Original manual

Functional Safety
Type Approved

Absolute Encoder CD_-75
PROFINET/PROFIsafe

Explosion Protection Enclosure
_A**75*
_A**88*
_A**100*
Protection Enclosure
_CDV115

CDH 75 M

CDW 75 M

CDV 75 M

DIN EN 61508: **SIL CL3**
DIN EN ISO 13849: **PL e**

_Safety instructions
_Device-specific specifications
_Installation/Commissioning
_Parameterization
_Cause of faults and remedies

User Manual
Interface

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1 General information

The present interface-specific User Manual addresses the following topics:

- Safety instructions
- Device-specific specifications
- Installation/Commissioning
- Parameterization
- Error causes and remedies

As the documentation is arranged in a modular structure, the User Manual is supplementary to other documentation, such as product data sheets, dimensional drawings, brochures, the Safety Manual, etc.

The User Manual may be included in the customer's specific delivery package or it may be requested separately.

1.1 Applicability

This User Manual applies exclusively to measuring system models according to the following type designation code with ***PROFINET IO*** interface and ***PROFIsafe*** profile:

* 1	* 2	* 3	* 4	* 5	-	* 6	* 6	* 6	* 6	* 6

Position	Notation	Description
* 1	A C	Explosion protection enclosure (ATEX); Absolute Encoder, programmable
* 2	D	redundant dual scanning unit
* 3	V H S W	Solid shaft Hollow shaft Blind-hole shaft Rope length transmitter (wire)
* 4	75 88 100 115	External diameter ∅ 75 mm External diameter ∅ 88 mm External diameter ∅ 100 mm External diameter ∅ 115 mm
* 5	M	Multi turn
* 6	-	Consecutive number

* = Wild cards

The products are labeled with affixed nameplates and are components of a system.

This means that, all in all, the following documentations are applicable:

- see chapter "**Other applicable documents**" in the Safety Manual

1.2 References

1.	IEC/PAS 62411	Real-time Ethernet PROFINET IO International Electrotechnical Commission
2.	IEC 61158	Digital data communications for measurement and control - Fieldbus for use in industrial control systems
3.	IEC 61784	Digital data communications for measurement and control - Fieldbus for use in industrial control systems - Profile sets for continuous and discrete manufacturing relative to fieldbus use in industrial control systems
4.	ISO/IEC 8802-3	Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications
5.	IEEE 802.1Q	IEEE Standard for Priority Tagging
6.	IEEE 1588-2002	IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems
7.	PROFINET Guideline	PROFIsafe – Environmental Requirements Order-No.: 2.232
8.	PROFIBUS Guideline	Profile Guidelines Part 1: Identification & Maintenance Functions. Order-No.: 3.502
9.	PROFINET Guideline	Design Guideline Order-No.: 8.062
10.	PROFINET Guideline	Installation Guideline for Cabling and Assembly Order-No.: 8.072
11.	PROFINET Guideline	Installation Guideline for Commissioning Order-No.: 8.082

1.3 Abbreviations and terms used

0x	Hexadecimal representation
A**75*	Explosion protection enclosure with ⌀ 75 mm and built-in measuring system, all variants
A**88*	Explosion protection enclosure with ⌀ 88 mm and built-in measuring system, all variants
A**100*	Explosion protection enclosure with ⌀ 100 mm and built-in measuring system, all variants
CAT	***Cat***egory: Organization of cables, which is used also in connection with Ethernet.
CDH	Absolute encoder with redundant dual scanning, hollow shaft design
CDV	Absolute encoder with redundant dual scanning, solid shaft design
CDV115	Series 75 measuring system installed in a 115 "Heavy Duty" protection enclosure
CD_	Absolute encoder with redundant dual scanning, all designs
CRC	***C***ylic ***R***edundancy ***C***heck
DC_{avg}	***D***iagnostic ***C***overage Average diagnostic coverage
EU	***E***uropean ***U***nion
EMC	***E***lectro ***M***agnetic ***C***ompatibility
Engineering tool	Projection and commissioning tool
F	Generally stands for the term safety or fail-safe
F-Device	Safety device for safety applications
Fault exclusion	Compromise between the technical safety requirements and the theoretical possibility of an error occurring
F-Host	Safety control for safety applications
FMEA	***F***ailure ***M***ode and ***E***ffects ***A***nalysis, reliability engineering methods, for finding potential weak points
Functional safety	Part of the overall system safety, which depends on the correct functioning of safety-related systems for risk reduction. Functional safety is ensured when each safety function is executed as specified.
GSD	Device Master File
GSDML	***G***eneral ***S***tation ***D***escription ***M***arkup ***L***anguage
I&M	***I***dentification & ***M***aintenance
IEC	***I***nternational ***E***lectrotechnical ***C***ommission
IEEE	***I***nstitute of ***E***lectrical and ***E***lectronics ***E***ngineers
IOCS	***IO C***onsumer ***S***tatus: Thus the Consumer of an IO Data Element signals the condition (good, bad with error location)
IOPS	***IO P***rovider ***S***tatus: Thus the Provider of an IO Data Element signals the condition (good, bad with error location)
IP	***I***nternet ***P***rotocol
IRT	***I***sochronous ***R***eal-***T***ime communication
ISO	***I***nternational ***S***tandard ***O***rganization

MAC	***M***edia ***A***ccess ***C***ontrol, Ethernet-ID
$MTTF_d$	***M***ean ***T***ime ***T***o ***F***ailure (dangerous) Mean time until dangerous failure
MRP	***M***edia ***R***edundancy ***P***rotocol
NRT	***N***on-***R***eal-***T***ime communication
Operator acknowl-edgment	Switching from substitute values to process data
PAS	***P***ublicly ***A***vailable ***S***pecification
Passivation	In the case of an F-Periphery with outputs, the F-System transmits substitute values (e.g. 0) to the fail-safe outputs during a passivation instead of the output values provided in the process image by the safety program.
PFD_{av}	***Av***erage ***P***robability of ***F***ailure on ***D***emand Average probability of failure of a safety function with low demand
PFH	***P***robability of ***F***ailure per ***H***our Operating mode with high requirement rate or continuous demand. Probability of dangerous failure per hour.
PNO	PROFIBUS User Organization (***P***ROFIBUS ***N***utzer***O***rganisation e.V.)
PROFIBUS	Manufacturer independent, open field bus standard
PROFINET	PROFINET is the open Industrial Ethernet Standard of the PROFIBUS User Organization for the automation.
Proof test	Recurring check for detection of hidden dangerous failures in a safety-related system.
RT	***R***eal-***T***ime communication
SCS	***S***afety ***C***omputer ***S***ystem with control function, also referred to as F-Host in relation to PROFIsafe
SIL	***S***afety ***I***ntegrity ***L***evel: Four discrete levels (SIL1 to SIL4). The higher the SIL of a safety-related system, the lower the probability that the system cannot execute the required safety functions.
SIS	***S***afety ***I***nstrumented ***S***ystem: is used to protect a dangerous process and reduce the risk of an accident. Process instruments are a constituent of a Safety Instrumented System. This comprises the essential components of a complete safety-relevant process unit: Sensor, fail-safe processing unit (control) and actuator
Slot	Plug-in slot: can be meant also in the logical sense as addressing of modules.
Subslot	Adressing of data
SNMP	***S***imple ***N***etwork ***M***anagement ***P***rotocol
STP	***S***hielded ***T***wisted ***P***air
Standard measuring-system	Definition: Safety-related measuring system, without explosion protection
TCP	***T***ransmission ***C***ontrol ***P***rotocol
UDP	***U***ser ***D***atagram ***P***rotocol
VDE	Association for Electrical, Electronic & Information Technologies
XML	E***X***tensibl***e*** ***M***arkup ***L***anguage

1.4 Main features

- PROFINET IO interface with PROFIsafe protocol, for transfer of a safe position and speed
- Quick process data channel via PROFINET IO, not safety-oriented
- Variant 1 only:
  Additional incremental or SIN/COS interface, not safety-oriented
- Two-channel scanning system, for generation of safe measured data through internal channel comparison
  - Variant 1:
    Channel 1, master system:
    optical Single-Turn scanning via code disk with transmitted light and magnetic Multi-Turn scanning
    Channel 2, inspection system:
    magnetic Single- and Multi-Turn scanning
  - Variant 2:
    Channel 1, master system:
    magnetic Single- and Multi-Turn scanning
    Channel 2, inspection system:
    magnetic Single- and Multi-Turn scanning
- A common drive shaft

The data of the master system are unevaluated in the non-safety-oriented process data channel with normal PROFINET IO protocol, but are made available with a short cycle time.

The inspection system serves for the internal safety check. The "safe data" obtained through two-channel data comparison are packed into the PROFIsafe protocol and also transmitted to the control via the PROFINET IO.

The incremental interface available in variant 1, or the optionally available SIN/COS interface, is derived from the master system and is not evaluated in relation to safety.

1.5 Principle of the safety function

System safety results when:

- Each of the two scanning channels is largely fail-safe thanks to individual diagnostic measures
- The measuring system internally compares the positions detected by both channels in two channels, also determines the speed in two channels and transfers the safe data to the PROFINET IO in the PROFIsafe protocol
- In the event of a failed channel comparison or other errors detected through internal diagnostic mechanisms, the measuring system switches the PROFIsafe channel into error state
- The measuring system initialization and execution of the preset adjustment function are appropriately verified
- The control additionally checks whether the obtained position data lie in the position window expected by the control. Unexpected position data are e.g. position jumps, tracking error deviations and incorrect direction of travel
- When errors are detected the control introduces appropriate safety measures defined by the system manufacturer
- The system manufacturer ensures, through correct mounting of the measuring system, that the measuring system is always driven by the axis for measurement and is not overloaded
- The system manufacturer performs a verified test during commissioning and in the event of any parameter modification

2 Safety instructions

2.1 Definition of symbols and notes

⚠ DANGER	means that death or serious injury will occur if the required precautions are not met.
⚠ WARNING	means that death or serious injury can occur if the required precautions are not met.
⚠ CAUTION	means that minor injuries can occur if the required precautions are not met.
NOTICE	means that damage to property can occur if the required precautions are not met.
	indicates important information or features and application tips for the product used.

2.2 Safety functions of the fail-safe processing unit

The **F-Host**, to which the measuring system is connected, must perform the following safety checks.

To enable the correct measures to be taken in the case of an error, the following applies:

If no safe position can be output due to an error detected by the measuring system, the PROFIsafe data channel is automatically put into fail-safe status. In this status so-called "passivated data" are output via PROFIsafe. Also see the chapter "Output of passivated data (substitute values) in case of error" on page 47.

Passivated data from the viewpoint of the measuring system are:

- PROFIsafe data channel: all outputs are set to 0
- PROFIsafe status: error bit 2^1 `Device_Fault` is set
- PROFIsafe-CRC: valid

Upon receipt of passivated data, the F-Host must put the system into a safe state. It is only possible to leave this error state by eliminating the error and then switching the supply voltage off and on again!

The process data channel addressable via PROFINET IO is not necessarily affected by this. If the internal diagnosis in the master channel does not detect an error, the process data are still output. However, these data are not safe for the purposes of a safety standard.

