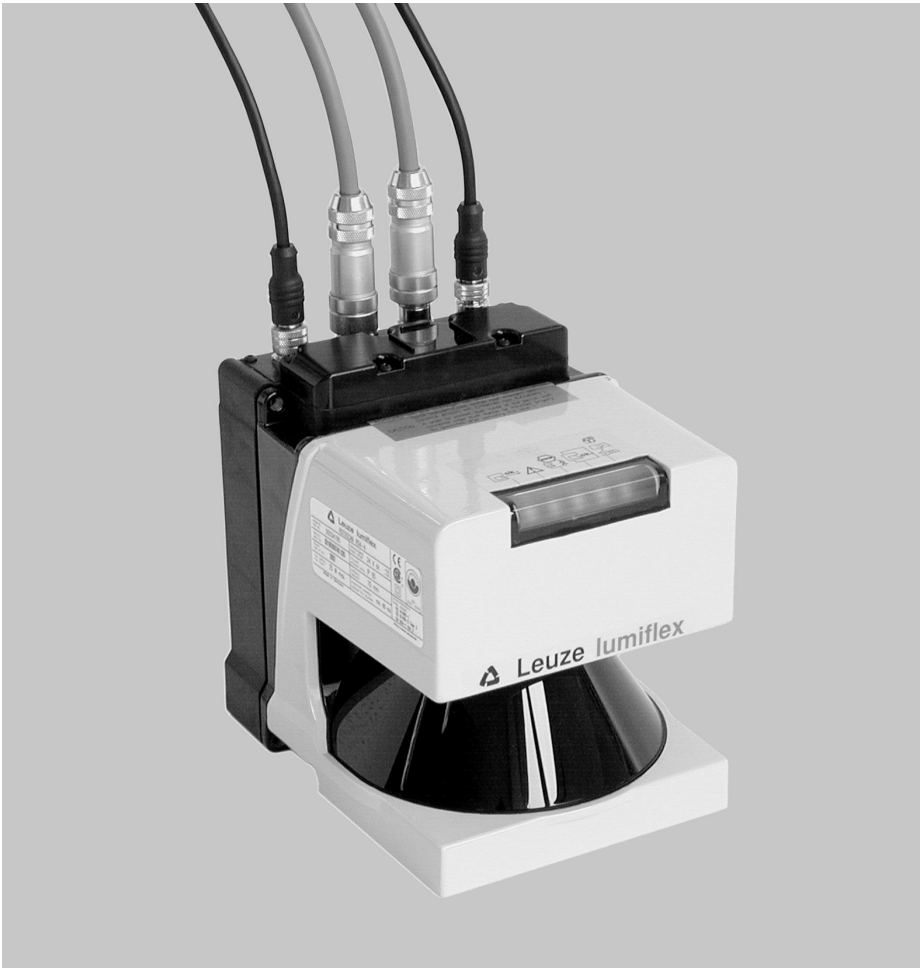




ROTOSCAN RS4/PROFIsafe

Zusatzinformationen zur Anschluss- und Betriebsanleitung des Laserscanner ROTOSCAN RS4-4

Additional Information to Connecting and Operating Instruction Laser Scanner ROTOSCAN RS4-4




About the Connecting and Operating Instruction




The Connecting and Operating Instruction for the ROTOSCAN RS4/PROFIsafe Laser Scanner contain all the information you need for the correct use, project configuration, assembly, electrical installation and commissioning of scanners with a PROFIBUS connection. Additional information will be found in the RS4soft User Manual. Both these documents, as well as the RS4soft software, form part of the RS4 setup set RS4-SWC, and are intended for the use of planners, operators and maintenance personnel of systems which are protected with the ROTOSCAN RS4/PROFIsafe Laser Scanner.

It is essential that all the instructions given in the Connecting and Operating Instruction and in the User Manual be observed, especially those relating to safety.

The Connecting and Operating Instruction and the User Manual should be carefully looked after. They must be available at all times throughout the period when the scanner is in use.

Safety instructions and warnings are indicated with the symbol .

Instructions relating to the safety of laser equipment are indicated with the symbol .

① indicates information without any safety implications.

The Leuze lumiflex GmbH + Co.KG is not liable for damage resulting from improper use. Acquaintance with these instructions constitutes part of the knowledge required for proper use.

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1 General remarks

The RS4 safety surface scanner is an **active opto-electronic protective device** or AOPD of type 3 as defined by EN/IEC61496-1 and (pr)EN/IEC61496-3. The PROFIsafe adapter is an accessory to the RS4 which serves for the safe connection of the device to PROFIBUS-DP.

1.1 Certification

The Laser Scanner ROTOSCAN RS4/PROFIsafe was developed and manufactured with regard to the applicable European guidelines and standards. An EC prototype test certificate as specified in EN/IEC 61496-1 und (pr)EN/IEC 61496-3 has been conferred by:

TÜV Süddeutschland Group ¹ Zertifizierstelle Ridlerstr. 65, D-80339 Munich GERMANY

Product



1.2 Symbols and terms

The following symbols are used in this document, and these are some of the terms that occur:

➤	Instructions relating to specific actions, informing the user of procedures to be followed / settings to be made
C1, C2	Class 1 or class 2: classification of PROFIBUS masters based on their support of different telegram formats
CPU	Central Processing Unit
CRC	Cyclic Redundancy Check, the check sum in a data telegram
DB	Data block
Download	Transfer of parameters from the master to a slave
DPV0, DPV1	Functional versions of PROFIBUS
DRa	Data record

1. Technischer Überwachungsverein:
authority responsible for maintaining industrial standards.

F-CPU	Failsafe CPU
F-device	Failsafe device (when a malfunction is detected, it automatically goes into safe mode)
F-system	Fail-safe system consisting of F-devices and other components
FB	Functional block
GSD	Electronic datasheet relating to a device that includes the device's communication parameters
LS	Laser scanner
Master	Control unit in a bus system, gives permission to slaves to access bus
MMC	Micro memory card
OSSD	Output signal switching device (safety-related switch output)
PC adapter	Cable connection between the optical parameterisation and diagnosis interface of the RS4/PROFIsafe and the RS232 interface of a PC
PDU	Protocol data unit
PROFIsafe	Application profile of PROFIBUS safety devices, realised by means of a safety software component, the PROFIsafe driver
Proxy-FB	Functional block in the S7 master, which carries out automatic parameter adjustment by referring to the RS4/PROFIsafe
PF	Protective field
SFC	System function call
Slave	Unit subordinated to the master for communication purposes. The only messages it sends on the bus are answers to requests from the master.
PLC	Programmable logic control
Upload	Transfer of parameters from a slave to a master
WF	Warning field
μ C1, μ C2	Abbreviations referring to the two micro-controllers in the PROFIsafe adapter

a German: DS = Datensatz.

2 System architecture

2.1 PROFIBUS DP

PROFIBUS is a manufacturer-independent, open field bus standard, with a wide area of application in manufacturing and process automation context. Independence of the manufacturer and openness are guaranteed by the international EN 50170 and IEC 61158. PROFIBUS makes it possible for the devices of different manufacturers to communicate with each other without any specially adapted interfaces, and is suitable both, rapid applications where time is a critical factor and for complex communication tasks. Continuous technical improvement means that PROFIBUS will continue to be the ultimately reliable industrial communications system of the future.

PROFIBUS offers the functionally graduated communication protocols (**communication profiles**) DP and FMS. Depending on the area of application, RS-485, IEC 1158-2 or optical fibre cables are available as **physical profiles** to facilitate the transfer of information.

Up to 126 stations can be connected to PROFIBUS DP. These divide up the transfer medium on a time-share basis. The configurable data transfer rate is 9.6 KBd to 12 MBd, the maximum possible rate being limited by the length of the cable. The RS485 cables that are most frequently used must have their ends terminated with a bus terminator(see the section on accessories, section 10.3, M12 terminal plugs).

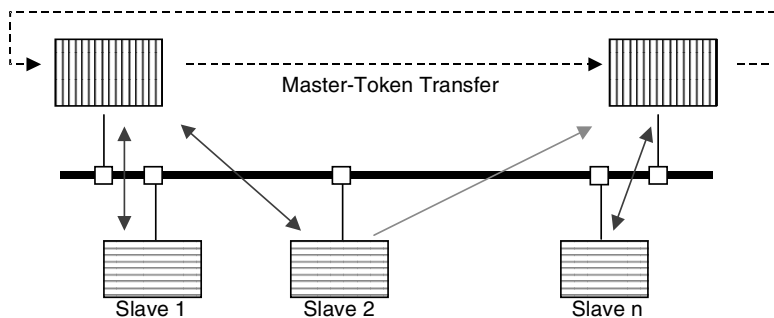


Fig. 2.1-1: The functional principle of PROFIBUS

Access to the bus is controlled by means of a master-slave protocol, with overriding token passing. What happens is that a master station generates a request to one of the slave stations that are subordinate to it for communication purposes, and the latter reacts to the master's request by sending a response telegram. Only the master that is currently in possession of the token is allowed to generate request telegrams. Passing the token brings it about that bus control rights are switched cyclically between the master stations. As well as peer to peer communication between a master and a slave, a master can also generate what are known as broadcast telegrams (which are sent to the address 127): these will be received and evaluated by all slaves simultaneously, but not acknowledged. With what are known as modular slaves, the PROFIBUS telegram may carry information on the slot and the channel as well as the slave address.

PROFIBUS DP incorporates two classes of master.

The class 1 master is the central component responsible for the polling/bus access procedure, and carries out data exchange with the input/output devices (slaves). It defines the data transfer rate, to which the slaves will normally adapt automatically, and controls the exchange of the token with other masters. Several class 1 masters may operate in the PROFIBUS DP system simultaneously. Typical class 1 masters are programmable logical controls (PLCs) and PCs responsible for system control.

Class 2 masters are generally used as project configuration or visualisation devices, and serve as auxiliary tools when starting up the system or for diagnosis.

Data exchange between the class 1 master and the slave may be cyclic or acyclic.

Cyclic data are read into the process imaging memory of the master in each bus cycle, or written from there to the slaves. Normally no programming is required: all that is needed here is a project configuration, that is to say, the allocation of the data of the master process image to the corresponding data in the PROFIBUS slaves. The PLC program simply accesses the data in the process imaging memory without "knowing" whether these data are being input/output locally in the context of the PLC, or by way of a PROFIBUS slave. PROFIBUS is responsible for the automatic cyclic exchange of information.

Acyclic exchange of data can be carried out by the master that has parameterised the slave. This uses the READ and WRITE functions. Acyclic data transfer is used, for example, in the transfer of parameter records from the master to the RS4/PROFIsafe (download) or from the RS4/PROFIsafe to the master (upload).

Alarms represent a special case. The master will be notified of these in the context of cyclic data transfer through the PROFIBUS status byte; the master then gets the actual alarm information from the slave that has signalled by means of an acyclic telegram. This information will then be written by the master to a memory area reserved for alarms (SAP51) and can be subsequently evaluated by the application program.

For the project configuration of every PROFIBUS DP class 1 master and of every slave, what is known as a an electronic data sheet GSD is required. This will be supplied by the manufacturer of the master or the slave, and describes its properties from the point of view of PROFIBUS. As well as including such PROFIBUS data as e.g.

- the data transfer rate supported
- the telegram length supported
- the quantity of input and output data

this file contains information about diagnosis signalling and specific device parameters.

2.2 PROFIsafe

PROFIsafe is a functional extension of PROFIBUS DP, and makes it possible to operate safety bus components along with non-safety-related standard components on the same bus. PROFIsafe devices do not call for any kind of modification to the existing hardware components, and can be integrated with existing systems without any problem.

The PROFIsafe driver is a software component that carries a TÜV¹ certification. Above the communication layers, it makes use of the functions of the PROFIBUS DP stack. Safety of data transfer is achieved by means of the special structure of the user data as well as including the actual safety data, these also incorporate a control byte, a serial number and a further check sum. The destination address makes it possible to address a PROFIsafe device uniquely, even in systems with several PROFIBUS lines, that is with multiple slave addresses for similar devices. Only cyclic data are transmitted safely, i.e. are processed by the PROFIsafe driver before transmission.

2.3 The ROTOSCAN RS4 Laser Scanner

The RS4 surface scanner is an opto-electronic protective device (AOPD) of type 3. It transmits very short laser impulses, and measures the time until the impulse impacts on an object and until the reflection reaches the RS4 receiver. The length of time enables the device to calculate the distance between the object and the RS4. The scanning unit in the RS4 rotates, and transmits/receives a laser pulse at every 0.36°. This enables it to scan a sector of up to 190°, with the RS4 situated at the midpoint.

The protective field that is to be monitored is limited by a user-defined curve around the scanner, the maximum distance from this to the midpoint of the scanner being 4 metres. If an object is detected between this boundary line and the scanner, thus violating the protective field, the scanner will switch off its safety-related OSSD output, bringing the hazardous movement to a standstill. While the device is operating, one of a maximum of 4 protective fields can be selected, by enabling one of 4 outputs.

1. German: Technischer Überwachungsverein: Technical Inspection Authority.

Without reference to the parameters, the scanner may put out a warning signal that is not safety-related, if a warning field defined by the user should be violated. This warning field is coupled to the protective field in a fixed pairing. All protective field pairs, together with the permissible switchings, will be adapted to the given application when the equipment is first put into operation.

2.4 The PROFIsafe adapter

The RS4/PROFIsafe consists of two components, the RS4 and the PROFIsafe adapter. The PROFIsafe adapter is responsible for the connection to PROFIBUS, and is designed as shown below:

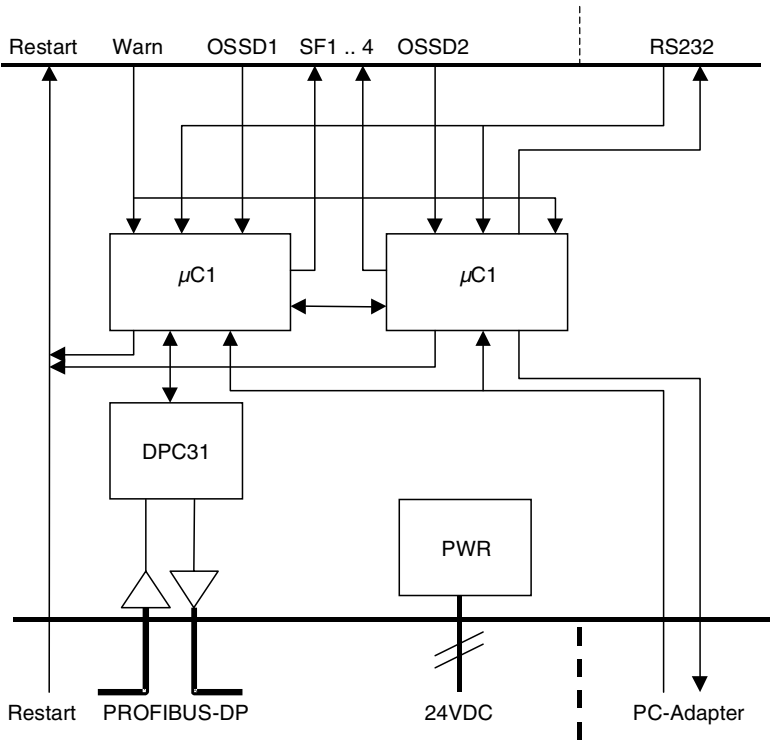


Fig. 2.4-1: Design of the PROFIsafe adapter

The safety-related output signals OSSD1 and OSSD2 and the warning signal of the RS4 is communicated to the PROFIBUS master (generally speaking a safety PLC) as one bit of a safety telegram. The program of this safety interface must bring about the switching-off of the hazardous movement (see section 7.3). The switching of the protective field pairs during operation is managed by output bits of the safety PLC, which are transmitted via PROFIBUS and the PROFIsafe adapter to the RS4 (protective fields 1 to 4). The restart signal for the RS4 can be given either by means of a button that is locally linked to socket 1 (section 4.3) or via PROFIBUS in the form of a bit of the cyclic output byte (section 5.1.2).

