PROFIsafe
User manual
CRD/S2

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1. Safety instructions

1.1 Scope of validity

This user manual applies exclusively to the following rotary encoders with PROFIsafe interface:

- CRDxx-xxxxRxxxxS2Zxx

1.2 Documentation

The following documents must be noted:

- The owner's system-specific operating instructions
- This user manual
- Data sheet number CRD 11947
- The pin assignment enclosed with the device
- Installation instruction TZY 10206 enclosed with the device

1.3 Proper use

TWK-ELEKTRONIK GmbH's rotary encoders and linear transducers are used to record rotary and linear positions, and make their measured values available as an electric output signal. As part of a system, they must be connected to the downstream electronics and must only be used for this purpose.

1.4 Commissioning

- The relevant device must only be set up and operated using this document and the documentation specified in point 1.2.
- Protect the device against mechanical damage during installation and operation.
- The device must only be commissioned and set up by a specialist electrician.
- Do not operate the device outside of the limit values which are specified in the data sheet.
- Check all electrical connections before commissioning the system.

2. General information on the CRD/S absolute encoder with SIL2 according to IEC 61508

Due to the general spread of the PROFIBUS DP /4/ field bus, only the PROFIsafe-specific extensions are dealt with in this manual. Fundamental and more extensive information on the PROFIBUS DP field bus and PROFIsafe can be obtained from the PNO user organisation (www.profibus.com).

The CRD PROFIsafe absolute encoders are designed for direct connection to the PROFIsafe as slave subscribers in accordance with the PROFIsafe Profile for Safety Technology according to No. 3.092 or 3.192 (PNO) /1/. The encoder protocol is structured in accordance with the PROFIBUS Profile for Encoders according to No. 3.062 (PNO) /2/.

PROFIBUS-DP according to IEC61158-3 is used as the data transmission medium. The encoder profile is defined in PNO 3.062. Communication is equipped with a ProfiSafe interface developed by Siemens.

All example applications refer to the SIMATIC S7 with distributed safety version 5.4.

The parameter data for the absolute encoder with PROFIsafe are described in a GSD file. This GSD file has been created separately and can only be applied for CRD/S2.

The CRD/S2 absolute encoder is a sensor for measuring the angular position of a rotating shaft and for determining the number of revolutions which have been carried out. Measurement of the angular speed also takes place.

The sensor scans a coding disk with the aid of a special opto chip as the dimensional embodiment of the angular position. Ascertainment of the number of revolutions which have been carried out is implemented via an electrically scanned, mechanical transmission.

The measured speed value is determined via the cyclically read-in position data. The dimension is digits per 10 ms with a resolution of 12 bits. The speed measurement resolution is independent of the single turn resolution.

The following parameters can be programmed:

Resolution:	2 to 4096 (8192) steps per revolution
Total measuring steps:	2 to 16,777,216 (33,554,432) steps
Code sense:	CW/CCW
Scaling:	Encoder programming via the bus can be activated or deactivated using a flag (scaling).

The following monitoring functions are implemented for safety-relevant use:

1. Monitoring of the controller function (memory test and CRC parameter test)
2. Programme sequence monitoring (implementation of inverse functions for the safety-critical programme functions).
3. Monitoring of the single turn position via movement detection in which impulses are generated from the position changes.
4. Monitoring of the revolution counter via parallel counting of the single turn zero transitions and comparison with multi-turn scanning.
5. Clock pulse and timer monitoring via a redundant clock pulse generator.
6. Functional monitoring of the FPGAs used to determine the position via a toggle bit which is triggered in the event of controller access.
7. Overvoltage and undervoltage monitoring.
8. Current monitoring for the position-determining light emitting diodes.
9. Supply current overcurrent protection.

In deviation from profile definition PNO 3.062, the encoder with Profisafe only has class 2 functionality. The definitions of the error statuses, which are displayed in the „Manufacturer-specific diagnosis“ diagnostic object, Octet 60-63, also deviate from the above mentioned profile

3. Specifications for meeting the safety standard

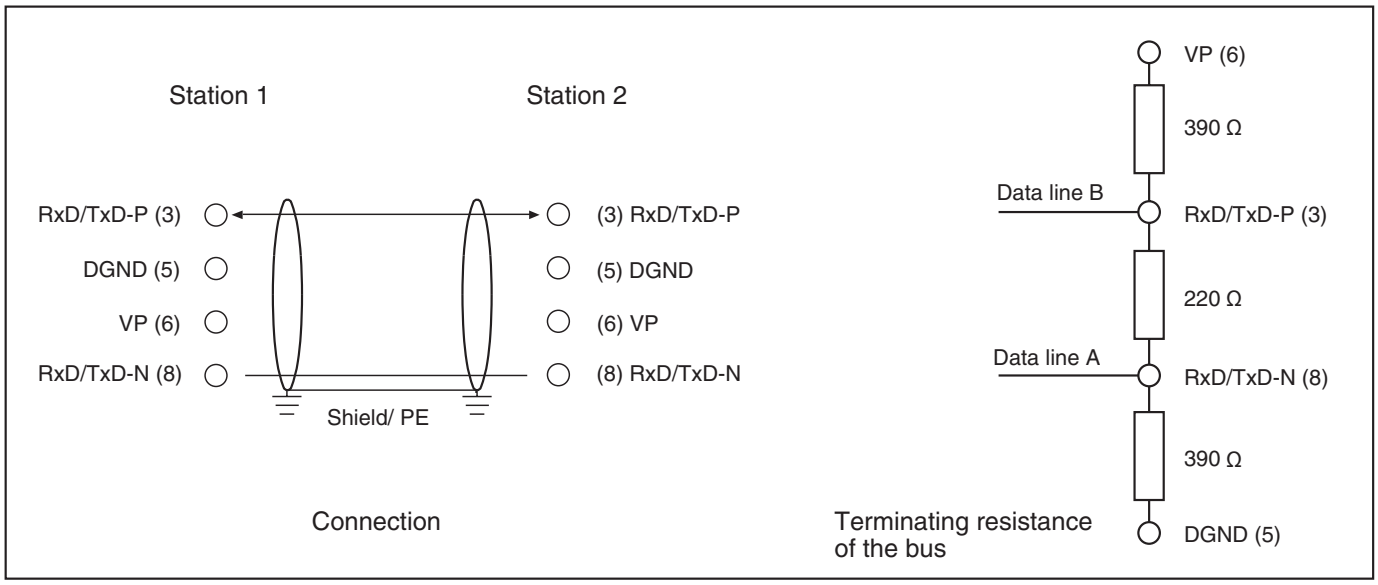
1. Observance of data sheet CRD11947 and the CRD11948 manual.
2. Maximum permissible rotational speed for applications with SIL2 classification 1000 rpm.
3. Use of an evaluation unit which supports the Profisafe protocol.
4. Evaluation of the F status and the encoder-specific diagnostic data.
5. Connection of a profibus cable in compliance with the standards /3/,/8/.

4. Installation instructions for PROFIsafe

Fundamental characteristics of the transmission technology (RS 485)

- Network topology: Linear bus, terminating resistors for bus termination
  Stub lines are only permissible with baud rates < 1.5 MBit/s
- Line: Shielded, twisted pair cable
- Number of stations: 32 stations in each segment without repeaters
  Can be extended to 126 with repeaters.

Wiring and bus termination for PROFIBUS-DP (note: 9-pin sub-D connector)



Transmission length depending on transmission speed for cable type A							
Baud rate [kBaud]	9.6	19.2	93.75	187.5	500	1500	12,000
Transmission length [m]	1200	1200	1200	1000	400	200	100

Cable type A specifications:

Characteristic impedance:	135...165 Ω
Capacitance per unit length coating:	< 30 pF/m
Loop resistance:	110 Ω/km
Core diameter:	0.64 mm
Core cross-section:	> 0.34 mm²

Also see: Installation Guideline for PROFIBUS -FMS/DP (Nr. 2.111/2.112 - PNO) /3/
and Profibus Installation Guideline (Nr. 8.021) /8/

Installation of the absolute encoder with connecting cap

The connecting cap for triple connection technology is a T coupler which is installed in the PROFIBUS. The connecting cap must be mounted on the absolute encoder in de-energised condition.

There are three cable glands, which are sub-divided as follows:

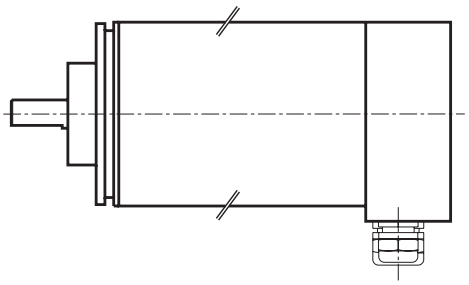
- M12x1.5: Voltage supply for the absolute encoder (24 VDC)
- M16x1.5: Bus in (receive/transmit data A,B)
- M16x1.5: Bus out (receive/transmit data A‘,B‘)

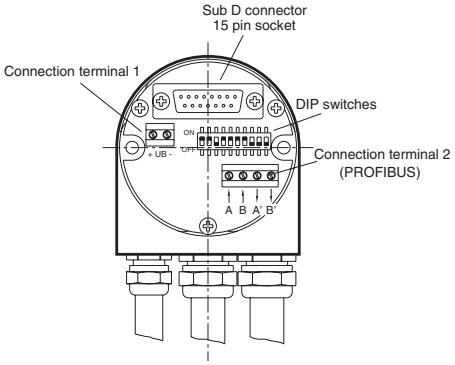
The absolute encoder is connected via the 15-pin SUB-D connector. In the event of an error, the encoder can be replaced without time-consuming installation. The connecting cap is disconnected from the absolute encoder by unscrewing 2 fastening screws. (Note: O-ring seal)

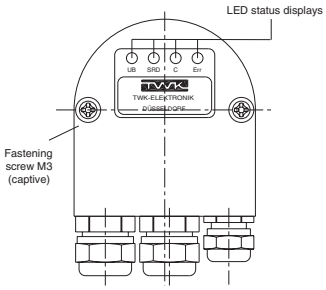
The station/subscriber address is set via the DIP switches in the connecting cap. The address range lies between 1 and 126 (default address: 123).