2.2.1 Mandatory safety checks / measures

Measures for commissioning, changes	F-Host error reaction
Application-dependent parameterization and definition of the necessary `iParameters`, see chapter "iParameters" on page 45.	–
In the event of parameter changes, check that the measure is executed as desired.	STOP

Check by F-Host	F-Host error reaction
Cyclical consistency check of the current safety-oriented data from the safety module in relation to the previous data.	STOP
Travel curve calculation and monitoring by means of cyclical data from the safety module.	STOP
Monitoring of cyclical data from the safety module, and the process data from the non-safety module.	Receipt of passivated data --> STOP
Timeout: Monitoring of the measuring system - response time. For checking e.g. cable breakage, power failure etc.	STOP

3 Technical Data

3.1 Safety

Startup time	Time between POWER-UP and safe position output
Overall system	≤ 7 s with SIMATIC S7, CPU317F-2
PFH, "High demand" operating mode	1.46 * 10^{-9} 1/h
Scanning, double magnetic	2.30*10^{-9} 1/h
PFD_{av} (T_1 = 20 a)	1.27 * 10^{-4}
$MTTF_d$ high	421 a
Scanning, double magnetic	110 a
*** DC_{avg} high**	95 %
Scanning, double magnetic	98.87 %
Internal process safety time	Time between occurrence of an F-Error and alarm indication
Overall system	≤ 6.5 ms
Process safety angle	Angle between error occurrence and alarm indication
Via channel-internal self-diagnosis	± 100 °, in relation to the measuring system shaft, at 6000 min^{-1}
Through channel comparison	Parameterizable with iParameter `Window increments`
T_1, Proof Test	20 years

* The assessment occurred in accordance with Note 2 on Table 6 of EN ISO 13849-1

3.2 Electrical characteristics

3.2.1 General

Supply voltage	13…27 V DC acc. to IEC 60364-4-41, SELV/PELV
Feed	single feed input, but electrically separated internally by means of two power supplies
Reverse polarity protection	yes
Short-circuit protection	yes, by internal 2 A safety fuse
Overvoltage protection	yes, up to ≤ 36 V DC
Current consumption without load	< 180 mA at 24 V DC
Option HTL-Level, 13…27 VDC	increased current consumption, see page 27

3.2.2 Device-specific

Total resolution ..... ≤ 268 435 456 steps

Number of steps / revolution ..... ≤ 8.192

Number of revolutions ..... ≤ 32.768

Functional accuracy ..... 8192 steps, Single-Turn
Scanning, double magnetic ..... 256 steps, Single-Turn

Safety-related applicable accuracy
Scanning, optical/magnetic ..... 256 steps, Single-Turn
Scanning, double magnetic ..... 128 steps, Single-Turn

Safety principle ..... 2 redundant scanning units with internal triangulation

PROFINET IO interface ..... according to IEC 61158, IEC 61784
PROFIsafe profile ..... 3.192b according to IEC 61784-3-3
MRP protocol ..... yes, series 75/100/115 ≤ MAC-address 00-03-12-EF-84-28
Integrated switch (2 ports) ..... yes, series 75/100/115
Additional functions ..... Preset
* Parameter
- Integration time Safe ..... 50 ms…500 ms
- Integration time Unsafe ..... 5 ms…500 ms
- Size of monitoring window ..... 50…4000 increments
- Idleness tolerance Preset ..... 1…5 increments/Integration time Safe
- Counting direction ..... forward, backward
PROFINET specification V2.2
Software stack V3.2.0.1
Conformance class ..... Conformance Class B, C
Physical Layer ..... PROFINET 100Base-TX, Fast Ethernet, ISO/IEC 8802-3
Output code ..... Binary
Cycle time ..... ≥ 1 ms (IRT / RT)
Transmission rate ..... 100 Mbit/s
Transmission ..... CAT-5 cable, shielded (STP), ISO/IEC 11801
***** Addressing ..... Per Name (name allocation about engineering tool).
Assignment Name→MAC during system boot
Real-Time-Classes ..... RT Class 1 Frames (RT), RT Class 2 Frames (RT),
RT Class 3 Frames (IRT)
* TR-specific functions ..... Speed output in increments/Integration time Safe

Incremental interface ..... Cable specification see page 22
Availability ..... Scanning system: optical/magnetic
Pulses / revolution ..... 1024, 2048, 3072, 4096, 5120 or
4096, 8192, 12288, 16384, 20480, via factory setting
A, /A, B, /B, TTL ..... RS422 (2-wire) according to EIA standard
A, /A, B, /B, HTL ..... optional 13…27 V DC, see page 27
Output frequency, TTL ..... ≤ 500 KHz
Output frequency, HTL ..... see page 27

SIN/COS interface, alternative ..... Cable specification see page 22
Availability ..... Scanning system: optical/magnetic
Number of periods ..... 4096 / revolution
SIN+, SIN–, COS+, COS– ..... 1 Vss ± 0.2 V at 100 Ω, differential
Short-circuit proof ..... yes

Cycle time
Not safety-oriented ..... 0.5 ms, output via non-safety module
Safety-oriented ..... 5 ms, output via safety module

Preset write cycles ..... ≥ 4 000 000

* parameterizable via PROFINET IO

3.3 Max. possible step deviation (master system / inspection system)

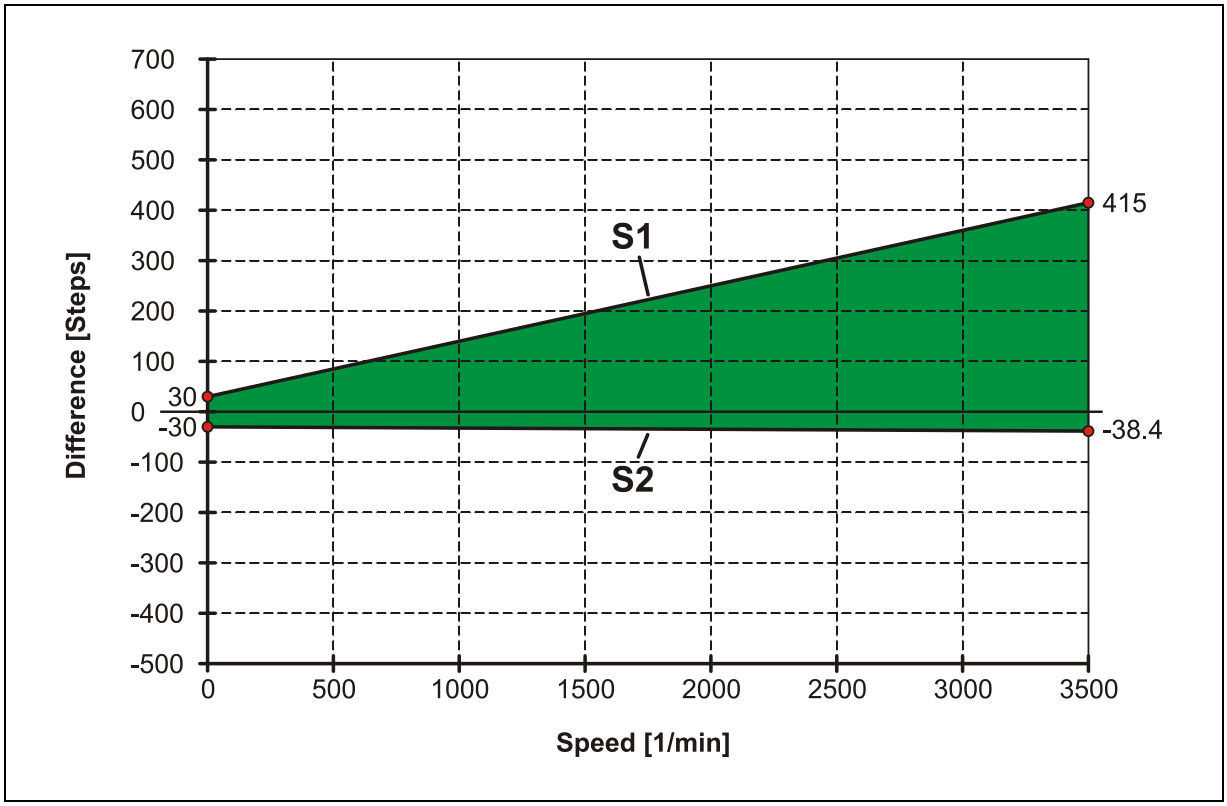


Figure 1: Dynamic view of the step deviation, counting direction rising (view onto flanging)

Figure 1 serves for the estimate of the possible step deviation. On the base of this estimate the parameter `Window increments` *can be adjusted, see chapter 5.6.2.3 on page 43.*

Function of the straight line S1:

S1 = 30 steps + (0.11 steps per revol. * actual speed [1/min])

Function of the straight line S2:

S2 = -30 steps + (-0.0024 steps per revol. * actual speed [1/min])

The max. possible step deviation results from the difference between S1 and S2

Example: Max. possible step deviation at 3500 1/min

S1 = 30 steps + (0.11 steps per revol. * 3500 1/min) = 415 steps
S2 = -30 steps + (-0.0024 steps per revol. * 3500 1/min) = -38.4 steps

Max. possible step deviation = 415 steps – (-38.4 steps) = **453.4 steps**

4 Installation / Preparation for Commissioning

4.1 Basic rules

⚠ WARNING ***Deactivation of the safety function through conducted interference sources!***

- All nodes of the safety-relevant communication must be certified according to IEC 61010 or must have a corresponding EC conformity declaration.
- All PROFIsafe devices used on the bus must have a PROFINET and a PROFIsafe - certificate.
- All safety devices must also have a certificate from a "Notified Body" (e.g. TÜV, BIA, HSE, INRS, UL, etc.).
- The 24 V power supplies used must comply with the requirements of IEC 60364-4-41 SELV/PELV and be NEC Class 2 compliant for UL applications.
- Only cables and connectors which are provided with a PROFINET manufacturer's declaration are to be used.
- The shielding effect of cables must also be guaranteed after installation (bending radii/tensile strength!) and after connector changes. In cases of doubt, use more flexible cables with a higher current carrying capacity.
- Only use M12 connectors for connecting the measuring system, which guarantee good contact between the cable shield and connector housing. The cable shield must be connected to the connector housing over a large area.
- A 5-wire cable with a PE-conductor isolated from the N-conductor (so-called TN network) must be used for the drive/motor cabling. This will largely prevent equipotential bonding currents and the development of interference.
- A shielded and stranded data cable must be used to ensure high electromagnetic interference stability of the system. The shielding should be connected with low resistance to protective ground using large shield clips at **both ends**. The shielding should be grounded **in the switch cabinet only** if the machine ground is heavily contaminated with interference towards the switch cabinet ground.
- Equipotential bonding measures must be provided for the complete processing chain of the system.
- Power and signal cables must be laid separately. During installation, observe the applicable national safety and installation regulations for data and power cables.
- Observe the manufacturer's instructions for the installation of converters and for shielding power cables between frequency converter and motor.
- Ensure adequate dimensioning of the energy supply.

Upon completion of installation, a visual inspection with report should be carried out. Wherever possible, the quality of the network should be verified using a suitable bus analysis tool: no duplicate IP-addresses, no reflections, no telegram repetitions etc.