The optical PC adapter is connected with the PROFIsafe adapter via the infrared interface. The adapter forwards the telegrams to the RS232 of the RS4, so long as a parameter matching with the Proxy-FB on the master is not currently running (section 5.1.2).



Although the data transfer is safe, the warning signal must not be used in a safety-related manner, as it is not delivered by the scanner as a safe signal.

- ① For the RS4/PROFIsafe, this document replaces the description of the connection to the machine interface given in the RS4-4 Connecting and Operating Instruction.



In sizing the dimensions for your application, it is essential that you take into account the longer response time of the RS4/PROFIsafe as compared with an RS4 that does not have a PROFIBUS connection (section 6.6)

3 Safety instructions

3.1 Hazardous consequences of failure to observe the safety instructions

The products of Leuze lumiflex are developed and manufactured through the careful application of the recognised rules of technology. The protective function of the equipment can however be impaired if it is inappropriately used or used otherwise than in the manner specified. In this case it may no longer be possible to protect danger areas, or protection will be less than adequate. This may result in danger to life and limb for personnel who are in close proximity to the machine or plant.



Warning: laser beam!

The RS4 laser scanner is a laser device of laser class 1. Please have regard to the applicable statutory and local regulations for the operation of laser systems. Avoid positioning the scanner at eye level.

3.2 Conditions and specifications of use

Use of the RS4/PROFI-safe surface scanner is governed by the relevant European prescriptions relating to plant safety, in particular:

- Machinery Directive 98/37/EC and
- Directive on the Use of Working Equipment 89/655/EEC

as well as the corresponding national laws that have been implemented in the various member states of the EU. In the Federal Republic of Germany the laws that apply are the Plant Safety Act¹ and the Ordinance on the Use of Working Equipment², in association with the Working Conditions Act³, statutory prescriptions for the avoidance of accidents, safety regulations and any other relevant safety prescriptions and standards.

Observation of these regulations is obligatory for the manufacturer and operator of the machine or equipment to which the opto-electronic protective device is attached. For the clarification of safety issues the responsible local authorities (e.g. industrial control authorities, professional trade associations or factory inspectorates) may be consulted. In general terms the conditions of use to be observed are as given below.

The equipment may be set up and connected to the power supply only by qualified personnel. The same goes for the testing that must be carried out before the equipment is put into operation, and for regular testing subsequently. Knowledge of the safety instructions contained in this Connecting and Operating Instruction forms part of the qualifications that the personnel are required to have. Special safety instructions relating to electrical connection may be found in section 4.

The RS4/PROFI-safe conforms to safety category 3 as defined by EN954-1. In order to maintain this level of safety, all elements in the safety chain that are installed on the downstream side, right up to the stopping of the hazardous movement, must also conform at least to the requirements of safety category 3.

1. German: Gerätesicherheitsgesetz.
 2. German: Arbeitsmittel-Benutzungsverordnung.
 3. German: Arbeitsschutzgesetz.

The use of the RS4/PROFI-safe Laser Scanner is subject to the relevant prescriptions of plant safety. For the clarification of safety issues the responsible authorities (e.g. professional trade associations, OSHA etc.) may be consulted. In general terms the conditions of use to be observed are as given below.

If the scanner is equipped with a protective housing, there should not be any further window materials (plastic, glass etc.) in the path of the scanning beam.

Avoid touching the scanner window and the six scattered light panes.

The RS4/PROFI-safe Laser Scanner is not suitable as a protective facility in situations where the overspill of dangerous liquids is a possibility, or where there are objects with long machine braking times (max. depth of protective field 4 m). In cases like these Leuze lumiflex can provide suitable door bolts (safety switches), either with or without guard interlocking.

The 24 V DC power supply (which may vary from +20% to -30%) must be by means of a safety transformer as defined by IEC 742. The same requirements apply to all incoming or outgoing power circuits that are connected to the system.

The scanner is to be connected to the power supply by way of a separate branch and by means of a 1.25 amp middle time-lag fuse installed in the switch cabinet.

The complete system (comprising scanner, machine, control and switching components) may only be tested when no hazards to personnel will result from this.

Interfering with or modifying the RS4/PROFI-safe Laser Scanner can lead to a loss of its safety functionality.

Putting the machine into operation, maintenance, setting of the parameters and configuration of the protective field are only to be carried out by properly qualified personnel. Knowledge of the safety instructions of this Connecting and Operating Instruction and of the User Manual contained in the RS4soft program forms part of the qualifications that personnel are required to have.

The password required for the configuration of safety-related settings is to be kept secret by the safety officer. Information about password levels will be found in the RS4soft User Manual

The use of the scanner for monitoring the passage of persons (vertical protective field) as defined by IEC 61496-3 is only permitted under the following conditions:

- non-detachable fixed mounting of the scanner
- non-removable walls for zoning the passage, which has to be protected
- response time of the entire protective device including PROFIBUS and PCL < 160 ms

3.3 Areas of use

ROTOSCAN RS4 Laser Scanners are primarily intended for the protection of danger areas. To do this, for the most part horizontal scanning serves to check for the presence of persons in the protective field at any time. When the RS4 is in use, access to the danger zone should only be possible by passing through the protective field. Between the protective field and the danger zone a defined safety distance must be maintained. This may be calculated from the formulas in the specific machine-related European 'C' standards or in the general 'B1' standard EN 999. The RS4 is absolutely **not** suitable as a protective facility when there is a risk that objects may be violently expelled or that hot or hazardous fluids may spurt out. Nor is it suitable for machines with long overtravel times. In cases like these Leuze lumiflex can provide suitable door bolts (safety switches), either with or without guard interlocking.



When using the RS4/PROFI-safe, please be aware that the response time is higher than that given in the ROTOSCAN RS4 Laser Scanner Connecting and Operating Instruction, and this will have implications for the permitted distance from the danger zone (see also section 6.6).

3.4 Organisational measures

3.4.1 Documentation

It is essential that all the instructions of this Connecting and Operating Instruction be observed, especially those given in chapters 2 and 7. Keep this Connecting and Operating Instruction in a safe place. It should be available at all times.

Regard must also be had to the ROTOSCAN RS4 Laser Scanner Connecting and Operating Instruction, which describe the function of the laser scanner.

3.4.2 Safety prescriptions

You should have regard to the statutory regulations that apply locally and to the prescriptions of professional trade associations.

3.4.3 Qualified personnel

The equipment should be installed, put into operation and maintained only by professionally qualified personnel. Electrical work may only be carried out by qualified electricians, who must also have the required familiarity with the RS4soft software.

3.4.4 Repairs

Repair work, especially involving the opening of the housing, may only be carried out by the manufacturer or by a person acting with the manufacturer's authorisation. An exception to this is the setting of the PROFIBUS address with the rotary control switch (see section 4.5).

3.4.5 Disposal

- ① Electronic scrap is special category waste! Please observe the locally valid prescriptions for the disposal of such waste! Neither the RS4/PROFIsafe Laser Scanner nor the PROFIsafe adapter contain any batteries or other materials that need to be removed before the equipment is disposed of.

4 Design, assembly and connection to the power supply

4.1 Design

The RS4/PROFIsafe consists of two components, the RS4 laser scanner and the PROFIsafe adapter. These have already been assembled together at the factory. The PROFIsafe adapter manages the processing of standard RS4 data for PROFIBUS.

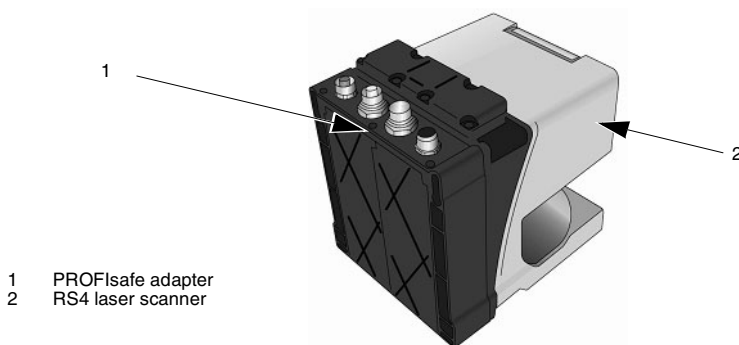
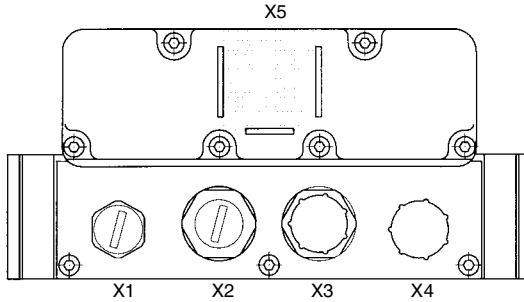


Fig. 4.1-1: Design of the RS4/PROFIsafe

4.2 Mounting

To mount the RS4/PROFIsafe you should use rather long fastening screws, with a length of at least 50 mm and a diameter of 5 mm; in other respects the mounting instructions for the RS4/PROFIsafe. The borehole measurements may be seen from the scale drawings in section 9.

4.3 Connecting the device to power supply



- X1 Restart button connection
- X2 PROFIBUS output cable
- X3 PROFIBUS input cable
- X4 Power supply
- X5 Optical PC interface

Fig. 4.3-1: Connecting the RS4/PROFIsafe to the power supply

Socket/ plug	Function	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5
X1	Restart button	n.c.	+24 V DC	n.c.	Restart	n.c.
			out		in	
X2	PROFIBUS output	VP	RxD/TxD-N	DGND	RxD/TxD-P	Shield
		out	out	out	out	out
X3	PROFIBUS input	n.c.	RxD/TxD-N	n.c.	RxD/TxD-P	Shield
			in		in	
X4	Power supply	+24 V DC	n.c.	0 V DC	n.c.	n.c.
		in		in		

Table 4.3-1: Terminal assignment of the RS4/PROFIsafe

Plug X1 of the PROFIsafe adapter serves for the connection of a restart button. This button serves first of all to unblock the startup/restart interlock that is internal to the scanner, if this has been activated; in addition this button is responsible for the acknowledgement of error messages. This is necessary if the scanner should malfunction.

When the restart button is activated, the safety outputs OSSD 1 and OSSD 2 of the RS4 are switched off, and the display on the scanner (LED 3) lights up red. The duration of the reset signal must be from 0.12 to 5 seconds. The length of the restart cable must not exceed 25 metres.

Shielded standard PROFIBUS cables, with the matching M12 PROFIBUS plug/socket, are screwed onto socket X2 and plug X3. If the RS4/PROFIsafe is the last device connected to PROFIBUS, a matching bus terminator must be connected to socket X2 (see section 10.3).

The RS4/PROFIsafe requires to be supplied via plux X4 with 24 V DC (which may vary between +20 and -30%) from a mains source conforming to protective class 2 by way of a unilaterally shielded supply line that should not exceed 50 m in length. The shield has to be connected with the cabinet. Power is supplied to the RS4 laser scanner via the PROFIsafe adapter.

For parameterisation purposes, and for local diagnosis of the RS4, a PC with the RS4soft parameterisation and diagnosis software is connected to the top side of the PROFIsafe adapter by way of an RS232 interface, the programming cable and the optical interface. The cable exit of the PC adapter on the RS4/PROFIsafe thus points in the direction of the protective field. A powerful magnet in the PC adapter not only brings about a mechanical halt but at the same time informs a reed contact in the device that the PC adapter is connected. The interface will only be linked to the RS4 if at the time no automatic parameter matching with the optional Proxy-FB in the master is being carried out (section 6.4).

The PROFIsafe adapter does read the stream of data, but does not modify it in any way. This interface thus corresponds in functional terms to the RS232 interface comprising SUB-D plugs in the RS4.

- ① As the power supply for the PC adapter comes through the PC's COM port, the latter must be "RS232 compliant", that is, with a load of 3 kOhm it must still be able to supply a voltage of 5 V. The claim to be "RS232 compatible" that is occasionally found with Notebook PCs is not sufficient here.
- ① A complete description of the software may be found in the RS4soft User Manual.

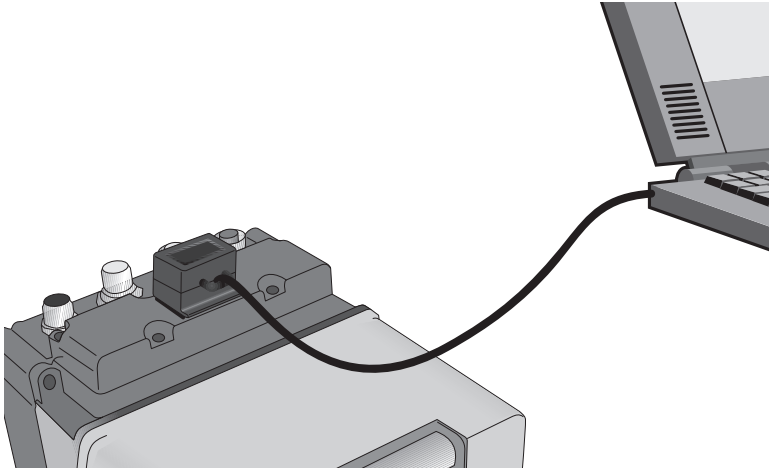


Fig. 4.3-2: Connecting PC and RS4/PROFIsafe with optical PC adapter

4.4 Display

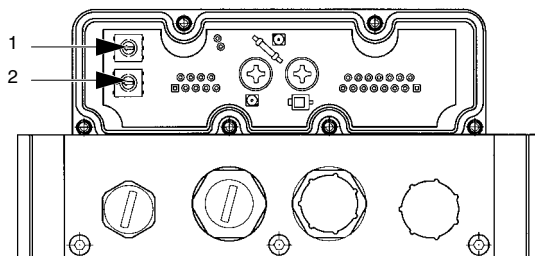
Below the surface on which the PC adapter is situated an LED is located, which displays the status of the PROFIBUS connection. When the power is switched on, the PROFIsafe adapter runs through an initialisation procedure, in the course of which the LED will give off continuous light for two to three seconds. Rapid flashing (at a frequency of ca. 5 Hz) indicates that the adapter is ready to set up the PROFIBUS connection. If the LED lights up continuously for longer than 3 seconds, or if the flashing frequency is less than 5 Hz, this indicates a malfunction. The varying flashing frequencies are intended to facilitate remote diagnosis by the service technician.

