User manual

Certificate
Z00358

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Z00359

Structure

1. General

The PROFIBUS is a field bus standard according to EN 50170. The technical and functional characteristics of the field bus system are defined in this standard.

The protocol architecture is based on the OSI reference model, in accordance with the international ISO 7498 standard. Layer 1 (Physical Layer) defines the transmission physics, layer 2 (Data Link Layer) the bus access protocol, and layer 7 (Application Layer) the application functions.

The PROFIBUS is comprised of 3 components, which are used in various applications.

A distinction is made between the following:

1.	PROFIBUS-DP	(Decentralized Periphery)
2.	PROFIBUS-PA	(Process Automation)
3.	PROFIBUS-FMS	(Fieldbus Message Specification)

The PROFIBUS-DP is specially designed for communication between automation systems and decentralized peripheral devices (RS-485 transmission technology or optical fibres), PROFIBUS-PA is specially designed for process technology (areas in which a risk of explosion exists, device data communication and energy supply in accordance with standard IEC 1158-2 integral field device safety and bus supply), and PROFIBUS-FMS for universal communication task solutions at a cell level (bus cycle time < 100 ms, RS-485 transmission technology or optical fibres).

The profile description for encoders contains applications for PROFIBUS-DP. This component is characterised by particularly efficient and rapid data transmission. Layers 1 (Physical Layer) and 2 (Data Link Layer) and the User Interface are used. The Direct Data Link Mapper (DDLM) provides the User Interface with comfortable access to layer 2.

The transmission speed can be selected within the range of 9.6 kBit/s and 12 MBit/s.

In the case of PROFIBUS-DP, data exchange between SPS/PC and the decentralised periphery (e.g. encoder) is carried out in a predominantly cyclical manner. For parameterisation, diagnostic and alarm handling purposes, acyclical communication functions are also required for intelligent field devices. In this case, reference must be made to the DIN 19245 Part 1 and 3 or to the EN 50170 standards.

In the case of PROFIBUS-DP, communication in the data back-up layer (layer 2) is carried out via the SRD (Send and Request Data with Reply) and SDN (Send Data with no Acknowledge) functions.

Mono or multi-master systems may be implemented with PROFIBUS-DP. A maximum of 126 devices (master or slaves) may be connected to one bus. The definition of the system configuration contains the number of stations, the allocation of the station address to the I/O addresses, data consistency of the I/O data, format of the diagnostic messages and the bus parameters which are used.

The parameters of the PROFIBUS subscribers are described in a GSD file (device data sheet). The specifications are executed in accordance with DIN 19245 Part 3 /4/.

This user manual describes the protocol of the TWK encoder as the DP slave subscriber in the PROFIBUS-DP. The SPC 3 is used as the interface module between the encoder electronics and the bus system.
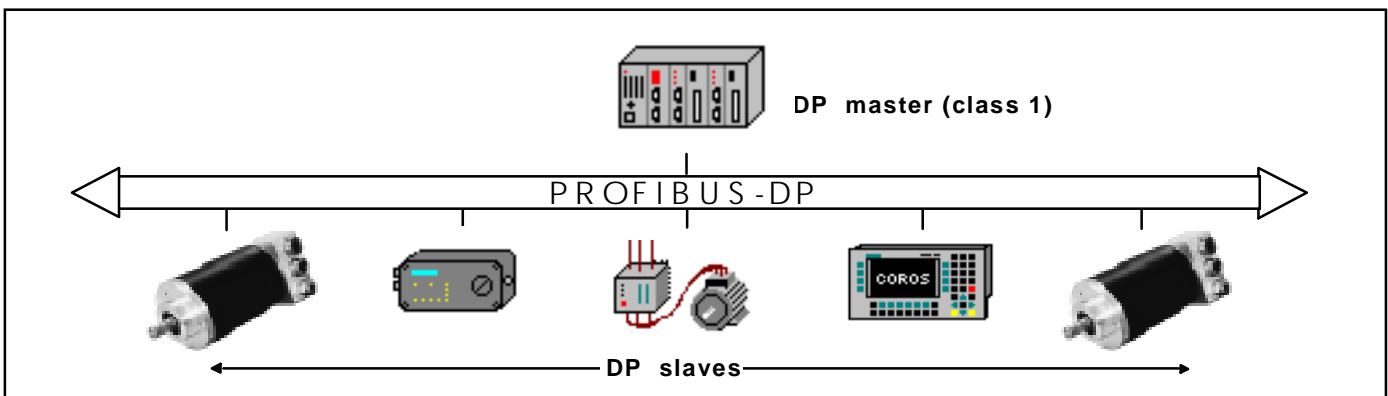
Experience acquired during "rough" everyday use reveals that the following notes are especially important.

Differentiation of the services, and an exact knowledge of these, are especially important for understanding the PROFIBUS-DP philosophy.

A distinction is made between the following in the manual:

☐ Check_Configuration: *Configuration of the encoder*
Integration of the encoder into the network with various data formats,
or as a programmable or non-programmable slave, is possible.
(Example: F1: programmable (32 bit input/output data) multitour encoder

☐ Data_Exchange: *Position data of the encoder*
Cyclical enquiry regarding the encoder position. The position value is depicted as a 16 bit or 32 bit value depending on the configuration.
Setting the preset value

☐ Set_Parameter: *Programming parameters*
Definition of the operating mode of the encoder and definition of the values for single turn resolution and total measuring range in units.

☐ Slave_Diagnosis: Diagnosis of the slave subscriber (encoder)
(also see error handling)

The GSD file enables the simplified handling and commissioning of PROFIBUS subscribers. Following the selection of the configuration, e.g. monotour or multitour encoder, programmable or non-programmable, the operating mode of the encoder (CW/CCW, class 1/2, scaling function or the values for total measuring range in units and number of revolutions) can be selected simply via clicking on. Of course, more exact knowledge is required when inputting hex values for the User_Parameter_Data. This means that the operating mode of the encoder is defined in Octet 9 of the parameter data. Which bit has which meaning is described in detail.

The continuous updating of the enclosed 3.5" diskette is a particular concern of TWK. In addition to example applications, e.g. for commissioning an encoder in the PROFIBUS network under the Step7 system prerequisites, replies are provided for frequently asked questions regarding current usage. An example of this is changing the address of the slave via the Set_Slave_Address service in the case of the plug-version encoders.

2. Installation instructions for PROFIBUS-DP - RS 485

Basic characteristics of RS-485 transmission technology /2/:

☐ Network topology: Linear bus, terminating resistors for bus termination
Stub lines are only permissible in the case of baudrates < 1.5 MBit/s

☐ Lead: Sheathed, twisted pair cable

☐ Number of stations: 32 stations in each segment without repeaters
Can be extended up to 126 with repeaters.

☐ Plug-type connector: Variants implemented in the case of the CRD model series:
Round plug RS 25, 12-pin
Connecting cap,
D-SUB 9-pin or others on request
(pin assignment according to /1/)

Wiring and bus termination for PROFIBUS-DP /2/, (Note: 9-pin Sub-D plug)
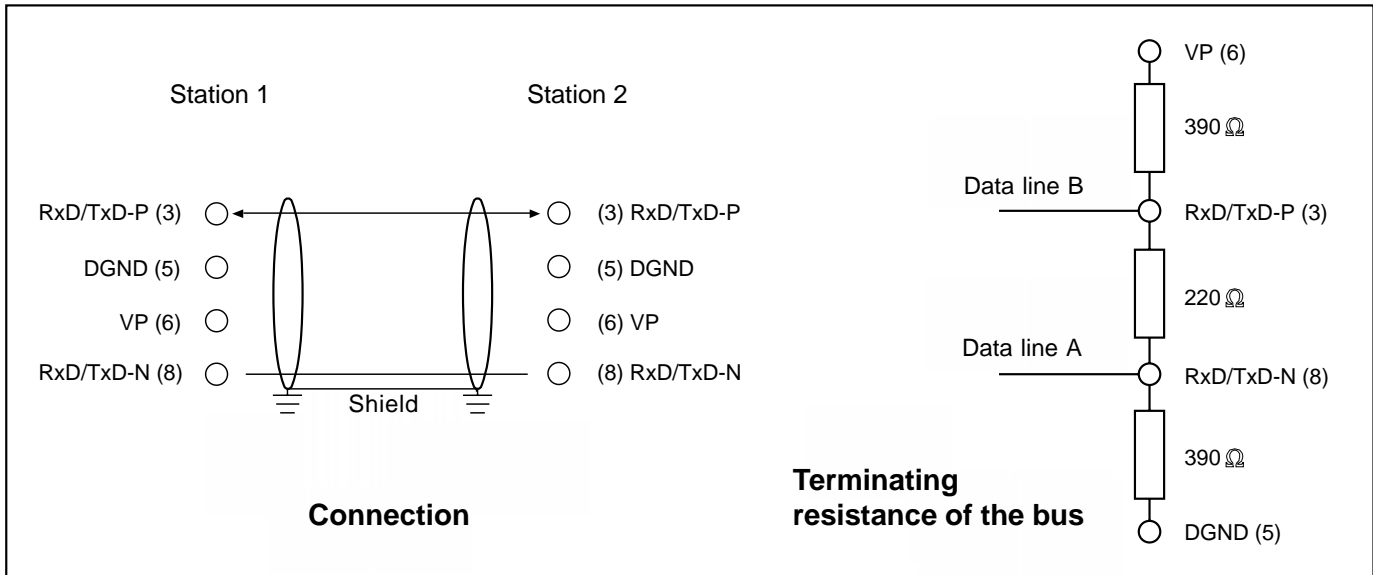
Transmission length depending on transmission speed for cable type A

Baud rate (kBit/s)	9,6	19,2	93,75	187,5	500	1500	12000
Transmission length in (m)	1200	1200	1200	1000	400	200	100

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

also see:
Installation guideline for PROFIBUS -FMS/DP (No. 2.111)
Implementation guide DIN E 19245 Part 3 (No. 2.041)

2.1 Connection of encoder with RS plug

The-pin assignment for the 12-pin RS plug (Note: Numeration of the-pins in clockwise direction (view facing contact side of the bushing), encoder: Bushing) conforms to the profile definition for encoders /1/.