To ensure safe and fault-free operation, the

- *PROFINET Design Guideline, PNO Order no.: 8.062*
- *PROFINET Assembly Guideline, PNO Order no.: 8.072*
- *PROFINET Commissioning Guideline, PNO Order no.: 8.082*
- *PROFIsafe "Environmental Requirements", PNO Order no.: 2.232*
- *and the referenced Standards and PNO Documents contained in it must be observed!*

In particular the EMC directive in its valid version must be observed!

4.2 PROFINET IO transfer technology, cable specification

The safety-related PROFIsafe communication as well as the PROFINET communication is transferred about the same network.

PROFINET supports linear, tree or star structures. The bus or linear structure used in the field buses is thus also available for Ethernet. This is particularly practical for system wiring, as a combination of line and stubs is possible. Because the measuring system of the series 75, 100 and 115 already has an integrated switch, the line topology can be realized in a simple manner. The measuring system of the series 88 supports only one PORT!

Use only cables and connectors which are provided with a PROFINET manufacturer's declaration. The cable type A/B/C, the mechanical and chemical properties as well as the type of the PROFINET cable have to be defined according to the automation task. The cables are designed for bit rates of up to 100 Mbit/s. Because the measuring system supports the “auto-crossover-function”, it can be used crossover cables as well as uncrossed cables. The transmission speed is automatically detected by the measuring system and does not have to be set by means of switches.

Addressing by switches as in the case of the PROFIBUS-DP is also not necessary, this is done automatically using the addressing options of the PROFINET-Controller, however the PROFIsafe destination address “F_Dest_Add” must be adjusted, see page 24.

The cable length including patch cables in case of copper wiring between two suscribers may amount max. 100 m. This transmission link has been defined as *PROFINET end-to-end link*. Within an end-to-end link the number of detachable links is limited up to six connector pairs (male connector/female connector). If more than six connector pairs are required, make sure that the attenuation values for the entire link are observed (channel class-D values).

Series 75 / 100 / 115:

In case of IRT communication the topology is projected in a connection table. Thereby you must pay attention on a right connection of the ports 1 and 2.
With RT communication this is not the case, it can be cabled freely.

4.3 Connection

4.3.1 Series 75 / 115

Destruction, damage and malfunction of the measuring system in case of infiltration of damp!

⚠ WARNING

NOTICE

- In case of storage as well as in the operation of the measuring system unused connecting plugs have to be provided either with a mating connector or with a protective cap. The IP protection class is to be selected according to the requirements.
- Protective cap with O-ring:
  In case of re-close of the protective cap the existence and the correct seat of the O-ring have to be checked.
- Corresponding protective caps see chapter accessories in the Safety Manual.

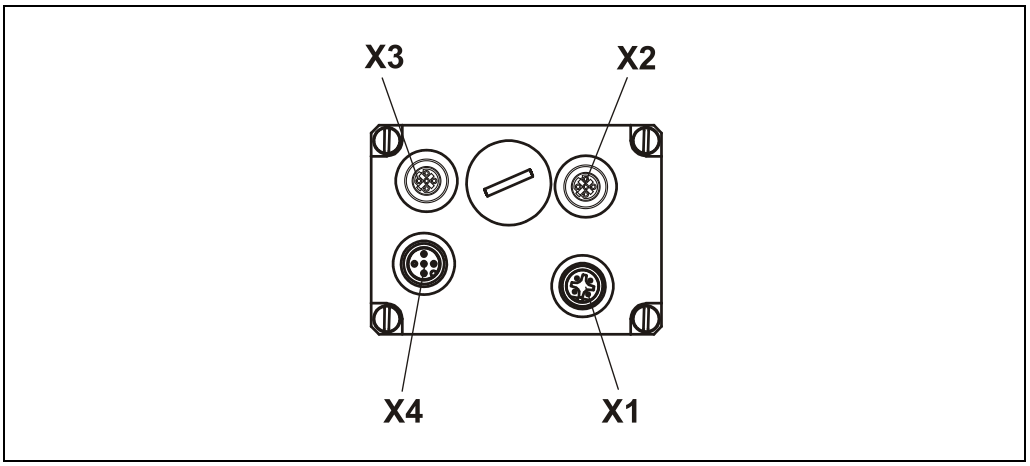


Figure 2: Connector assignment

4.3.2 Series 88

The measuring system of the series 88 is supplied with an Ethernet Hybrid Cable without connecting plug.

4.3.3 Series 100

⚠ WARNING

Danger of explosion!

NOTICE

- Open, wire (including potential equalization) and close only using and observing all instructions in the Ex User Manual!

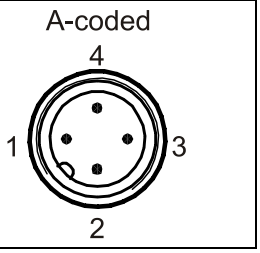
4.3.4 Supply voltage

NOTICE

Danger of unnoticed damage to the internal electronics, due to unacceptable overvoltages!

- If an overvoltage of >36 V DC is inadvertently applied, the measuring system must be checked in the factory. The measuring system is permanently switched off for safety reasons, if the overvoltage is applied for more than 200 ms.
  - ➢ The measuring system must be shut down immediately
  - ➢ When sending the measuring system to the factory, the reasons and circumstances relating to the overvoltage must be specified
  - ➢ The power supply used must meet the requirements of SELV/PELV (IEC 60364-4-41:2005)

Series75 / 115:

X1	Signal	Description	Pin, M12x1, 4 pole
1	+ 24 V DC (13…27 V DC)	supply voltage	
2	n.c.	-	
3	0 V	GND	
4	n.c.	-	

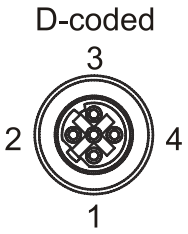
Cable specification: min. 0.34 mm^2 (recommended 0.5 mm^2) and shielded.
General the cable cross section and the cable length must be well-matched.

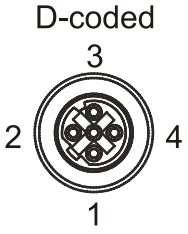
Series 88:

Signal	Description	Cable color
+ 24 V DC (13…27 V DC)	supply voltage	red
0 V	GND	black

4.3.5 PROFINET

Series 75 / 115:

X2	Signal	Description	Socket, M12x1, 4 pol.
1	TxD+, Transmission Data +	PORT 2	
2	RxD+, Receive Data +		
3	TxD–, Transmission Data –		
4	RxD–, Receive Data –		

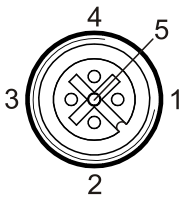
X3	Signal	Description	Socket, M12x1, 4 pol.
1	TxD+, Transmission Data +	PORT 1	
2	RxD+, Receive Data +		
3	TxD–, Transmission Data –		
4	RxD–, Receive Data –		

Series 88:

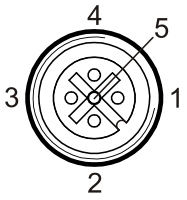
Signal	Cable color	Description
TxD+, Transmission Data +	green/white	PORT 1
RxD+, Receive Data +	white/orange	
TxD–, Transmission Data –	green	
RxD–, Receive Data –	orange	

4.3.6 Incremental interface / SIN/COS interface

Series 75 / 115:

X4	Signal	Description	Socket, M12x1, 5 pole
[1] 1	Channel B +	5 V differential / 13…27 V DC	A-coded 
[1] 2	Channel B –	5 V differential / 13…27 V DC	
[1] 3	Channel A +	5 V differential / 13…27 V DC	
[1] 4	Channel A –	5 V differential / 13…27 V DC	
5	0 V, GND	Data reference potential	

Alternative with SIN/COS signals

X4´	Signal	Description	Socket, M12x1, 5 pole
1	SIN +	1 Vss, differential	A-coded 
2	SIN –	1 Vss, differential	
3	COS +	1 Vss, differential	
4	COS –	1 Vss, differential	
5	0 V, GND	Data reference potential	

Cable specification: min. 0.25 mm² and shielded.
To guarantee the signal quality and minimization of possible environmental influences it is recommended urgently to use a shielded twisted pair cable.

Series 88:

Signal	Description	Cable color
[1] Channel B +	5 V differential / 13…27 V DC	blue
[1] Channel B –	5 V differential / 13…27 V DC	yellow
[1] Channel A +	5 V differential / 13…27 V DC	white
[1] Channel A –	5 V differential / 13…27 V DC	brown
0 V, GND	Data reference potential	gray

Alternative with SIN/COS signals

Signal	Description	Cable color
SIN +	1 Vss, differential	blue
SIN –	1 Vss, differential	yellow
COS +	1 Vss, differential	white
COS –	1 Vss, differential	brown
0 V, GND	Data reference potential	gray

[1] TTL/HTL – Level variant: see type plate

4.4 PROFIsafe Destination address “F_Dest_Add”

The PROFIsafe destination address corresponds to the F-parameter `F_Dest_Add` and defines an unique source address within a PROFIsafe cluster.

Valid addresses: 1…99, also see chapter “F_Source_Add / F_Dest_Add” on page 42.

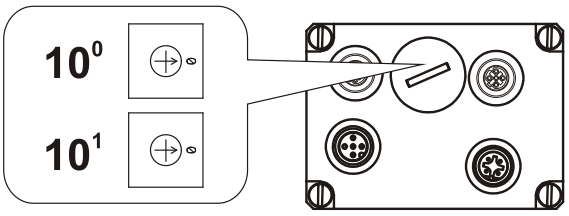
4.4.1 Series 75 / 115

⚠ WARNING ***Destruction, damage and malfunction of the measuring system in case of infiltration of foreign substances and damp!***

NOTICE

- The access to the address switches has to be locked after the settings with the screw plug. Tighten firmly!

The PROFIsafe destination address is adjusted by means of two BCD-switches which are read only at the starting moment. Subsequent settings during ongoing operation will no longer be detected.



4.4.2 Series 88

Requirements

- An IP-address must have been assigned to the measuring system.
- Between client computer and measuring system (server) there must be an active TCP/IP communication. After POWER ON a TCP socket server is started at IP-port 60042.
- On the client computer the TCP socket client – software “TR Address Client” must be available.
  Download: www.tr-electronic.de/f/zip/TR-ECE-SW-DGB-0002
- IP-address and MAC-address must be known. The MAC-address can be read from the nameplate of the measuring system.
- From view of the client computer the connection is executed via a certain port number. In this connection, the range of the port numbers can be between 49152 and 65535. It must be made sure that a firewall does not block the connection.

Procedure

- ➢ Start TCP socket client.
- ➢ Enter the IP-address and MAC-address valid for the device.
- ➢ Enter desired PROFIsafe destination address `F_Dest_Add`.
- ➢ Click `Send` button.
  - – After successful execution the programmed PROFIsafe destination address is confirmed.

4.4.3 Series 100

⚠ WARNING ***Danger of explosion!***

NOTICE

- Open, justify and close only using and observing all instructions in the Ex User Manual!

4.5 Incremental interface / SIN/COS interface

Series 88: optional feature
Series 100: not supported

In addition to the PROFINET IO interface for output of the absolute position, the measuring system in the standard version also has an incremental interface.

However, this can alternatively also be designed as a SIN/COS interface.

⚠ WARNING ***This additional interface is not evaluated in relation to safety and must not be used for safety-oriented purposes!***

- The measuring system checks the outputs of this interface for the feed-in of external voltages. In the event of voltages > 5.7 V, the measuring system is switched off for safety reasons. In this state the measuring system behaves as if it were not connected.
- The interface is generally used as position feedback for motor control applications.