- ① If there is a malfunction but the LED does not indicate an error, the power supply should be checked.

4.5 PROFIBUS address

After removing the 6 screws on the top of the PROFIsafe adapter, the lid of the adapter may be taken off. This makes it possible to access the two hex switches which are used to set the PROFIBUS address. HexL sets the lower-value four bits, and HexH the higher-value four bits of the PROFIBUS address. Addresses greater than decimal 126 (hex 7E) are not allowed. This is ensured by not evaluating the highest value bit 7. The settings 127 (hex 7F) and 255 (hex FF) must not be used. The factory setting is address 4.

- ① What is known as the F_Dest_Add, which is necessary for the PROFIsafe protocol, does not need to be set separately, as it results from the simple addition of 500 to the PROFIBUS address. It is therefore only necessary, when configuring the system, to ensure that in each of the PROFIBUS lines that are linked in a system each RS4/PROFIsafe has a unique PROFIBUS address.



- 1 HexL
2 HexH

Fig. 4.5-1: PROFIBUS address switches

5 Data structure

The RS4/PROFIsafe supports both cyclic and acyclic data transfer. In cyclic operation, that is to say, in each bus cycle, what are referred to as the cyclic input and output data are exchanged between the master and the RS4/PROFIsafe. The terms “input and output data” have reference to the master’s point of view. Thus -

- Input data are read by the master, are therefore data output by the RS4/PROFIsafe
- Output data are written by the master, and are the control signals for the RS4/PROFIsafe.

The system supports the acyclic commands READ and WRITE, so that on the request of a master large blocks of data can be transferred, either for parameterisation purposes or to give a read-out of measurement data, without having a long-term adverse impact on cyclic real-time operations.

5.1 Cyclic data exchange

After the parameters have been successfully set, cyclic data transfer will be started, irrespective of the status of the RS4. The input data will be set to safe values, until the RS4 has started up, after which its set of parameters may be checked by the Proxy-FB.

5.1.1 Cyclic input data

The device supplies the safety master with input data of the length of 1 byte, having the following structure:

Bit	Designation	Value	Significance
7	OSSD	Indicates the status of the RS4’s OSSDs	
		0	At least one of the two OSSDs of the RS4 is off, or its signal could not be properly registered. It is possible to find out the cause for the signal OSSD = 0 from bits 1 to 5.
		1	Both OSSDs of the RS4 are switched on.
6	Warning output	Replicates the status of the warning output of the RS4. In the course of the parameterisation of the RS4 the warning “dirty screen” should be assigned to the warning output.	
		0	The warning output has been set.
		1	The warning output has not been set.

Table 5.1-1: Cyclic input data

Bit	Designation	Value	Significance
5	Error	Indicates whether an error has occurred (OSSD = 0 in case of error). Information on the nature of the error will be found in section 5.3.2.	
		0	No error has occurred in the RS4 or in the PROFIsafe adapter.
		1	An error has occurred in the RS4 or in the PROFIsafe adapter.
4	Operating status	Displays the operating status of the device The RS4 may be parameterised either by way of PROFIBUS (C1 or C2 service) or by using the PC interface and the PC adapter.	
		0	Normal protective operation
		1	RS4 parameterisation status, RS4 initialisation phase, or the automatic parameter monitoring has not yet taken place or has not yet been completed; OSSD = 0.
3	RS232 active	Shows whether the optical PC adapter is connected to the RS232. When the signal switches from 1 to 0, that is to say, when the PC adapter is uncoupled, the Proxy Request bit (bit 2) will always be set, so that the Proxy-FB can update its parameter settings in the master if necessary.	
		0	No PC adapter is connected.
		1	The optical PC adapter is connected. No RS4 parameterisation can be carried out by way of PROFIBUS; C1 and C2 services will be acknowledged with an error message.
2	Proxy Request	In the first setting of parameters, and during subsequent parameter adjustment, the OSSD bit is set to 0. If during parameter adjustment the optical PC adapter is connected, the RS232 and bit 3 will only be activated when the parameter adjustment has been completed. While this is going on, the RS4soft program on the PC cannot set up any connection to the RS4.	
		0	Monitoring of the parameter settings by the Proxy-FB need not be carried out. At the start of parameter checking this bit is set to 0. If during the parameter checking an error occurs, it will be reset to 1.
		1	The RS4/PROFIsafe indicates to the Proxy-FB in the master that it must request or supply the RS4/PROFIsafe's parameters and validate them.

Table 5.1-1: Cyclic input data



Bit	Designation	Value	Significance
1	Protective field	Shows that the protective field has been violated.  This bit must not be used for decisions with safety implications!	
		0	The protective field has not been violated.
		1	The protective field has been violated.
0	Warning field	Shows if the warning field has been violated.  This bit must not be used for decisions with safety implications!	
		0	The warning field has not been violated.
		1	The warning field has been violated.

Table 5.1-1: Cyclic input data

The cyclic input data are transferred as PROFIsafe data with 16 bit CRC.



Bits 0-6 must **not** be used for decisions that have safety implications. The failsafe PLC must only evaluate bit 7 to release the machine that is connected on the outgoing side if necessary.

5.1.2 Cyclic output data

The RS4/PROFIsafe expects to receive output data from the safety master (PLC) with the length of 1 byte, having the following structure:

Bit	Designation	Value	Significance
7	Restart	Generates a restart signal on the restart line of the RS4 The timing that is defined for the RS4 must be guaranteed by the PLC or by external sensors.	
		0	No restart pulse, line set to 0
		1	The restart input of the RS4 is switched to 1 (restart activated).

Table 5.1-2: Cyclic output data

Bit	Designation	Value	Significance																				
6	Proxy Enable		This bit determines whether, when the scanner is switched on or when the scanner parameters are modified by way of the optical PC interface, an automatic adjustment by the Proxy-FB will be carried out. This bit will be evaluated when the PROFIBUS starts up and when the optical PC adapter is uncoupled. In the user program it should be definitely assigned either to 1 or to 0.																				
		0	The OSSD bit is released without the Proxy-FB having run. The Proxy Request bit in the cyclic input byte (see section 5.1.1) will nonetheless be set, but the master will not necessarily take this into account. No automatic parameter adjustment is possible when RS4/PROFIsafe is replaced.																				
		1	The Proxy-FB is activated; automatic matching of parameters between the master and the RS4/PROFIsafe will take place.																				
5	reserved	Expects the value 0																					
4	reserved	Expects the value 0																					
3	reserved	Expects the value 0																					
2 1 0	Protective field number	<p>Selects a protective field / warning field pairing on the RS4</p> <p>The number of the protective field to be called up is expected to lie in the range 1 to 4. Any other number would generate a switching error, and will not be forwarded to the RS4. If an invalid protective field number is supplied, the OSSD bit will be set to 0. Approximately 500 ms after a valid protective field number has been subsequently supplied, the OSSD bit will be released again.</p> <p>This does not mean that absolutely any protective fields from 1 to 4, as well as any kind of protective field switchings, are permitted, as additional restrictions may be made by way of the RS4 parameterisation. The RS4soft software defines for the RS4 which protective fields may be switched on and in what order, and which protective field may be activated when the system is switched on.</p> <p>The PROFIsafe adapter ensures that correct timing will be observed when switching. This means that the PLC program can – by contrast with the description given in connection with the RS4 – switch directly from one to another permissible protective field, without activating both protective fields together for more than one second at most.</p> <p>The protective field number is coded as follows:</p> <table border="1"> <thead> <tr> <th>Protective field number</th> <th>Bit 2</th> <th>Bit 1</th> <th>Bit 0</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>0</td> <td>0</td> <td>1</td> </tr> <tr> <td>2</td> <td>0</td> <td>1</td> <td>0</td> </tr> <tr> <td>3</td> <td>0</td> <td>1</td> <td>1</td> </tr> <tr> <td>4</td> <td>1</td> <td>0</td> <td>0</td> </tr> </tbody> </table>		Protective field number	Bit 2	Bit 1	Bit 0	1	0	0	1	2	0	1	0	3	0	1	1	4	1	0	0
Protective field number	Bit 2	Bit 1	Bit 0																				
1	0	0	1																				
2	0	1	0																				
3	0	1	1																				
4	1	0	0																				

Table 5.1-2: Cyclic output data

The cyclic output data are transferred as PROFIsafe data with 16 bit CRC.

- ① As the PROFIsafe adapter always selects protective field 1 when PROFIBUS is starting up, if you want to be able to start up (after occurrence of an error, or when switching on the system) with any protective field, then in setting the RS4 parameters you must at least authorise the switching sequences that follow from protective field 1.

5.2 Acyclic data exchange

Acyclic data exchange is advantageous if relatively large quantities of data have to be transferred rather infrequently. The overall load on the bus can in this way be kept comparatively low, which ensures that the real-time functioning of the cyclic telegrams can be maintained. The READ and WRITE commands enable you to transfer acyclic PROFIBUS data, for instance in order to make a comparative adjustment of parameter settings, to read out measurement data from the scanner or to transmit control commands.

Class 1 master commands

The RS4/PROFIsafe requires the acyclic class 1 READ and WRITE commands for automatic parameter matching, which is managed by the Proxy-FB (section 6.4). It is also possible to generate RS4 commands using the safety master and to send these to the scanner (section 5.2.3), having regard to the communication protocol and the safety prescriptions. In addition to this, control commands for the PROFIsafe adapter can be generated. These have the same format as RS4 commands (section 5.2.2). Please be aware that acyclic communication based on the PLC user program is only possible when the following conditions are fulfilled:

- The RS4/PROFIsafe must be in a normal state of operation.
- No PC adapter may be connected to the optical interface (reed contact not activated).
- The Proxy-FB has concluded its data adjustment procedure.

So long as the PC adapter is connected to the optical interface, all acyclic WRITE commands will be ignored. If the Proxy-FB has not yet finished its data adjustment procedure, an acyclic command to the RS4/PROFIsafe that is generated by the user program will result in the termination of the Proxy-FB's processing, along with the delivery of an error message. These commands, consequently, have to be synchronised with the Proxy-FB (see section 6.4, FB_BUSY).

- ① A faulty command to the RS4 in the course of normal operations can trigger an error in the RS4, so that this will be put into safe mode (OSSD = 0).

Class 2 master commands

All RS4 commands may be used as class 2 master commands (section 5.2.3), but not the special commands for the PROFIsafe adapter that are designed to control the automatic configuration (section 5.2.2). All commands are transmitted to and from the RS232 of the RS4 transparently. Communication by means of class 2 commands is only permitted for one master at any given time.

5.2.1 Header for acyclic commands

Commands that are to be relayed to the RS4 on an acyclic basis may need more than 240 bytes, so that they must be broken up into several blocks. To ensure a consistent telegram format, every data block that is transmitted acyclically (including those that do not need as many as 240 bytes) will be introduced by a header. This header (see table below) replaces, in an RS4 command, all RS232-specific formattings (starting identifier, terminal identifier, labelling of two consecutive zeroes by means of subsequent 0xff and the check character).

Byte	Description
1	Data flow control byte (see table 5.2-2)
2	Block length in bytes, including header
3	Higher-value byte (most significant byte) of the number of the data block, beginning with zero; the last block is always assigned the number 0xff (even when the first and the last block are identical).
4	Low-value byte (least significant byte) of the number of the block, beginning with zero; the last block is always assigned the number 0xff (even when the first and the last block are identical).
5 - 196	User data

Table 5.2-1: Header for acyclic command telegrams

As the RS4 needs up to 2 minutes to process data, the data flow control byte for the READ command will be set by the RS4/PROFIsafe and must be evaluated by the master. With the WRITE command the master sets this byte to zero.

Both for READ and for WRITE, the individual bits in the data flow control byte will be set by the RS4/PROFIsafe as follows:

Bit	Value	Significance
0	0	The RS4/PROFIsafe cannot handle WRITE commands. If a WRITE command is sent to the RS4/PROFIsafe all the same, it will not be processed; instead an error signal will be entered in the error buffer and an alarm sent to the master.
	1	The PROFIsafe adapter is ready to write the first or the next data block.
1	0	This data block contains no user data.
	1	This data block contains user data.
2	0	Reserved
3	0	Reserved
6, 5, 4	The communication status of the PROFIsafe adapter is displayed in these bits in the form of a number.	
	0, 0, 1	It has not proved possible so far to set up a path of communication. Can only be received by a class 2 master, if the PROFIsafe adapter has not yet concluded the startup procedure.
	0, 1, 0	The PC adapter is connected to the optical interface. In this mode acyclic WRITE commands will be ignored; no error message will be given.
	0, 1, 1	The Proxy-FB of the master is currently processing an acyclic command (READ or WRITE). Any additional acyclic WRITE or READ command will result in an error in the Proxy-FB's process sequence. These errors can be prevented by checking the FB output FB_BUSY on the master.
	1, 0, 0	Normal operation: acyclic READ and WRITE commands can be transmitted, having regard to bits 0 and 1.
	1, 0, 1	There is no active communication link in place. That is to say, there is no link to a class 1 master and the PC adapter is not connected to the optical interface. This status report can only be given to a class 2 master.
7	0	Reserved

Table 5.2-2: Structure of the dataflow control byte

The maximum length for a data record is 240 bytes, the minimum length is 5 bytes. Only slot 0 should be used. Either 2 or 3 may be used as an index; they will be treated in the same way by the PROFIsafe adapter. If the master is not capable of handling dynamic data record length, it is possible nonetheless by using these two indices to minimise the load on the bus, in as much as short messages will be transmitted through a short data record (e.g. DR2 (index 2)) and long messages through a long data record (e.g. DR3 (index 3)).

Which data record will be used is determined by the master. Only the data bytes described in the header will be evaluated.

Apart from local parameterisation by way of the PC RS232 interface, PROFIBUS parameterisation of the RS4 by means of the Proxy-FB of a class 1 master (with automatic parameter adjustment) can only be carried out on the basis of acyclic READ and WRITE commands.

In a later section the structure of acyclic commands will be examined in more detail. This can be defined by the user. A distinction must be made here between commands for the PROFIsafe adapter and commands for the RS4.

