EnDat Interface

VERSION 2.2

Bidirectional synchronous-serial Interface for Position-Encoders

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⚠ Also see www.endat.de and EnDat Application Notes D722024

1 Bidirectional synchronous serial interface for position encoders

The interface described below is intended for the **serial transmission of digital data between linear encoders, rotary encoders or angle encoders, touch probes, accelerometers** and **subsequent electronics** such as numerical controls, servo amplifiers and programmable logic controllers etc. It features the following benefits:

- Can be used for absolute encoders and incremental encoders,
- Minimized transmission times for the position value. With applications in a closed control loop dead times are reduced and improved control responses are achieved,
- **Bidirectional interface** with the possibility for both the **customer** and the **encoder manufacturer** of saving **parameters in the encoder** and **exporting** these (commissioning is simplified),
- Support for **monitoring- and diagnostic functions** of the subsequent electronics,
- With **absolute position encoders** the **transmission** of connected values fundamentally occurs, meaning **independently of the method of determining the absolute position value** (gray code, PRC code, several incremental tracks with predefined differing grating period etc.), no non-identical evaluation in the subsequent electronics is required. The absolute position value is unsigned.
- Setting up safety-relevant systems is possible. Observe the catalog of measures!

EnDat 2.1 is a subset of the command set for EnDat 2.2.
Encoders with EnDat version 2.2 can be used as replacements for encoders with EnDat version 2.1.
If there are any deviations, they are described in the specifications.
EnDat 2.1 replacement encoders can sometimes also have the EnDat 2.2 command set.

2 Hardware

The bidirectional transfer of data (measured values and parameters) between the position encoder and subsequent electronics is implemented via transceiver components compliant to **RS 485** (differential signals), synchronous to a clock signal defined by the subsequent electronics (CLOCK). It is also possible to transmit and evaluate **sinusoidal incremental signals optionally** in the subsequent electronics to complement the serial data transfer. These have **signal levels of 1 Vpp.** See the encoder's specifications to see if it supports additional sinusoidal incremental signals.

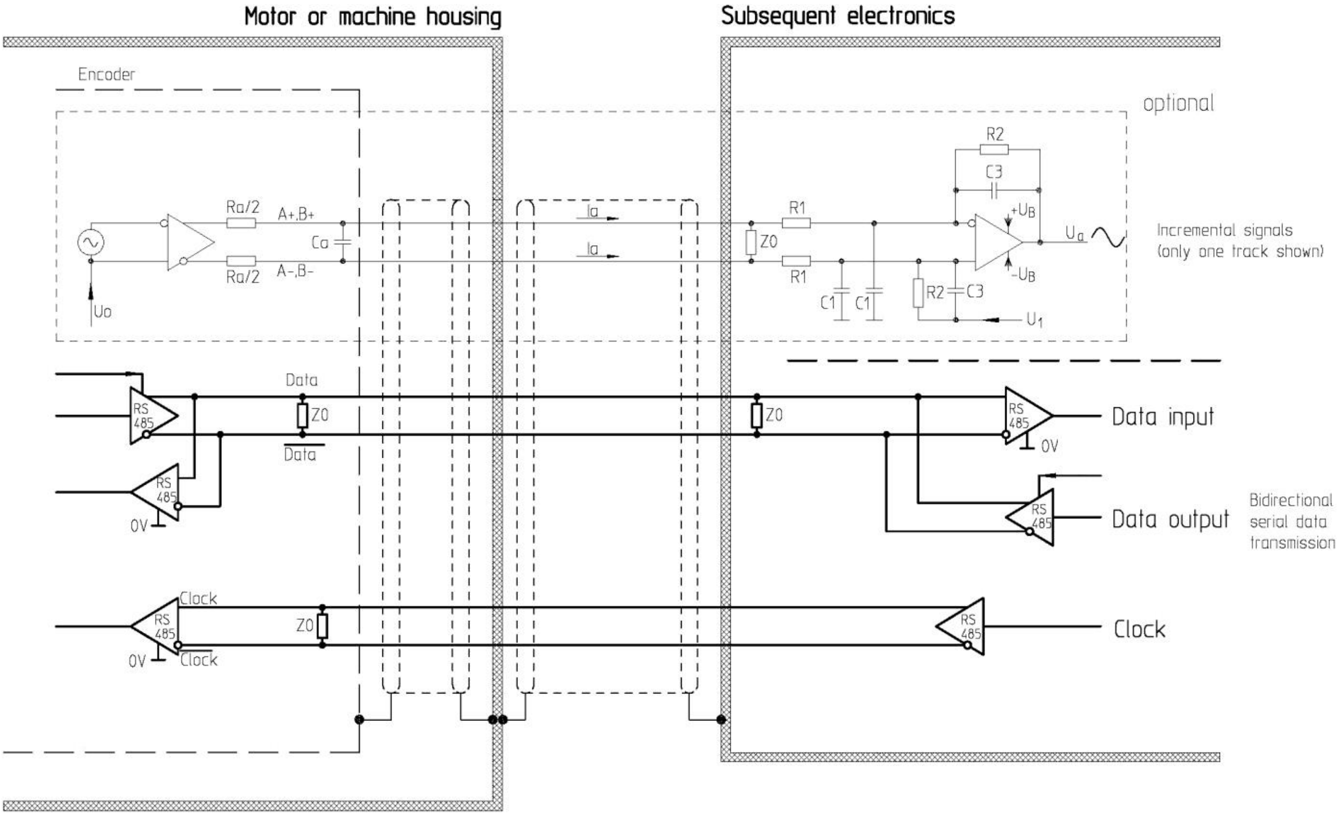


Figure 1

Ra < 100 ohms
Ca < 50 pF
$\sum$Ia < 1 mA
Uo = 2.5 V $\pm$ 0.5 V

Zo = 120 ohms
U1 $\approx$ Uo
RS 485 transceiver

The C1 and C3 capacitors are for improving the noise immunity.

⚠ The propagation times vary between the serially transferred data and the additional incremental signals. These differences depend on the encoder and the characteristics of the transmission path.

The maximum permissible clock pulse frequency depends upon the cable length and the subsequent electronics. With the subsequent electronics, two versions are fundamentally differentiated between:

- Without delay compensation
- With delay compensation

2.1 Versions of the subsequent electronics

2.1.1 Without delay compensation

The **clock pulse frequency** is **variable**. The **minimum possible clock pulse frequency** is **100 kHz**, and the **maximum possible clock pulse frequency is 2 MHz**. The **maximum permissible clock pulse frequency depends on the cable length** between the encoder and the subsequent electronics. The following diagram shows the maximum permissible clock pulse frequency f_c subject to the cable length L_K between the encoder and subsequent electronics with a duty cycle on the clock line of 1:1.

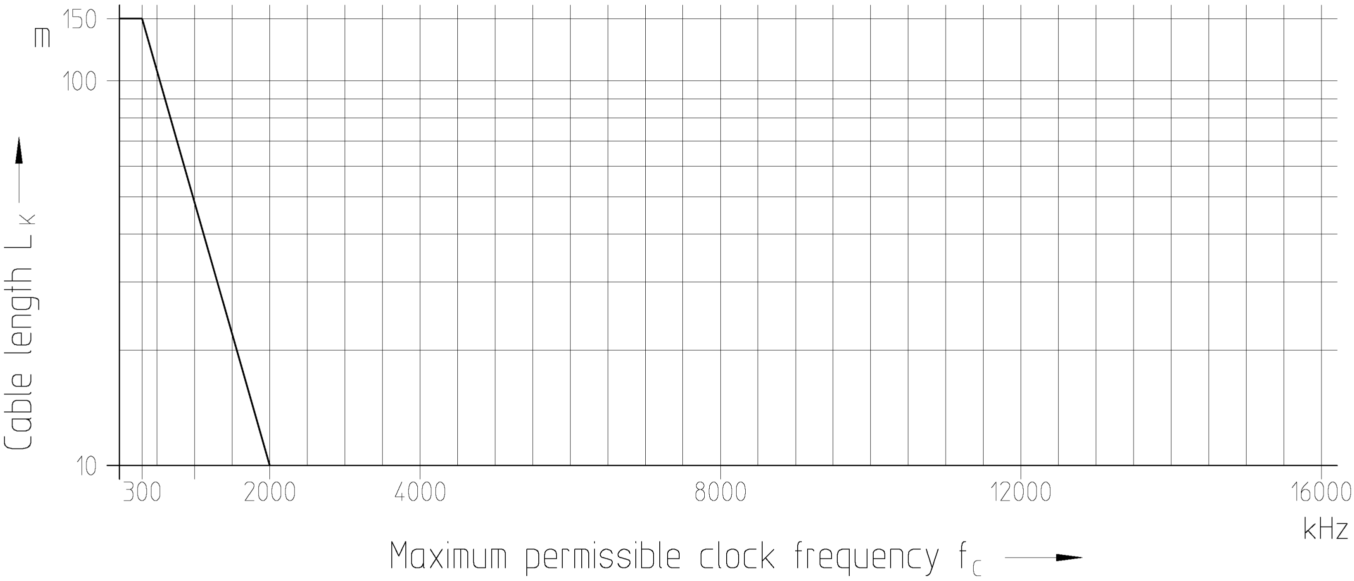


Figure 2

With deviating duty cycle $f_c = \frac{1}{2t_{min}}$ whereby for t_{min} the following relationship applies:

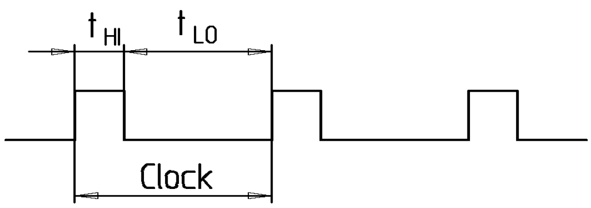
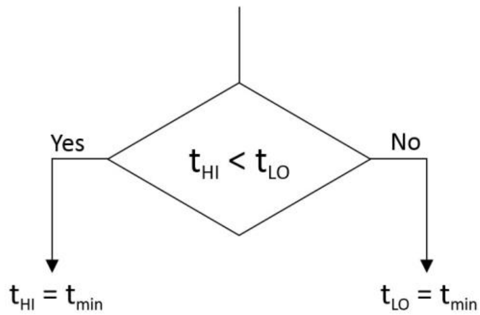


Figure 3



2.1.2 With delay compensation

With long cable lengths and high clock pulse frequency the propagation time on the transmission path assumes orders of magnitude that must be compensated to achieve unambiguous assignment to the data. The compensation is realized by calculating the propagation time and by its consideration in the subsequent electronics during data evaluation. Temperature variations must not influence the propagation time. This makes a maximum clock pulse frequency of 8 MHz possible, regardless of the cable length (maximum: 100 m). Under certain conditions cable lengths to 300m can be realized following consultation with HEIDENHAIN.
The clock pulse frequency of 8 to 16 MHz is intended for special applications.

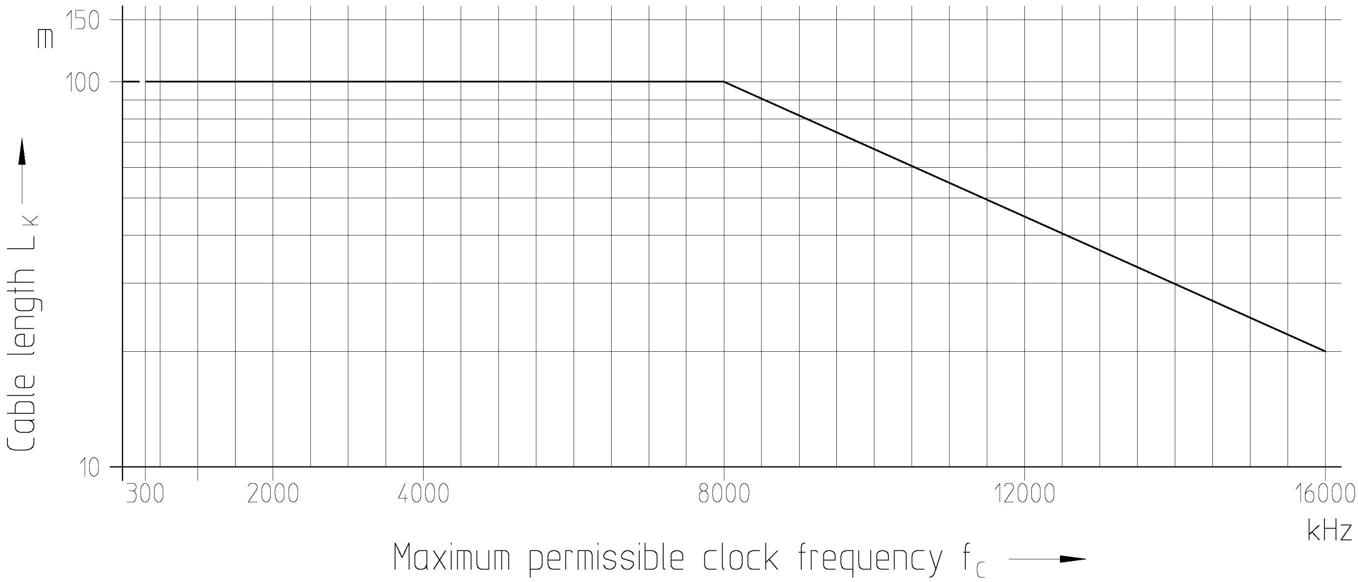


Figure 4

⚠ Pay attention to the attenuation and transmission behavior!

⚠ The description refers to standard applications with a maximum clock frequency of 8 MHz!

Calculation of the propagation time must be with reduced clock pulse frequency (100 kHz to 200 kHz) after each hardware modification to the transmission path, and must be implemented automatically following each power interruption. To achieve sufficient accuracy for the propagation time t_D (data delay time), scanning must be implemented with a significantly higher internal frequency than the maximum clock pulse frequency intended for subsequent data transfer.

For every rising clock pulse edge after the "Encoder send position values" mode command and after the transceiver has finished switching the encoder to sending, i.e. after every 10 clock pulse periods T, a counter must be started in the subsequent electronics. The value of the counter must be saved with every rising clock pulse edge of the start bit. This process should be repeated at least three times and consistency should be checked, in order to exclude interferences while determining the propagation time.

In all of the following pulse diagrams only the non-inverted signals are displayed in the interests of simplification.

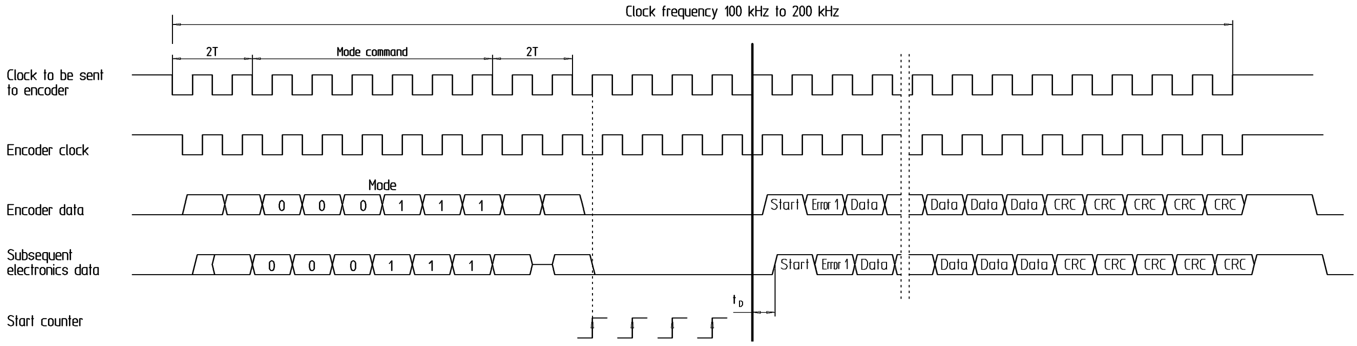


Figure 5

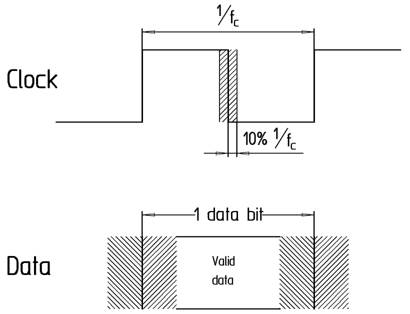


Figure 6

The frequency f_e for calculating the propagation time t_D must be several times greater than the maximum clock pulse frequency f_c intended for the subsequent data transfer. In order to ensure an accurate and interference-free value determination, the frequency for determining the propagation time can vary by a maximum of ±10%.

Example:

Maximum clock pulse frequency for subsequent data transfer f_c = 4 MHz → Frequency for determining the propagation time f_e = 4 MHz x 8 = 32 MHz; frequency tolerance ±3.2 MHz

This measurement must be carried out at least three times, and an arithmetic mean must be found. To guarantee unambiguous assignment of the data bits, the three measured values must not deviate from the calculated mean value by more than 1/8 of the pulse duration of the maximum clock pulse frequency f_c.

2.2 Signal assignment

With encoders with additional **sinusoidal incremental signals**, these can be used as **redundant position information** for supporting **machine safety concepts**. In this case it is necessary to check that the incremental position value agrees with the serially transferred position value. The position value is saved in the encoder with the falling clock edge (latch signal;→see point 2.3.1.1).

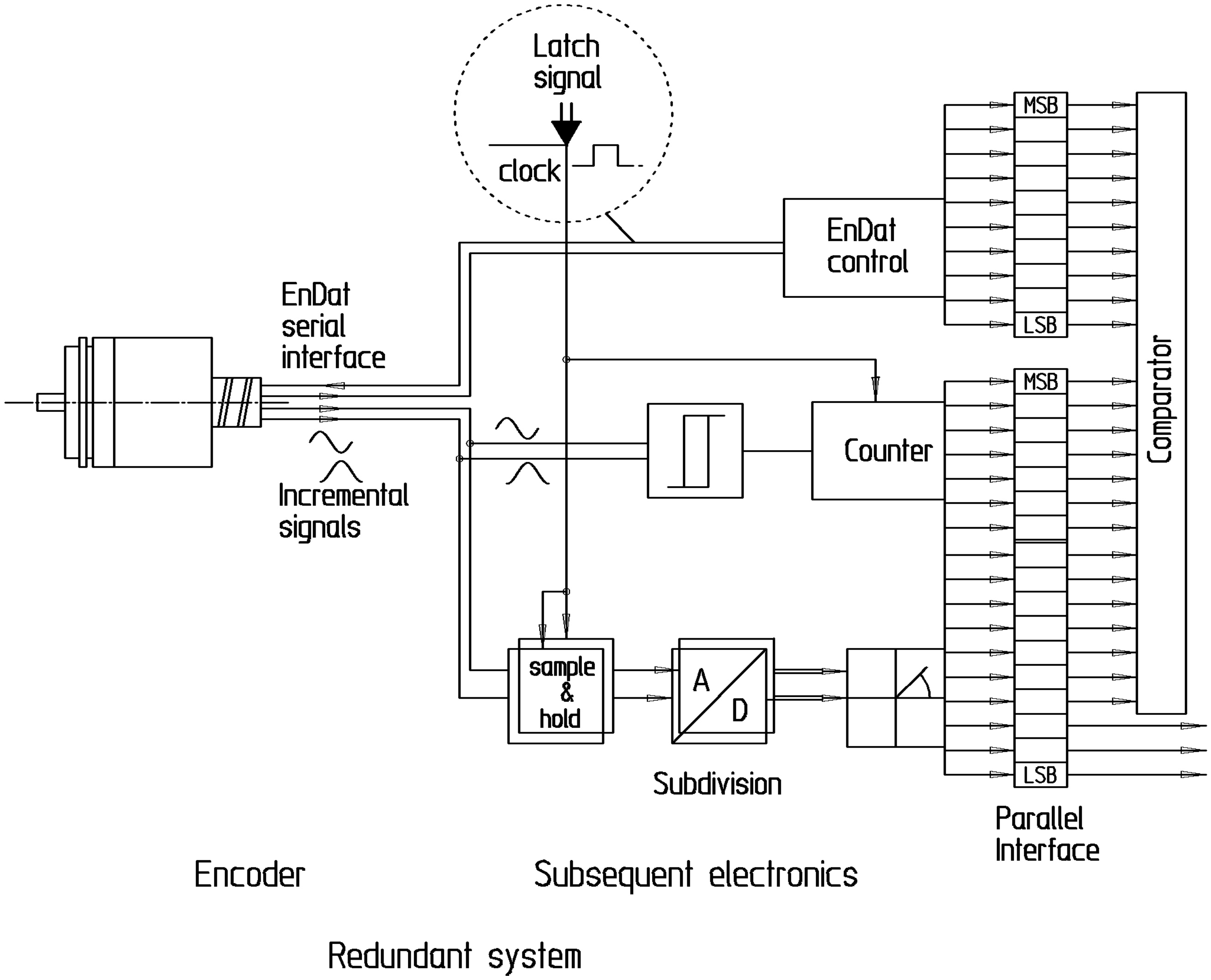


Figure 7

The accuracy ranges for this agreement vary depending on the rotational or traverse speed. The encoder manufacturer stores the relevant accuracy ranges for each encoder in the encoder's memory.

Encoders with pure serial data transfer also support machine safety concepts because monitoring takes place in the encoder and redundant additional data are transferred.

⚠ If the specified accuracy ranges are exceeded this must be detected by the safety-oriented application.

The incremental signals are assigned to the serially transferred position values as follows.

Sinusoidal incremental signals

Positive measuring direction

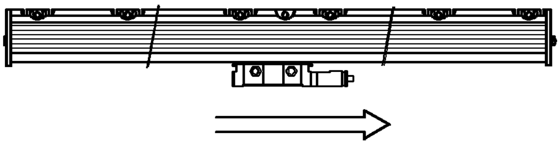


Figure 8

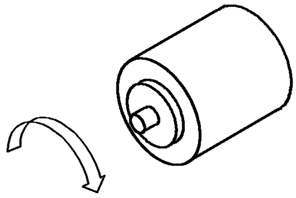
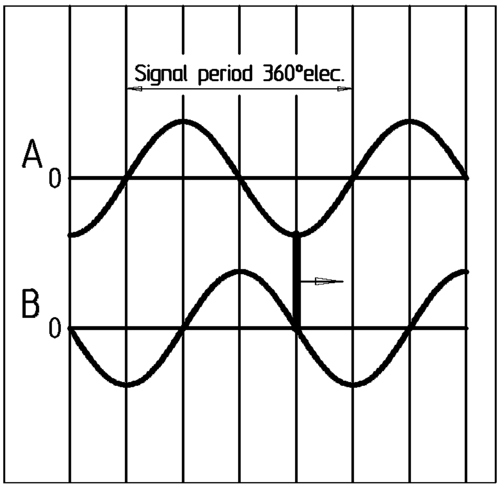


Figure 9



Output of zero position of serially transmitted position value to the incremental signal for increasing position values. The tolerance of the zero position depends on the encoder (see the specifications).

Figure 10

Signal	Level
A, B	approx. 1 V_{PP}

Suitable connecting elements and their pin layouts for encoders with EnDat interface are shown in **Appendix A1.**

2.3 Data transfer

With data transfer a differentiation is made between the **transfer of position values** and the **transfer of parameters**. The encoder can be recognized as an EnDat encoder before data transfer begins by the logic level on the data line. To gain an unambiguous level on the data lines, the flow diagram in accordance with **Appendix A5** and the power-on conditions (→see point 2.3.3) must be observed.

Encoders starting with EnDat version 2.2 support transfer of position values with additional data.

The **transfer type is selected** with **mode commands** that are sent to the encoder by the subsequent electronics. **The subsequent electronics** must send the respective **mode bit of these commands in synchronicity with the falling clock edge**. The encoder **accepts the mode bit** in **synchronicity with the rising clock edge**. To ensure reliable transfer of mode commands, the first three mode bits are transferred inverted or doubly, i.e. redundantly. If the encoder detects a faulty transfer of mode bits, an error message is generated as shown in **Appendix A2.** With each transfer and with the first falling clock edge, the send block in the encoder must be deactivated (t_{ST}, observe the time conditions). The send block is activated in the subsequent electronics with the second falling edge and the mode word is then transferred. After the mode word, the subsequent electronics deactivates the send block again and switches the encoder on (observe the propagation times,→see point 2.1.2). The subsequent electronics continue to transmit clock pulses to the encoder and observe the data line to detect the start bit. Following transfer of the data and the CRC, it can then be decided whether and to what extent additional data follows by determining the logic level on the data line. The transfer is terminated after expiry of a certain time (recovery time I).

⚠ With safety-oriented applications the propagation times and response times of the interface must be monitored.
Encoders supporting the mode command "Encoder receive communication command" must not be used for safety-oriented applications.

⚠ EnDat version 2.1 supports type 2.1 mode commands. Version 2.2 supports type 2.2 mode commands and type 2.1 commands.

Mode command	Model	Mode bit M2	M1	M0	(M2)	(M1)	(M0)
Encoder send position values	**2.1**	**0**	**0**	**0**	1	1	1
Encoder send position values with additional data	**2.2**	**1**	**1**	**1**	0	0	0
Selection of memory area	**2.1**	**0**	**0**	**1**	1	1	0
Encoder send position values and selection of memory area or of the additional data	**2.2**	**0**	**0**	**1**	0	0	1
Encoder send parameters	**2.1**	**1**	**0**	**0**	0	1	1
Encoder send position values and send parameter	**2.2**	**1**	**0**	**0**	1	0	0
Encoder receive parameters	**2.1**	**0**	**1**	**1**	1	0	0
Encoder send position values and receive parameter	**2.2**	**0**	**1**	**1**	0	1	1
Encoder receive reset	**2.1**	**1**	**0**	**1**	0	1	0
Encoder send position values and receive error reset	**2.2**	**1**	**0**	**1**	1	0	1
Encoder receive test command	**2.1**	**1**	**1**	**0**	0	0	1
Encoder send position values and receive test command	**2.2**	**1**	**1**	**0**	1	1	0
Encoder send test values	**2.1**	**0**	**1**	**0**	1	0	1
Encoder receive communication command	**2.2**	**0**	**1**	**0**	0	1	0

Independently of the mode command, with delay compensation a maximum clock pulse frequency of 8 MHz (16 MHz) is possible for data transfer up to 100 m of cable. The subsequent electronics must take the determined propagation time into account.
To avoid a collision on the data line, for data transfer with delay compensation it must be observed that for each transfer a Low Level t_{ST} for the first clock must not be exceeded. The time point at which the data is assumed by the subsequent electronics is the falling clock pulse edge plus the propagation time t_D.

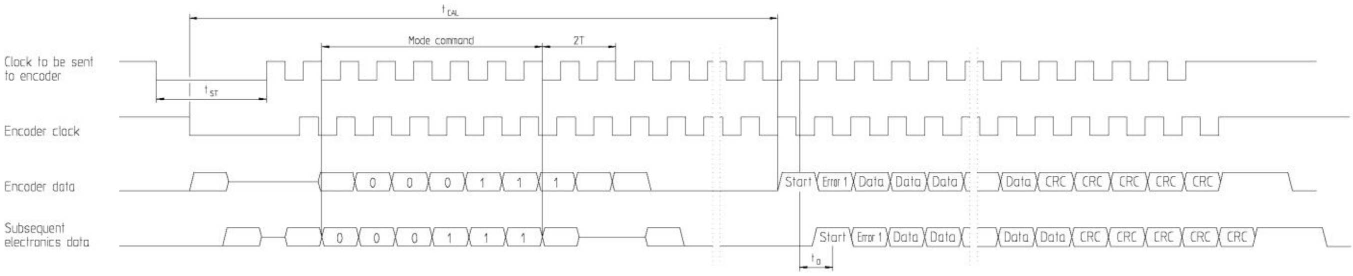


Figure 11

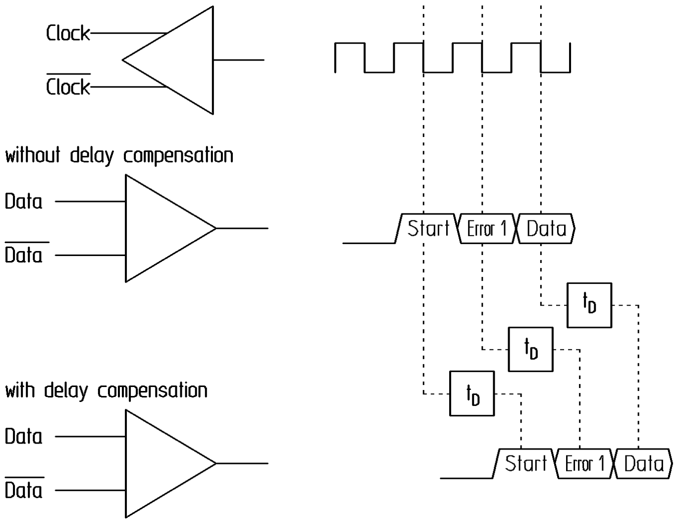


Figure 12

To guarantee unambiguous assignment to the data bit, the set Data Delay Time with a tolerance of ±10% x f_C must not be exceeded.

2.3.1 Transferring the Position Value

The position value is requested with one of the following mode commands:

M2	M1	M0	(M2)	(M1)	(M0)	
0	**0**	**0**	1	1	1	without additional data, EnDat 2.1
1	**1**	**1**	0	0	0	with additional data, EnDat 2.2

With transfer of the position value a differentiation is made between **interrupted and continuous clock.** The **interrupted clock** is intended particularly for **time-based systems**, **such as closed control loops**. A continuous clock is only possible with EnDat 2.1 with the mode command "Encoder send position values". This is achieved by sending once from the subsequent electronics only with the first data query of the mode command.

A continuous clock is only possible with the mode command "Encoder send position value 000111"
(see Figure 15).

2.3.1.1 Encoder send position values

The following mode command requests position values without additional data:

M2	M1	M0	(M2)	(M1)	(M0)
0	**0**	**0**	1	1	1

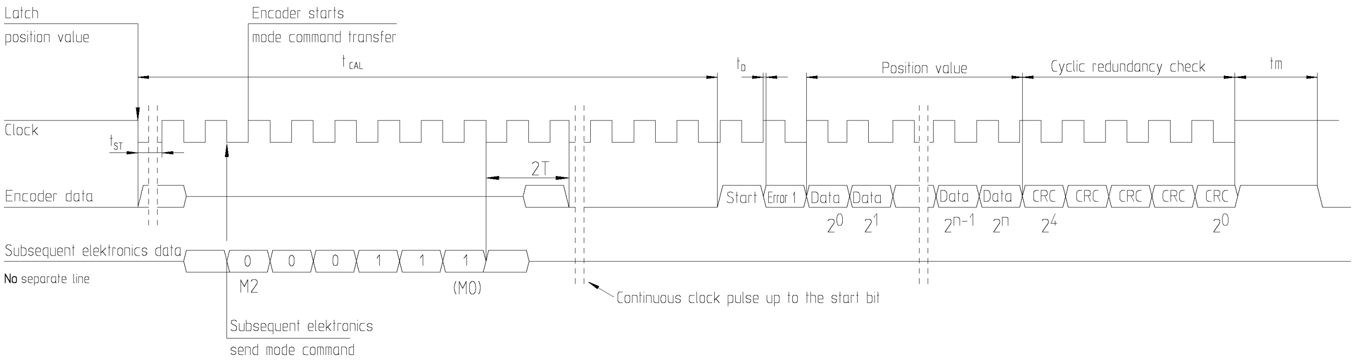


Figure 13

Interrupted clock

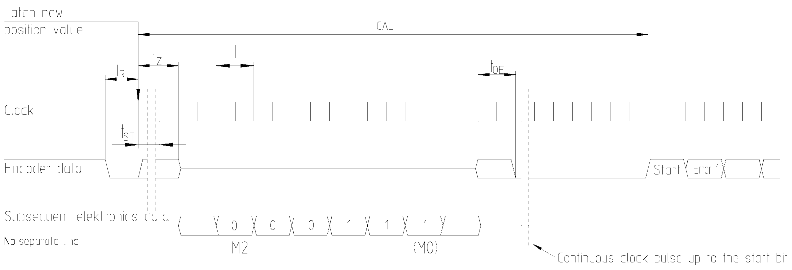


Figure 14

Continuous clock

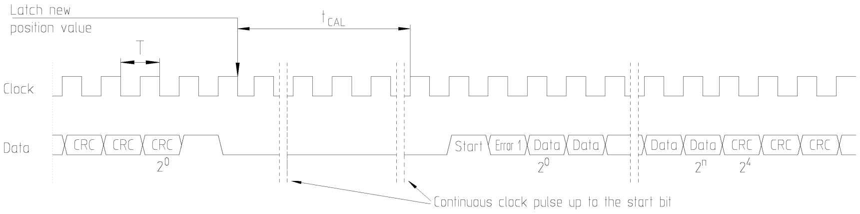


Figure 15

Independently of the t_{CAL}, a maximum of 7 Low Bits (internal synchronization) are inserted.

2.3.1.2 Encoder send position values with additional data

The following mode command can be used to request additional data, such as diagnostic values, commutating values, and acceleration values:

M2	M1	M0	(M2)	(M1)	(M0)
1	**1**	**1**	0	0	0

See the encoder specifications to determine which additional data are supported by the encoder. This information is also saved in the memory of the encoder for parameters compliant to EnDat 2.2 (word 0 and word 1).