NOTICE ***Danger of damage to subsequent electronics due to overvoltages caused by a missing ground reference point!***

- If the ground reference point is completely missing, e.g. 0 V of the power supply not connected, voltages equal to the supply voltage can occur at the outputs of this interface.
  - It must be guaranteed that a ground reference point is present at all times,
  - or corresponding protective measures by the system operator must be provided for subsequent electronics.

The signal characteristics of the two possible interfaces are shown below.

4.5.1 Signal characteristics

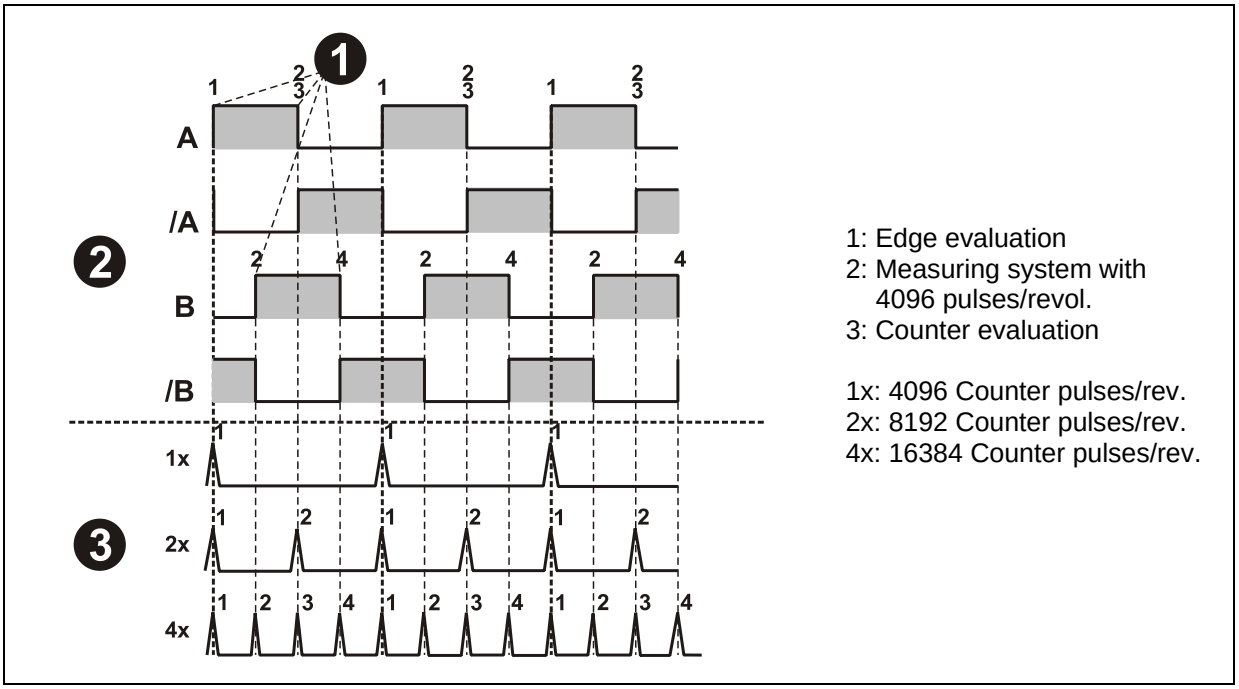


Figure 3: Counter evaluation, incremental interface

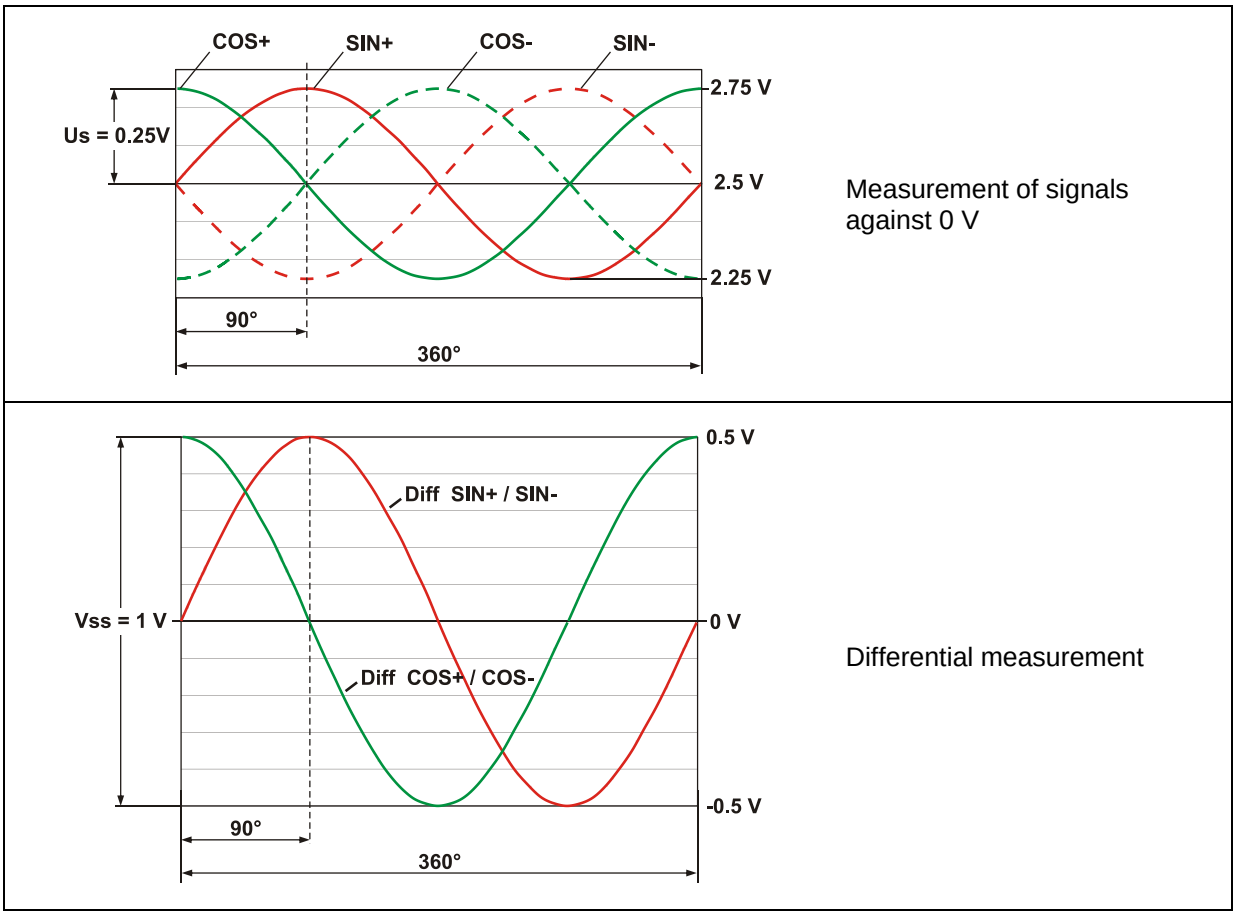


Figure 4: Level definition, SIN/COS interface

4.5.2 Optional HTL-Level, 13…27 VDC

Optionally, the incremental interface is also available with HTL levels. For technical reasons, the user has to take the following general conditions into account with this version: ambient temperature, cable length, cable capacitance, supply voltage, and output frequency.
In this case, the maximum output frequencies that can be reached via the incremental interface are a function of the cable capacitance, the supply voltage and the ambient temperature. Therefore, the use of this interface is reasonable only if the interface characteristics meet the technical requirements.

From the view of the measuring system, the transmission cable represents a capacitive load which must be reloaded with each impulse. The load quantity required varies strongly depending on the cable capacitance. It is this reloading of the cable capacitances that is responsible for the high power dissipation and heat, which result in the measuring system.

Assuming a cable length (75 pF/m) of 100 m, with half the limit frequency being associated with the rated voltage of 24 VDC, the current consumption of the measuring system is twice as high.

Due to the developing heat, the measuring system may only be operated with approx. 80 % of the working temperature specified.

The following diagram shows the different dependencies with respect to three different supply voltages.

Fixed variables are

- Cable capacitance: 75 pF/m
- Ambient temperature: 40 °C and 70 °C

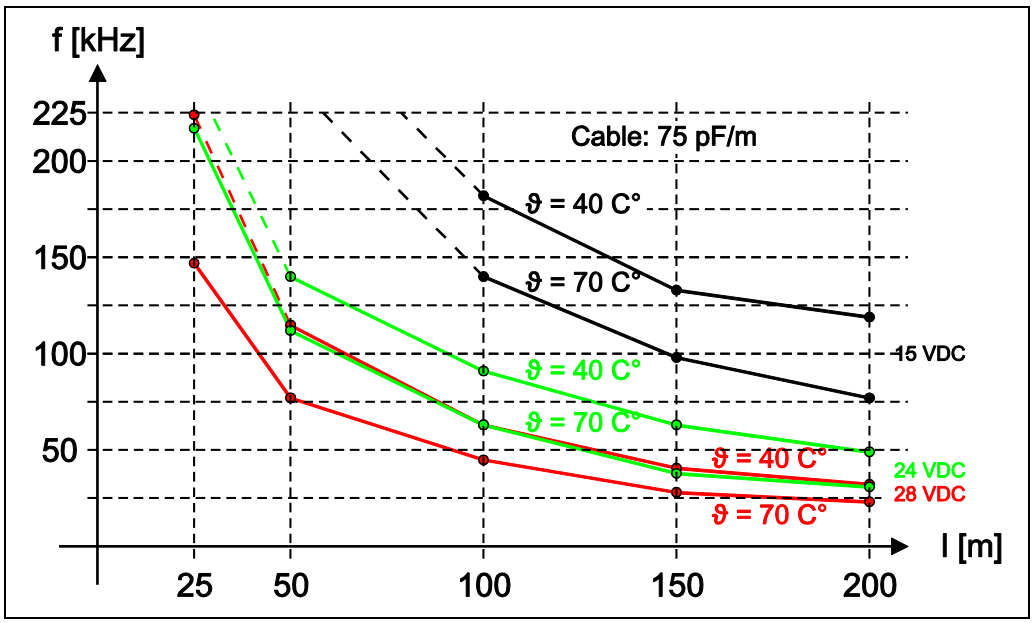


Figure 5: Cable lengths / Limiting frequencies

Other cable parameters, frequencies and ambient temperatures as well as bearing heat and temperature increase via the shaft and flange, can yield a considerably poorer result in practice.

Therefore, the fault-free function of the incremental interface with the application-dependent parameters has to be checked prior to productive operation.

5 Commissioning

5.1 PROFINET IO

Important information for the commissioning can be found in the PROFINET Guideline:

- PROFINET Commissioning Guideline, Order No.: 8.082

These and further information on PROFINET or PROFIsafe are available from the offices of the PROFIBUS User Organization:

PROFIBUS Nutzerorganisation e.V.,
Haid-und-Neu-Str. 7,
D-76131 Karlsruhe,
www.profibus.com/
www.profisafe.net/
Tel.: ++ 49 (0) 721 / 96 58 590
Fax: ++ 49 (0) 721 / 96 58 589
Email: mailto:germany@profibus.com

5.1.1 Device classes

In a PROFINET IO - system the following device classes are differentiated:

- **IO-Controller**
  For example a PLC, which controls the connected IO-Device.