As the RS4/PROFIsafe requires commands in order to supply RS4 data, an RS4 data record cannot be called up directly by means of a READ command. A complete RS4 data query therefore consists of

- a WRITE, in which the master specifies which data it wants to read
- followed by a READ, through which the requested data, that have in the mean time been supplied, will be read out.

On the other hand, some commands to the PROFIsafe adapter can be directly implemented with a WRITE command.

All the RS4/PROFIsafe command telegrams described below must in addition be started by the header (Table 5.2-1) described earlier (master → RS4/PROFIsafe) or will have a header supplied by the PROFIsafe adapter (RS4/PROFIsafe → master). Only the user data will be described here. For this reason the numbering starts, in the tables below, with byte 5, which is the first byte of user data.

5.2.2 Commands to the PROFIsafe adapter

When any class 1 or class 2 telegram is received, the first byte will indicate whether it is intended for the PROFIsafe adapter or for the RS4.

If the command byte (byte 5) is not one of those shown below, the telegram will be forwarded, without any further checking, to the RS4. If the RS4 does not recognise the telegram either, depending on the status of the RS4 either an error telegram will be the response (RS4 goes into error mode), or the telegram will be simply ignored.

If the telegram is intended for the PROFIsafe adapter, the length of the telegram and the parameter area limits will be checked. If these are in error, an error telegram will be sent in response. In case of erroneous master READ commands, the PROFIsafe adapter response is :

Byte	Description
5	0x93 = error in the telegram
6	Error specification : 0 = incorrect length, 1 = incorrect parameters
7	Command byte of the faulty telegram

Table 5.2-3: Response of the PROFIsafe adapter in case of error

5.2.2.1 Resetting the PROFIsafe adapter

Using the WRITE command shown below, the master can reset the PROFIsafe adapter. Here is the request the master needs to make:

Byte	Description
5	0x94 = PROFI_CMD_RESET Reset command to the PROFIsafe adapter, no additional parameters

Table 5.2-4: PROFIsafe adapter – resetting

There will not be any response from the PROFIsafe adapter. Immediately on reception of this command the resetting of the PROFIsafe adapter (in the form of a power-on reset) will be executed. This means that the PROFIBUS connection will be interrupted for approximately two seconds. The RS4 will not be affected by this (for RS4 restart, see section 5.1.2).

5.2.2.2 Forwarding RS4 telegrams

On the basis of this WRITE command the master prescribes which RS4 data are to be forwarded to the master by the PROFIsafe adapter. Here are the master's request options:

Byte	Description
5	0x92 = PROFI_CMD_GET_RS4_DATA Processing of the RS4's telegrams
6	The bit combination determines what telegrams will be forwarded to the master. Bit 0 = 1 Measurement value telegrams will be forwarded to the master Bit 1 = 1 Alive telegrams will be forwarded to the master Bit 2 = 1 Warning telegrams will be forwarded to the master Bit 3 = 1 Error telegrams will be forwarded to the master If this byte = 0, no further telegrams will be forwarded.

Table 5.2-5: PROFIsafe adapter – forwarding RS4 telegrams

Byte	Description
7	0 = only one telegram will be forwarded to the master. 1 = the telegrams selected above will continue to be forwarded to the master (in the case of measurement value telegrams, only use this facility if the master will really read the telegram, otherwise the telegrams become obsolete.) Error – or warning – telegrams will be sent by RS4 once only, so that these can only be reliably received if byte 7 = 1. >1 = not permissible.

Table 5.2-5: PROFIsafe adapter – forwarding RS4 telegrams

In response the selected telegram or telegrams will be dispatched. As the PROFIsafe adapter can put a number of RS4 telegrams into intermediate storage, if the requested telegram is found, a response will be immediately provided and can be read out. Only after this has been downloaded by the master will a new telegram be supplied, on the basis of the telegrams that have been received from the RS4 at the present time.

If measurement value telegrams are to be forwarded to the master on an ongoing basis, and if the RS4 should generate an error or a warning message by telegram, this will be stored in a second buffer for the master, if this also needs to be forwarded. This means that even a slow master can both read out all measurement value telegrams and also receive error and warning telegrams.

5.2.2.3 Determining the version of the PROFIsafe adapter

With this WRITE command, followed by a subsequent READ command, the master can find out what version of the PROFIsafe adapter is in use. Here is the WRITE request of the master:

Byte	Description
5	0x90 = PROFI_CMD_GET_VERSION, version determination

Response of the PROFIsafe adapter to the following master READ command:

Byte	Description	Response from the PROFIsafe adapter
5	Version query response	0x90
6	PROFIsafe version (high byte)	1
7	PROFIsafe version (low byte)	0
8	PROFIBUS DP version (high byte)	1
9	PROFIBUS DP version (low byte)	0

Table 5.2-6: PROFIsafe adapter: version determination

Byte	Description	Response from the PROFIsafe adapter
10	DPV1SL components (high byte) 0x01 = V1SL_COMP_INSTALLED_C2 0x02 = V1SL_COMP_INSTALLED_C2_RQB_IFA 0x04 = V1SL_COMP_INSTALLED_IBC 0x08 = V1SL_COMP_INSTALLED_ASPC2 0x10 = V1SL_COMP_INSTALLED_DPC31 0x20 = V1SL_COMP_INSTALLED_SPC3 0x40 = V1SL_COMP_INSTALLED_DPR	0x11
11	DPV1SL components (low byte) 0x01 = V1SL_COMP_INSTALLED_C2 0x02 = V1SL_COMP_INSTALLED_C0_RQB_IFA 0x04 = V1SL_COMP_INSTALLED_SUB_AL 0x08 = V1SL_COMP_INSTALLED_SUB_C1 0x20 = V1SL_COMP_INSTALLED_SUB_S7 0x40 = V1SL_COMP_INSTALLED_SUB_SC	0x0D
12	DPV1SL main interface	6
13	DPV1SL function	5
14	DPV1SL bugfix	1

Table 5.2-6: PROFIsafe adapter: version determination

5.2.2.4 Reading out the most recent error of the PROFIsafe adapter

With this WRITE command, followed by a subsequent READ command, the master can read out the most recent error from the PROFIsafe adapter. Here is the WRITE request of the master:

Byte	Description
5	0x84 = PROFI_CMD_ERROR Querying the fault that most recently occurred in the PROFIsafe adapter

Response of the PROFIsafe adapter to the master's subsequent READ command:

Byte	Description
5	0x84 = response for last error from slave
6	high byte error number in μ C2
7	low byte error number in μ C2
8	high byte of error number since the power was turned on in μ C2
9	low byte of error number since the power was turned on in μ C2
10	high byte error number in μ C1
11	low byte error number in μ C1
12	low byte of error number since the power was turned on in μ C1
13	high byte of error number since the power was turned on in μ C1

Table 5.2-7: PROFIsafe adapter – reading out the most recent error

5.2.2.5 Reading out the error register of the PROFIsafe adapter

With this WRITE command, followed by a subsequent READ command, the master can obtain a complete read-out of the error register of the PROFIsafe adapter. Here is the WRITE request of the master:

Byte	Description
5	0x91 = PROFI_CMD_GET_ERROR, querying the error register of the PROFIsafe adapter

Response of the PROFIsafe adapter to the master's subsequent READ command:

Byte	Description
5	0x91 = response for all errors from the PROFIsafe adapter
6	Write index of the most recent error in μ C2 that has been entered in the ring buffer
7	0 = error occurred in the most recent cycle 1 = error occurred earlier
8	Error number (high byte) for index 0 in ring buffer of μ C2
9	Error number (low byte) for index 0 in ring buffer of μ C2
10	Error number (high byte) for index 1 in ring buffer of μ C2
11	Error number (low byte) for index 1 in ring buffer of μ C2
...	...
...	...
46	Error number (high byte) for index 19 in ring buffer of μ C2
47	Error number (low byte) for index 19 in ring buffer of μ C2
48	Write index of the most recent error in μ C1 that has been entered in the ring buffer
49	0 = error occurred in the most recent cycle 1 = error occurred earlier
50	Error number (high byte) for index 0 in ring buffer of μ C1
51	Error number (low byte) for index 0 in ring buffer of μ C1
52	Error number (high byte) for index 1 in ring buffer of μ C1
53	Error number (low byte) for index 1 in ring buffer of μ C1
...	...
...	...
88	Error number (high byte) for index 19 in ring buffer of μ C1
89	Error number (low byte) for index 19 in ring buffer of μ C1

Table 5.2-8: PROFIsafe adapter – reading out data from the error register

The content of the error register is maintained intact when the system is restarted, but is lost when the device is switched off.

5.2.3 Commands to the RS4

The RS4 commands described below use so called option bytes, that is to say control flags carrying e.g. status information, which are transmitted along with each message. The first option byte is always transmitted, and defines protocol information, such as for instance the number of option bytes that are being transmitted. All the other optional characters will only be transmitted when this is necessary, i.e. when at least one status bit is set. The three possible option bytes have the following structure:

Name	Description																																																						
Option 1	<p data-bbox="292 392 796 416">Option 1 is always sent, and has the following layout:</p> <div data-bbox="300 440 967 1026" style="border: 1px solid black; padding: 10px;"> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 20px; text-align: center; border: 1px solid black;">7</td> <td style="width: 20px; text-align: center; border: 1px solid black;">6</td> <td style="width: 20px; text-align: center; border: 1px solid black;">5</td> <td style="width: 20px; text-align: center; border: 1px solid black;">4</td> <td style="width: 20px; text-align: center; border: 1px solid black;">3</td> <td style="width: 20px; text-align: center; border: 1px solid black;">2</td> <td style="width: 20px; text-align: center; border: 1px solid black;">1</td> <td style="width: 20px; text-align: center; border: 1px solid black;">0</td> <td style="padding-left: 10px;">Bit</td> </tr> <tr> <td colspan="8" style="border: none;"></td> <td style="border: none;">} number of optional fields, i.e. at least 1</td> </tr> <tr> <td colspan="8" style="border: none;"></td> <td style="border: none;">} current operating status</td> </tr> <tr> <td colspan="8" style="border: none;"></td> <td style="border: none;">0 = without password 1 = with password</td> </tr> <tr> <td colspan="8" style="border: none;"></td> <td style="border: none;">0 = without acknowledgement 1 = with acknowledgement</td> </tr> <tr> <td colspan="8" style="border: none;"></td> <td style="border: none;">reserved</td> </tr> </table> <p data-bbox="292 1050 997 1289"> The number of option bytes can only lie between 1 and 3 (bit 0 & bit 1). The <i>current operating status</i> field (bits 2-4) shows the current operating status, and has the following layout: 000 – no information (with messages to the RS4) 001 – initialisation 010 – measurement operations 011 – configuration 100 – error/malfunction As the number of option bytes has to be at least 1, <i>option 1</i> can never have the value 0x00. </p> </div>	7	6	5	4	3	2	1	0	Bit									} number of optional fields, i.e. at least 1									} current operating status									0 = without password 1 = with password									0 = without acknowledgement 1 = with acknowledgement									reserved
7	6	5	4	3	2	1	0	Bit																																															
								} number of optional fields, i.e. at least 1																																															
								} current operating status																																															
								0 = without password 1 = with password																																															
								0 = without acknowledgement 1 = with acknowledgement																																															
								reserved																																															

Table 5.2-9: Structure of the option byte in RS4 commands

Name	Description								
Option 2	<p>Option 2 transmits status information about the individual protective fields + malfunction + warning + restart interlock. It will only be transmitted if at least one flag is set, i.e. this byte can never have the value 0x00. If this option is transmitted, the number of optional fields in <i>option 1</i> must be at least two. This optional character has the following layout:</p> <div style="text-align: center; margin: 10px 0;"> <table border="1" style="display: inline-table; border-collapse: collapse;"> <tr> <td style="padding: 2px 5px;">7</td> <td style="padding: 2px 5px;">6</td> <td style="padding: 2px 5px;">5</td> <td style="padding: 2px 5px;">4</td> <td style="padding: 2px 5px;">3</td> <td style="padding: 2px 5px;">2</td> <td style="padding: 2px 5px;">1</td> <td style="padding: 2px 5px;">0</td> </tr> </table> Bit </div> <p style="margin-left: 20px;"> currently active protective field 0 = free 1 = occupied currently active warning field 0 = free 1 = occupied warning malfunction restart interlock 2nd protective field 0 = free 1 = occupied 2nd warning field 0 = free 1 = occupied = 1 (for option 3) </p> <p>With messages to the RS4 this option byte has no significance. Bit 7 will be set to 1 if option 3 has to be transmitted, so as to make it impossible for option 2 to have the value 0.</p>	7	6	5	4	3	2	1	0
7	6	5	4	3	2	1	0		

Table 5.2-9: Structure of the option byte in RS4 commands

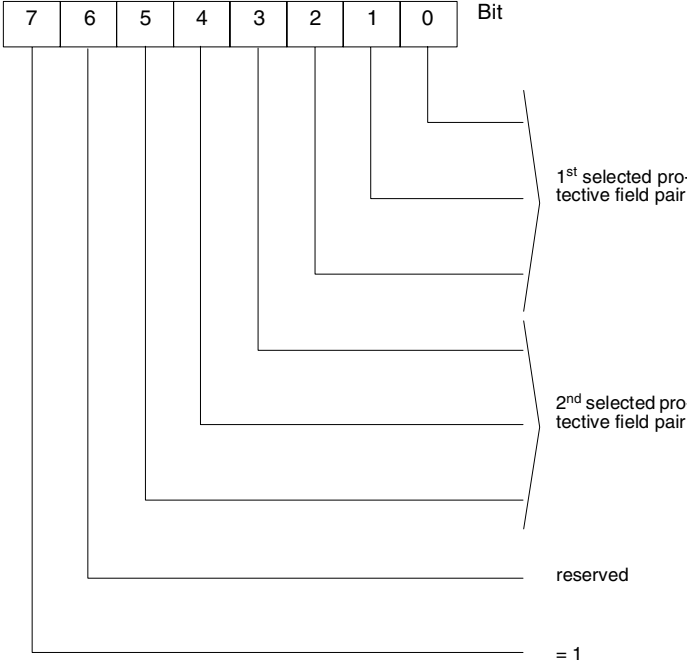
Name	Description
Option 3	<p>Option 3 transmits status information about the selected protective field pairs. It will only be transmitted if at least one flag is set, i.e. this byte can never have the value 0x00. If this option is transmitted, the number of optional fields in the <i>option 1</i> byte must be at least three. This option byte has the following layout:</p>  <p>The diagram shows a byte with bits 7 to 0. Bit 0 is reserved. Bits 1-4 are grouped as the 1st selected protective field pair. Bits 5-8 are grouped as the 2nd selected protective field pair. Bit 7 is reserved.</p> <p>As it can happen that when the protective fields are being switched two protective field pairs may be selected simultaneously, it is necessary to give two specifications for the selected protective field pair. For the selected protective field pairs, 0 means that no selection has been made, 1-4 indicates selection of protective field pairs 1-4. With messages to the RS4 this byte has no significance.</p>

Table 5.2-9: Structure of the option byte in RS4 commands

5.2.3.1 Alive telegrams

When alive telegrams are enabled with PROFIsafe_CMD_GET_RS4_DATA (see section 5.2.2.2), the master can read these in the following format:

Byte	Description
5	0x14 = COM_CMD_ALIVE
6	Option 1
7	Option 2
8	Option 3

Table 5.2-10: Structure of the alive telegram

If no RS4 telegram is available, a block without data content will be sent.

