Please note

- No photos or videos during the presentation or the company tour
- No publishing of content without prior approval

Bitte beachten

- Keine Fotos oder Videos während der Präsentation oder des Firmenbesuchs
- Veröffentlichung von Inhalten nur nach Freigabe

EnDat 2.2 Seminar – Basics

- Demands on a modern encoder interface
- General information and documentation
- Interface physics and timing
- Power-on behavior
- Position value formation
- Mode commands
- Additional datum
- Memory areas
- Error handling

EnDat 2.2 Seminar – Basics

- **Demands on a modern encoder interface**
- General information and documentation
- Interface physics and timing
- Power-on behavior
- Position value formation
- Mode commands
- Additional datum
- Memory areas
- Error handling

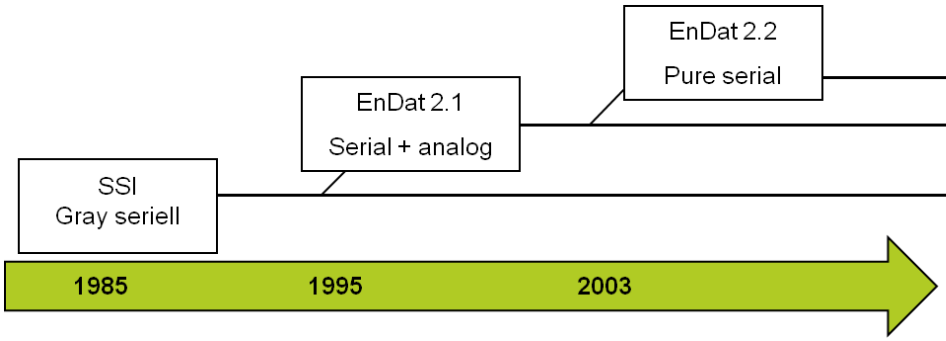
History

EnDat 2.1

- Serial data transfer (max. 2 MHz)
- Interpolation of 1 Vpp signals in the subsequent electronics
- Errors and warnings
- Automatic self-configuration (parameters, etc.)
- Electronic ID label
- Typical application:
  - EnDat communication with µC
  - Unique query of the absolute position
  - Control loop functions with the interpolated 1 Vpp signals

EnDat 2.2

- Purely serial data transfer (max. 8...16 MHz)
- A single interface for all absolute and incremental encoders
- Certified for safety technology
- Greater possibilities for encoder diagnosis
- Additional data (temperature, etc.)
- Simpler plug and connection technology
- Expanded power supply range
- Typical application:
  - EnDat communication with FPGA
  - Control loop functions with the absolute values

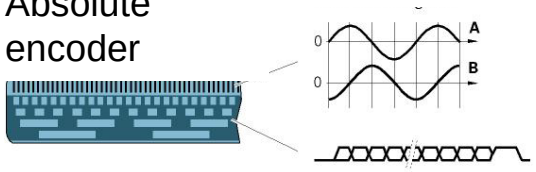


EnDat 2.2: A single interface for all absolute and incremental encoders

Uniform Interface

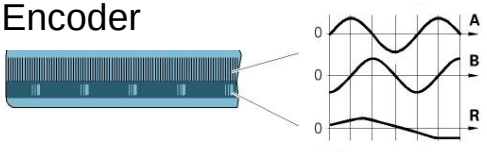
Uniform interface

Absolute encoder



EnDat 2.1

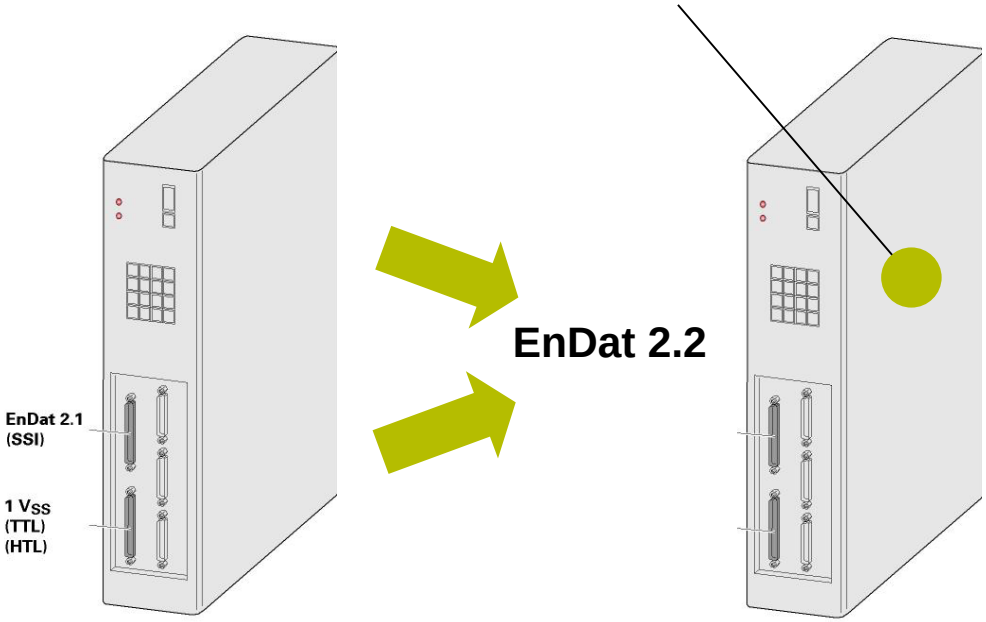
Incremental Encoder



1 Vpp

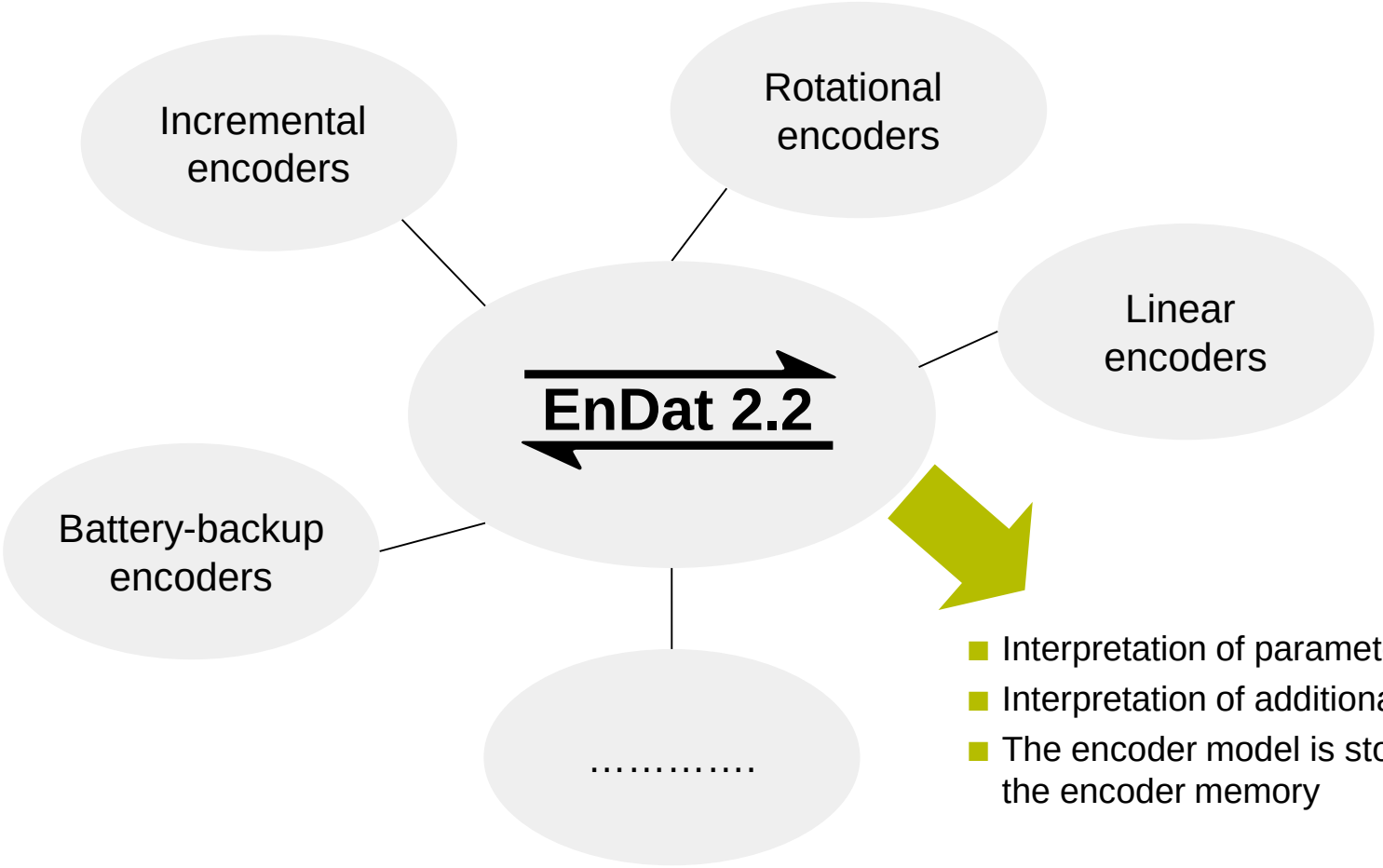
EnDat 2.2 Master

- Is available as FPGA soft macro
- Additional EnDat Masters are available from Texas Instruments, Hilscher, Renesas, etc.



Uniform interface for incremental and absolute encoders

Uniform Interface

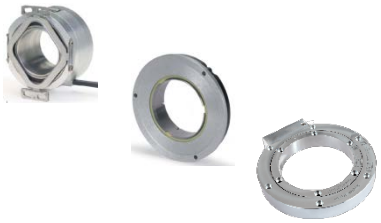


- Interpretation of parameters
- Interpretation of additional data
- The encoder model is stored in the encoder memory

Product History and Roadmap

			EnDat 2.2 pure serial	EnDat 2.2 pure serial Functional Safety
Sealed Linear Encoder				
LC 1xx; full-size		ML 140 ... 4240 mm; Accuracy ±3 µm / 5 µm	✓	✓
LC 4xx; small-size		ML 70 ... 2040 mm ; Accuracy ±3 µm / 5 µm	✓	✓
LC 2xx; full-size		ML 3240 ... 28040 mm; Accuracy ±5 µm	✓	In preparation
Angle Encoder with Integral Bearing				
RCN 2xxx/5xxx/8xxx		Accuracy ±1” ... ±10” Hollow shaft 20 mm ... 180 mm	✓	✓
RCN 6xxx			✓	✓
ECN 2xxx			✓	–
ROC 2xxx ROC 7xxx		Accuracy ±5”; Solid shaft Ø10 mm Accuracy ±2”; Solid shaft Ø14 mm	✓	–
Angle Encoders without Integral Bearing				
ECA		Outer diameter 104 mm ... 560 mm Accuracy > ±2”	✓	✓
ERM		Outer diameter 65 mm ... 453 mm Accuracy > ±6,5”	✓ (+ EIB)	–
Exposed Linear Encoders				
LIC 4100 (absolute)		ML 70 ... 27040 mm; Accuracy ±15/±5/±3 µm	✓	✓
LIC 2100 (absolute)		ML 120 ... 6020 mm; Accuracy ±15 µm	✓	–
LIP		ML 20 ... 3040 mm; Accuracy ±3/±1/±0,5 µm	✓	–
LIF		ML 70 ... 3040 mm; Accuracy ±3/±1 µm	✓ (+ EIB)	–
LIDA 400 LIDA 200		ML 140 ... 30040 mm; Accuracy ±15/±5/±3 µm Up to 10000 mm, Accuracy ±15 µm	✓	In preparation

Encoder Roadmap

				EnDat 2.2 pure serial	EnDat 2.2 pure serial Functional Safety
Integrated Rotary Encoder, construction form 35 mm					
Optical ST + MT		Singleturn 23 bit/Multiturn 12 bit	IP 40	✓	✓
Inductive ST + MT		Singleturn 19 bit/Multiturn 12 bit	IP 00	–	✓
Inductive ST + BBMT		Singleturn 18 bit/Multiturn 16 bit	IP 00	✓	–
Integrated Rotary Encoder, construction form 56 mm					
Optical ST + MT		Singleturn 25 bit/Multiturn 12 bit	IP 40	✓	✓
Inductive ST + MT		Singleturn 19 bit/Multiturn 12 bit	IP 20	✓	✓
Integrated Rotary Encoder, construction form 87 mm					
Optical ST		Singleturn 25 bit Hollow shaft 25…50 mm	IP 64	✓	–
Inductive ST, BBMT		Singleturn 19 bit/Multiturn 16 bit Hollow shaft 30 … 50 mm	IP 20	✓	–
ExI 4000 ST, BBMT		Singleturn 20 bit/Multiturn 16 bit Hollow shaft 90 mm/180 mm	IP 40	✓	✓
Mounted Rotary Encoder, construction form 35 mm					
Optical ST + MT		Singleturn 23 bit/Multiturn 12 bit Hollow shaft Ø 6 mm Solid shaft Ø 4 mm	IP 64	✓	–
Mounted Rotary Encoder, construction form 56 mm					
Optical ST + MT		Singleturn 25 bit/Multiturn 12 bit Hollow shaft Ø 8/10/12 mm Solid shaft Ø 6/10 mm	IP 64	✓	✓

Low System Costs

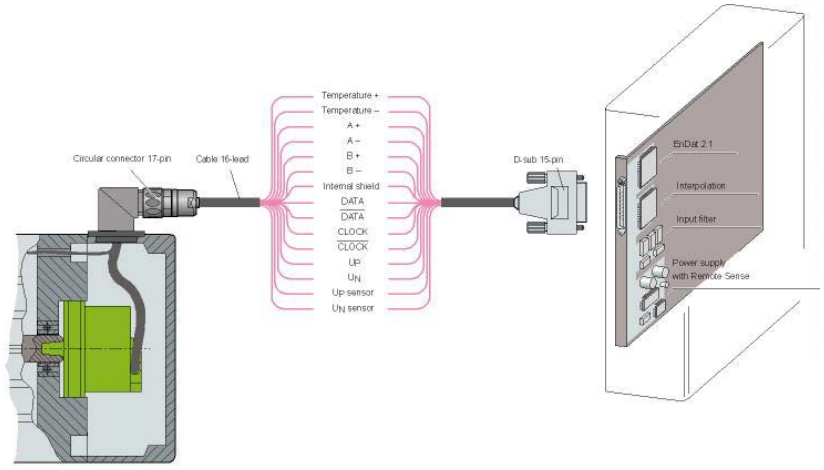
- Simple Subsequent Electronics (Purely Digital, per RS-485)
- Simply supply voltage (without remote sense)
- Low-cost connection technology
- No additional costs for sensors

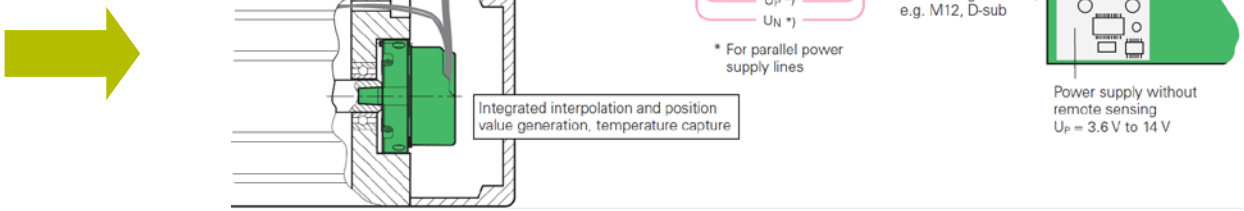
Simple Subsequent Electronics (Purely Digital, per RS-485)

- EnDat Master: different versions are available from different providers
- 1 V_{pp} receiver and interpolation can be omitted

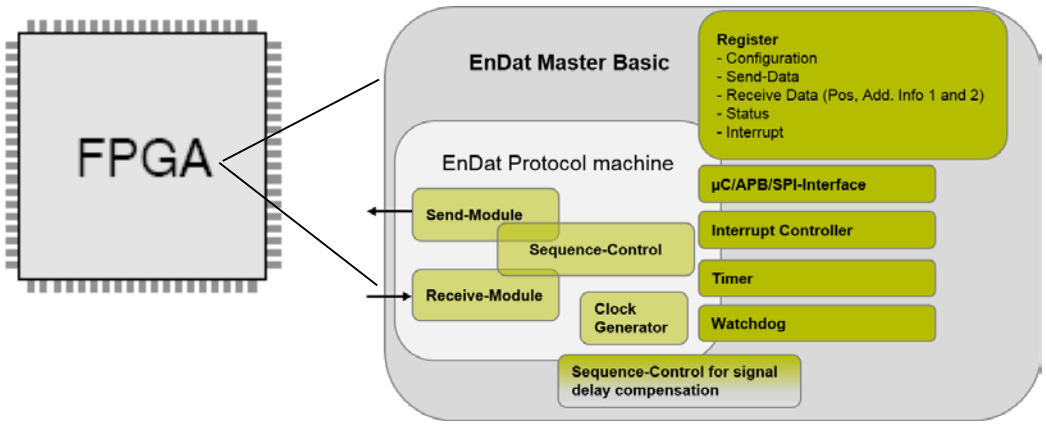
Voltage required at encoder

EnDat 2.1	5 V ± 5 %	5 V with remote sense
EnDat 2.2	3.6 ... 5.25 V or 14 V	without remote sense





Simple Subsequent Electronics (Purely Digital, per RS-485)



- EnDat Master Safe
- EnDat Master Basic
- EnDat Master Reduced
  (EnDat Master Mini see separate slide)
- EnDat Master Light

EnDat Master “light” and “reduced” contain only the EnDat protocol machine and the sequential control for compensating the run time.