Attention! The profibus address in the connecting cap must correspond to the F parameter „F_Dest_Add“ (see Chapter 8.2)**.**

The terminating resistors are set via the 10-fold DIP switch (9,10) in the connecting cap; if necessary, these can be activated as line termination.

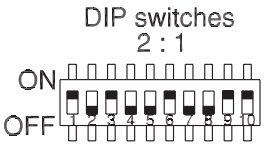






DIP switches - address setting/terminating resistors

Switch	1	2	3	4	5	6	7	8	9	10
ON = 1	LSB						MSB	n.c.	Terminating resistors: On	
OFF = 0	Address can be set from 1- 126 (Default address: 123)								Terminating resistors: Off	



Status LEDs

UB – operating voltage	**UB**
SRD – data transfer	**SRD**
C - class 2	**C**
Error message	**Err**

Description of error types see Chapter 5.

5. Monitoring functions for safety-relevant use

The additionally implemented error types for achieving safety level SIL2 according to IEC 61508 are described in the following. For implementation purposes, extensive modifications have been carried out to the hardware and software in comparison with the basic CRD model absolute encoder with PROFIBUS interface.

Error output is carried out via the connecting cap's LEDs, via the profibus diagnostic data (standard and manufacturer-specific diagnosis) (see Chapter 9.2) and via the F status. The bits which are set in the profibus diagnostic data and in the F status are specified in the "Reaction" column.

5.1 Error type overview table

Error	Cause of error	Reaction	LEDs*			
			UB	SRD	C	Err
Position	Single turn array illumination faulty	EXT_Diag Flag = 1 Manufacturer Diag: PositionError F_Status: Device_Fault = 1 FV_activated = 1	on	off	off	on
	Impermissible difference between movement detection and position					
	Difference between multi-turn counter (software) and multi-turn scanning					
	Overvoltage at the supply input					
Speed	Impermissible difference between timer controller and external timer	EXT_Diag Flag = 1 Manufacturer Diag: SpeedError F_Status: Device_Fault = 1 FV_activated = 1	on	off	off	on
MSA	Toggle bit error FPGA	EXT_Diag Flag = 1 Manufacturer Diag: MSAError F_Status: Device_Fault = 1 FV_activated = 1	on	off	off	on
Parameter	Error in parameter message	EXT_Diag Flag = 1 Manufacturer Diag: ScalingError Diag.Prm_Fault = 1 Diag.Station_Not_Ready = 1	on	off	on	on
	Error in the standard parameters					
F parameter	Error in the parameter message	Manufacturer Diag: F Parameter	on	off/ on	off/ on	on
	F parameter faulty					
F parameter CRC	CRC error in the F parameters	Manufacturer Diag: F Parameter CRC	on	off/ on	off/ on	on
Configuration	Master and slave configurations differ	Diag.Cfg_Fault = 1	on	on	off	on
Preset	Incorrect preset value	EXT_Diag Flag = 1 Manufacturer Diag: PresetError F_Status: FV_activated = 1	on	off	off	on
Internal	Incorrect programme sequence	Stop controller	LED: Flashing code 1			
	CRC Error ROM	Stop controller	LED: Flashing code 2			
	RAM/XRAM Error	Stop controller	LED: Flashing code 3			
	Initialization sensor	Stop controller	LED: Flashing code 4			
	CRC EEPROM	Stop controller	LED: Flashing code 5			
	Error in the sensor, parameter access has failed	Stop controller	LED: Flashing code 6			
	Connecting cap expander error	Stop controller	LED: Flashing code 7			
*UB – operating voltage, SRD – data transfer, C - class 2, Err – error message						

5.2 Description of error types

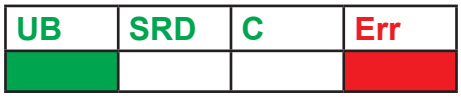
5.2.1 Position

The position and speed data cannot be used.
Causes:

- Single turn monitoring scanning error
- Error in the transmission diode unit
- Difference between multi-turn scanning and multi-turn counter
- FPGA error
- Overvoltage at the supply voltage input
- Rotational speed too high

Actions:

- Device_Fault = 1
- FV_activated = 1
- ExtDiag Flag = 1
- Manufacturer-specific diagnosis = position error (see Octet 60-63)
- Light emitting diodes: Error on
  SRD off
  Class off



Remedy:

- Reduce the rotational speed to below the maximum value specified in the data sheet.
- Check the supply voltage. This must lie within the limits specified in the data sheet.

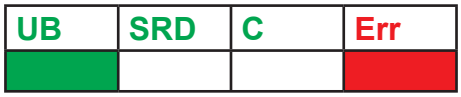
5.2.2 Speed

The position data are OK. Speed measurement is defective.
Causes:

- Impermissible difference between controller timer and external timer

Actions:

- Device_Fault = 1
- FV_activated = 1
- ExtDiag Flag = 1
- Manufacturer-specific diagnosis = speed error (see Octet 60-63)
- Light emitting diodes: Error on
  SRD off
  Class off



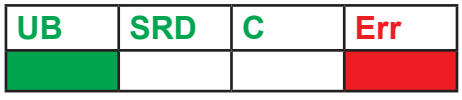
5.2.3 MSA

The position and speed data are presumably incorrect. The Multi-turn Single turn Array (MSA) is defective.
Causes:

- Toggle flag does not function correctly

Actions:

- Device_Fault = 1
- FV_activated = 1
- ExtDiag Flag = 1
- Manufacturer-specific diagnosis = MSA error (see Octet 60-63)
- Light emitting diodes: Error on
  SRD off
  Class off



5.2.4 Parameters

The encoder does not start up.
Causes:
- Error in standard parameter parameterisation

Actions:
- ExtDiag Flag = 1
- Manufacturer-specific diagnosis = scaling error (see Octet 63-66)
- Light emitting diodes: Error on
  SRD off
  Class on

UB	SRD	C	Err

Remedy:
- Set permissible values for the standard parameters.

5.2.5 F parameters

The encoder achieves data exchange status if no further error is present.
Causes:
- The transferred F parameters are faulty

Actions:
- Manufacturer-specific diagnosis = F parameter error (see Octet 60-63)
- Light emitting diodes: Error on
  SRD off/on
  Class off/on

UB	SRD	C	Err

Remedy:
- Set permissible values for the F parameters. A typical error is an incorrect slave address (F_Dest_Add)

5.2.6 F parameter CRC

The encoder achieves data exchange status if no further error is present.
Causes:
- The transferred F parameter checksum (CRC1) is incorrect

Actions:
- Manufacturer-specific diagnosis = F parameter CRC error (see Octet 60-63)
- Light emitting diodes: Error on
  SRD off/on
  Class off/on

UB	SRD	C	Err

5.2.7 Configuration

The encoder does not start up.
Causes:
- Difference between master configuration and slave configuration.

Actions:
- Light-emitting diodes: Error on
  SRD off/on
  Class off/on

UB	SRD	C	Err

Remedy:
- Transfer a correct configuration message (see Chapter 7)

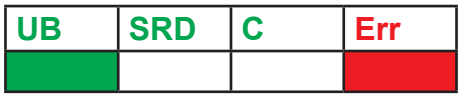
5.2.8 Preset

The encoder is fully operable.
Causes:

- The preset value lies outside of the set total measuring steps
- The scaling flag in the operating mode byte is deactivated.

Actions:

- FV_activated = 1
- Manufacturer-specific diagnosis = preset value error (see Octet 60-63)
- Light emitting diodes: Error on
  SRD off
  Class off



Remedy:

- Transfer a pre-set value which lies between 0 and the total measuring steps -1.
- Before setting the pre-set value, the "scaling function" bit must be set to "enable". (see Chapter 6.4)

5.2.9 Error

The micro-controller of the encoder stops all actions. A flashing code for the cause of the error is output.

LED: Flashing code	Error cause	Number of flashes (Period approx. 1 s)
Flashing code 1	Programme sequence error	1
Flashing code 2	CRC Error ROM	2
Flashing code 3	RAM/XRAM memory error	3
Flashing code 4	Sensor initialisation error	4
Flashing code 5	EEPROM memory error	5
Flashing code 6	Parameter access has failed	6
Flashing code 7	Connecting cap expander error	7

Remedy:

- Please send the device for repair back to TWK.