5.2.3.2 Error telegrams

If an error occurs in the RS4, the following command will be sent as an alarm (section 5.3.2) or else sent to the master in response to an acyclic READ command.

Byte	Description
5	0x53 = COM_CMD_ERROR_OCCURRED
6	Option 1
7	Option 2
8	Option 3
9	RS4 error number (high byte)
10	RS4 error number (low byte)
11	RS4 error parameter (high byte)
12	RS4 error parameter (low byte)
13	RS4 error function (high byte)
14	RS4 error function (low byte)

Table 5.2-11: Structure of the error telegram

5.2.3.3 Warning telegrams

If the window of the RS4 becomes too dirty, the following command will be sent as an alarm (section Diagnosis alarms) or else sent to the master in response to an acyclic READ command.

Byte	Description
5	0x54 = COM_CMD_WARNING_OCCURRED
6	Option 1
7	Option 2
8	Option 3
9	RS4 error number (high byte)
10	RS4 error number (low byte)
11	RS4 error parameter (high byte)
12	RS4 error parameter (low byte)
13	RS4 error function (high byte)
14	RS4 error function (low byte)

Table 5.2-12: Structure of the warning telegram

5.2.3.4 Measurement value telegrams

When alive telegrams are enabled with PROFIL_CMD_GET_RS4_DATA, if the RS4 sends measurement value telegrams the master can read these in the following format:

Byte	Description
5	0x23 = COM_CMD_MESS_16_RT
6	Option 1
7	Option 2
8	Option 3
9 ...	User data (see below)

Table 5.2-13: Structure of the measurement value telegram

The number of bytes of user data is dependent on the parameterisation of the RS4. If no RS4 telegram is available, a user data block without data content will be sent.

Every outline measured has 529 measurement values (angle of -5.04° to $+185.04^\circ$ with 0.36° resolution). Every individual measurement value has a segment number beginning with 0. This means that the measurement value at the -5.04° point has the segment number 0, and the measurement value at the 0° point has the segment number 14. Within a measurement message it is not necessarily the case that all values of the outline measured will be transmitted (see resolution, output start and output stop below). The following data will be transmitted within a measured outline:

Byte	Name	Description	Sizes
9	Scan number	<p>With every revolution of the RS4, the scan number will be incremented. This scan number can be used to determine the distance in time between two measurement contours that have been output.</p> <p>The actual scan number has a size of 32 bits. So as to rule out the possibility of a small value producing a multiple zero in the transmission of these 4 bytes, filler bytes are inserted between the individual bytes of the scan number. This results in the scan number having the following structure:</p> <p>Bits 24-31 0xFE Bits 16-23 0xFE Bits 8-15 0xFE Bits 0-7 0xFE</p>	8 bytes
17	Resolution	<p>Gives the distance in segments (measurement points) between two consecutive measurement values. For example, the measurement outline is output, starting from measurement value 0 through to 528, and the resolution is set to 4. Measurement values will be output for the following segments of the outline measured:</p> <p>0 4 ... 524 528</p>	1 byte
18	Output start	Indicates at which segment (between 0 and 528) the measured outline of the output starts.	2 bytes

Table 5.2-14: Structure of the measurement data in the measurement value telegram

Byte	Name	Description	Sizes
20	Output stop	Indicates which segment (between 0 and 528) supplies the last measurement value. If the relation between the number of measurement values output (resulting from output start and output stop) and the resolution is not exact, then the measurement value corresponding to output stop will be output as well.	2 bytes
22	Measurement values	In succession, the individual measurement values are transmitted, starting with the measurement value that corresponds to output start and ending with the measurement value that corresponds to output stop. Each measurement value here corresponds to the distance measured between the RS4's rotational axis and object at the given angular position, in millimetres. Bit 0 of each measurement value indicates whether between the given measurement value and the previous one the measured outline has violated a protective field. This means that when the measurement values are evaluated as a value of distance, bit 0 has to be masked out.	Depending on output start and output stop, 2 bytes in each case

Table 5.2-14: Structure of the measurement data in the measurement value telegram

2-byte values within the measurement value telegram are transmitted with the high byte coming first and the low byte second.

5.3 Alarms

Alarms will be automatically transmitted by PROFIBUS to the master, if they are reported to the master in the cyclic telegram in the PROFIBUS status byte. The master will then get the actual alarm information from the slave that has reported it by means of an acyclic telegram, and write it to a storage area reserved for alarms (SAP51). The application program can then evaluate the alarm report, without having to call up these data by means of an explicit READ command.

5.3.1 Alarm update messages

If after a C2-initiate a class 2 master accesses the PROFIsafe adapter in order to write for the first time, this will be communicated to the class 1 master by means of the alarm update facility. The alarm update PDU is coded as follows:

Byte	Bit								Description
	7	6	5	4	3	2	1	0	
1	0	0	0	0	0	1	0	0	Length of the alarm PDU (including header) = 4 bytes
2	0	0	0	0	0	1	1	0	Type = alarm update
3	0	0	0	0	0	0	0	0	No slots (slot 0)
4	0	0	Sequ. no.			1	0	0	No alarm differentiation, with acknowledgement, sequential numbers 0-7

Table 5.3-1: Structure of the alarm update message

5.3.2 Diagnosis alarms

Errors and warnings of the RS4, as well as errors in the PROFIsafe adapter, will be reported as PROFIBUS diagnosis alarms. Each new error will be reported as a new incoming alarm. Errors that persist with a standing connection will be reported only once. If the connection is broken off and cyclic data traffic is later resumed, the last error that has occurred, if it is still found to be present, will be reported once more as an incoming alarm. If no error is found for a minimum of 500 ms, an outgoing alarm will be sent. A sequential modality for 8 alarms is supported, that is to say that up to 8 alarms can be held on the PROFIsafe adapter's intermediate storage before being fetched by the master. The diagnosis alarm PDU is coded as follows:

Byte	Bit								Description
	7	6	5	4	3	2	1	0	
1	0	0	0	0	1	1	0	1	Length of the alarm PDU including header, dependent on the alarm
2	0	0	0	0	0	0	0	1	Type = diagnosis alarm
3	0	0	0	0	0	0	0	0	No slots (slot 0)
4	0	0	Sequ. no.			1	0	0	No alarm differentiation, with acknowledgement, sequential numbers 0-7
5	1	0	0	0	0	1	0	0	Error code 0x84 = error from slave
6	x	x	x	x	x	x	x	x	High byte of μ C2 error number
7	x	x	x	x	x	x	x	x	Low byte of μ C2 error number

Table 5.3-2: Structure of the diagnosis alarm

Byte	Bit								Description
	7	6	5	4	3	2	1	0	
8	x	x	x	x	x	x	x	x	High byte of the number of this error in $\mu\text{C}2$ since the system was last started up
9	x	x	x	x	x	x	x	x	Low byte of the number of this error in $\mu\text{C}2$ since the system was last started up
10	x	x	x	x	x	x	x	x	High byte of $\mu\text{C}1$ error number
11	x	x	x	x	x	x	x	x	Low byte of $\mu\text{C}1$ error number
12	x	x	x	x	x	x	x	x	High byte of the number of this error in $\mu\text{C}1$ since the system was last started up
13	x	x	x	x	x	x	x	x	Low byte of the number of this error in $\mu\text{C}1$ since the system was last started up

Table 5.3-2: Structure of the diagnosis alarm

The error code contained in bytes 6 to 7 and 10 to 11 respectively displays on the PROFIsafe adapter the most recent error occurring in the RS4 or in the $\mu\text{C}1$ or $\mu\text{C}2$. It has the following significance:

Code	Cause/significance	Measures to be taken to rectify error
	LED on the RS4 does not light up	Check the +24 V DC power supply (also check for polarity reversal), check the connection lead, if necessary replace faulty equipment.
0x2418	The PROFIsafe driver cannot check the cyclic output data	Invalid operating status; can occur in case of PROFIBUS malfunctions.
0x2419	The processing of the output data yields no consistent results	Invalid operating status; can occur in case of PROFIBUS malfunctions.
0x2600	Incorrect protective field number	Only select protective fields 1 to 4.
0x2A04	PROFIBUS telegram could not be processed	Evaluate the data flow control byte (section 5.2.1) in acyclic WRITE commands.
0x2A05	All reading buffers for PROFIBUS telegrams are occupied	After each WRITE command the result requested by the PROFIsafe adapter must be fetched by the master.
0x2A06	PROFIBUS telegram is too long (≥ 1100 Byte)	Only generate valid acyclic WRITE commands.

Table 5.3-3: Error codes of the PROFIsafe adapter

Code	Cause/significance	Measures to be taken to rectify error
0x2A0B	Unexpected block number in PROFIBUS telegram	The blocks of the telegrams must be numbered in continuous sequence.
0x2B01	Unknown status of the Proxy-FB	Acyclic READ and WRITE commands can only be processed when the Proxy-FB has finished executing parameter adjustment; watch for the FB_BUSY signal (section 6.4).
0x2B09	Error in CRC comparison	
0x2B1X	Echo data for CRC no. x are incorrect	
0x2B2X	CRC no. x is different on the second reading	

Table 5.3-3: Error codes of the PROFIsafe adapter

6 Project configuration of the master

While the parameterisation of the RS4 laser scanner is being effected by means of the RS4soft PC software, the PC adapter and the optical interface on the PROFIsafe adapter, the scanner on the master side (this will generally be a safety PLC system incorporating a PROFIsafe master) must be linked in with the user program. Later on this linking-in will be explained in detail. It is carried out by means of the STEP 7 software, which makes possible the project configuration and programming of the safety controls of the S7-400 and S7-300 series.

A special functional block for these controls – the Proxy-FB, which has already been mentioned a number of times – makes it possible for the parameter settings to be exchanged in a completely automatic way between the RS4 and the PLC. As a result of this FB it is possible for equipment to be immediately replaced if a fault occurs; on the scanner, which has not yet been parameterised, only the PROFIBUS address requires to be set (section 4.5). When the power is switched on, the parameter settings will be automatically loaded to the new hardware by the PLC, by way of PROFIBUS. For this the Proxy-FB must be linked into the user program, as described below.

6.1 Hardware configuration by means of STEP 7

When the hardware configuration program is opened, as a first step the components that are needed must be inserted in the project by dragging and dropping from the hardware catalogue.

- ① If the RS4 cannot be found in the hardware catalogue, the GSD file that forms part of the standard delivery should first be reinstalled in the hardware configuration program.

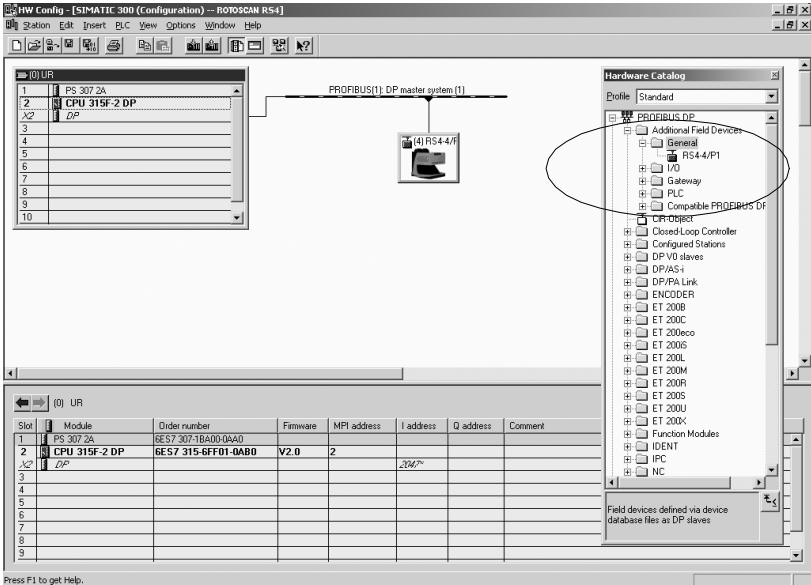


Fig. 6.1-1: Hardware configuration by means of STEP 7

In the next step the RS4 has to be configured as a PROFIBUS slave. The PROFIBUS address should be entered in the hardware configuration program (this has also been defined on the RS4 by means of the hex switches). In addition, the starting addresses of the input and output bytes will be set. PROFIBUS writes the RS4 input byte (section 5.1.1) to the input byte cyclically, while the output byte is cyclically transmitted to the RS4 (section 5.1.2). A simple user program is able to work only with these two bytes of the process image.

6.2 Configuration of the PROFIsafe driver by means of STEP 7

PROFIsafe carries out its safety measures in reliance on the PROFIBUS standard by means of a software function that is referred to as the PROFIsafe driver. This driver runs both on the master and on safety slaves like the RS4/PROFIsafe, and is consequently programmed with extreme flexibility. It therefore only requires to be adapted to the equipment in question by means of a few defined parameters. These safety-relevant parameters of the PROFIsafe driver are known as the F-parameters, and they are contained in the GSD-file. Only some of these parameters can actually be set by the user of the RS4/PROFIsafe. Further device-dependent parameters, those known as the i-parameters and other user parameters, are loaded directly to the scanner without any recourse to the GSD. The following table gives an overview of the F-parameters, their ranges of values and their significance:

GSD parameter name	Explanation
F_Check_SeqNr	Can be set to 0 or 1 (default = 0) 0 – the current number is not taken into account by the CRC 1 – the current number is taken into account by the CRC
F_Check_iPar	Cannot be adjusted, is preset to 0 for no i-parameters
F_SIL	Cannot be adjusted, is preset to 1 for SIL2
F_CRC_Length	Cannot be adjusted, is preset to 1 for 2-byte CRC
F_Block_ID	Cannot be adjusted, is preset to 0
F_Par_Version	Cannot be adjusted, is preset to 0
F_Source_Add	Can be set in a range between 1 and 65534 (default = 1) Note: this is automatically allocated by the SIMATIC Manager.
F_Dest_Add	This must be set to 500 + the PROFIBUS address (factory setting = 504). The device incorporates hex switches by means of which the PROFIBUS address can be set. The PROFIsafe destination address is formed from the 16-bit sum of 500 and the PROFIBUS address, and should be defined by the user as part of the project configuration. In this way it can be ensured, in systems that have only one PROFIBUS line, that the destination address is unique. Only this destination address will be accepted by the RS4/PROFIsafe. In systems that have more than one PROFIBUS line, it is the responsibility of the user to ensure that all RS4s that form part of the entire system have different PROFIBUS addresses, so as to bring about the required uniqueness of the destination address. The device described here is a PROFIBUS slave with just one PROFIsafe module. Consequently there is no need for any further mechanism to distinguish the individual modules from one another.
F_WD_Time	Watchdog time, can be set in a range between 10 and 1000 milliseconds (default = 10). In the project configuration the value of F_WD_Time must always be set higher on the master, in accordance with the equation $F_WD_Time = \max(10 \text{ ms}, t_{\text{scan_rec}}) * 2 + 4 * \text{Bus_Cycle_Time}$ where $t_{\text{scan_rec}}$ = the cycle time of the safety program on the PLC. To obtain the system response time, the response time of the RS4 (which can be configured to a value ≥ 80 ms) must be added to the value to which F_WD_Time has been set.