	EnDat 2.2 Master		EnDat 2.2 Master	
	“light”	**“reduced” (base for “Mini”)**	**“Basic”**	**“Safe”**
Logic counts	Approx. 160	Approx. 650	> 2100	> 6300
For use with	All EnDat 2.2 encoders: Linear, angle and rotary encoders with photoelectric, inductive and magnetic scanning			
	Only absolute encoders	Incremental and absolute encoders with battery back up		
Additional data 1 and 2	No	Yes		
Support for Functional Safety	No	See Functional Safety without EnDat Master Safe		Yes (pure serial)
Bus interface included	No		Yes	
Properties	VHDL example code (covers only part of the EnDat functions). Suitable for implementation in subsequent electronics to only limited extent	Only pure EnDat functionality (EnDat protocol machine) integrated. Advisable, e.g. for multi-channel applications. Code was tested in a sample application	Encapsulated code block (tested by HEIDENHAIN); designed for short “time-to-market” and simple operation	Master for functional safety applications (corresponds to Master Basic with expansions)

EnDat 2.2 Master

EnDat 2.2 Master

- Refer to the HEIDENHAIN website:
  http://www.heidenhain.de/de_EN/documentation/fundamentals/interfaces/endat-22/endat-master/

- FPGA-based versions (see previous slide)

- µC-based
  - Solutions with integrated EnDat Master (SoC-based)
    - Texas Instruments
    - Renesas
    - Hilscher
  - µC in general: EnDat realized by means of software
    - Example code is available but must be adapted to the respective µC

Low-cost Connection Technology

- Simpler connecting elements
- Lower assembly costs
- Only single-shielded cable
- HMC 6

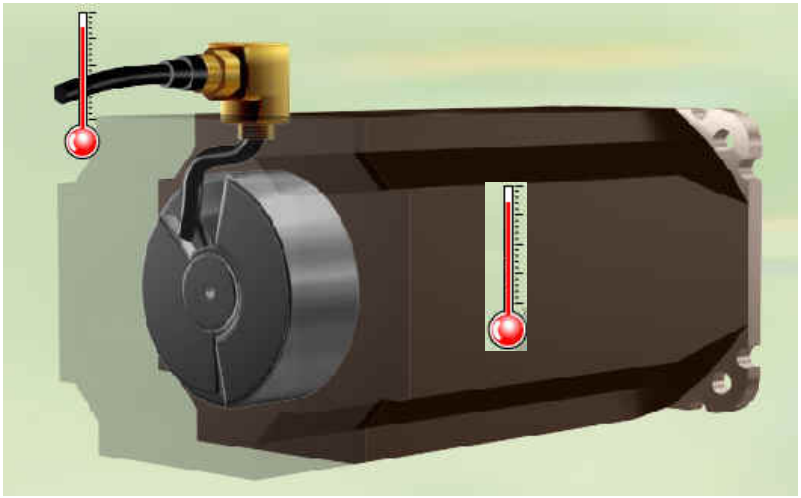
EnDat 2.1

EnDat 2.2

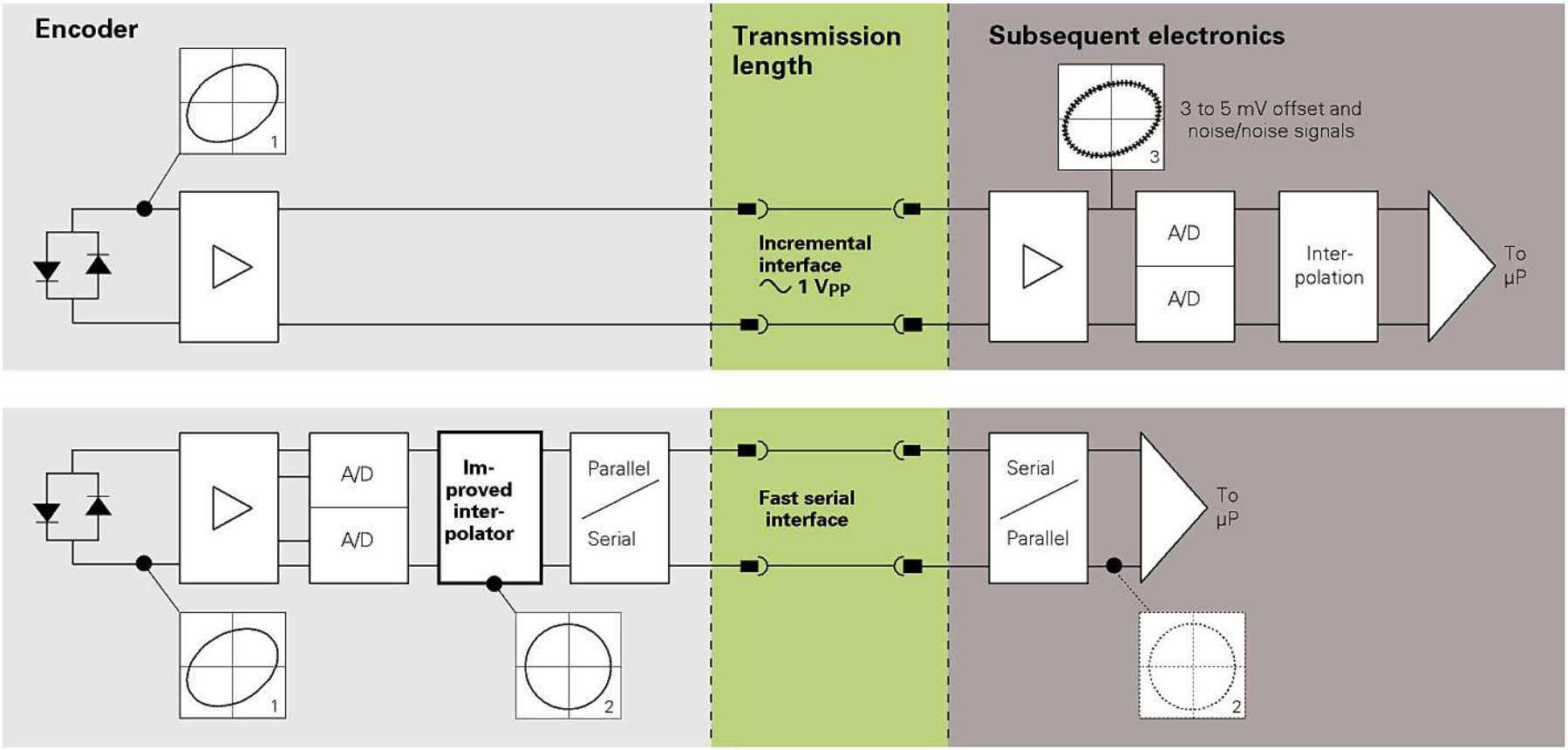
No Additional Costs for Sensors

Two temperature sensors are supported:

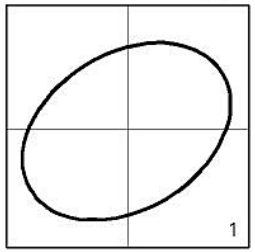
- Internal sensor: Used to capture the encoder temperature; a warning threshold can be programmed
- External sensor: Used to capture the temperature of the winding lower assembly costs
- Support of KTY 84-130, PT 1000



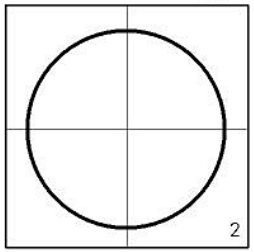
Improved Workpiece Quality



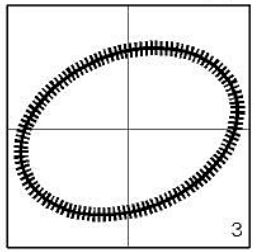
Interpolation error approx. 1 %



Interpolation error approx. 0.5 %



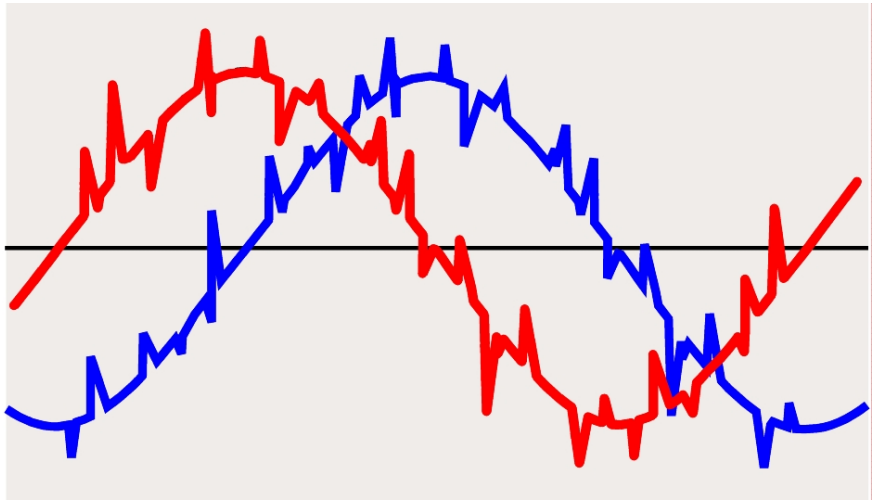
Interpolation error approx. 2 %



Less Influence of EMC on the Position Value

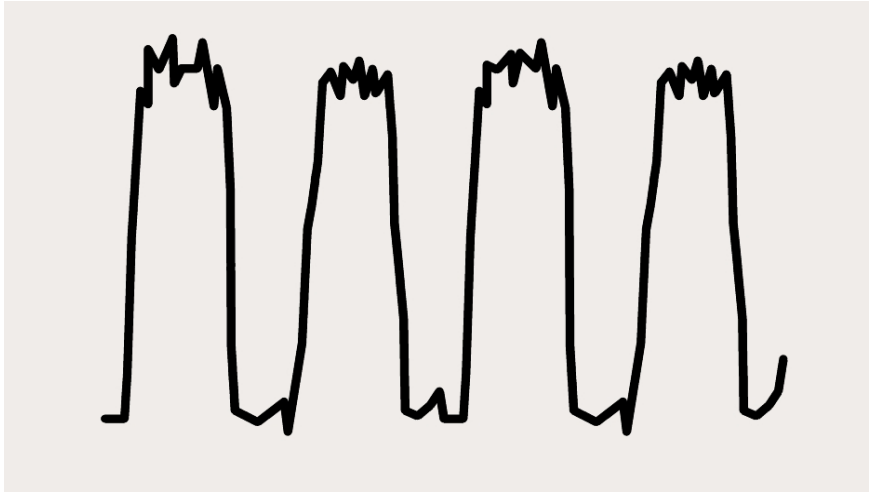
Analog signal transfer:

- Influences on the signal shape impair the position information



Purely serial data transfer:

- Influences on the signal shape do not impair the position information



Higher Availability

Commissioning times

- Memory module in encoder for commissioning parameters for the control or drive (“electronic ID label”)
- Encoder parameters for commissioning the sensors in the encoder

Diagnostics

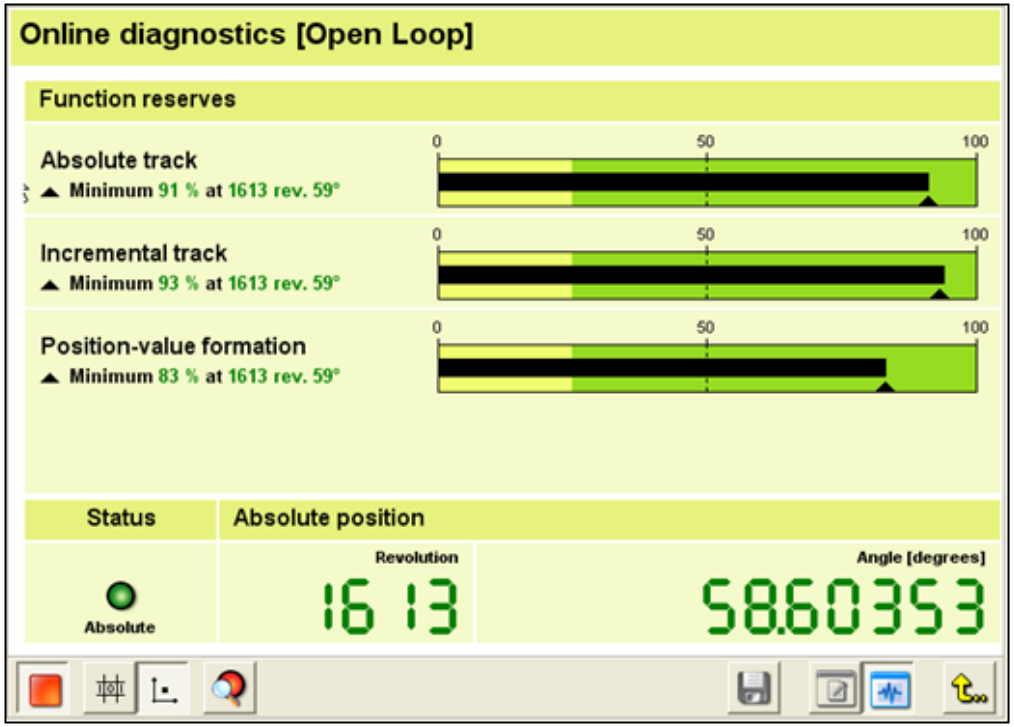
- Error bits for detection of encoder-specific malfunctions
- Warning bit for minimizing maintenance work
- Valuation numbers

Components

- Fewer components in the system
- Simpler, and therefore more reliable, wiring of electrical components
- Increased integration density of electrical components in encoder

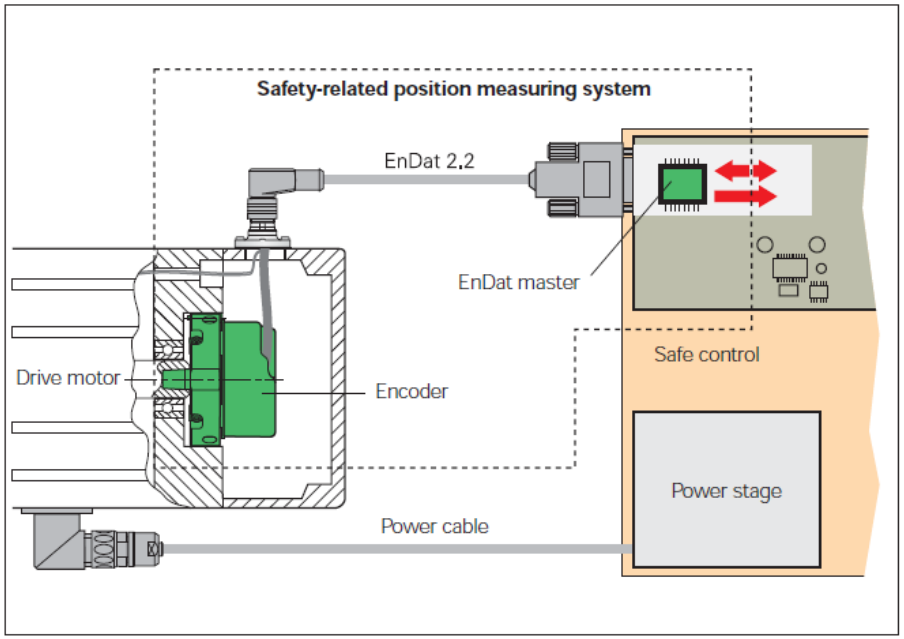
Diagnostics

- Evaluation of the encoder's function reserves by means of valuation numbers



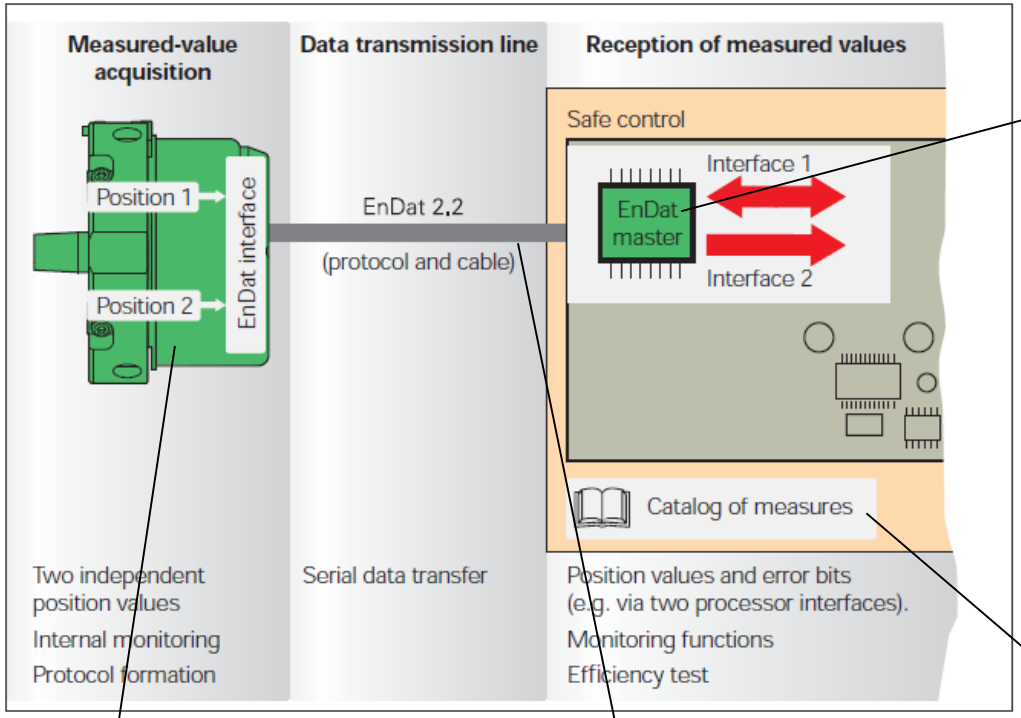
In practice, the complete "safe drive" system consists of:

- Safety-related position measuring system
- Safety-oriented control
  - EnDat master with monitoring functions (EnDat Master Safe, see figure below) or
  - EnDat master without monitoring functions (EnDat Master Basic)
- Power stage with motor power cable and drive
- Physical connection between encoder and drive (e.g. shaft connection/coupling)



	ECN 1325 Singleturn	EQN 1337 Multiturn
Safety-related data	Applicable as single-encoder system in the control loop for applications of the control category • SIL 2 (Safety Integrated Level) as in DIN EN IEC 61508 • PL2 (Performance Level) as in DIN EN ISO 13849 • Category 3 according to EN 954-1 Safe in the singleturn range	
PFH	≤ 1 x 10^{-8} Probability of failure per hour	
Angular error of the safe position	≤ ± 0.7° (9 bits)	

Safety Technology



EnDat Master „Safe“

- Position values and error bits via two processor interfaces
- Monitoring Functions
- Efficiency tests

Note:

- The EnDat master and the package of measures are independent of the encoder (rotary, linear, angular encoder)

- Two independent position values
- Internal monitoring
- Protocol generation
- Serial data transfer (EnDat22 + HEIDENHAIN cable)
- Measures for safe control

The integration of safety functions in a technical device only works if the encoder functions with the safety-oriented application.
EnDat 2.2 is only one of the factors in achieving this goal.