The terminating resistors must be implemented in the counterplug or in the subsequent electronics.
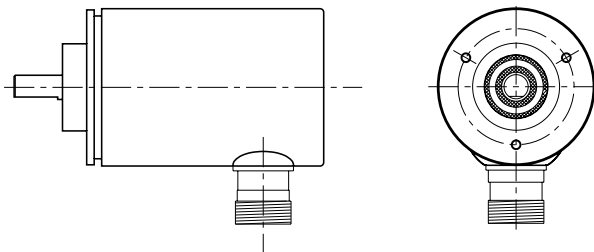
When delivered, each encoder with RS plug has the default address 123. Via the DP master, it is possible to change the address of a DP slave. The slave address which is to be newly assigned must lie within the range 1-126 (DDLM_Set_Slave_Add).

2.2 Connection of encoder with connecting cap
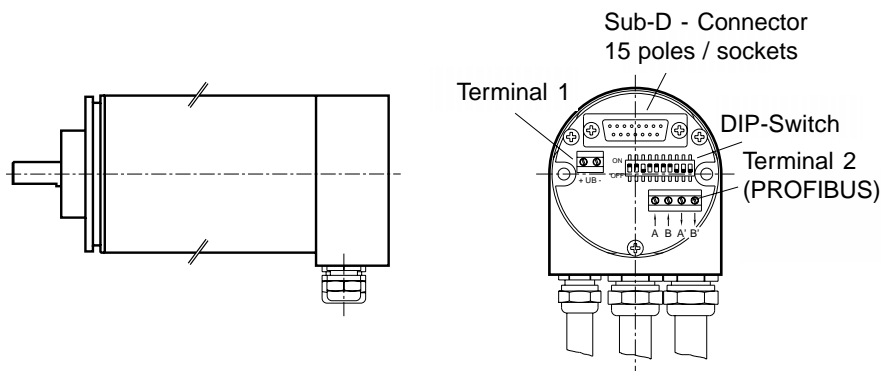
The connecting cap for triple connection technology is a T-coupler, which is installed in the PROFIBUS.
It is equipped with three PG connections, which are subdivided as follows:

- □ PG 7: Voltage supply for the encoder (24 VDC +/-)
- □ PG 9: Bus in (Receive/transmit data A,B)
- □ PG 9: Bus out (Receive/transmit data A',B')

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

Setting the station/subscriber address is carried out via the DIP switches in the connecting cap.The address range lies between 1 and 126 (Default address: 123). The address cannot be changed via the DDLM_Set_Slave_Add service. (Note: GSD file in accordance with encoder version).

DIP switch – address setting

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

DIP switch

2 : 1
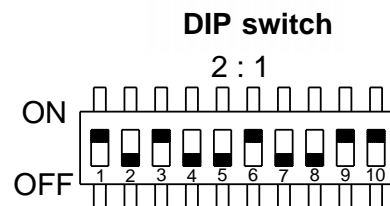
Setting the terminating resistors is carried out via the 10-fold DIP switch (9,10) in the connecting cap, which may be activated as lead termination as required.

DIP switch – terminating resistors

Switch	9	10	Designation
ON = 1	1	1	Terminating resistors
OFF = 0	0	0	No terminating resistors

DIP-Switch

2 : 1
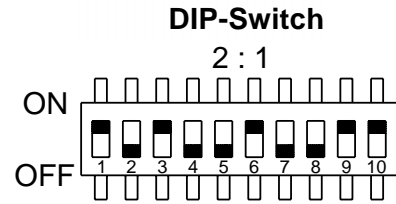
Terminating resistors switched on

The following status LEDs are located in the rear wall of the connecting cap:

Status LED (connecting cap)

	Err	**C**	**SRD**
Incorrect configuration	x		x
Impermissible parameter	x	x	
Code error	x		
Class 1 device configuration ok			x
Class 2 device configuration ok		x	x
x = LED on, UB = Operating voltage, Err = Error message			
C = Class, SRD = Data transfer			
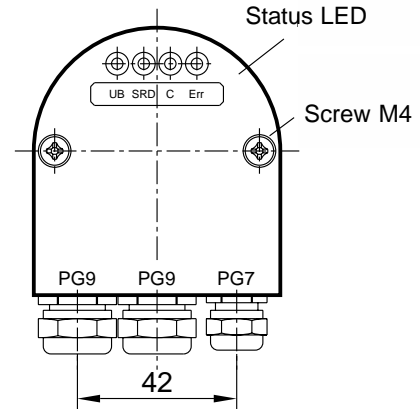
3. Configuration function (DDLM_Chk_Cfg)

The absolute encoders with PROFIBUS-DP are classified as follows:

Encoder with Class 1 functionality

Class 1 devices are characterised by the fact that only the position value (16 bit or 32 bit) of the encoder is transmitted via the bus. No parameterisation of encoder parameters is carried out. In this case, a distinction is made between the D0 and D1 configurations. The D0 configuration contains the data format: 1 word input data, consistency and D1 contains 2 word input data, consistency.

Encoder with Class 2 functionality

Class 2 devices are characterised by the fact that they can be parameterised via the bus. In this case, a distinction is made between the F0 and F1 configurations. The F0 configuration has the data format 1 word input data, 1 word output data, consistency and F1 contains 2 word input data, 2 word output data, consistency .

ID (Identification/Configuration)

Identification	**208**	**209**	**1AX**	**2AX**
Type	Inputs	Inputs	In/Outputs	In/Outputs
Length	1	2	1	2
Format	Word	Word	Word	Word
Module consistency over entire length	yes	yes	yes	yes
Class	Class 1	Class 1	Class 2	Class 2
Configuration	D0	D1	F0	F1

4. Data exchange function (DDLM_Data_Exchange)

Input data are data which are transmitted from the peripheral devices to the master or into the bus. The control of the preset value (see below) is listed as an example of output data at this point.

4.1 Actual position value

The actual position value is output in 16 or 32 bit data format (input data), also see identification of the encoder.

Actual position value (DDLM_Data_Exchange) 16 bit data format

Octet	1	2
Bit	15 - 8	7 - 0
Data	2^{15} - 2^8	2^7 - 2^0

Actual position value (DDLM_Data_Exchange) 32 bit data format

Octet	1	2	3	4
Bit	31 - 24	23 - 16	15 - 8	7 - 0
Data	2^{31} - 2^{24}	2^{23} - 2^{16}	2^{15} - 2^8	2^7 - 2^0

4.2 Set preset value

The set preset value function should only be executed when the encoder shaft is stationary!
In order to compare machine position values and the absolute position of the encoder, setting the preset value is unavoidable in certain cases. The preset value is the position value which is displayed in the reference point. The possibility of setting the preset value is available in the case of the TWK encoder with class 2 functionality.

The user must note the fact that the preset value must lie within the total measuring range in units. In particular, this must be taken into consideration when changing the total measuring range in units.
The preset value (binary code) is transmitted in data exchange mode by setting bit 31 (32 bit data format) or bit 15 (16 bit data format).

The following explanations refer to the 32 bit data format.

Set preset value (DDLM_Data_Exchange)

Octet	1		2	3	4
Bit	31	30 - 34	23 - 16	15 - 8	7 - 0
Data	0/1	2^{30} - 2^{24}	2^{23} - 2^{16}	2^{15} - 2^8	2^7 - 2^0
	Preset Control	Preset value - 31 Bit			

Example: Setting the preset value

	Bit 31	**Bit 30 - 0**
Data	1	000 0000 0000 0000 0000 0000 0000 **1000**
		Preset value: 8

Following the receipt of this message, an offset value (from the current actual position value and preset value) is calculated by the encoder.

If the output position value is equal to the preset value, bit 31 can be reset by the master, as the preset mode is terminated. The timing diagrams are specified in a separate TY sheet. After bit 31 = 0 has been reset, the encoder operates in normal operating mode.

The offset value is stored in the diagnostic data and can be read in the event of a power failure and restarting (Also see Diagnostic messages in Chapter 6).

5. Programming parameters for class 1/2 encoder (DDLM_Set_Prm) /4/

The parameterisation data are comprised from bus-specific data and DP slave-specific data.

Bus-specific data:	Octet 1-7	Octet 1 – Station status
		Octet 2 - WD_Fact_1
		Octet 3 - WD_Fact_2
		Octet 4 - Min. station delay responder (min T_{SDR})
		Octet 5 - Ident_Number) 19
		Octet 6 - Ident_Number) 62H
		Octet 7 - Group_Ident
DP slave-specific data:	Octet 8-9	Class 1 encoder (2 byte User_Prm_Data)
	Octet 8-29	Class 2 encoder (22 byte User_Prm_Data)
	See below for description	

Programm operating parameters			
Parameter	**Datatype**	**Parameter octet number**	**Encoder Device Class**
Standard parameter data	Byte	1 - 7	1,2
User_Prm_Data			
	Byte	8	1,2
Code sequence	Bit	9	1,2
Class 2 functionality	Bit	9	1,2
Commissioning diagnostic control	Bit	9	optional
Scaling function control	Bit	9	2
Measuring units per revolution	unsigned 32	10 - 13	2
Total measuring range	unsigned 32	14 - 17	2
Reserved for future use		18 - 25	2
Manufacturer specific functions		26 - 29	optional

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

Example:	desired total measuring range in units	:	20480
	desired single turn resolution	:	4096
	desired number of revolutions	:	5
	internal encoder calculation		
	actual total measuring range in units	:	32768
	actual single turn 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 32767 steps and not, as desired, after 20479 steps.)