Table 6.2-1: Parameters of the PROFIsafe driver

GSD parameter name	Explanation
F_Par_CRC	Must be correctly set by the PROFIsafe project configuration tool to CRC1 for the F-parameter block (default = CRC1 for default F-parameters).

Table 6.2-1: Parameters of the PROFIsafe driver

Under the heading 'PROFIsafe', the minimum requirement is the adjustment of the F_WD_Time parameter in keeping with section 6.6. If the PROFIBUS address deviates from the factory setting of 4, the F_Dest_Add parameter must be adjusted as well.

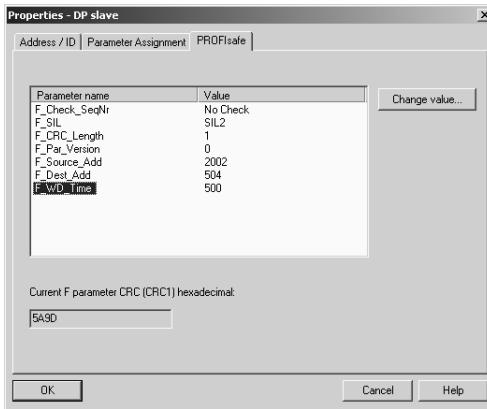


Fig. 6.2-1: F-parameters of the PROFIsafe driver

The Proxy-FB requires 34 remanent markers. These, as well as any further remanent markers that may be used by the user program, should be reserved here (50 in the example shown).

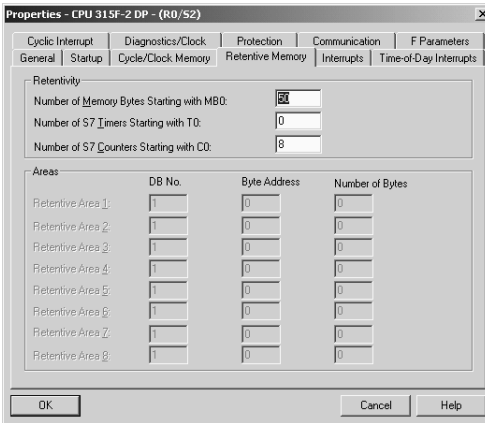


Fig. 6.2-2: Setting the remanent markers

Now the hardware configuration can be converted and loaded to the CPU.

6.3 Diagnosis data

While the system is being put into operation it is possible for the project configuration tool to access the PROFIsafe diagnosis data. These relate only to errors in the setting of the parameters for the PROFIsafe driver. The diagnosis data are supplied as a PDU indicative of status, in which, after the first 6 bytes of standard diagnosis, the following bytes 7 to 11 are supplied:

Byte	Bit								Description
	7	6	5	4	3	2	1	0	
Byte 7	0	0	0	0	0	1	0	1	Length of the PDU indicating status is 5 (including header)
Byte 8	1	0	0	0	0	0	0	1	Type = status message
Byte 9	0	0	0	0	0	0	0	0	No slots
Byte 10	0	0	0	0	0	0	0	0	No status differentiation
Byte 11	x	x	x	x	x	x	x	x	Error in F-parameters (error number), see below

The error number is coded in the following way:

Byte 11	0	0	0	0	0	0	0	0	0 = no errors
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Table 6.3-1: Diagnosis data of the PROFIsafe driver

Byte	Bit								Description
	7	6	5	4	3	2	1	0	
Byte 11	0	1	0	0	0	0	0	1	65 = internal error in F_Dest_Add
Byte 11	0	1	0	0	0	0	0	1	66 = incorrect F_Dest_Add
Byte 11	0	1	0	0	0	0	0	1	67 = incorrect F_Source_Add
Byte 11	0	1	0	0	0	1	0	0	68 = incorrect F_WD_Time setting
Byte 11	0	1	0	0	0	1	0	1	69 = incorrect SIL setting
Byte 11	0	1	0	0	0	1	1	0	70 = incorrect CRC length
Byte 11	0	1	0	0	0	1	1	1	71 = incorrect F_Block_ID or F_ParVersion
Byte 11	0	1	0	0	1	0	0	0	72 = incorrect CRC1 by way of the F-parameters

Table 6.3-1: Diagnosis data of the PROFIsafe driver

6.4 Proxy Function Block (“FB RS4”)

The Proxy-FB works as the “deputy” of an RS4/PROFIsafe laser scanner in a safety PLC system of the SIMATIC S7-300F series. It runs **in the standard part** of the user program, and manages the mutual adjustment of parameters between the RS4/PROFIsafe and the master PLC, so that automatic parameterisation can take place if the RS4 is replaced. It is recommended that one FB RS4 is used for each RS4 Laser Scanner that forms part of the system.

① For the data processing date and time are used. Therefore the CPU date and time has to be set correctly.

Parameter exchange is possible in both directions – either PLC → RS4/PROFIsafe or RS4/PROFIsafe → PLC. The Proxy-FB expects the following input variables (INPUT) and supplies the following output variables (OUTPUT):

Parameter	Declaration	Data type	Storage area
FIRST_IN_BYTE_RS4	INPUT	BYTE	I, O, M, D, L
FIRST_OUT_BYTE_RS4	INPUT	BYTE	I, O, M, D, L
START_ADDRESS_REM_MARKER	INPUT	INT	I, O, M, D, L, Const.
DB_MMC_RS4_CONFIG	INPUT	INT	I, O, M, D, L, Const.
DB_RS4_CONFIG	INPUT	INT	I, O, M, D, L, Const.
DB_MMC_RS4_DATA	INPUT	INT	I, O, M, D, L, Const.
DP_DIAGNOSIS_ADDRESS_RS4	INPUT	WORD	I, O, M, D, L, Const.

*) Constant

Table 6.4-1: Input and output variables of the “FB RS4” RS4 data functional block

Parameter	Declaration	Data type	Storage area
ERROR_NUMBER_FB	OUTPUT	WORD	I, O, M, D, L
ERROR_CODE_SFC	OUTPUT	WORD	I, O, M, D, L
CONFIG_SET_TO_DEFAULT	OUTPUT	BOOL	I, O, M, D, L
FB_BUSY	OUTPUT	BOOL	I, O, M, D, L
ERROR_NUMBER_RS4	OUTPUT	BYTE	I, O, M, D, L

Table 6.4-1: Input and output variables of the “FB RS4” RS4 data functional block

FIRST_IN_BYTE_RS4 is allocated the value of the RS4’s cyclic input byte. Bit 2 of this (Proxy Request) will be evaluated, so as to activate the Proxy-FB if required, i.e. to carry out parameter matching between the RS4 and the master. The FB RS4 will be informed in which direction the parameters are to be transmitted, or whether the RS4 status is that defined by RS4/PROFIsafe when it was delivered from the factory. While the parameters are being adjusted, the output signal FB_BUSY will be set. After the parameters have been successfully adjusted, the Proxy-FB reads the RS4 identification data from the scanner, so that in future it can recognise what is happening when a device is replaced without any possibility of mistake.

If an error occurs while the parameters are being transmitted (e.g. negative acknowledgement, the command to cancel being given etc.), the FB RS4 will terminate the procedure and wait until it is called up again.

FIRST_OUT_BYTE_RS4 is associated with the cyclic output byte. At present it has no function, though it may be used in subsequent versions.

START_ADDRESS_REM_MARKER points to the start of the block consisting of the marker bytes (of which there must be a minimum of 34). These bytes are required for internal purposes, and do not have a data structure that has any relevance to the user program. The starting address of this remanent marker area cannot be set by the SIMATIC software automatically, but must be set manually in the course of the S7 hardware configuration (section 6.2).

DB_MMC_RS4_CONFIG, DB_RS4_CONFIG and DB_MMC_RS4_DATA are supplied with the relevant data component number. Whereas DB_MMC_RS4_CONFIG and DB_MMC_RS4_DATA are addressed to data blocks on the micro memory card, the data block addressed by DB_RS4_CONFIG is located in working storage.

① The data components that fall under the acronym MMC (micro memory card) exchange their data only with the associated SFCs (SFC 83 "READ_DBL" and SFC 84 "WRIT_DBL").

DP_DIAGNOSIS_ADDRESS_RS4 contains the PROFIBUS diagnosis address of the RS4/PROFIsafe. In the S7 hardware configuration program it can be brought up by means of the menu sequence “Properties / General / Diagnosis address”.

CONFIG_SET_TO_DEFAULT comes directly from the scanner, and indicates to the user program that the RS4/PROFIsafe is reset or has been reset to the factory setting. The output here is a “1” when the RS4/PROFIsafe is linked for the first time to the safety controls if the Proxy-FB has not yet read a valid data record from the RS4 and saved it on the PLC system.

After an unsuccessful parameter adjustment (in either direction) – that is, if either the upload or the download fails – the RS4/PROFIsafe will be returned to the factory settings. The Proxy-FB will be notified of this. The user then has to parameterise the RS4/PROFIsafe once again, using the RS4soft software.

FB_BUSY indicates that the Proxy-FB is currently carrying on a parameter adjustment with the RS4 with which it is associated. To do this it uses acyclic READ and WRITE commands. As these commands extend the cycle time of the user program, further acyclic READ or WRITE commands by the user program – to the same, or to a different PROFIBUS address – should be avoided while parameter adjustment is being carried on.

If several RS4/PROFIsafes are installed on a PROFIBUS system – that is to say, if several Proxy-FBs are being used on the master PLC – these should be synchronised with one another, so that if several parameter adjustment operations are launched simultaneously an overflow of the cycle time of the user program will be prevented. This can happen, for instance, if the cyclic input byte is not switched directly to FIRST_IN_BYTE_RS4 but is set by means of a marker byte. If one of the Proxy-FBs has set its FB_BUSY output signal (indicating that parameter adjustment is being carried on), the marker bytes of the other RS4/PROFIsafe will for a temporary period not be switched to the respective Proxy-FBs, or the Proxy Request bit will be masked out.

ERROR_NUMBER_RS4 is intended for remote diagnosis by the manufacturer's services. It supplies the error code of the RS4.

The Proxy-FB uses SFCs to communicate via PROFIBUS. Error messages relating to these SFCs, as well as error codes of the Proxy-FB, will be made available to the user program under ERROR_NUMBER_FB and ERROR_CODE_SFC. The table below contains the error numbers of the Proxy-FB that may be output by way of the ERROR_NUMBER_FB parameter. If the ERROR_CODE_SFC is not equal to zero, this table makes it possible to determine the corresponding SFC. The SFC error code can be decoded with the SIMATIC reference manual "System software for S7/300/400 system functions and standard functions".

If Proxy-FB processing is resumed, ERROR_NUMBER_FB, ERROR_CODE_SFC and ERROR_NUMBER_RS4 will be reset to the value zero.

Error number	SFC	Item no.	Explanation
0x0101	83	01	Error copying data component from upload area to data component in working storage
0x0201	58	02	Error in writing data record – functional block to RS4/PROFIsafe
0x0301	59	03	Error in reading data record – RS4/PROFIsafe to functional block
0x0302		03	Error in RS4/PROFIsafe data record

Table 6.4-2: Error codes of the Proxy-FB

Error number	SFC	Item no.	Explanation
0x0401	58	04	Error in writing data record – functional block to RS4/PROFIsafe
0x0501	59	05	Error in reading data record – RS4/PROFIsafe to functional block
0x0502		05	Error in RS4/PROFIsafe data record
0x0601	59	06	Error in reading data record – RS4/PROFIsafe to functional block
0x0602		06	Error in RS4/PROFIsafe data record
0x0701	59	07	Error in reading data record – RS4/PROFIsafe to functional block
0x0801	58	08	Error in writing data record – functional block to RS4/PROFIsafe
0x0902		09	Error in RS4/PROFIsafe data record
0x1001	58	10	Error in writing data record – functional block to RS4/PROFIsafe
0x1101	58	11	Error in writing data record – functional block to RS4/PROFIsafe
0x1201	59	12	Error in reading data record – RS4/PROFIsafe to functional block
0x1202		12	Error in RS4/PROFIsafe data record
0x1301	84	13	Error copying data component in working storage to data component in upload area
0x2101	58	21	Error in writing data record – functional block to RS4/PROFIsafe
0x2201	59	22	Error in reading data record – RS4/PROFIsafe to functional block
0x2202		22	Error in RS4/PROFIsafe data record
0x2301	59	23	Error in reading data record – RS4/PROFIsafe to functional block
0x2302		23	Error in RS4/PROFIsafe data record
0x2401	58	24	Error in writing data record – functional block to RS4/PROFIsafe
0x2501	83	25	Error copying data component from upload area to data component in working storage

Table 6.4-2: Error codes of the Proxy-FB

Error number	SFC	Item no.	Explanation
0x2601	58	26	Error in writing data record – functional block to RS4/PROFIsafe
0x2701	58	27	Error in writing data record – functional block to RS4/PROFIsafe
0x2801	59	28	Error in reading data record – RS4/PROFIsafe to functional block
0x2802		28	Error in RS4/PROFIsafe data record
0x2901	58	29	Error in writing data record – functional block to RS4/PROFIsafe
0x3001	59	30	Error in reading data record – RS4/PROFIsafe to functional block
0x3002		30	Error in RS4/PROFIsafe data record
0x3101	59	31	Error in reading data record – RS4/PROFIsafe to functional block
0x3102		31	Error in RS4/PROFIsafe data record
0x3201	58	32	Error in writing data record – functional block to RS4/PROFIsafe
0x3301	58	33	Error in writing data record – functional block to RS4/PROFIsafe
0x3401	59	34	Error in reading data record – RS4/PROFIsafe to functional block
0x3402		34	Error in RS4/PROFIsafe data record
0x4001	58	40	Error in writing data record – functional block to RS4/PROFIsafe
0x4101	59	41	Error in reading data record – RS4/PROFIsafe to functional block
0x4102		41	Error in RS4/PROFIsafe data record
0x4201	84	42	Error copying data component in working storage to data component from upload area
0x4501	58	45	Error in writing data record – functional block to RS4/PROFIsafe
0x5001	59	50	Error in reading data record – RS4/PROFIsafe to functional block

Table 6.4-2: Error codes of the Proxy-FB

6.5 The user program

So as to link them into your user program, please copy the following elements:

- FB RS4 (FB 10)
- DB RS4 CONFIG (DB 101)
- DB MMC RS4 CONFIG (DB 100)
- DB MMC RS4 DATA (DB 102)

from the sample RS4 project that forms part of the standard delivery into your own safety program.