6. Data exchange function (DDLM_Data_Exchange)

Input data are data which are transmitted from the slave subscribers to the master (actual position value -> master). Reference value control (see below) is listed here as an example of output data; in this case, the master transmits data to the slave (absolute encoder).

6.1 Data format of I/O data

Input data: Slave to host

Octet 1	Octet 2	Octet 3	Octet 4	Octet 5	Octet 6	Octet 7	Octet 8	Octet 9	Octet 10
MSB	Position Data		LSB	MSB Speed	LSB	F-Data			

Definition of F-Data can be found in /1/.

Output data: Host to slave

Octet 1	Octet 2	Octet 3	Octet 4	Octet 5	Octet 6	Octet 7	Octet 8	Octet 9	Octet 10
MSB*	Preset Value		LSB	MSB Dummy	LSB	F-Data			

* Preset control via bit 31: 1/0

6.2 Positions data

The position value is output as a 32-bit unsigned integer value in Motorola format (Big-Endian).

Octet 1								Octet 2								Octet 3								Octet 4							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	25 Bit Position Data CRDxx-8192R4096S2Zxx																								
0	0	0	0	0	0	0	0	24 Bit Position Data CRDxx-4096R4096S2Zxx																							

6.3 Speed

The speed value is determined via the cyclically read-in of the position data. In the standard version, the dimension is steps per 10 ms. The speed measurement resolution is independent of the resolution set for the position value (resolution parameter). It is always based on a resolution of 4096 steps per revolution.

The steps/10 ms unit can be converted to rpm as follows:

$$u = \frac{v\ [\text{steps/10ms}] \times 6000}{4096\ \text{steps}}$$

v = speed in steps/10ms
u = speed in rpm

The speed value is output as a 16-bit signed integer value in Motorola format (Big-Endian). The following applies to the prefix:

Clockwise direction of rotation* (cw)	positive
Counter-clockwise direction of rotation* (ccw)	negative

This is independent of the code direction set for the position value (code sequence parameter)

Octet 5								Octet 6							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Speed															

*Viewing direction towards the shaft

6.4 Set reference value (preset)

The set reference value function should only be carried out when the absolute encoder shaft is stationary!

In order to compare machine position values and the absolute position of the absolute encoder, setting the reference value is unavoidable in certain cases. The reference value is the position value which is displayed in the reference point. The user must note the fact that the reference value must lie within the range 0 to (total measuring steps - 1). In particular, this must be taken into consideration when changing the total measuring steps. The reference value is transferred in data exchange mode by setting bit 31/octet 3.

The reference value can only be set when scaling is activated (see Chapter 8.1)**!**

Octet 1								Octet 2								Octet 3								Octet 4							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0/1	0	0	0	0	0	0	25 Bit Preset Value CRDxx-8192R4096S2Zxx																								
0/1	0	0	0	0	0	0	0	24 Bit Preset Value CRDxx-4096R4096S2Zxx																							

After receiving this message, an offset value (from the current actual position value and the reference value) is calculated by the encoder. If the output actual position value is identical to the reference value, bit 31/octet 1 can be reset by the master, as preset mode is terminated. The timing diagrams are specified in a separate TY sheet. After bit 31 has been reset, the absolute encoder operates in „normal operating mode“.

On inputting a faulty preset value, control bit 31 must be set to zero before inputting the correct preset value in order to rectify the error. After setting control bit 31 to 1, the preset value can then be set again.

7. Configuration (DDLM_Chk_Cfg)

Only Class 2 encoders are supported. Class 2 - devices are programmable via the Profibus (set reference value (preset)). The data format is: 10 byte input data and 10 byte output data. The identification is: 0xC8,0x89,0x89,0x03,0x03 ,0x03,0xA,0x03,0x03,0x03,0x0A.

Configuration function (DDLM_Chk_Cfg)			
Selection	**Identifier byte**	**Data**	**Data format**
Class 2	0xC8,0x89,0x89,0x03,0x03,0x03, 0xA,0x03,0x03,0x03,0x0A	10 Byte Input data	**Encoder position** Octet 1/Bit 7: MSB Octet 4/Bit 0: LSB
			Velocity signal Octet 5/Bit 7 MSB Octet 6/ Bit 0: LSB
			F-Data Octet 7-Octet 10
		10 Byte Output data	**Preset value** Octet 1/Bit 7: Preset Control Octet 1/Bit 0: MSB Octet 4/ Bit 0: LSB
			Dummy Octet 5/Bit 7: MSB Octet 6/Bit 0: LSB
			F-Data Octet 7-Octet 10

8. Programming parameters for absolute encoders with PROFIsafe (DDLM_Set_Prm)

The parameterisation data are sub-divided into standard parameters (bus-specific parameters and manufacturer-specific parameters) and the F parameters.

Octet 1-7	Standard parameters	Bus-specific parameters
Octet 8-29		Encoder-specific parameters
Octet 0-13	F-parameters	

8.1 Standard parameters

8.1.1 Bus-specific parameters

Octet	Data type	Description	Default
1	BYTE	Station status	-
2	BYTE	WD_Fact_1	-
3	BYTE	WD_Fact_2	-
4	BYTE	Min. Station Delay Responder (min T_{SDR})	-
5/6	WORD	Ident_Number	0x1962
7	BYTE	Group_Ident	0

The definition of the bus-specific parameters can be found in /4/

8.1.2 Encoder parameters

8.1.2.1 Overview

Octet	Data type	Description	Default
8	BYTE	Reserved	0
9	BYTE	Operating mode	0x08
10 - 13	LONG	Single turn resolution	4096 (8192)
14 - 17	LONG	Total measuring steps	16.777.216 (33.554.432)
18 - 25	STRING	Reserved for profile	0
26 - 29	LONG	Reserved for manufacturer	0

The values in brackets represent the rotary encoders with 25-bit total measuring steps (CRDxx-8192R4096S2Zxx).

8.1.2.2 Description of encoder parameters

Octet 11: Operating mode				
Bit Nr.	**Parameter**	**Range of values**	**Default**	**Description**
0	Code sequence	0: clockwise (cw) 1: counter clockwise (ccw)	clockwise (cw)	Ascending values on rotation clockwise (cw) or counter-clockwise (ccw). (Viewing direction towards the shaft)
1-2	not used			
3	Scaling function status	0: disabled 1: enabled	enabled	Must be set to "enabled" to change the reference value, resolution and total measuring steps.
4-7	not used			

Octet 12 - 31:				
Octet Nr.	**Parameter**	**Range of values**	**Default**	**Description**
12 - 15	Singleturn resolution	1 - 4096 (8192)	4096	To change, the "scaling function status" parameter must be set to "enabled".
16 - 19	Total measuring steps	1 - 16.777.216 (33.554.432)	16.777.216	To change, the "scaling function status" parameter must be set to "enabled".
20 - 27	Reserved for profile			
28 - 31	Reserved for manufacturer			

Note: It must be noted that the calculation of the number of revolutions is carried out in 2n powers internally within the encoder. Regardless of this requirement, the user may programme the desired total measuring steps and the desired resolution in accordance with the application. During calculation, the absolute encoder accesses the next highest 2n power if required. In this case, the values are designated as the actual resolution or as the actual total measuring steps, and are displayed as the output value.

Example:
Desired total measuring steps: 20,480
Desired resolution: 4096

Desired number of resolutions: 5 Internal absolute encoder calculation
Actual total measuring steps: 32,768
Actual resolution: 4096
Calculated number of revolutions: 8

(Note: The above mentioned note must be taken into consideration in the event of irreversible operation. In the example which is described, the position 0 is only achieved after 32,767 steps and not, as desired, after 20,479 steps.)

8.2 F parameters (version 1.30)

8.2.1 Overview

Overview				
	Octet No.	Data type	Description	GSD-file
F_Prm_Block	0	BYTE	Block length	0x0E
	1	BYTE	Command = 0x05	0x05
	2	BYTE	Slot	-
	3	BYTE	Specifier	0x0A
F_Parameter	4	BYTE	F_Prm_Flag1	14
	5	BYTE	F_Prm_Flag2	0
	6-7	WORD	F_Source_Add	-
	8-9	WORD	F_Dest_Add	123
	10-11	WORD	F_WD_Time	2000
End_F_Prm_Block	12-13	WORD	F_Par_CRC (=CRC1)	

8.2.2 Description of encoder parameters

Octet 4: F_Prm_Flag1				
Bit No.	**Parameter name**	**Range of values**	**Default**	**Parameter description**
0	**F_Check_SeqNr**	0 – the sequential No. is not integrated into the CRC 1 – the sequential No. is integrated into the CRC	No check	The parameter determines whether the sequential number (consecutive number) is taken into consideration in CRC calculation of the F useful data message.
1	**F_Check_iPar**	0,1	0	0 – individual CRC3 parameters are not integrated into CRC2 1 - individual CRC3 parameters are integrated into CRC2 CRC1 – F parameter checksum CRC2 – Process data checksum CRC3 – Individual parameter checksum
2-3	**F_SIL**	00b - SIL1 01b - SIL2 10b - SIL3 11b - NO SIL	SIL2 firmly set	SIL 1-3 or No SIL (Safety Integrity Level) according to IEC 61508 (functional safety of safety-related electrical / electronic / programmable electronic systems)
4-5	**F_CRC_Length**	00b - 3 bytes, V2 mode 01b - 2 bytes, V1 mode 10b - 4 bytes, optionally V1/V2 mode 11b	2 bytes CRC	CRC2 check value (from F useful data), V2 mode is not supported
6-7	Not used			