Position values with one additional piece of information
Propagation time not included in this view

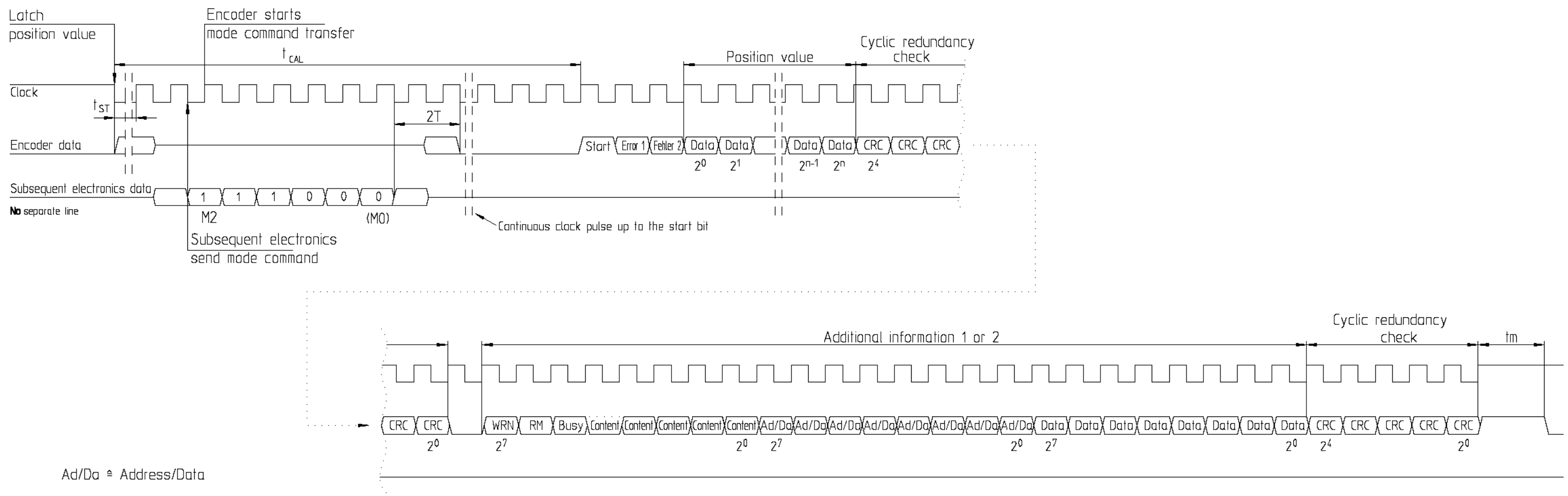


Figure 16

Position values with two additional pieces of information
Propagation time not included in this view

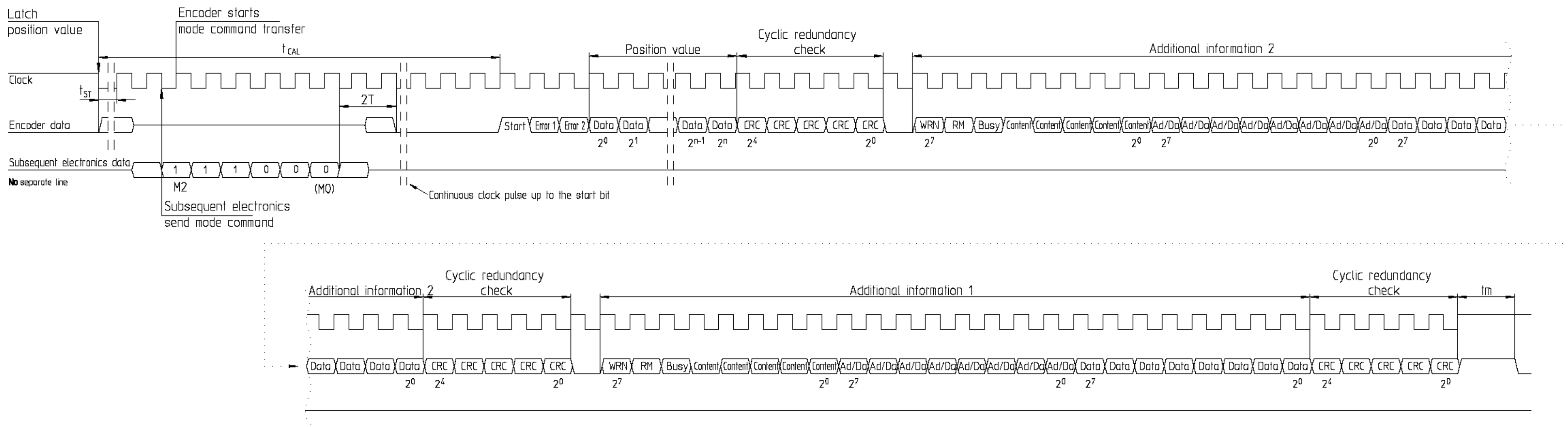


Figure 17

Start bit		Signals the beginning of data transfer
Error message 1	**0**	No error message 1
	1	Specifies that an error has occurred (group message). The cause for an error message 1 can be read from the memory of the encoder (→ see point 3.4.1 Error message).
Error message 2	**0**	Specifies that an error has occurred (group message). The reason for an error message 2 can be read from the memory of the encoder (→ see point 3.4.1 Error message).
	1	No error message 2
WRN bit	**0**	No warning
	1	Specifies that a warning has occurred (group message) The cause of the warning can be read from the encoder memory (→ see point 3.4.2 Warnings).
Busy bit	**0**	Ready for internal data processing (read/write), parameter interrogation possible
	1	Internal data processing (read/write) active ①
RM bit	**0**	Reference run not finished
	1	Reference run finished, absolute position value available. Already set with switch-on with absolute encoders.
Cyclic Redundancy Check (CRC)		The CRC serves to check that the data was transmitted correctly. CRC generation is implemented compliant to the method described in **Appendix A4**.

① If the busy bit is set to 1, new position values, acceleration and diagnostics continue to be determined and transferred. Only access to the encoder memory is disabled. Accordingly, an access attempt with EnDat 2.1 commands and the reset command with Busy = 1 is acknowledged by the encoder with a type II error message compliant to **Appendix A2**. Parameter access attempts with EnDat 2.2 commands will be ignored.

⚠ Error message 2 is only output with type 2.2 mode commands.
For safety-oriented applications, error message 2 is generated with a separate error detection unit. The safety-oriented application must request this additional data in order to receive redundant position values!

A position value transfer flowchart is shown in **Appendix A5**.

2.3.2 Timing conditions

The following table shows the values to be maintained with respect to the encoder:

Designation	Symbol	Minimum Without Delay compensation	Minimum With Delay compensation	Maximum Without Delay compensation	Maximum With Delay compensation
Frequency ④	f_c	100 kHz		2 MHz	8 MHz
Calculation time	t_{cal}	$\frac{10{,}5}{f_C}$		1 ms ⑦	
Memory access time for read/write parameters	t_{ac}	0		12 ms	
Recovery time I ⑤ **For type 2.1 mode commands**	t_m	10 µs		30 µs	
For type 2.2 mode commands	t_m	10 µs or 1.25 µs ③ ($f_c \geq 1$ MHz)		30 µs or 3.75 µs ③ ($f_c \geq 1$ MHz)	
Data delay time	t_D	0		$(0.2 + L_K \cdot 0.01)$ µs ① ②	
Recovery time II	t_R	500 ns ⑨		Any	
Recovery time III	t_{ST}		2 µs ⑧		See encoder specifications
Positive pulse width	t_{HI}	0.2 µs		10 µs	
Negative pulse width	t_{LO}	0.2 µs		See encoder specifications	
On-off ratio error			0%		±10%
Clock low to Data Inactive ⑥	t_Z			$T = \frac{1}{f_{C\,min}}$	
Clock low to Data Active ⑥	t_{OE}			T	
Time between cycle	t_b	EnDat 2.1 commands : $t_b > 1$ ms			

① L_K : Cable length in m

② Note the specific values for each cable!

③ Only valid if recovery time I is set to 1.25 µs $\leq t_m \leq$ 3.75 µs (word 3 bit $2^0 = 1$ and bit $2^1 = 0$; →see point 3.4.4)

④ Observe the cable length (→see point 2.1.1)!

⑤ To achieve shorter cycle times during transfer, it is possible to shorten the recovery time with type 2.2 mode commands (→see point 2.3.2.1).

⑥ On the encoder (observe the propagation times)

⑦ (depends on the encoder) see the technical data of the encoder

⑧ The 2 µs relate to a cable length of 100 m and can be reduced with a shorter cable. Recommendation for f_c = 2…8 MHz: t_{st} = 2µs specification for f_c = 16 MHz: t_{st} = 1µs (linear adaptation in range of 8…16 MHz t_{st})

⑨ Time before the next query can be received.

Only after expiry of the time t_{cal} can the position value be fetched from the encoder. To achieve shortest possible access times on the position value, the time t_{ST} (dependent on the cable length) and the necessary polling of the start bit must be taken into account. Polling the start bit must be independent of t_{CAL}; this means clock pulses must be continuously sent to enable the encoder to send the start bit. This is necessary for the synchronization of the encoder with the clock pulse from the subsequent electronics. To obtain an encoder-independent, optimized access time on the position value the position query should always be performed with the maximum possible clock pulse frequency (depending on the cable, cable length etc.).
The precise values of t_{cal} should be requested from the encoder manufacturer.

2.3.2.1 Overview of mode commands

		Mode bit					
	Mode command	**M2**	**M1**	**M0**	**(M2)**	**(M1)**	**(M0)**
	Encoder send position values	**0**	**0**	**0**	1	1	1
	Selection of memory area	**0**	**0**	**1**	1	1	0
	Encoder receive parameters	**0**	**1**	**1**	1	0	0
Type 2.1 (As of EnDat version 2.1)	**Encoder send parameters**	**1**	**0**	**0**	0	1	1
	Encoder receive reset	**1**	**0**	**1**	0	1	0
	Encoder send test values	**0**	**1**	**0**	1	0	1
	Encoder receive test command	**1**	**1**	**0**	0	0	1
	Encoder send position values with Additional data	**1**	**1**	**1**	0	0	0
	Encoder send position values and selection of the memory area	**0**	**0**	**1**	0	0	1
	Encoder send position values and receive parameter	**0**	**1**	**1**	0	1	1
Type 2.2 (As of EnDat version 2.2)	**Encoder send position values and send parameter**	**1**	**0**	**0**	1	0	0
	Encoder send position values and receive test command	**1**	**1**	**0**	1	1	0
	Encoder send position values and receive error reset	**1**	**0**	**1**	1	0	1
	Encoder receive communication command	**0**	**1**	**0**	0	1	0

2.3.3 Power-on conditions

The information refers to measurements at the encoder.

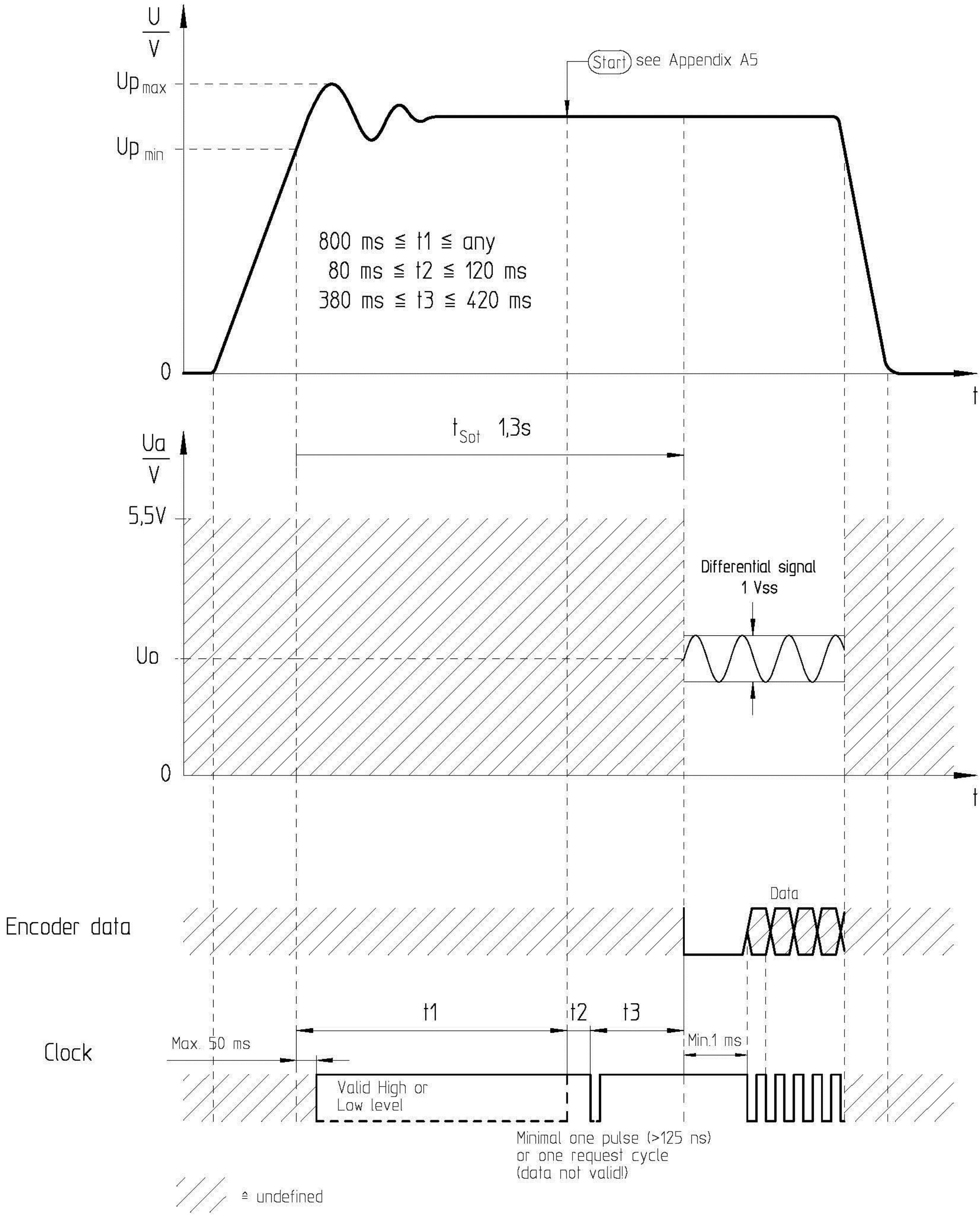


Figure 18

2.3.4 Transfer format for position values

The format for transmitting the position value is variable in length and depends on the respective encoder. The **time for transmitting the position value** to the subsequent electronics is **minimized** with EnDat**.** The number of clock pulses required for transmission of the position value (without mode-, start-, error- and CRC bits) must be read from the memory area of the encoder manufacturer.

The **position value** is **always output in binary code**. A differentiation is made between **multiturn rotary encoder** and **singleturn rotary encoder**, **absolute linear encoder** or **incremental encoder and touch probes**. The subsequent electronics must support a **data width of the position value** of 48 bits.

2.3.4.1 Multiturn rotary encoder

Clock ①	1	• • •	S	S+1	• • •	S+M
Data	LSB_S	• • •	MSB_S	LSB_M	• • •	MSB_M
	2^S: Measuring steps per revolution			2^M: Number of distinguishable revolutions		

S Singleturn

M Multiturn

① Clock pulse period with respect to the position value

Example: Multiturn rotary encoder 4096 distinguishable revolutions (≙ 12 bit)
8192 measuring steps per revolution (≙ 13 bit)

Clock	1	2	3	4	5	6	7	8	9	10	11	12	13
Data	2^0	2^1	2^2	2^3	2^4	2^5	2^6	2^7	2^8	2^9	2^{10}	2^{11}	2^{12}
	Measuring steps per revolution												

Clock	14	15	16	17	18	19	20	21	22	23	24	25
Data	2^0	2^1	2^2	2^3	2^4	2^5	2^6	2^7	2^8	2^9	2^{10}	2^{11}
	Distinguishable revolutions											

2.3.4.2 Singleturn rotary encoder, absolute linear encoder

Clock ①	1	• • •	n
Data	LSB	• • •	MSB
	2^n: Measuring steps, i.e. measuring steps per revolution		

① Clock pulse period with respect to the position value

Example: Singleturn rotary encoder with 65,536 measuring steps per revolution (≙16 bit)

Clock	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Data	2^0	2^1	2^2	2^3	2^4	2^5	2^6	2^7	2^8	2^9	2^{10}	2^{11}	2^{12}	2^{13}	2^{14}	2^{15}
	Measuring steps per revolution															

2.3.4.3 Incremental encoders

In principle, incremental encoders transmit relative position values. After switching on the supply voltage, the momentary signal period is output when interrogating the relative position of the interpolation value.

Clock ①	1	• • •	n
Data	LSB	• • •	MSB
	2^n: Measuring steps with respect to the relative position		

① Clock pulse period with respect to the position value

Example: Incremental encoder with 65,536 measuring steps per revolution (≙ 16 bit)

Clock	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Data	2^0	2^1	2^2	2^3	2^4	2^5	2^6	2^7	2^8	2^9	2^{10}	2^{11}	2^{12}	2^{13}	2^{14}	2^{15}
	Measuring steps with respect to the relative position															

While relative position values can already be transmitted after switch-on, to gain absolute position values it is necessary to "cross" a reference mark (or two sequential reference marks with encoders with distance-coded reference marks). This "crossing" is designated in the RM status bit.

The information

- Reference run finished, i.e. absolute position value available, and
- Position value 2

can be requested with the "Encoder send position values with additional data" mode command.

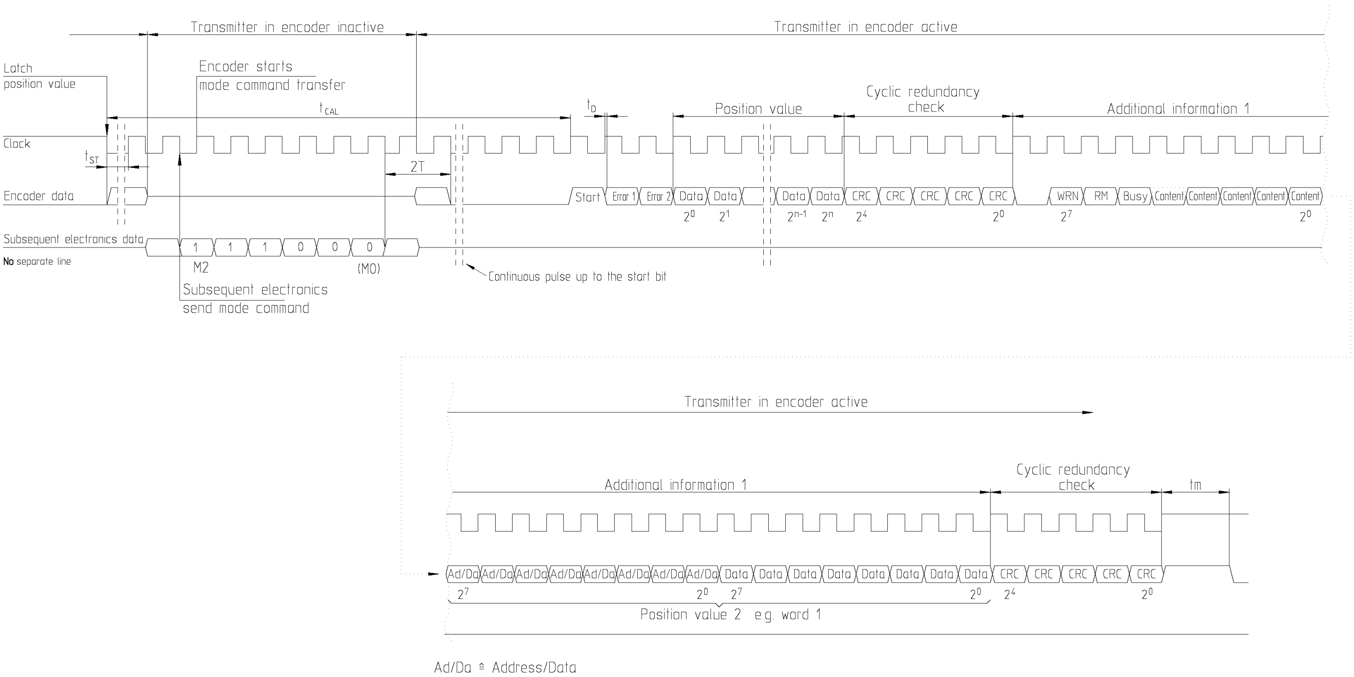


Figure 19

Incremental rotary encoder with one reference mark

Shown without datum shift

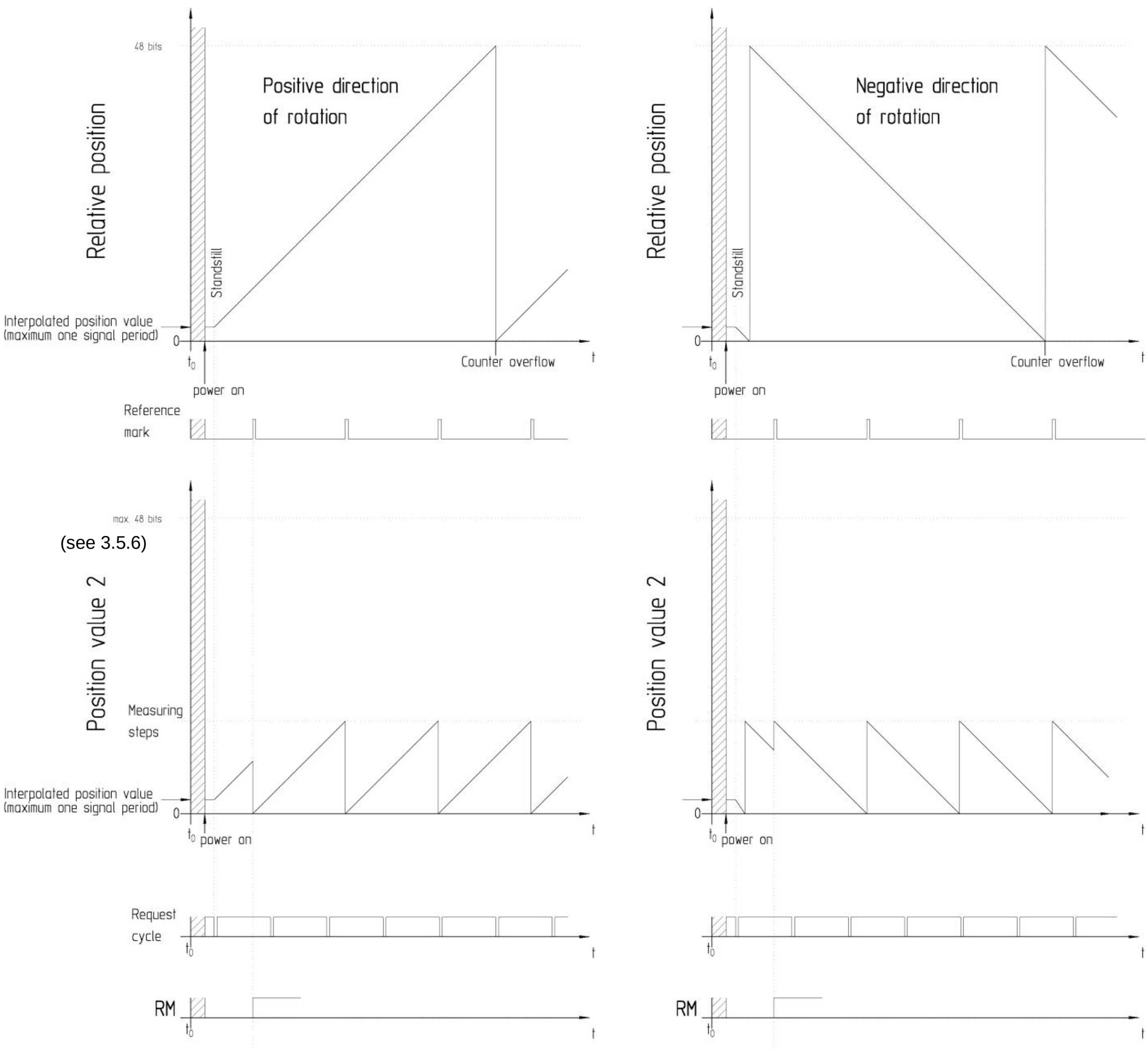


Figure 20

⚠ Because data packages with 16 bits are always output as additional data, several interrogation cycles must be executed with encoders with position resolutions of greater than 16 bits to gain a complete position value 2.

Incremental linear encoder with one reference mark

Shown without datum shift

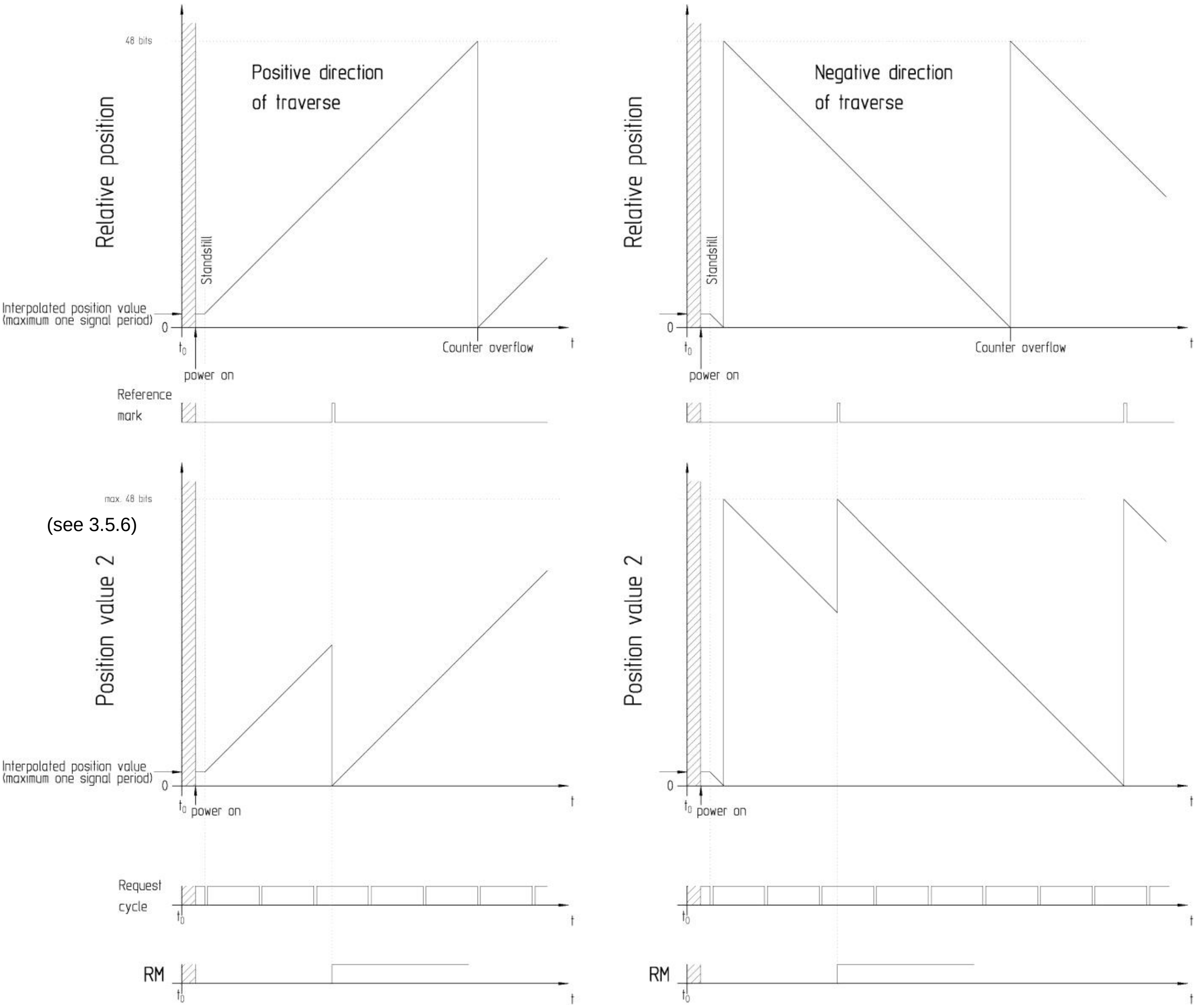


Figure 21

⚠ Because data packages with 16 bits are always output as additional information, several interrogation cycles must be executed with encoders with position resolutions of greater than 16 bits to gain a complete position value 2.

Incremental rotary encoder with distance-coded reference marks

Shown without datum shift

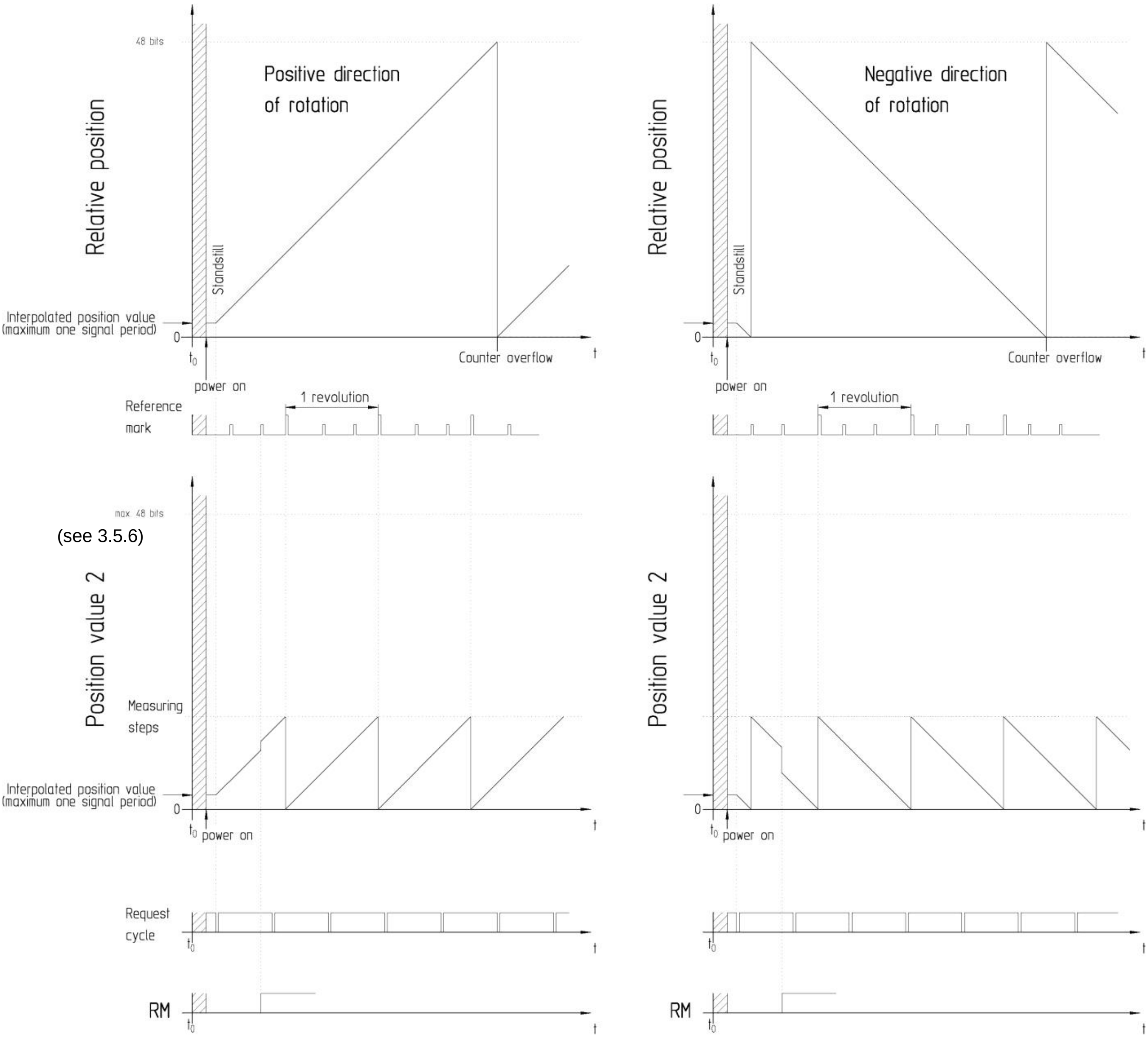


Figure 22

⚠ Because data packages with 16 bits are always output as additional information, several interrogation cycles must be executed with encoders with position resolutions of greater than 16 bits to gain a complete position value 2.

incremental linear encoder with distance-coded reference marks
Shown without datum shift

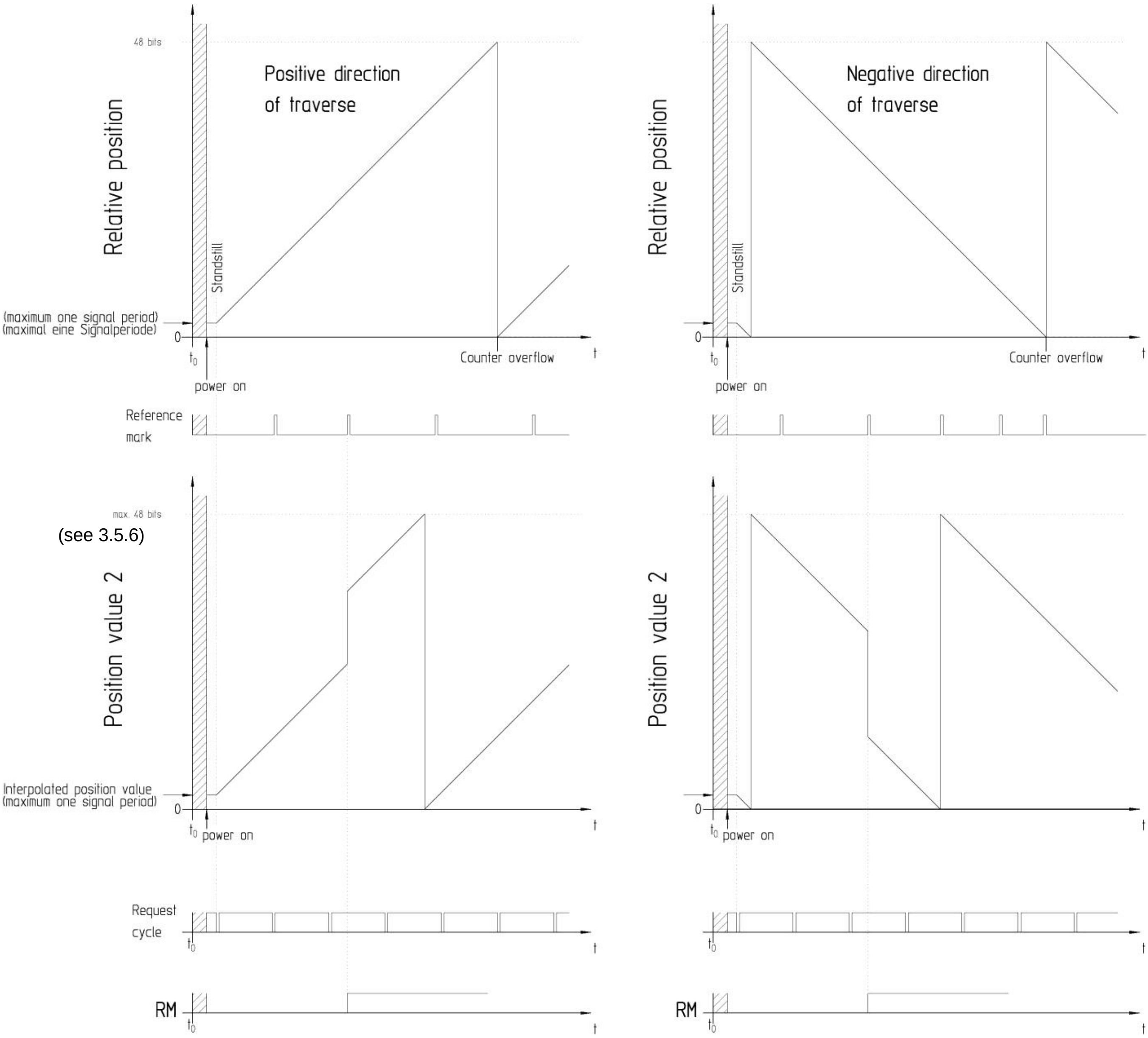


Figure 23

⚠ Because data packages with 16 bits are always output as additional data, several interrogation cycles must be executed with encoders with position resolutions of greater than 16 bits to gain a complete position value 2.