5.1 Definition of the programming parameters

5.1.1 Operating mode of the encoder

Octet	9
Bit	7 - 0
Data	$2^7 - 2^0$

Operating parameters (definition of the operating mode of the encoder)

- Code sequence: The code sequence defines the direction of rotation in which the position value corresponds to increasing values (viewed in the direction of the shaft).

  ☐   CW - clockwise   ☐   CCW - counter clockwise

- Class 2: This operating parameter serves to distinguish between encoders with class 1 or class 2 functions.

  ☐   Class 1:   Code sequence, release of the class 2 functions
  ☐   Class 2:   Contains class 1 functions
                    Scaling function control (see below)

- Diagnostic routine: The diagnostic routine enables the extensive examination of all encoder components to ensure perfect functional capability. The routine is run through each time the device is switched on. If faults are determined by the diagnostic routine, these are displayed with the alarm bit.
  This function is not currently supported.

- Scaling function control: The scaling function control releases the parameterisation of the single turn resolution and the total measuring range in units. This function is only effective when changing the single turn resolution and total measuring range in units parameters.
  Following the execution of scaling function control, the position value is recalculated and output.

Logic table for Octet 9 (Operating parameters)

Bit	Definition	= 0	= 1
0	Code sequence	CW	CCW
1	Class 2 functionality	disable	enable
2	Commissioning diagnostic control	no	yes
3	Scaling function control		enable scaling function and set scaling parameters to the values sent in this message
4,5	Reserved for future use	-	-
6,7	Manafacturer specific functions	-	-

5.1.2 Measuring units per revolution

Octet	10	11	12	13
Bit	31 - 24	23 - 16	15 - 8	7 - 0
Data	2^{31} - 2^{24}	2^{23} - 2^{16}	2^{15} - 2^{8}	2^{7} - 2^{0}

5.1.3 Total measuring range in units

Octet	14	15	16	17
Bit	31 - 24	23 - 16	15 - 8	7 - 0
Data	2^{31} - 2^{24}	2^{23} - 2^{16}	2^{15} - 2^{8}	2^{7} - 2^{0}

Note: On parameterisation of the total measuring range in units via project planning software such as, e.g. COM ET200 or S7, the 32 bit value is subdivided amongst two words as follows:

Designation	Default value	Bit	Comment
Total measuring range(units)hi	256	31 - 16	Hi-Word
Total measuring range(units)lo	0	15 - 0	Lo-Wort

The decimal value for the total measuring range in units must now be subdivided in binary form amongst these two words, whereby, however, the input is carried out in decimal form.

e.g.:

Total measuring range in units(dec)	Total measuring range in units(hex)	Hi-word(hex)	Hi-word(dec) (Input)	Lo-word(hex)	Lo-word(dec) (Input)
64	40	0	0	40	64
10000	2710	0	0	2710	10000
200000	30D40	3	3	0D40	3392

5.2 Examples of parameterisation (User_Prm_Data)

Class 1 encoder (9 parameter data (including 7 bytes of bus-specific data)*:

Octet	01	02	03	04	05	06	07	08	09	
Data	Bus-specific Data: Octet 01 - 07								Bit 0 = 0	Code sequence: CW
									Bit 1 = 0	Class 2 functions: no
									Bit 2 = 0	Diagnostic routine: no
									Bit 3 = 0	Scaling function control: no
									Bit 4 - 7 = 0	

Octet	01	02	03	04	05	06	07	08	09	
Data	Bus-specific Data: Octet 01 - 07								Bit 0 = 1	Code sequence: CCW
									Bit 1 = 0	Class 2 functions: no
									Bit 2 = 0	Diagnostic routine: no
									Bit 3 = 0	Scaling function control: no
									Bit 4 - 7 = 0	

Class 2 encoder (29 parameter data (including 7 bytes of bus-specific data)*:

Octet	01 02 03 04 05 06 07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Data	Bus-specific Data (Octet 01 - 07)	00	**0A**	00	00	**10**	**00**	**01**	**00**	**00**	**00**	00	00	00	00	00	00	00	00	00	00	00	00

Description

Octet 9	0AH:	Bit 0 = 0	Code sequence CW	
		Bit 1 = 1	Class 2 functions: yes	
		Bit 2 = 0	Diagnostic routine: no	
		Bit 3 = 1	Scaling function control: yes	
		Bit 4-7 = 0		
Octet 10-13	1.000H:		4096 steps/revolution	
Octet 14-17	1.000.000H:		16.777.216 total measuring range in units	

* Examples contain the DP slave-specific parameter data only (also see DIN 19245-3)

6. Diagnostic messages (DDLM_Slave_Diag)

Overview of diagnostic information

No.	Diagnostic function	Data type	Diagnosis Octet Number	Encoder class
1	Standard diagnostic information		1 - 6	
	Device-related diagnosis			
2	Extended header byte	Octet string	7	1,2
3	Alarm messages	Octet string	8	1,2
4	Operating mode/encoder status	Octet string	9	1,2
5	Encoder type	Octet string	10	1,2
6	Single turn resolution	unsigned 32	11 - 14	1,2
7	Measurement range	unsigned 16	15 - 16	1,2
8	Additional alarm messages	Octet string	17	2
9	Supported alarm messages	Octet string	18 - 19	2
10	Warning messages	Octet string	20 - 21	2
11	Supported warning messages	Octet string	22 - 23	2
12	Profile version	Octet string	24 - 25	2
13	Software version	Octet string	26 - 27	2
14	Operating time	unsigned 32	28 - 31	2
15	Offset value	unsigned 32	32 - 35	2
16	Manufacturer offset value	unsigned 32	36 - 39	2
17	Single turn resolution	unsigned 32	40 - 43	2
18	Total measuring units / revolution	unsigned 32	44 - 47	2
19	Serial number	ASCII String	48 - 57	2
20	Reserved for future use		58 - 59	2
21	Manufacturer-specific diagnosis		60 - 63	2

Explanations regarding the diagnostic information:

6.1 Standard diagnostic information (Octet 1-6):
> For detailed description, see DIN 19245-3 /4/
> (Note: Octet 5,6: Manufacturer identification: 1962H)
> This manufacturer identification number is stored in the PNO, and identifies the subscriber as a TWK encoder.

6.2 Device-related diagnosis
In the range from Octet 7 up to max. 244 (according to standard /4/), the DP slave may store its specific diagnosis.

6.2.1 Extended header byte (Octet 7):

In the header diagnosis (Octet 7), the length of the extended diagnosis bytes, including the header, is specified.

(Class 1 encoder: 0AH = 10 d

      -> 6 (Standard diagnosis) + 1(Octet 7)+ 9 (Octet 8-16) = 16 diagnosis bytes,

 Class 2 encoder: 39H = 57d

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

Octet	7	
Bit	Definition	Data
0 - 5	Length including header	xxH (Note: hexadecimale specification)
6	Display of device-related diagnosis	0
7	Display of device-related diagnosis	0

6.2.2 Alarm messages (Octet 8):

Output of the current alarm status. TWK currently supports memory errors only.

Octet	8			
Bit	Definition	Data		Comment
		= 0	= 1	
0	Position error	no	yes	not supported
1	Supply voltage error	no	yes	not supported
2	Current to high	no	yes	not supported
3	Commissioning diagnostic	no	yes	not supported
4	Memory error	ok	error	supported
5 - 7	Currently not assigned			

6.2.3 Operating mode (Octet 9)

Current encoder status. This byte is described via the parameterisation of the master, and is read by the diagnosis string.

Octet	9		
Bit	Definition	Data	
0	Code sequence	0 = CW	1 = CCW
1	Class 2 functions	0 = no	1 = yes
2	Diagnostic routine	0 = no	1 = yes
3	Scaling function control	0 = no	1 = yes
4 - 7	Currently not assigned		

6.2.4 Encoder type (Octet 10)

The encoder type is set to multitour absolute. The code is stored in hexadecimal form (00-FFH)

Octet	10	
Bit	Definition	Code (in hex)
Data	Multitour absolute	01

6.2.5 Single turn resolution (Octet 11-14)

The maximum possible selection of measuring units per revolution, specified via the single turn resolution of the encoder shaft. The value is stored in the binary code.

Octet	11	12	13	14
Bit	31 - 24	23 - 16	15 - 8	7 - 0
Data	$2^{31} - 2^{24}$	$2^{23} - 2^{16}$	$2^{15} - 2^8$	$2^7 - 2^0$

6.2.6 Measuring range (Octet 15, 16)

The maximum possible number of revolutions, specified via the single turn resolution of the multitour section. Depiction in hexadecimal form, e.g. 4096 revolutions = 1000H.

Octet	15	16
Bit	15 - 8	7 - 0
Data	$2^{15} - 2^8$	$2^7 - 2^0$

End of diagnostic data for class 1 encoder !

6.2.7 Additional alarm messages (Octet 17)

Not currently assigned.

Octet	17
Bit	7 - 0
Data	Not currently assigned

6.2.8 Supported alarm messages (Octet 18,19)

The error entitled memory error is currently supported (10H).

Octet	18,19		
Bit	Definition	Data	
0	Position error	0 = not supported	1 = supported
1	Voltage supply error	0 = not supported	1 = supported
2	Current excessive	0 = not supported	1 = supported
3	Diagnostic routine	0 = not supported	1 = supported
4	Memory error	0 = not supported	1 = supported
5 - 15	Not currently assigned		

6.2.9 Warning messages (Octet 20,21)

This function is not currently supported.