- **IO-Device**
  Decentralized arranged field device (measuring system), which is assigned to one or several IO-Controllers and transmits, additionally to the process and configuration data, also alarms.

- **IO-Supervisor** (Engineering Station)
  A programming device or an Industrial PC, which has also access to all process- and parameter data additionally to an IO-Controller.

5.1.2 Device description file (XML)

The GSDML file and the corresponding bitmap file are components of the measuring system.

Download
- Series 75 / 100 / 115: www.tr-electronic.de/f/TR-ECE-ID-MUL-0031
- Series 88: www.tr-electronic.de/f/TR-ECE-ID-MUL-0050

5.1.2.1 MRP protocol support, series 75 / 100 / 115

In the GSDML file versions 2.x are always contained two Device Access Points (DAP´s).

1. DAP without support of the MRP protocol: `CD_75_-EPN V2.x`
2. DAP with support of the MRP protocol: `CD_75_-EPN MRP V2.x`

“Legacy devices”

Measuring systems > MAC-address 00-03-12-EF-84-28 generally support no MRP protocol and must be configured under DAP `CD_75_-EPN V2.x`.

“New devices”

Measuring systems ≤ MAC-address 00-03-12-EF-84-28 generally support the MRP protocol and must be configured under DAP `CD_75_-EPN MRP V2.x`.

In case of replacement, legacy device against new device, the measuring system may be configured also under the DAP `CD_75_-EPN V2.x`.

5.1.3 Device identification

Each PROFINET IO-Device possesses a device identification. It consists of a firm identification, the Vendor-ID, and a manufacturer-specific part, the Device-ID. The Vendor-ID is assigned by the PNO. For TR-Electronic the Vendor-ID contains the value 0x0153, in case of the series 75, 100 and 115 the Device-ID has the value 0x0401 and in case of series 88 the Device-ID has the value 0x0403.
When the system boots up the projected device identification is examined. In this way errors in the project engineering can be recognized.

5.1.4 Distribution of IP addresses

Parameter	Default value	Description
MAC Address	-	By default in the delivery state the measuring system has saved his *MAC-Address* which is printed on the connection hood of the device, e.g. “00-03-12-04-00-60”. The MAC-Address is not changeable.
Device type	Series 75 / 100 / 115: TR CD_75_-EPN Series 88: TR AD_88_-EPN	The name for the device type is - Series 75 / 100 / 115: “TR CD_75_-EPN” - Series 88: “TR AD_88_-EPN” and is allocated by TR-Electronic. The Device type is not changeable.
Device name	-	Before an IO-Device can be controlled by an IO-Controller, it must have a *Device name*, because the IP-Address is assigned directly to the Device name. If necessary when the system boots up the IO-Controller distributes the IP-addresses to the IO-Devices according to their device names. This procedure has the advantage that names can be handled more simply than complex IP-Addresses. Assigning a device name for a concrete IO-Device is to compare with the adjusting of the PROFIBUS address in case of a DP-slave. In the delivery state as well as after a system boot up the measuring system has not saved a device name. Only after assignment of a device name with the engineering tool the measuring system for an IO-Controller is addressable, e. g. for the transmission of the project engineering data (e.g. the IP-Address) when the system boots up or for the user data exchange in the cyclic operation. The name assignment is executed by the engineering tool before the beginning of operation. In case of PROFINET IO-Field devices the standard DCP-Protocol is used.
IP Address	0.0.0.0	In the delivery state as well as after a system boot up the measuring system has not saved an IP-Address.
Subnet mask	0.0.0.0	In the delivery state as well as after a system boot up the measuring system has not saved a Subnet mask.

Proceeding at the distribution of Device names and Addresses
in case of an IO-Device

- Define Device name, IP-Address and Subnet mask. Depending on configuration this process can be executed also automatically by the IO-Controller.
- Device name is assigned to an IO-Device (MAC-Address)
  - Transmit Device name to the device
- Load projection into the IO-Controller
- When the system boots up the IO-Controller distributes the IP-Addresses to the Device names. The distribution of the IP-Address also can be switched off, in this case the existing IP-Address in the IO-Device is used.

5.2 PROFINET IO System boot

With a successful system boot the IO-Devices start automatically with the data transmission. In case of PROFINET IO a communication relation always follows the provider consumer model. With cyclical transmission of the measuring value, the IO-Device corresponds to the provider of the data, the IO-Controller (e.g. a PLC) corresponds to the consumer. The transferred data always contains a status (good or bad).

5.3 Bus status display, series 75 / 115

⚠ WARNING ***Destruction, damage and malfunction of the measuring system in case of infiltration of foreign substances and damp!***

NOTICE

- The access to the LEDs has to be locked after the settings with the screw plug. Tighten firmly!

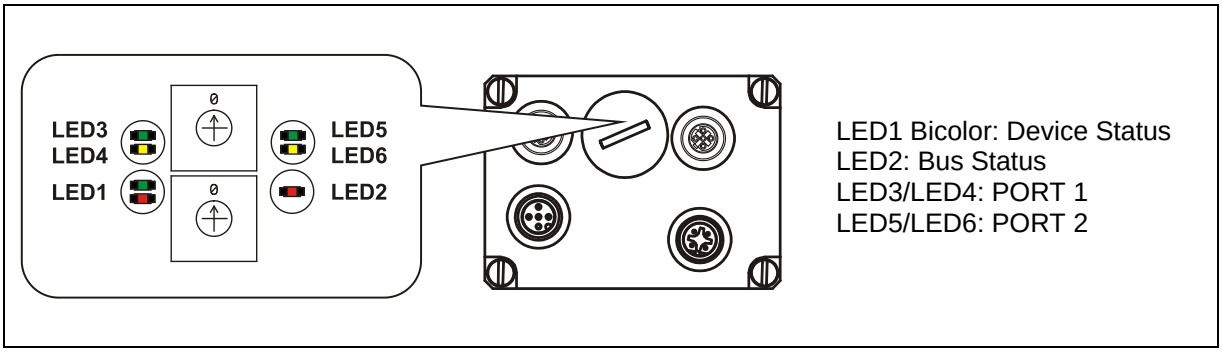


Figure 6: Bus status display

■	ON
□	OFF
▬	FLASHING

Device Status, LED1 Bicolor	
	green
□	No supply voltage, hardware error
■	Operational
▬	Operator acknowledgment required, 3x 5 Hz

	red
■	System or safety relevant error

Bus Status, LED2	
	red
	No error
	Parameter- or F-Parameter error; 0.5 Hz
	No link to the IO-Controller

PORT 1; LED3 = Link, LED4 = Data Activity		
	LED3, green	Ethernet connection established
	LED4, yellow	Data transfer TxD/RxD

PORT 2; LED5= Link, LED6 = Data Activity		
	LED5, green	Ethernet connection established
	LED6, yellow	Data transfer TxD/RxD

For appropriate measures in case of error, see chapter "Troubleshooting and Diagnosis Options", page 50.

5.4 Commissioning using the SIEMENS SIMATIC S7 control

Download

- Technical Information: www.tr-electronic.de/f/TR-ECE-TI-DGB-0233

5.5 Configuration

The following definition applies:
Data flow for input data: F-Device --> F-Host
Data flow for output data: F-Host --> F-Device

5.5.1 Safety-oriented data

Structure of the input data

Byte	Bit	Input data	
X+0	2^8-2^{15}	Cams	Unsigned16
X+1	2^0-2^7		
X+2	2^8-2^{15}	TR-Status	Unsigned16
X+3	2^0-2^7		
X+4	2^8-2^{15}	Speed	Integer16
X+5	2^0-2^7		
X+6	2^8-2^{15}	Actual value, Multi-Turn, 15 bit	Integer16
X+7	2^0-2^7		
X+8	2^8-2^{15}	Actual value, Single-Turn, 13 bit	Integer16
X+9	2^0-2^7		
X+10	2^0-2^7	Safe status	Unsigned8
X+11	2^{16}-2^{23}	CRC2	3 Bytes
X+12	2^8-2^{15}		
X+13	2^0-2^7		

Structure of the output data

byte	Bit	Output data	
X+0	2^8-2^{15}	TR-Control1	Unsigned16
X+1	2^0-2^7		
X+2	2^8-2^{15}	TR-Control2	Unsigned16
X+3	2^0-2^7		
X+4	2^8-2^{15}	Preset, Multi-Turn	Integer16
X+5	2^0-2^7		
X+6	2^8-2^{15}	Preset, Single-Turn	Integer16
X+7	2^0-2^7		
X+8	2^0-2^7	Safe Control	Unsigned8
X+9	2^{16}-2^{23}	CRC2	3 Bytes
X+10	2^8-2^{15}		
X+11	2^0-2^7		

5.5.1.1 Input data

5.5.1.1.1 Cams

Unsigned16

Byte	X+0	X+1
Bit	15 – 8	7 – 0
Data	2^{15} – 2^{8}	2^{7} – 2^{0}

Bit	Description
2^{0}	Speed overflow The bit is set if the speed value is outside the range of –32768…+32767.
2^{1}…2^{15}	reserved

5.5.1.1.2 TR-Status

Unsigned16

Byte	X+2	X+3
Bit	15 – 8	7 – 0
Data	2^{15} – 2^{8}	2^{7} – 2^{0}

Bit	Description
2^{0}	Preset_Status The bit is set if the F-Host triggers a preset request. When the preset has been executed, the bit is automatically reset.
2^{1}…2^{14}	reserved
2^{15}	Error The bit is set if a preset request could not be executed due to excessive speed. The current speed must be in the range of the speed set under `Preset Standstill Tolerance`. The bit is reset after the host has cleared the variable associated to the control bit 2^{0} `iPar_EN`, also see page 47.

5.5.1.1.3 Speed

Integer16

Byte	X+4	X+5
Bit	15 – 8	7 – 0
Data	$2^{15} – 2^{8}$	$2^{7} – 2^{0}$

The speed is output as a two's complement value with preceding sign.

Setting the direction of rotation = forward

– Looking at the flange connection, turn the shaft clockwise:
--> positive speed output

Setting the direction of rotation = backward

– Looking at the flange connection, turn the shaft clockwise:
--> negative speed output

If the measured speed exceeds the display range of
–32768…+32767, this results in an overflow, which is reported in the cams register via bit 2^{0}. At the time of the overflow the speed stops at the respective +/- maximum value, until the speed is once again in the display range. In this case the message in the cams register is also cleared.
The speed is specified in `increments` per `Integration time Safe`.

5.5.1.1.4 Multi turn / Single turn

Multi-Turn, Integer16

Byte	X+6	X+7
Bit	15 – 8	7 – 0
Data	$2^{15} – 2^{8}$	$2^{7} – 2^{0}$

Single-Turn, Integer16

Byte	X+8	X+9
Bit	15 – 8	7 – 0
Data	$2^{15} – 2^{8}$	$2^{7} – 2^{0}$

The number of revolutions is noted in the `Multi-Turn` register, and the current Single-Turn position is noted in steps in the `Single-Turn` register. Together with the measuring system resolution, max. number of steps per revolution according to type plate, the actual position can then be calculated:

Position in steps = (steps per revolution * number of revolutions) + Single-Turn position

Steps per revolution: 8192 ≙ 13 bit

Number of revolutions: 0…32767 ≙ 15 bit

The output position does not have a preceding sign.