EnDat 2.2: Functional Safety

Use of EnDat Master Safe

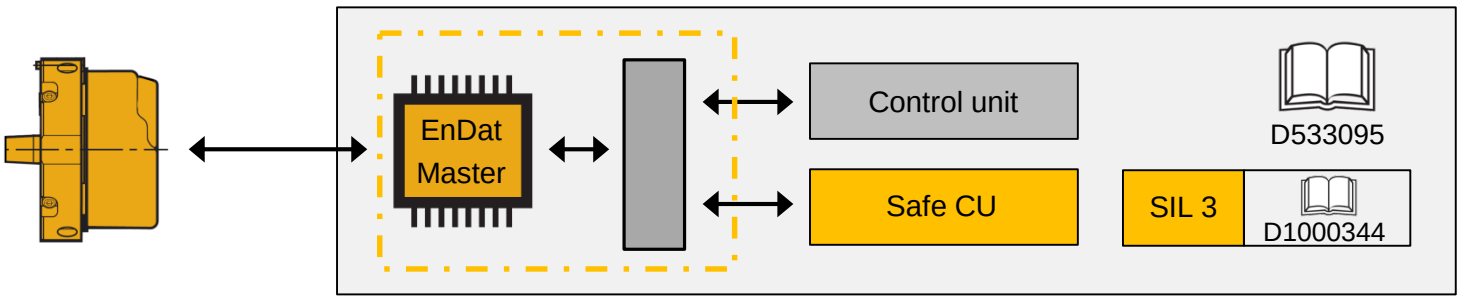
- The EnDat Master performs preprocessing and verification of the safety information
- Safety functions are performed by the EnDat Master and safe control
- Up to SIL 3 is possible (but only with EnDat Master Safe)

Benefits:

- EnDat Master relieves the safe CU
- EnDat Master buffers safety information (decoupling of the cycle times of safety and control)
- Safety functions in EnDat Master are pretested and verified

Disadvantages:

- EnDat Master is a part of the safety chain
  → Decoupling of the pure control functions and safety function is laborious and depends on the control design and safety design.
- EnDat Master must be certified (and with it usually the FPGA)
- Size of the EnDat Master



EnDat 2.2: Functional Safety

Use of a non-safe EnDat Master

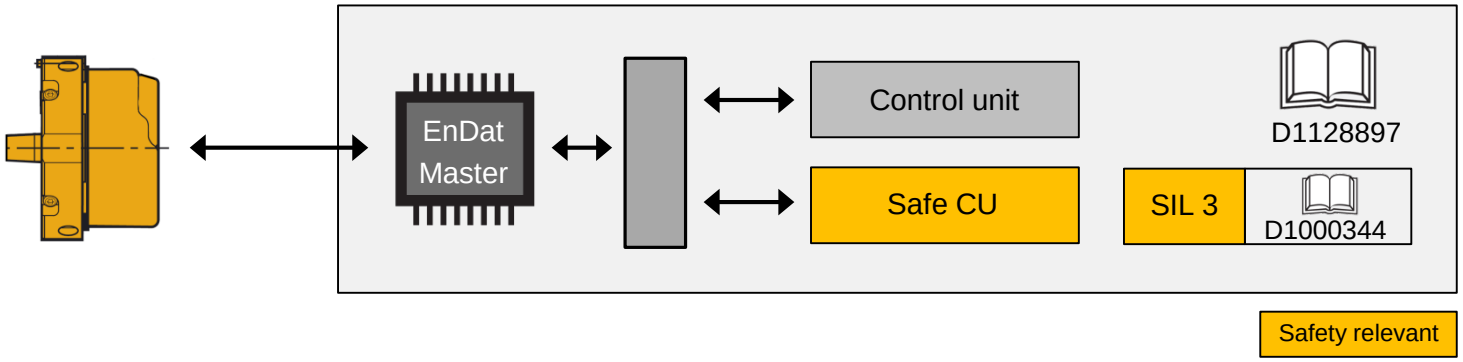
- The EnDat Master transfers the complete EnDat communication for evaluation to the safe CU.
  As a supplement, a measurement of the so-called “recovery-time t_M” is required. This measurement is a diagnostic function, not a safety function
- The EnDat Master does not modify the data and also does not perform any safety functions
- The EnDat Master is not a part of the safety chain
- Up to SIL 3 is possible

Benefits:

- The EnDat Master is not a part of the safety chain:
  → Certification of the EnDat Master is not necessary
  → Decoupling of control functions and safety functions
- Easy integration into a wide range of safety architectures
- Size of the EnDat Master

Disadvantages:

- The safe CU has to evaluate all data of the EnDat transmission because there is no preprocessing of the data in the EnDat Master (safe CU has to process the data in the control cycle)
  → The interface with the safe CU must be designed appropriately and the safe CU must process the data quickly enough.



Command Sets

- EnDat 2.2 includes all functinalities of EnDat 2.1
- EnDat 2.2 includes the EnDat 2.1 command set

EnDat 2.2 command set (includes EnDat 2.1 command set)
- Position values for incremental and absolute encoders
- Additional data on the position value
  - Diagnostics, test values
  - Absolute position values after reference run of incremental encoders
  - Parameter upload/download
  - Commutation
  - Acceleration
  - Limit position signal
  - Position value 2 for safety-related applications or incremental encoders

EnDat 2.1 command set
- Absolute position values
- Send and receive parameters
- Reset
- Test command
- Test values

			Mode bit					
No.	Mode command		M2	M1	M0	(M2)	(M1)	(M0)
1	Encoder send position values	EnDat 2.1 command set / EnDat 2.2 command set	0	0	0	1	1	1
2	Selection of memory area		0	0	1	1	1	0
3	Encoder receive parameter		0	1	1	1	0	0
4	Encoder send parameter		1	0	0	0	1	1
5	Encoder receive reset[1]		1	0	1	0	1	0
6	Encoder send test values		0	1	0	1	0	1
7	Encoder receive test command		1	1	0	0	0	1
8	Encoder send position value with additional data	EnDat 2.2 command set	1	1	1	0	0	0
9	Encoder send position value and receive selection of memory area[2]		0	0	1	0	0	1
10	Encoder send position value and receive parameter[2]		0	1	1	0	1	1
11	Encoder send position value and send parameter[2]		1	0	0	1	0	0
12	Encoder send position value and receive error reset[2]		1	0	1	1	0	1
13	Encoder send position value and receive test command[2]		1	1	0	1	1	0
14	Encoder receive communication command[3]		0	1	0	0	1	0

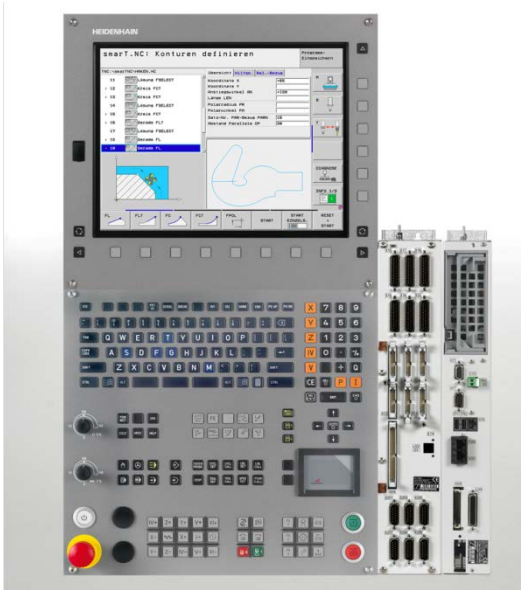
[1] Same reaction as from switching the power supply off and on
[2] Selected additional data is also transmitted
[3] Reserved for encoders that do not support the safety system

Parameters, OEM Memory

- Along with the "Parameters of the encoder manufacturer for EnDat 2.1," EnDat 2.2 also features the "Parameters of the encoder manufacturer for EnDat 2.2.“
- Some EnDat 2.1 parameters might have different values under EnDat 2.2, such as the measuring step (due to the internal interpolation, a higher singleturn resolution results, meaning a smaller measuring step.)
- Absolute linear encoders have different calculation times for position values t_{CAL} under EnDat 2.1 and EnDat 2.2. If the incremental signals are evaluated for axis control (i.e. only sporadic interrogation of the absolute values), then the corresponding EnDat 2.1 mode command should be used for the position interrogation.
- OEM memory area: All EnDat 2.2 encoders have more OEM memory available, but under circumstances different OEM ranges and addresses.
- The correct functioning of encoders from Service as replacements for existing EnDat 2.1 encoders must be tested on a case-by-case basis.

Connection to Subsequent Electronics

- In principle, EnDat 2.1 and EnDat 2.2 encoders can be used in any combination with EnDat 2.1- and EnDat 2.2-compatible controls, respectively.



Availability and processing of incremental signals:
EIB can only be connected to EnDat 2.2-compatible controls.

Benefits for Control and Drive Technology

- **Uniform interface**
  for incremental and absolute encoders
- **Low system costs**
  Low-cost connectors, cables and receiver components
- **Improved quality of workpiece (contour accuracy, surface finish)**
  through optimized control loop timing and optimized interpolation strategies
- **Improved noise immunity**
  through digital signal transmission
- **High availability through automatic self-configuration,**
  diagnosis and reduced number of components
- **Certified for safety technology**
- **Compatible with EnDat 2.1 encoders**

Overview of Information Transmission

Position
Send / Receive parameters
Additional data (temperature, etc.)
Access to OEM memory
Diagnostics
. . . .

during closed-loop operation

EnDat 2.2 Seminar – Basics

- Demands on a modern encoder interface
- **General information and documentation**
- Interface physics and timing
- Power-on behavior
- Position value formation
- Mode commands
- Additional datum
- Memory areas
- Error handling

Order Designation

Ordering designation *) [2]	Power supply *)	Command set	Version	Max. clock frequency [5]
EnDat 01	See specification of the encoder	See specifications of the encoder	With incremental signals	≤ 2 MHz
EnDat 21			Without incremental signals	
EnDat 02	Expanded range: 3.6 ≥ Up ≥ 5.25 V respectively 14 V [1]	EnDat 2.2	With incremental signals	≤ 2 MHz [2] [3] 8 ≤ f_{CLK} ≤ 16 MHz [2] [4]
EnDat 22			Without incremental signals	8 ≤ f_{CLK} ≤ 16 MHz [2]

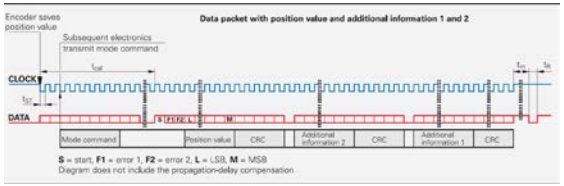
*) Name on ID label
[1] Exception EIB: Supply voltage 5V +/- 10%
[2] Value can be read out via parameters
[3] For encoders with fixed cable assembly
[4] For encoders with pluggable cable assembly
[5] Please observe max. permissible cable lengths

- **The order designation is indicated on the ID label!**
- **In the future, EnDat 2.1 encoders (EnDat 01 or 21) will also be available with the EnDat 2.2 command set!**
- **The clock frequency values apply to the encoder only (to be taken into account for pluggable cable assemblies)**
- **Service encoders: Pay attention to the parameters!**

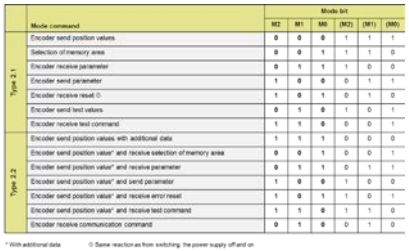
Customer Support in Implementation

Implementation steps:

- **Step 1:**
  Physical layer
  (Timing, “bits and bytes”)

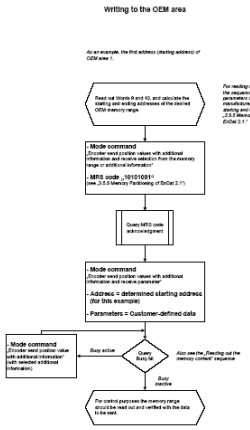


- **Step 2:**
  Communication on the basis of mode commands; handling of parameters and memory areas



- **Step 3:**
  Realization of complex sequences, e.g. deletion of errors

- **Step 4:**
  Integration of EnDat sequences in the customer application



HEIDENHAIN offers:

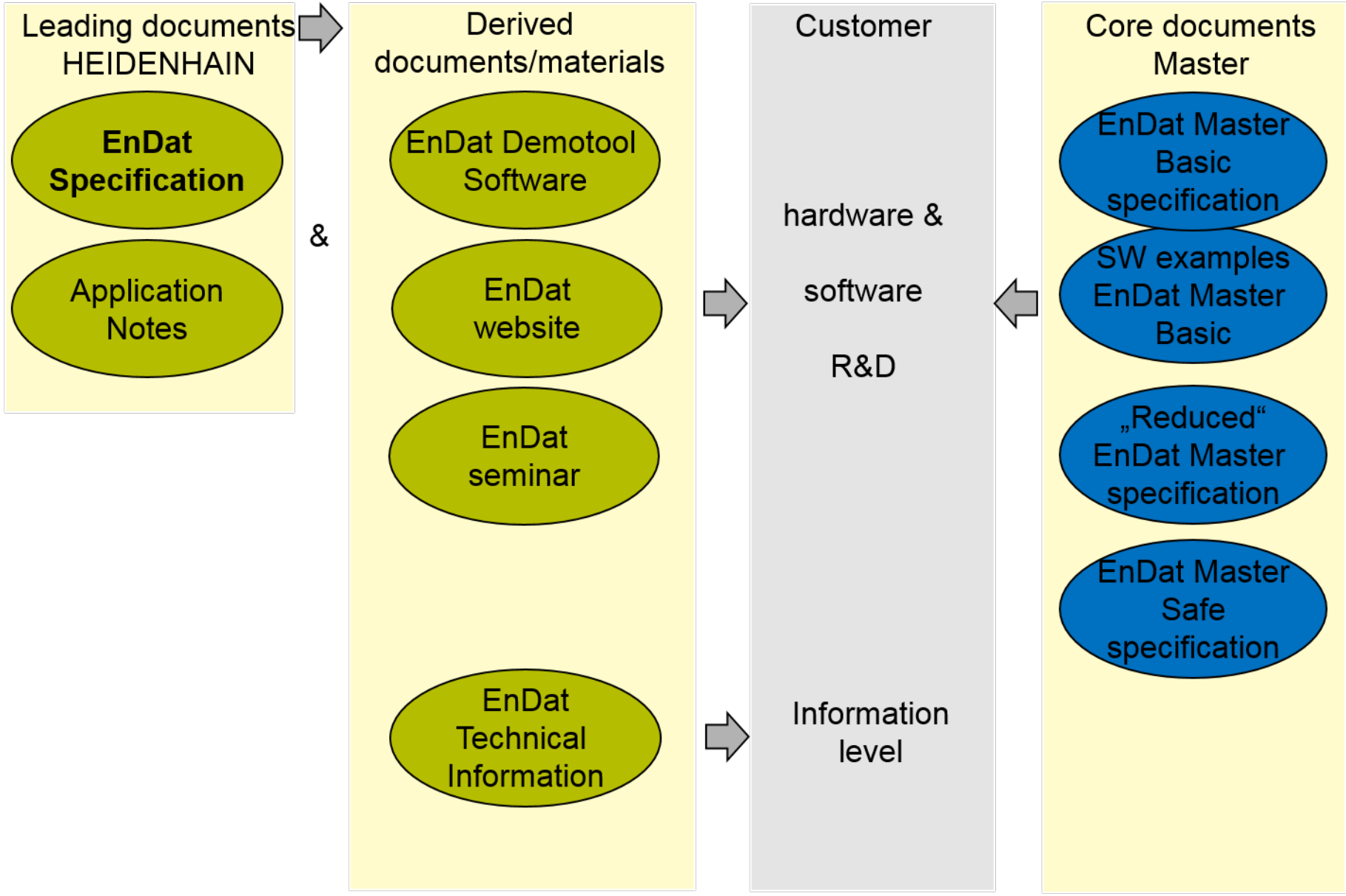
- **Step 1:**
  EnDat Master

- **Step 2:**
  EnDat demo tool software or the customer’s “low-level” application software in conjunction with the EnDat Master

- **Step 3:**
  Software sequences
  (see EnDat Application Note)