Incremental linear encoder with equidistant reference marks
Shown without datum shift

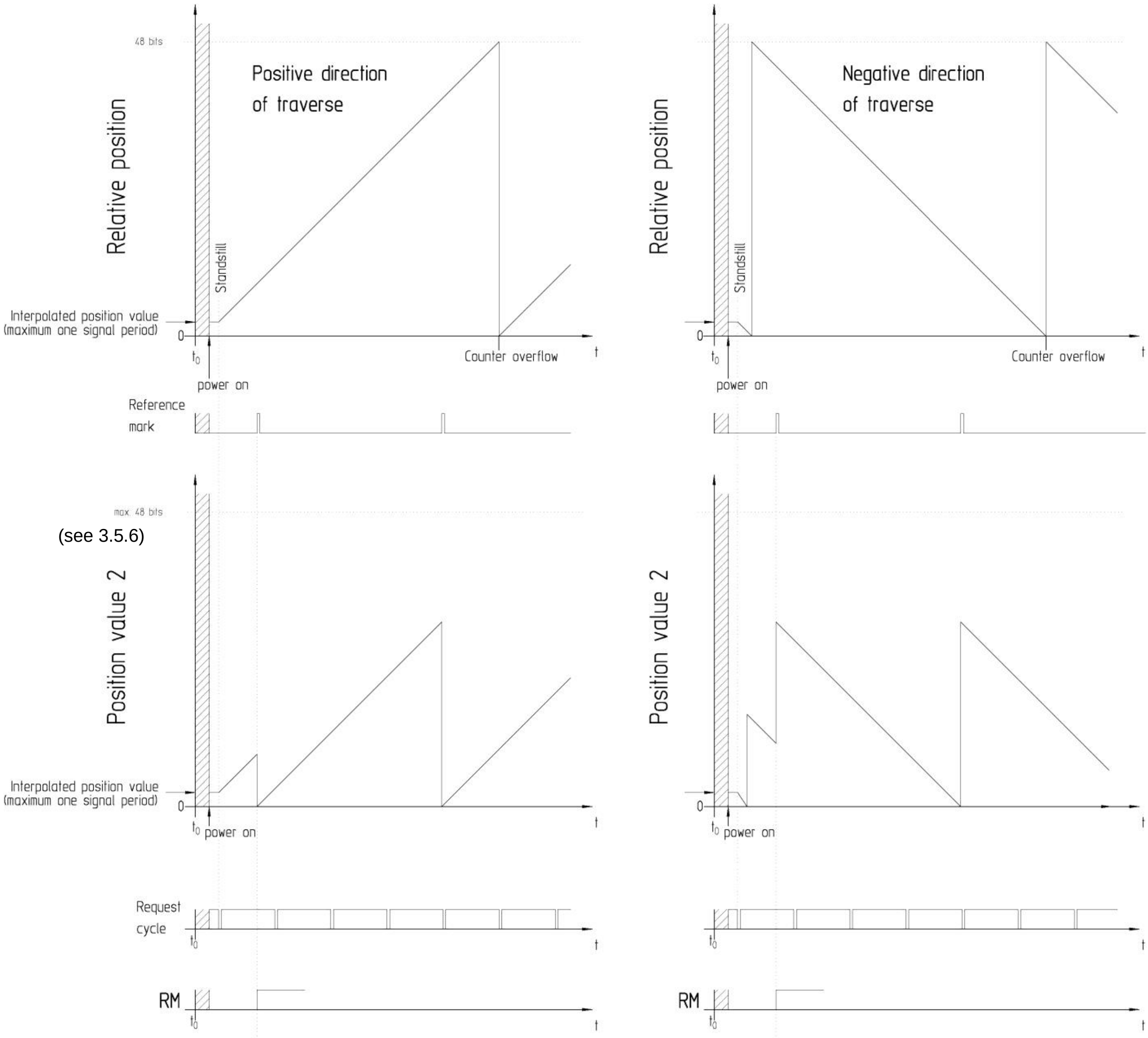


Figure 24

Because data packages with 16 bits are always output as additional data, several interrogation cycles must be executed with encoders with position resolutions of greater than 16 bits to gain a complete position value 2.

Depending on the encoder, reference marks can be selected using the hardware.

2.3.4.4 Transfer format for touch probes

The format for data transfer has 16 bits for touch probes. The LSB indicates to the trigger status of the system that the next 15 bits may contain differing information.

Clock ①	1	• • •	16
Data	LSB	• • •	MSB
	Trigger status	TBD	

① Clock pulse period with respect to the position value

2.3.5 Transfer format for additional data

The format for transfer of additional data always has 24 bits.

Clock ①	0	...				7	8	...	15	16	...	23
Data	**Status & information** Byte 0						**Address or data** Byte 1			**Data** Byte 2		
	WRN	RM	Busy	I4	...	I0	MSB	...	LSB	MSB	...	LSB
	Status			Information			A7/D7		A0/D0	D7		D0

① Clock pulse period with respect to the additional data

2.3.5.1 Additional data 1

The status information (WRN; RM; Busy) and information about the data content of the following two bytes are defined in byte 0:

I4 - I0 binary	**Byte 0**	**Byte 1**		**Byte 2**
0	No data content is transferred (NOP) ①	Any		Any
1	Diagnosis ②	Address		Data
2	Position value 2 word 1 LSB	MSB data		LSB data
3	Position value 2 word 2	MSB data		LSB data
4	Position value 2 word 3 MSB	MSB data		LSB data
5	Memory parameters	Address		LSB data
6	Memory parameters	Address		MSB data
7	MRS Code	MRS code		Any ④
8	Acknowledgment of test command	Port address		Any
9	Test values word 1 LSB	MSB data		LSB data
10	Test values word 2	MSB data		LSB data
11	Test values word 3 MSB	MSB data		LSB data
12	Temperature sensor 1	MSB data		LSB data
13	Temperature sensor 2	MSB data		LSB data
14	Additional sensors	4-bit address	4 bits MSB data	LSB data
15	Type III error handling ③	Any		Any

① →See point 2.4.2.2
② →See Appendix 4.3
③ →See Appendix 4.2
④ This block address is transferred with units supporting expansion of memory area Section 2. (→see point 2.4.2)

Example: Position value 2 word 2

I4	I3	I2	I1	I0
0	0	0	1	1

The additional data located in byte 0 can be selected or deselected with the "Selection of memory area or of additional data" mode command. The information is transmitted until a new "Select additional data" mode command is sent. After a reset or power-on, the position value is sent without any additional data until the first selection of additional data. To ensure synchronization between position value and position value 2 or test values, the position value 2 or test values are always updated by querying the first word or the test values LSB. The corresponding words 2 and 3 can then be retrieved.
If further sensors are queried these cannot be addressed directly but must be queried until the desired sensor is sent. The address is increased by X+1 each interrogation cycle.

Addresses 0 to 2 of the additional information **"Additional sensors"** have a fixed meaning and are reserved for capturing the motor temperature via external temperature sensors:

Address	Meaning
0	Temperature 1
1	Temperature 2
2	Temperature 3

The meaning of addresses 3 to 15 is dependent on the unit or application and can be viewed in the encoder documentation.
The so-called "leading temperature" is output via the additional information "temperature sensor 1". According to the number of external temperature sensors activated or that can be connected to the encoder (see point 3.6.8), the following value is output via this additional information:
One temperature sensor: Value of this temperature sensor
More than one temperature sensor: Maximum of the numerical values of the available temperature sensors

The single values of the temperature sensors can be queried via the "additional sensors" additional information if this is supported by the encoder.

Caution: Because the "additional sensors" are output in 12 bit format, an offset of 115 K is applied to these (see point 3.9.6).

2.3.5.2 Additional data 2

The status information (WRN; RM; Busy) and information about the data content of the following two bytes are defined in byte 0:

<table>
<tr><th>I4 - I0 binary</th><th>Byte 0</th><th colspan="6">Byte 1</th><th>Byte 2</th></tr>
<tr><td>16</td><td>No data content is transferred (NOP)</td><td colspan="6">Any</td><td>Any</td></tr>
<tr><td rowspan="2">17</td><td rowspan="2">Commutation</td><td>u</td><td>v</td><td>w</td><td colspan="3">Currently not assigned</td><td rowspan="2">Currently not assigned</td></tr>
<tr><td>D7</td><td>D6</td><td>D5</td><td>D4</td><td></td><td>D0</td></tr>
<tr><td>18</td><td>Acceleration</td><td colspan="6">MSB data</td><td>LSB data</td></tr>
<tr><td rowspan="2">19</td><td rowspan="2">Commutation & acceleration</td><td>u</td><td>v</td><td>w</td><td colspan="3">MSB acceleration data</td><td rowspan="2">LSB acceleration data</td></tr>
<tr><td>D7</td><td>D6</td><td>D5</td><td>D4</td><td>...</td><td>D0</td></tr>
<tr><td rowspan="2">20</td><td rowspan="2">Limit position signals</td><td>L1</td><td>L2</td><td colspan="4">Currently not assigned</td><td rowspan="2">Currently not assigned</td></tr>
<tr><td>D7</td><td>D6</td><td>D5</td><td colspan="2"></td><td>D0</td></tr>
<tr><td rowspan="2">21</td><td rowspan="2">Limit position signals & acceleration</td><td>L1</td><td>L2</td><td>Currently not assigned</td><td colspan="3">MSB acceleration data</td><td rowspan="2">LSB acceleration data</td></tr>
<tr><td>D7</td><td>D6</td><td>D5</td><td colspan="2"></td><td>D0</td></tr>
<tr><td>22</td><td>Position value asynchronous / Position value 2 ② Word 1 LSB</td><td colspan="6">MSB data</td><td>LSB data</td></tr>
<tr><td>23</td><td>Position value asynchronous / Position value 2 ② Word 2</td><td colspan="6">MSB data</td><td>LSB data</td></tr>
<tr><td>24</td><td>Position value asynchronous / Position value 2 ② Word 3 MSB</td><td colspan="6">MSB data</td><td>LSB data</td></tr>
<tr><td>25</td><td>Operating status error sources</td><td colspan="6">MSB data</td><td>LSB data</td></tr>
<tr><td>26</td><td>Reserved</td><td colspan="6"></td><td></td></tr>
<tr><td>27</td><td>Timestamp</td><td colspan="6">MSB data</td><td>LSB data</td></tr>
<tr><td>:
:</td><td></td><td colspan="6"></td><td></td></tr>
<tr><td>31</td><td>Type III error handling ①</td><td colspan="6">Any</td><td>Any</td></tr>
</table>

① See Appendix 4.2

② Position value 2 in additional data 2 is a special function and in normal cases is not supported by encoders that output a position 2 via additional data 1.

u, v, w ≙ commutation

See the encoder specifications for the commutation signals and their allocation to the absolute position value.

E.g. limit position signals

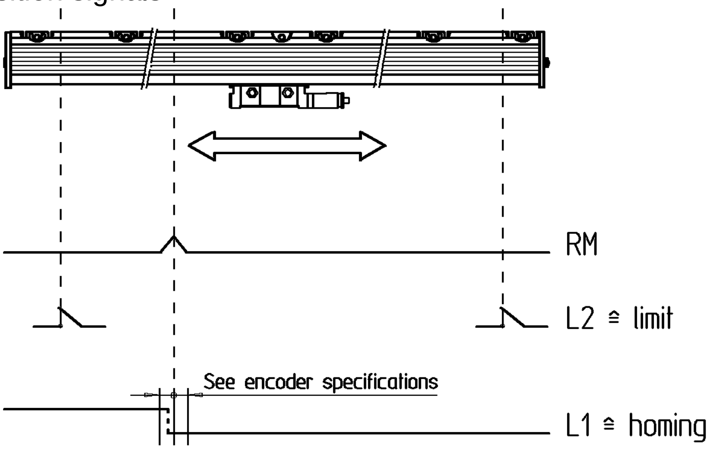


Figure 25

⚠ The additional data is only output if it is selected once with a "Selection of memory area" mode command. The additional data selected in byte 0 are transmitted until another selection from byte 0 is chosen, or a reset is commanded.

2.3.5.3 Operating status error sources

The operating status error sources provide a detailed breakdown of the error messages. The EnDat 2.2 parameter "Support of operating status error sources" includes information about whether and which error messages are supported by the respective encoder.

Clock ①	0	Byte 0 (25)				7	8	Byte 1						15	16	Byte 2						23
Data		Status & information					Address or data								Data							
	WRN	RM	Busy	I4	...	I0	MSB	...						LSB	MSB	...						LSB
	Status			Information			A7/D7							A0/D0	D7							D0
Operating status error sources							M Battery	Overflow/Underflow	M Power interruption	M System	M Pos2	M Pos1	S Power interruption	S System	S Pos2	Temperature exceeded	Overcurrent	Undervoltage	Overvoltage	S Pos1	Signal amplitude	Lighting

Figure 26

① Clock pulse period with respect to the additional data

⚠ Operating status error sources cannot be subjected to forced dynamic sampling. Through forced dynamic sampling of the error messages, several operating status error sources can set an error bit.

2.4 Selection of memory area

In order to **send or read parameters**, the **memory area** must **first** be **selected**. This is done with the mode command, followed by a code for the memory area to be selected—the Memory Range Select (MRS) code. The encoder acknowledges the command.

The following mode command is required to select the memory area:

M2	M1	M0	(M2)	(M1)	(M0)
0	**0**	**1**	1	1	0

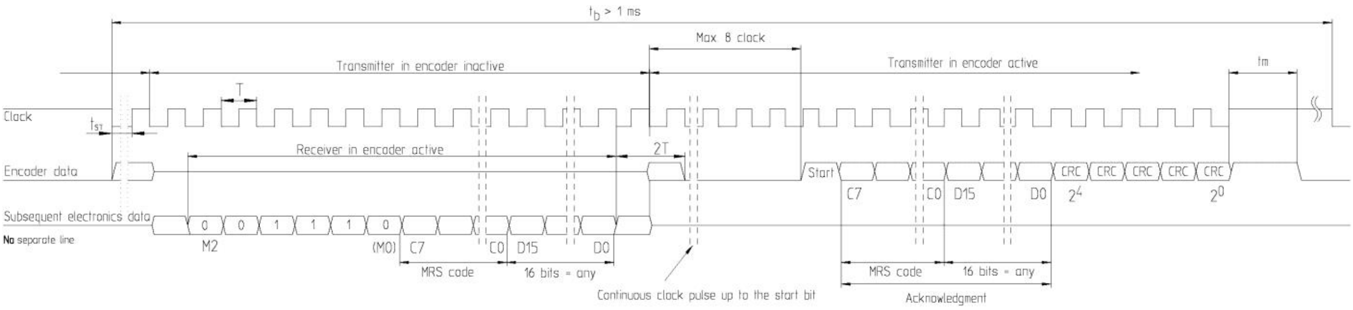


Figure 27

2.4.1 MRS Code for selecting the EnDat 2.1 memory area

If a **non-permissible memory area** is received by the encoder an error message is output compliant to **Appendix A2**. The memory area is then selected as shown in the table.

	MRS code C7	C6	C5	C4	C3	C2	C1	C0	Number of assigned words	Address area
Operating status	1	0	1	**1**	**1**	**0**	**0**	1	4	00_{hex} - 03_{hex}
Parameters of the encoder manufacturer	1	0	1	**0**	**0**	**0**	**0**	1	12	04_{hex} - $0F_{hex}$
	1	0	1	**0**	**0**	**0**	**1**	1	16	00_{hex} - $0F_{hex}$
	1	0	1	**0**	**0**	**1**	**0**	1	16	00_{hex} - $0F_{hex}$
Operating parameters	1	0	1	**0**	**0**	**1**	**1**	1	16	00_{hex} - $0F_{hex}$
Parameters of the OEM	1	0	1	**0**	**1**	**0**	**0**	1	See Point 3.7	
	1	0	1	**0**	**1**	**0**	**1**	1		
	1	0	1	**0**	**1**	**1**	**0**	1		
	1	0	1	**0**	**1**	**1**	**1**	1		
Compensation values of the encoder manufacturer	1	0	1	**1**	**0**	**0**	**0**	1	See Point 3.8	
	1	0	1	**1**	**0**	**0**	**1**	1		
	1	0	1	**1**	**0**	**1**	**0**	1		
	1	0	1	**1**	**0**	**1**	**1**	1		

Then the subsequent electronics sends the mode command "Encoder **send** parameter" with the desired address and with the assigned parameters, or "Encoder **receive** parameter" with the desired address. If more clock pulses than required are sent with this transmission, an error message is output compliant to **Appendix A2.**

2.4.2 Encoder send position value and Selection of memory area or block address (as of EnDat version 2.2)

The following mode command is necessary in order to request a position value and to select the memory area or block address in the same cycle:
The block address is used for addressing further Section 2 memory areas (→see point 3.2).

M2	M1	M0	(M2)	(M1)	(M0)
0	**0**	**1**	0	0	1

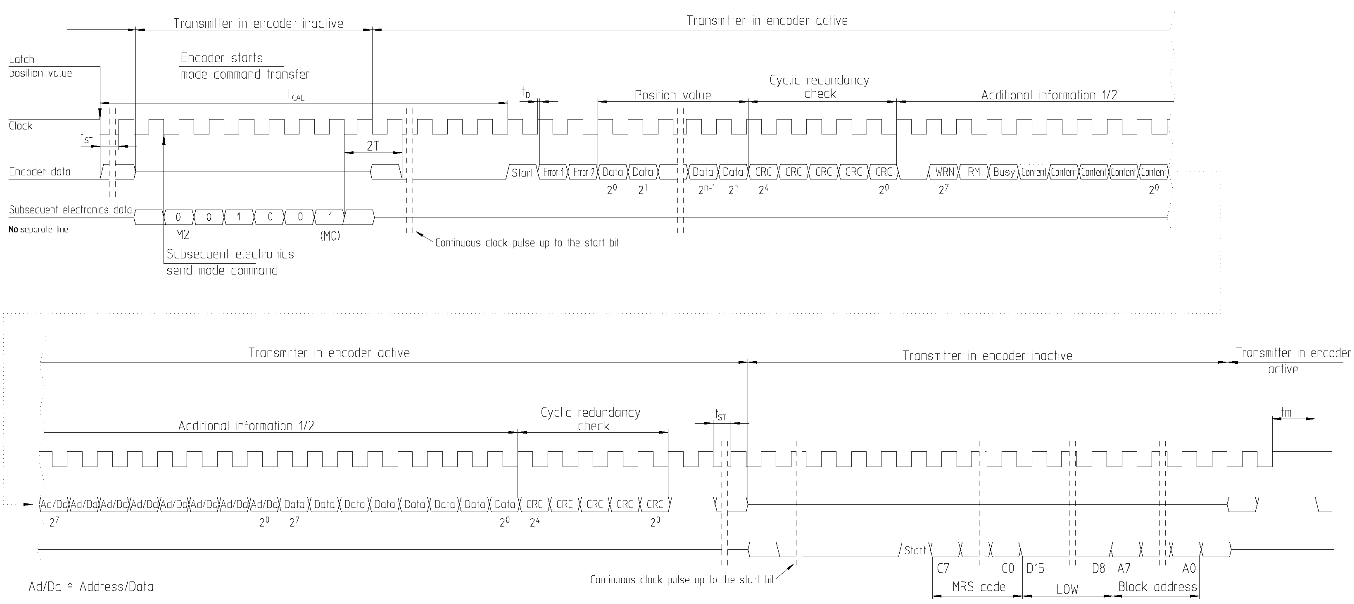


Figure 28

	A7	A6	A5	A4	A3	A2	A1	A0
Block 0	0	0	0	0	0	0	0	0
Block 1	0	0	0	0	0	0	0	1
Block 2	0	0	0	0	0	0	1	0
Block 3	0 : :	0 : :	0 : :	0 : :	0 : :	0 : :	1 : :	1 : :

To prevent a collision between the data drivers, following transmission of the position value and CRC it must be monitored if an error (→see Appendix 4.2) has occurred during the transmission.

The number of blocks supported can be seen in Word 24 "Parameters of the encoder manufacturer for EnDat 2.2."

2.4.2.1 MRS code for selecting the memory area (as of EnDat Version 2.2)

If a **non-permissible memory area** is received by the encoder or more clock pulses than necessary are sent, an error message is output compliant to **Appendix A2**. The memory area is then selected as shown in the table.

	MRS code C7	C6	C5	C4	C3	C2	C1	C0	Number of assigned words	Address area
Operating status	1	0	1	**1**	**1**	**0**	**0**	1	4	00_{hex} - 03_{hex}
Parameters of the encoder manufacturer	1	0	1	**0**	**0**	**0**	**0**	1	12	04_{hex} - $0F_{hex}$
	1	0	1	**0**	**0**	**0**	**1**	1	16	00_{hex} - $0F_{hex}$
	1	0	1	**0**	**0**	**1**	**0**	1	16	00_{hex} - $0F_{hex}$
Operating parameters	1	0	1	**0**	**0**	**1**	**1**	1	16	00_{hex} - $0F_{hex}$
Parameter of the OEM	1	0	1	**0**	**1**	**0**	**0**	1	See Point 3.7	
	1	0	1	**0**	**1**	**0**	**1**	1		
	1	0	1	**0**	**1**	**1**	**0**	1		
	1	0	1	**0**	**1**	**1**	**1**	1		
Compensation values of the encoder manufacturer	1	0	1	**1**	**0**	**0**	**0**	1	See Point 3.8	
	1	0	1	**1**	**0**	**0**	**1**	1		
	1	0	1	**1**	**0**	**1**	**0**	1		
	1	0	1	**1**	**0**	**1**	**1**	1		
Parameters of the encoder manufacturer for EnDat 2.2	1	0	1	**1**	**1**	**1**	**0**	1	64	00_{hex} - $3F_{hex}$
Parameters of the section 2 memory area	1	0	1	**1**	**1**	**1**	**1**	1	see Point 3.7 and 3.9.18	
Operating parameters 2	1	0	1	**1**	**1**	**0**	**1**	1	see Point 3.10	

The MRS code for the "Parameters of the encoder manufacturer for EnDat 2.2" can only be set with the mode command "Encoder send position value and selection of the memory area or block address".
The EnDat 2.2 parameters can then be read out with EnDat 2.1 commands. The time conditions 2.3.2 must be adhered to.

2.4.2.2 MRS code for selecting the additional data

The additional data are selected as shown in the table.
The configurations supported are indicated in **word 0** and **word 1** in the "Parameters of the encoder manufacturer for EnDat 2.2" area.
After switch-on or after a reset, no additional data are transmitted until the MRS code for selection of the additional data.

C7	C6	C5	C4	C3	C2	C1	C0	MRS code for selecting the additional data	
			I4	I3	I2	I1	I0	**Acknowledgment of selection of additional data**	
0	1	0	0	0	0	0	0	Send additional data 1 without data content (NOP) ①	Additional data 1
0	1	0	0	0	0	0	1	Send diagnostic values	
0	1	0	0	0	0	1	0	Send position value 2 word 1 LSB	
0	1	0	0	0	0	1	1	Send position value 2 word 2	
0	1	0	0	0	1	0	0	Send position value 2 word 3 MSB	
0	1	0	0	0	1	0	1	Acknowledge memory content LSB	
0	1	0	0	0	1	1	0	Acknowledge memory content MSB	
0	1	0	0	0	1	1	1	Acknowledge MRS code	
0	1	0	0	1	0	0	0	Acknowledge test command	
0	1	0	0	1	0	0	1	Send test values word 1 LSB	
0	1	0	0	1	0	1	0	Send test values word 2	
0	1	0	0	1	0	1	1	Send test values word 3 MSB	
0	1	0	0	1	1	0	0	Transmit temperature 1	
0	1	0	0	1	1	0	1	Send temperature 2	
0	1	0	0	1	1	1	0	Additional sensors	
0	1	0	0	1	1	1	1	Stop sending additional data 1 ②	
0	1	0	1	0	0	0	0	Send additional data 2 without data contents ①	Additional data 2
0	1	0	1	0	0	0	1	Transmit commutation	
0	1	0	1	0	0	1	0	Send acceleration	
0	1	0	1	0	0	1	1	Send commutation & acceleration	
0	1	0	1	0	1	0	0	Send limit position signals	
0	1	0	1	0	1	0	1	Send limit position signals & acceleration	
0	1	0	1	0	1	1	0	Asynchronous position value word 1 LSB	
0	1	0	1	0	1	1	1	Asynchronous position value word 2	
0	1	0	1	1	0	0	0	Asynchronous position value word 3 MSB	
0	1	0	1	1	0	0	1	Operating status error sources	
0	1	0	1	1	0	1	0	Currently not assigned	
0	1	0	1	1	0	1	1	Timestamp	
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	Reserved Extension planned	
0	1	0	1	1	1	1	1	Stop sending additional data 2 ②	

③ See Figure 29

① Send additional data without data contents

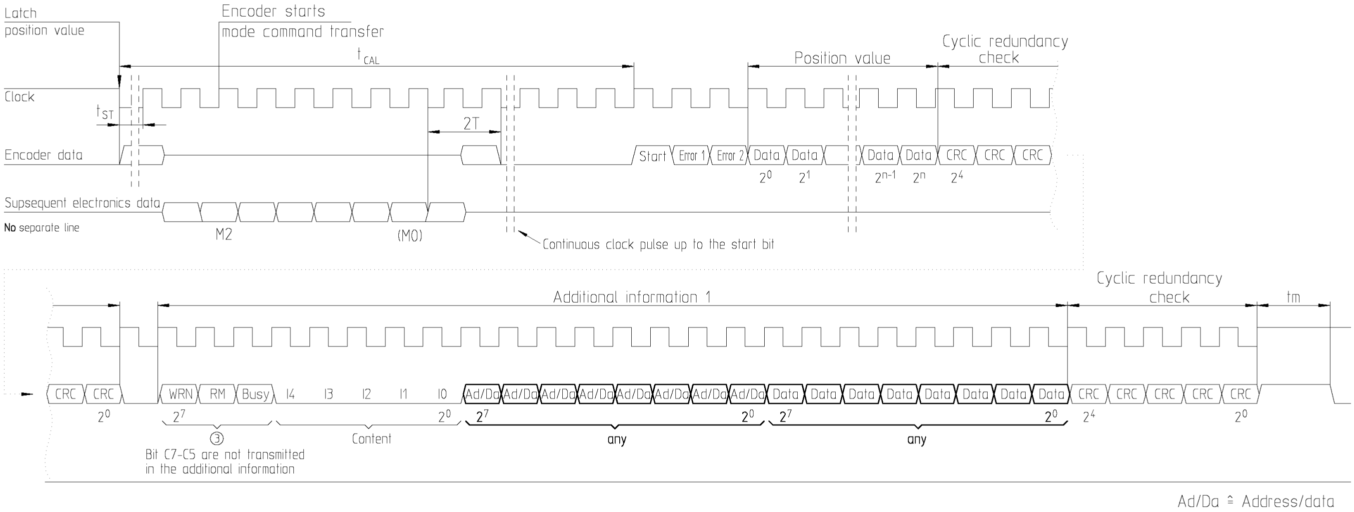


Figure 29

② Stop sending additional data

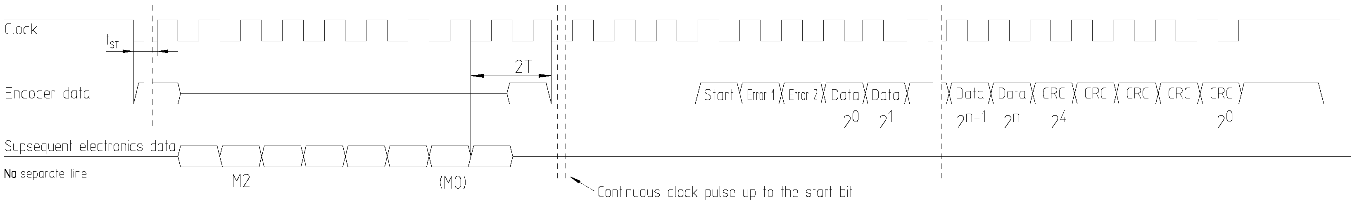


Figure 30

2.4.2.3 MRS code for selecting the asynchronous position

The selection of an asynchronous position produced by the oversampling is via the following MRS code.
After switch-on or a reset, the asynchronous position is transferred with time delay 0 until the MRS code selection.

	MRS code								**Number of assigned words**	**Address area**
	C7	**C6**	**C5**	**C4**	**C3**	**C2**	**C1**	**C0**		
Asynchronous position value	0	1	1	0	0	0	0	0	256	00_{hex} - FF_{hex}

	A7	**A6**	**A5**	**A4**	**A3**	**A2**	**A1**	**A0**
Time delay 0	0	0	0	0	0	0	0	0
Time delay 1	0	0	0	0	0	0	0	1
Time delay 2	0	0	0	0	0	0	1	0
	:	:	:	:	:	:	:	:

The exact evaluation of the oversampling is described in the specifications.

2.5 Encoder send parameters

The following mode command is required for reading parameters:

M2	M1	M0	(M2)	(M1)	(M0)
1	0	0	0	1	1

Reading is from the memory area previously selected as valid.