6.2.10 Supported warnings (Octet 22,23)

This function is not currently supported.

6.2.11 Profile version (Octet 24,25)

Profile version: e.g. 01.00

Octet	24	25
Bit	15 - 8	7 - 0
Data	$2^{15} - 2^8$	$2^7 - 2^0$
	Revisions number	Index

6.2.12 Software version (Octet 26,27)

Software version: e.g. 01.00

Octet	26	27
Bit	15 - 8	7 - 0
Data	$2^{15} - 2^8$	$2^7 - 2^0$
	Revisions number	Index

6.2.13 Operating time (Octet 28-31)

This function is not currently supported. The operating time default is set as FFFF FFFF$_{hex}$ in accordance with the encoder profile.

6.2.14 Offset value (Octet 32-35)

The offset is the shift in the zero point on setting the reference point, with reference to the output (according to the calculation).

Octet	32	33	34	35
Bit	31 - 24	23 - 16	15 - 8	7 - 0
Data	$2^{31} - 2^{24}$	$2^{23} - 2^{16}$	$2^{15} - 2^8$	$2^7 - 2^0$

6.2.15 Manufacturer offset value (Octet 36-39)

The manufacturer offset is the shift in the zero point of the encoder with regard to its physical zero point. The manufacturer offset value is not currently supported (Assignment: 00 00 00 00H).

Octet	36	37	38	39
Bit	31 - 24	23 - 16	15 - 8	7 - 0
Data	$2^{31} - 2^{24}$	$2^{23} - 2^{16}$	$2^{15} - 2^8$	$2^7 - 2^0$

6.2.16 Single turn resolution (Octet 40-43)

In this case, the single turn resolution set in the parameter programme is reflected.

Octet	40	41	42	43
Bit	31 - 24	23 - 16	15 - 8	7 - 0
Data	$2^{31} - 2^{24}$	$2^{23} - 2^{16}$	$2^{15} - 2^8$	$2^7 - 2^0$

6.2.17 Total measuring units per revolution (Octet 44-47)

In this case, the total measuring units per revolution set in the parameter programme is reflected.

Octet	44	45	46	47
Bit	31 - 24	23 - 16	15 - 8	7 - 0
Data	$2^{31} - 2^{24}$	$2^{23} - 2^{16}$	$2^{15} - 2^8$	$2^7 - 2^0$

6.2.18 Serial number (Octet 48-57)

This parameter is not currently supported.

Octet	48 - 57
Bit	79 - 0
Data	2A 2A 2A 2A 2A 2A 2A 2A 2A 2A

6.2.19 Reserved for future use (Octet 58,59)

6.2.20 Manufacturer-specific diagnosis (Octet 60-63)

Octet	60	61	62	63
Bit	31 - 24	23 - 16	15 - 8	7 - 0
Data	see table			

Byte	Bit	Definition	Comment	Possible error rectification
60	0 - 7	Currently not assigned		
61	0 - 7	Currently not assigned		
62	0	ErrEE	EEPROM error	Reset encoder
	1	ErrMSA	MSA error	Reset encoder
	2	ErrXRAM	External RAM error	Reset encoder
	3	ErrExp	Cap errror	Reset encoder
	4	IniFlg	Reinitialisation of EEPROM	
	5 - 7	Currently not assigned		
63	0	ErrCRC0	CRC0 error	Reprogramming and rebooting of the encoder
	1	ErrCRC1	CRC1 error	Reprogramming and rebooting of the encoder
	2	ErrPar	Incorrect revolution parameter	Reprogramming
	3	ErrSkal	Scaling error	Is coverd by communication
	4	ErrMem	ROM code error	Reset encoder
	5	ErrInt	Internal controller error	Reset encoder
	6	ErrPre	Preset value error	Input preset * value within total measuring range in units -1
	7	ErrStat	Unknown order from communication	Proper order from communication

* If a faulty preset value is input, control bit 31 must be set to zero before inputting the correct preset value in order to eradicate the error. The preset value can subsequently be reset after setting control bit 31 to 1. After resetting bit 31 to the value zero, the position value may then be output.

6.2.21 Example of diagnostic message

Octet	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
01-16	0	0C	0	2	19	62	39	0	0A	1	0	0	10	0	10	0
17-32	0	0	10	0	0	0	0	1	0	1	7	FF	FF	FF	FF	0
33-48	0	0	42	0	0	0	0	0	0	4	0	0	0	10	0	2A
48-63	2A	2A	2A	2A	2A	2A	2A	2A	2A	0	0	0	0	0	0	

Explanation:
Octet:

1-6	Standard diagnostic information	01:	00H:	
		02:	0CH:	Response monitoring activated, bit 2 set to 1
		03:	00H:	
		04:	02H:	Parameterisation via master with address 02
		05-06:	1962H:	Ident_Number
7	Extended header byte		39H:	3 diagnosis bytes
8	Alarm messages		00H:	No alarms are present
9	Operating mode		0AH:	CW, class 2, diagnosis: no, scaling yes
10	Encoder type		01H:	Multitour, absolute
11-14	Single turn resolution		1000H:	4096 S/U
15-16	Measuring range		1000000H:	16.777.216 Total measuring range
17	Additional alarm messages		00H:	No alarms are present
18-19	Supported alarm messages		0010H:	Memory error is supported
20-21	Warning messages		0000H:	
22-23	Supported warning messages		0000H:	
24-25	Profile version		0100H:	Hardware version: 1.00
26-27	Software version		0108H:	Software version: 1.08
28-31	Operating time		FFFFFFFFH:	
32-35	Offset value		00000000H:	
36-39	Manufacturer offset value		00000000H:	Is not currently supported
40-43	Single turn resolution		00000400H:	1024 S/U
44-47	Total measuring units per revolution		00001000H:	4096 Total measuring range
48-57	Serial number	2A2A2A2A2A2A2A2A2AH:		
58-59	Reserved for future use		0000H:	
60-63	Manufacturer-specific diagnosis		00000000H:	No errors are present

7. COM ET200 WINDOWS

By using the COM ET 200 software (is included in the scope of delivery of the Siemens SINEC L2-DP development package 4), the user is able to set up and commission the SINEC L2 DP bus. Within the framework of the manual, information which prerequires an exact knowledge of this software is provided. More detailed information may be obtained from the corresponding manuals.
In our example, a CRD encoder and a Siemens IM 180 master are configured as an example application for the PROFIBUS-DP. The IM 180 master (PC plug-in card) is included in the scope of delivery of development package 4.
Prior to the commencement of the example, it should be pointed out that an example type file and the bitmap are contained in the enclosed 3.5" diskette (CRD scope of delivery).
Read type files in
After the type file has been copied into the ...\ Type file directory and the bitmap into the ...\Bitmap directory, COM ET 200 can be started. With the Read type file in command, COM ET 200 is informed that new or corrected type files are located in the type file directory. The **Read type file in** item is selected under the File menu item. No feedback is provided after the type file has been successfully read in

New programme file or open programme file
The **New** or **Open** item is selected under the **File** menu item. Under the **New** menu item, a new programme file can be opened. In this case, the master station type, including the station address and the other subscribers in the bus, are configured. Under the **Open** menu item, an existing programme file is opened. Other subscribers may be added via the slave button. In this case, the subscribers, including the station address, are configured. The slave parameters can be changed in accordance with the application.
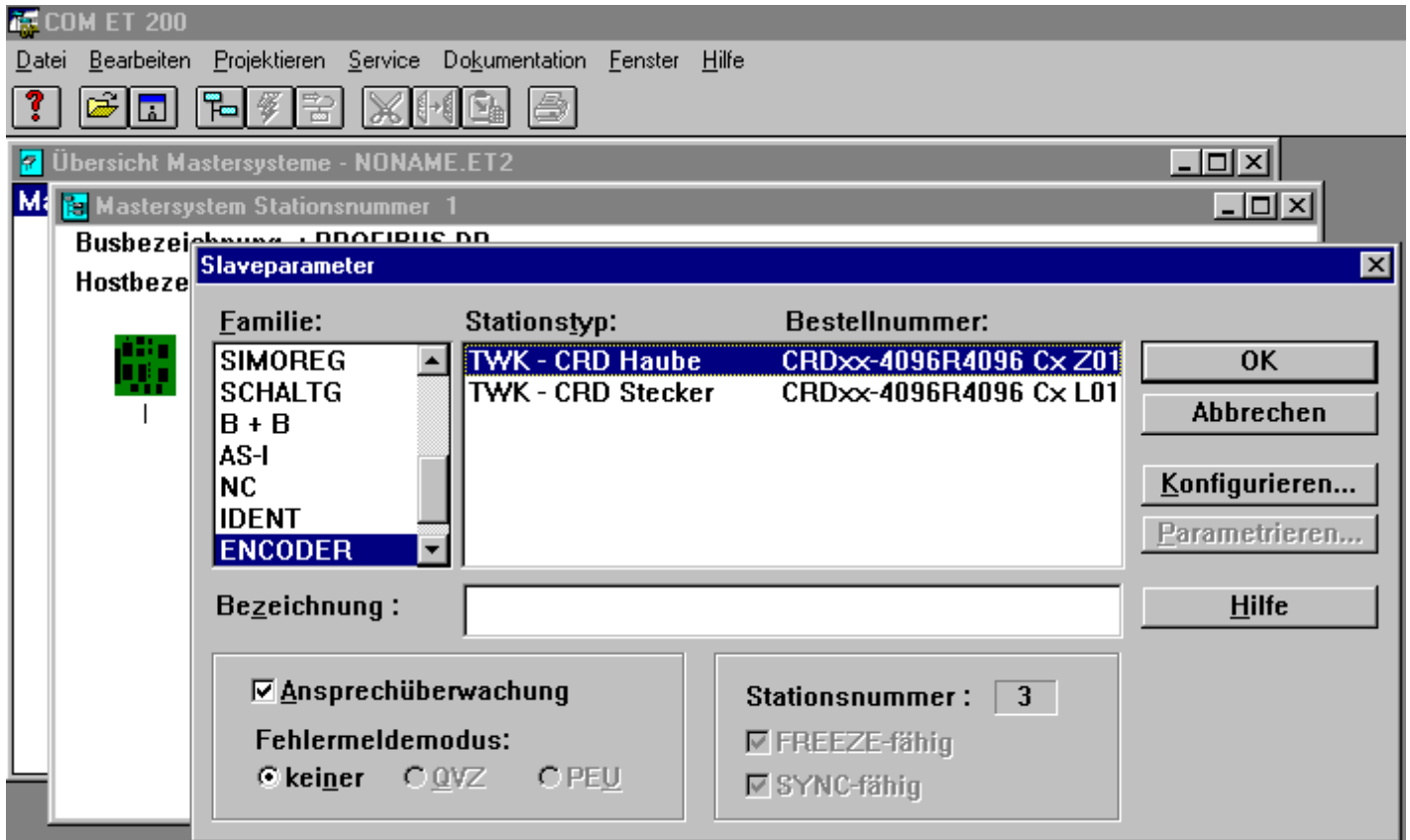The installation of a master-slave bus system is described in the following.
After opening the file window, the master-host selection may be made via the **New** menu item. In our example, the master station type IM 180 master (host station type: PC-EKIT4) is confirmed under station address 1.
The selection of a slave is carried out by clicking onto the ENCODER button in the slave window. By using the mouse, the slave is inserted (via mouse click) under the station type which has already been installed. After confirming the mouse button, the profibus address set in the encoder must be specified. In this example, station number 3 has been selected.
(Note: The COM ET 200 software provides the option of documentation. In the case of comprehensive, and therefore complex, systems, this feature is a suitable tool for the rapid allocation of the subscribers to their station addresses.)
After address allocation has been carried out, the following window, in which the encoder type (plug version or version with connecting cap) must be selected, is opened.