5.5.1.1.5 Safe status

Unsigned8

Byte	X+10
Bit	7 – 0
Data	2^7 – 2^0

Bit	Description
2^0	**iPar_OK:** New iParameter values have been assigned to the F-Device
2^1	**Device_Fault:** Error in F-Device or F-Module
2^2	**CE_CRC:** Checksum error in communication
2^3	**WD_timeout:** Watchdog timeout during communication
2^4	**FV_activated:** Fail-safe values activated
2^5	**Toggle_d:** Toggle bit
2^6	**cons_nr_R:** Virtual consecutive number has been reset
2^7	reserved

Safe status can only be indirectly accessed from the safety program with the aid of variables, see chapter "Access to the safety-oriented data channel" on page 47.

A detailed description of the status bits can be taken from the PNO document "PROFIsafe – Profile for Safety Technology on PROFIBUS DP and PROFINET IO", Order No.: 3.192b.

5.5.1.2 Output data

5.5.1.2.1 TR-Control1

Unsigned16

Byte	X+0	X+1
Bit	15 – 8	7 – 0
Data	$2^{15} – 2^{8}$	$2^{7} – 2^{0}$

Bit	Description
2^{0}	Preset_Request The bit serves to control the preset adjustment function. When this function is executed, the measuring system is set to the position value stored in the `Preset Multi-Turn/Preset Single-Turn` registers. A precise sequence must be observed in order to execute the function, see chapter “Preset Adjustment Function" on page 47.
$2^{1}…2^{15}$	reserved

5.5.1.2.2 TR-Control2

Reserved.

5.5.1.2.3 Preset multi turn / Preset single turn

Preset Multi-Turn, Integer16

Byte	X+4	X+5
Bit	15 – 8	7 – 0
Data	$2^{15} – 2^{8}$	$2^{7} – 2^{0}$

Preset single turn, Integer16

Byte	X+6	X+7
Bit	15 – 8	7 – 0
Data	$2^{15} – 2^{8}$	$2^{7} – 2^{0}$

The desired preset value must be in the range of 0 to 268 435 455 (28 bit). Together with the measuring system resolution, max. number of steps per revolution according to type plate (8192), the corresponding values for `Preset Multi-Turn/Preset Single-Turn` can then be calculated:

Number of revolutions = desired preset value / steps per revolution

The integer part from this division gives the number of revolutions and must be entered in the `Preset Multi-Turn` register.

Single-Turn-Position = desired preset value – (steps per revolution * no. of revolutions)

The result of this calculation is entered in the `Preset Single-Turn` register.

The preset value is set as new position when the preset adjustment function is executed, see chapter “Preset Adjustment Function" on page 47.

5.5.1.2.4 Safe-Control

Unsigned8

Byte	X+8
Bit	7 – 0
Data	2^7 – 2^0

Bit	Description
2^0	**iPar_EN:** iParameter assignment unlocked
2^1	**OA_Req:** Operator acknowledgment required
2^2	**R_cons_nr:** Resetting of the counter for the virtual consecutive no.
2^3	reserved
2^4	**activate_FV:** Activate fail-safe values
2^5	**Toggle_h:** Toggle bit
2^6-2^7	reserved

The Safe-Control register can only be indirectly accessed from the safety program with the aid of variables, see chapter "Access to the safety-oriented data channel" on page 47.

A detailed description of the control bits can be taken from the PNO document "PROFIsafe – Profile for Safety Technology on PROFIBUS DP and PROFINET IO", Order No.: 3.192b.

5.5.2 Not safety-oriented Process data

Structure of the input data

Byte	Bit	Input data	
X+0	2^8-2^{15}	Cams	Unsigned16
X+1	2^0-2^7		
X+2	2^8-2^{15}	Speed	Integer16
X+3	2^0-2^7		
X+4	2^8-2^{15}	Actual value, Multi-Turn, 15 bit	Integer16
X+5	2^0-2^7		
X+6	2^8-2^{15}	Actual value, Single-Turn, 13 bit	Integer16
X+7	2^0-2^7		

5.5.2.1 Input data

5.5.2.1.1 Cams

Unsigned16

Byte	X+0	X+1
Bit	15 – 8	7 – 0
Data	2^{15} – 2^8	2^7 – 2^0

Bit	Description
2^0	Speed overflow The bit is set if the speed value is outside the range of –32768…+32767.
2^1…2^{15}	reserved

5.5.2.1.2 Speed

Integer16

Byte	X+2	X+3
Bit	15 – 8	7 – 0
Data	$2^{15} – 2^{8}$	$2^{7} – 2^{0}$

The speed is output as a two's complement value with preceding sign.

Setting the direction of rotation = forward

– Looking at the flange connection, turn the shaft clockwise:
--> positive speed output

Setting the direction of rotation = backward

– Looking at the flange connection, turn the shaft clockwise:
--> negative speed output

If the measured speed exceeds the display range of
–32768…+32767, this results in an overflow, which is reported in the cams register via bit 2^{0}. At the time of the overflow the speed stops at the respective +/- maximum value, until the speed is once again in the display range. In this case the message in the cams register is also cleared.
The speed is specified in `increments` per `Integration time Unsafe`.

5.5.2.1.3 Multi turn / Single turn

Multi-Turn, Integer16

Byte	X+4	X+5
Bit	15 – 8	7 – 0
Data	$2^{15} – 2^{8}$	$2^{7} – 2^{0}$

Single-Turn, Integer16

Byte	X+6	X+7
Bit	15 – 8	7 – 0
Data	$2^{15} – 2^{8}$	$2^{7} – 2^{0}$

The number of revolutions is noted in the `Multi-Turn` register, and the current Single-Turn position is noted in steps in the `Single-Turn` register. Together with the measuring system resolution, max. number of steps per revolution according to type plate, the actual position can then be calculated:

Position in steps = (steps per revolution * number of revolutions) + Single-Turn position

Steps per revolution: 8192 ≙ 13 bit

Number of revolutions: 0…32767 ≙ 15 bit

The output position does not have a preceding sign.

5.6 Parameterization

Normally the configuration program provides an input box for the IO-Controler with which the user can enter parameter data or select from a list. The structure of the input box is stored in the device master file.

⚠ DANGER

NOTICE

- **Danger of death, serious physical injury and/or damage to property due to malfunction, caused by incorrect parameterization!**
  - ➢ The system manufacturer must ensure correct functioning by carrying out a protected test run during commissioning and after each parameter change.

5.6.1 F-Parameters (F_Par)

The F-Parameters supported by the measuring system are listed below.

Byte order = Big Endian

Byte	Parameter	Type	Description		Page
X+0	-	Bit	Bit 0 = 0: not used		-
	F_Check_iPar	Bit	Bit 1 = 0: No check		41
	F_SIL	Bit range	Bit 3-2	00: SIL1 01: SIL2 10: SIL3 [default] 11: no SIL	42
	F_CRC_Length	Bit range	Bit 5-4	00: 3-Byte-CRC	42
X+1	F_Block_ID	Bit range	Bit 5-3	001: 1	42
	F_Par_Version	Bit range	Bit 7-6	01: V2-Mode	42
X+2	F_Source_Add	Unsigned16	Source address, Default = 1 Range: 1-65534		42
X+4	F_Dest_Add	Unsigned16	Destination address, Default = 1 Range: 1-99		42
X+6	F_WD_Time	Unsigned16	Watchdog time, Default = 125 Range: 125-10000		42
X+8	F_iPar_CRC	Unsigned32	CRC of i-Parameters, Default = 1132081116 Range: 0-4294967295		42
X+12	F_Par_CRC	Unsigned16	CRC of F-Parameters, Default = 17033 Range: 0-65535		42

5.6.1.1 F_Check_iPar

The parameter is set to "NoCheck" and cannot be changed. This means the check sum value is not evaluated about the iParameters.

5.6.1.2 F_SIL

F_SIL specifies the SIL which the user expects from the respective F-Device. This is compared with the locally saved manufacturer's specification. The measuring system support the safety classes no SIL and SIL1 to SIL3, SIL3 = standard value.

5.6.1.3 F_CRC_Length

The measuring system supports the CRC length of 3 bytes. This value is predefined and cannot be changed.

5.6.1.4 F_Block_ID

As the measuring system supports device-specific safety parameters such as e.g. "Integration time Safe", this parameter is preconfigured with the value "1 = generate F_iPar_CRC" and cannot be changed.

5.6.1.5 F_Par_Version

The parameter identifies the PROFIsafe version "V2-Mode" implemented in the measuring system. This value is predefined and cannot be changed.

5.6.1.6 F_Source_Add / F_Dest_Add

The parameter `F_Source_Add` defines a unique source address within a PROFIsafe cluster. The parameter `F_Dest_Add` defines a unique destination address within a PROFIsafe cluster.
The PROFIsafe destination address must correspond to the address deposited in the measuring system, also see page 24.
Valid addresses: 1…99.
Standard value `F_Source_Add` = 1, Standard value `F_Dest_Add` = 1,
`F_Source_Add` ≠ `F_Dest_Add`.

5.6.1.7 F_WD_Time

This parameter defines the monitoring time [ms] in the measuring system. A valid current safety telegram must arrive from the F-Host within this time, otherwise the measuring system will be set to safe status.
The predefined value is 125 ms.
The watchdog time must generally be set at a level where telegram runtimes are tolerated by the communication, but it must also allow quick execution of the error reaction function in case of error.

5.6.1.8 F_iPar_CRC

This parameter represents the checksum value (CRC3), which is calculated from all iParameters of the device-specific part of the measuring system and ensures safe transmission of the iParameters. The calculation occurs in a program called "TR_iParameter" provided by TR-Electronic. The checksum value calculated there must then be manually entered in the F-Host engineering tool, also see chapter "Parameter Definition / CRC Calculation" on page 45.

5.6.1.9 F_Par_CRC

This parameter represents the checksum value (CRC1), which is calculated from all F-Parameters of the measuring system and ensures safe transmission of the F-Parameters. The calculation occurs externally in the F-Host engineering tool and must then be entered here under this parameter, or is generated automatically.

5.6.2 iParameters (F_iPar)

Application-dependent device characteristics are defined with the iParameters. A CRC calculation is necessary for safe transmission of the iParameters, see chapter "iParameters" on page 45.
The iParameters supported by the measuring system are listed below.

Byte order = Big Endian

Byte	Parameter	Type	Description	Page
X+0	Integration time Safe	Unsigned16	Default = 2 Range: 1-10	43
X+2	Integration time Unsafe	Unsigned16	Default = 20 Range: 1-100	43
X+4	Window increments	Unsigned16	Default = 1000 Range: 50-4000	43
X+6	Idleness tolerance Preset	Unsigned8	Default = 1 Range: 1-5	44
X+7	Direction	Bit	0: Backward 1: Forward [default]	44

5.6.2.1 Integration time Safe

This parameter is used to calculate the safe speed, which is output via the cyclical data of the safety module. High integration times enable high-resolution measurements at low speeds. Low integration times show speed changes more quickly and are suitable for high speeds and high dynamics. The time basis is predefined to 50 ms. 50…500 ms can thus be set using the value range of 1…10. Standard value = 100 ms.