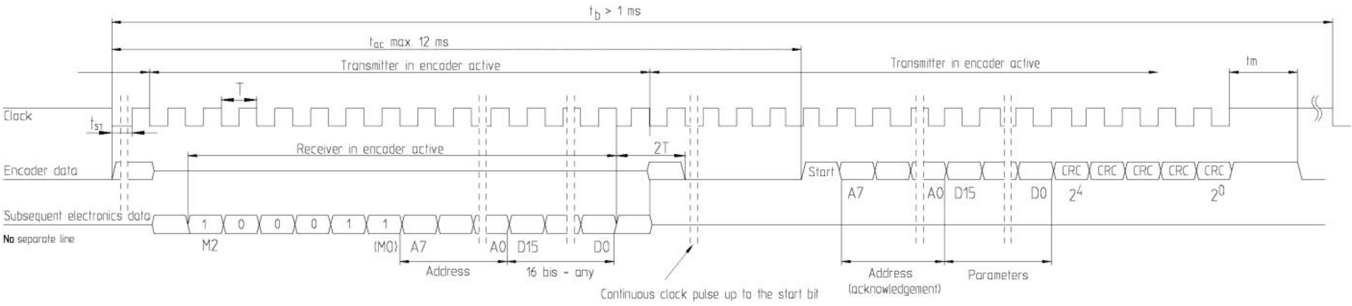


Figure 31

2.5.1 Encoder send position value and send parameter

The following mode command is necessary if you want to request a position value and in the same cycle send parameters necessary for read access:

M2	M1	M0	(M2)	(M1)	(M0)
1	**0**	**0**	1	0	0

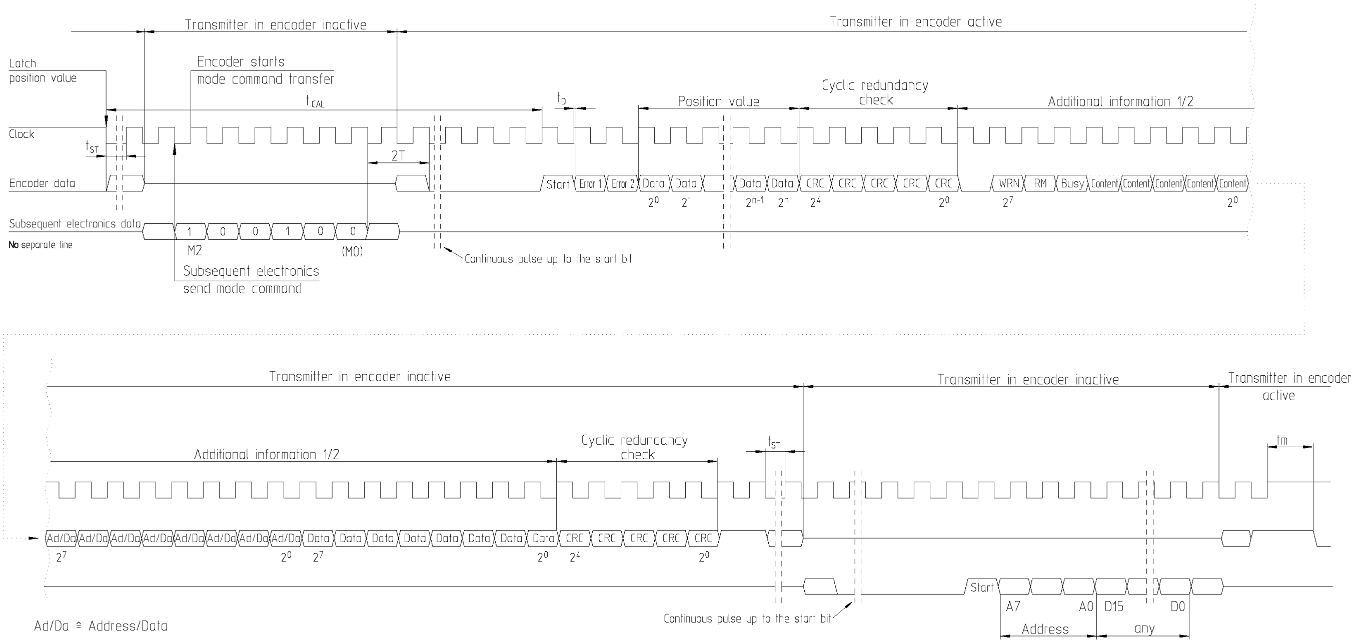


Figure 32

To prevent a collision between the data drivers, following transmission of the position value and CRC it must be monitored if an error (→see Appendix 4.2) has occurred during the transmission.
The data or confirmations must be sent with additional data 1. As long as processing of the data in the encoder is not complete, the busy bit is set to logical 1 in the first byte of the additional data. During this time no further write access, read access or reset, also not after type 2.1 mode commands, must be performed.

⚠ The data can only be read after the encoder has reset the busy bit. This means an additional information must be queried between the commands for reading or sending of parameters in order to interrogate the status of the busy bit.

2.6 Encoder receive parameters

The following mode command is required for writing parameters:

M2	**M1**	**M0**	**(M2)**	**(M1)**	**(M0)**
0	**1**	**1**	1	0	0

The memory area previously selected as valid is written to.

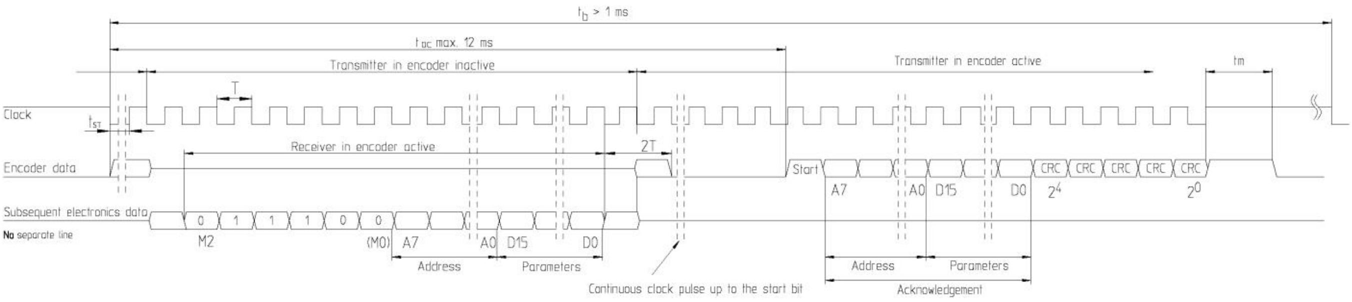


Figure 33

2.6.1 Encoder send position value and receive parameter

The following mode command is necessary in order to request a position value and write parameters in the same cycle:

M2	M1	M0	(M2)	(M1)	(M0)
0	**1**	**1**	0	1	1

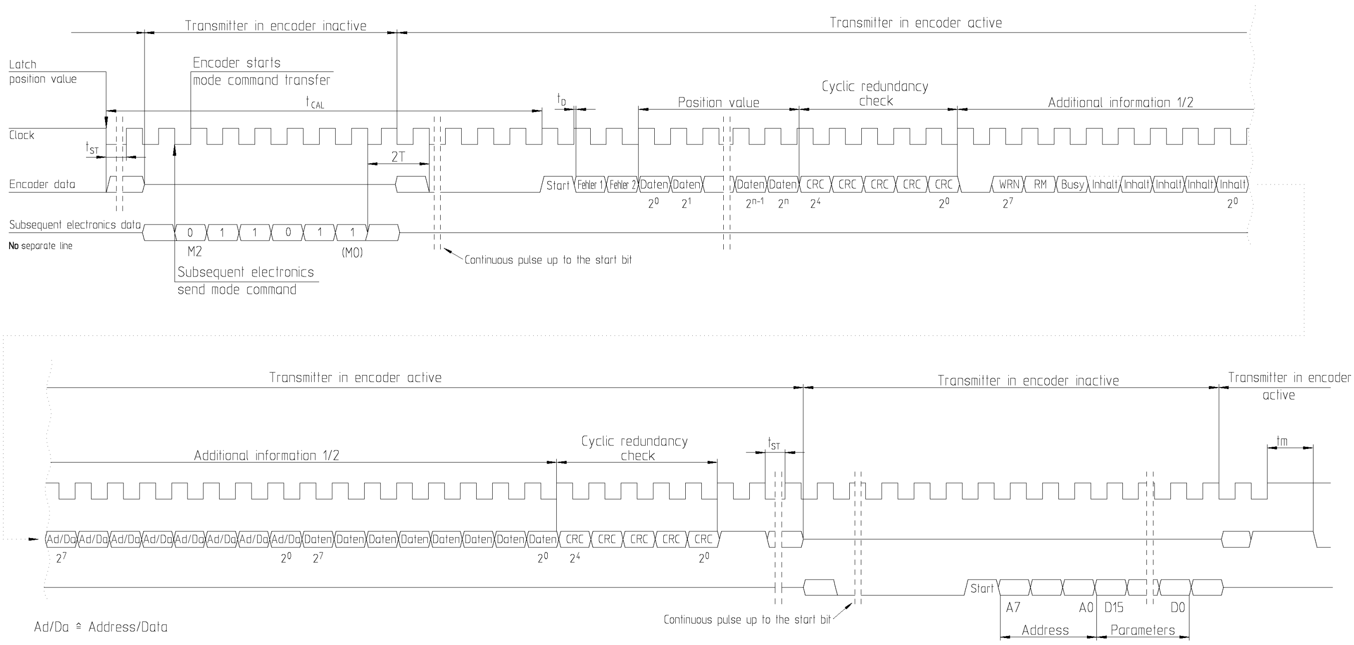


Figure 34

To prevent a collision between the data drivers, following transmission of the position value and CRC it must be monitored if an error (→see Appendix 4.2) has occurred during the transmission.

As long as processing of the data in the encoder is not complete, the busy bit is set to logical 1 in the first byte of the additional data. During this time no further write access, read access or reset, also not after type 2.1 mode commands, must be performed.

To test whether the data were correctly saved the parameters must be subsequently queried and checked.

⚠ The data can only be read after the encoder has reset the busy bit. This means an additional information must be continuously queried between the commands for reading or sending parameters in order to interrogate the status of the busy bit.

Example: Accessing address 0B parameter A5B4 in the OEM2 area

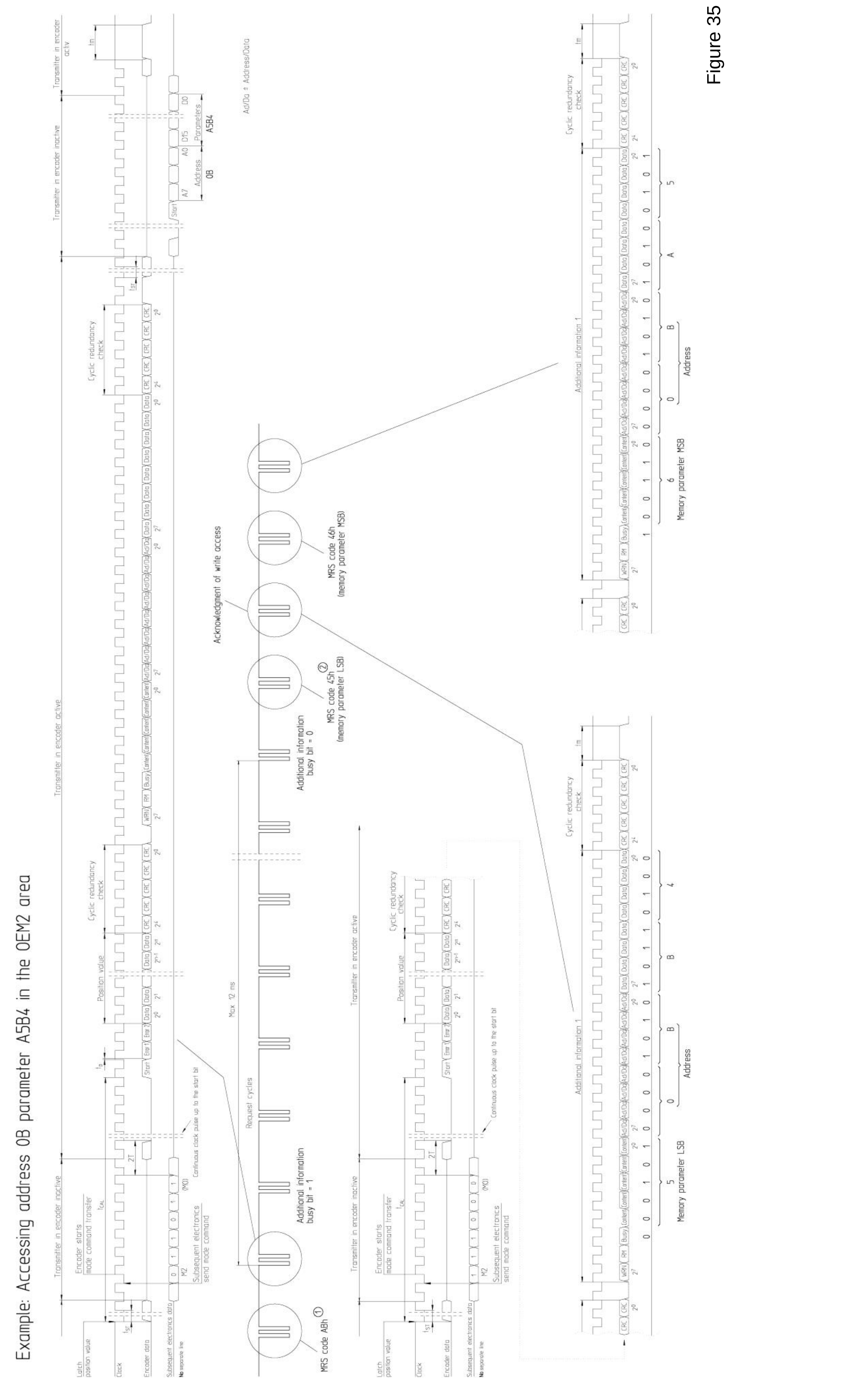


Figure 35

①

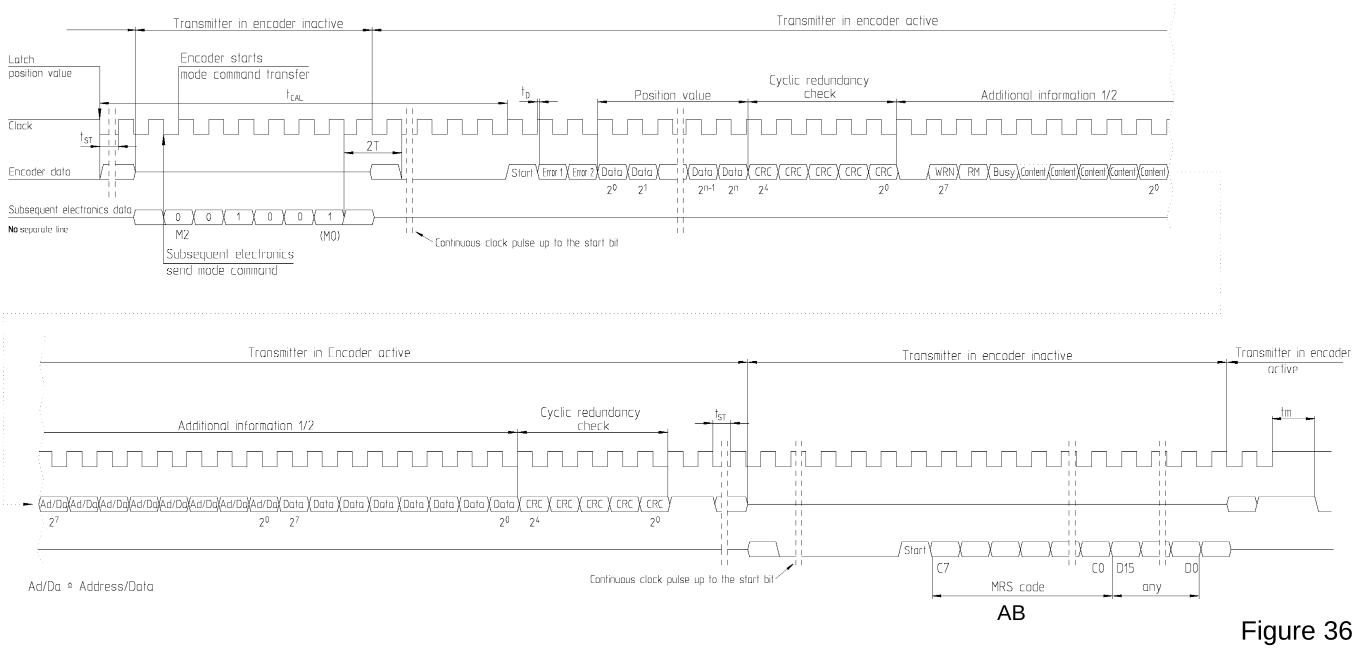


Figure 36

②

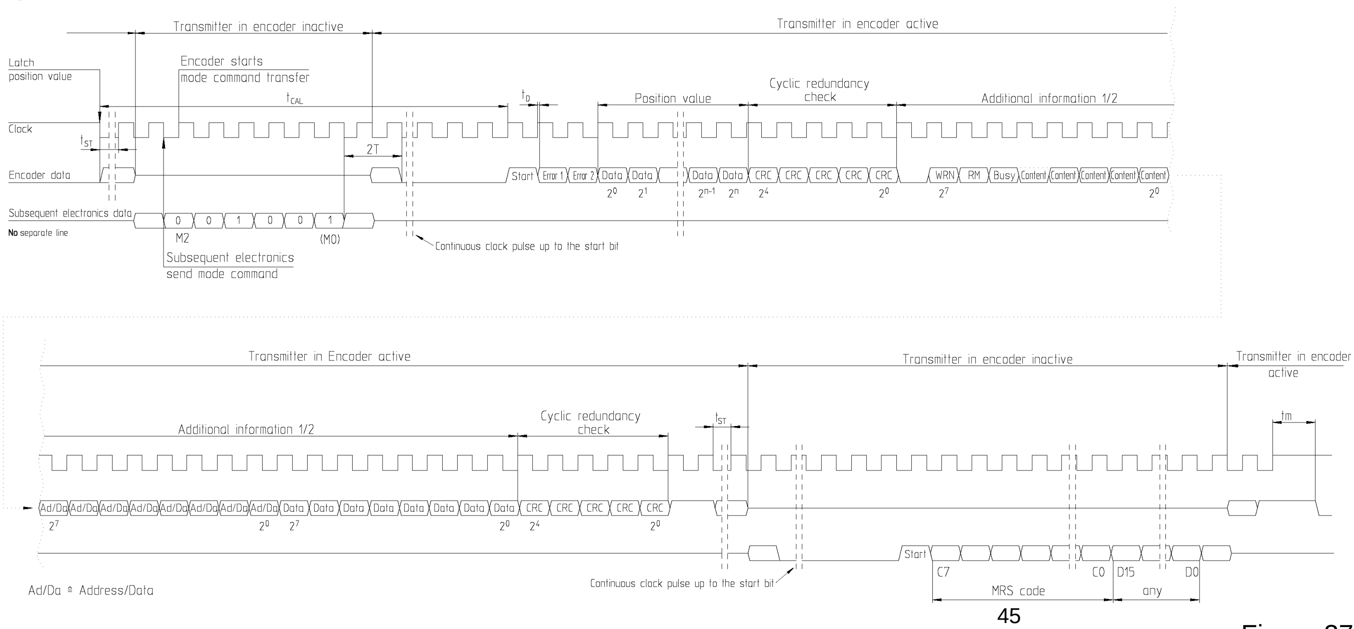


Figure 37

2.7 Encoder receive reset

The following mode command is required for executing a reset:

M2	M1	M0	(M2)	(M1)	(M0)
1	**0**	**1**	0	1	0

During the transfer the clock from the subsequent electronics must be continuously sent (observe the timeout!).

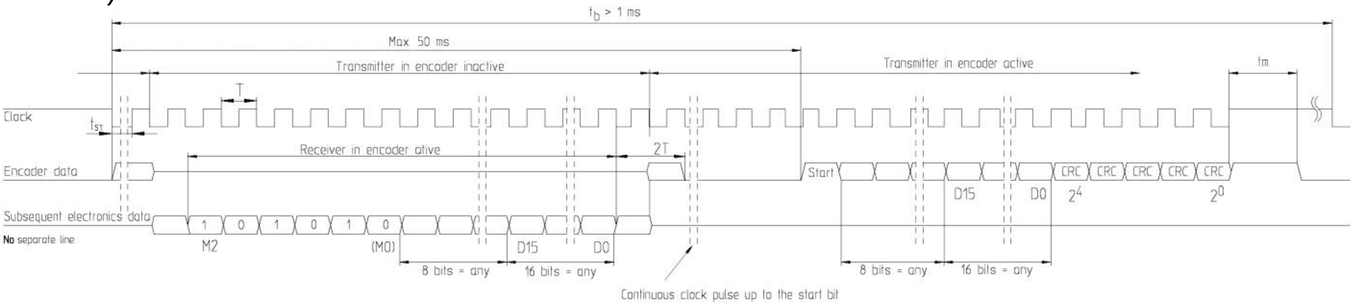


Figure 38

⚠ If resetting the RM bit is supported, this bit is set to 0 via the "Encoders receive reset" command which initiates setting the warning "Reference point not reached" (see warnings). Position value 1 and position value 2 are not influenced by this.

2.7.1 Encoder send position value and receive error reset

The following mode command is necessary in order to request position values and reset errors in the same cycle:

⚠ Divergently to the "Encoder receive reset" command, only error messages and warnings are reset with error resets.

M2	M1	M0	(M2)	(M1)	(M0)
1	**0**	**1**	1	0	1

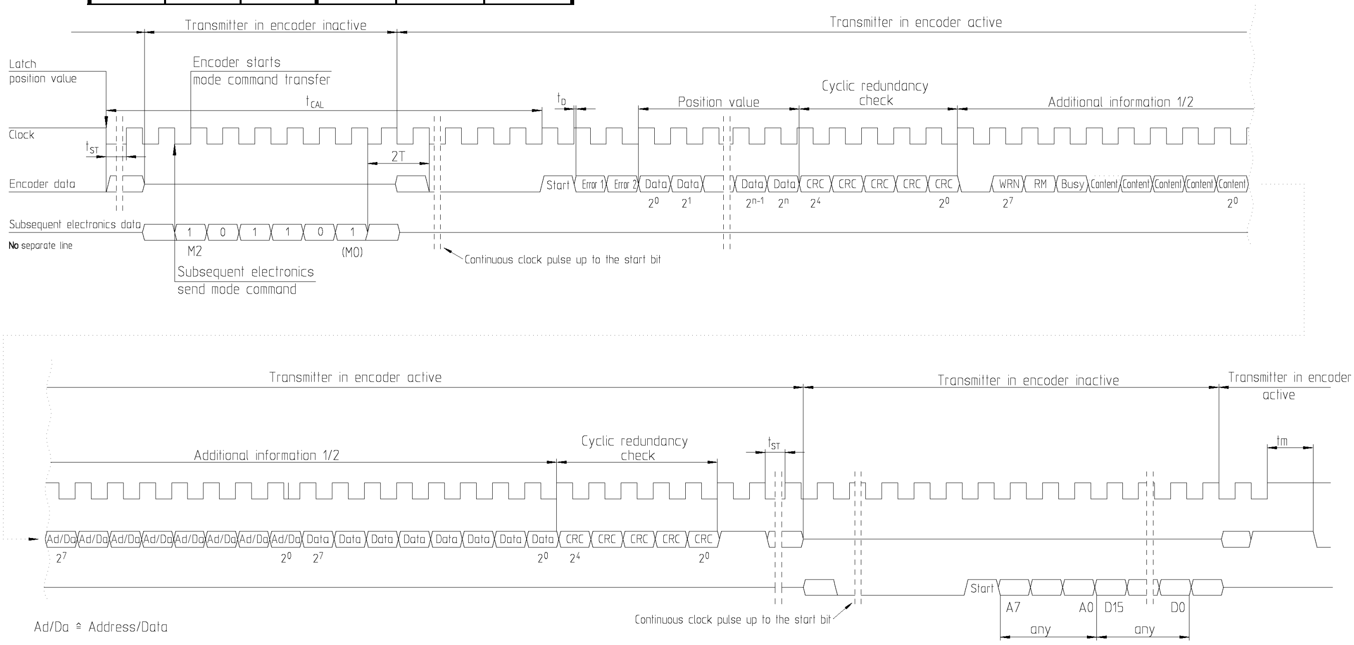


Figure 39

With this command, the words 0 and 1 (error messages and warnings) are also reset in the memory area for the operating status.
To prevent a collision between the data drivers, following transmission of the position value and CRC it must be monitored if an error (→see Appendix 4.2) has occurred during the transmission.

2.8 Encoder receive test command

To query test values, in the first step the "Encoder receive test command" mode command is sent with the port address to be queried (→see Point 3.5.2). The following mode command is necessary:

M2	M1	M0	(M2)	(M1)	(M0)
1	**1**	**0**	0	0	1

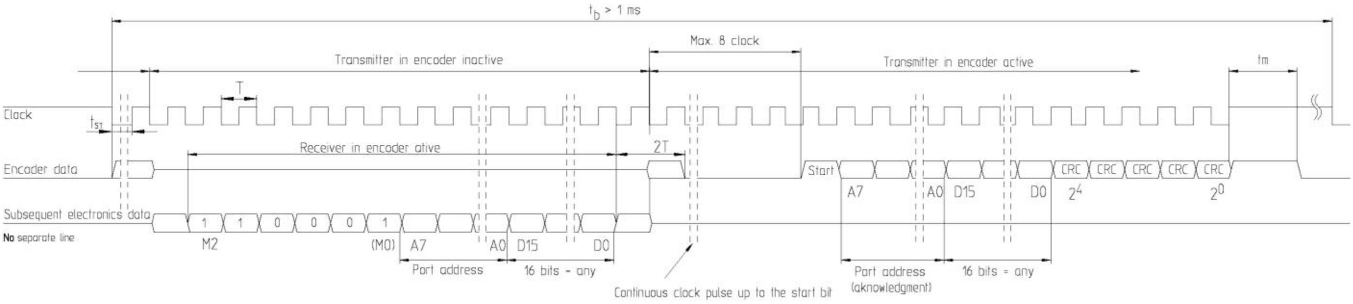


Figure 40

2.8.1 Encoder send position values and receive test command

The following mode command is required for requesting position values and for writing a test command in the same cycle: (→see point 3.5.3)

M2	M1	M0	(M2)	(M1)	(M0)
1	**1**	**0**	1	1	0

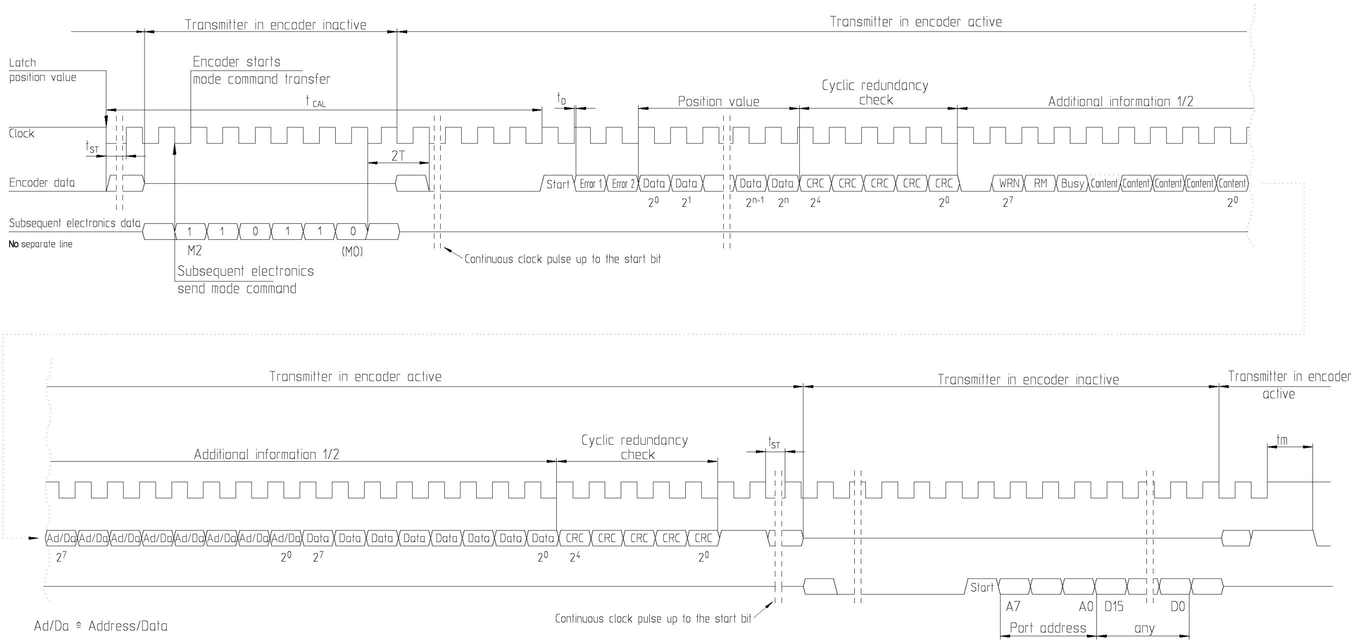


Figure 41

To prevent a collision between the data drivers, following transmission of the position value and CRC it must be monitored if an error (→see Appendix 4.2) has occurred during the transmission.

2.9 Encoder send test values

The following mode command is necessary to interrogate test values:

M2	M1	M0	(M2)	(M1)	(M0)
0	1	0	1	0	1

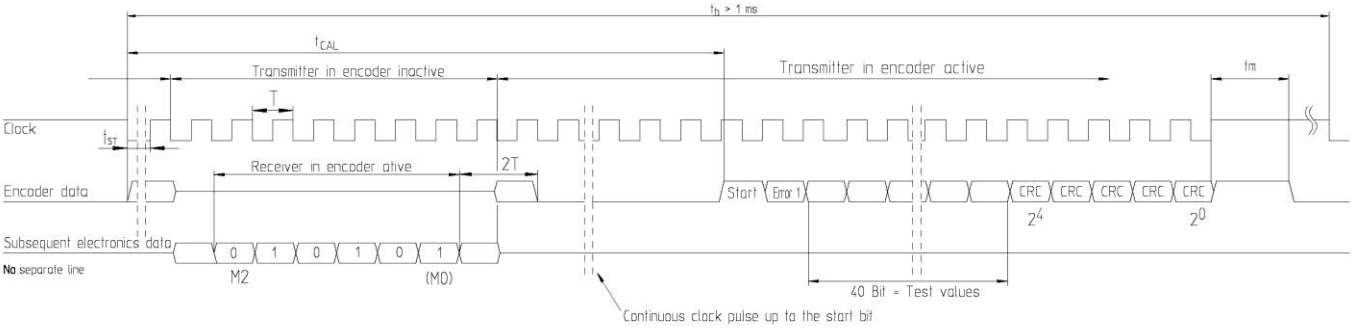


Figure 42

With some encoders without gray code sampling, operating status error sources are transferred with port address 0 with the test values (please request further information from the encoder manufacturer).

2.10 Encoder receive communication command

The following mode command is necessary to send communication data:

M2	M1	M0	(M2)	(M1)	(M0)
0	**1**	**0**	0	1	0

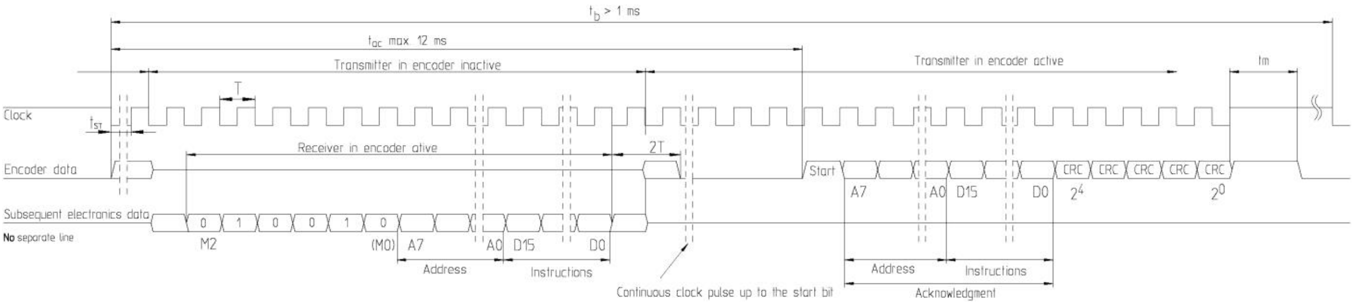


Figure 43

After the address has been assigned with the "Write parameters" mode command, all other mode commands for data exchange can be used.

Only the encoder with the previously selected address reacts to the following mode commands, until a new address is given.

The encoder address is saved in word 4 of the memory area for operating parameters.

Example: Address 17

17 ≙ 11_{hex}

4	x	x	x	x	x	x	x	x	0	0	0	1	0	0	0	1	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	

5	x	x	x	x	x	x	x	x	x	x	x	x	x	1/0	1/0	1/0	r/w
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	

The instructions are saved in word 5 of the memory area for operating parameters.

5

Bit	Instructions	= 0	= 1
2^0	Energy-saving mode	Deactivated	Activated
2^1	Data driver at high-impedance	Deactivated	Activated
2^2	No updating of position values	Deactivated	Activated
•	Currently not assigned Extension planned		
•			
•			
2^{15}	Storage in NVM	Deactivated	Activated

The address 0000_{hex} can be used to address all encoders at the same time. The acknowledgment is implemented from the encoder addressed with the address 0000_{hex} before sending the command. Before addressing a new encoder, the mode command "Encoder receive communication command" must be sent with the address 0000_{hex} and the instruction (data driver active at high-impedance). This ensures that there is no conflict on the data line.
The instructions are remanently saved in the NVM.

3 Memory allocation in the encoder

The memory in the encoder allows the end user, the OEM and the encoder manufacturer to **store parameters** and **read them out**.
There are six different memory areas:

Memory area for the **operating status** (→ see point 3.4)
Memory area for the **parameters of the encoder manufacturer** (→ see point 3.5)
Memory area for **operating parameters** (→ see point 3.6)
Memory area for **parameters of the OEM** (→ see point 3.7)
Memory area for **compensation values** of the encoder manufacturer (→ see point 3.8)
Memory area for **parameters of the encoder manufacturer** for commands of type 2.2 (→ see point 3.9)
Section 2 memory area expanded for **parameters of the OEM** (→ see point 3.2)
Memory area for operating parameter 2 (→ see point 3.10)

Together, the memory area for the operating status and for the parameters of the encoder manufacturer always have a size of 48 words. The memory area of the encoder manufacturer for type 2.2 commands always consists of 64 words. Four words are intended for the operating status (warnings, error message and write protection). The memory area for operating parameters has a size of 16 words (→ see point 3.1).

