of detection zone changeover	6	No valid detection zone info could be gained from the data from the input cables
3016	Monitoring the access authorization with one-shot password	11	Confirmed one-shot password was entered incorrectly

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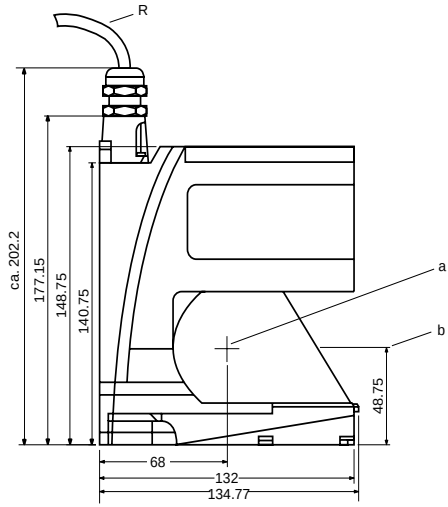
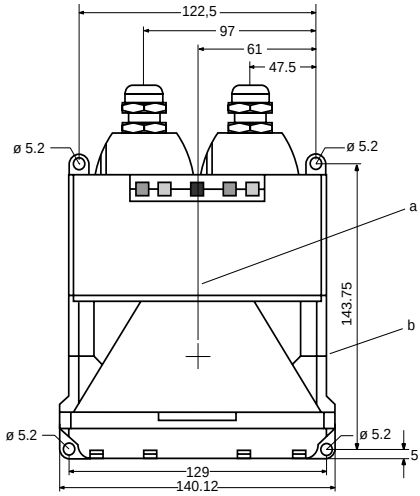
Maßbilder des ROTOSCAN RS4
Dimensional Drawings of the ROTOSCAN RS4

Seitenansicht
Side view



Vorderansicht
Front view

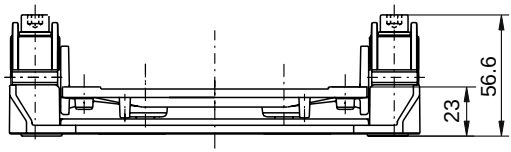


R = Kleinster Biegeradius = 50 mm (Lumiflex-Zubehör)
Smallest bending radius = 50 mm (Lumiflex accessory)
a = Drehspiegelachse / Axis of the rotating mirror
b = Scanebene / Scanning plane

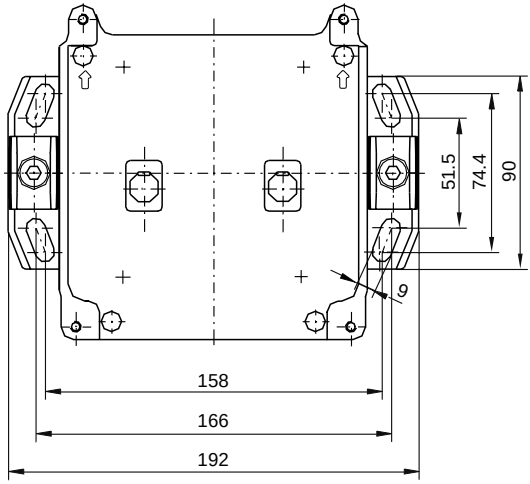
Alle Maßangaben in mm / All measurements given in mm

Maßbilder des Montagesystems
Dimensional Drawings of the Mounting System

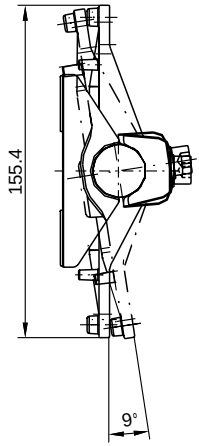
Seitenansicht
Side view



Scannermontage-
fläche
Scanner
mounting
surface



Teileübersicht
Overview of parts



Alle Maßangaben in mm
All measurements given in mm

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