The slave subscriber must now be configured and parameterised. Configuration is called up via the corresponding button. (See Chapter 3)

Following the selection of the configuration, the I/O addresses may be defined.

Parameterisation is called up via the corresponding button. The following window, which displays all parameters which are available in the case of class 2, appears. Double-clicking onto the grey fields calls up a selection dialogue for setting the parameter. The values in the white fields can be overwritten by the user. (See Chapter 5 and comply with the instructions on Pages 11 and 12)
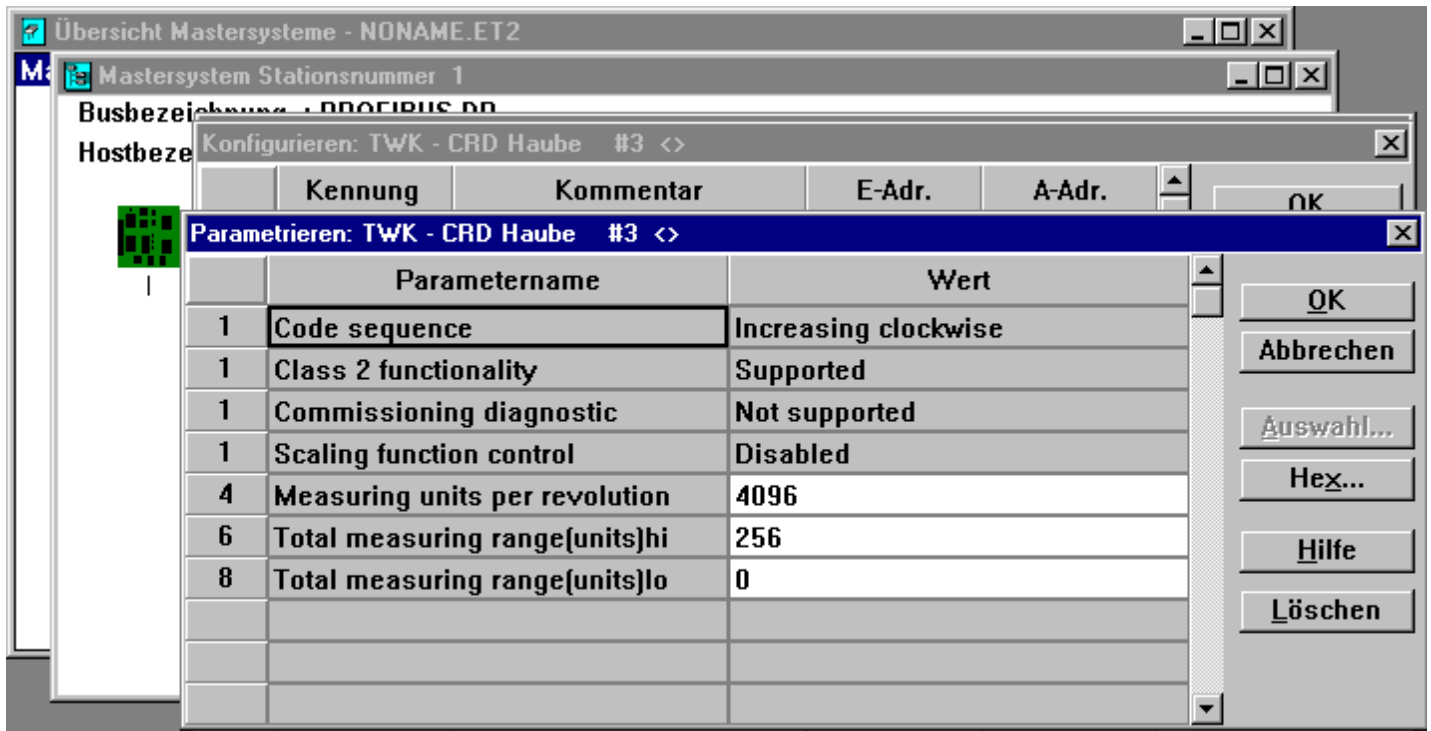
After closing the window with OK, the encoder is integrated as a new subscriber in the profibus.

Following configuration and parameterisation, this bus application can be stored under *.et2. The generation of a binary file (*.2bf) is carried out after calling up the File/Export/Binary file menu. In the event of an error, the configuration or parameterisation of the relevant slave must be checked.
With the binary file, the user is in a position, e.g. via the DPMT.EXE file (Scope of delivery of development package 4) to implement this bus configuration in practical terms.

8. Simatic Step7

This Chapter explains the procedure for integrating the TWK encoder into the profibus of Siemens S7 control system, and the set up and the utilisation of the example programmes for Step7. The basis of the documentation is Step 7 Version 5.0.

8.1 Integration of the TWK profibus encoder

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

8.1.1 Installation of the GSD file

- Close all projects in the hardware configuration.
- Insert the diskette provided by TWK into your disk drive.
- In the hardware configuration, select **Install new GSD** under **Options**.
- Select the GSD file which corresponds to your encoder from the diskette:
  - Version with connecting cap: TWKZ1962.GSD
  - Version with plug connection: TWKL1962.GSD
- Update the Step7 hardware catalogue via **Options**, **Update Catalog**.

8.1.2 Installation of the TWK encoder symbol

Via the installation of the TWK encoder symbol, your encoder is not depicted as an unknown subscriber in the hardware configuration, but assumes the appearance of your encoder. This is not, however, of significance as regards the function of the encoder.
In order to install the symbol (bitmap), copy the two files: CRD_Z_an.BMP and CRD_L_an.BMP from A:\Bitmaps\ into the C:\Siemens\Step7\S7Data\NSBMP\ directory (if C: is your S7 drive). The symbols first appear after restarting the Simatic Manager.

8.1.3 Selection of the TWK encoder from the Step7 hardware catalogue

- After opening the hardware catalogue, you will find, under **Profibus-DP, Additional Field Devices**, **General,** the TWK profibus-encoder Encoder CRD plug (encoder in plug version) or Encoder CRD cap (encoder with connecting cap).
- Now open your project, mark the bus and integrate the encoder into the bus by double-clicking onto the corresponding line in the hardware catalogue (Encoder CRD plug or Encoder CRD cap).

8.1.4 Configuration of the encoder

After the appropriate encoder type has been selected in the (hardware) Catalog, the following window appears for the selection of encoder functionality and single turn resolution.
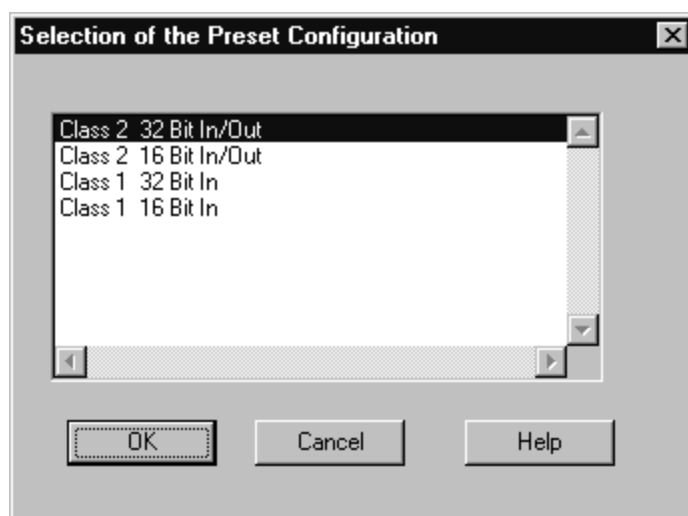

In this case, select class 1 or class 2 functionality and 16 or 32 bit single turn resolution in accordance with your requirements. (See Chapter 3)

8.1.5 Allocation of profibus address

If you have selected your nominal configuration, the following window, in which you must specify the profibus address set in the encoder, appears. For the example programmes, please select address 123 for the first and address 122 for the second encoder here.Note: The profibus address of the encoder is set, in the case of the cap version, via dip switches (See Chapter 2.2) and, in the case of the plug version, via software (See Chapter 8.2). In addition, select your planned profibus in the Subnet, and quit the window with OK.