- **Step 4:**
  e. g. EnDat demo program for EIB 74x

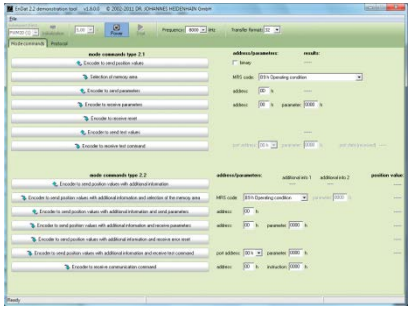
Customer Support in Implementation



Tools for Implementation and Testing

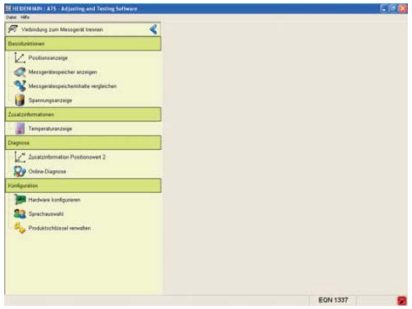
PWM 20 or rather PWM 21

EnDat Demotool Software



„Engineering“

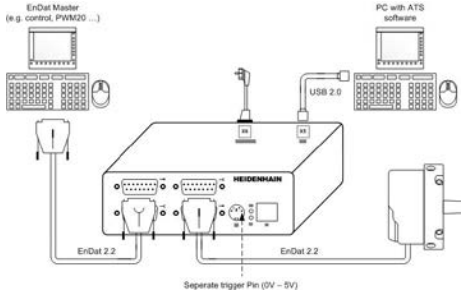
ATS Software



„Service“

Special Hard- and Software-Version

EnDat Error injection tool



„Engineering“

➔ **Special Agreement and Treatment**

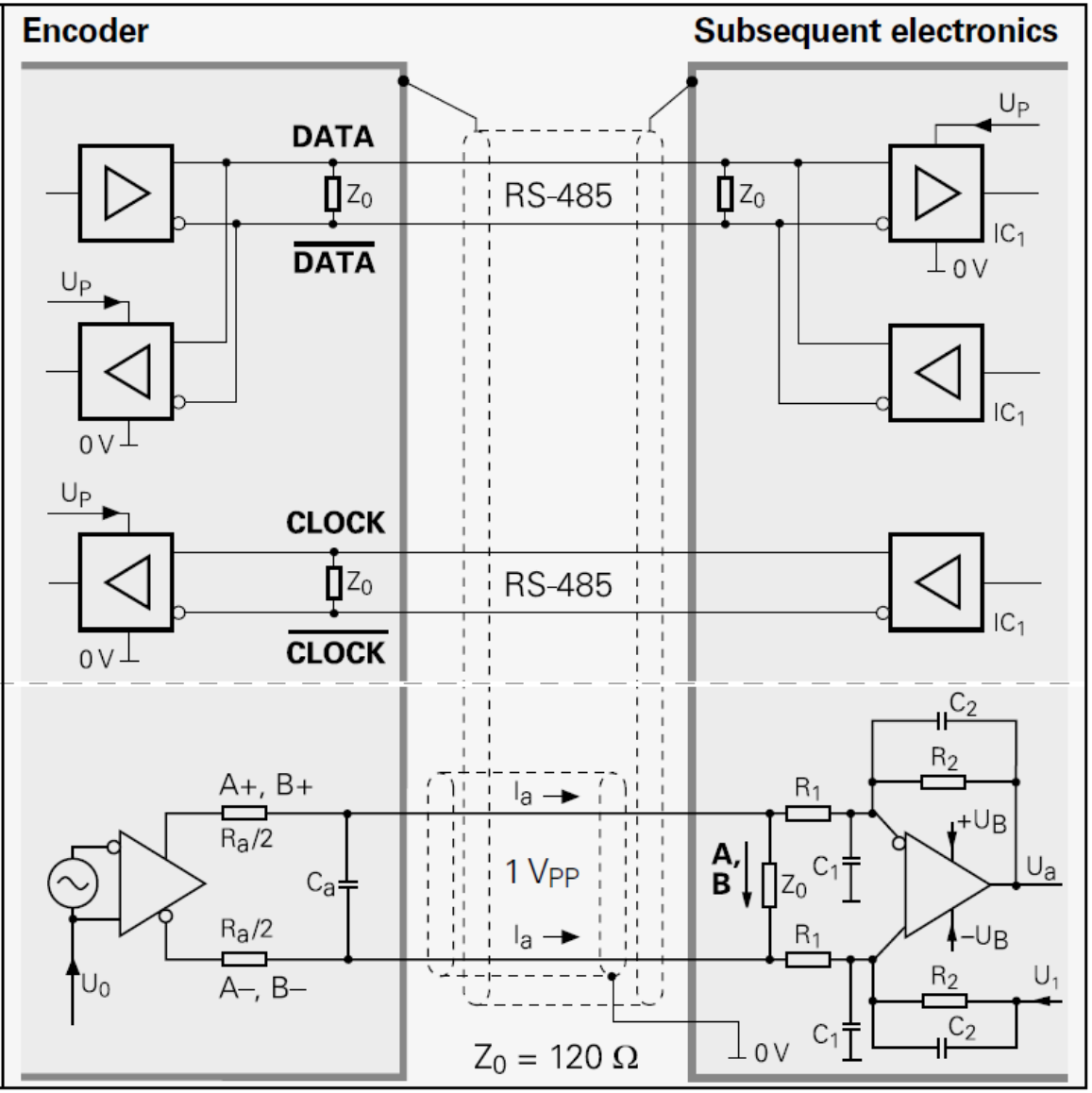
EnDat 2.2 Seminar – Basics

- Demands on a modern encoder interface
- General information and documentation
- **Interface physics and timing**
- Power-on behavior
- Position value formation
- Mode commands
- Additional datum
- Memory areas
- Error handling

Recommended Input Circuitry

Data transfer

Incremental signals
depending on the encoder (e.g. 1 V_{PP})



Recommended Input Circuitry

1 Vpp Interface:

- Note the power supply range and modulation range
- Conduct bandwidth limiting
- Conduct EMC noise suppression measures

Serial Interface:

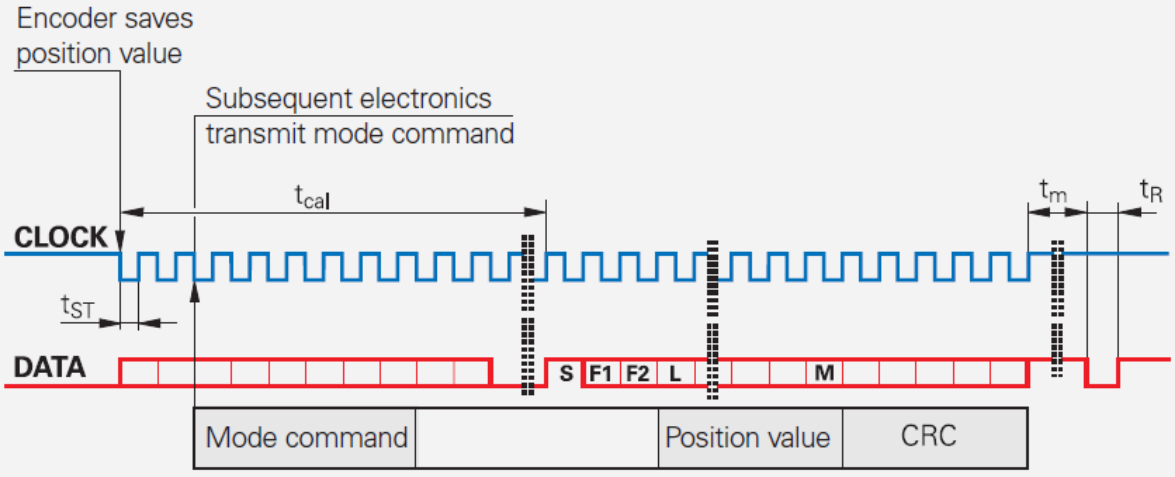
- Standard RS-485 transmission
- Maximum clock frequency 8 … 16 MHz → the driver must be designed for this
- Currently recommended driver: SN65HVD10 from TI
- The driver must be able to drive a load of 60 Ohm on the data line.
- Take EMC interference suppression measures.

Further driver see www.endat.de/FAQ
→ RS-485 Transceiver → What requirements or recommendations are there?

Timing

- **t_{ST} (recovery time III):** Must be considered when propagation-delay compensation is used to prevent collisions on the data line.
- **t_{CAL} (calculation time):** Time for forming the position value in the encoder (word 39).
- **t_M (recovery time I):** Marks the end of an EnDat transmission.
- **t_R: (recovery time II):** Required for the encoder to reach a defined initial state.

Position value packet without additional data



S = start, **F1** = error 1, **F2** = error 2, **L** = LSB, **M** = MSB
Diagram does not include the propagation-delay compensation

Timing

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		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			

EEPROM !

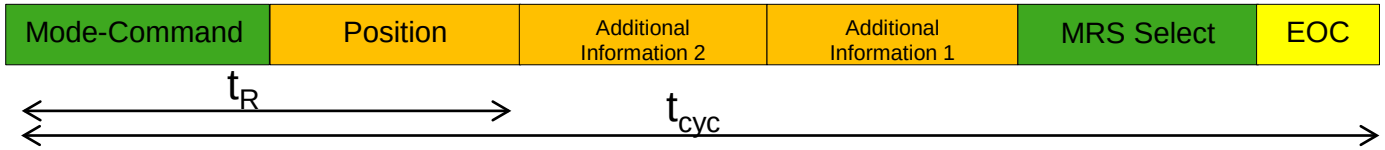
Driver + cable

Specifications of RS485 transceiver

General Information

- The higher the clock frequency, the higher the demands on the transceiver components.
- If the clock pulse must be interrupted during applications with microcontrollers, the clock pulse should be kept at low level.
- The cable properties do not only influence the propagation time, but have also a considerable influence on the transmission properties.
  → Not every cable is suitable for EnDat transmission (the higher the frequency, the higher the demands on the cable is also true in this case).
- With reduced “recovery time,” higher requirements for timing are applicable.
- Controls supporting EnDat 2.2 should start working with a low clock frequency after power-on (e.g. 300 kHz; this covers cable lengths up to 150 m). This is necessary because it is not known whether an EnDat 2.2 or EnDat 2.1 encoder is connected and the propagation delay has not been compensated yet.

Attainable TransmissionTimes



- t_R: Readout time (time till position is available at the EnDat Master)
- t_{Cyc}: Cycle time (attainable cycle time)

→ **Depending on: Encoder (t_{CAL}, bit-length), clock frequency and cable and requested information**

Example:

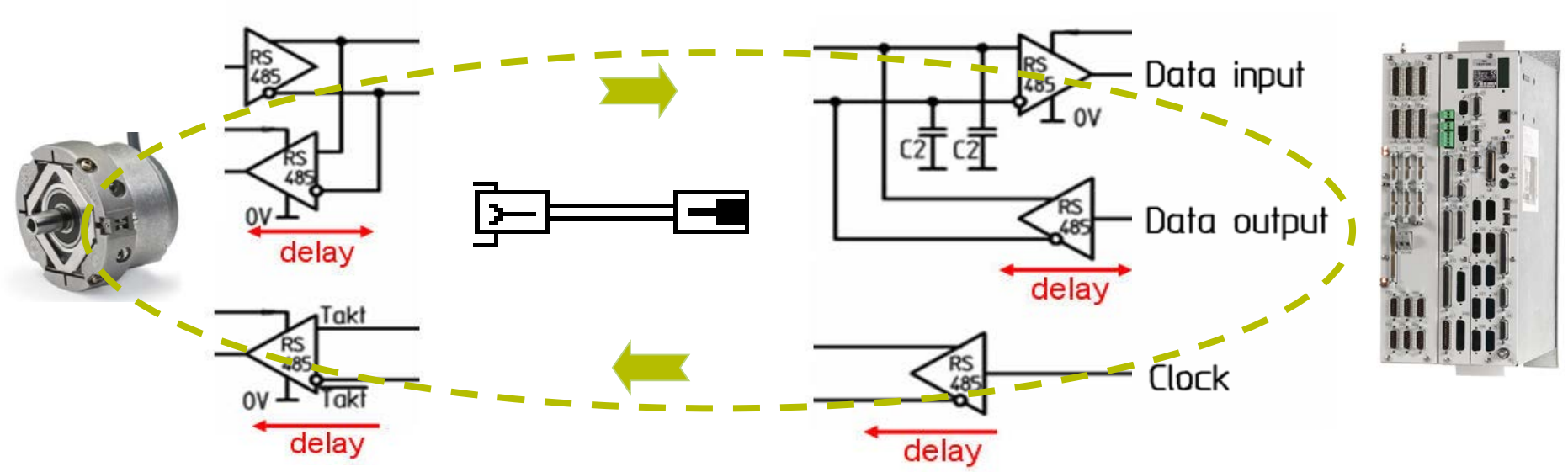
- 37 Bit
- t_{CAL} = 7 µs
- 20 m cable
- t_R → Readout time
- t_{Cyc} → Cycle time

Requested Info	f_{CLK}	t_R	t_{cyc}
Position only	4 MHz	~ 19 µs	~ 24 µs
	8 MHz	~ 13 µs	~ 18 µs
	16 MHz	~ 10 µs	~ 15 µs
+ one additional information	4 MHz		~ 42 (31) µs
	8 MHz		~ 28 (22) µs
	16 MHz		~ 21 (17) µs
+ two additional information	4 MHz		~ 49 (39) µs
	8 MHz		~ 32 (25) µs
	16 MHz		~ 23 (18) µs

Values in brackets: no change in selection of additional information; no „MRS Select“

Signal Propagation

- The data output of the encoder occurs on the rising clock edge



The original pulse of the subsequent electronics and the data received have a propagation time to each other consisting of the propagation times of the RS-485 transceiver (t_D approx. 20 .. 100 ns per driver) and the cable propagation time t_{cable} (approx. 6..10 ns per meter): Propagation time = $4*t_D + 2*\text{cable length}*t_{cable}$

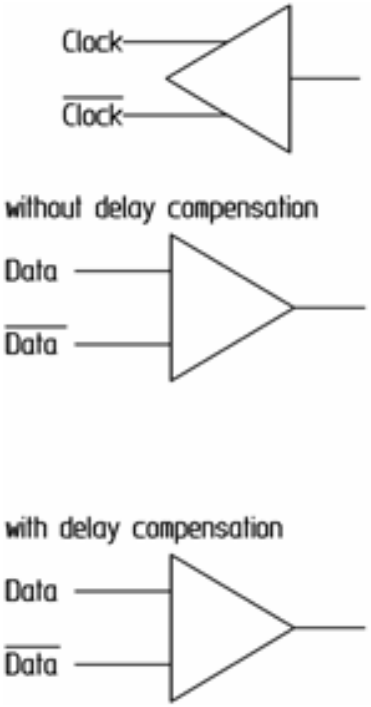
Data Acceptance

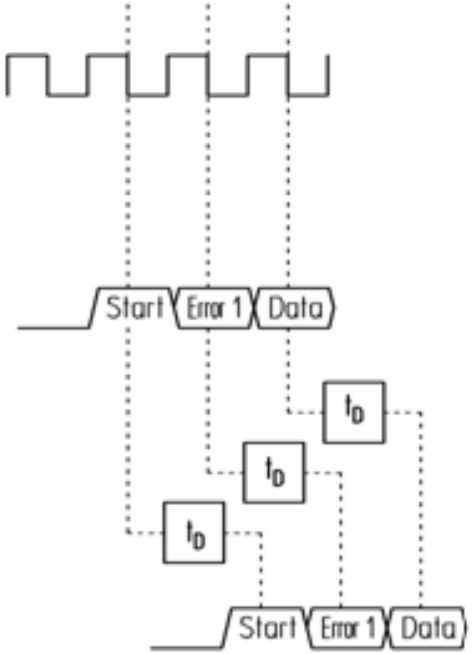
Without propagation-delay compensation:

- Ideal:
  Data transfer in the subsequent electronics shou
  occur in the “center” of the data bit.
- Recommended:
  Acceptance of data with rising edge of subseque
  clock pulse.
- The resulting maximum permissible clock
  frequency depends on the cable length.

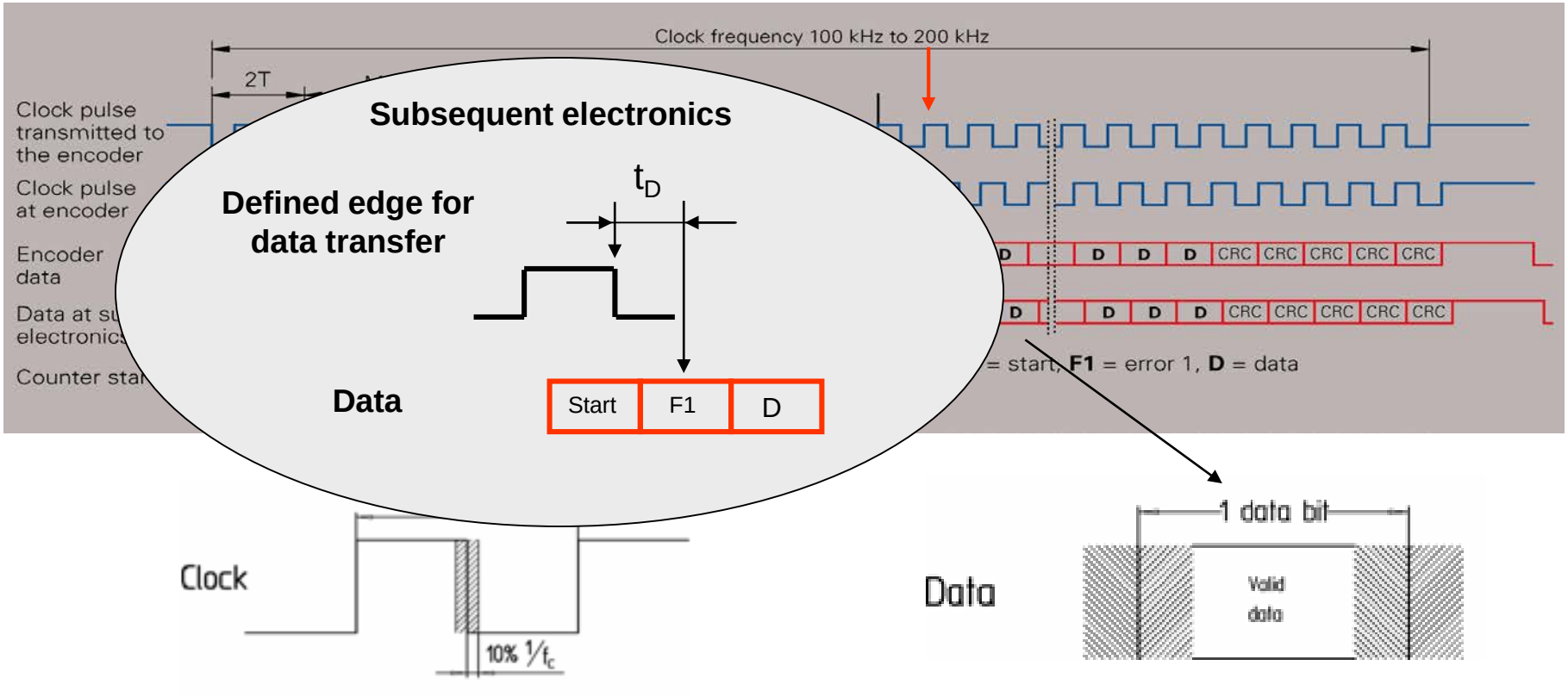
With propagation-delay compensation:

- The complete propagation time in the system mu
  be measured and compensated in the subs.
  electronics.
- This must be carried out during each power-up;
  averaging of several measurements is
  recommended.