5.6.2.2 Integration time Unsafe

This parameter is used to calculate the unsafe speed, which is output via the process data of the non-safety module. High integration times enable high-resolution measurements at low speeds. Low integration times show speed changes more quickly and are suitable for high speeds and high dynamics. The time basis is predefined to 5 ms. 5…500 ms can thus be set using the value range of 1…100.
Standard value = 100 ms.

5.6.2.3 Window increments

This parameter defines the maximum permissible position deviation in increments of the master / slave scanning units integrated into the measuring system. The permissible tolerance window is basically dependent on the maximum speed occurring in the system and must first be determined by the system operator. Higher speeds require a larger tolerance window. The value range extends from 50…4000 increments. Standard value = 1000 increments.

The larger the window increments, the larger the angle until an error will be recognized.

5.6.2.4 Idleness tolerance Preset

This parameter defines the maximum permissible speed in `increments` per `Integration time Safe` for performance of the preset function, see page 47. The permissible speed is dependent on the bus behavior and the system speed, and must be determined by the system operator first. The value range extends from 1 increment per `Integration time Safe` to 5 increments per `Integration time Safe`. That means that the shaft of the measuring system must be nearly at rest, so that the preset function can be executed.
Standard value = 1 increment per standard value `Integration time Safe`.

5.6.2.5 Direction

This parameter defines the current counting direction of the position value looking at the flange connection, turning the shaft clockwise.

Forward = Counting direction increasing
Backward = Counting direction decreasing

Standard value = Forward.

6 Parameter Definition / CRC Calculation

It is best to define the known parameters before configuration in the F-Host, so that they can be taken into account during configuration.

The TR_iParameter software required for the CRC calculation can be downloaded from: www.tr-electronic.com/service/downloads/software.html

6.1 iParameters

The iParameters are preconfigured with meaningful values in the default setting and should only be changed if expressly required by the automation task. A CRC calculation is necessary for safe transmission of the individually set iParameters. This must be performed when changing the predefined iParameters via the TR program "TR_iParameter". The calculated checksum as decimal value corresponds to the F-Parameter F_iPar_CRC. This must be entered in the field with the same name in the F-Host when configuring the measuring system.

Procedure - CRC-calculation

- Start TR_iParameter by means of the start file "TR_iParameter.exe", then open the template file provided with the measuring system with the menu Datei --> Vorlage öffnen...

- Modify the relevant parameters if necessary, then click on the CRC bilden switch for the F_iPar_CRC calculation. The result is displayed in the field F_iPar_CRC as decimal value.

Each parameter change requires a new F_iPar_CRC calculation, which must then be taken into account in the projection.

6.2 F-Parameters

The F-Parameters are already preconfigured with meaningful values in the default setting and should only be changed if expressly required by the automation task. A CRC which is usually automatically calculated by the Engineering tool is necessary for safe transmission of the individually set F-Parameters. This checksum corresponds to the F-Parameter F_Par_CRC.

Each parameter change, including F_iPar_CRC, also gives a new F_Par_CRC value.

7 Integration of the measuring system into the safety program

This chapter describes the necessary steps for the integration of the measuring system into the safety program and is not related to a certain control unit. The exact process is control specific and must be taken from the system documentation of the control unit manufacturer.

7.1 Prerequisites

⚠ WARNING ***Danger of deactivation of the fail-safe function through incorrect configuration of the safety program!***

- The safety program must be created in conjunction with the system documentation provided by the control unit manufacturer.
- It is essential to observe and comply with the information and instructions provided in the system documentation, particularly the safety instructions and warnings.

7.2 Hardware configuration

- Create a new project
- Perform the general hardware configuration (CPU, Voltage supply)
- Provide a digital input module, in order to be able to carry out the operator acknowledgment
- Install the GSDML file belonging to the measuring system
- Defining the properties of the hardware configuration
  - Access protection via password allocation
  - Ethernet (IP-Address, Subnet mask, Device Name, Synchronization)
  - I/O modules (Operating mode, F-Parameter, Diagnosis, Arrangements for the operator acknowledgment)

7.3 Parameterization

- Parameterize device specific `iParameter` in the non-safety module, also see starting from page 43 and 45
- Define PROFIsafe specific `F-Parameter` in the safety module, also see starting from page 41 and 45
- Save and if necessary compile hardware configuration

7.4 Generating the safety program

- Define the program structure, access protection via password allocation
- Create modules for the program call, Diagnosis, Data, Program, Functions, Periphery, System etc., can partly performed also automatically
- Edit modules for the program call, operator acknowledgment of the safety-oriented periphery
- Define program sequence
- Define cycle time for the program call of the safety program
- Generate safety program
- Load safety program into the control unit
- Perform a complete functional test of the safety program according to the automation task
- Perform an acceptance test of the safety system by an independent expert

7.5 Access to the safety-oriented data channel

The safety-oriented data channel in the safety module of the measuring system may only be accessed from the safety program. A direct access is not permitted.
For this reason the registers `Safe-Control` and `Safe-Status` can be accessed only indirectly about variables. The range of the variables and the way how the variables can be addressed is control dependent. This information must be taken from the system documentation provided by the control unit manufacturer.

The variables must be accessed in the following cases:

- during operator acknowledgment of the measuring system after communication errors or after the start-up phase, is indicated via the status LED see page 29
- during execution of the preset adjustment function
- when analyzing whether passivated or cyclical data are output
- if the cyclical data of the safety module are to be passivated depending on defined states of the safety program

7.5.1 Output of passivated data (substitute values) in case of error

The safety function requires that for passivation in the safety-oriented channel in the safety module, the substitute values (0) are used in the following cases instead of the cyclically output values. Dependent on the control, this condition is indicated over an appropriate variable.

- at start-up of the safety-oriented system
- in the case of errors in the safety-oriented communication between control unit and measuring system via the PROFIsafe protocol
- if the value set for the `Window increments` under the `iParameters` is exceeded and/or the internally calculated PROFIsafe telegram is defective
- if the permissible ambient temperature range, as defined under the corresponding article number, is fallen below or exceeded
- if the measuring system is supplied with >36 V DC for longer than 200 ms
- Hardware related errors in the measuring system
- Scanning system, double magnetic: if the electrically permissible speed has been exceeded which is defined in the safety manual. Since up to this limit value a fault-free operation is guaranteed, the real output of safe data is performed therefore only explicitly above the given limit value

8 Preset Adjustment Function

⚠ WARNING

NOTICE

- **Danger of death, serious physical injury and/or damage to property due to uncontrolled start-up of the drive system during execution of the preset adjustment function!**
  - Execute preset function only in the standstill, see chapter “Idleness tolerance Preset” on page 44
  - The relevant drive systems must be locked to prevent automatic start-up
  - It is advisable to protect the preset triggering via the F-Host by means of additional protective measures, such as e.g. key-operated switch, password etc.
  - The operational sequence described below is to be kept mandatorily. In particular the status bits are to be evaluated by the F-host, in order to check the successful and/or incorrect execution.
  - The new position must be checked after execution of the preset function

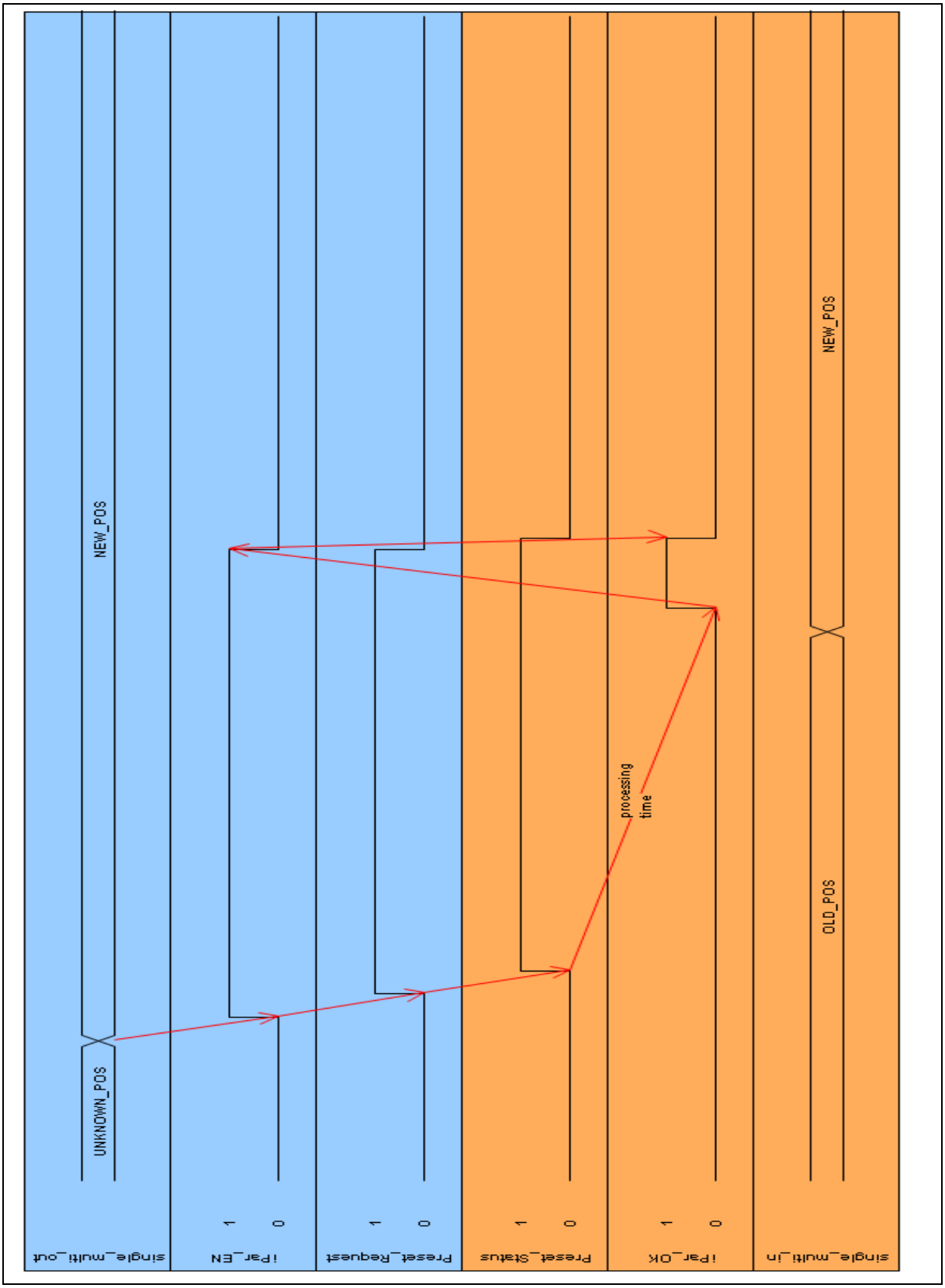
The preset adjustment function is used to set the currently output position value to any position value within the measuring range. The displayed position can thus be set to a machine reference position purely electronically.