The **memory area for compensation values** of the encoder manufacturer and **parameters of the OEM** must consist of a **maximum of 960 words in total** (1920 bytes). The memory area available to an encoder depends on the size of its memory. This memory area can be partitioned in different ways. The partitioning with the start and end addresses is stored in data words 9 to 12 in the memory area of the encoder manufacturer. The memory area for compensation values is available exclusively to the encoder manufacturer.
Certain memory areas can be write-protected. The procedure for activating write protection is described in the "Write protection status" section (→ see point 3.4.3).

The single memory areas are differentiated via the MRS code (→ see point 0).

3.1 Memory area overview

Example: Memory size of NVM with 1024 words

Word Number	Memory area	Access	MRS code $C_7C_6C_5C_4C_3C_2C_1C_0$	**NVM** Byte
0 .. 3	Operating status (warnings, error message, write protection, configuration, additional data)	r / w	10111001	0 .. 7
4 .. 15	Parameters of the encoder manufacturer (EnDat version, ID number, serial number etc.)	r	10100001	8 .. 31
0 .. 15			10100011	32 .. 63
0 .. 15			10100101	64 .. 95
0 .. 15	Operating parameters	r / w *)	10100111	96 .. 127
64 .. 255	OEM	r / w *)	10101001	128 .. 511
0 .. 255			10101011	512 .. 1023
0 .. 255			10101101	1024 .. 1535
0 .. 255	Compensation values specified by the encoder manufacturer	r	10110111	1536 .. 2047
0 .. 63	Parameters of the encoder manufacturer for EnDat 2.2	r	10111101	1920 .. 2047

*) w = write can be locked by the customer (write protection), but access to r = read is maintained

3.2 Overview of memory area for section 2 expanded memory area

The memory area of section 2 is configured block-wise; the block address always starts at 0. The number of blocks supported can be seen in word 24 "Parameters of the encoder manufacturer for EnDat 2.2." (→see point 3.9.18). Within a block
256 EnDat words (word address 0 ... 255) are available.
For addressing a block, the MRS code "10111111" (→see point 2.4.2.1) and the desired block address must be sent to the encoder with the mode command "Encoder send position value and selection of the memory area or block address" (→see point 2.4.2). The sending and receiving of parameters is described in point 2.5 and 2.6.

Example: Expansion of memory area by 1024 words ≙ 4 blocks

Word Number	Memory area	Access	MRS code for selecting the memory area $C_7C_6C_5C_4C_3C_2C_1C_0$	**NVM** Byte
0 ... 255	OEM	r / w *)	10111111 Block 0	2048 ... 2559
256 ... 511	OEM	r / w *)	10111111 Block 1	2560 ... 3071
512 ... 767	OEM	r / w *)	10111111 Block 2	3072 ... 3583
768 ... 1023	OEM	r / w *)	10111111 Block 3	3584 ... 4095

*) w = write can be locked by the customer (write protection), but access to r = read is maintained

3.3 Memory allocation tables

The memory is allocated as shown below.
Value (binary)
or coding

10	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	r/w
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

Address (decimal)

Content (binary)

Type of access
r = read
w = write
r/w = read and write

11	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	r/w
	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	

The memory allocation described in this document refers to Version 2.2

3.4 Operating status

3.4.1 Error message

An error message is set if there is a malfunction in the encoder that could be causing incorrect position values. **Word 0** stores the reasons for the error messages. If **an error bit is set**, with the **data transmission of measured values error bit 1** is set to logical **High** and **error bit 2** to logical **Low** (observe supported error messages). **Error bits can be deleted** by **overwriting the word 0 with 0000$_{\text{hex}}$** and sending the **mode command "Encoder receive reset"**.

If supported, it is also possible to read out error messages via the operating status error messages (→see point 2.3.5.3) with EnDat2.2 encoders.

0	x	x	x	x	x	x	x	x	x	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r/w
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

Bit		**= 0**	**= 1**
2^0	Lighting	OK	Failure ①
2^1	Signal amplitude	OK	Faulty ①
2^2	Position	OK	Faulty ①
2^3	Overvoltage	None	Yes ①
2^4	Undervoltage	None	Undervoltage supply ①
2^5	Overcurrent	No	Yes ①
2^6	Battery	OK	Change required ②
•	Currently not assigned Extension planned		
•			
•			
2^{15}			

① Can also be set after the power supply is switched off or on.
② Only with battery-buffered encoders.

Each error bit from every encoder is fundamentally **not** supported. The error bits for error message 1 that are supported by an encoder are stored in word 35 in the memory area for the encoder manufacturer's parameters. The error bits for error message 2 that are supported by an encoder are stored in word 6 in the memory area for the EnDat 2.2 encoder manufacturer's parameters. The encoder specifications describe how each bit is set. With some encoders (see word 1 "Parameters of the encoder manufacturer for EnDat 2.2") the source of the error message can be determined by reading out the operating status error sources.

All errors must be deleted simultaneously by writing 0000$_{\text{hex}}$ to **word 0**. Specifically deleting a single error bit is not possible.

An extension of the error messages 2^7 to 2^{15} is being planned!

If a supported error message is subjected to dynamic sampling, the corresponding error bit is set until the dynamic sampling is reset.

3.4.2 Warnings

Warnings show that the **tolerance specifications** for certain internal encoder parameters **were exceeded**. Over extended periods, this can trigger error messages. Warnings therefore enable the user to correct problems before they can cause errors. For this reason it is recommended to query this word at regular intervals, or with encoders supporting EnDat 2.2 to query the group bit for warnings (WRN) with the mode command "Encoder send position value with additional data".

In contrast to error messages, erroneous position values must not be assumed with warnings.
Warnings are saved in **word 1**. They can be read out by the manufacturer of the subsequent electronics. **Warnings can be cleared** by **overwriting** the **word 1 with 0000$_{\mathbf{hex}}$** and sending the **mode command "Encoder receive reset."** With units supporting EnDat 2.2, the **mode command "Encoder send position values and receive error reset"** is used for this purpose.

1	x	x	x	x	x	x	x	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r/w
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

Bit		= 0	= 1
2^0	Frequency collision	None	Yes ①
2^1	Temperature exceeded	None	Yes ①
2^2	Light-source control reserve	Not reached	Reached ①
2^3	Battery charge	OK	Too low ②
2^4	Reference point	Reached	Not reached ③
2^5	Cyclic mode	Cyclic	Acyclic
2^6	Limit position (see 3.9.30)	Not reached	Reached
2^7	Standby	Yes	None
2^8	Diagnostics	OK	Below threshold value
•	Currently not assigned Extension planned		
•			
•			
2^{15}			

① Can also be set after the power supply is switched off or on.
② Only with battery-buffered encoders.
③ Only for incremental encoders.

All warnings from every encoder are **not** fundamentally supported. The warnings that are supported by an encoder are stored in word 36 in the memory area for the encoder manufacturer's parameters. The specifications for each encoder model describe how the bits are set.
The trigger threshold of the warning bit for excessive temperature 2^1 is only triggered by the internal temperature sensor (integrated in the encoder). The threshold value can be gathered from word 6 "operating parameters".

All warnings must be deleted simultaneously by writing 0000$_{hex}$ to **word 1**. Specifically deleting a single warning is not possible.

An extension of the warnings 2^7 to 2^{15} is being planned!

3.4.3 Write-protected status

The **write protection status** of each memory area is saved in **word 2**. The **write protection** for parameters of the **encoder manufacturer** and if applicable the write protection for compensation values are **factory set to active** and **cannot be reset**. Write protection for factory-unprotected memory areas is activated as follows and can also no longer be reset:

2	x	x	x	x	x	x	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r/w
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	

Bit	Write protection	= 0	= 1
2^0	Encoder manufacturer Encoder manufacturer EnDat 2.2	No protection	Protection activated
2^1	Operating parameters	No protection	Protection activated
2^2	OEM	No protection	Protection activated
2^3	Compensation values MRS code 10110111	No protection	Protection activated
2^4	Compensation values MRS code 10110101	No protection	Protection activated
2^5	Compensation values MRS code 10110011	No protection	Protection activated
2^6	Section 2 memory area block 0	No protection	Protection activated
2^7	Section 2 memory area block 1	No protection	Protection activated
2^8	Section 2 memory area block 2	No protection	Protection activated
2^9	Section 2 memory area block 3-n ①	No protection	Protection activated
• • • 2^{15}	Currently not assigned Extension planned		

① n $\triangleq$ Number of blocks

Example:

1st Read word 2.

0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

2. Gate word 2 (OR gate) with the desired write protection bit and write back in word 2. (see Appendix 4.2).

Word 2

0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

+ desired bit

0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1
2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

3. Send the "Encoder receive reset" mode command or switch the power supply off and on.

3.4.4 Function Initialization

The customer can set the function parameters in **word 3**.

3	x	x	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r/w
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

Bit	Information	= 0	= 1
2^{0}	Recovery time I t_m ①	10 µs $\leq t_m \leq$ 30 µs	1.25 µs $\leq t_m \leq$ 3.75 µs
2^{1}	Recovery time I t_m ①	1.25 µs $\leq t_m \leq$ 3.75 µs	10 µs $\leq t_m \leq$ 30 µs
2^{2}	Reference pulse initialization	Deactivated	Activated
2^{3}	Reference pulse initialization	Activated	Deactivated
2^{4}	Oversampling	Deactivated	Activated
2^{5}	Oversampling	Activated	Deactivated
2^{6}	EnDat 2.2 cyclic operation	Deactivated	Activated
2^{7}	EnDat 2.2 cyclic operation	Activated	Deactivated
2^{8}	Multiturn overflow error message	Deactivated	Activated
2^{9}	Multiturn overflow latch	Deactivated	Activated
2^{10}	Multiturn error messages ②	Deactivated	Activated
2^{11}	Multiturn counter reset	Deactivated	Activated
2^{12}	Multiturn counter reset	Activated	Deactivated
2^{13}	Diagnostics reset	Deactivated	Activated
2^{14}		:	:
2^{15}		:	:

① only valid for type 2.2 mode commands (→see mode commands, point 2.3)

② with exception of multiturn overflow error message bit 2^8

The factory default setting for the recovery time I is programmed to 10 µs $\leq t_m \leq$ 30 µs
Recovery time I can only be changed to 1.25 µs $\leq t_m \leq$ 3.75 µs for type 2.2 mode commands. With clock pulse frequencies of $\leq$ 1 MHz the recovery time I must be set to 10 µs $\leq t_m \leq$ 30 µs.

Word 3 is only activated after the mode command "Encoder receive reset" is sent.

Both the activation and deactivation of individual functions must be performed actively by the subsequent electronics (e.g. resetting the multiturn counter reset).

Functions are initialized encoder-specifically. For more information, please refer to the Specifications.

3.5 Parameters of the encoder manufacturer

3.5.1 Overview of parameters of the encoder manufacturer

Word	Content	Unit: Linear encoder	Unit: Rotary encoder/ angular encoder	MRS code: C7 ..	C6	C5	C4	C3	C2	C1	C0	Address HEX
4	Mask 0	—										04
5	Mask 1	—										05
6	Mask 2	—										06
7	Mask 3	—										07
8	Version of the EnDat interface	—										08
9	Memory allocation for	—										09
10	Parameters of the OEM			1	0	1	0	0	0	0	1	0A
11	Memory allocation for	—										0B
12	Compensation values											0C
13	Number of clock pulses for transfer of the position value (transmission format)	—										0D
14	Encoder model	—										0E
15	Signal period or signal periods per revolution	nm	—									0F
16	for incremental output signals											00
17	Distinguishable revolutions (with multiturn encoders only)	—	—									01
18	(Nominal) increment of reference marks	mm	Signal periods									02
19	Position of the first reference mark	mm										03
20	Measuring step or measuring steps / revolution at	nm										04
21	of the serial data transfer											05
22	Datum shift	Signal periods	Signal periods									06
23	from the encoder manufacturer			1	0	1	0	0	0	1	1	07
24	ID number	—	—									08
25												09
26												0A
27	Serial number	—	—									0B
28												0C
29												0D
30	Direction of rotation or traverse	—	—									0E
31	Status of commissioning diagnostics	—	—									0F
32	Maximum mechanically permissible linear velocity or shaft speed	m/min	min^{-1}									00
33	Accuracy depending on linear velocity or shaft speed, area I	LSB ①	LSB ①									01
34	Accuracy depending on linear velocity or shaft speed, area II	LSB ①	LSB ①									02
35	Support of error messages 1	—	—	1	0	1	0	0	1	0	1	03
36	Support of warnings	—	—									04
37	EnDat command set	—	—									05
38	Measuring length (with linear encoders only) ②	—	—									06
39	Max. calculation time, position value	—	—									07
40	EnDat ordering designation	—	—									08
41	OEM-specific data											09
42												0A
43												0B
44												0C
45												0D
46												0E
47	CHECKSUM	—	—									0F

① high-value byte contains division factor related to the maximum permissible speed up to which this accuracy is valid.

② not supported by all linear encoders; preset with the value 0.

3.5.2 Commissioning diagnostics for encoders with gray code sampling (see Appendix A7)

3.5.3 Forced dynamic sampling

The mode commands "Encoder receive test command" and "Encoder send position values and receive test command" are uncoupled from each other. This means ports set via the "Encoder receive test command" mode command have no influence on ports set via the "Encoder send position values and receive test command" mode command and vice versa. Forced dynamic sampling can only be activated/deactivated with an EnDat 2.2 mode command "Encoder send position value and receive test command".

If an error message is subjected to forced dynamic sampling (operating status error sources cannot be force sampled), with one of the next EnDat 2.2 queries (< 1 ms) the error message 1 or 2 must be verified for "Error message active". Then forced sampling is deactivated again by writing the port address 0000_{hex}. Sending of the correct forced sampling can be verified by reading out the error messages in word 0 (see Catalog of Measures D533095).

M2	**M1**	**M0**	**(M2)**	**(M1)**	**(M0)**
1	**1**	**0**	1	1	0

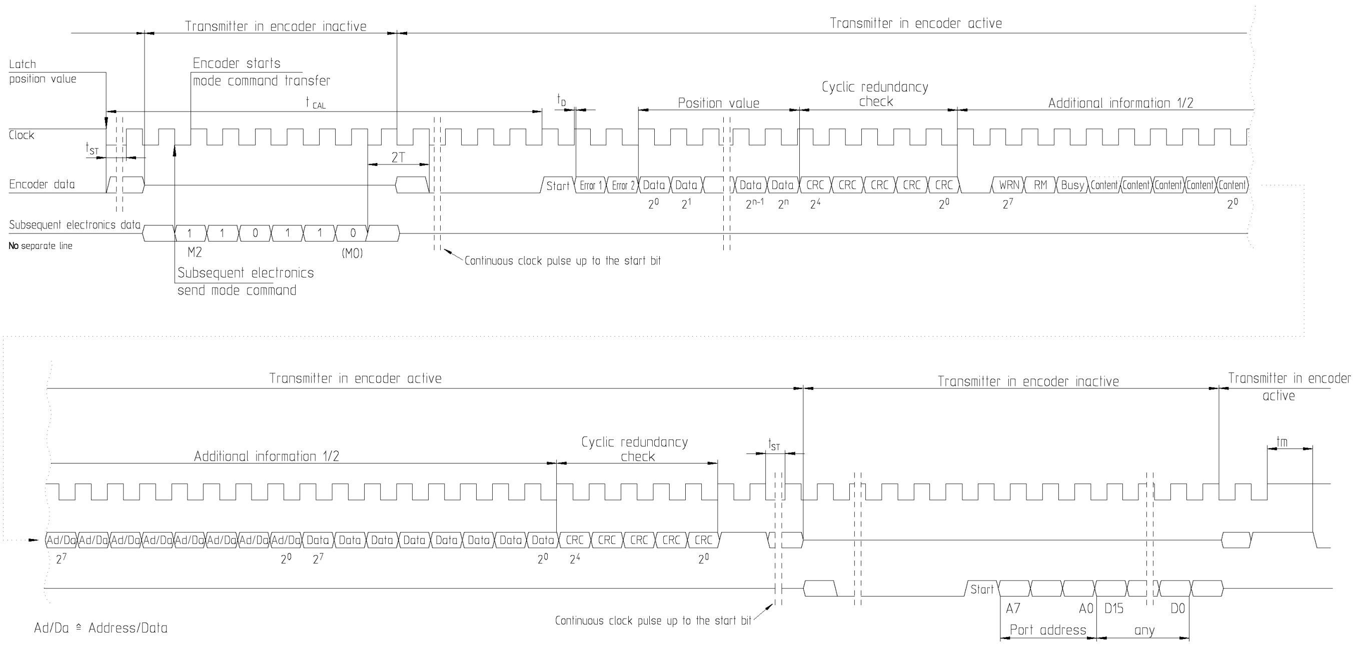


Figure 44

		Port addresses							
		A7	A6	A5	A4	P3	P2	P1	P0
Error message 1	Forced sampling of light source	0	0	0	0	0	0	0	1
	Forced sampling of signal amplitude	0	0	0	0	0	0	1	0
	Forced sampling of position error	0	0	0	0	0	0	1	1
	Forced sampling of overvoltage	0	0	0	0	0	1	0	0
	Forced sampling of undervoltage	0	0	0	0	0	1	0	1
	Forced sampling of overcurrent	0	0	0	0	0	1	1	0
	Forced sampling of battery failure	0	0	0	0	0	1	1	1
Error message 2	Forced sampling of light source	0	0	0	0	1	0	0	1
	Forced sampling of signal amplitude	0	0	0	0	1	0	1	0
	Forced sampling of position error	0	0	0	0	1	0	1	1
	Forced sampling of overvoltage	0	0	0	0	1	1	0	0
	Forced sampling of undervoltage	0	0	0	0	1	1	0	1
	Forced sampling of overcurrent	0	0	0	0	1	1	1	0
	Forced sampling of battery failure	0	0	0	0	1	1	1	1

⚠ All other port addresses lead to the deactivation of forced dynamic sampling.

While an error message 1 (high active) must switch to logical high via the forced dynamic sampling, an error message 2 (low active) must switch to logical low via the sampling.

3.5.4 Version

Word 8 in the memory indicates the version of the EnDat interface and thus the associated definition of the parameters defined by the encoder manufacturer.

8	**1***	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

Example Version 4

8	**1***	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

* is always set to logical "high" for NVM checking.

⚠ Numbers after the decimal point in the version of the documentation are not stored in this word because these are always backward compatible, and have no influence on earlier hardware and software of the subsequent electronics. For example, with version 1.2 only the value 1 is stored in word 8

3.5.5 Memory allocation EnDat 2.1

Start and end addresses

Words 11 and **12** contain information on the start and end addresses of the memory area for the encoder compensation values.

Four bits are used per address. The address starts with the MRS code $C_7...C_0 \triangleq$ 10101001 and ends with the MRS code $C_7...C_0 \triangleq$ 10110111. Also see the description below.

The entire memory area of the encoder is always reduced by 64 words in which the operating status and the parameters of the encoder manufacturer are saved. The remaining memory area is used for the parameters of the OEM and encoder compensation values. Because the memory area required for compensation values depends on the encoder type, the corresponding start and end addresses of the **memory available to the OEM are stored in words 9 and 10.**

Start or end address	Bit combination
0	0000
31	0001
63	0010
64	0011
127	0100
255	0101
Not available	1111

	Parameters of the OEM																
	MRS code: $C_7..C_0$ = 10101011								**MRS code: $C_7..C_0$ = 10101001**								
	End address				**Start address**				**End address**				**Start address**				
9	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	

	Parameters of the OEM																
	MRS code: $C_7..C_0$ = 10101111								**MRS code: $C_7..C_0$ = 10101101**								
	End address				**Start address**				**End address**				**Start address**				
10	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	

	Compensation values specified by the encoder manufacturer																
	MRS code: $C_7..C_0$ = 10110011								**MRS code: $C_7..C_0$ = 10110001**								
	End address				**Start address**				**End address**				**Start address**				
11	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	

	Compensation values specified by the encoder manufacturer																
	MRS code: $C_7..C_0$ = 10110111								**MRS code: $C_7..C_0$ = 10110101**								
	End address				**Start address**				**End address**				**Start address**				
12	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	

Example 256 words

Memory area for **parameters of the OEM:** 128 words
Memory area for **compensation values:** 64 words

Parameters of the OEM:	**Compensation values:**
Area 1: –	Area 1: –
Area 2: 0-63	Area 2: –
Area 3: 0-63	Area 3: –
Area 4: –	Area 4: 0-63

	Parameters of the OEM																
	MRS code: $C_7..C_0$ = 10101011								**MRS code: $C_7..C_0$ = 10101001**								
	End address				**Start address**				**End address**				**Start address**				
9	0	0	1	0	0	0	0	0	1	1	1	1	1	1	1	1	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
	Range 2								Range 1								

	Parameters of the OEM																
	MRS code: $C_7..C_0$ = 10101111								**MRS code: $C_7..C_0$ = 10101101**								
	End address				**Start address**				**End address**				**Start address**				
10	1	1	1	1	1	1	1	1	0	0	1	0	0	0	0	0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
	Range 4								Range 3								

	Compensation values																
	MRS code: $C_7..C_0$ = 10110011								**MRS code: $C_7..C_0$ = 10110001**								
	End address				**Start address**				**End address**				**Start address**				
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
	Range 2								Range 1								

	Compensation values																
	MRS code: $C_7..C_0$ = 10110111								**MRS code: $C_7..C_0$ = 10110101**								
	End address				**Start address**				**End address**				**Start address**				
12	0	0	1	0	0	0	0	0	1	1	1	1	1	1	1	1	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
	Range 4								Range 3								

3.5.6 Transfer format for position values

In **word 13** the **number of clock pulse periods for transferring the position value** (without additional data) is specified.

Note: This information refers **only** to the position value. The required clock pulse periods for start bits, error bits and CRC bits are not taken into account.

13																
1*	x	x	x	x	x	x	x	x	x	1/0	1/0	1/0	1/0	1/0	1/0	r
2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

Example: 25-bit format ≙ 25 clock pulse periods
25 bit ≙ 19_{hex}

13																
1*	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	r
2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

* is always set to logical "high" for NVM checking.

3.5.7 Encoder type

Word 14 indicates the **type of encoder.**

14																
	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	**1**	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

* Always set to logical High for NVM checking

	Word 14			
	2^{15}	**2^{14}**	**2^{13}**	**2^{12}**
Incremental linear encoder				
with distance-coded reference marks	0	0	0	1
without distance-coded reference marks	0	0	0	0
with battery buffer				
with distance-coded reference marks	0	0	1	1
without distance-coded reference marks	0	0	1	0
Absolute linear encoder	0	1	0	0
With cyclic coding	0	1	1	0
Note touch probes D1 – D11	0	1	0	1
Incremental rotary encoder or incremental angle encoder				
with distance-coded reference marks	1	0	0	1
without distance-coded reference marks	1	0	0	0
with battery buffer				
with distance-coded reference marks	1	0	1	1
without distance-coded reference marks	1	0	1	0
Singleturn rotary encoder or singleturn angle encoder	1	1	0	0
Multiturn rotary encoder with gears	1	1	1	0
Multiturn rotary encoder with battery buffer	1	1	0	1
External Interface Box (EIB)	1	1	1	1
Note D1 – D11	0	1	1	1

⚠ In the memory area of an EIB (External Interface Box) the encoder type F_{hex} and the memory size, serial number and ID number are saved in factory delivery state. Other parameters must be saved during initial commissioning. With the EIB words 20 and 21 are also scaled differently; see point 3.5.12. The encoder type must be modified during initial commissioning according to the connected encoder.

⚠ To support further encoder types, bits 2^{11} to 2^{1} will be used in the future, e.g. for absolute encoders with cyclic coding 7073_{hex}

⚠ 2^{11} reserved for JH
2^{10} reserved for AMO

3.5.8 Signal period or signal periods per revolution

Words 15 and **16** supply the **signal period of the incremental output signals.** For encoders with ordering designation EnDat01 or EnDat02, 1-V_{pp} signals apply at the output connecting element for further processing in the control. For this reason, the signal period is specified with these units.

For encoders with ordering designation EnDat21 or EnDat22, **no** 1-V_{pp}signals apply at the output connecting element. For this reason, "0" is assigned to words 15 and 16.

⚠ Exception EIB, incremental encoders - see Appendix 4.10

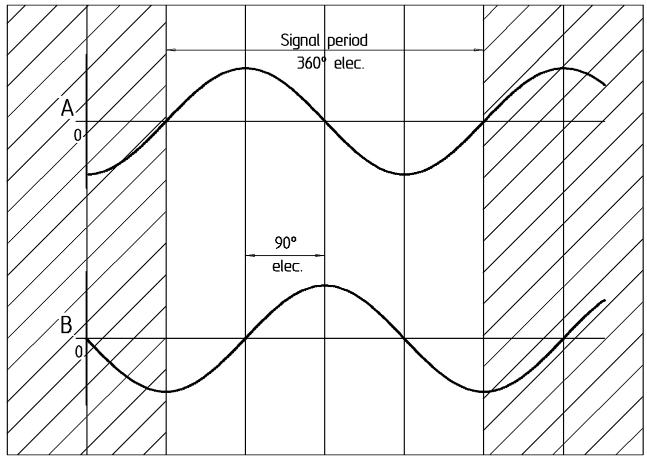


Figure 45

Definition of the signal period with sinusoidal output signals and square-wave pulse sequences

15

1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	nm or P/rev

16

1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	nm or P/rev

Linear encoders
The specification is made in **nm** (0.001 µm).

Example: Signal period 20 µm
$20000 \triangleq 4E20_{hex}$

15

0	1	0	0	1	1	1	0	0	0	1	0	0	0	0	0
2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

16

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}

Rotary or angle encoders

The specification is made in **signal periods per revolution** (P/rev)

Example: 2048 signal periods per revolution
2048 ≙ 0800_{hex}

15	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}

3.5.9 Number of distinguishable revolutions

With **multiturn encoders,** specification of the distinguishable revolutions is contained in **word 17.**
Up to 65,535 revolutions maximum can be distinguished.

17	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

Example: 2048 distinguishable revolutions
2048 ≙ 0800_{hex}

17	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

Note: With a singleturn encoder the value 0000_{hex} is saved in word 17.

⚠ If more than 65535 revolutions can be distinguished, then word 34 in the "Parameters of the encoder manufacturer for EnDat 2.2" range must be taken into account.
The value 65535 is then entered in word 17.

3.5.10 Distance of reference marks

With encoders with distance-coded reference marks, word 18 specifies the **nominal increment of the associated reference marks.** With absolute encoders without additional reference marks, 0000_{hex} is saved in this word.
With linear encoders without distance-coded reference marks the distance between two adjacent reference marks is contained in word 18.
The specification is made in **millimeters (mm)** or **signal periods (P)**.

18	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	mm P

3.5.10.1 Encoders with distance-coded reference marks

Linear encoders

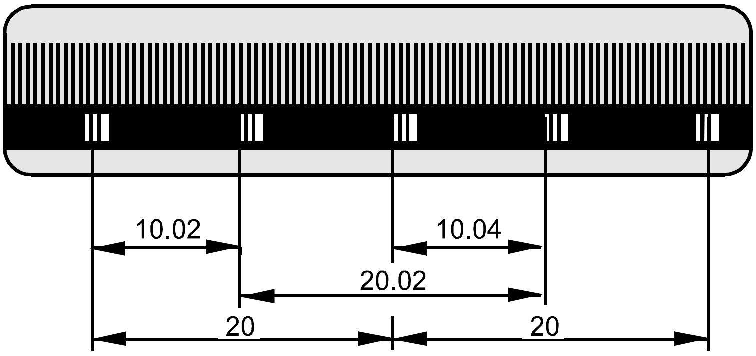


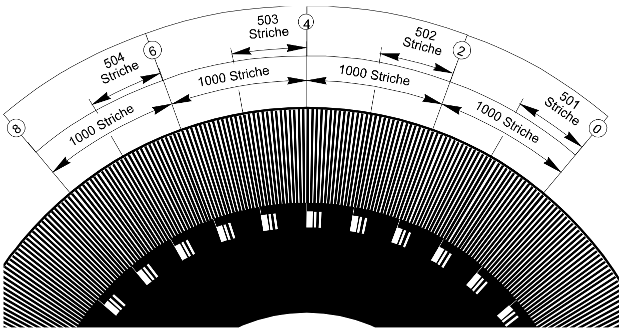
Figure 46

Dimensions in mm for a 20 µm grating period,
nominal increment 20 mm.

Example: Nominal increment: 20 mm
$20 \mathrel{\hat{=}} 14_{hex}$

18	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

Rotary or angle encoders



Line count 18,000, nominal increment of distance-coded reference marks 20°, i.e. 1000 lines

Figure 47

The specification is made in **signal periods (P)** whereby the maximum nominal increment consists of 65,535 signal periods.

Example: Nominal increment: 1000 signal periods
$1000 \mathrel{\hat{=}} 3E8_{hex}$

18	0	0	0	0	0	0	1	1	1	1	1	0	1	0	0	0
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

3.5.10.2 Encoders with equidistant reference marks

The specification is in **millimeters with linear encoders** (maximum displayable distance approx. 65 m) or **signal periods (P) with rotary encoders and angular encoders.**

Example: Increment: 50 mm
$50 \mathrel{\hat{=}} 32_{hex}$

18	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

3.5.11 Position of the first reference mark

With linear encoders without distance-coded reference marks, word 19 specifies the **position of the first reference mark** relative to the end position. The information is given in **mm.** Zero is stored in word 19 for units with selectable reference marks. See the encoder specifications for more detailed information. The position of the first reference mark is not supported with all encoders. Default value $\hat{=}$ 0

19	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	mm

Example: Position of the first reference mark: 20 mm
$20 \mathrel{\hat{=}} 14_{hex}$

19	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

3.5.12 Measuring step or measuring steps per revolution

Words 20 and 21 indicate the measuring step in nm or measuring steps per revolution.

20	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	M/rev or nm

21	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	M/rev or nm

If the value 0 is saved in words 20 and 21, then words 27, 28 and 29 must be considered in the "Parameters of the encoder manufacturer for EnDat 2.2" memory.

Linear encoders

With linear encoders, **words 20** and **21** specify the **measuring step** output by the encoder during **serial transmission of the position value**. The specification is in **nm**

Example: Measuring step 100 nm
$100 \mathrel{\hat{=}} 64_{hex}$

20	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}

Rotary or angle encoders

With rotary encoders or angular encoders, **words 20** and **21** specify the **number of measuring steps per revolution** output during **serial transmission** of the **position value**. The specification is in measuring steps per revolution (M/rev).

Example: Measuring steps per revolution: 1,800,000
$1{,}800{,}000 \mathrel{\hat{=}} 1B7740_{hex}$

20	0	1	1	1	0	1	1	1	0	1	0	0	0	0	0	0
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

21	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1
	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}

3.5.13 Datum shift of the encoder manufacturer

Words 22 and **23** specify the **datum shift** of the **encoder manufacturer**. The value must be added to the datum of the encoder. In the factory setting of the encoder, this value is also stored by the encoder manufacturer in the operating parameter memory area under "datum shift," i.e., in words 0 and 1.

⚠ Only the value stored in words 0 and 1 of the memory area for operating parameters is calculated for the serially output position value of the encoder. Words 22 and 23 of the encoder manufacturer's parameters therefore have **no effect** on the position value output. They merely indicate the preset datum shift of the encoder manufacturer.

⚠ The encoder manufacturer alone can change words 22 and 23.

The value is shown as a two's complement, where bit 2^{31} in word 23 indicates the direction. For an EnDat-compliant datum shift (assignment of datum to the signal period) the value of the datum shift with linear encoders must be a multiple of the measuring steps per signal period. With absolute rotary encoders and angular encoders, the value of the datum shift must be a multiple of the number of measuring steps per revolution divided by the number of incremental signal periods per revolution.

22	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	M/rev or M

23	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	M/rev or M

Linear encoders

Example:

Shift: +20 mm (with 0.1 µm absolute measuring step and 16 µm incremental grating period) ≙ 200,000 measuring steps

$$\frac{16\,\mu m \;\dfrac{1}{\text{Teilungsperiode}}}{0{,}1\,\mu m \;\dfrac{1}{\text{Messschrit}}} = 160\;\frac{\text{Messschrite}}{\text{Teilungsperiode}}$$

200,000 is an integral multiple of 160, and therefore complies with the conditions for a datum shift in conformance with EnDat.