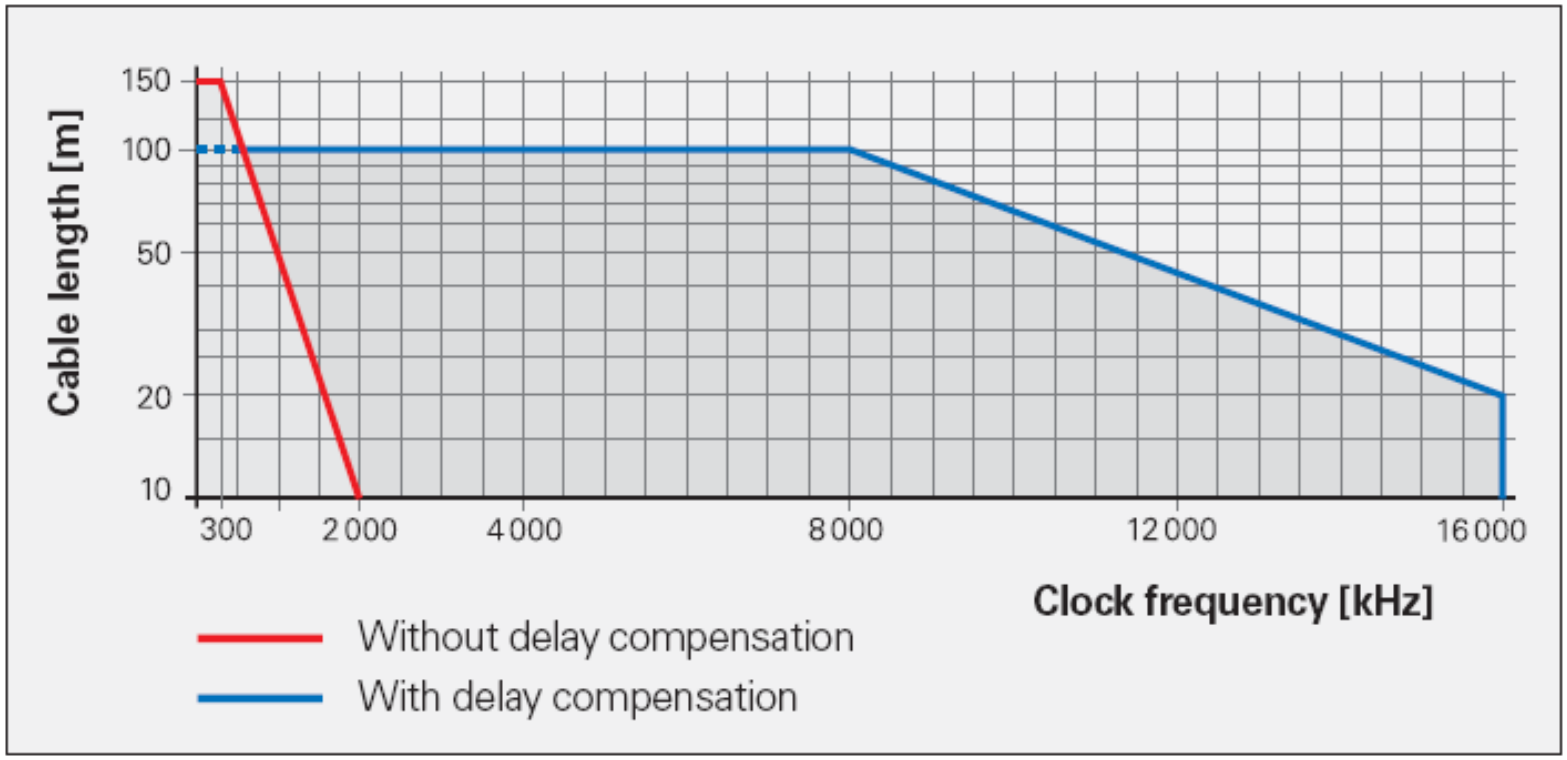


Delay Compensation



- The internal clock frequency for determining the propagation time must be 8 times higher than the clock frequency used later.
- The frequency for determining the propagation time may vary by max. 10 %.
- Use the EnDat 2.1 position command (recovery time)
- Several measurements should be averaged.

Cable Length / Frequency

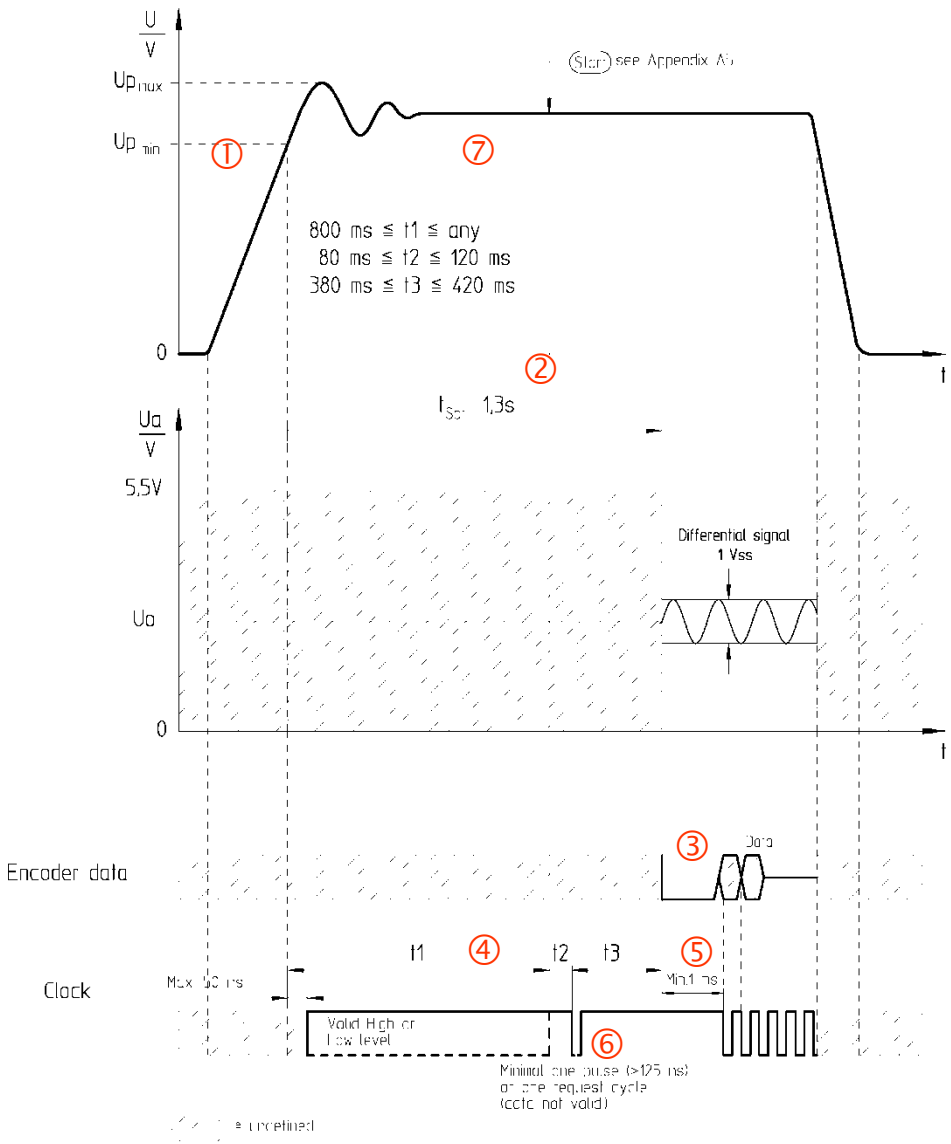


The receiver hardware (transceiver) of EnDat 2.1 or 2.2 encoders differs.
➔ The max. clock frequency is not only determined by the command set, but also by transceiver, cable, incremental signal transfer, ...

EnDat 2.2 Seminar – Basics

- Demands on a modern encoder interface
- General information and documentation
- Interface physics and timing
- **Power-on behavior**
- Position value formation
- Mode commands
- Additional datum
- Memory areas
- Error handling

Power-on Behaviour



① Build-up time of supply voltage until Up.min is reached should be > 10 V/sec.

② The time until the 1 Vpp incremental signals assume valid values is max. 1.3 sec.

③ After power-on, the level of the data line is used to determine whether it is an EnDat or SSI encoder.

④ Clock pulse edges during t1 or t2 can interrupt booting; this can only be corrected by switching the encoder off and then on again.

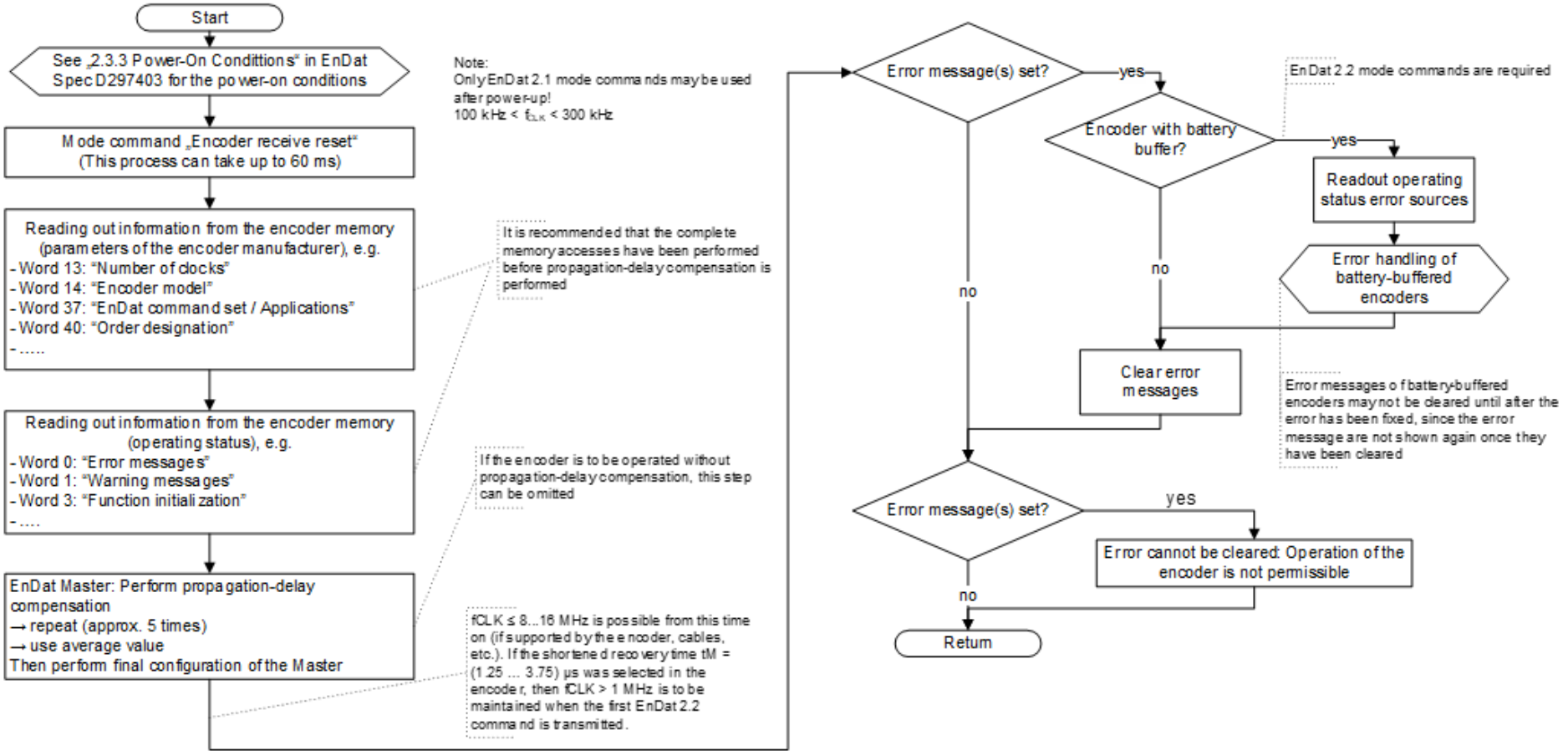
⑤ A first EnDat request (falling edge) is permissible once t3 has ended after at least 1 ms (there is no maximum time limit). After the first clock pulse, the direction of data on the data line is reversed (this is why the data line is then at “high impedance”).

⑥ The encoder requires a defined reset:
Falling edge + end of recovery time;
For the duration of the low phase the following applies:
0.125 < tlow < 30 µs

⑦ t1: Boot or reset time of the EnDat encoder
t2: Initialization phase of the EnDat encoder
t3: Must be maintained for downward compatibility to EnDat 2.1

Power-on Behaviour

Power-on procedure



See also the EnDat Application Note, Chapter “Sequences and data structures”

EnDat 2.2 Seminar – Basics

- Demands on a modern encoder interface
- General information and documentation
- Interface physics and timing
- Power-on behavior
- **Position value formation**
- Mode commands
- Additional datum
- Memory areas
- Error handling

Date Word Width

Transfer format for position values

- The format for transfer of position values varies in length depending on the encoder model. The time for transmitting the position value to the subsequent electronics is minimized with EnDat. The number of clocks required for transmitting the position value (without mode, start, error and CRC bits) must be read out from the encoder manufacturer's memory area.
- The position value is always output in pure binary code. A distinction is made between multiturn rotary encoders and singleturn rotary encoders, absolute linear encoders and incremental encoders. The subsequent electronics must support a data width of the position value of 48 bits.

Important points

- The number of bits to be transmitted is variable and depends on the encoder.
- The structure of the position value telegram is determined by the encoder model.
- The subsequent electronics must support a data width of 48 bits.

Transmission Format

- EnDat uses "LSB first" for transmitting the position value.

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

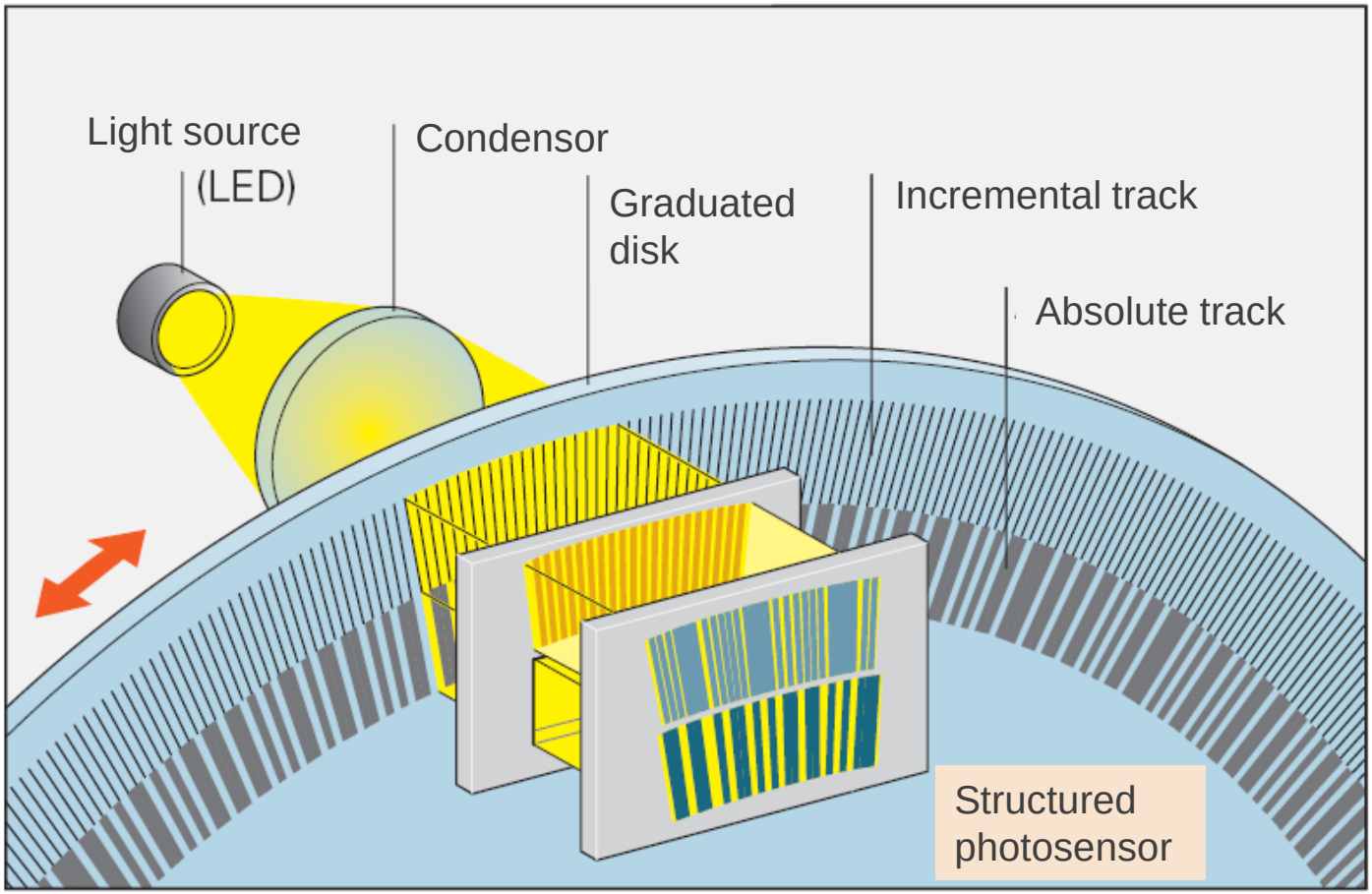
Example: Multiturn rotary encoder 4096 distinguishable revolutions (≙ 12 bit)
8192 measuring steps per revolution (≙ 13 bit)