The DB instance “DB RS4“ (DB 10) need not be copied, because this will be automatically generated when the FB RS4 is called up.

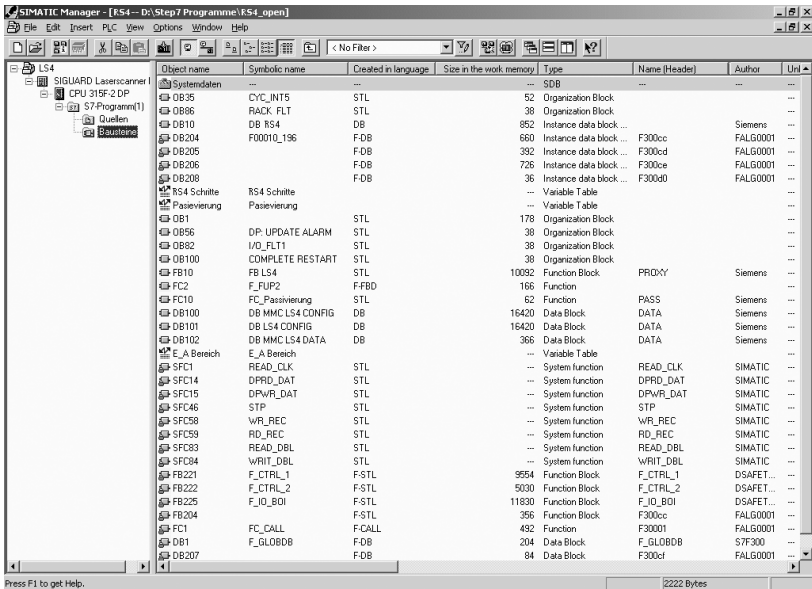


Fig. 6.5-1: Linking in the FB RS4

The number of the elements may be altered at will, e.g.:

- FB RS4 (FB 30)
- DB MMC RS4 CONFIG (DB 32)
- DB RS4 CONFIG (DB 33)
- DB MMC RS4 DATA (DB 34)

Before calling them up, the bit “Proxy Enable” (bit 6 of the cyclic output byte, section 5.1.2) must be set by the user program to the fixed value “1”, so that in case of need the RS4/PROFIsafe will send the “Proxy Request” bit in the cyclic input byte (section 5.1.1) of the RS4.

- ① Transfer the input and output bytes of the RS4 to internal marker bytes, and communicate these to the FB RS4. In this way it is possible, if necessary, to mask out the “Proxy Request” bit until such time as the current parameter adjustment with another RS4 has been concluded (evaluation of FB_BUSY signals of all FB RS4). This makes it possible to ensure that only one parameter adjustment operation will be running at any given time, thus avoiding unnecessarily extending the cycle time of the user program.

A DB instance must be supplied when the FB is called up.

```

For example:                CALL "FB RS4" , DB10
CALL "FB RS4" , "DB RS4"
FIRST_IN_BYTE_RS4          := "FIRST IN BYTE RS4"
FIRST_OUT_BYTE_RS4         := "FIRST OUT BYTE RS4"
START_ADDRESS_REM_MARKER := 10 //
                           start address (34 bytes of remanent
                           markers)!!!

DB_MMC_RS4_CONFIG          := 100
DB_RS4_CONFIG              := 101
DB_MMC_RS4_DATA            := 102
DP_DIAGNOSIS_ADDRESS_RS4  := W#16#3FE //
                           DP diagnosis address RS4: 1022
                           (hex: 3FE)

ERROR_NUMBER_FB            := "ERROR NUMBER FB"
ERROR_CODE_SFC             := "ERROR CODE SFC"
CONFIG_SET_TO_DEFAULT      := "CONFIG SET TO DEFAULT"
FB_BUSY                    := "FB_BUSY"
ERROR_NUMBER_RS4           := "ERROR NUMBER RS4"

```

After these elements have been transferred to the CPU, the CPU can then be switched to “RUN”. Now the FB RS4 is ready to communicate with the RS4/PROFIsafe.

- ① No communication can take place when the optical PC adapter is attached to the RS4/PROFIsafe.

6.6 Response time

The overall response time for a safety system based on RS4/PROFIsafe is composed of:

- the response time of the RS4, including the PROFIsafe adapter,
- the time taken to transmit data from the RS4/PROFIsafe to the master program,
- the cycle time of the master's PROFIsafe program,
- the time taken for the safety circuit to cut out, possibly involving an output by way of PROFIBUS and
- the time the machine takes to come to a standstill.

The response time up to the completed evaluation of the OSSD bit in the master's safety program is determined by the following equation:

$$T_R = T_{\text{Scanner}} + T_{\text{WD}}$$

where

T_R response time from the moment when a protective field is violated until the evaluation of the OSSD bit on the master,

T_{Scanner} response time of the RS4 (minimum of 80 ms, can be set in 40ms steps/ decrements) and

T_{WD} watchdog time = $\max(10 \text{ ms}, t_{\text{scan_rec}}) * 2 + 4 * \text{Bus_Cycle_Time}$

where $t_{\text{scan_rec}}$ = the cycle time of the PROFIsafe part on the master.

T_R is the time taken until the PLC output switches off. The time taken till the power switching circuit is broken and the time taken for the machine to come to a standstill must also be taken into account.



As a fundamental principle it should be noted that the extension of response time as compared with an RS4 without a PROFIsafe adapter means that the safety distances to be maintained must likewise be higher.

7 Putting the system into operation, and replacing components

Before putting the RS4/PROFIsafe into operation, you must carry out the following operations:

- set the address of the RS4/PROFIsafe adapter,
- create the correct physical link to the PROFIBUS network,
- create a link to the STEP 7 hardware configuration,
- set the PROFIsafe parameters of the master,
- program, load and start the user program and
- parameterise the RS4 with RS4soft by means of the optical PC adapter.

The linking-in of the Proxy-FB “FB RS4” (see section 6.4) is optional. This makes it possible to replace faulty equipment simply and quickly in case of a malfunction. It is not required for the transmission of cyclic real time data. In the simplest case, the user program will just read the OSSD bit of the cyclic input data in the safety part of the PLC program, and will then write the cyclic output byte (see example in section 5.1.1).



After alterations of the RS4 parameters using the optical adapter cable or after automatic data exchange the effectiveness of the switch-off function must be tested along the defined contour of the detection zones.

7.1 Behaviour of the system when switching on

The optical PC interface has important implications for the system properties when the system is switched on, or when a connecting to PROFIBUS.

7.1.1 PC adapter not connected

This is the normal operating situation. After a short initialisation phase when the system is switched on, in which the connection with the PROFIBUS master will be established, the PROFIsafe adapter is ready for cyclic PROFIsafe data operations. The OSSD bit (bit 7) in the cyclic input data is set to 0 (off) in the first instance).

The RS4 itself will only be operationally ready after about 30 seconds. Then the “Proxy Request“ bit (bit 2) will be set in the cyclic input data. From this point we must distinguish between two possible continuations:

1. The “Proxy Enable“ bit in the cyclic output byte is not set, i.e. = 0.

It is assumed that no Proxy-FB has been installed on the master for the RS4/PROFIsafe. The release of the OSSD bit will take place immediately, in dependence on the OSSD outputs of the RS4.

2. The “Proxy Enable“ bit in the cyclic output byte is set permanently to 1.

Only when the Proxy-FB in the PROFIBUS master has successfully carried out the automatic parameter adjustment operation will the OSSD bit be set, in keeping with the OSSD outputs of the RS4. If the data on the master are consistent and no new RS4 has been recognised, the release of the OSSD bit will take place immediately. The parameters will be verified in the background. If parameters have to be written to the RS4, the release of the OSSD bit only takes place after the parameter settings have been successfully transmitted to the RS4.

7.1.2 PC adapter connected

This situation should only occur in the installation phase or for control purposes. After a short initialisation phase, in which the connection with the PROFIBUS master will be established, the PROFIsafe adapter is ready for cyclic PROFIsafe data operations. The RS4 will be operationally ready in about 30 seconds. The OSSD bit of the cyclic input data corresponds to the status of the OSSD of the RS4: until the RS4 reaches the state of operational readiness it will therefore be 0 (off), and subsequently it will be dependent on the violation of the currently active protective field.

The “Proxy Request” bit will not be set as long as the PC adapter remains connected. Consequently there will not be any automatic parameter adjustment with the PROFIBUS master either. Only when the PC adapter is removed does the PROFIsafe adapter set the “Proxy Request” bit, and the parameter adjustment with the master follows, if an Proxy-FB (“FB RS4” functional block) on the master has been allocated to the RS4/PROFIsafe.

If the connection between the optical PC interface and the RS4 has once been switched through, all acyclic PROFIBUS commands will be acknowledged with an error message. Cyclic data operations will not be directly affected by this. Of course the OSSD signal switches off during a download by way of this interface, if the data set on the RS4 is changed.

Removing or replacing the optical PC adapter in the course of active operations only has an effect on the “Proxy Request” bit. When the adapter is removed, there is an automatic request for parameter adjustment. The OSSD bit will not be affected by this, so long as no errors occur in the course of the parameter adjustment operation.

- ① The optical PC adapter must not be left permanently connected, as in that case the PROFIBUS master will not take on the parameter settings of the RS4. Please note as well that when the PC adapter is connected, some of the PROFIBUS alarms cease to be available.

7.2 Scenarios

If the Proxy-FB functional block has been linked into the non-safety part of the user program, the following possible operating scenarios result:

- First start-up with RS4/PROFIsafe connected; a new system is put into operation for the first time.
- Changing the parameterisation of an RS4/PROFIsafe that is known to the master.
- Normal start-up with a correctly parameterised RS4/PROFIsafe.
- First start-up after a defective RS4/PROFIsafe has been replaced by a new device.

The behaviour of the Proxy-FB and the RS4/PROFIsafe in each of these four cases will be described below.

7.2.1 Putting the system into operation for the first time

On the PROFIBUS master no valid parameter settings are available. On the RS4 the parameters are in the first instance those that were set at the factory. The RS4/PROFIsafe goes into normal operating mode; all parameters conform to the factory settings. In addition, the output CONFIG_SET_TO_DEFAULT of the FB RS4 is set. As the factory safety settings generally do not correspond to the requirements of the situation of use, the user will need to parameterise the RS4/PROFIsafe in the situation of use by means of the optical PC adapter. This gives us our second scenario.

7.2.2 Changing the parameterisation

At the site where the equipment is installed, the parameterising PC is connected to the parameterising interface of the RS4/PROFIsafe by way of the optical PC adapter. After all the parameters on the RS4 have been set and checked with RS4soft, once parameterisation has been successfully concluded the PC goes directly into normal operating mode, with cyclic exchange of data.

Only when the PC adapter is removed from the interface is the PROFIsafe adapter informed that it should send the new parameter settings to the Proxy-FB on the PROFIBUS master. This parameter adjustment takes place automatically in the background; if parameter settings have already been saved on the Proxy-FB, these will be overwritten.

7.2.3 Switching on a parameterised device

Depending on whether the PC adapter is connected to the optical PC interface or not, the system will operate as described in 7.1.1 or 7.1.2. The RS4/PROFIsafe goes into normal operating mode.

7.2.4 Device replacement

The serial number that is saved on the RS4 and in the Proxy-FB enables the system to identify the scanner, so that it will automatically recognise when a device has been replaced. The parameter settings saved on the PROFIBUS master will be automatically transferred to the RS4/PROFIsafe without need of any further programming. The Proxy-FB saves the new serial number, and the RS4/PROFIsafe goes into normal operating mode.

① The automatic parameter adjustment between the PROFIBUS master and the RS4/PROFIsafe can take up to 3 minutes.

If a Proxy-FB has once read the parameter settings of an RS4/PROFIsafe, a new RS4/PROFIsafe will always be loaded with the parameter settings of the old RS4/PROFIsafe by the Proxy-FB, as it takes this to be a device replacement.

If it is really the case that you want to work with a new RS4/PROFIsafe **and** new parameters on the PROFIBUS address that has already been defined, first of all the RS4/PROFIsafe must be introduced to the Proxy-FB, by being connected to PROFIBUS; automatically, in the first instance the old parameter settings will be transferred to the new RS4/PROFIsafe.

Subsequently the RS4/PROFIsafe parameters will be changed via the optical PC adapter. When the parameterising is concluded, the new parameters will be automatically transferred to the Proxy-FB.



When the parameters are downloaded, the user passwords will not be overwritten by the Proxy-FB. Consequently they must be manually altered by the user, either before setting the system or at a later stage.

7.3 Examples of system programming

7.3.1 Setting up the hardware configuration of the ROTOSCAN RS4 laser scanner

PROFIsafe destination address:

The RS4/PROFIsafe derives its PROFIsafe destination address from the PROFIBUS address according to the following formula:

$$F_Dest_Add = 500 + PROFIBUS\ address$$

The default setting for the PROFIBUS address is 4 (hex switches underneath plastic cover) and the default value for F_Dest_Add, in accordance with the GSD, is 504, so that in systems with just one RS4/PROFIsafe in normal circumstances there is no need to change anything.

Watchdog time:

The watchdog time must be set to values > 60ms.



As when changes are made to the F-parameters the starting value for the CRC calculation of the cyclic PROFIsafe data changes as well, after any such change all the safety elements must be reconverted.