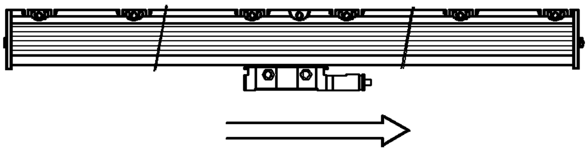


Figure 48

Note: With movement in the direction of decreasing position values, directly after the zero position follows the position value 2^x-1, 2^x-2,...
x ≙ the number of required clock pulse periods (word 13 → see point 3.5.6)

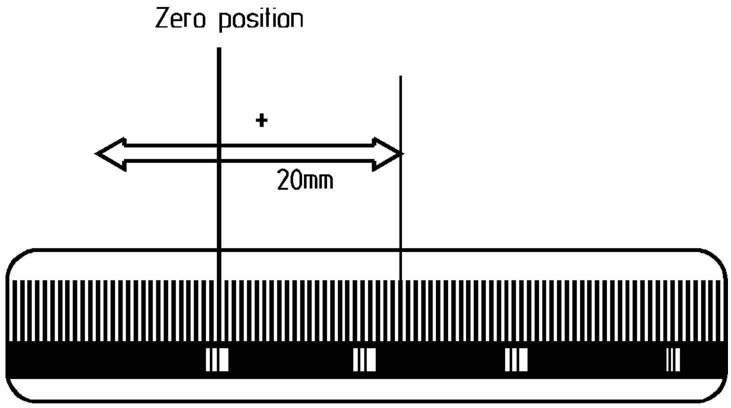


Figure 49

200000 ≙ $30D40_{hex}$
Two's complement ≙ $FFFCF2C0_{hex}$

22

1	1	1	1	0	0	1	0	1	1	0	0	0	0	0	0
2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

23

1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}

Rotary or angle encoders

Example:

Shift: +45° (with 8192 measuring steps / revolution and 2048 periods / revolution)

$$\frac{8192 \ \frac{\text{Messschrite}}{\text{Umdrehung}}}{2048 \ \frac{\text{Perioden}}{\text{Umdrehung}}} = 4 \ \frac{\text{Messschrite}}{\text{Periode}}$$

1024 is an integral multiple of 4, and therefore complies with the conditions for a datum shift in conformance with EnDat.

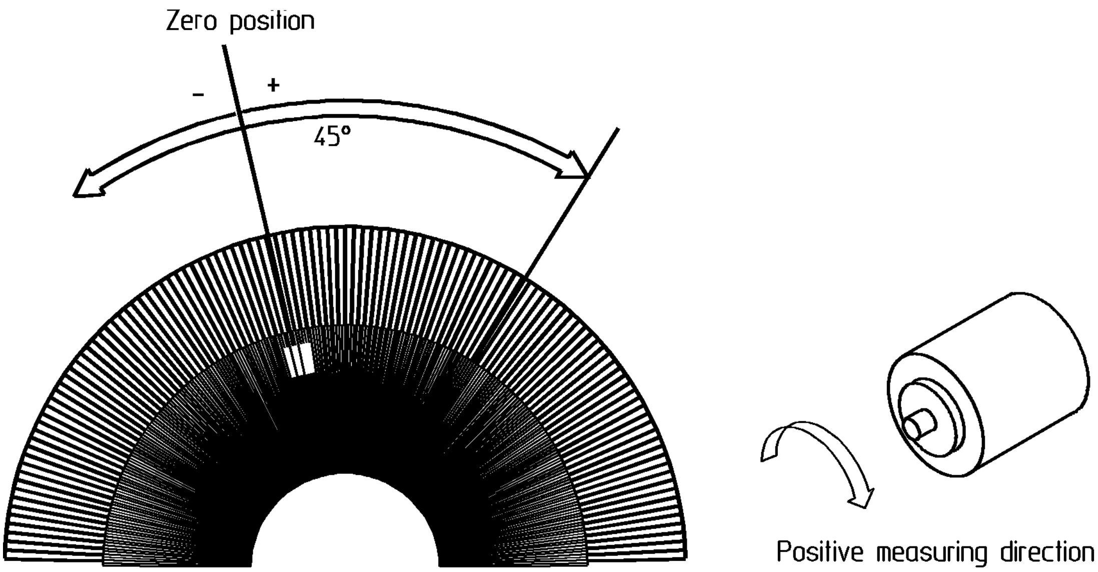


Figure 50

1024 ≙ 400_{hex}

Two's complement ≙ $FFFFFC00_{hex}$

22

1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

23

1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}

3.5.14 ID number

Words 24, 25 and **26** indicate the ID number (part number) of the encoder. In words 25 and 26, the first 6 digits of the ID number are saved as binary values. In word 24 the last two digits of the ID number are saved in binary-coded ASCII format (→ see also Appendix 4.6).

	ASCII binary-coded								ASCII binary-coded								
24	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0	

	binary-coded (ID number)																
25	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	

	binary-coded (ID number)																
26	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	

Example: ID number 262 144 A1
$262144 \hat{=} 40000_{hex}$

	A $\hat{=}$ 41_{hex}								1 $\hat{=}$ 31_{hex}							
24	0	1	0	0	0	0	0	1	0	0	1	1	0	0	0	1
	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0

25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

26	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}

3.5.15 Serial number

Words 27, 28 and **29** are provided for the serial number of the encoder, where the first and last 8 bits are saved in binary-coded ASCII format.

Word	Binary coded								ASCII binary-coded								
27	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0	

Word	Binary coded																
28	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	

Word	ASCII binary-coded								Binary coded								
29	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	

Example: Serial number □2637991A
2637991 $\hat{=}$ 2840A7$_{hex}$

Word									A $\hat{=}$ 41$_{hex}$							
27	1	0	1	0	0	1	1	1	0	1	0	0	0	0	0	1
	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0

Word																
28	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0
	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8

Word	Empty $\hat{=}$ 20$_{hex}$															
29	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}

3.5.16 Direction of rotation

The direction of measurement and direction of rotation with rotary encoders and angular encoders, and the direction of traverse with linear encoders, is only depicted in an exemplary way in the EnDat description.

Word 30 defines whether ascending or falling position values are output via the serial interface with respect to the direction of measurement specified in the encoder documentation.
Default = 0

30	1*	x	x	x	x	x	x	x	x	x	x	x	x	x	x	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

* Always set to logical High for NVM checking

Bit		= 0	= 1
2^0	Direction of measurement ①	Ascending position values	Falling position values
2^1	Currently not assigned Extension planned		
•			
•			
•			
2^{15}		NVM error	—

① Does not affect the complementary output of incremental signals.

3.5.17 External commissioning diagnostics

Word 31 indicates whether the encoder supports external commissioning diagnostics.

31	1*	x	x	x	x	x	x	x	x	x	x	x	x	x	x	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

* Always set to logical High for NVM checking

Bit		= 0	= 1
2^0	External commissioning diagnostics	Supported	**Not** supported
2^1	Currently not assigned Extension planned		
•			
•			
•			
2^{15}		NVM error	—

3.5.18 Maximum permissible mechanical velocity or shaft speed

The maximum permissible mechanical velocity v_{max} and shaft speed n_{max} are saved in **word 32**

	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	**r**
32	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	**m/min** or **min^{-1}**

The maximum permissible mechanical velocity or shaft speed is not saved with all encoders. Default ≙ 0.

Depending on the specific encoder, further specifications for mechanically permissible velocity must be observed and can be read in the documentation of the encoder

Linear encoders

Example: Maximum permissible mechanical velocity v_{max} 120 m/min
120 ≙ 78_{hex}

	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0
32	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

Rotary or angle encoders

Example: Maximum permissible mechanical shaft speed n_{max} 15,000 rpm
15,000 ≙ $3A98_{hex}$

	0	0	1	1	1	0	1	0	1	0	0	1	1	0	0	0
32	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

3.5.19 Accuracy with respect to linear or rotational velocity

Due to different limit frequencies, the incremental values differ from the absolute values, depending on the velocity. For this reason and if possible, two velocity ranges are defined with a maximum deviation between the incremental value and absolute value and contained in words 33 and 34.

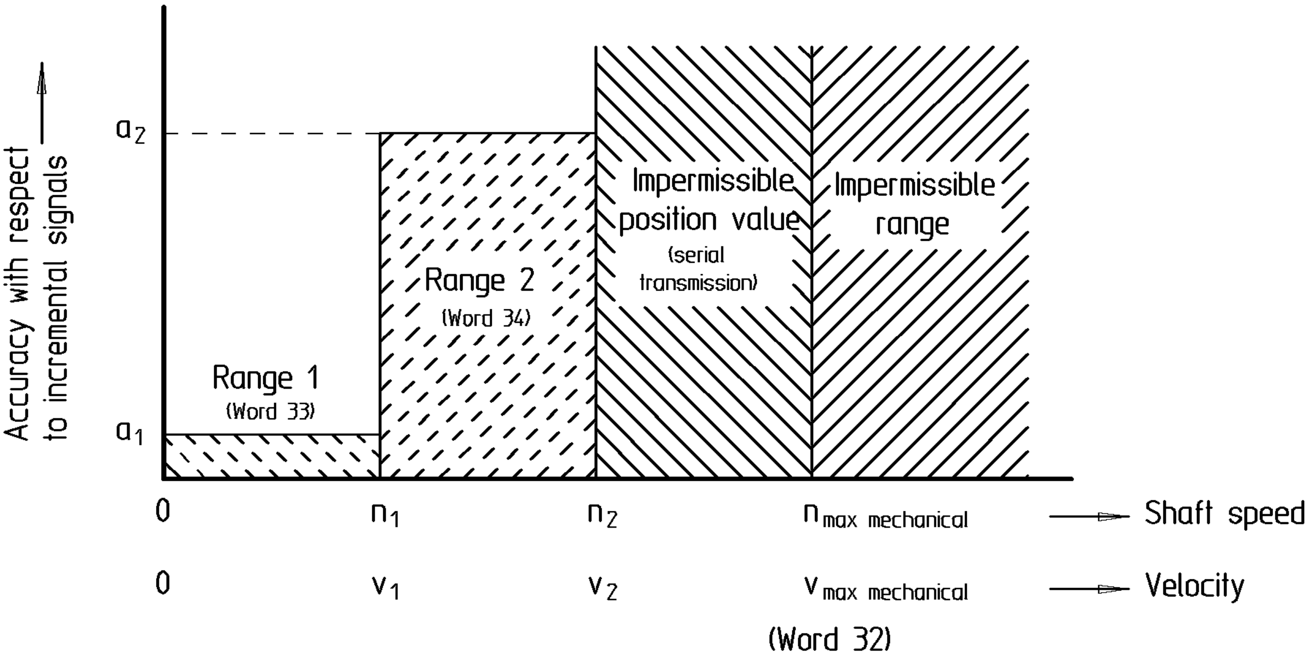


Figure 51

The **lower linear or rotational velocity range** and the corresponding accuracy of the position value are contained in **word 33**. **The higher linear or rotational velocity range** and the corresponding accuracy of the position value are contained in **word 34**. The lower-value byte of the word in each case specifies the valid accuracy and the higher-value byte the maximum permissible velocity or shaft speed (conversion factor). The accuracy is specified as a multiple of the lowest measuring step (LSB) transmitted via the serial interface. The maximum permissible velocity or shaft speed with each range results from a division of the maximum permissible mechanical velocity or shaft speed by the factor c_1 or c_2 saved in the specific higher-value byte.

$$v_i = \frac{v_{max}}{c_i} \qquad \text{or} \qquad n_i = \frac{n_{max}}{c_i} \qquad i = 1.2$$

If the value 65535 is saved in **word 33** and **word 34** of the "Parameters of the encoder manufacturer for EnDat 2.1," then words **11** to **14** of the "Parameters of the encoder manufacturer for EnDat 2.2" must be considered.

The velocity-dependent or shaft-speed-dependent accuracy is not connected with the system accuracy of the encoder.

3.5.19.1 Linear or rotational velocity range 1

	Conversion factor for maximum permissible linear or rotational velocity c_1								Accuracy a_1								
	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	**r**
33	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	

3.5.19.2 Linear or rotational velocity range 2

	Conversion factor for maximum permissible linear or rotational velocity c_2								Accuracy a_2								
	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	**r**
34	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	

Example **Linear encoder**

Maximum permissible mechanical velocity 120 m/min (word 32)

Velocity range 1 v_1 3 m/min

Accuracy for range 1 a_1 ± 16 LSB

Velocity range 2 v_2 3 m/min

Accuracy for range 2 a_2 ± 16 LSB

$c_1 = 40 \Rightarrow$ (120 m/min) / 40 = 3 m/min $a_1 = \pm 16$ LSB

	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
33	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

$c_1 = 40 \Rightarrow$ (120 m/min) / 40 = 3 m/min $a_2 = \pm 16$ LSB

	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0
34	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

Example **Rotary or angle encoder**

Maximum permissible mechanical velocity 15,000 min^{-1} (word 32)

Velocity range 1 n_1 1,500 rpm

Accuracy for range 1 a_1 ± 1 LSB

Velocity range 2 n_2 15,000 min^{-1}

Accuracy for range 2 a_2 ± 50 LSB

$c_1 = 10 \Rightarrow 15000 min^{-1} / 10 = 1500 min^{-1}$ $a_1 = \pm 1$ LSB

	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1
33	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

$c_1 = 10 \Rightarrow 15000 min^{-1} / 1 = 15000 min^{-1}$ $a_2 = \pm 50$ LSB

	0	0	0	0	0	0	0	1	0	0	1	1	0	0	1	0
34	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

3.5.20 Support of error messages 1

Depending on the encoder, not all error bits are supported in word 0 of the operating status. It is defined in **Word 35** whether a function of the encoder is monitored and if the corresponding error bit is set in word 0 with a malfunction.

35	x	x	x	x	x	x	x	x	x	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

Bit		**= 0**	**= 1**
2^0	Lighting	Not supported	Supported
2^1	Signal amplitude	Not supported	Supported
2^2	Position	Not supported	Supported
2^3	Overvoltage	Not supported	Supported
2^4	Undervoltage	Not supported	Supported
2^5	Overcurrent	Not supported	Supported
2^6	Battery	Not supported	Supported
•	Currently not assigned Extension planned		
•			
•			
2^{15}			

Support of error messages 2 (→see point 3.9.8)

3.5.21 Support of warnings

Depending on the type of encoder, not all warning bits are supported in word 1 of the operating status. It is defined in **Word 36** whether a function of the encoder is monitored and if the corresponding warning bit is set in word 1 with a malfunction.

36	x	x	x	x	x	x	x	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

Bit		**= 0**	**= 1**
2^0	Frequency collision	Not supported	Supported
2^1	Temperature exceeded	Not supported	Supported
2^2	Light-source control reserve	Not supported	Supported
2^3	Battery charge	Not supported	Supported
2^4	Reference point	Not supported	Supported
2^5	Cyclic mode	Not supported	Supported
2^6	Limit position	Not supported	Supported
2^7	Standby	Not supported	Supported
2^8	Diagnostics	Not supported	Supported
•	Currently not assigned Extension planned		
•			
•			
2^{15}			

3.5.22 EnDat command set / applications

The command set available (type 2.1 or 2.2) depends on the encoder, and is described in its specifications. The command set supported by the encoder is contained in **word 37**.

37																	
	x	x	x	x	x	x	x	x	x	x	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	

Bit		= 0	= 1
2^0	Command set type 2.2	Not supported	Supported
2^1		Supported	Not supported
2^2	Safety-relevant applications ①	Not supported	Supported
2^3		Supported	Not supported
2^4	Mode command "Encoder receive communication command"	Not supported	Supported
2^5		Supported	Not supported
•	Currently not assigned Extension planned	:	:
•		:	:
•		:	:
2^{15}		:	:

① Observe the documentation of the encoder.

⚠ The function is only supported if the associated bits are inversely saved.

3.5.23 Measuring length

The usable measuring length of a linear encoder is saved in **word 38**.

With a saved scale length of 940 mm (or scale length of 940 mm printed on the ID plate) it must not be expected that position values 0 mm to 940 mm are output. The position values can be shifted due to the scale beginning at a value other than 0, or as the result of a datum shift. A position value of 20 mm to 960 mm can therefore certainly be output with a scale length of 940 mm. Also, the usable measuring length can be minimally exceeded, depending on the encoder model.
The measuring length is not saved with all encoders. Default value ≙ 0

Since EnDat does not support negative position values, the position value $2^{\text{Number of clock pulses until the position value is transmitted}}$ is output instead of a negative algebraic sign.

	Measuring length unit			Measuring length													
38	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	

000 Measuring length in grating periods
001 Measuring length in micrometers
010 Measuring length in millimeters
011 Measuring length in meters
100 Specification of maximum measuring length in meters

Example: Linear encoder with measuring length of 940 mm

Indicated in mm			940												
0	1	0	0	0	0	1	1	1	0	1	0	1	1	0	0

3.5.24 Maximum processing time

The maximum internal calculation time t_{CAL} for the position value of the encoder is stored in **word 39**.

Only after the expiry of the calculation time t_{CAL} ① can the position value be sent from the encoder.

	Unit of time			Processing time													
39	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

2^{15}	**2^{14}**	**2^{13}**	**Processing time**
0	0	0	Specification of calculation time is not supported
0	0	1	In microseconds
0	1	0	In milliseconds
0	1	1	In nanoseconds
1	0	0	To be determined

Example: Linear encoder with calculation time of 1 ms

Indicated in ms			1												
0	1	0	0	0	0	1	1	1	0	1	0	1	1	0	0

① valid for f_c 8 MHz, t_{st} = 2 µs, without cable propagation time

3.5.25 EnDat ordering designation

The EnDat ordering designation is stored in **word 40**. The ordering designation is also indicated on the ID label of the encoder. The ordering designation consists of 7 characters and the first 5 characters always consist of "EnDat". The next two characters define the characteristics of the EnDat interface. These two characters are stored in binary-coded ASCII format in the ordering designation (→ also see Appendix 4.6).
If the value 0000_{hex} is saved in word 40, this parameter is <u>not</u> yet supported by the encoder.

	ASCII binary-coded								ASCII binary-coded								
40	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0	

Example: ordering designation EnDat22

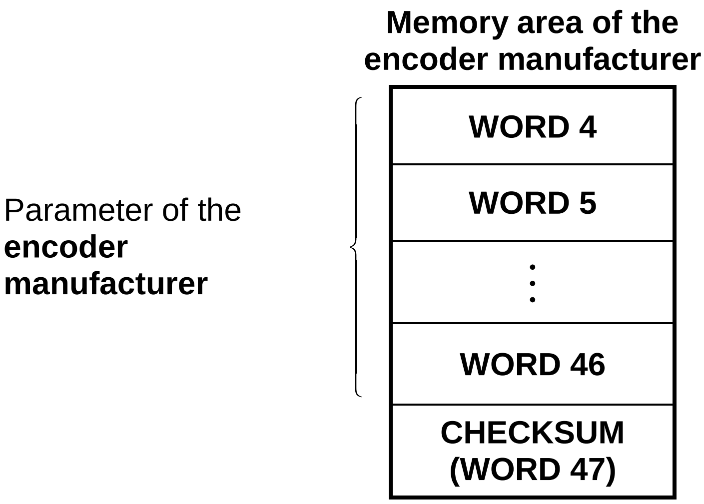
	$2 \triangleq 32_{hex}$								$2 \triangleq 32_{hex}$							
40	0	0	1	1	0	0	1	0	0	0	1	1	0	0	1	0
	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0

The ordering designation provides the following information:

Ordering designation	Execution
EnDat01	With incremental signals
EnDat21	Without incremental signals
EnDat02	With incremental signals
EnDat22	Without incremental signals

3.5.26 CHECKSUM

The checksum is stored in **word 47** of the encoder manufacturer's memory area in order to make it possible to check the correctness of the saved data. The checksum is formed from words 4 to 46.



The CHECKSUM is formed word by word, whereby the overflow is not considered:
CHECKSUM = WORD (4) + WORD (5) + ... + WORD (46)

3.6 Operating parameters

The operating parameters can be configured by the customer.

⚠ Changes to the values do not become valid until the mode command "Encoder receive reset" is transmitted.

3.6.1 Overview of the operating parameters

Word	Content	Unit: Linear encoder	Unit: Rotary encoder/ angular encoder	MRS code: C7 ..	C6	C5	C4	C3	C2	C1	C0	Address HEX
0	Datum shift	—		1	0	1	0	0	1	1	1	00
1		—										01
2		—										02
3	Diagnostics configuration	—										03
4	Address assignment	—										04
5	Instruction	—										05
6	Trigger threshold of the warning bit Temperature exceeded	K	K									06
7	Cycle time	ns	ns									07
8		ns	ns									08
9	Temperature sensor type	—										09
10	Connected temperature sensor type	—										0A
11		—										0B
12		—										0C
: :												: :
15												0F

3.6.2 Datum shift

Words 0, 1 and **2** can be used by the customer to perform a **datum shift**. In the factory setting, the datum shift as factory-set by the encoder manufacturer is stored in these words; for safety purposes this datum shift is also stored in word 22 and
word 23 of the parameters of the encoder manufacturer. If a datum shift by the customer is required this must be added and written to words 0, 1 and 2. With incremental encoders the datum shift only affects the absolute position (Pos2); with absolute coded encoders it affects the position value (Pos1).

The value is shown as a two's complement. For EnDat-compliant datum shift (association between the datum and the signal period) the value of the datum shift with linear encoders must be a multiple of the measuring steps per signal period. With absolute rotary encoders and angular encoders, the value of the datum shift must be a multiple of the number of measuring steps per revolution divided by the number of incremental signal periods per revolution. If the association between the datum and the signal period is irrelevant, then any position can be defined as the datum.
The operating parameters can be write-protected by the customer.

0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r/w
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
1	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r/w
	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	

With a position value > 32 bits, word 2 of the "operating parameters" area is activated and used for expansion of the datum shift.

0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r/w
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
1	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r/w
	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	
2	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r/w
	2^{47}	2^{46}	2^{45}	2^{44}	2^{43}	2^{42}	2^{41}	2^{40}	2^{39}	2^{38}	2^{37}	2^{36}	2^{35}	2^{34}	2^{33}	2^{32}	

Linear encoders

Example: shift: 40 mm (+ 20 mm from encoder manufacturer)
Measuring step 0.1 µm

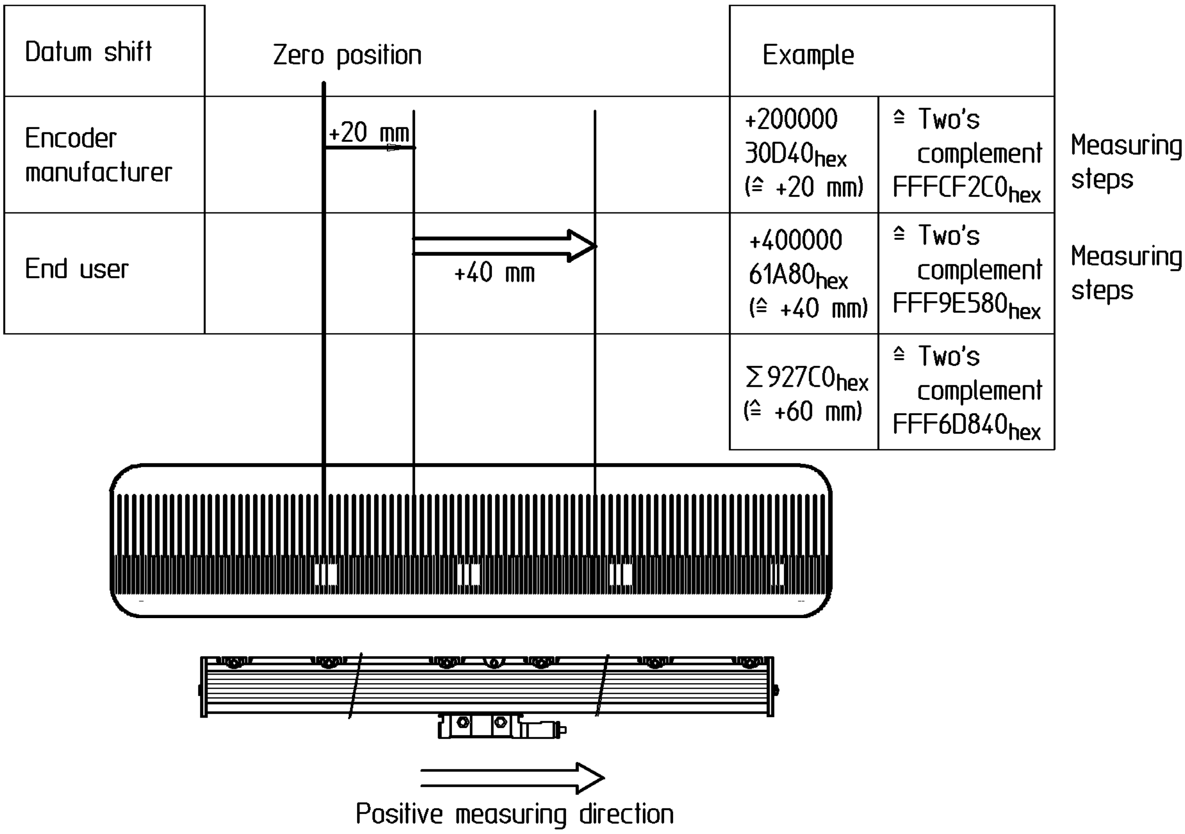


Figure 52

Note: With movement in the direction of decreasing position values, directly after the zero position follows the position value 2^x-1, 2^x-2,...
x ≙ number of required clock pulse periods (word 13 → see point 3.5.6)

Example:

1. Reading of words 0 and 1 (MRS code $A7_{hex}$)

0																
	1	1	1	1	0	0	1	0	1	1	0	0	0	0	0	0
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

≙ $FFFCF2C0_{hex}$

1																
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}

2. Gate word 0 and 1 with new datum shift (40 mm)
   $FFFCF2C0_{hex}$ + $FFF9E580_{hex}$ = $FFF6D840_{hex}$
3. Write words 0 and 1.

0																
	1	1	0	1	1	0	0	0	0	1	0	0	0	0	0	0
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

≙ $FFF6D840_{hex}$

1																
	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0
	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}

4. Send the "Encoder receive reset" mode command or switch the power supply off and on.

Rotary and angle encoders

Example: shift: + 20° (+ 5° from encoder manufacturer)

→ 569 measuring steps with 8192 measuring steps per revolution

→ With an encoder with 2048 grating periods, and to ensure the reference to the incremental track

is maintained, the

value 568 ≙ 238_{hex} must be saved for an EnDat-compliant datum shift.

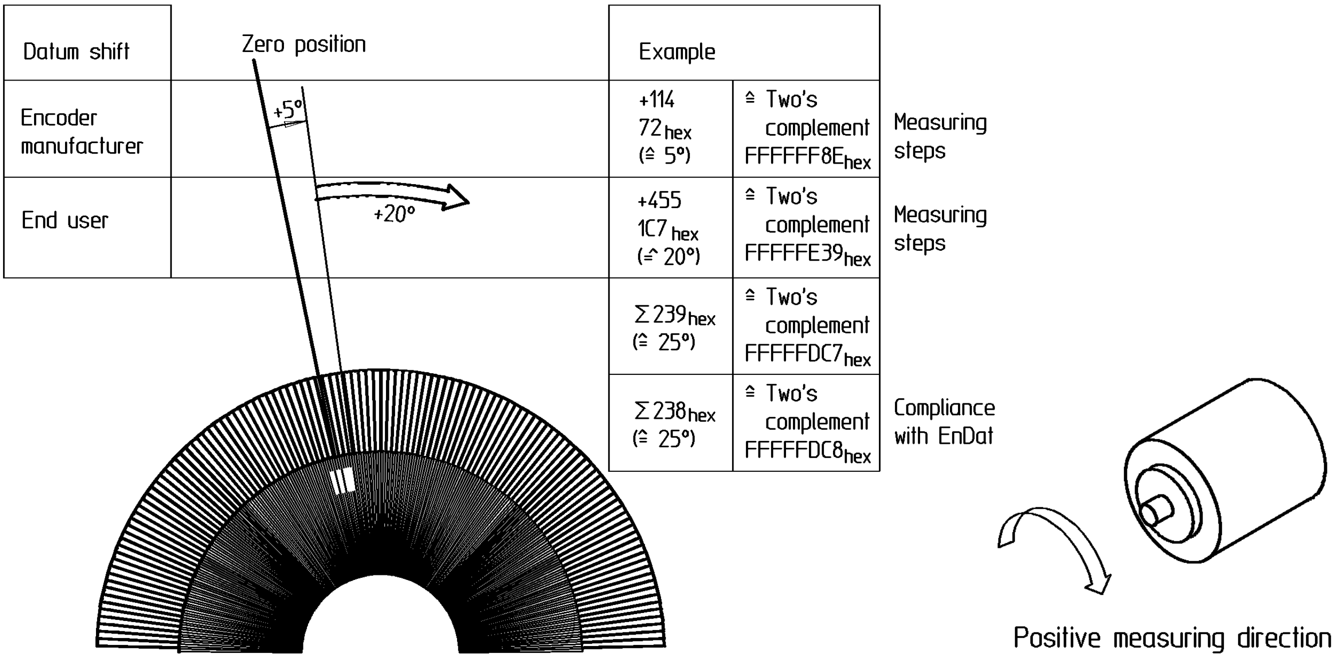


Figure 53

Example:

1. Reading of words 0 and 1 (MRS code $A7_{hex}$)

0

1	1	1	1	1	1	1	1	1	0	0	0	1	1	1	0
2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

≙ $FFFFFF8E_{hex}$

1

1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}

2. Gate words 0 and 1 with a new datum shift

$FFFFFF8E_{hex}$ + $FFFFFE39_{hex}$ = $FFFFFDC7_{hex}$

EnDat-compliant ≙ $FFFFFDC8_{hex}$

3. Write words 0 and 1.

0

1	1	1	1	1	1	0	1	1	1	0	0	1	0	0	0
2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

≙ $FFFFFDC8_{hex}$

1

1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}

4. Send the "Encoder receive reset" mode command or switch the power supply off and on.

3.6.3 Diagnostics configuration

The customer can specify the configuration of the diagnostics values in **word 3** of the operating parameters.
For each interrogation of a diagnostic value, activated valuation numbers are transmitted serially.

3	1/0	x	x	x	x	x	x	x	x	x	1/0	1/0	1/0	1/0	1/0	1/0	r/w
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

Bit		**= 0**	**= 1**
2^0	Valuation number 1	Deactivated	Activated
2^1	Valuation number 2	Deactivated	Activated
2^2	Valuation number 3	Deactivated	Activated
2^3	Valuation number 4	Deactivated	Activated
2^4	Valuation number 5	Deactivated	Activated
2^5	Valuation number 6	Deactivated	Activated
•	Currently not assigned Extension planned		
•			
•			
2^{15}	System-specific data	Deactivated	Activated

3.6.4 Address assignment

The encoder address for bus systems can be saved in **word 4**.

4	x	x	x	x	x	x	x	x	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r/w
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

⚠ Error bit 1 is always set if a bit is set in this word. This can only be cleared by resetting the word to 0000_{hex} and switching the power off and on.

3.6.5 Instructions

Instructions are saved in **word 5** of the memory area for operating parameters.

5	x	x	x	x	x	x	x	x	x	x	x	x	x	1/0	1/0	1/0	r/w
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

Bit		**= 0**	**= 1**
2^0	Energy-saving mode	Deactivated	Activated
2^1	Data driver at high-impedance	Deactivated	Activated
2^2	No updating of position values	Deactivated	Activated
•	Currently not assigned Extension planned		
•			
•			
2^{15}			

3.6.6 Trigger threshold of the warning bit for excessive temperature

derived from the internal temperature sensor (integrated in the encoder)

The trigger threshold of the warning bit for excessive temperature is saved in Kelvin in **word 6**.

6	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	K

Example: Trigger threshold of the warning bit for "excessive temperature" 110 °C
110°C $\hat{=}$ 383.1 K with scaling factor of 0.1
(see word 4 "Parameters of the encoder manufacturer for EnDat 2.2")
gives the value 2731 + 1100 = 3831 $\hat{=}$ $EF7_{hex}$

6	0	0	0	0	1	1	1	0	1	1	1	1	0	1	1	1
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

As the default value the maximum encoder temperature should be saved in word 22 "Parameters of the encoder manufacturer for EnDat 2.2" minus a safety reserve adapted to the application. It must also be observed that the warning bit "Temperature exceeded" (see word 36 "Parameters of the encoder manufacturer for EnDat 2.1") and the temperature sensor 2 (see word 0 "Parameters of the encoder manufacturer for EnDat 2.1") are supported.
If the default 0 is stored in word 22, the value 0 is also stored in word 6.

3.6.7 Cycle time

The cycle time (time between two position queries)
can be stored in **word 7** and **word 8** by the subsequent electronics. Default value: 1 ms.

7	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	r/w
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

8	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	r/w
	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	

The information is given in ns.

Example: Cycle time 125 µs = 125000 ns

7	1	1	1	0	1	0	0	0	0	1	0	0	1	0	0	0
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}

3.6.8 Temperature sensor type

In **word 9** the evaluation of the external temperature sensors can be activated (also see point 2.3.5.1). The conversion tables stored in the encoder are activated after sending the mode command "Encoder receive reset". Not all encoders support setting of the temperature sensor type. For which temperature sensor types an evaluation in the encoder is implemented is stored in **word 50 of the parameters of the encoder manufacturer for EnDat2.2**.

9	x	x	x	x	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r/w
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
	Reserved				Temperature 3				Temperature 2				Temperature 1				

Four bits are available for defining the sensor format for each temperature. The specific sensors are deactivated with the MSB. If bit 2^3 is set to 0, temperature 1 is output to address 0 of the additional sensors, with bit 2^7 = 0 temperature 2 is output to address 1, and with bit 2^{11} = 0 temperature 3 is output to address 2. If the specific bits are set to 1, then the corresponding address of the additional sensors is not output.
The three LSBs enable evaluation in each case according to the table below.