CRC1 – F parameter checksum
CRC2 – Process data checksum
CRC3 – Individual parameter checksum

Octet 5: F_Prm_Flag2				
Bit No.	**Parameter name**	**Range of values**	**Default**	**Parameter description**
0-2	Not used			
3-5	**F_Block_ID**		F host/F slave relationship	Firmly set
6-7	**F_Par_Version**	00b - V1.30 mode 01b - V2 mode 10b 11b	V1.30 mode	Parameter version, V2 mode is not supported

Octet 6-13				
Octet	**Parameter name**	**Range of values**	**Default**	**Parameter description**
6-7	**F_Source_Add**	1 - 65,534		Automatically assigned by the SIMATIC manager
8-9	**F_Dest_Add**	1 - 123	123	Must correspond to the address set in the connecting cap (DIP switches)!
10-11	**F_WD_Time**	1 - 65,534	2000	Monitoring time in the failsafe DP standard slave. Within the monitoring time, a valid, current safety message must be received from the F CPU. (1 – 65,534 ms)
12-13	**F_ParCRC (CRC1)**	0 - 65,535		

9. Diagnostic messages (DDLM_Slave_Diag)

9.1 Diagnostic overview

Diagnostic messages DDLM_Slave_Diag				
Diagnostic octet number	**Diagnostic function**	**Octet**	**Default**	**Remark**
1-6	Standard diagnostic information	01	00hex	
		02	0Chex	Response monitoring activate, bit 2 firmly to 1
		03	00hex	
		04	01hex	Parameterisation via master with address 1
		05-06	1962hex	ID number CRD
Device-related diagnosis				
7	Extended header byte	39hex		57 diagnostic bytes
8	Alarm messages	00hex		Not supported
9	Absolute encoder operating parameters	08hex		CW, scaling on
10	Encoder type	01hex		Absolute multi-turn encoder
11(MSB)-14(LSB)	Resolution	1000hex (2000hex)		4096 (8192) steps/ revolutions
15-16	Measuring range	1000hex		4096 revolutions
17	Additional alarm messages	00hex		None
18-19	Supported alarm messages	0000hex		None
20-21	Warning messages	0000hex		Not supported
22-23	Supported warning messages	0000hex		Not supported
24-25	Profile version	0x0101		
26-27	Software version	xx.xx		
28-31	Operating time	FFFF.FFFFhex		Not supported
32-35	Offset value	0000.0000hex		
36-39	Manufacturer offset value	0000.0000hex		
40 (MSB) - 43 (LSB)	Resolution	0000.1000hex 0000.2000hex		
44(MSB) - 47 (LSB)	Total measuring steps	01.000.000hex 02.000.000hex		
48-57	Serial number	2A2A2A2A2A 2A2A2A2A2Ahex		Not supported
58-59	Reserved	0000hex		
60-63	Manufacturer-specific diagnosis	00000000hex		Defined during run time

9.2 Diagnostic description

Explanations regarding the diagnostic information:

9.2.1 Standard diagnostic information (Octet 1-6)

For a detailed description, see IEC 61158 Type 3 and IEC 61784, PROFIBUS DP Specification /4/ (Note: Octet 5,6: Manufacturer identification: 1962hex)

The manufacturer identification is stored in the PNO and identifies the subscriber as a TWK absolute encoder.

9.2.2 Extended header byte (Octet 7)

The length of the extended diagnostic bytes including the header is specified in the diagnostic header (Octet 7).

(Class 2 absolute encoder: 39hex = 57d

-> 6 (standard diagnosis) + 1 (Octet 7)+ 56 (Octet 8-63) = 63 diagnosis bytes)

9.2.3 Alarm messages (Octet 8)

No alarm messages are output here. All error messages are output in the manufacturer-specific diagnostic range (octets 63-66)

9.2.4 Operating status (Octet 9)

Mirroring of the parameter operating mode

9.2.5 Encoder Typ (Octet 10)

The byte is set firmly to 0x01, i.e. "absolute multiturn encoder"

9.2.6 Resolution (Octet 11-14)

Maximum value for the parameter resolution.

Parameter	Resolution			
Diagnosis Octet	11	12	13	14
Bit	MSB 31-24	23-16	15-8	7-0 LSB

9.2.7 Measuring range (Octet 15, 16)

The maximum possible number of revolutions, specified via the resolution of the multi-turn section. Depiction in hexa-decimal form, e.g. 4096 revolutions = 1000hex.

Parameter	Measuring range	
Diagnosis octet	15	16
Bit	MSB 15-8	7-0

9.2.8 Additional alarm messages (Octet 17)

Not currently assigned.

9.2.9 Supported alarm messages (Octet 18,19)

No alarm messages supported.

9.2.10 Warning messages (Octet 20,21)

These functions are not supported at present.

9.2.11 Supported warnings (Octet 22,23)

These functions are not supported at present.

9.2.12 Profile version (Octet 24,25)

Parameter	Profile version	
Diagnosis Octet	24	25
Definition	Revisionsnummer	Index

Actuel encoder profile version: 1.1.

9.2.13 Software version (Octet 26,27)

Parameter	Software version	
Diagnosis Octet	26	27
Definition	Revisionsnummer	Index

Actual software version, 3.3.

9.2.14 Operating time (Octet 28-31)

This function is not supported at present. The operating time is set to FFFF FFFFhex as default according to the encoder profile.

9.2.15 Offset value (Octet 32-35)

The offset value is the value for the shift in the zero point after setting the preset value.

Parameter	Offset value			
Diagnosis octet	32	33	34	35
Bit	MSB 31-24	23-16	15-8	7-0 LSB

9.2.16 Manufacturer offset value (Octet 36-39)

Not supported at present.

9.2.17 Resolution (Octet 40-43)

The resolution set by parametration.

Parameter	Resolution			
Diagnosis Octet	40	41	42	43
Bit	MSB 31-24	23-16	15-8	7-0 LSB

9.2.18 Total measuring steps (Octet 44-47)

Set total measuring steps incremented to the next highest power of two. In this regard, also see the note under Chapter 8.1.2.2

Parameter	Total measuring steps			
Diagnosis Octet	44	45	46	47
Bit	MSB 31-24	23-16	15-8	7-0 LSB

9.2.19 Serial number (Octet 48-57)

This parameter is not supported at present.

9.2.20 Octet 58,59

Reserved

9.2.21 Manufacturer-specific diagnosis (Octet 60-63)

Overview

Manufacturerspecific diagnosis octet No.	Bit	Error
60	0	F parameter CRC
	1	F parameter
	2-7	Not supported
61	Not used	
62	Not used	
63	0	Scaling
	1	Preset value
	2	Position
	3	Speed
	4	MSA
	5-7	Not supported

A detailed description of the error can be found in Chapter 5!

10. Simatic Step7 with distributed safety

This chapter explains the procedure for integrating the TWK absolute encoder into the profibus of a Siemens S7 control system. The documentation is based on Step 7 with distributed safety version 5.4.

10.1 Integration of the TWK profibus absolute encoder

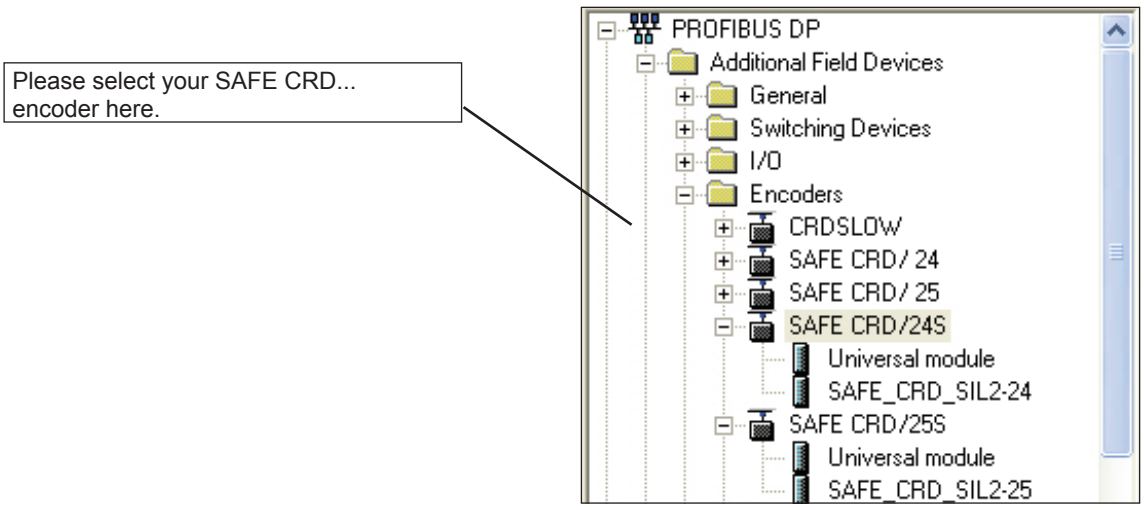
Prerequisites: You have configured your hardware in accordance with the structure of your control system and have installed a profibus sub-network.