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											

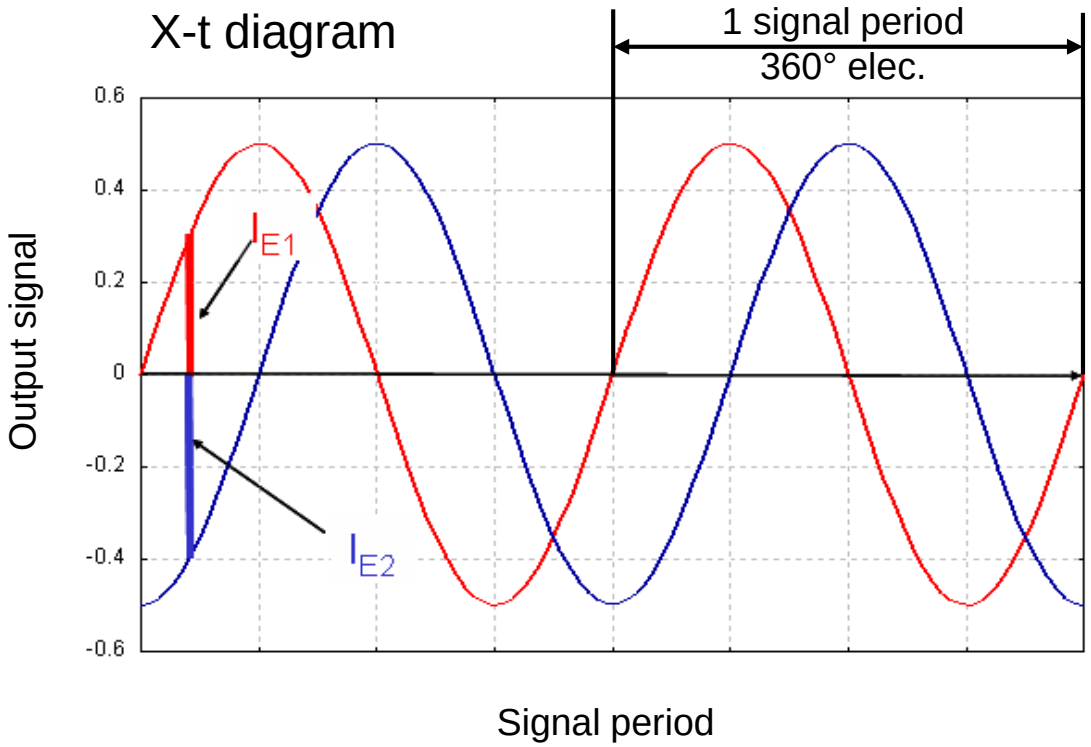
Absolute Scanning

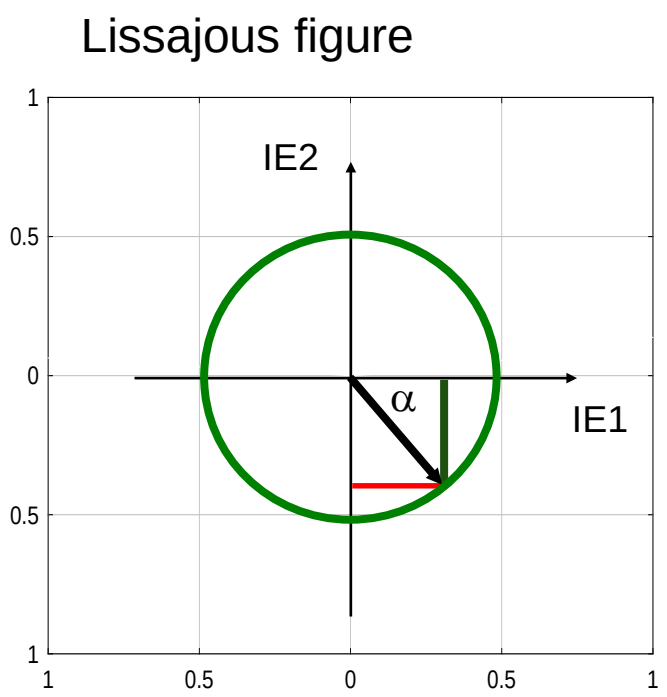
- **Incremental track**
  Absolute (one-to-one) within one signal period
- **Absolute track**
  absolute (one-to-one) within one revolution



Signal Period and Interpolation

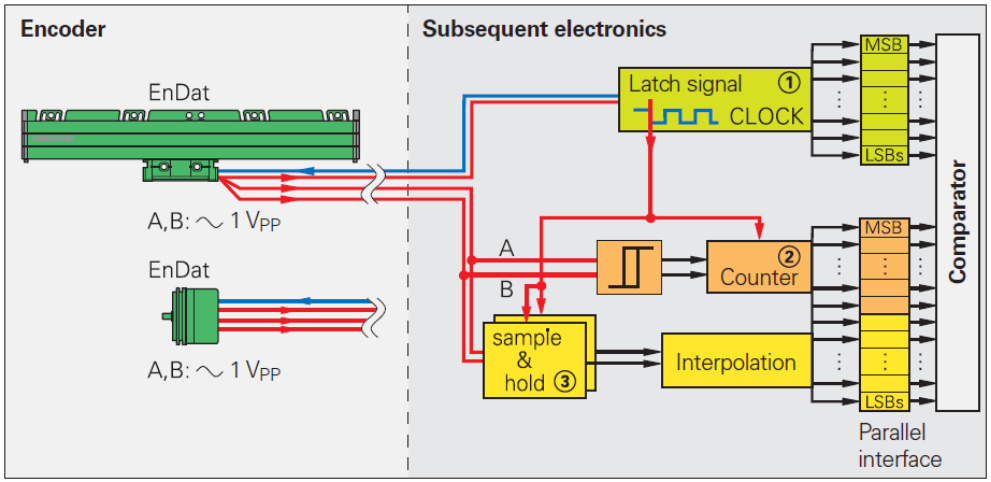
- Two output signals that are phase-shifted relative to each other by 90° are required to distinguish a forward movement from a backward movement.
- To determine the angle, α α = ArcTan (IE2/IE1) must be formed.
- The angle α is one-to-one within one signal period.
- AD converters are normally used for measuring the amplitudes.

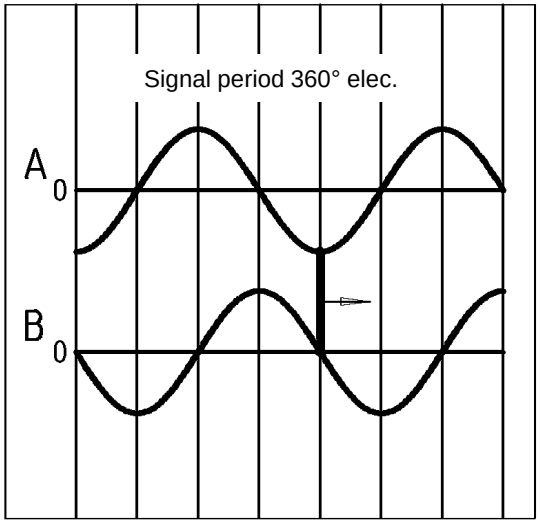




Absolute / Incremental Synchronization

- The absolute value unambiguously identifies a signal period.
- The position value is absolute within one sinusoidal period of the incremental signal.
- The counter is used to count the number of signal periods.
  Due to the control cycle time at high traversing speeds, it is not guaranteed that the position is determined within each signal period.



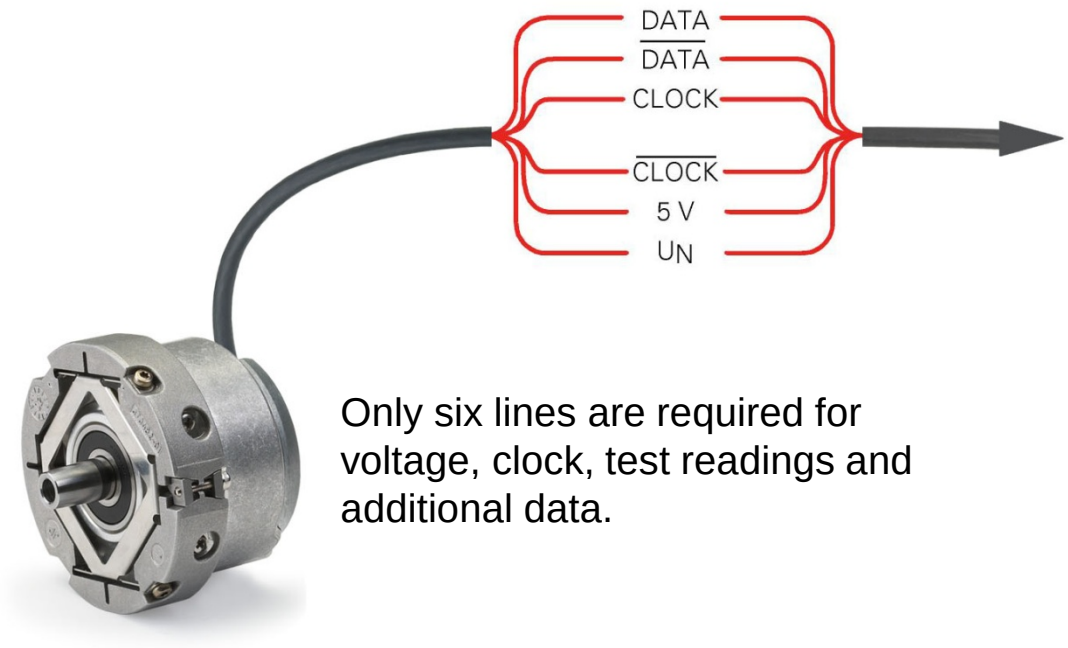


Output of zero position of serially transmitted position value to the incremental signal for increasing position values. The tolerance of the zero position depends on the encoder (see Specifications).

Encoders without Incremental Signals

- Complete position-value formation performed in encoder (including interpolation, typically 14 bits).
- No need for incremental signals.

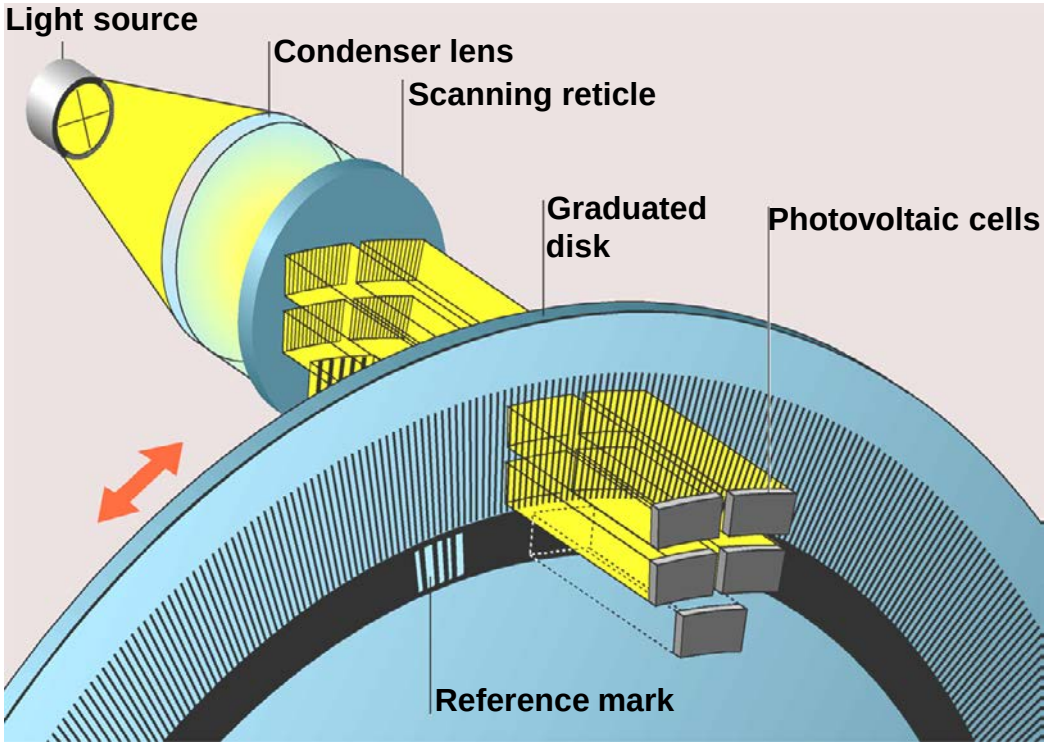
EnDat 2.2

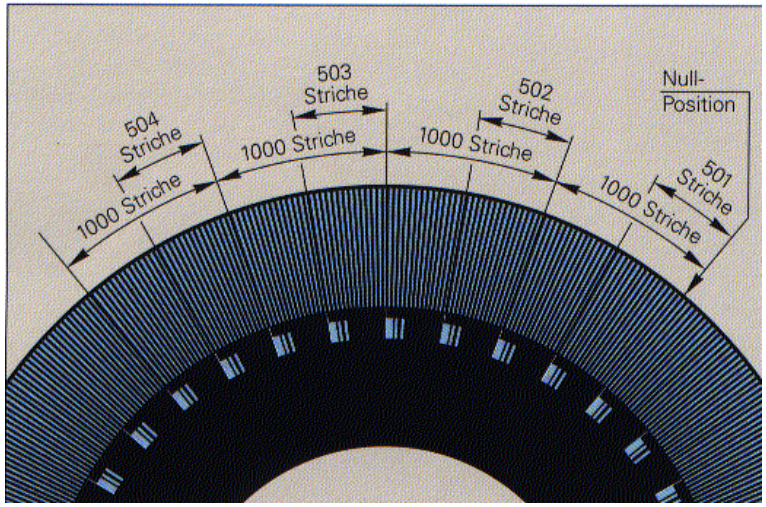


Only six lines are required for voltage, clock, test readings and additional data.

Incremental Encoders

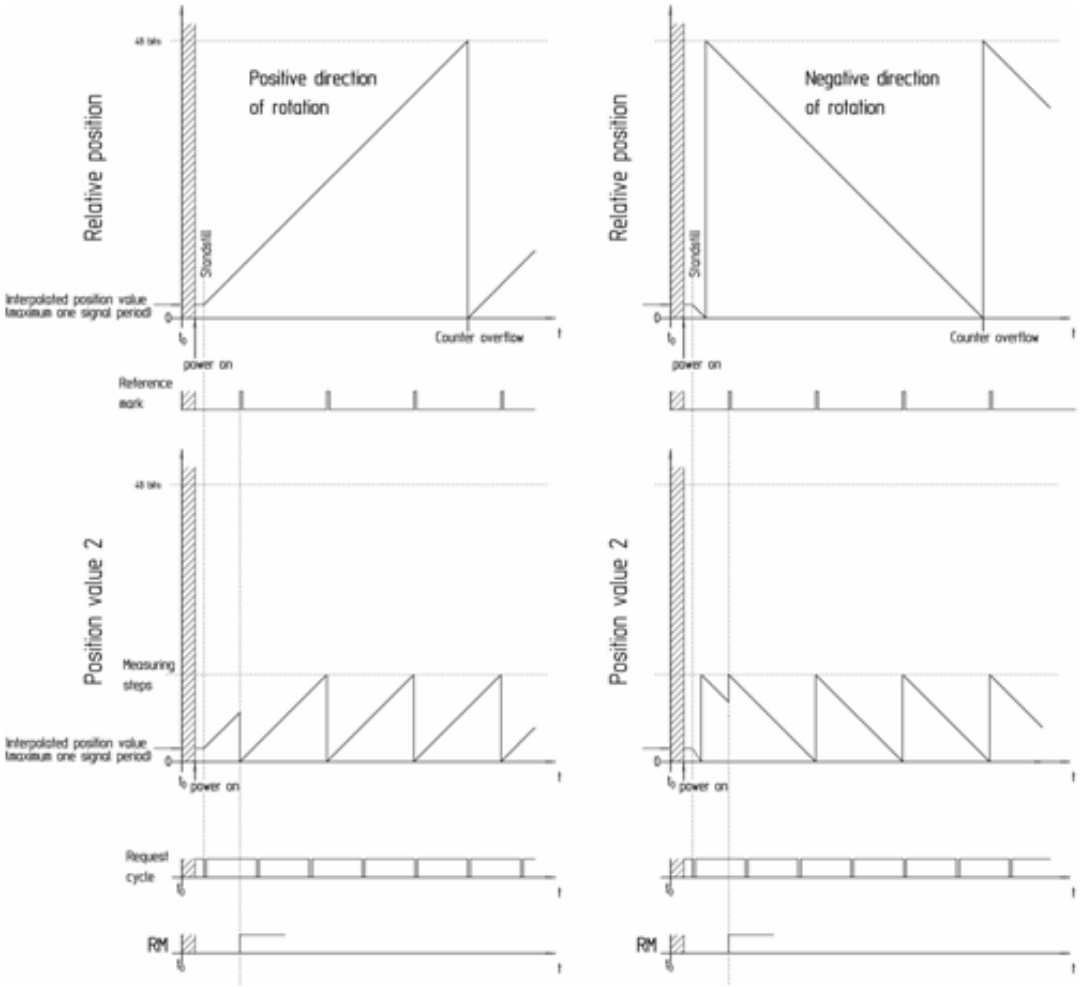
- A signal period is unambiguously identified by the reference mark.
- Distance-coded reference marks reduce the so-called reference run.





Incremental Encoders

- The relative position is transferred as position value. The recognition of the reference mark does not cause a sudden step change of the position value.
- Position value 2 (additional datum) is set to the absolute value, once the reference mark has been recognized.
- The recognition of the reference mark also results in the RM bit being set. The RM bit can be interrogated in the additional datum.



EnDat 2.2 Seminar – Basics

- Demands on a modern encoder interface
- General information and documentation
- Interface physics and timing
- Power-on behavior
- Position value formation
- **Mode commands**
- Additional datum
- Memory areas
- Error handling

Overview

General:

- The transfer type is selected with mode commands that are sent to the encoder by the subsequent electronics.
- A mode command consists of 6 bits.
- To ensure reliable transfer, the first three bits are transferred doubly or inverted.
- The data direction(s) is (are) determined by the type of mode command.
- EnDat 2.2 encoders support EnDat 2.1 and 2.2 mode commands.
- EnDat 2.2 mode commands are designed so that the entire communication can be carried out in the closed control loop.
- The maximum clock frequencies do not depend on the mode command.
  The maximum clock frequency is determined by the encoder.