The encoder subsequently appears as a subscriber in your profibus. Depending on the configuration and address, this may appear as follows:
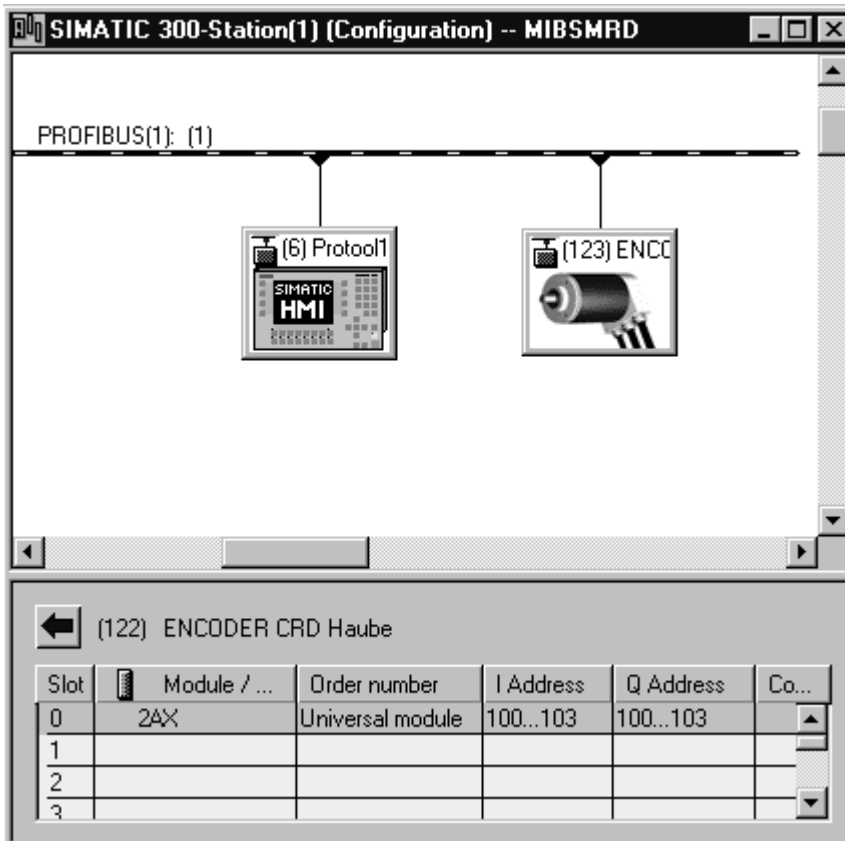
Double-clicking for the diagnostic address configuration (See 8.1.8)

Double-clicking for the address configuration and parameter programming (See 8.1.6 und 8.1.7)

The value for Module / DP-ID results from the configuration which is selected. The values for I/O address are default values which may vary depending on the control system.

8.1.6 Setting the I/O addresses (S7 addresses)

Double-clicking onto the "Slot 0" line opens the **Properties - DP slave** window with the **Address / ID** and **Parameter Assignment** registers. In the Address / ID registers, under output (in the case of class 2 encoder only) and input, the addresses under which the encoder is to be addressed in S7 must be allocated. The other entries in this register should not be changed. The following Figure depicts an example of this register for a class 2 encoder with 32 bit single turn resolution.

For the example programme, please input address 100 for outputs and inputs.
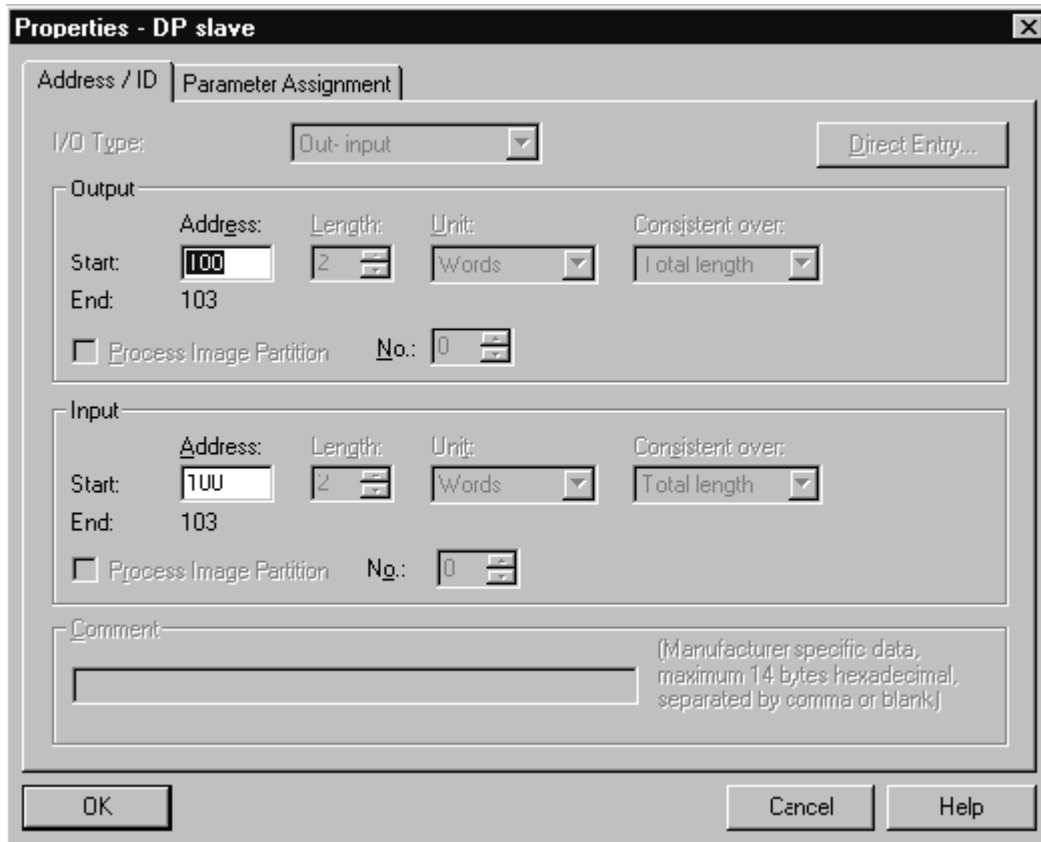
8.1.7 Parameterisation of the encoder

Via the **Parameter Assignment** register, the following window, in which the characteristics of the encoder can be defined, is accessed. The parameters of a class 2 slave are shown. In the case of a class 1 slave, only the code sequence parameter can be set here.
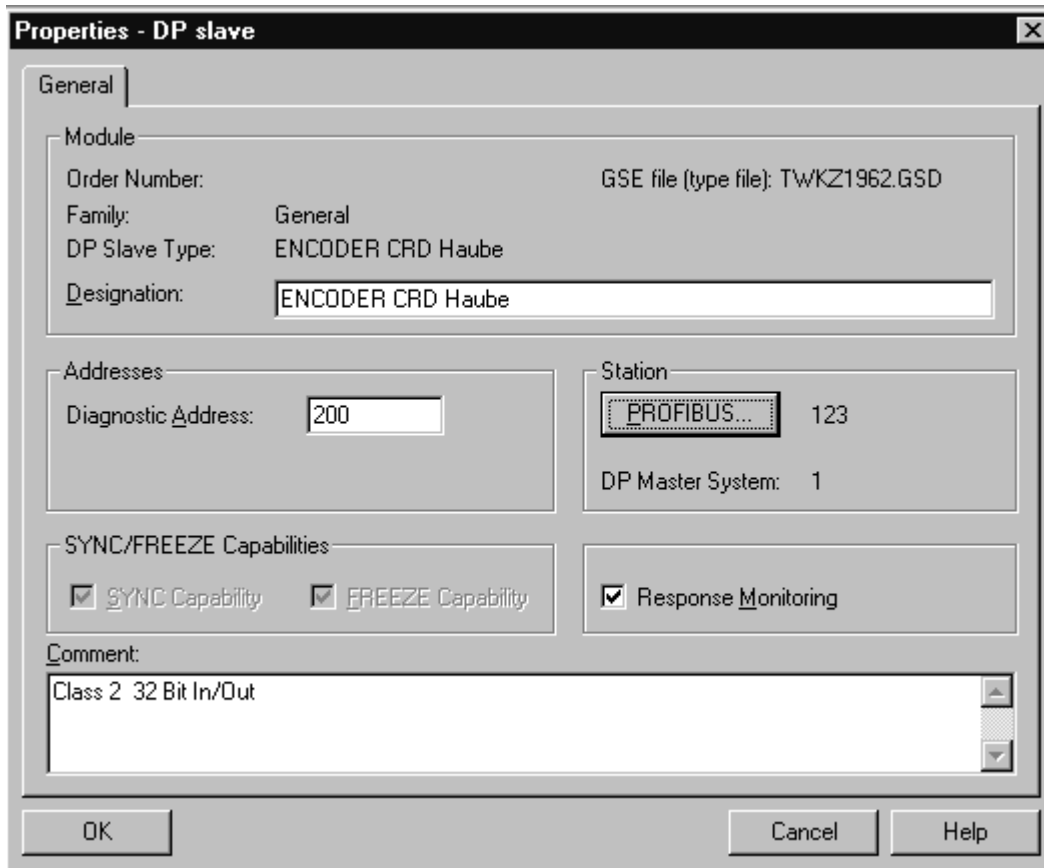
(See Chapter 5 and comply with the instructions on Pages 11 and 12)