Decimal value of the 3 LSBs of temperature x, x = 1, 2, 3	Temperature sensor type
0	Reserved
1	KTY 84-130
2	PT 1000
3	PT 100
4	KTY 83-110
5	Currently not assigned
6	
7	

0 must be written to the reserved bits 2^{12} to 2^{15}.

Example:
PT 1000 sensors are connected to each of the temperature sensor inputs 1 and 2. Input 3 should not be used. Word 9 is then assigned as follows:

9	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

3.6.9 Connected temperature sensor type

The type of temperature sensor connected to the external sensor inputs can be saved in **word 10** and **word 11**. The parameter indicates which temperature sensor type is actually connected, and serves as information for the user for example or the application software in the control. The parameter is for information only and therefore does not influence the encoder-internal processing of the sensor data.

10

1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r/w
2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
Temperature 2								Temperature 1								

11

x	x	x	x	x	x	x	x	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r/w
2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
Reserved								Temperature 3								

For each temperature, one byte is provided for specification of the connected type of temperature sensor. The values to 207 are reserved for standardization purposes. Values from 208 upwards can be used for individually agreed identifiers.

Temperature 1, 2, 3 **(decimal)**	**Connected temperature sensor type**
0	Temperature sensor type unknown
1	KTY 84-130
2	PT 1000
3	PT 100
4	KTY 83-110
5…7	Reserved
8	KTY 81-210
9	PTC 100
10	PTC 100 - Drilling
11	PTC 120
12	PTC 120 - Drilling
13	PTC 145
14	PTC 145 - Drilling
15	PTC 160
16	PTC 160 - Drilling
17	Bimetal
18…207	Reserved
208…255	Freely usable

3.7 Parameters of the OEMs

The **memory area for parameters of the OEM** can be **freely defined** by the machine manufacturer. The drive manufacturer for example can store the motor type and maximum currents etc. in this area.
Depending on the total available encoder memory, there are four different memory configurations for the OEM. The number of available memory areas, their MRS codes and the specific memory size (start and end address) are derived from words 9 and 10 of the parameters of the encoder manufacturer (→ see point 3.5.5).
To ensure data security, HEIDENHAIN recommends generating and saving a checksum of the memory.
With some EnDat 2.2 units the OEM memory area has been expanded with Section 2 (→ see point 3.9.18).

3.8 Compensation values specified by the encoder manufacturer

The memory allocation for compensation values is defined by the encoder manufacturer in the specifications for each encoder.

3.9 Parameters of the encoder manufacturer for EnDat 2.2

Data required for type 2.2 mode commands is stored in this memory area.

3.9.1 Overview of "Parameters of the encoder manufacturer for EnDat 2.2"

Word	Content	Unit		MRS code								Address HEX
		Linear encoder	Rotary encoder/ angular encoder	C7 ..	C6	C5	C4	C3	C2	C1	C0	
0	Status of additional data 1	—	—	1	0	1	1	1	1	0	1	00
1	Status of additional data 2	—	—									01
2	Status of additional functions	—	—									02
3	Acceleration	m/s^2	$1/s^2$									03
4	Scaling function for temperature	K	K									04
5	Diagnostic status	—	—									05
6	Support of error message 2	—	—									06
7	Dynamic sampling status	—	—									07
8	Dynamic sampling status	—	—									08
9	Measuring step or measuring steps per revolution for position value 2											09
10												0A
11	Accuracy of position value 2 depending on linear velocity or shaft speed, area I	LSB ①	LSB ①									0B
12	Accuracy of position value 2 depending on linear velocity or shaft speed, area I	LSB ①	LSB ①									0C
13	Accuracy of position value 2 depending on linear velocity or shaft speed, area II	LSB ①	LSB ①									0D
14	Accuracy of position value 2 depending on linear velocity or shaft speed, area II	LSB ①	LSB ①									0E
15	Number of distinguishable revolutions of position value 2	—	—									0F
16	Direction of rotation or traverse of position value 2	—	—									10
17	Encoder identification	—	—									11
18	Encoder identification	—	—									12
19	Encoder identification	—	—									13
20	Encoder identification	—	—									14
21	Support of instructions	—	—									15
22	Max. permissible encoder temperature at measuring point, see dimension drawing	K	K									16
23	Max. permissible acceleration	m/s^2	$1/s^2$									17
24	Number of blocks for memory area, Section 2	—	—									18
25	Maximum clock frequency	kHz	kHz									19
26	Number of bits for position comparison	—	—									1A
27	Scaling factor for resolution	—	—									1B
28	Measuring step, or measuring steps per revolution or subdivision values of a grating period	—	—									1C
29		—	—									1D
30	Max. speed or rpm for constant code value	m/min	rpm									1E
31	Offset between position value and position value 2											1F
32												20
33												21
34	"Number of distinguishable revolutions" with scaling factor											22
35	Support of operating status error sources											23
36	Safety-relevant measuring steps											24

37												25
38												26
39	Non-safety-relevant subdivision of the relative											27
40	position											28
41	Non-safety-relevant subdivision of the absolute											29
42	position											2A
43	Generation of a warning message through limit position signals											2B
44	Support of touch probe statuses											2C
45	Timestamp for unit of measure											2-D
46	Referencing of incremental encoders											2E
47	Support of I/O's											2F
48	Assigned											30
49	Assigned											31
50	Support of temperature sensor types											32
: :												: :
63	CHECKSUM	—	—									3F

① MSB byte contains divisor with respect to the maximum permissible linear velocity or rotational shaft speed up to which this accuracy is valid.

3.9.2 Status of additional data 1

The additional data 1 that are available depend on the encoder, and are documented in **word 0** according to the following table.

0	x	x	x	x	x	x	x	x	x	x	x	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

Bit		**= 0**	**= 1**
2^0	Position value 2	Not supported	Supported
2^1	Test values	Not supported	Supported
2^2	Temperature sensor 1 (external)	Not supported	Supported
2^3	Temperature sensor 2 (on board)	Not supported	Supported
2^4	Additional sensors	Not supported	Supported
• • • **2^{15}**	Currently not assigned Extension planned		

3.9.3 Status of additional data 2

The additional data 2 that are available depend on the encoder, and are documented in **word 1** according to the following table.

1	x	x	x	x	x	x	x	x	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

Bit		= 0	= 1
2^0	Commutation	Not supported	Supported
2^1	Acceleration	Not supported	Supported
2^2	Limit position signals	Not supported	Supported
2^3	Asynchronous position value	Not supported	Supported
2^4	Operating status error sources	Not supported	Supported
2^5	Reserved	Not supported	Supported
2^6	Position value 2 (see 2.3.5.2)	Not supported	Supported
2^7	Timestamp	Not supported	Supported
•	Currently not assigned Extension planned		
•			
•			
2^{15}			

3.9.4 Status of additional functions

The additional functions that are available depend on the encoder, and are documented in **word 2** according to the following table.

2	x	x	x	x	x	x	x	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

Bit		= 0	= 1
2^0	Reference pulse initialization	Not supported	Supported
2^1	Settable recovery time I t_m	Not supported	Supported
2^2	Oversampling	Not supported	Supported
2^3	Time-triggered operation	Not supported	Supported
2^4	Multiturn overflow error message can be disabled	Not supported	Supported
2^5	Multiturn overflow latch can be disabled	Not supported	Supported
2^6	Disabling of multiturn Error message ①	Not supported	Supported
2^7	Multiturn counter reset	Not supported	Supported
2^8	EnDat2.2 cyclic operation	Not supported	Supported
•	Currently not assigned Extension planned		
•			
•			
2^{15}			

① with exception of multiturn overflow error message bit 2^4

3.9.5 Acceleration

A scaling factor for the acceleration is saved in **word 3**.

	Scaling factor for acceleration [$^1/_{s^2}$ or $^m/_{s^2}$]																
3	1*	0	0	0	0	0	0	0	0	0	0	0	0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	

* Always set to logical High for NVM checking

2^2	2^1	2^0	**Scaling Factor**
0	1	1	10^8
0	1	0	10^6
0	0	1	10^4
0	0	0	10^2
1	1	1	10^0
1	1	0	10^{-2}
1	0	1	10^{-4}
1	0	0	10^{-6}

⚠ Acceleration is not supported with all encoders
Default ≙ $0x8000_{hex}$

3.9.6 Scaling function for temperature

A scaling factor for the temperature and sensors is saved in **word 4**.

⚠ 0°C ≙ 273.1 K

	Scaling factor for temperature [K] and sensors																
4	1*	0	0	0	0	0	0	0	0	0	0	0	0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

* Always set to logical High for NVM checking

Default value ≙ $0x8000_{hex}$

2^2	2^1	2^0	Scaling Factor
0	0	0	0.1

Instead of an analog temperature sensor, an "opening contact" can also be evaluated. The value range for an opening contact must be determined from the specifications.

A fixed scaling applies for outputting temperature values in the additional sensors (12 bit format). The measured values are output with a resolution of 0.1 K and an offset of 115 K.

Output value EnDat 2.2	Temperature [K]	Temperature [°C]
0	115.0 K	-158.15 °C
1	115.1 K	-158.05 °C
…	…	…
1580	273.0 K	-0.15 °C
1581	273.1 K	-0.05 °C
1582	273.2 K	0.05 °C
1583	273.3 K	0.15 °C
…	…	…
4094	524.4 K	251.25 °C
4095	524.5 K	251.35 °C

3.9.7 Diagnostic status

Depending on the encoder, not all diagnostic values are supported.
Word 5 contains the information about which diagnostic values are supported.

5	1/0	x	x	x	x	x	x	x	x	x	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

Bit		**= 0**	**= 1**
2^0	Valuation number 1	Not supported	Supported
2^1	Valuation number 2	Not supported	Supported
2^2	Valuation number 3	Not supported	Supported
2^3	Valuation number 4	Not supported	Supported
2^4	Valuation number 5	Not supported	Supported
2^5	Valuation number 6	Not supported	Supported
•	Currently not assigned		
•	Expansion planned		
2^{15}	System-specific data	Not supported	Supported

3.9.8 Support of error messages 2

Depending on the encoder, not all error bits are supported in word 0 of the operating status. It is defined in **Word 6** whether a function of the encoder is monitored and if the corresponding error bit is set in word 0 with a malfunction.

6	x	x	x	x	x	x	x	x	x	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

Bit		**= 0**	**= 1**
2^0	Lighting	Not supported	Supported
2^1	Signal amplitude	Not supported	Supported
2^2	Position error	Not supported	Supported
2^3	Overvoltage	Not supported	Supported
2^4	Undervoltage	Not supported	Supported
2^5	Overcurrent	Not supported	Supported
2^6	Battery failure	Not supported	Supported
•	Currently not assigned		
•	Extension planned		
2^{15}			

3.9.9 Dynamic sampling status

In order to inspect static signals in the control cycle, you can call a targeted signal change. It is activated by sending the "Encoder send position value and receive test command" mode command and setting a forced sampling. The bits that can be sampled are determined in **words 7** and **8.**

7	x	x	x	x	x	x	x	x	x	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

8	x	x	x	x	x	x	x	x	x	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

Error message 1

Bit		= 0	= 1
2^{0}	Forced sampling of light source	Not supported	Supported
2^{1}	Forced sampling of signal amplitude	Not supported	Supported
2^{2}	Forced sampling of position error	Not supported	Supported
2^{3}	Forced sampling of overvoltage	Not supported	Supported
2^{4}	Forced sampling of undervoltage	Not supported	Supported
2^{5}	Forced sampling of overcurrent	Not supported	Supported
2^{6}	Forced sampling of battery failure	Not supported	Supported
2^{7} – 2^{15}	Reserved for the encoder manufacturer		

Error message 2

Bit		= 0	= 1
2^{0}	Forced sampling of light source	Not supported	Supported
2^{1}	Forced sampling of signal amplitude	Not supported	Supported
2^{2}	Forced sampling of position error	Not supported	Supported
2^{3}	Forced sampling of overvoltage	Not supported	Supported
2^{4}	Forced sampling of undervoltage	Not supported	Supported
2^{5}	Forced sampling of overcurrent	Not supported	Supported
2^{6}	Forced sampling of battery failure	Not supported	Supported
2^{7} – 2^{15}	Reserved for the encoder manufacturer		

3.9.10 Measuring step or measuring steps per revolution of position value 2

Words 9 and **10** specify the resolution of the position value in accordance with the scaling factor in Word 27 "Parameters of the encoder manufacturer EnDat 2.2".

9	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	[1)]

10	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	[1)]

[1)] according to scaling factor

Linear encoders

With linear encoders, **words 9** and **10** specify the **measuring step** with which position value 2 is output in the additional data.

Example: measuring step 100 nm (scaling factor 000; specification is in **nm**)
100 ≙ 64_{hex}

9	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}

Rotary or angle encoders

With rotary encoders or angle encoders, **words 9** and **10** specify the **number of measuring steps per revolution** that position value 2 in the additional data can maximally assume.

Example: measuring steps per revolution 1,800,000 (scaling factor 000; specification is in measuring steps per revolution **M/rev**)
1,800,000 ≙ $1B7740_{hex}$

9	0	1	1	1	0	1	1	1	0	1	0	0	0	0	0	0
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

10	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1
	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}

3.9.11 Accuracy with respect to linear or rotational velocity

The accuracy of the position value transmitted via the serial interface (relative position or position value 1) depends on the velocity or shaft speed according to the specific encoder.
Because of different limit frequencies, the incremental values differ from the absolute values in accordance with the speed. Therefore, if possible, two speed ranges are defined with a maximum deviation between the incremental and absolute values, and are saved in Words 11 through 14.
With units supporting position value 2, the values stored in words 11 to 14 specify the maximum value of the deviation in accuracy of the relative position (or position value 1) to the incremental track, or of position 2 to the incremental track. The higher values are saved in words 11 to 14.
Separately saving the accuracy values, relative position and position 2 is not necessary because only the maximum deviation to the incremental track is decisive.

⚠ The velocity-dependent or shaft-speed-dependent accuracy is not connected with the system accuracy.

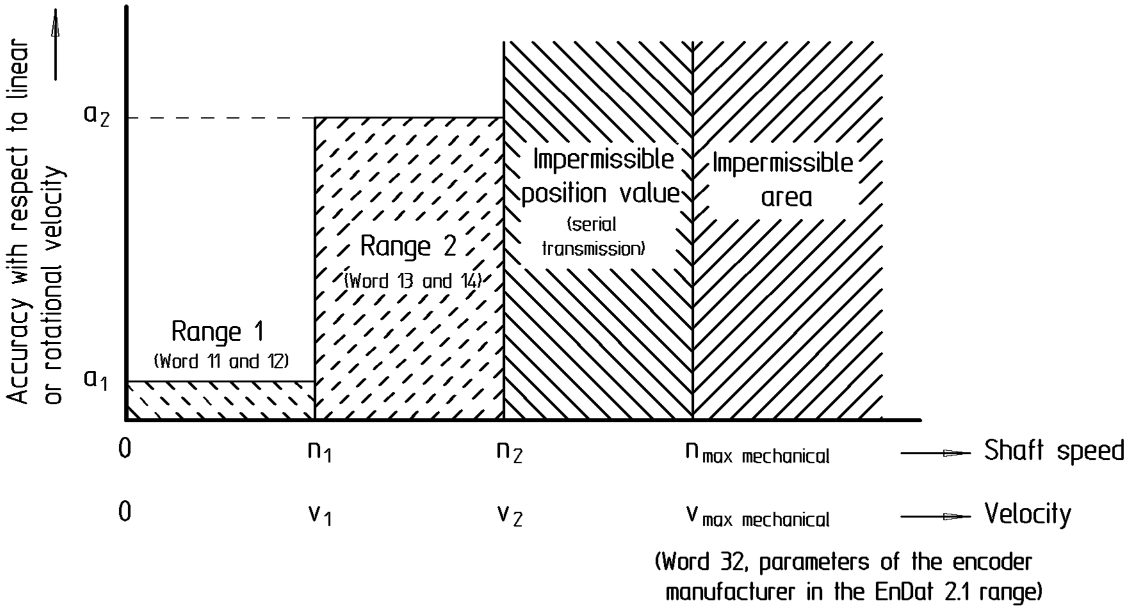


Figure 54

The **lower linear or rotational velocity range** and the corresponding accuracy of the position value are saved in **words 11** and **12**. **The higher linear or rotational velocity range** and the corresponding accuracy of the position value are saved in **words 13** and **14**. Word 12 and word 14 specify the accuracy valid in each case for the velocity or shaft speeds stored in **word 11** and
word 13. The accuracy is specified as a multiple of the lowest measuring step (LSB) transmitted via the serial interface. The maximum permissible velocity or shaft speed per area results from dividing the maximum permissible mechanical velocity or shaft speed by the factor c_1 or c_2 saved in **word 11** and **word 13** in each case.

$$v_i = \frac{v_{max}}{c_i} \quad \text{or} \quad n_i = \frac{n_{max}}{c_i} \qquad i = 1.2$$

3.9.11.1 Linear or rotational velocity range 1

	Conversion factor for maximum permissible velocity or shaft speed c_1																
	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	**r**
11	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

$\mathbf{2^{15}}$	$\mathbf{2^{14}}$	$\mathbf{2^{13}}$	**Scaling Factor**
0	0	0	x1
0	0	1	x2
0	1	0	x4
0	1	1	x8
1	0	0	x16
1	0	1	x32
1	1	1	Not supported

	Accuracy a_1																
	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	**r**
12	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

$\mathbf{2^{15}}$	$\mathbf{2^{14}}$	$\mathbf{2^{13}}$	**Scaling Factor**
0	0	0	x1
0	0	1	x2
0	1	0	x4
0	1	1	x8
1	0	0	x16
1	0	1	x32
1	1	1	Not supported

3.9.11.2 Linear or rotational velocity range 2

	Conversion factor for maximum permissible velocity or shaft speed c_2																
	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	**r**
13	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

$\mathbf{2^{15}}$	$\mathbf{2^{14}}$	$\mathbf{2^{13}}$	**Scaling Factor**
0	0	0	x1
0	0	1	x2
0	1	0	x4
0	1	1	x8
1	0	0	x16
1	0	1	x32
1	1	1	Not supported

14	Accuracy a_2																
	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	**r**
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	

$\mathbf{2^{15}}$	$\mathbf{2^{14}}$	$\mathbf{2^{13}}$	**Scaling Factor**
0	0	0	x1
0	0	1	x2
0	1	0	x4
0	1	1	x8
1	0	0	x16
1	0	1	x32
1	1	1	Not supported

Example **Linear encoder**

Maximum mechanically permissible velocity 120 m/min (word 32 in the memory area of the parameters of the encoder manufacturer)

Velocity range 1 v_1 3 m/min
Accuracy for range 1 a_1 ± 16 LSB
Velocity range 2 v_2 3 m/min
Accuracy for range 2 a_2 ± 16 LSB

$c_1 = 40 \Rightarrow$ (120 m/min)/40 = 3 m/min

11	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

x1

$a_1 = \pm$ 16 LSB

12	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

x1

$c_2 = 40 \Rightarrow$ (120 m/min)/40 = 3 m/min

13	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

x1

$a_2 = \pm$ 16 LSB

14	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

x1

Example **Rotary or angle encoder**

Maximum mechanically permissible velocity 15,000 min^{-1} (word 32 "Parameters of the encoder manufacturer")

Velocity range 1	n_1	1,500 rpm
Accuracy for range 1	a_1	± 1 LSB
Velocity range 2	n_2	15,000 min^{-1}
Accuracy for range 2	a_2	± 50 LSB

$c_1 = 10 \Rightarrow 15000\ min^{-1}/10 = 1500\ min^{-1}$

	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
11	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

x1

$a_1 = \pm 1$ LSB

	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
12	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

x1

$c_2 = 1 \Rightarrow 15000\ min^{-1}/1 = 15000\ min^{-1}$

	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
13	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

x1

$a_2 = \pm 50$ LSB

	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0
14	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

x1

3.9.12 Number of distinguishable revolutions of position value 2

With **multiturn encoders** the distinguishable revolutions are specified in the additional data in **word 15.**

15	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

Example: 2048 distinguishable revolutions

$2048 \triangleq 0800_{hex}$

15	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

Note: With a singleturn encoder the value 0000_{hex} is saved in word 15.

Caution! Observe the scaling factor **word 34** in the area "Parameters of the encoder manufacturer for EnDat 2.2".

If the value 0 is stored in word 15, no multiturn position value 2 is output

3.9.13 Direction of rotation or traverse for position value 2

In **word 16** it is defined whether ascending or falling values are output for the position value 2 with respect to the positive direction of rotation or traverse specified in the documentation.

16	**1***	x	x	x	x	x	x	x	x	x	x	x	x	x	x	1/0
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

* Always set to logical High for NVM checking

Bit		**= 0**	**= 1**
2^0	Direction of measurement ①	Ascending position values	Decreasing position values
•	Currently not assigned Extension planned		
•			
•			
2^{15}		NVM error	—

① Does not affect the complementary output of incremental signals.

3.9.14 Encoder identification

Words 17, 18, 19 and **20** are intended for identification of the encoder. The encoder identification is stored in binary-coded ASCII format (→ also see Appendix 4.6).

	ASCII binary-coded								ASCII binary-coded								
17	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{3}	2^{2}	2^{1}	2^{0}	2^{3}	2^{2}	2^{1}	2^{0}	2^{3}	2^{2}	2^{1}	2^{0}	2^{3}	2^{2}	2^{1}	2^{0}	

	ASCII binary-coded								ASCII binary-coded								
18	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

	ASCII binary-coded								ASCII binary-coded								
19	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	

	ASCII binary-coded								ASCII binary-coded								
20	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{47}	2^{46}	2^{45}	2^{44}	2^{43}	2^{42}	2^{41}	2^{40}	2^{39}	2^{38}	2^{37}	2^{36}	2^{35}	2^{34}	2^{33}	2^{32}	

Example: LC185

	C $\hat{=}$ 43_{hex}								L $\hat{=}$ $4C_{hex}$							
17	0	1	0	0	0	0	1	1	0	1	0	0	1	1	0	0
	2^{3}	2^{2}	2^{1}	2^{0}	2^{3}	2^{2}	2^{1}	2^{0}	2^{3}	2^{2}	2^{1}	2^{0}	2^{3}	2^{2}	2^{1}	2^{0}

	8 $\hat{=}$ 38_{hex}								1 $\hat{=}$ 31_{hex}							
18	0	0	1	1	1	0	0	0	0	0	1	1	0	0	0	1
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

	Empty $\hat{=}$ 20_{hex}								5 $\hat{=}$ 35_{hex}							
19	0	0	1	0	0	0	0	0	0	0	1	1	0	1	0	1
	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}

	Empty $\hat{=}$ 20_{hex}								Empty $\hat{=}$ 20_{hex}							
20	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0
	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}

3.9.15 Support of instructions

Depending on the encoder, not all instructions are supported. **Word 21** specifies whether the encoder supports an instruction.

21																	
	x	x	x	x	x	x	x	x	x	x	x	x	x	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

Bit		**= 0**	**= 1**
2^0	Energy-saving mode	Not supported	Supported
2^1	Data driver at high-impedance	Not supported	Supported
2^2	No updating of position values	Not supported	Supported
•	Currently not assigned Extension planned		
•			
•			
2^{15}			

3.9.16 Maximum permissible encoder temperature

The maximum permissible encoder temperature is saved in Kelvin in **word 22**.

22																	
	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	K

Example: Max. permissible encoder temperature 115 °C
115°C ≙ 388.1 K ⇒ a scaling factor of 0.1 (see word 4 "Parameters of the encoder manufacturer for EnDat 2.1") gives the value 2731 (≙ 0°) + 1150 (≙ 115.0°) = 3881 ≙ $F29_{hex}$

22																
	0	0	0	0	1	1	1	1	0	0	1	0	1	0	0	1
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

The maximum permissible encoder temperature may be applied at the measuring point (see dimension drawing). The temperature ranges for cables and connectors are not considered and must be separately covered. If the encoder manufacturer does not indicate a maximum encoder temperature, the default value of 0 is entered.

3.9.17 Maximum permissible mechanical acceleration

The maximum permissible mechanical acceleration is saved in **word 23**.

23																	
	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	K

Example: Max. permissible acceleration
120 000 $^1/_{s^2}$ ⇒ a scaling factor of 100 (see word 3 "Parameters of the encoder manufacturer for EnDat 2.1") gives the value 1200 ≙ $4B0_{hex}$

23																
	0	0	0	0	0	1	0	0	1	0	1	1	0	0	0	0
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

The acceleration is not stored with all encoders. Default value ≙ 0

3.9.18 Number of blocks for memory area section 2

The number of blocks for the section 2 memory area is entered in **word 24.**

24																	
	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	

0 $\hat{=}$ Section 2 memory area is not supported

3.9.19 Maximum clock frequency

In **word 25** the maximum possible clock pulse frequency in kHz for EnDat 2.2 transmissions is specified.

25																	
	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	

Example: Max. permissible clock frequency 8 MHz
Specification in kHz $\Rightarrow$ 8000 kHz $\hat{=}$ $1F40_{hex}$

25																
	0	0	0	1	1	1	1	1	0	1	0	0	0	0	0	0
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

This value reflects the properties of the encoder, which are mostly the consequence of the speed and circuitry of the RS-485 transceiver. The attainable clock frequency not only depends on the encoder properties, but is significantly influenced by the properties of the cable assembly used as well as the plug connections and desired cable lengths. The usability of the cable ("cable quality") must be assessed separately for all applications.

With encoders with firmly connected cable assemblies the maximum clock pulse frequency is limited to 2 MHz with use of incremental signals.
With encoders where various cable assemblies can be connected; with and without incremental signals; the properties of the encoder (with EnDat 2.2 usually 8 MHz) are specified with respect to the maximum clock pulse frequency. This is because the cable assembly determines the properties of the transmission path.

3.9.20 Number of bits for position comparison

For safety-oriented applications, the number of bits relevant for the comparison of Pos1 and Pos2 is saved in **word 26**.

26																	
	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	

Example: 9 bits are available for the comparison.

26																
	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

⚠ If the **words 36** through **42** in the "Parameters of the encoder manufacturer for EnDat 2.2" area are supported for safety-oriented applications, the value 0 is entered in **word 26**.

3.9.21 Scaling factor for resolution

A scaling factor for words 9 and 10 or 28 and 29 is stored in **word 27** (→ see point 3.5.12)

	Scaling factor																
27	x	x	x	x	x	1/0	1/0	1/0	x	x	x	x	x	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

absolut Position (2^{10}–2^{8})

relative Position (2^{2}–2^{0})

Pos.2

10	2^9	2^8	**Scaling factor for words 9 and 10**
0	0	0	Entry in nm or measuring steps per revolution
0	0	1	Subdivision values of a grating period
0	1	0	Entry in measuring steps per revolution in powers of 2
0	1	1	Specifies the measuring steps in pm
1	0	0	Not supported

Pos.1

2^2	2^1	2^0	**Scaling factor for words 28 and 29**
0	0	0	Note words 20 and 21 in the "Parameters of the encoder manufacturer for EnDat 2.1." Words 28 and 29 in the "Parameters of the encoder manufacturer for EnDat 2.2" are assigned the value 0.
0	0	1	Subdivision values of a grating period
0	1	0	Specifies the measuring steps or measuring steps per revolution raised to the second power.
0	1	1	Specification of measuring steps in pm
1	0	0	Not supported

3.9.22 Measuring step, or measuring steps per revolution or subdivision values of a grating period

28	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

29	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	

Example: 12-bit subdivision values $\triangleq$ 2^{12} = 4096 values / grating period $\triangleq$ 1000_{hex}

27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

28	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}

3.9.23 Maximum speed or RPM for constant code value

The maximum speed for a constant code value is saved in **word 30**. "Constant code value means": The calculation of the code value for the absolute tracks with different frequencies can be performed up to a certain rpm.

30	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	m/min or min^{-1}

The maximum velocity or shaft speed for constant code value is not saved with all encoders.
Default $\triangleq$ 0

Linear encoders

Example: Maximum permissible mechanical velocity v_{max} 120 m/min for constant code value
120 $\triangleq$ 78_{hex}

	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0
30	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

Rotary or angle encoders

Example: Maximum permissible mechanical velocity n_{max} 15,000 min^{-1} for constant code value 15,000 $\triangleq$ $3A98_{hex}$

	0	0	1	1	1	0	1	0	1	0	0	1	1	0	0	0
30	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

3.9.24 Offset between position value and position value 2

The offset between position value and position value 2 is specified in **words 31** to **33**.
The offset corresponds to the resolution of position value 2.

Word																	
31	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

Word																	
32	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	

Word																	
33	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{47}	2^{46}	2^{45}	2^{44}	2^{43}	2^{42}	2^{41}	2^{40}	2^{39}	2^{38}	2^{37}	2^{36}	2^{35}	2^{34}	2^{33}	2^{32}	

3.9.25 "Number of distinguishable revolutions" with scaling factor

Only if the value 65535 is stored in **word 17** of the area "Parameters of the encoder manufacturer for EnDat 2.1" is a scaling factor and the number of distinguishable revolutions saved in **word 34**.

	Scaling factor			Number of distinguishable revolutions													
34	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	

2^{15}	**2^{14}**	**2^{13}**	
0	0	0	Number of distinguishable revolutions saved in word 17 of the "Parameters of the encoder manufacturer for EnDat 2.1" range
0	0	1	Information given in 2^x

2^x = number of distinguishable revolutions

Example: distinguishable revolutions 65536

	Information given in 2^x			2^{16} distinguishable revolutions x = 16												
34	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

3.9.26 Support of operating status error sources

Depending on the encoder, not all operating status error sources are supported. Whether an encoder function is supported, and whether with a malfunction the associated bit is set, is stored in ***word 35*** *"Parameters of the encoder manufacturer for EnDat 2.2".*

35	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	

Bit		= 0	= 1
2^0	Lighting	Not supported	Supported
2^1	Signal amplitude	Not supported	Supported
2^2	S Pos1	Not supported	Supported
2^3	Overvoltage	Not supported	Supported
2^4	Undervoltage	Not supported	Supported
2^5	Overcurrent	Not supported	Supported
2^6	Temperature exceeded	Not supported	Supported
2^7	S Pos2	Not supported	Supported
2^8	S System	Not supported	Supported
2^9	S Power interruption	Not supported	Supported
2^{10}	M Pos1	Not supported	Supported
2^{11}	M Pos2	Not supported	Supported
2^{12}	M System	Not supported	Supported
2^{13}	M Power interruption	Not supported	Supported
2^{14}	Overflow/Underflow	Not supported	Supported
2^{15}	M Battery	Not supported	Supported

3.9.27 Safety-relevant measuring steps

For safety-relevant applications, the measuring steps that are relevant for comparing the position and position value 2 are stored in words 36 through 38.

36	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	

37	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	

38	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{47}	2^{46}	2^{45}	2^{44}	2^{43}	2^{42}	2^{41}	2^{40}	2^{39}	2^{38}	2^{37}	2^{36}	2^{35}	2^{34}	2^{33}	2^{32}	

With rotary encoders these are the number of safety-relevant measuring steps per revolution. With linear encoders this parameter indicates the number of safety-relevant measuring steps with respect to the maximum output value.

Example: EQN 1337 – 512 safety-relevant measuring steps

36	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}

38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2^{47}	2^{46}	2^{45}	2^{44}	2^{43}	2^{42}	2^{41}	2^{40}	2^{39}	2^{38}	2^{37}	2^{36}	2^{35}	2^{34}	2^{33}	2^{32}

Note: 0000 0000 0000 $_{hex}$ corresponds to 2^{48} safety-relevant measuring steps
The default value for non-safety-relevant applications: 0000 0000 0000 $_{hex}$

3.9.28 Non-safety-relevant subdivision of the position

For the safety-oriented applications, the limit between the safety-relevant and non-safety-relevant parameters is required within the subdivision. The value for the position is stored in **words 39** and **40**.

39	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

40	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	

Example: ECN 1325 –

2^{25} bits (resolution): 2^{9} bits (safety-relevant measuring steps)= 2^{16} bits (non-safety-relevant)

39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}

Default value for non-safety-oriented applications: 0000 0000 $_{hex}$

3.9.29 Non-safety-relevant subdivision of the position value 2

For safety-oriented applications, the factor between safety-relevant and non-safety-relevant parameters is required. The value for position value 2 is stored in **words 41** and **42**.

41																	
	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

42																	
	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	

Example: ECN 1325

$$\frac{2^9 \text{ Messschritt bzw. Messschritte pro Umdrehung des Positionswertes 2}}{2^9 \text{ (sicherheitsrelevante Messschritte) für den Positionswert 2}} = 1$$

41																
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

42																
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}

Default value for non-safety-oriented applications: 0000 0000 $_{hex}$

3.9.30 Generation of a warning message through limit position signals

Which limit position signal causes a warning is saved in **word 43**

43																	
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

Bit		**= 0**	**= 1**
2^0	Warning message for limit position signal L1	Not supported	Supported
2^1	Warning message for limit position signal L2	Not supported	Supported
• • 2^{15}	Currently not assigned Extension planned		

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3.9.31 Support for touch probes

The functions of a touch probe supported are saved in **word 44**

	Touch probes																
44	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

3.9.32 Timestamp time unit only for touch probes

A time unit is saved in **word 45.** The switching time of an encoder can be determined together with the value of the timestamp

	Unit of time																
45	1/0	1/0	1/0	X	X	X	X	X	X	X	X	X	X	X	X	X	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

2^{15}	2^{14}	2^{13}	**Timestamp for unit of time**
0	0	0	Specification of the timestamp is not supported
0	0	1	Information given in 2 microseconds
0	1	0	Information given in 1 microsecond
0	1	1	Information given in 500 nanoseconds
1	0	0	Information given in 125 nanoseconds

Example: Touch probes with a timestamp with a time unit of 1 µs

0	1	0	x	x	x	x	x	x	x	x	x	x	x	x	x

Value in
1 µs

3.9.33 Referencing of incremental encoders

For incremental encoders, whether the encoder supports the resetting of the RM bit and therefore re-referencing via EnDat command, or whether re-referencing can only be performed by disconnecting and reapplying the supply voltage is saved in **word 46**.