10.1.1 Installation of the GSD file

- Close all projects in the hardware configuration.
- Insert the CD-ROM provided by TWK into your drive.
- In the hardware configuration, select Install GSD files under Options.
- Set your CD-ROM drive as the directory and install the GSD file **Safec24s.GSD** for the 24-bit absolute encoder or **Safec25s.GSD** for the 25-bit absolute encoder.
- The absolute encoder symbol is also installed automatically.

10.1.2 Selection of the TWK absolute encoder from the Step7 hardware catalogue

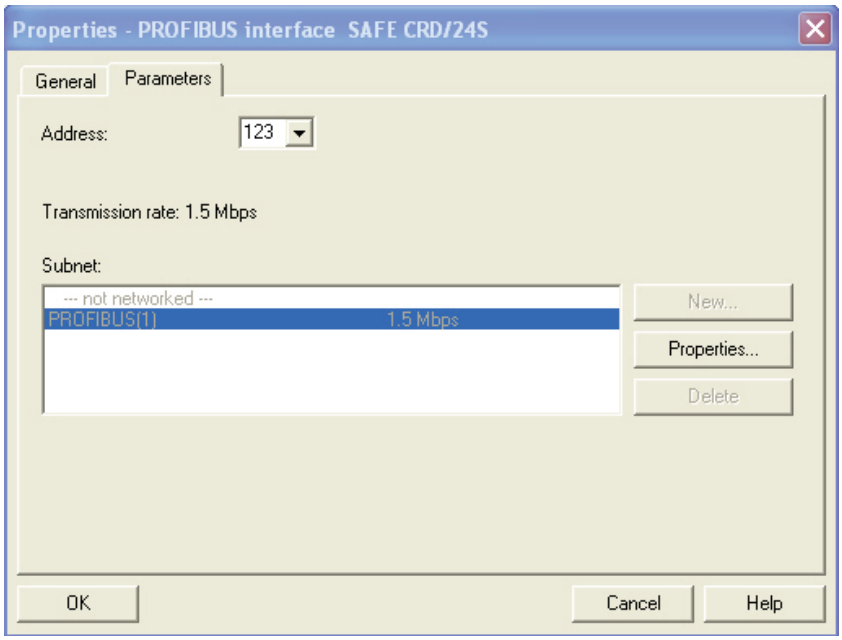
- After opening the hardware catalogue, you will find the encoder Safe CRD/24S or Safe CRD/25S under Profibus-DP, Additional Field Devices, Encoders.
- Now open your project, mark the bus and integrate the absolute encoder into the bus by double-clicking onto the corresponding line of the hardware catalogue.
- After selecting the profibus address (see Chapter 10.1.3), drag the Safe_CRD... module to slot 1 of the module list.



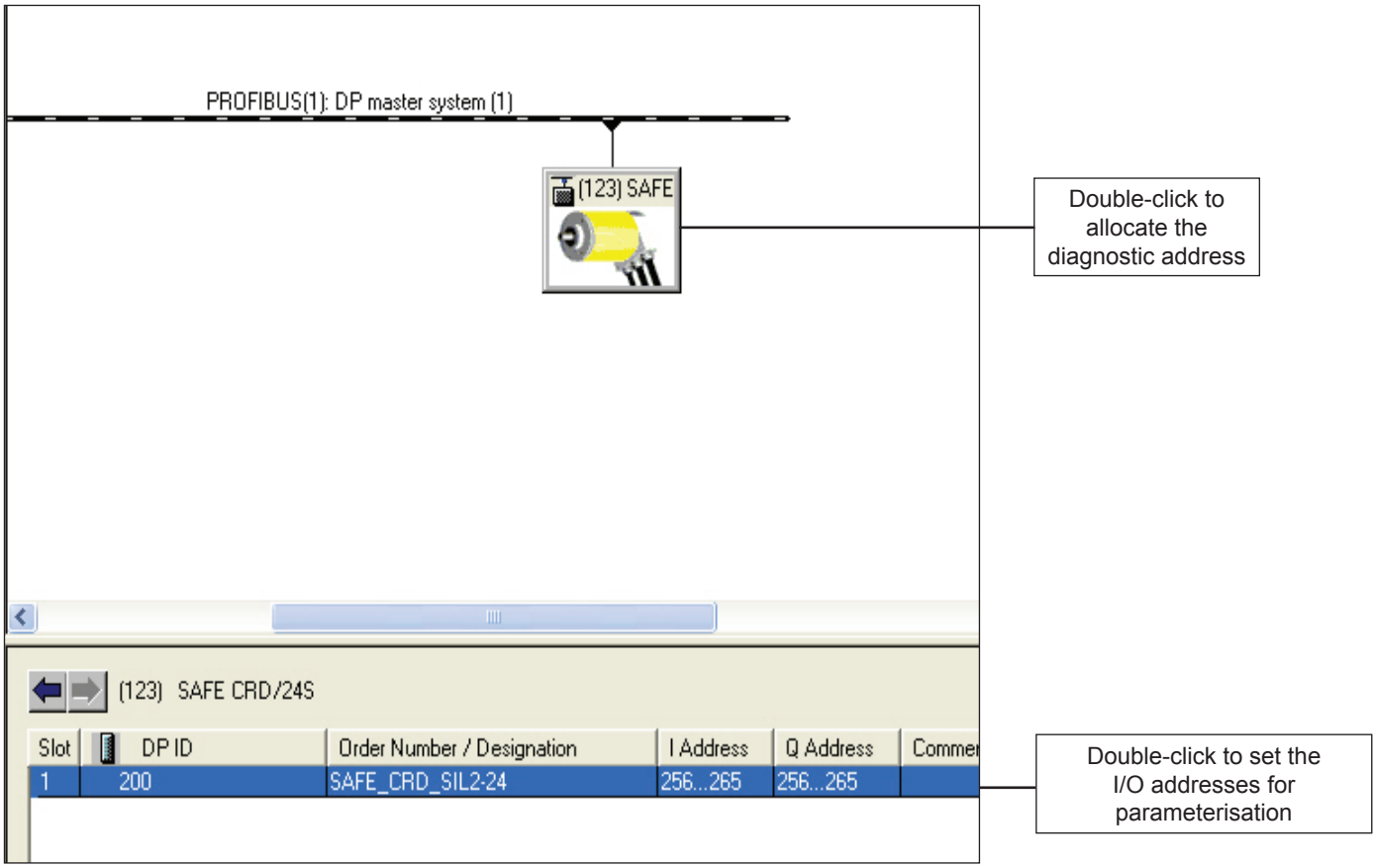
10.1.3 Allocation of the profibus address

Please specify the address set in the connecting cap via the DIP switches here.

In the Subnet field, additionally select your planned profibus and exit the window with OK.



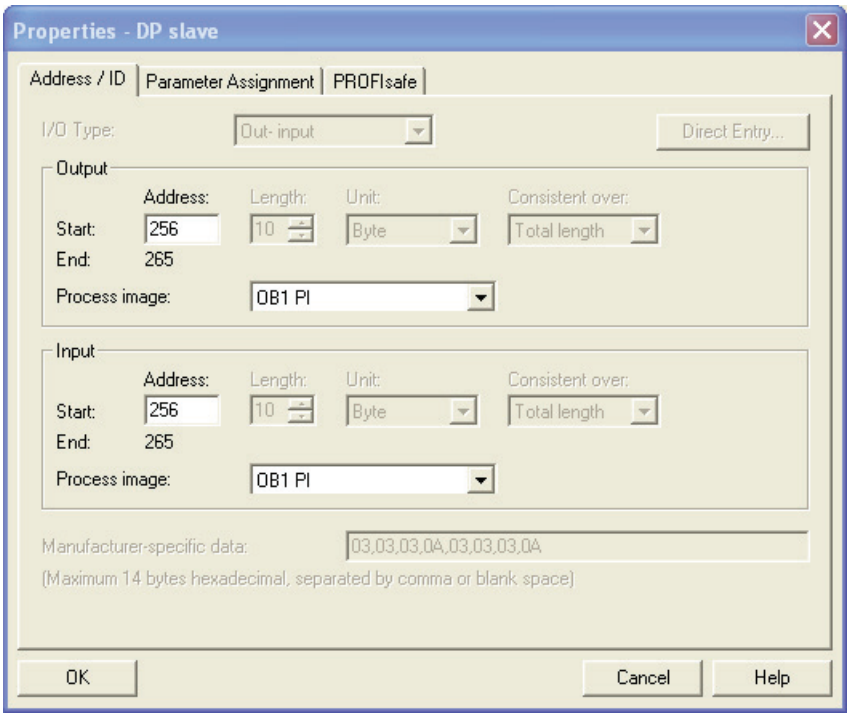
Then drag the **Safe_CRD** ... module to slot 1 of the module list. The absolute encoder should then appear as follows in your project planning.



The **DP ID** value results from the configuration, which is firmly set in the case of the Profisafe absolute encoder. The I/O address values are default values, which vary depending on the control system.