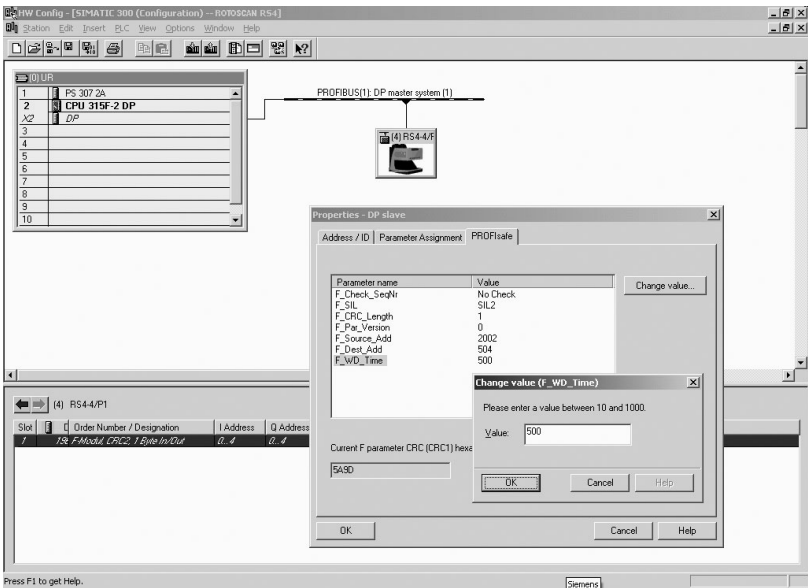


Fig. 7.3-1: Example of system programming, hardware configuration

7.3.2 The user program

Please copy the following components, so as to link them into your user program:

- RS4 restart inhibition
- RS4 automatic start
- RS4 field pair switching

When you wish to use the RS4 Laser Scanner, you should carry out an operation in the safety program to cancel the scanner's passivity. This applies to the other F-peripherals as well. If, for example, an error occurs in communication between the RS4 and the PLC the scanner will be put into passive mode. That is, it returns the substitute value 0. As a result the function that it monitors is suspended.

When the error has been rectified, the ACK_REQ bit will be set, and the scanner can be reintegrated with the system by means of ACK_REI. It will now return its current data once more. The parameters ACK_REQ and ACK_REI are to be found in the database instance of the scanner.

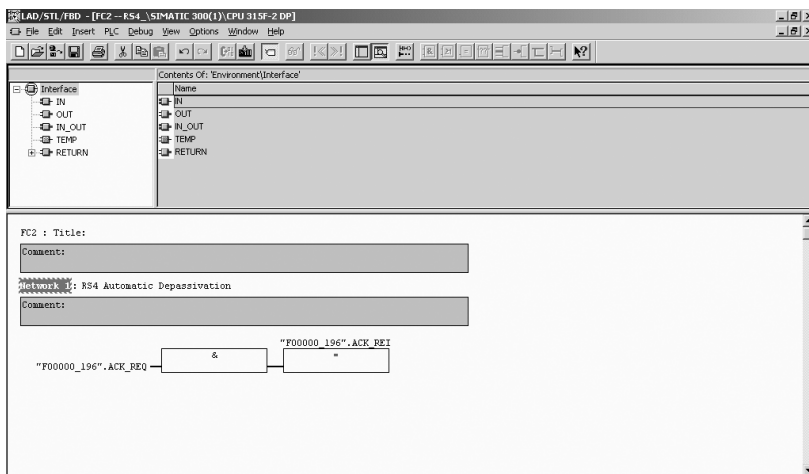


Fig. 7.3-2: Example of system programming: evaluation of ACK_REI signal

7.3.2.1 The component RS4 restart inhibition

This component ensures that when the laser scanner is switched off as a result of the protective field being violated, the system will not automatically start up again without prior acknowledgement. This component also includes electronic device monitoring. When you incorporate this component in your fail-safe user program, the following parameters need to be defined:

- | | |
|-------------------------------------|--|
| Restart: | This parameter must be connected to the input coming from the restart button. |
| Electronic device monitoring (EDM): | This parameter is assigned the value of the contactor feedback that is responsible for the switching of the safety function. |
| OSSD: | This input receives the laser scanner's OSSD bit. |
| Switch_off: | This output controls the contactor that is responsible for the switching of the safety function. |

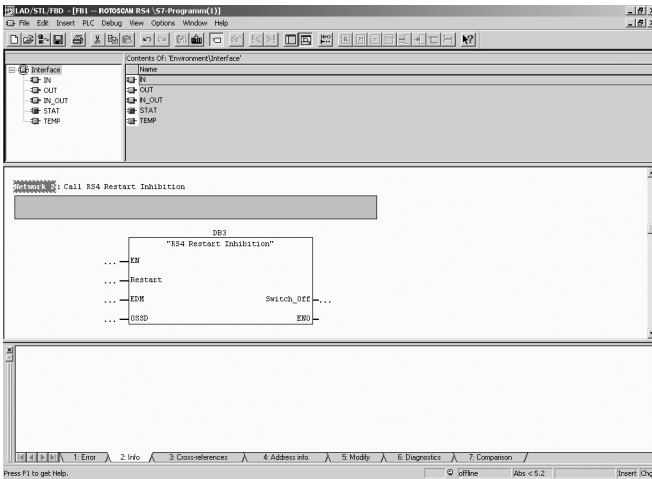


Fig. 7.3-3: Example of system programming: restart inhibition

7.3.2.2 The component RS4 automatic start

This component makes it possible for the system to resume operations immediately, once the protective field of the scanner is clear again. This function can be used in connection with driverless transport systems, for example.

When you incorporate this component in your fail-safe user program, the following parameters need to be defined:

- | | |
|-------------------------------------|--|
| OSSD: | This input receives the laser scanner's OSSD bit. |
| Electronic device monitoring (EDM): | This parameter is assigned the value of the contactor feedback that is responsible for the switching of the safety function. |
| Switch_off: | This output controls the contactor that is responsible for the switching of the safety function. |

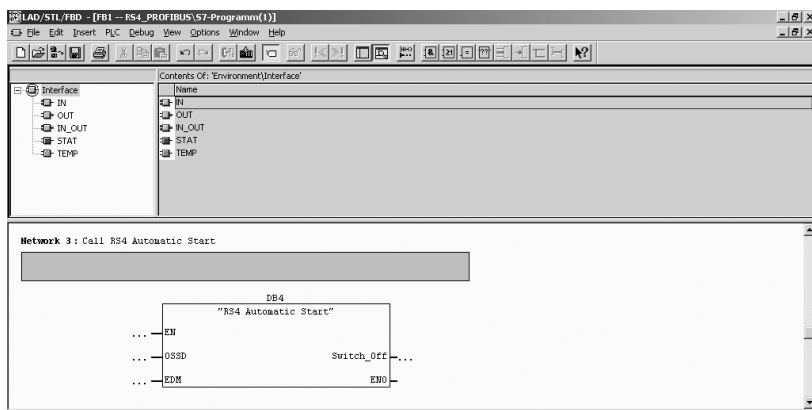


Fig. 7.3-4: Example of system programming: RS4 automatic start component

7.3.2.3 The component RS4 field pair switching

This component enables you to switch the protective fields of the RS4 Laser Scanner. Here you do not need to bother about the timing, as this will be managed by the RS4 itself.

When you incorporate this component in your fail-safe user program, the following parameters need to be defined:

Changeover_FP_1: This input must be connected with the sensor that is responsible for activating the first pair of fields.

Changeover_FP_2: This input must be connected with the sensor that is responsible for activating the second pair of fields.

Changeover_FP_3: This input must be connected with the sensor that is responsible for activating the third pair of fields.

Changeover_FP_4: This input must be connected with the sensor that is responsible for activating the fourth pair of fields.

Field_Pair_Bit_0: Cyclic output data of the scanner: bit x.0

Field_Pair_Bit_1: Cyclic output data of the scanner: bit x.1

Field_Pair_Bit_2: Cyclic output data of the scanner: bit x.2

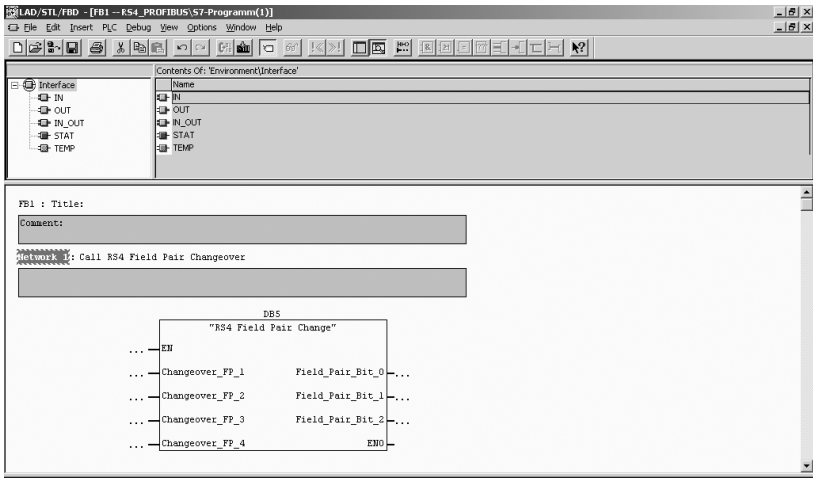


Fig. 7.3-5: Example of system programming – switching the protective fields

8 Testing

8.1 Tests before the system is first put into operation

The tests that precede the system's first being put into operation should be carried out by qualified personnel, and must ensure that the automatic optoelectronic protective device, the safety program on the master PLC and any other safety components that are present have been properly selected in conformity with the local regulations, particularly as specified by the Machine Safety Directive and the Directive on the Use of Working Equipment, and in Germany the Operational Safety Ordinance¹, and that they afford the required level of protection when operating in the manner prescribed.

You should test the protective device in accordance with local prescriptions, making sure that the protective equipment has been properly assembled, that it is electrically connected to the controls and that it is effective in all operational modes of the machine.

The same testing requirements apply if the machine is out of action for any length of time, after large-scale modifications of the equipment or after repairs, if these could have implications for safety.

Please have regard to the requirement that operating personnel should be instructed by qualified persons before taking up their duties. Training of personnel is the responsibility of the company operating the machine.

8.2 Regular testing

Regular testing should be carried out, again in keeping with local requirements. The object of these is to detect changes (e.g. with reference to overtravel times) or modifications to the machine or protective equipment.

You should have the effectiveness of the protective equipment checked by qualified personnel at the prescribed intervals.

8.3 Cleaning the window

The window of the RS4 should be cleaned regularly, depending on how dirty it has become. A flashing yellow LED 5 indicates "Dirty window"; the window must then be cleaned. If the situation is not improved by cleaning, it may be necessary to replace the window. You are recommended to use the cleaning set that is obtainable as an accessory (430400) in order to clean the scratch-proof window. The window has good resistance properties against diluted acids or alkalis, and is resistant to some extent to organic solvents (see the RS4's Connecting and Operating Instruction).

1. German: Betriebssicherheitsverordnung.

9 Technical specifications and dimensional drawings

Safety category	Type 3 as defined by EN IEC 61496
Us power supply	+ 24 V DC (+ 20 % / - 30%), external power supply unit, must be reliably independent of mains and able to compensate for a 20 ms power failure, current reserve 1 A, protection class 2, unilaterally shielded cable, shield placed on switch cabinet
Residual ripple of power supply	± 5% within the Us limits
Power consumption	320 mA (Us = 28.8 V; +20%) 350 mA (Us = 24 V) 500 mA (Us= 16.8 V; -30%)
External fuse	1,25 A
Protection category	IP65
Ambient operating temperature	0 ... +50° C *
Ambient temperature for storage	-20 ... +60° C
Relative humidity	15 ... 95%, without condensation
Dimensions (height x width x depth)	167 mm x 141 mm x 168 mm
Weight	2.25 kg
PROFIBUS data rate	9.6 kBd ...12 MBd
PROFIBUS connection	M12 plug, b-coded
Response time of PROFIsafe adapter	10 ms (> 90 ms)
Length of power supply lead	50 m
Length of restart lead	25 m

* not suitable for outdoor applications

① Further technical data see “Technical description“ Laser Scanner ROTOSCAN RS4.

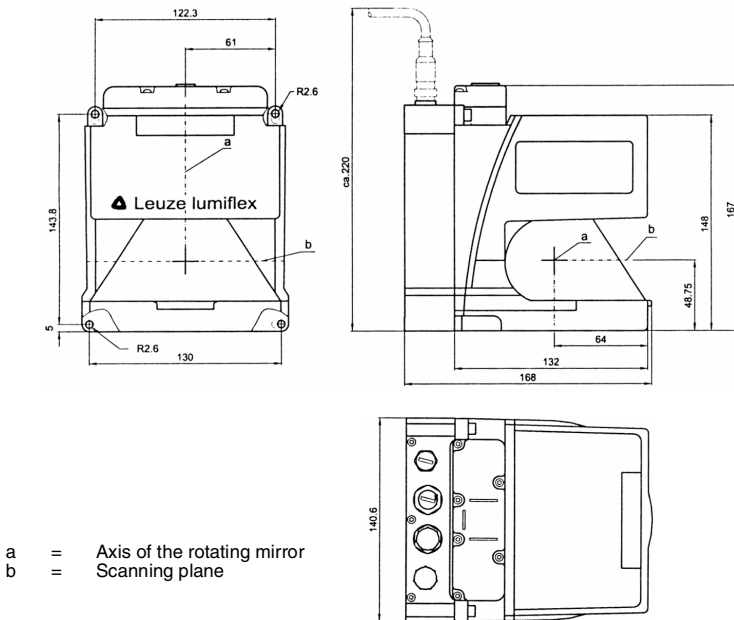


Fig. 9.0-1: Dimensional drawing RS4/PROFIsafe

10 Standard delivery and order details

10.1 Standard delivery

The following form part of the standard delivery:

- Laser Scanner ROTOSCAN RS4/PROFIsafe
- Data Sheet PR4/PROFIsafe

10.2 Start-up Set

RS4 start-up set is required. This can be used either with the AS-i or with the PROFIsafe version. It consists of the following components:

- optical PC adapter cable
- CD ROM containing the RS4soft software
- CD-ROM with additional components for linking to PROFIBUS
- ROTOSCAN RS4 Connecting and Operating Instruction
- RS4soft User Manual

- this Connecting and Operating Instruction with additional information to RS4/PROFIsafe
- the Connecting and Operating Instruction with additional information to RS4/AS-i

10.3 Order details RS4/PROFIsafe and accessories RS4/PROFIsafe

Artikelbezeichnung	RS4/PROFIsafe	Order no.
RS4/-4P1	Laser Scanner ROTOSCAN RS4/PROFIsafe	580012
CB-PCO-3000	Optical PC adapter cable	520072
RS4-SWC	Start-up Set RS4	970078
AC-M12-PBT1	PROFIBUS M12 terminal plug	147500
RS4-clean-Set1	150 ml Cleaning fluid for synthetic materials, 25 cleaning cloths, soft and lint-free	430400
RS4-clean-Set2	1000 ml Cleaning fluid for synthetic materials, 100 cleaning cloths, soft and lint-free	430410
RS4-TB70-500	Test body, cylindrical, 500 mm in length, diameter 70 mm, reflectance factor ca. 1.8%	50036433
RS4-TB200-1000	Test body, cylindrical, 1000 mm in length, diameter 200 mm, reflectance factor ca. 1.8%	50036434
RS4-MS	Montagesystem für die Anbindung und Justage des RS4 PROFIsafe	50033346
RS4-Adap-P	Adapterplatte bei bereits bestehenden Montagesystemen	50035814