8.1 Procedure

- Prerequisite: The measuring system is in cyclical data exchange.
- Write the `Preset Multi-Turn` and `Preset Single-Turn` registers in the output data of the safety module with the desired preset value.
- The F-Host must set the variable associated to the control bit 2^0 `iPar_EN` to 1. With the rising edge, the measuring system is now switched ready to receive.
- With the rising edge of Bit 2^0 `Preset_Request` in the `TR-Control1` register, the preset value is accepted. The receipt of the preset value is acknowledged in the `TR-Status` register by setting Bit 2^0 `Preset_Status`.
- After receipt of the preset value, the measuring system checks that all prerequisites for execution of the preset adjustment function are fulfilled. If so, the preset value is written as the new position value. In case of error, the execution is rejected and an error message is output via the `TR-Status` register by setting Bit 2^{15} `Error`.
- After execution of the preset adjustment function, the measuring system sets the variable associated to the status bit 2^0 `iPar_OK` to 1 and thus indicates to the F-Host that the preset execution is complete.
- The F-Host must now reset the variable associated to the control bit 2^0 `iPar_EN` to 0. The variable associated to the status bit 2^0 `iPar_OK` and Bit 2^0 `Preset_Status` in the `TR-Status` register are thus also reset with the falling edge. Bit 2^0 `Preset_Request` in the `TR-Control1` register must be reset manually again.
- Finally, the F-Host must check that the new position corresponds to the new nominal position.

8.2 Timing Diagram

blue area: Output signals F-Host -> Measuring system
orange area: Input signals Measuring system -> F-Host



9 Troubleshooting and Diagnosis Options

9.1 Optical displays

For assignment and position of the status LEDs see chapter "Bus status display, series 75 / 115" on page 31.

9.1.1 Device Status, LED1 Bicolor

green	*Cause*	*Remedy*
OFF	Power supply absent	Check power supply, wiring
	Hardware error, measuring system defective	Replace measuring system
3x 5 Hz repeating	– Measuring system could not synchronize with the F-Host in the start-up phase and requests an operator acknowledgment – An error in the safety-oriented communication or a parameterization error was detected, and has been eliminated	For the operator acknowledgment of the measuring system an acknowledgment about the safety program at the corresponding variable is required
ON	Measuring system ready for operation	–

red	*Cause*	*Remedy*
ON	**A safety-relevant error was detected, the measuring system was put into fail-safe status and is outputting its passivated data:**	**In order to restart the measuring system after a passivation the error must generally be eliminated first of all and then the supply voltage switched OFF/ON.**
	– Error in the safety-oriented communication	– Try to localize the error with the aid of diagnosis variables (dependent on the control unit) – Check that the set value for the `F_WD_Time` parameter is suitable for the automation task, see chapter "F_WD_Time" on page 42 – Check whether the PROFINET connection between F-CPU and measuring system is faulty
	– The set value for the `Window increments` parameter was exceeded	– Check that the set value for the `Window increments` parameter is suitable for the automation task, see chapter "Window increments" on page 43
	– The permissible ambient temperature range, as defined under the corresponding article number, was fallen below or exceeded	– Suitable measures must be taken to ensure that the permissible ambient temperature range can be observed at all times
	– The measuring system was supplied with >36 V DC for longer than 200 ms	– The measuring system must be shut down immediately and checked in the factory. When sending the measuring system to the factory, the reasons and circumstances relating to the overvoltage must be specified
	– The internally calculated PROFIsafe telegram is defective	– Power supply OFF/ON. If the error persists after this measure, the measuring system must be replaced
	– Scanning system, double magnetic: the electrically permitted speed which is defined in the safety manual was exceeded	– Bring speed into the permissible range. Error-acknowledgement about power supply OFF/ON.

9.1.2 Bus Status, LED2

red LED	*Cause*	*Remedy*
OFF	No error	–
0.5 Hz	– F-Parameterization defective, e.g. incorrectly set PROFIsafe destination address `F_Dest_Add` – Incorrectly configured `F_iPar_CRC` value	– Check the adjusted PROFIsafe destination address. Valid PROFIsafe destination addresses: 1–99, see chapter PROFIsafe Destination address “F_Dest_Add” on page 24 – The checksum calculated for the defined iParameter set is incorrect, or was not included in the projection, see chapter "Parameter Definition / CRC Calculation" on page 45
ON	– No connection to the IO-Controller	– Check Device name, IP-address and Subnet mask

9.1.3 Link Status, PORT1:LED3; PORT2:LED5

green LED	*Cause*	*Remedy*
OFF	Voltage supply absent or too low	Check voltage supply and wiring
	No Ethernet connection	Check Ethernet cable
	Hardware error, measuring system defective	Replace measuring system
ON	Measuring system ready for operation, Ethernet connection established	-

9.2 PROFINET IO Diagnostic

PROFINET IO supports a continuous diagnostic concept, which makes possible an efficient fault locating and recovery. At occurrence of an error the faulty IO-Device generates a diagnostic alarm to the IO-Controller. This alarm calls a corresponding program routine in the user program to initiate a reaction to the error.

By means of record data, alternatively the diagnostic information can be read directly from the IO-Device and can be displayed on an IO-Supervisor.

9.2.1 Diagnostic alarm

Alarms are part of the acyclic frames which are transferred about the cyclical RT-channel. They are also indicated with the EtherType 0x8892.

The measuring system supports only manufacturer specific diagnostic alarms which can be identified about the *UserStructureIdentifier* 0x5555. After this identification a 4 byte error code (*user data)* follows. Here the first occurred error is reported, saved and is displayed about the LED “Device Status, LED1 Bicolor”. The IOPS bit is set to *BAD*.

Because the measuring system can generate hundreds of error codes, these are not indicated here.

Error remedy see chapter “Optical displays”. If the error cannot be eliminated, the error code with information of the article number can be transmitted for evaluation to the company TR-Electronic.

9.2.2 Diagnostics about Record Data

Diagnostic data can be requested also with an acyclic read service *RecordDataRead(DiagnosisData)*, if they were saved in the IO-Device.
For the requested diagnostic data from the IO-Controller a read service with the corresponding record index must be sent.

The diagnostic information is evaluated on different addressing levels:

- AR (Application Relation)
- API (Application Process Identifier)
- Slot
- Subslot

A group of diagnostic records are available at each addressing level. The exact structure and the respective size is indicated in the PROFINET specification *Application Layer protocol for decentralized periphery and distributed automation,* order no.: 2.722.

Synonymously to the manufacturer specific diagnostic alarm, the diagnostic data can be read also manually about the record index 0xE00C. Similar as in the case of a diagnostic alarm a saved error is indicated with the *UserStructureIdentifier* 0x5555. Immediately afterwards the error code is transferred, see diagnostic alarm above.

9.3 Data status

With cyclic Real-Time communication the transferred data contains a status message. Each subslot has its own status information: *IOPS*/*IOCS*.

This status information indicates whether the data are valid = *GOOD* (1) or invalid = *BAD* (0).

During parameterization, as well as in the boot-up phase the output data can change to *BAD* for a short time. With a change back to the status *GOOD* a "Return-Of-Submodule-Alarm" is transferred.

In the case of a diagnostic alarm the status is also set to *BAD*, but can be reset only with a re-start.

Example: Input data IO-Device --> IO-Controller

VLAN	Ethertype	Frame-ID	Data	IOPS	...	IOPS	...		Cycle	Data Status	Transfer Status	CRC
4	0x8892	2	1..	1		1			2	1	1	4

Example: Output data IO-Controller --> IO-Device

VLAN	Ethertype	Frame-ID	IOCS	IOCS	...	Data	IOPS ...	Data ...IOPS.	Cycle	Data Status	Transfer Status	CRC
4	0x8892	2	1..	1		1 ...		1..	2	1	1	4

9.4 Return of Submodule Alarm

By the measuring system a so-called "Return-of-Submodule-Alarm" is reported if

- the measuring system for a specific input element can provide valid data again and in which it is not necessary to execute a new parameterization
- or if an output element can process the received data again.

In this case the status for the measuring system (submodule) IOPS/IOCS changes from the condition "BAD" to "GOOD".

9.5 Information & Maintenance

9.5.1 I&M0, 0xAFF0

The measuring system supports the I&M-Function **"I&M0 RECORD"** (60 byte), like PROFIBUS "Profile Guidelines Part 1".
I&M-Functions specify the way how the device specific data, like a nameplate, must be created in a device.

The I&M record can be read with an acyclic read service.
The record index is 0xAFF0, the read service is sent to module 1 / submodule 1.

The received 60 bytes have the following contents:

Contents	Number of bytes
Manufacturer specific (block header type 0x20)	6
Manufacturer_ID	2
Order-No.	20
Serial-No.	16
Hardware revision	2
Software revision	4
Revision state	2
Profile-ID	2
Profile-specific type	2
I&M version	2
I&M support	2

9.6 Behavior of the measuring system outputs

Condition	Safety-related data	NON-Safety-related data
IOPS = BAD	Values are set to 0	Values are set to 0
Disconnection (abort)	Values are set to 0	Values are set to the last value before the connection was interrupted
Supply Voltage ON	Values are initialized to 0	Values are initialized to 0

10 Checklist, part 2 of 2

We recommend that you print out and work through the checklist for commissioning, replacing the measuring system and when changing the parameterization of a previously accepted system and store it as part of the overall system documentation.

Documentation reason	Date	Edited	Checked

Sub-item	To note	Can be found under	yes
Present user manual has been read and understood	–	Document no.: TR-ECE-BA-GB-0095	☐
Check that the measuring system can be used for the present automation task on the basis of the specified safety requirements	• Safety functions of the fail-safe processing unit • Compliance with all technical data	• Chapter Safety functions of the fail-safe processing unit, Page 14 • Chapter Technical Data, Page 15	☐
Requirement for the power supply	• The power supply used must meet the requirements of SELV/PELV (IEC 60364-4-41:2005)	• Chapter Supply voltage, Page 21	☐
Correct PROFINET installation	• Observance of the international standards valid for PROFINET / PROFIsafe or the directives specified by the PROFIBUS User Organization	• Chapter Installation / Preparation for Commissioning, Page 18 • Chapter Commissioning, page 28	☐
System test after commissioning and parameter changes	• During commissioning and after each parameter change all affected safety functions must be checked	• Chapter Parameterization, Page 41	☐
Preset Adjustment Function	• The preset adjustment function may only be executed when the affected axis is stationary • It must be ensured that the preset adjustment function cannot be inadvertently triggered • After execution of the preset adjustment function the new position must be checked before restarting	• Chapter Preset Adjustment Function, Page 47	☐
Device replacement	• It must be ensured that the new device corresponds to the replaced device • All affected safety functions must be checked	• Safety Manual (checklist part 1 of 2) • Chapter Parameterization, Page 41	☐

11 Appendix

11.1 TÜV certificate

Download
- www.tr-electronic.de/f/TR-ECE-TI-DGB-0297

11.2 PROFINET IO certificates

Download
- CD_75: www.tr-electronic.de/f/TR-ECE-TI-GB-0217
- AD_88: www.tr-electronic.de/f/TR-ECE-TI-GB-0290

11.3 PROFIsafe certificates

Download
- CD_75: www.tr-electronic.de/f/TR-ECE-TI-GB-0218
- AD_88: www.tr-electronic.de/f/TR-ECE-TI-GB-0291

11.4 EU Declaration of Conformity

Download
- www.tr-electronic.de/f/TR-ECE-KE-DGB-0337

11.5 Drawings

see subsequent pages

Download
- www.tr-electronic.de/f/04-CDV75M-M0011
- www.tr-electronic.de/f/04-CDH75M-M0005