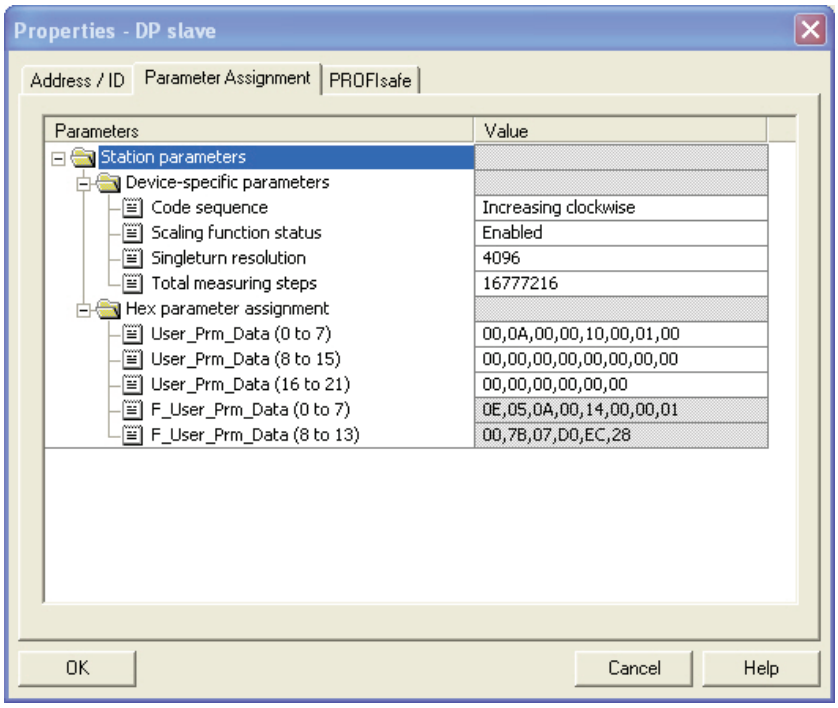
10.1.4 Setting the I/O addresses (S7 addresses)

Double-clicking onto the „Slot 1“ line opens up the Properties – DP slave window with the Address / ID, Parameter Assignment and PROFIsafe registers. The addresses for the absolute encoder, under which this is to be addressed in the S7, must be assigned under output and input in the Address / ID register.



10.1.5 Parameterisation of the absolute encoder

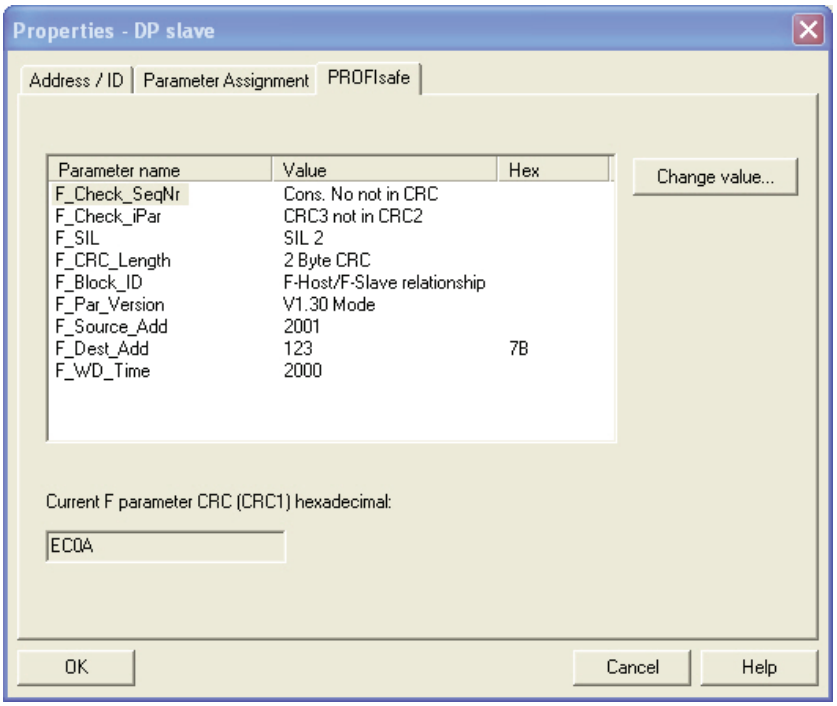
Via the Parameter Assignment register, the following window, in which the characteristics of the absolute encoder can be defined, is accessed. (see Chapter 8.1)



10.1.6 Setting the F paramters

Via the PROFIsafe register, the following window, in which the F parameters can be defined, is accessed.
(see Chapter 8.2)

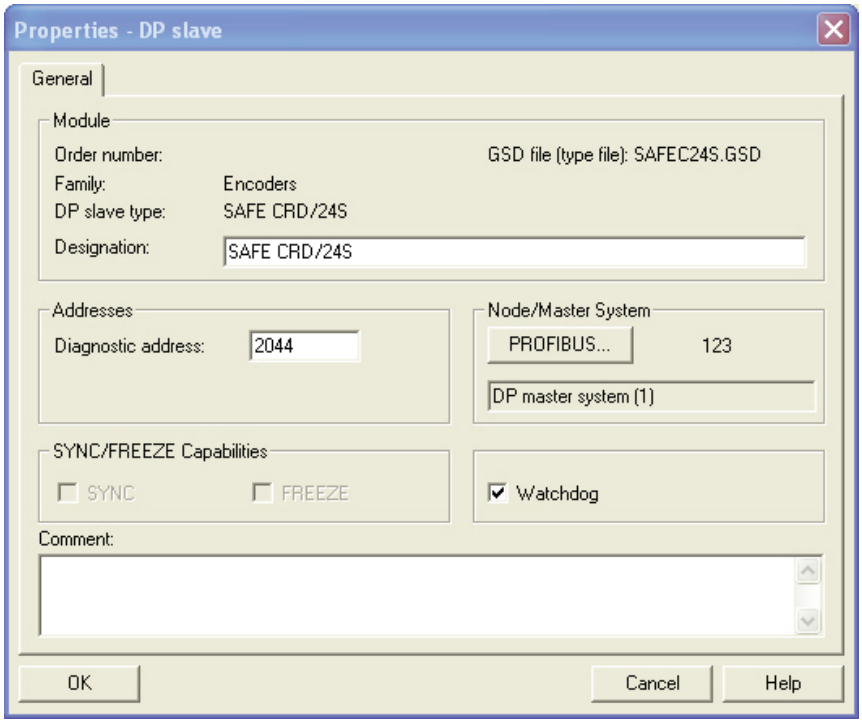
Note: Under certain circumstances, Step7 may show a different default value for F_Dest_Add here. This must be set to the set profibus address!



10.1.7 Setting the diagnostic address

So that the absolute encoder‘s diagnostic area can be accessed within the S7 programme, it is necessary to assign a specific S7 diagnostic address to it. This may lie within the entire periphery area of the control system. It does not therefore occupy any input/output addresses.

The **Properties – DP slave** window with the **General** register appears by double-clicking onto the encoder symbol. You can now set the diagnostic address and confirm it with OK.



10.2 Example programme

The following example shows how to access the position value and the F periphery DB of the Profisafe absolute encoder in the safety programme. Setting a preset value is also demonstrated.

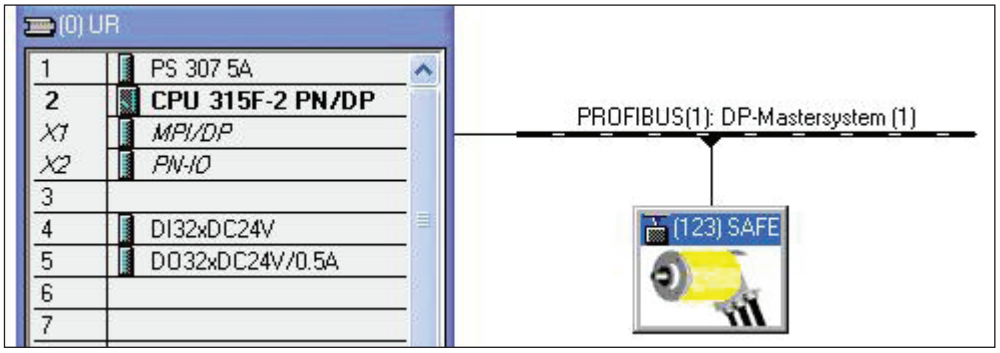
Only the programming steps which refer to the TWK absolute encoder are shown here. Knowledge regarding the programming and sequence of the failsafe S7 programme is assumed. As an introduction to failsafe programming, we recommend „SIMATIC S7 Distributed Safety - Getting Started“ /7/ and „SIMATIC S7 Distributed Safety – Project Planning and Programming“ /6/.

Note: TWK-ELEKTRONIK GmbH does not undertake to provide any guarantee for the error-free function of the example programmes shown here!

Devices required to operate the example programme

- F CPU with profibus interface
- Standard input assembly
- Standard output assembly
- Profisafe CRD absolute encoder
- Step7 as of V5.4 + S7 distributed safety as of version V5.4

Hardware structure of the example programme



Assigned I/O addresses:

Input assembly DI32	Bytes 0...4
Output assembly DO32	Bytes 4...7
Absolute encoder	Bytes 100...109

F periphery DB

On translation of the hardware configuration, an **F periphery DB** is generated for the absolulute encoder, as for each other Profisafe subscriber. In our example, it bears the automatically assigned, symbolic name „F00100_200“.