46																
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	

Bit		= 0	= 1
2^0	Resetting of the RM bit via EnDat command with incremental encoders	Not supported	Supported
2^1	Currently not assigned Extension planned	:	:
•		:	:
•		:	:
•		:	:
2^{15}		:	:

3.9.34 Support of I/O's

Which I/Os are available depends on the specific encoder and is saved in **word 47** according to the table below.

47																	
	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	

3.9.35 Word 48/49 preset by HEIDENHAIN

3.9.36 Support of temperature sensor types

For which types of temperature sensor an evaluation in the encoder is implemented is stored in **word 50**.

50																	
	1/0	x	x	x	x	x	x	x	x	x	x	1/0	1/0	1/0	1/0	1/0	r
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

Bit		**= 0**	**= 1**
2^0	Reserved	Not supported	Supported
2^1	KTY 84-130	Not supported	Supported
2^2	PT 1000	Not supported	Supported
2^3	PT 100	Not supported	Supported
2^4	KTY 83-110	Not supported	Supported
2^5	Currently not assigned Extension planned	:	:
•		:	:
2^7		:	:
2^8	Not available		
•			
2^{14}			
2^{15}	Support of setting	Not supported	Supported

If bit 2^{15} (support of setting) has the value 0 the user cannot set the type of temperature sensor and only the standard setting KTY 84-130 is supported.

3.9.37 CHECKSUM

The checksum is stored in **word 63** of the memory area for parameters of the encoder manufacturer for EnDat 2.2 in order to make it possible to check the correctness of the saved data. The checksum is formed from words 0 to 62.

Memory area of the encoder manufacturer

Parameter of the encoder manufacturer	**WORD 0**
	WORD 1
	⋮
	WORD 62
	CHECKSUM (WORD 63)

The CHECKSUM is formed word by word, whereby the overflow is not considered:

CHECKSUM = WORD (0) + WORD (1) + ... + WORD (62)

3.10 Operating parameter 2

In operating parameter 2 you can activate feature initialization functions, in a similar manner as in word 3, and verify their activation.

⚠ Value changes in the "Operating parameter 2" area become active for EnDat 2.1 at the latest with receipt of the acknowledgment in the subsequent electronics, or for EnDat 2.2 with resetting of the BUSY bit (BUSY = 0) in the additional data.

⚠ Pay attention to the default value after power off/on.

⚠ The values set in operating parameter 2 are only saved until the next power off/on.

Word			MRS code for selecting the memory area
Number	Memory area	Access	$C_7C_6C_5C_4C_3C_2C_1C_0$
0 ... 255	Operating parameters 2	r / w	10111011

3.10.1 Overview of operating parameter 2

Word	Content	Unit: Linear encoder	Unit: Rotary encoder/ angular encoder	MRS code C7 ..	C6	C5	C4	C3	C2	C1	C0	Address HEX
0	I/0	—	—									00
1		—	—									01
2 3	Status of touch probes	—	—									02 03
4 : 10	Currently not assigned											04 : A
11	Referencing of incremental encoders	—	—									B
12	Encoder-specific data	—	—									C
13 : : 127	Currently not assigned ① Extension planned	—	—									D : : 7F
128 : : 255	Encoder-specific data	—	—									80 FF

① Word 100 preset by HEIDENHAIN.

3.10.2 I/O

I/O can be defined in **word 0** and **word 1**. Which I/O are supported is specified in word 47 of the parameters of the encoder manufacturer for EnDat 2.2.

0	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	r/w
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	r/w
	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	

Bit		**= 0**	**= 1**
2^0	I/O	Deactivated	Activated
2^1	:		
•	:		
•	:		
•	:		
2^{15}	I/O	Deactivated	Activated

3.10.3 Touch probe control commands

Word 2 through word 4 are reserved for touch probes.

3.10.4 Words 5-10 are currently not assigned

3.10.5 Referencing of incremental encoders

The RM bit can be reset with incremental encoders by writing **word 11** of operating parameter 2.

11																	
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	1/0	1/0	r/w
	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	

Bit		= 0	= 1
2^{0}	Resetting of the RM bit via EnDat command with incremental encoders	Deactivated	Activated①
2^{1}		Activated①	Deactivated
2^{2}	Currently not assigned Extension planned		
•			
•			
•			
2^{15}			

① Resetting of the RM bit also means the "Reference point not reached" warning (see warnings) is set. This does not influence position value and position value 2.

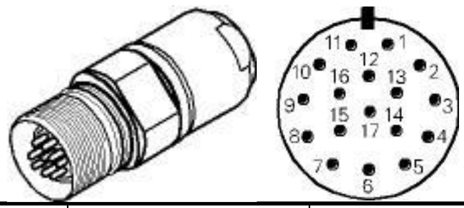
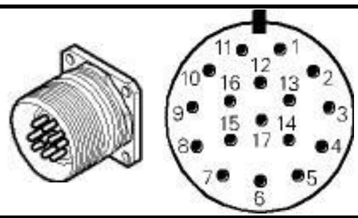
3.10.6 HEIDENHAIN layout

Word 12 is preset by HEIDENHAIN.

4 Appendix

4.1 Appendix A1 Pin Layout

17-pin M23 coupling or flange socket (pin)

17-pin HEIDENHAIN coupling	17-pin flange socket
	

Signal	A		B		R 3)		Data		Clock	
	+	-	+	-	+	-	+	-	+	-
Contact	15	16	12	13	3	2	14	17	8	9
Color	Green/Black	Yellow/Black	Blue/Black	Red/Black	Red	Black	Gray	Pink	Violet	Yellow

Signal	U_P	U_N	U_P Sensor 1)	U_N Sensor 1)	Internal shield	free 2)	free 2)
Contact	7	10	1	4	11	5	6
Color	Brown/Green	White/Green	Blue	White	Internal shield	/	/

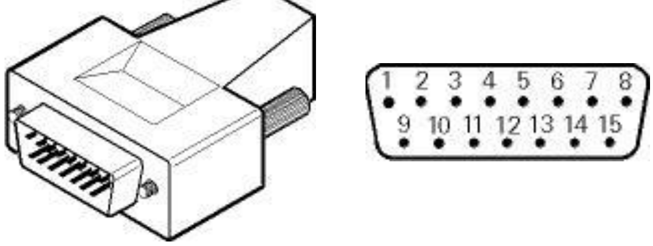
External shield lies on coupling housing or flange socket housing

1) only with 5 V version; do not assign with 7 V to 12 V or 30 V

2) reserved for temperature sensors

3) reserved for reference signal with purely incremental systems

15-pin D-sub connector (pin)

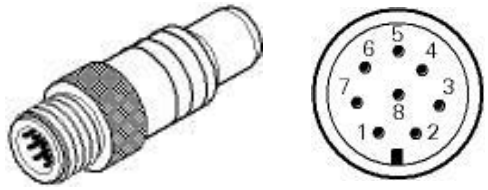


Signal	A		B		R 3)		Data		Clock	
	+	-	+	-	+	-	+	-	+	-
Contact	1	9	3	11	14	7	5	13	8	15
Color	Green/Black	Yellow/Black	Blue/Black	Red/Black	Red	Black	Gray	Pink	Violet	Yellow

Signal	U_P	U_N	U_P Sensor 1)	U_N Sensor 1)	Internal shield
Contact	4	2	12	10	6
Color	Brown/Green	White/Green	Blue	White	Internal shield

External shield lies on housing.

8-pin M12 connector (pin)

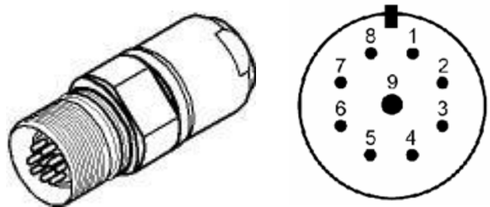
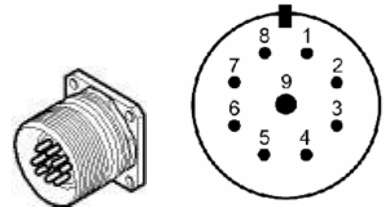


Signal	Data		Clock		U_N 1)	U_P 1)	U_P	U_N
	+	-	+	-				
Contact	3	4	7	6	1	2	8	5
Color	Gray	Pink	Violet	Yellow	White	Blue	Brown/Gree n	White/Green

External shield lies on housing.

1) for parallel supply lines or battery buffer

9-pin M23 coupling or flange socket (pin)

17-pin HEIDENHAIN coupling	**17-pin flange socket**
	

Signal	Data		Clock		U_N 1)	U_P 1)	U_P	U_N
	+	-	+	-				
Contact	5	6	1	2	8	7	3	4
Color	Gray	Pink	Violet	Yellow	White	Blue	Brown/Green	White/Green

External shield lies on housing.

1) pins or conductors not used for parallel supply lines or battery buffer can be assigned

4.2 Appendix A2 Interface error handling

There are four types of error handling routines depending on the cause of the fault.

<table>
<tr><th>Cause</th><th>Error handling</th></tr>
<tr><td>1 Transfer of mode command disrupted or not supported</td><td rowspan="6">Type I</td></tr>
<tr><td>2 Frame disrupted with MRS code transfer
C7 C6 C5 C0 $\neq$ 1011
C7 C6 C5 $\neq$ 010 (only permitted with mode command type 2.2)
C7 C6 C5 $\neq$ 011 (only permitted with mode command type 2.2)</td></tr>
<tr><td>3 A transmission was not completed (Busy error).
The error handling will be transferred with the next query.</td></tr>
<tr><td>4 010010 received, but not permissible</td></tr>
<tr><td>5 Not yet initiated EnDat encoders (Extended Interface Box EIB).</td></tr>
<tr><td>6 Communication command → data driver deactivated at high-impedance with address $0000_{hex.}$</td></tr>
<tr><td>7 Currently impermissible memory area is selected.
<table>
<tr><th>C4</th><th>C3</th><th>C2</th><th>C1</th></tr>
<tr><td>1</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>1</td></tr>
</table>
(permitted with mode command type 2.2)</td><td rowspan="6">Type II</td></tr>
<tr><td>8 Selection of an impermissible or unavailable address with reading or writing of parameters, with an EnDat reset or with still set active busy bit.</td></tr>
<tr><td>9 Writing of parameters into write-protected memory area.</td></tr>
<tr><td>10 Writing a bit in write protection status with 0 after activation of the write protection.</td></tr>
<tr><td>11 Impermissible block address is selected.</td></tr>
<tr><td>12 Communication command → the activated unit receives a communication command with unknown address.
Access to currently unassigned or unsupported operating parameter 2 address</td></tr>
<tr><td>13 Currently impermissible additional data is selected.
<table>
<tr><th>I4</th><th>I3</th><th>I2</th><th>I1</th><th>I0</th></tr>
<tr><td>1</td><td>1</td><td>0</td><td>1</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>1</td><td>0</td></tr>
</table></td><td rowspan="3">Type III</td></tr>
<tr><td>14 Selected additional data is not supported via configuration (word 0 and 1 in the area "Encoder manufacturer for EnDat 2.2").</td></tr>
<tr><td>15 Several additional data with the same identifier I4 – I0 are simultaneously activated</td></tr>
<tr><td>16 An available additional data could not be updated. This may also affect individual addresses of the additional sensors in additional data 1
.</td><td>Type IV</td></tr>
</table>

4.2.1 Error handling for type I

Data transfer:

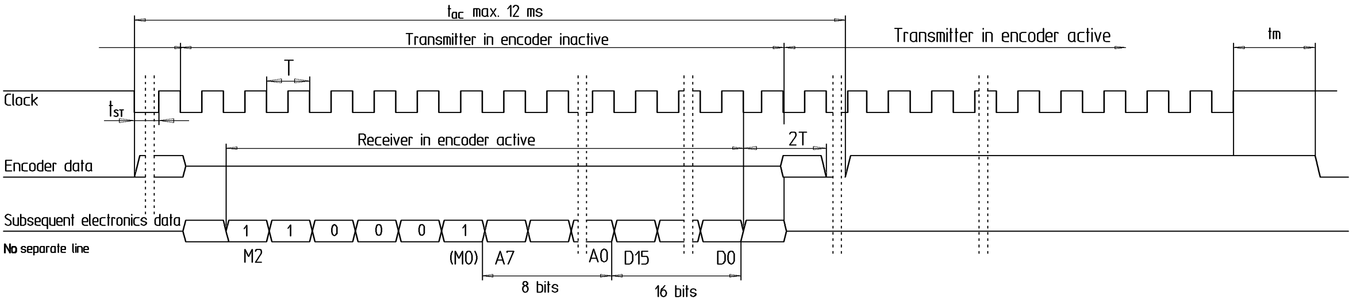


Figure 55

Position transfer:

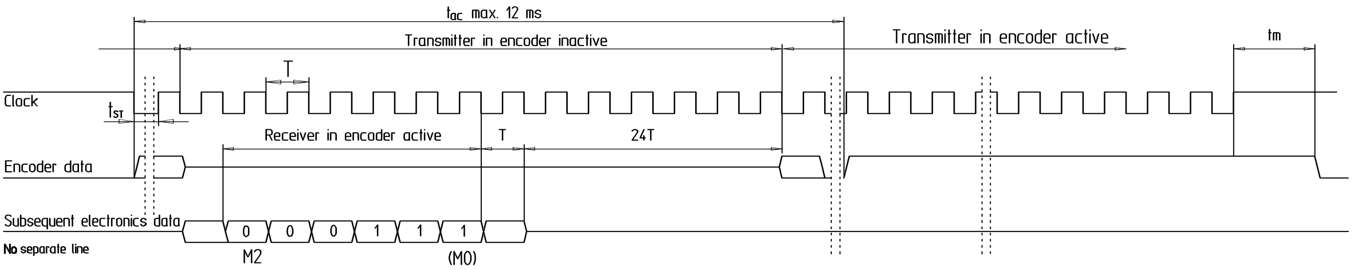


Figure 56

The required response of the control in this case is setting of the clock line to High (clock = 1) and to wait for the time t_m before renewed data transfer is possible.

⚠ After an error handling, the maximum t_m of 30 µs must at least be waited before the next command.

4.2.2 Error handling for type II

With the acknowledgment, with "read parameter", "write parameter" and also with acknowledgment of the MRS code (block address) the address or parameter is returned inverted compared to the original value sent from the subsequent electronics.

4.2.3 Error handling for type III

When reading the additional data 1, the value 15 for I[4:0], or for additional data 2 the value 31, is returned to the subsequent electronics until a valid and supported additional data is selected.
The data in bytes 1 and 2 of the respective additional data are invalid in this case.

4.2.4 Error handling for type IV

The field Information I[4:0] of an additional data identifies the content of the additional data. The value 0 with additional data 1 and the value 16 with additional data 2 mean NOP (see section 2.3.5).
When reading the additional data, NOP is returned as information to the subsequent electronics for as long as the additional data cannot be updated.
The data in bytes 1 and 2 of the respective additional data are invalid in this case.

4.3 Appendix A3 Diagnosis

The EnDat interface makes extensive monitoring and diagnosis of an encoder possible without an additional line.

For evaluating the functionality of the encoder, so-called valuation numbers can be cyclically exported from the encoder with EnDat 2.2 units. The valuation numbers provide the current state of the encoder and ascertain the encoder's "function reserves." Their scaling is identical for all HEIDENHAIN encoders. This makes integrated evaluation possible. Which valuation numbers are supported by the specific encoder is stored in **word 5** in the "Parameters of the encoder manufacturer for EnDat 2.2" memory area.

Bit for diagnostics enabling Word 3 of operating parameters	Address	Meaning	Areas
Bit 0	1 (1+0)	Valuation number 1	Valuation numbers
	17 (1+16)		
	33 (1+32)		
	49 (1+48)		
Bit 1	2	Valuation number 2	
	18		
	34		
	50		
Bit 2	3	Valuation number 3	
	19		
	35		
	51		
Bit 3	4	Valuation number 4	
	20		
	36		
	52		
Bit 4	5	Valuation number 5	
	21		
	37		
	53		
Bit 5 .. Bit 6	: : :	Valuation number 6 : :	
Bit 7	8		
	24		
	40		
	56		
Bit 8	9		Parameter, states
	25		
	41		
	57		
Bit 9 .. .. Bit 14	: : : :	: : : :	
Bit 15			System-specific data

⚠ If system-specific data are transferred the subsequent electronics must ignore undefined addresses.

⚠ Please request further information from the encoder manufacturer.

4.4 Appendix A4 Cyclic redundancy check

In order to detect errors resulting from interference during data transmission, a **5-bit CRC code** is assigned to every data word. The CRC code is generated by hardware in the encoder. The evaluation in the subsequent electronics can also be realized with the hardware.
All single errors with data transmission can be detected via the CRC. The detection of high-order data transmission errors depends on the data word length. The error bit is taken into account during generation of the CRC code.

4.4.1 Hardware CRC generation

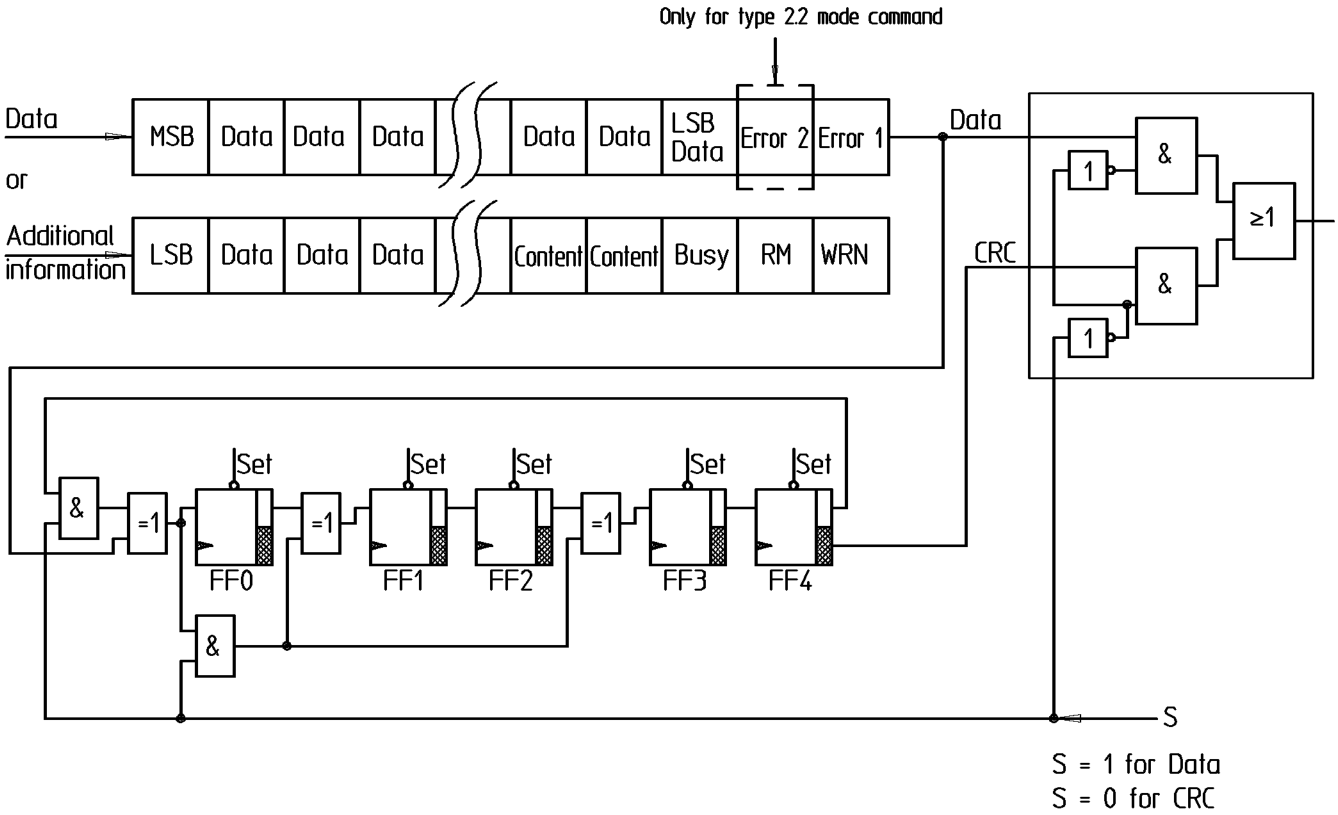


Figure 57

<u>Procedure</u>
1. Preload flip-flops via Set with a logical "1".
2. Move data.
3. Output CRC code.

4.4.2 Software CRC generation

Function: MakeCrcNorm

The function MakeCrcNorm generates the CRC code for the following mode commands:

- Selection of memory area
- Encoder receive parameters
- Encoder send parameters
- Encoder receive reset
- Encoder receive test command
- Additional data (EnDat 2.2)

Parameters

param8 : 8 bit value (address, MRS code, additional data content,...)
param16 : 16 bit value (parameter, additional information data)

Return value

CRC code (5 bits)

Example

param8 = 13
param16 = 32793
Return value: 14

C source text

```
unsigned int MakeCrcNorm(
  unsigned int param8,
  unsigned int param16)
{
  unsigned int ff[5];                // State of the 5 flip-flops
  unsigned int code[24];             // Data-bit array
  unsigned int ex;                   // Auxiliary variable
  unsigned int crc = 0;              // Determined CRC code
  signed int i;                      // Controlled variable for looping

  for(i = 0; i < 5; i++)             // set all flip-flops to 1
    ff[i] = 1;
  for(i = 0; i < 8; i++)             // read 8 bit parameter into code array
  {                                  // and convert the bit sequence
    code[i] = (param8 & 0x0080) ? 1 : 0;
    param8 <<= 1;
  }

  for(i = 8; i < 24; i++)            // read 16 bit parameter into code array
  {                                  // and convert the bit sequence
    code[i] = (param16 & 0x8000) ? 1 : 0;
    param16 <<= 1;
  }

  for(i = 0; i < 24; i++)            // calculate CRC, analog to
  {                                  // described generator hardware
    ex = ff[4] ^ code[i];
    ff[4] = ff[3];
    ff[3] = ff[2] ^ ex;
    ff[2] = ff[1];
    ff[1] = ff[0] ^ ex;
    ff[0] = ex;
  }

  for(i = 4; i >= 0; i--)            // save CRC in variable
  {
    ff[i] = ff[i] ? 0 : 1;           // invert bits
    crc <<= 1;
```

```
    crc |= ff[i];
  }

  return crc;
}
```

Function: MakeCrcPos

The function MakeCrcPos generates the CRC code for the following mode commands:

- Encoder send position values (EnDat 2.1)
- Encoder send position values (EnDat 2.2)
- Encoder send test values

Parameters

clocks	:	Data width in bits For the mode command "Encoder send position values" this value is specific to the encoder and can be transferred from word 13 of the parameter area for the encoder manufacturer. For the mode command "Encoder send test values," the data width is always 40 bits.
error1	:	Error message 1
error2	:	Error message 2 (any with EnDat 2.1)
endat22	:	0 = CRC calculation for "Encoder send position value (EnDat 2.1)" 1 = CRC calculation for "Encoder send position value (EnDat 2.2)"
highpos	:	Bits 32 to 63 of the position value or of the test value
lowpos	:	Bits 0 to 31 of the position value or of the test value

Return code

CRC code (5 bits → see point 2.3.1 Transferring the Position Value)

Example: CRC calculation for "Encoder send position value (EnDat 2.2)"

```
clocks = 25
error1 = 0
error2 = 1          // any for EnDat 2.1
endat22 = 1         // for EnDat 2.2
highpos = 0
lowpos = 104462
Return value: 3
```

C source text

```
unsigned int MakeCrcPos(
  unsigned int clocks,
  unsigned int error1,
  unsigned int error2,
  unsigned int endat22,
  unsigned long highpos,
  unsigned long lowpos)
{
  unsigned int ff[5];          // State of the 5 flip-flops
  unsigned int code[66];       // Data-bit array
  unsigned int ex;             // Auxiliary variable
  unsigned int crc = 0;        // Determined CRC code
  signed int i;                // Controlled variable for looping
```

```
  for(i = 0; i < 5; i++)           // set all flip-flops to 1
    ff[i] = 1;

  if (endat22)                     // load alarm bits into code array
  {
    code[0] = error1;
    code[1] = error2;
  }
  else
    code[1] = error1;

  for(i = 2; i < 34; i++)          // load lowpos bits into code array
  {
    code[i] = (lowpos & 0x00000001L) ? 1 : 0;
    lowpos >>= 1;
  }

  for(i = 34; i < 66; i++)         // load highpos bits into code array
  {
    code[i] = (highpos & 0x00000001L) ? 1 : 0;
    highpos >>= 1;
  }

  for(i = (endat22 ? 0 : 1); i <= (clocks+1); i++)
  {                                // Calculate the CRC analog to the
    ex = ff[4] ^ code[i];          // described generator hardware
    ff[4] = ff[3];
    ff[3] = ff[2] ^ ex;
    ff[2] = ff[1];
    ff[1] = ff[0] ^ ex;
    ff[0] = ex;
  }

  for(i = 4; i >= 0; i--)          // save CRC in variable
  {
    ff[i] = ff[i] ? 0 : 1;         // invert bits
    crc <<= 1;
    crc |= ff[i];
  }

  return crc;
}
```

4.5 Appendix A5 omitted Transfer of the position value

4.6 Appendix A6 7 bit ASCII code and powers of 2

Character	Decimal	HEX
NUL	000	00
SOH	001	01
STX	002	02
ETX	003	03
EOT	004	04
ENQ	005	05
ACK	006	06
BEL	007	07
BS	008	08
HT	009	09
LF	010	0A
VT	011	0B
FF	012	0C
CR	013	0D
SO	014	0E
SI	015	0F
DLE	016	10
DC1	017	11
DC2	018	12
DC3	019	13
DC4	020	14
NAK	021	15
SYN	022	16
ETB	023	17
CAN	024	18
EM	025	19
SUB	026	1A
ESC	027	1B
FS	028	1C
GS	029	1D
RS	030	1E
US	031	1F
SP	032	20
!	033	21
"	034	22
#	035	23
$	036	24
%	037	25
&	038	26
´	039	27
(	040	28
)	041	29
*	042	2A
+	043	2B
,	044	2C
-	045	2-D
.	046	2E
/	047	2F

Character	Decimal	HEX
0	048	30
1	049	31
2	050	32
3	051	33
4	052	34
5	053	35
6	054	36
7	055	37
8	056	38
9	057	39
:	058	3A
;	059	3B
<	060	3C
=	061	3D
>	062	3E
?	063	3F
@	064	40
A	065	41
B	066	42
C	067	43
D	068	44
E	069	45
F	070	46
G	071	47
H	072	48
I	073	49
J	074	4A
K	075	4B
L	076	4C
M	077	4D
N	078	4E
O	079	4F
P	080	50
Q	081	51
R	082	52
S	083	53
T	084	54
U	085	55
V	086	56
W	087	57
X	088	58
Y	089	59
Z	090	5A
[	091	5B
\	092	5C
]	093	5D
^	094	5E
–	095	5F

Character	Decimal	HEX
`	096	60
a	097	61
b	098	62
c	099	63
d	100	64
ES	101	65
f	102	66
g	103	67
h	104	68
IT	105	69
Y	106	6A
k	107	6B
l	108	6C
m	109	6D
n	110	6E
o	111	6F
p	112	70
q	113	71
r	114	72
s	115	73
t	116	74
u	117	75
v	118	76
w	119	77
x	120	78
y	121	79
z	122	7A
{	123	7B
¦	124	7C
}	125	7D
~	126	7E
DEL	127	7F

Powers of two

n	2^n
0	1
1	2
2	4
3	8
4	16
5	32
6	64
7	128
8	256
9	512
10	1 024
11	2 048
12	4 096
13	8 192
14	16 384
15	32 768
16	65 536
17	131 072
18	262 144
19	524 288
20	1 048 576
21	2 097 152
22	4 194 304
23	8 388 608

4.7 Appendix A7 Mask / flowchart for commissioning diagnostics

See EnDat Application Notes D722024

4.8 Appendix A8 Abbreviations

EnDat interface	**Encoder Data Interface**
a	Accuracy
A	1 Vpp signal
B	1 Vpp signal
C	Conversion factor
C_a	Output capacitance
CRC	Cyclic Redundancy Check
f_C	Clock frequency
f_e	Frequency for determining the propagation time
HI	high
I_a	Output current
L_C	Cable length
LO	low
LSB	Least significant bit
M0,M1,M2	Mode
M	Multiturn
M/rev	Measuring steps / revolution
MRS	Memory range select
MSB	Most significant bit
n	Speed
NSR	Non-safety-relevant
NVM	Non-volatile memory
OEM	Original equipment manufacturer
P	Periods
P/rev	Periods per revolution
r	Read
RM	Reference mark
R_a	Output resistor
S	Singleturn
SR	Safety-relevant
SSI	Serial-synchronous interface
Sot	Switch on time
t_{ac}	Memory access time
TBD	To be defined
t_{CAL}	Processing time
t_D	Data delay time
t_{HI}	Positive pulse width
t_{LO}	Negative pulse width
t_m	Recovery time I
t_{OE}	Clock low to data active
t_R	Recovery time II
t_{ST}	Recovery time III
t_Z	Clock low to data inactive
U_0, U_1	Voltage
U_N	Negative supply voltage
U_P	Positive supply voltage
sqrt	Velocity
V_{pp}	Volt peak-to-peak

EnDat interface	Encoder Data Interface
w	Write
Z_0	Terminating resistor

4.9 Appendix A9 Procedures

See EnDat Application Notes D722024

Forced dynamic sampling

see supplementary document for EnDat description D533095-09-A-01

4.10 Appendix A 10 Exception of EIB

Incremental encoders and the EIB are exceptions. To determine the weighting of the LSB (see also EnDat 2.2 "Parameters of the encoder manufacturer"; words 27 - 29) the signal period of the incremental encoder must be specified. The signal period is thus specified despite the ordering designation "EnDat22" with incremental encoders and the EIB.

The ordering designation is provided in **word 40**, parameters of the encoder manufacturer.

Definition of the signal period with sinusoidal input and output signals on the EIB and square-wave pulse sequences in EnDat signal processing electronics.

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1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	nm or P/rev

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1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0	r
2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}	nm or P/rev

4.11 Appendix A11 History of revisions

History of revisions is based on the German version of this document.

	SR	NSR
Version 2.0 (as of 13. Dec. 1995) to version 2.1 D297403-01-A-01 (as of March 1999) Revision of the entire EnDat interface description. Necessary additions and corrections. Version 2.1 is 100% backward compatible.		X
Version 2.2 D297403-02-K-01 (as of September 2002) Addition of a purely serial transfer variant without sinusoidal incremental signals with a greater transmission frequency via longer cables. With EnDat 2.2 it is also possible to transfer additional data/diagnostics values. Version 2.2 is backward compatible with EnDat 2.1 (⚠ no sinusoidal incremental signals).		X
Version 2.2 D297403-03-B-01 (as of December 2002) Expansion: With all EnDat mode commands of type 2.2 an additional data can be requested after the position value. Addition: The mode command "Encoder receive communication command."		X
Version 2.2 D297403-04-A-01 (as of January 2003) Expansion: Possibility of additional data transfer with all type 2.2 mode commands. Addition: The mode command "Encoder receive communication command." Revision: MRS code for selecting the additional data		X
Version 2.2 D297403-05-D-01 (as of November 2004) Expansion: Section 2 memory area Addition: Word 6, operating parameters Word 22 ... 30 EnDat 2.2 EIB encoder model Revision: Continuous clock Zero point shift Appendix A1 Pin layout		X
Version 2.2 D297403-06-B-01 (as of May 2005) Expansion: Accuracy with respect to linear or rotational velocity Addition: Words 7 and 8, operating parameters Parameters of the encoder manufacturer in the EnDat 2.2 range Asynchronous position value Alarm handling for battery-buffered multiturn		X
Version 2.2 D297403-07-B-01 (as of July 2007) Expansion: Operating status error sources, EnDat ordering designation Addition: Description of diagnostics, flow chart Deleted: Operating status warning sources Appendix A9: Adaptation of flow charts: "Power-on procedure" and "Deletion of errors and warnings" Appendix A 10 Exception of EIB		X
Version 2.2 D297403-08-A-01 (as of July 2007) Correction: Power-on conditions Figure 18 (page 20)		X

	SR	NSR
Version 2.2 D297403-09-A-01 (as of September 2011) Expansion: EnDat for touch probes Referencing of incremental encoders Operating parameters 2 Section 2 memory area Flow chart in document D727963		X
Version 2.2 D297403-10-A-01 (as of May 2017) Addition: Explanations and notes Forced dynamic sampling in catalog of measures D533095 instead of D727963 Temperature sensor type added Correction: The following was deleted… The requirement of a separate receiver-/driver component for safety-oriented applications		X