Overview

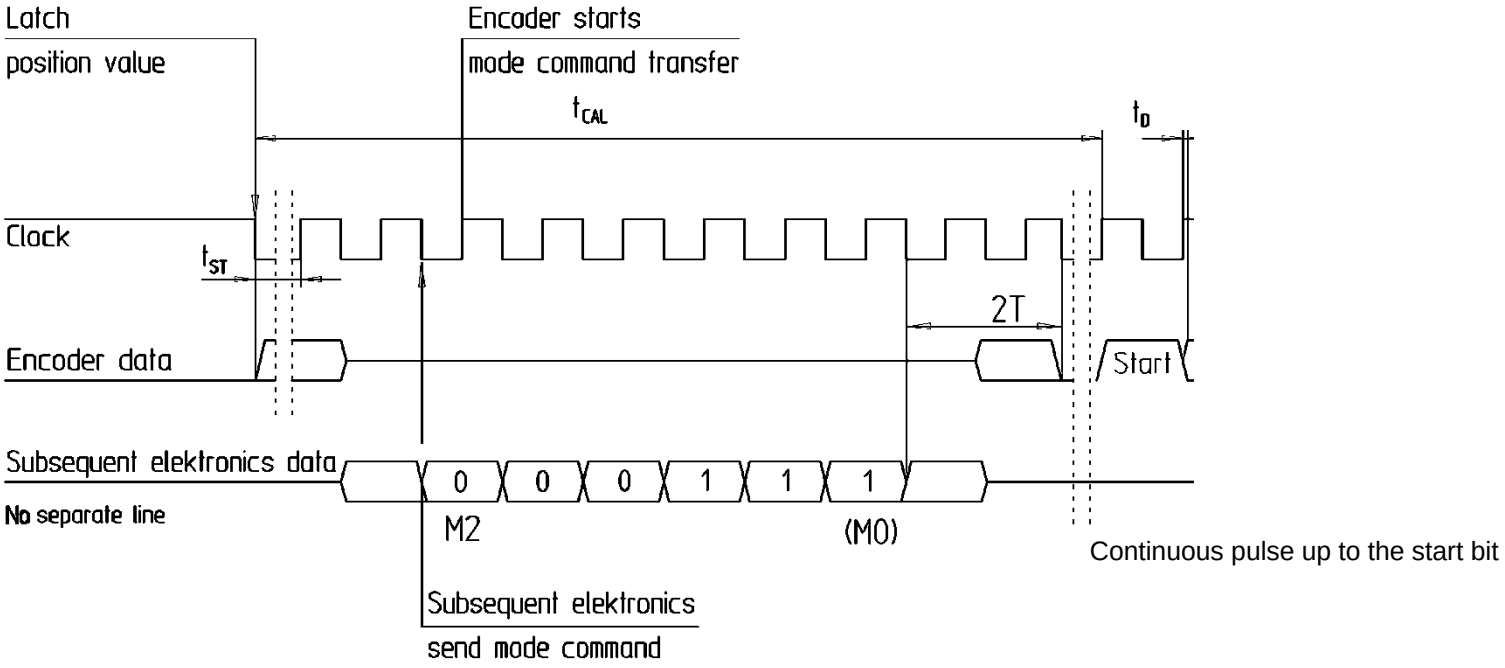
	Mode command	Mode bit					
		M2	M1	M0	(M2)	(M1)	(M0)
Type 2.1	Encoder send position values	**0**	**0**	**0**	1	1	1
	Selection of memory area	**0**	**0**	**1**	1	1	0
	Encoder receive parameter	**0**	**1**	**1**	1	0	0
	Encoder send parameter	**1**	**0**	**0**	0	1	1
	Encoder receive reset ①	**1**	**0**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

* With additional data

① Same reaction as from switching the power supply off and on

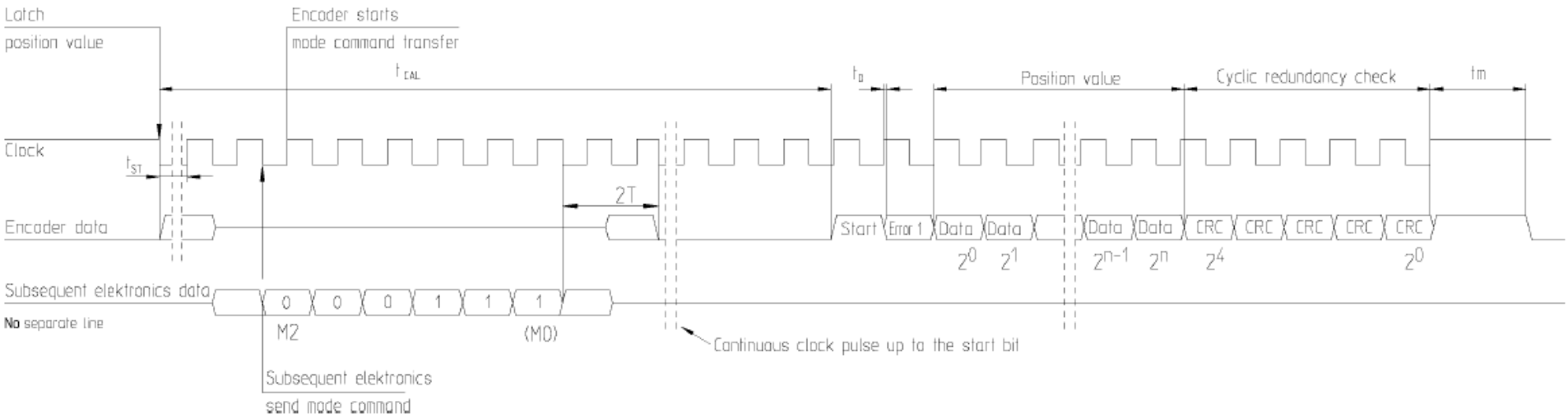
Data Direction Switching

- 1st clock period: The driver in the encoder is deactivated
- 2nd clock period: The driver in the subsequent electronics is activated
- 3rd to 8th clock period: Transmission of mode word
- 9th clock period: The driver in the subs. electronics is deactivated
- 10th clock period: The driver in the encoder is activated
- From the 11th clock period: Polling to the start bit

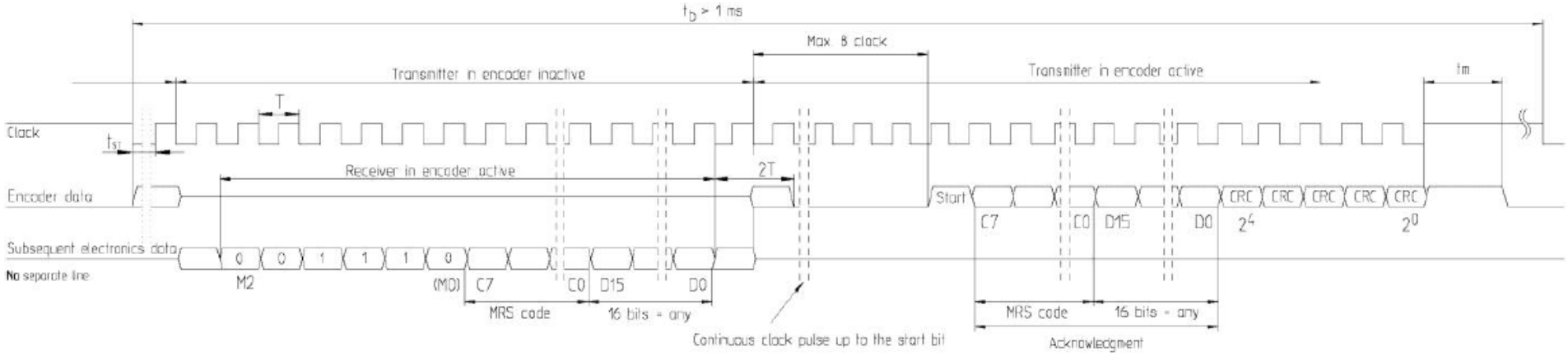


EnDat 2.1 Mode Commands: Overview (I)

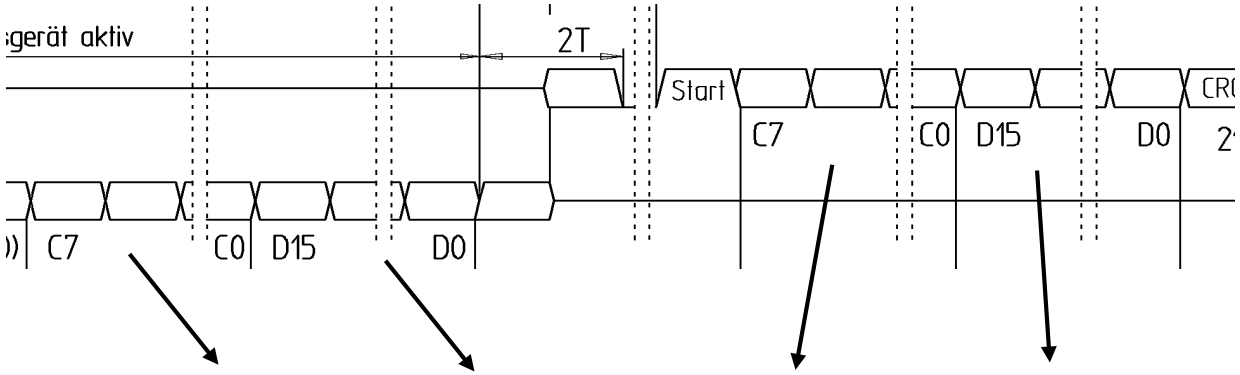
Send position



Selection of memory area



EnDat 2.1 Mode Commands: Overview (II)

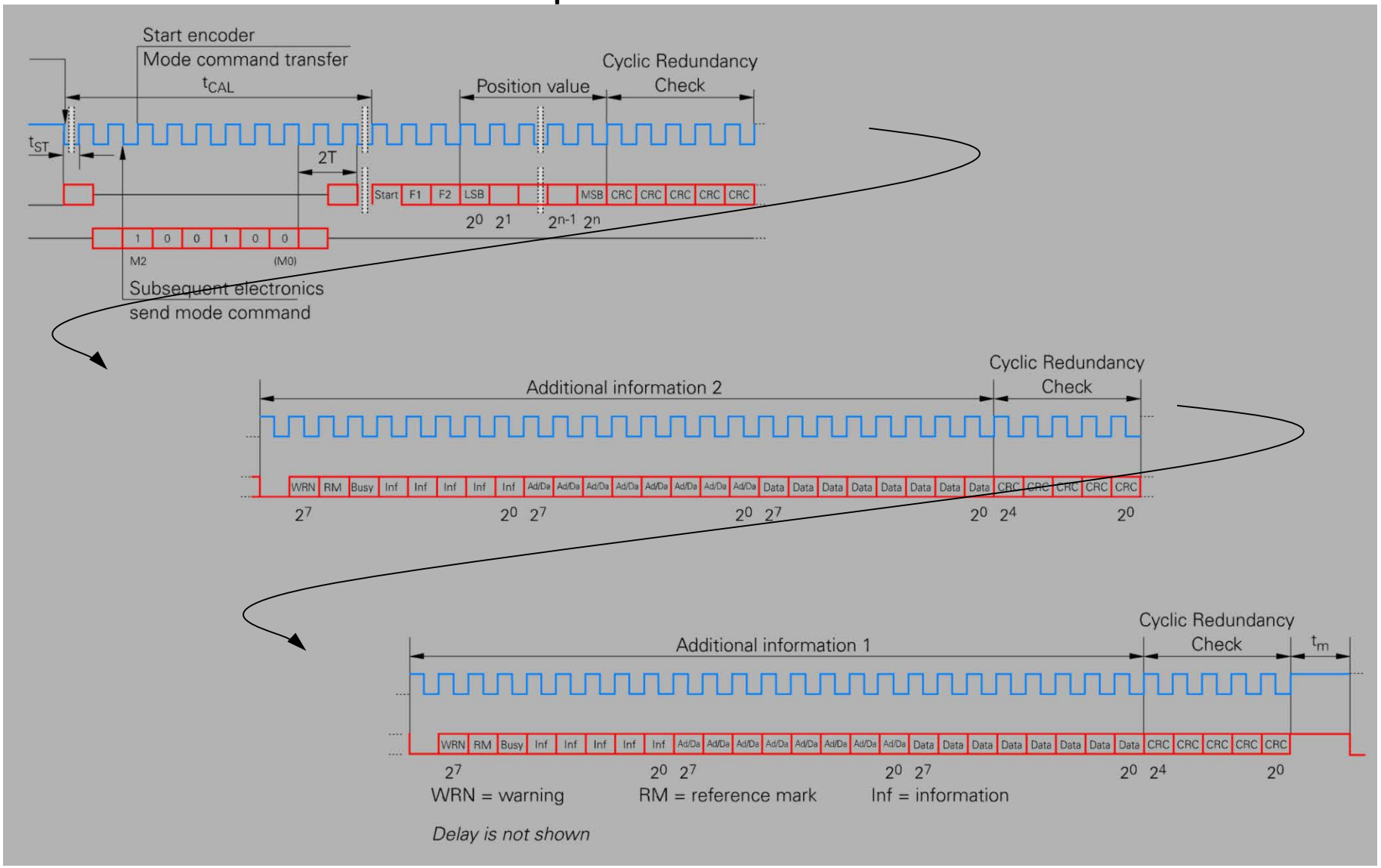


Mode command	C7 .. C0 (or A7 .. A0)	D15 .. D0	C7 .. C0 (or A7 .. A0)	D15 .. D0
Selection of memory area	MRS	Any	MRS (acknowledgment)	Any
Encoder receive parameter	Address	Parameter	Address (acknowledgment)	Parameter (acknowledgment)
Encoder send parameter	Address	Any	Address (acknowledgment)	Parameter
Encoder receive reset	Any	Any	Any	Any

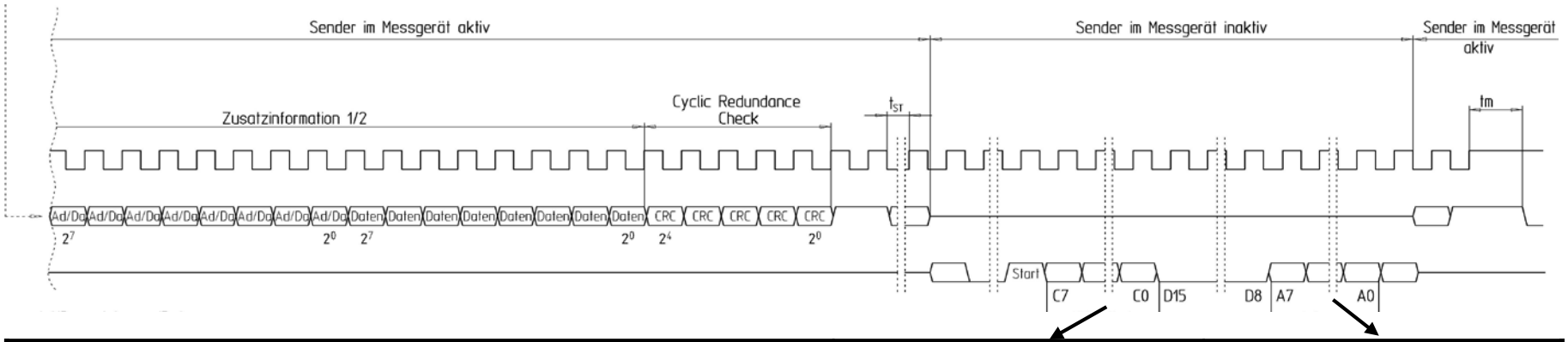
Observe the specific temporal conditions of the individual mode commands (see EnDat specification).

EnDat 2.2 Mode Commands: Overview (I)

Encoder send position values with additional data



EnDat 2.2 Mode Commands: Overview (I)



Mode command: **Encoder send position values with additional data and …**	**C7 .. C0** (or A7 .. A0)	**D15 .. D8 + A7 .. A0** (or D15 .. D0)
…selection of memory area or block address	MRS	A0..A7 block address for section 2 memory area
... and receive parameter	Address	Parameter
... send parameter	Address	Any
... and receive error reset	Any	Any
... and receive test command	Port address	Any

- **Observe the specific temporal conditions of the individual mode commands (see EnDat specification).**
- **Acknowledgement of MRS selection or test command or reading out of memory content is via the additional datum 1**

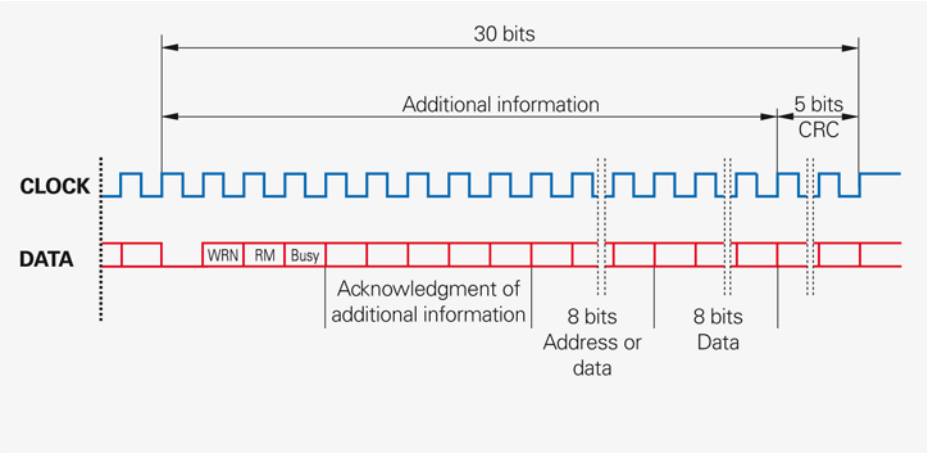
EnDat 2.2 Seminar – Basics

- Demands on a modern encoder interface
- General information and documentation
- Interface physics and timing
- Power-on behavior
- Position value formation
- Mode commands
- **Additional datum**
- Memory areas
- Error handling

Overview

General

- Max. two pieces of additional data can be transferred.
- The data packets are appended to the position information.
- The additional datum is stored in the registers in the ASIC.
  → Reduced access time and therefore availability in each control cycle.
- The requested additional datum is selected solely via
  MRS codes (no word address required).
- Additional data can be selected or deselected arbitrarily.
- Word 0 and 1 in the EnDat 2.2 parameters indicate which additional data is supported.



Overview

General

- By selecting one of the MRS codes on the left, the corresponding additional datum is transferred with the following requests.
- Deselection occurs if the MRS code “No longer send additional datum 1 or 2” is selected.
- More than one word is required for transmitting the complete information of position value 2, test values, or asynchronous position.
  The total value is updated when the LSB is requested.