The F periphery DB enables access to the control and status byte of the profisafe protocol. It has the following appearance:

Address	Declaration	Name	Type	Initial value	Comment
0.0	in	PASS_ON	BOOL	FALSE	1=ACTIVATE PASSIVATION
0.1	in	ACK_NEC	BOOL	TRUE	1=ACKNOWLEDGEMENT NECESSARY
0.2	in	ACK_REI	BOOL	FALSE	1=ACKNOWLEDGEMENT FOR REINTEGRATION
0.3	in	IPAR_EN	BOOL	FALSE	1=ENABLE I-PARAMETER ASSIGNMENT
2.0	out	PASS_OUT	BOOL	TRUE	1=PASSIVATION OUTPUT
2.1	out	QBAD	BOOL	TRUE	1=FAIL-SAFE VALUES ARE OUTPUT
2.2	out	ACK_REQ	BOOL	FALSE	1=ACKNOWLEDGEMENT REQUEST
2.3	out	IPAR_OK	BOOL	FALSE	1=NEW I-PARAMETER VALUES ASSIGNED
3.0	out	DIAG	BYTE	B#16#0	DIAGNOSTIC INFORMATION
4.0	out	QBAD_I_00	BOOL	TRUE	1=FAIL-SAFE VALUE IS OUTPUT AT INPUT CHANNEL 0
4.1	out	QBAD_I_01	BOOL	TRUE	1=FAIL-SAFE VALUE IS OUTPUT AT INPUT CHANNEL 1

In the example programme, the variables „ACK_REQ“ and „ACK_REI“ are used for reintegration and „DIAG“ and „QBAD“ for diagnosis. For a detailed description of the F periphery DB, refer to „SIMATIC S7 Distributed Safety – Project Planning and Programming“ /6/.

Programming

Access to the profisafe absolute encoder is carried out in an F programme module (here FB100), which must be called up in an F call-up module F CALL. Calling the FB100 in the F CALL is not described here.

The preset value and preset bit compilation is contained in a standard module (here OB1). This is carried out here under the prerequisite that setting the preset is not a safety-relevant function.

Note: The decision regarding whether setting the preset value is a safety-relevant function must be made depending on the application.

Important for the fail safe operation of the encoder are: reintegration after communication or F periphery errors, as depicted in FB100 NW1 and NW2, evaluation of the failsafe status as depicted in FB100 NW3 and the evaluation of the diagnostic data, as depicted in OB1 NW4.

Note: Access to the profisafe absolute encoder‘s I/O data in the safety programme is only possible on a word-by-word basis.

Inputs and outputs used in the programme:

E 0.0	Acknowledgement for reintegration
E 0.1	Set preset
EW 100	High word of the encoder position value
EW 102	Low word of the encoder position value
A 4.0	„Acknowledgement required“ display
A 5.0	Failsafe status display
AW 100	High word of the encoder preset value
AW 102	Low word of the encoder preset value

Attention: The OB1 and FB100 modules shown in the following only represent part of the safety programme and only refer to the example structure‘s hardware. The creation of a complete and error-free safety programme is the sole responsibility of the user.

The OB1 and FB100 modules are contained on the supplied CD in the „S7_Bsp“ directory in archive file „TwkBspS2.zip“. The password for the FB100 is „twk“.

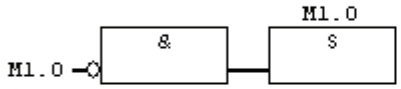
The non-secure signals in the safety programme (FB100 in this case) are shown in red here.

OB1 : "Main Program Sweep (Cycle)"

The preset value is stored in the MD100. This is then read word-by-word in the safety programme (FB100). The safety programme is called by the FC100.

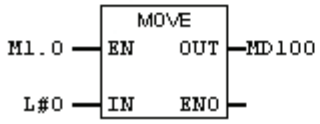
Network 1: Title:

Generate one flag



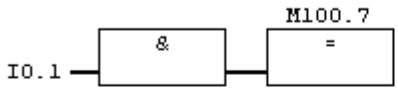
Network 2 : Title:

Write preset value (here 0) to double flag word.



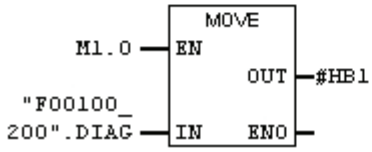
Network 3 : Title:

Set preset bit (highest-value bit in the double flag word) via a push button input



Network 4 : Title:

Display of F error messages (here in help byte 1; in a real system, this should be further processed in the error message system). Polling the DIAG variable in the safety programme is not permissible.
(Meaning of the individual bits in /6/)

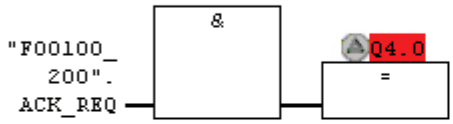


FB100 : TWK CRD absolute encoder with SIL2 as a PROFISAFE subscriber

Acknowledgement, set preset and read out actual value

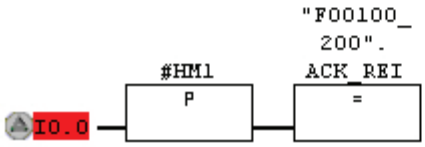
Network 1 : Title:

Display necessary user acknowledgement



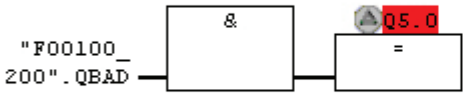
Network 2 : 1=ACKNOWLEDGEMENT FOR REINTEGRATION

Carry out user acknowledgement



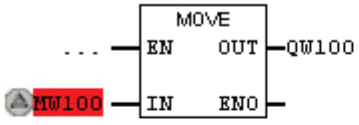
Network 3 : Title:

Polling of the failsafe status of the absolute encoder (Here displayed at Output
5.0). In a real system this bit must be polled to introduce the fail safe state of the system. In case of QBAD = 1 the system has to go in the fail safe state.



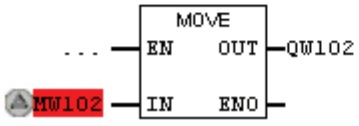
Network 4 : Title:

Write higher-value preset value from OB1 to higher-value output word
(Only word-by-word access is permitted in the safety programme)



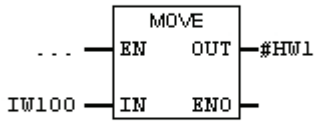
Network 5 : Title:

Write lower-value preset value from OB1 to lower-value output word



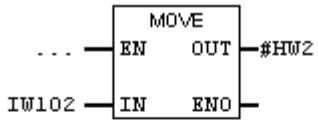
Network 6 : Title:

Display of the higher-value actual position value
(Only word-by-word access is permitted in the safety programme)



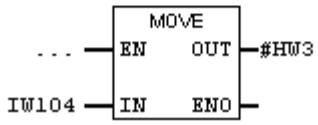
Network 7 : Title:

Display of the lower-value actual position value



Network 8 : Title:

Display of the speed value



FB100 help flag:

	Name	Data Type	Address	Initial Val	Exclusion address	Term
	HM1	Bool	0.0	FALSE	☐	
	HW1	Int	2.0	0	☐	
	HW2	Int	4.0	0	☐	
	HW3	Int	6.0	0	☐	
					☐	

10.3 General notes regarding the PROFIsafe programme

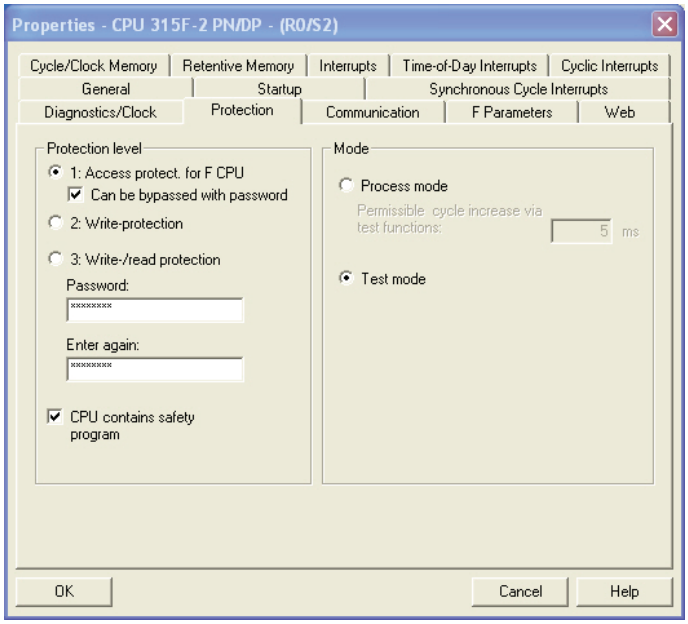
Due to the very complex scope for F programme project planning and programming, reference must be made to the documentation from Siemens at this point.

SIMATIC S7 Distributed Safety – Project Planning and Programming, Programming and Operating Manual (A5E00109536-03) /6/ and SIMATIC S7 Distributed Safety Getting Started /7/.