- 25 -
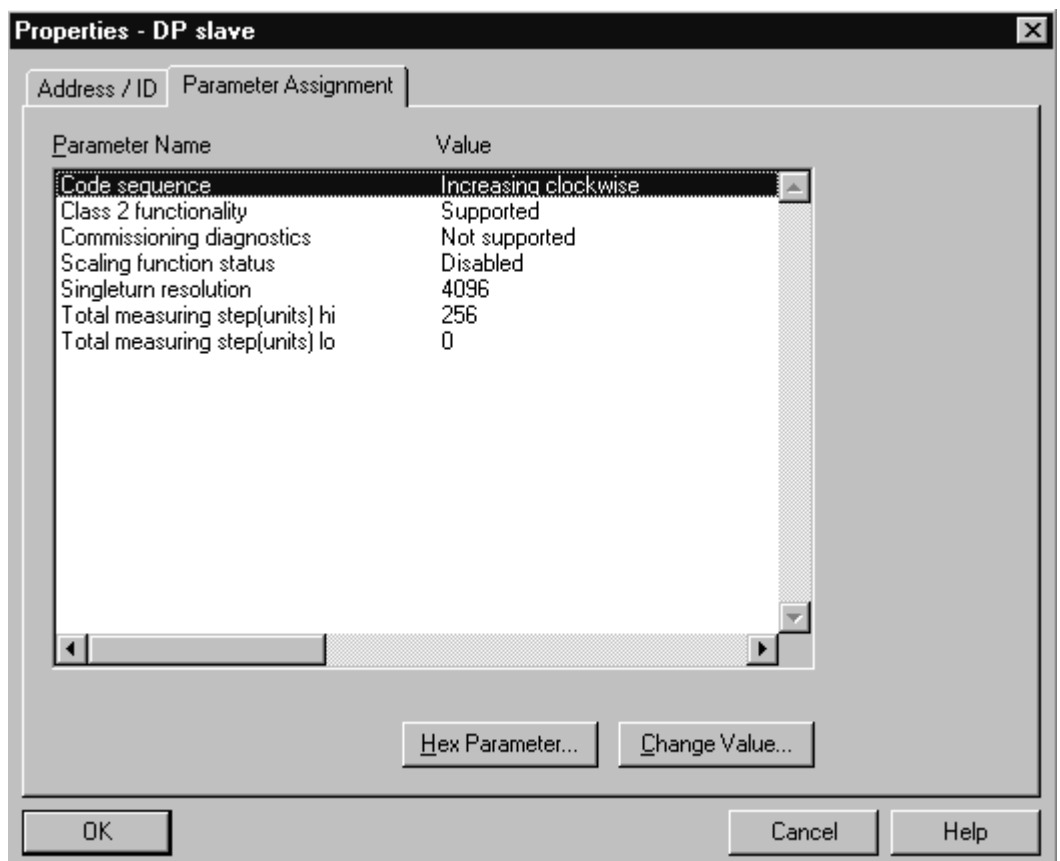
8.1.8 Setting the diagnostic address

Setting the diagnostic address is only required if the special profibus diagnostic functions are used within the S7 programme.
So that the diagnostic range of the encoder can be accessed within the S7 programme, a special S7 diagnostic address must be allocated to this. This address may lie within the entire peripheral range of the control system. It does not, therefore, occupy any input/output addresses.

By double-clicking onto the encoder symbol, the **Properties - DP slave** window appears with the **General** register.
For the example programme please specify diagnostic address 200 for the first encoder and 202 for the second encoder.

```
Properties - DP slave                                              ☒
┌─General─┐
│         └──────────────────────────────────────────────────────
│ ┌─Module────────────────────────────────────────────────────────┐
│ │  Order Number:                    GSE file (type file): TWKZ1962.GSD
│ │  Family:         General
│ │  DP Slave Type:  ENCODER CRD Haube
│ │  Designation:    [ENCODER CRD Haube                           ]
│ └───────────────────────────────────────────────────────────────┘
│ ┌─Addresses──────────────────────┐  ┌─Station──────────────────┐
│ │  Diagnostic Address:  [200  ]  │  │  [ PROFIBUS... ]   123    │
│ │                                │  │                           │
│ │                                │  │  DP Master System:   1    │
│ └────────────────────────────────┘  └───────────────────────────┘
│ ┌─SYNC/FREEZE Capabilities───────┐  ┌───────────────────────────┐
│ │  ☑ SYNC Capability  ☑ FREEZE Capability │  ☑ Response Monitoring │
│ └────────────────────────────────┘  └───────────────────────────┘
│ Comment:
│ [Class 2  32 Bit In/Out                                        ▲]
│ [                                                              ▼]
│
│  [  OK  ]                          [ Cancel ]   [  Help  ]
└──────────────────────────────────────────────────────────────────
```

Following confirmation with OK, the encoder is configured and parameterised. The hardware configuration can now be translated and transferred into S7.

8.2 Setting the subscriber address in the case of the plug-version encoder

Setting the address of the plug-version CRD under S7 is possible with a profibus protocol-capable MPI card from Siemens (e.g.: CP5611).
According to Siemens, the prerequisites for allocating a new address are as follows:

1. No DP master is contained in the PROFIBUS network.
2. At least one DP slave exists in the PROFIBUS network.
3. A PROFIBUS address has already been directly allocated to each DP slave in the
   PROFIBUS network (either via software via PG - DP slave direct connection
   or via setting the switches on the DP slave; Assignment is DP slave-dependent,
   therefore consult the DP slave manual)
4. You have connected the programming device to the PROFIBUS network via a stub line
   (See the manual regarding the DP master).
(See on-line help under Assignment of profibus address" in the Simatic Manager)

I.e. if the encoder is not the only slave on the profibus/MPI card, all slaves contained in the bus must possess a unique (allocated only once) address, and the master (S7-CPU) must be disconnected from the bus. It is therefore impossible, for example, to simultaneously connect two encoders with address 123 to the bus and to then assign a new address to one of the two.

If the encoder whose address is to be changed has already previously been used in bus operation, this must be rendered potential-free before it can be set to a new address.

Address setting is carried out in the Simatic Manager under **"PLC** , **Assign PROFIBUS Address**". If the encoder is connected to the profibus/MPI interface of your programming device, the depicted dialogue appears.
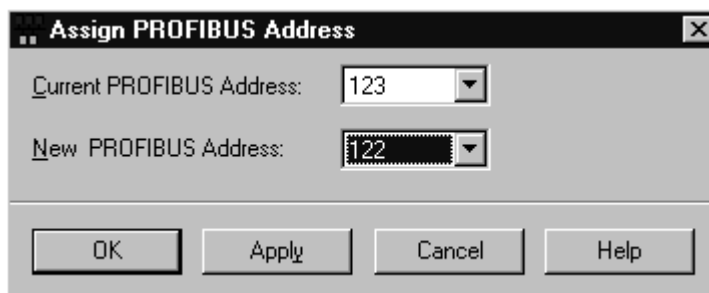
This displays the current address of the encoder, and requests the input of the new profibus address. If this is confirmed with **Apply**, the new address is stored in the encoder in a zero-voltage-protected manner. The dialogue subsequently displays the new address as the current address.

8.3 Example programmes

On the diskette which is supplied by TWK, path \S7_BSP\ contains several S7 archive files, which contain S7 example programmes which have been generated by TWK for working with the TWK profibus encoder. The programmes have been developed for a CPU315-2DP, and have been designed such that no periphery other than a TWK profibus encoder is required. The diskette contains one project for encoders with class 1 functionality and one for encoders with class 2 functionality. Each project contains several programme folders for different application cases. The standard "Sources" and "Blocks" folders are located beneath the programme folders.

The TWK examples only contain modules which have been generated with the KOP/FUP/AWL Editor. The generation language was FUP. Within the modules, comprehensive documentation is made available on the basis of network comments.

TWK cannot undertake to provide any guarantee for the function of these programmes on customers' systems/control systems. Programmes in the archive files:

- TWKDPCL1.ARJ : Class 1 project with Diagnosis and Istwert programme folders, comments in German
- TWKDPCL2.ARJ : Class 2 project with Diagnosis, IstRef and Istwert programme folders, comments in German
- DP_C1_GB.ARJ : Class 1 project with Diagnosis and Istwert programme folders, comments in English
- DP_C2_GB.ARJ : Class 2 Project with Diagnosis, IstRef and Istwert programme folders, comments in English

8.3.1 The TWKDPCL1 project

The following Figure shows the class 1 project programme folders:

Program Istwert: The program Istwert is comprised only of an OB1 and is intended to briefly show the manner in which the actual position value of the encoder is accessed within the S7 programme.

Program Diag1:   In addition to the program Istwert, the Diag1 programme also contains error handling
        f   or a class 1 encoder. It contains, amongst other things, OB86 for detecting the failure of the encoder, and OB82 for detecting a diagnostic request on the part of the encoder. Step7 system function SFC13 is used to read the diagnostic range out. (The diagnostic range of the class 1 encoder is 16 bytes. See Chapter 6)

Program Diag2:   The Diag2 programme provides the same functionality as Diag1, but is designed for two encoders.

Within each programme, a selection may be made between functions for a 16 or 32 bit-wide encoder input. To achieve this, either the 16 or the 32 bit function is simply provided with a "1" signal (one-marker M 0.1) at the EN input, and the non-required function with a "0" signal (zero-marker M 0.0).