The sequences required for the PROFIsafe application are listed briefly in the following.

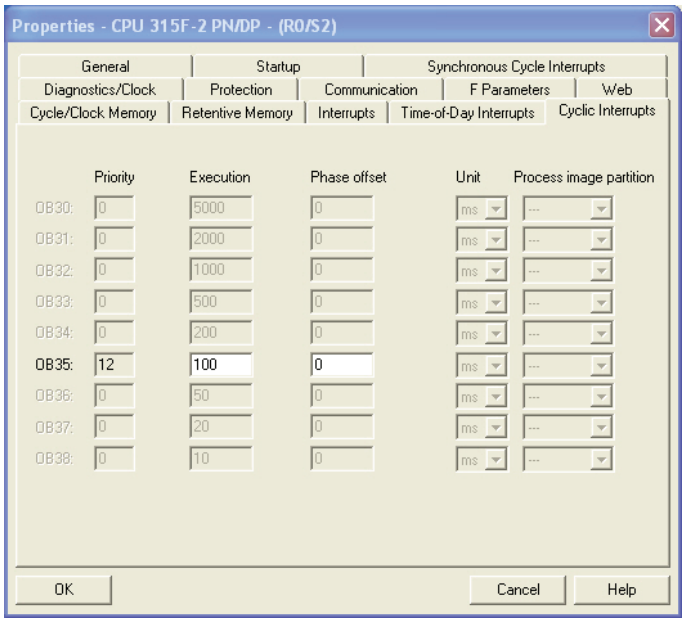
PROFIsafe CPU parameters

Access to the F CPU is protected against unauthorised access via a password prompt.



PROFIsafe OB 35

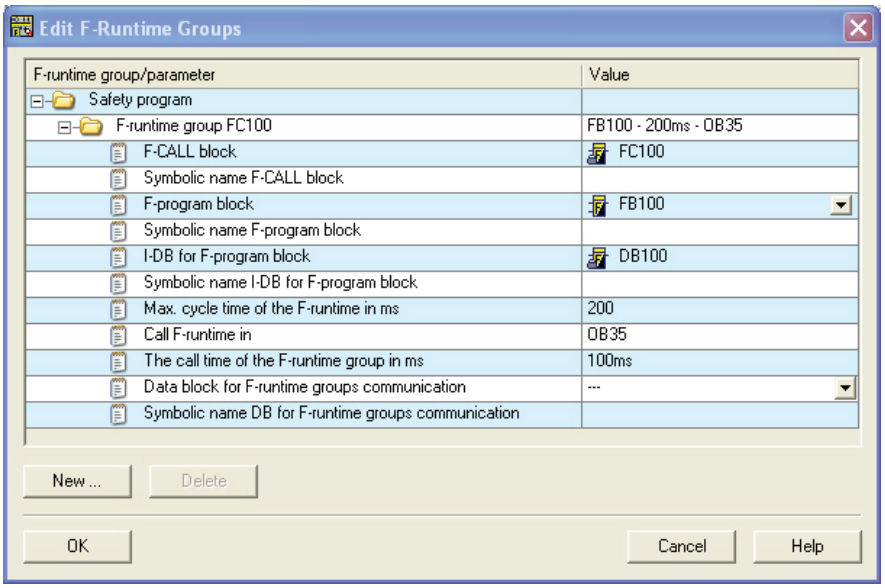
The safety programme is acessed by calling F CALL; this takes place directly in an OB, e.g. OB 35. In a wake-up alarm OB, the safety programme is called up and run through at fixed intervals of time.



Processing the F sequence module

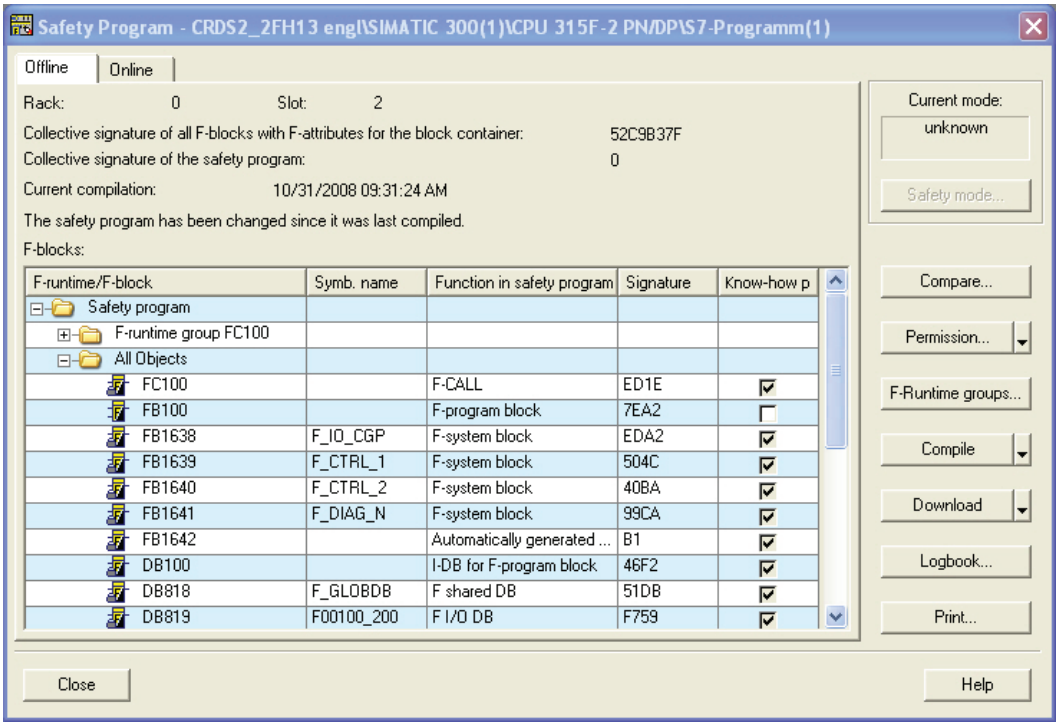
To facilitate handling, a safety programme consists of F sequence modules. These consist of:

- An F call module F CALL
- An F programme module F-PB (this is an F-FB/F-FC, which you assign to the F CALL)
- Poss. further F-FBs/F-FCs
- One or more F-DBs
- F periphery DBs
- F library F modules
- F system modules (F-SBs)
- Automatically generated F modules



Generating and downloading the PROFIsafe programme

Finally, the PROFIsafe programme has to be generated and loaded into the CPU.



11. Scope of delivery

The scope of delivery includes:
- Absolute encoder with PROFIsafe interface
- Pin assignment TY XXXXX (depending on the device variant)
- CD-ROM with GSD file and user manual in PDF format

12. Literature

/1/ PROFIsafe Profile for Safety Technology, Order No. 3.092, PROFIBUS Nutzerorganisation e. V. Haid-und-Neu-Str. 7, D-76131 Karlsruhe, www.profibus.com
PROFIsafe Profile for Safety Technology, Order No. 3.192, PROFIBUS Nutzerorganisation e. V. Haid-und-Neu-Str. 7, D-76131 Karlsruhe, www.profibus.com

/2/ PROFIBUS Profile for Encoders, Order No. 3.062, PROFIBUS Nutzerorganisation e. V. Haid-und-Neu-Str. 7, D-76131 Karlsruhe, www.profibus.com

/3/ Installation Guideline for PROFIBUS DP/FMS, Order No. 2111/ 2.112, PROFIBUS Nutzerorganisation e. V. Haid-und-Neu-Str. 7, D-76131 Karlsruhe, www.profibus.com

/4/ IEC 61158 Type 3 and IEC 61784, PROFIBUS DP Specification

/5/ PROFIsafe - Environmental Requirements related to PROFIsafe - Profile for Safety Technology on PROFI BUS DP and PROFINET IO (IEC 61784-3-3), Order No. 2.232, PROFIBUS Nutzerorganisation e. V. Haid-und-Neu-Str. 7, D-76131 Karlsruhe, www.profibus.com

/6/ SIMATIC S7 Distributed Safety – Project Planning and Programming, Programming and Operating Manual (A5 E00109536-03)

/7/ SIMATIC S7 Distributed Safety Getting Started (A5E00320725-01)

/8/ Profibus Installation Guideline, Order No. 8.021, PROFIBUS Nutzerorganisation e. V. Haid-und-Neu-Str. 7, D-76131 Karlsruhe, www.profibus.com

Appendix A: Absoute encoder terms

Parameter	Explanation
Resolution – steps/360°	The resolution specifies the number of steps per revolution (360°).
Measuring range	The measuring range specifies the maximum number of revolutions. The revolutions must be specified in 2n powers.
Total measuring steps	The total measuring steps arise as follows: Total measuring steps = resolution x measuring range
Code sequence	The code sequence specifies the direction of rotation in which the encoder‘s output code corresponds to ascending values. A distinction is made between the following depending on the direction of rotation: CW - clockwise, clockwise direction of rotation CCW - counter clockwise, anti-clockwise direction of rotation (viewed in the direction of the shaft)
Reference value	The reference value is the value which appears after the preset function as the encoder‘s actual position value. It lies in the range of values from 0 to total measuring steps -1.