8.3.2 The TWKDPCL2 project

The class 2 project contains the following programme folders:

Program Istwert:	Identical to class 1 programme
Program IstRef:	The program IstRef contains the reading out of the actual position value and, in addition, the setting of a preset value, which is possible in the case of class 2 functionality.
Program Diag1:	In the same manner as Diag1 from the class 1 project, the Diag1 programme contains the error handling of a class 2 encoder. In this case, the scope of the diagnostic range is 63 bytes.
Program Diag2:	Once again, Diag2 is the variant of Diag1 which is extended to encompass two encoders.

8.3.3 Installation of the example programmes

Prerequisites:

-   You have generated a project and have inserted a control system into this with its hardware configuration. This may appear as follows, for example:

·   In the hardware configuration, you have connected one or two encoders with the following settings to a profibus subnetwork (See Chapter 8.1).

First encoder:	Profibus address 123
	Inputs/outputs: From address 100
	Diagnostic address: 200
Poss.: Second encoder:	Profibus address 122
	Inputs/outputs: From address 110
	Diagnostic address: 202

Installation:

-   In the Simatic Manager, select **File**, **Retrieve**. Change the file type to *.arj and select the class 1 or class 2 project in the \S7_BSP\ directory on the enclosed diskette.
-   In the next window, specify your project directory (normally S7proj) .
-   Via integration with OK, the dearchiving programme is started. After terminating this, you will find your selected TWK example project in your S7 project directory.
-   If you now select **File**, **Open**, **User project**, you will be provided with a list of the projects available on your system. If the example project is not yet available here, select **Browse** and search for the TWKDPCL1.s7p (or TWKDPCL2.s7p) file under the TWK example project.
-   Open the example project so that you now have both projects, your own and the example project, open. This may then, for example, look like the Figure on the next Page.
-   Select a subordinate S7 programme folder of the TWK example project. (In this case, either Diag1, Diag2, IstRef or Istwert. Also see: Chapter 8.3.1)
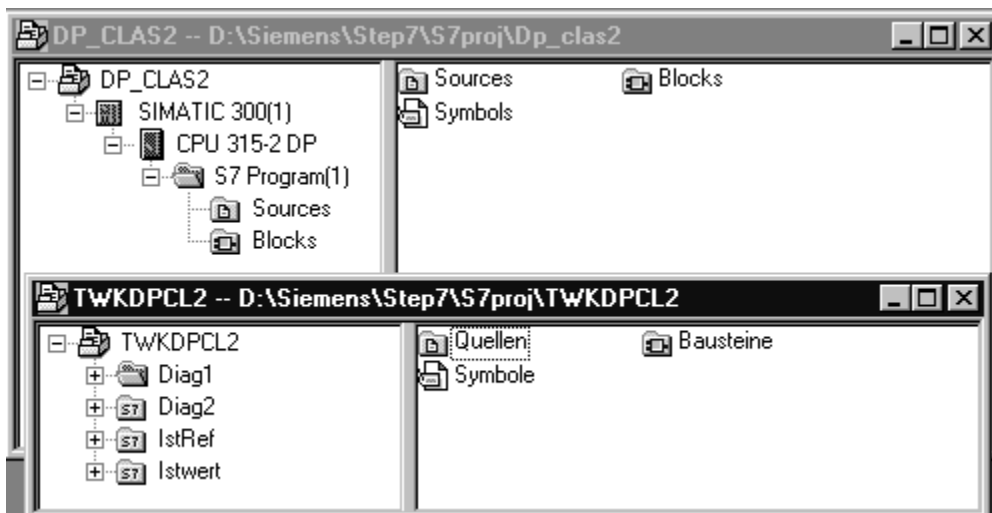
- Copy all of the module container's modules from the selected programme folder (e.g. Diag1 from TWKDPCL2) into your own project's still empty module container (e.g. S7 programme (1) from DP_CLAS2). (Note: Each module container, even an empty one, contains at least one OB1; this is, of course, also empty, and can therefore be overwritten.)

- If you have installed a class 2, 16 bit encoder, and have selected the ActualRef or Diag1/2 programme, you must, in order to set the preset value, release the FB10 in the OB1, i.e. supply the EN input with M 0.1 and block the FB11 (s), i.e. supply the EN input with M 0.0.

- If necessary, replace the M 1.0 – Acknowledge message and the M 10.0 (and M 10.1 in the case of two encoders) – Set the preset value, with your signals.

- Transfer all modules into the control system.

- Now call up the OB1 in the on-line view, and switch Test, Observe on, in order to have the current values of the encoder displayed on the monitor.

- For ActualRef and Diag1/2 programme only: Enter a preset value into DB100 data doubleword 0 (for the second encoder, DB100 data doubleword 8), and set this with the M 10.0 (or M 10.1). If the preset value lies outside of the parameterised measurement range of the encoder, the corresponding error message is set in OB1.

8.3.4 Explanations regarding the example programmes

Each programme folder contains a symbol table, which contains all global variables of the maximum expansion (class 2 project, Diag2 programme).

The programme structure of this maximum expansion is explained in the following. The reference data provide the following overview: (The symbolic name is always contained in the round brackets)

The entire diagnostic range of the disturbed encoder is always read out via system function SFC13 (16 bytes in the case of class 1 and 63 bytes in the case of class 2). The address of this slave is provided by OB82 in its local data.

Only the manufacturer-specific error message bits are evaluated, and of these, only those which may occur in Data Exchange Mode (in normal bus operation). Errors which can occur during bus initialisation cannot be detected by OB82. In this case, the error messages must be read out via the **Diagnosing hardware** function of the Step7 package.

9. Scope of delivery

The scope of delivery includes:
- Encoder with DP interface, optional connecting cap for triple connection technology
- Pin assignment   TY XXXXX (depending on the device variant)
- CRD 10617 user manual
- 3.5" diskette with GSD file, Typ5.X type file, Simatic S7 example software,
  user manual in PDF format

10. Literature

/1/   PROFIBUS Profile for Encoders
         Order No. 3.062
         1997, PROFIBUS User Organisation Regd. Assoc.
         Haid-und-Neu-Str. 7
         D-76131 Karlsruhe
/2/   PROFIBUS
         Brief Technical Description
         Version: April 1997
         PROFIBUS User Organisation
/3/   DIN 19245 Part 1
         PROFIBUS
         Process Field Bus
         Transmission Technology, Bus Access and Transmission Protocol,
         Service Interface for Application Layer, Management
/4/   DIN 19245 Part 3
         PROFIBUS
         Process Field Bus
         Decentralised Periphery (DP)
/5/   SIMATIC
         ET 200 Decentralised Periphery System
         Manual
         Order No.: 6ES5 998-3ES12
/6/   SIEMENS
         SINEC L2
         SPC 3 Siemens PROFIBUS Controller
         User Description
         Order No.: 6ES7 195-0BD00-8AA0

Appendix A: Definitions of terms

PROFIBUS	Process Fieldbus
PNO	PROFIBUS User Organisation Regd. Assoc., Karlsruhe
GSD	Device master data file, also see type file
DDLM	Direct Data Link Mapper
MAX Tsdr	This is the maximum time which a responder requires in the case of a certain baudrate, in order to respond to a request telegram (see GSD file).
Freeze Mode	DP slaves which support the Freeze Mode guarantee that the inputs are frozen. Following the Freeze control command, the frozen values are transmitted to the bus in the next data cycle.
Sync Mode	The DP slave device supports the synchronisation mode.

Appendix B: PROFIBUS-DP basic functions /2/

Transmission technology:	- RS-485 twisted two-wire lead or optical fibre
	- Baudrates of 9.6 kBit/s up to 12 MBit/s
Bus access:	- Token Passing procedure between the masters and master-slave
	procedure for communication between master and slaves
	- Mono-master or multi-master systems possible
	- Master and slave devices, max. 126 subscribers in the bus
Communication:	- Point to point (useful data traffic) or multicast (control commands)
	- Cyclical master-slave useful data traffic and acyclical master-
	master data transfer
Operating modes:	- Operate: Cyclical transmission of input and output data
	- Clear: Inputs are read, outputs remain in safe state
	- Stop: Only master-master data transfer is possible
Synchronisation:	- Control commands enable the synchronisation of the inputs and outputs
	- Sync Mode: Outputs are synchronised
	- Freeze Mode: Inputs are synchronised
Functionality:	- Cyclical useful data traffic between DP master and DP slave(s)
	- Dynamic activation or deactivation of individual DP slaves
	- Checking the configuration of the DP slaves
	- High-performance diagnostic functions, 3 graduated diagnostic message levels
	- Synchronisation of the inputs and/or outputs
	- Address allocation for the DP slaves via the bus
	- Configuration of the DP master (DPM class 1) via the bus
	- A maximum of 246 bytes of input and output data possible per DP slave
Protective functions:	- All messages are transmitted with Hamming distance HD = 4
	- Response monitoring in the case of the DP slaves
	- Access protection for DP slave inputs/outputs
	- Monitoring of useful data traffic with adjustable monitoring
	timer in the case of the master
Device types:	- DP master class 2, e.g. programming/project planning devices
	- DP master class 1, e.g. central automation devices such as SPS, PC ...
	- DP slaves, e.g. encoder

Appendix C: Encoder terms

Parameter:	Explanation
Measuring units per revolution:	The single turn resolution specifies the number of measuring units per revolution (360°).
Measuring range:	The measuring range specifies the maximum number of revolutions.
	Specification of the revolutions must be carried out in 2^n powers.
Total measuring range in units:	The total measuring range in units is revealed as follows:
	Total measuring range in units = Single turn resolution x Measuring range
Code sequence:	The code sequence specifies the direction of rotation in which the output code
	of the encoder corresponds to increasing 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)
Preset value:	The preset value is the value which appears in the encoder's output value parameter
	according to the preset function.