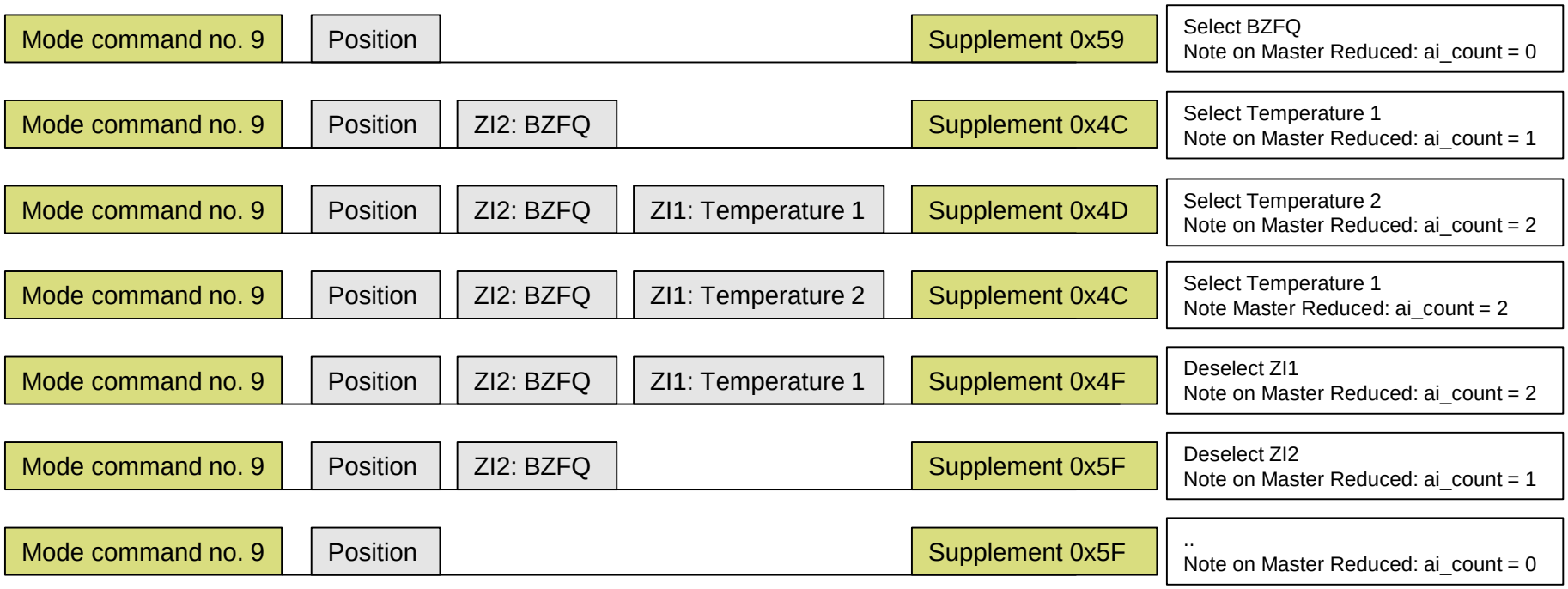
C7	C6	C5	C4	C3	C2	C1	C0	MRS code for selecting the additional information
			I4	I3	I2	I1	I0	Acknowledgment of selection of additional information
0	1	0	0	0	0	0	0	Send additional info 1 without data contents (NOP) ①
0	1	0	0	0	0	0	1	Send diagnostic values
0	1	0	0	0	0	1	0	Send position value 2 word 1 LSB
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	Send 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 information 1 ②

Additional Information 1

0	1	0	1	0	0	0	0	Send additional information 2 without data contents ①
0	1	0	1	0	0	0	1	Send 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
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	Currently not assigned
0	1	0	1	1	1	1	1	Stop sending additional information 2 ②

Additional Information 2

Selection of Additional Information (ZI)



Comments

- ZI … Additional data
- BZFQ … Operating status error sources
- ai_count … For the EnDat master reduced, this variable must be used to set the quantity of additional data. The EnDat Master Basic determines this quantity automatically (via the MRS codes for selecting the additional data).

Transmission Format

Important points:

- WRN – warnings: Group bit for warning that has occurred.
- RM – reference mark: Indicates whether the reference run is finished (for absolute encoders always "1").
- Busy – parameter request: Indicates whether the EEPROM is currently being accessed. If the busy bit is set, no more memory accesses are permitted.
- I4..I0: The number of the additional data is returned.
- 16 bits are available for address and data.
- To ensure reliable transfer, a CRC is used.

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

Additional Datum 1 (I)

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)

Additonal Datum 1 (II)

- **Diagnosis:**
  The valuation numbers must be selected beforehand (see Operating Parameters: "Configuration of Diagnosis." The values are output in a rolling request process. Identification is possible via the supplied address.
- **Position value 2:**
  With incremental encoders, the absolute position value is output after the reference mark has been crossed. Since a maximum position length of 48 bits is supported, 3 words are required for position 2. The redundant position value is output for encoders supporting the safety concept.
- **Memory parameters:**
  Synchronization is required for reading out parameters from the EEPROM in the closed control loop due to the long time (max. 12 ms) required for accessing the EEPROM (also see "memory accesses"). Transmission is divided between LSB and MSB to be able to transmit the address simultaneously.
- **Acknowledgment of MRS code:**
  With EnDat 2.2, the selected MRS code is no longer acknowledged directly (also see "Mode Commands"); acknowledgement must be requested actively via the additional data.

Additional Datum 1 (III)

- **Acknowledgement of test command:**
  After selection of the port address (also see "Mode Commands"), the selected port address should be returned for safety.
- **Test values:**
  Test values must be read out from the encoder for the commissioning diagnosis. Due to the data width of 40 bits, 3 words are required.
- **Temperature sensor 1 or 2:**
  Transmission of the current value of the temperature sensor. Sensor 1 is an external sensor, and sensor 2 is in the encoder. The scaling is stored in the EnDat 2.2 range.
- **Additional sensors:**
  The EnDat 2.2 protocol permits the connection of 16 further sensors (4-bit address). The sensor values are output in a rolling request process (x+1); the assigned sensor can be identified based on the supplied address. If fewer than 16 sensors are supported, then only the supported addresses are output.

Additional Datum 2 (I)

I4 - I0 binary	Byte 0	Byte 1						Byte 2
16	No data contents are transferred (NOP)	Any						Any
17	Commutation	u	v	w	Currently not assigned			Currently not assigned
		D7	D6	D5	D4		D0	
18	Acceleration	MSB data						LSB data
19	Commutation & acceleration	u	v	w	MSB acceleration data			LSB acceleration data
		D7	D6	D5	D4	...	D0	
20	Limit position signals	L1	L2	Currently not assigned				Currently not assigned
		D7	D6	D5			D0	
21	Limit position signals & acceleration	L1	L2	Currently not assigned	MSB acceleration data			LSB acceleration data
		D7	D6	D5			D0	
22	Asynchronous position value / Position value 2 ② Word 1 LSB	MSB data						LSB data
23	Asynchronous position value / Position value 2 ② Word 2	MSB data						LSB data
24	Asynchronous position value / Position value 2 ② Word 3 MSB	MSB data						LSB data
25	Operating status error sources	MSB data						LSB data
26	Reserved							
27	Timestamp	MSB data						LSB data
: :								
31	Type III error handling ①	Any						Any

Additional Datum 2 (II)

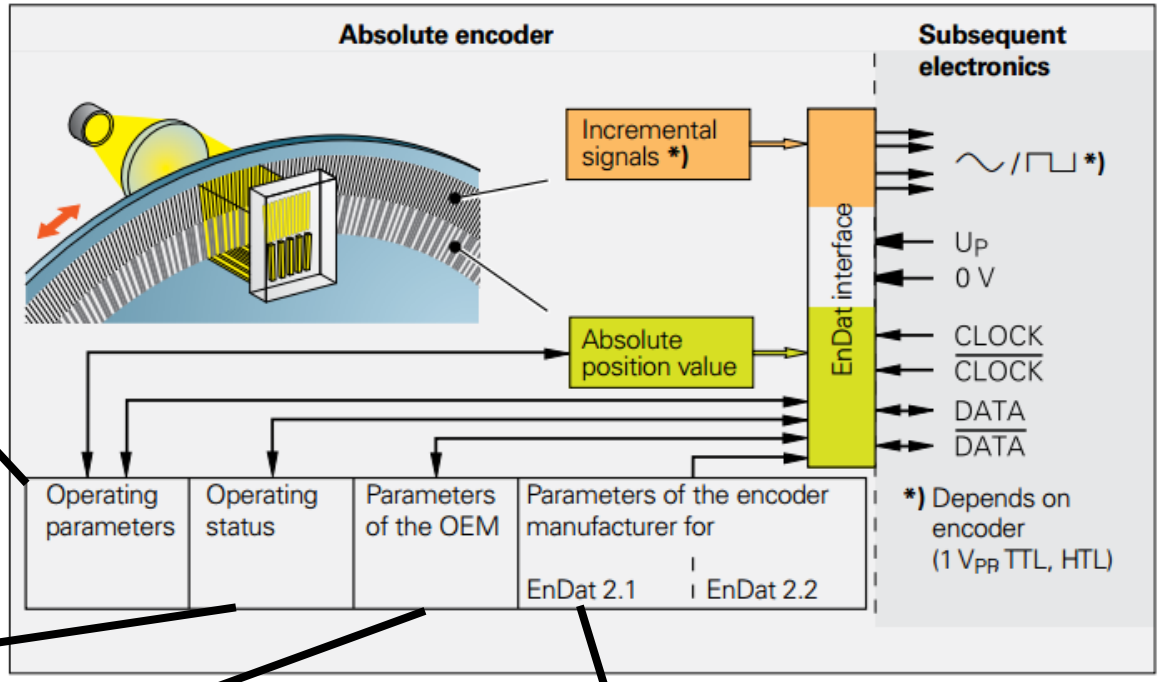
- **Commutation:**
  For more detailed information, see encoder specifications.
- **Acceleration:**
  Transmission of values from acceleration sensor. The acceleration scaling is stored in word 3 of the EnDat 2.2 parameters.
- **Limit position signals:**
  Some of the encoders support limit position signals ("soft limit switches") or homing signals (from which direction must the reference mark be approached).
- **Asynchronous position value (depends on encoder):**
  Reserved for future applications.
  A position, formed by oversampling between two regular requests, can be read out. An MRS code + address is required for defining the time stamp or a copy of the position value of Additional Datum 1.
- **Operating status error sources:**
  Detailed information about an error for optimizing the error handling of the control (see encoder specifications).
- **Timestamp:**
  Reserved for touch probes. Probe time in relation to request time.

EnDat 2.2 Seminar – Basics

- Demands on a modern encoder interface
- General information and documentation
- Interface physics and timing
- Power-on behavior
- Position value formation
- Mode commands
- Additional datum
- **Memory areas**
- Error handling

Overview

- Datum shift
- Configuration of diagnosis
- Bus operation (in preparation)
- I/O functionality
- Status of touch probe
- Re-referencing



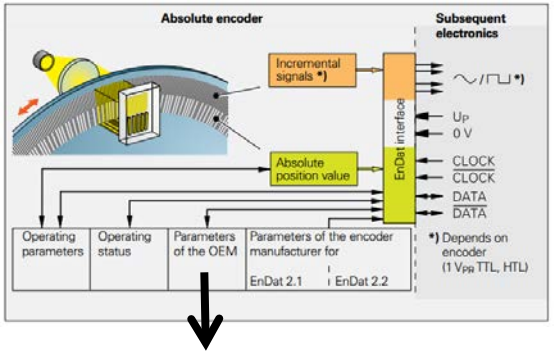
- Errors
- Warnings
- Write protection
- Function initialization

- Freely program-mable by OEM
- "Electronic ID label"

- Encoder-specific parameters for automatic self-configuration
- Supported errors, warnings, functions
- ...

Electronic ID Label

- System-related information can be saved in the "Parameters of the OEM" area.
  - Unambiguous identification and configuration of the drive system
  - Error-prone manual parameterization is avoided
  - Shorter commissioning time
  - Support provided to the Service technician minimizes standstill times



- Frei programmierbar durch den OEM
- „Elektronisches Typenschild“

- Type of information that is typically saved
  - Information on the motor
    - Logistics: ID number, serial number, ...
    - Mechanics: Design of the brake, torques, ...
    - Electronics: Current limit values, control parameters
  - Service information
    - Further information on the system configuration, maintenance dates, ...
  - Status data
    - Status data are usually captured by the higher-level control and stored in the encoder, for example during start-up

MRS – Code and Addresses

	MRS code C7	C6	C5	C4	C3	C2	C1	C0	Number of assigned words	Address range
Operating condition	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 section 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 section 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 sections 3.7 and 3.9.18	

This data is stored in an EEPROM (access time !)

- Each time a parameter is accessed, the MRS code (Memory Range Select) must be selected correctly.
- After the MRS code has been selected, the corresponding address must be communicated to the encoder for the desired parameter to be accessed.
- For safety reasons, in controlled operation the MRS code should point to a write-protected area.

Memory Organization

Parameter 2.1 / 2.2
OEM Memory
Operating status
Operating parameters

MRS code
+
Word address

EEPROM used as memory
↳ Access time of max. 12 mx (waiting!)
↳ Access in closed control loop is possible only through synchronization! (busy bit!)

EEPROM memory | **Addressing** | **Behaviour in control loop**

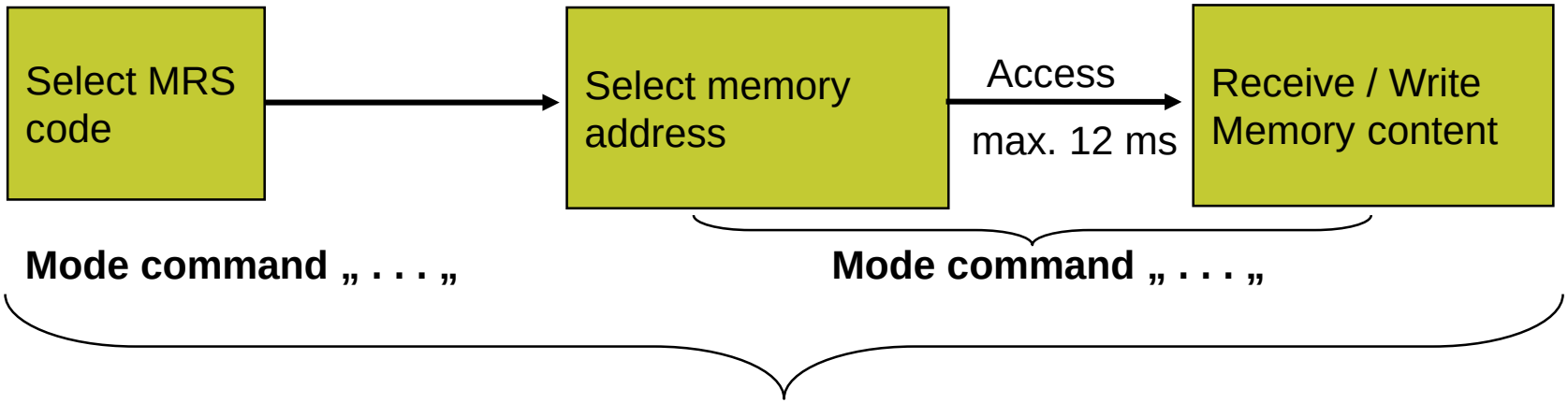
Additional datum 1
Additional datum 2

MRS code

Access via ASIC register
↳ **Access time in ns range**
↳ **Working in closed control loop possible!**

ASIC register | **Addressing** | **Behaviour in control loop**

Memory Access with EnDat 2.1



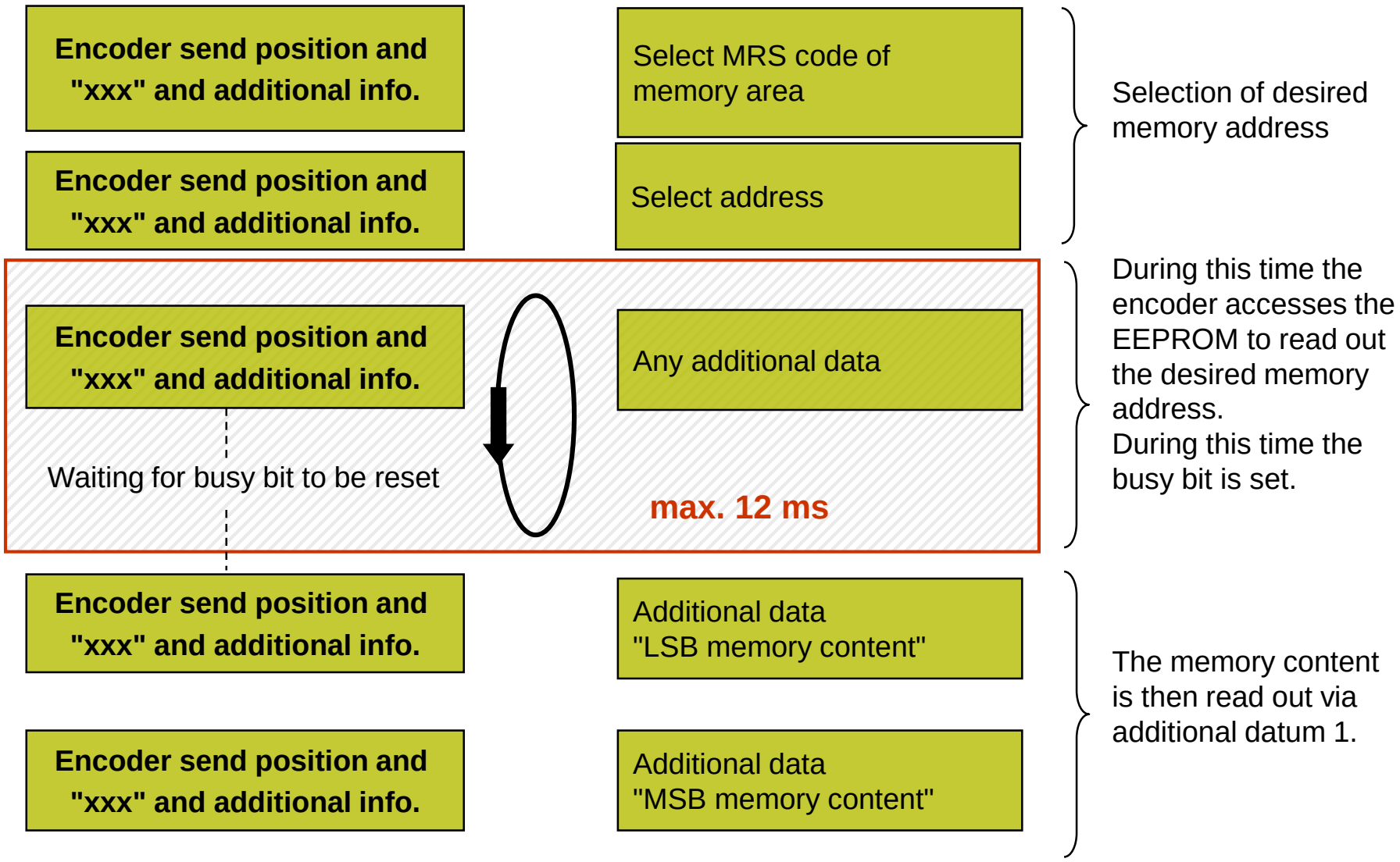
001110	MRS code	xxxxxxxxxxxxxxx
100011	Adress	xxxxxxxxxxxxxxx
011100	Adress	yyyyyyyyyyyyyyy

x = random y = parameter

MRS code	xxxxxxxxxxxxxxx	Memory area selection
Adress	Parameter	Read parameter
Adress	yyyyyyyyyyyyyyy	Write parameter

Acknowledgment

Memory Access with EnDat 2.2 (in principle)



EnDat 2.2 Seminar – Basics

- Demands on a modern encoder interface
- General information and documentation
- Interface physics and timing
- Power-on behavior
- Position value formation
- Mode commands
- Additional datum
- **Memory areas: Operating parameters**
- Error handling

Operating Parameters: Datum Shift

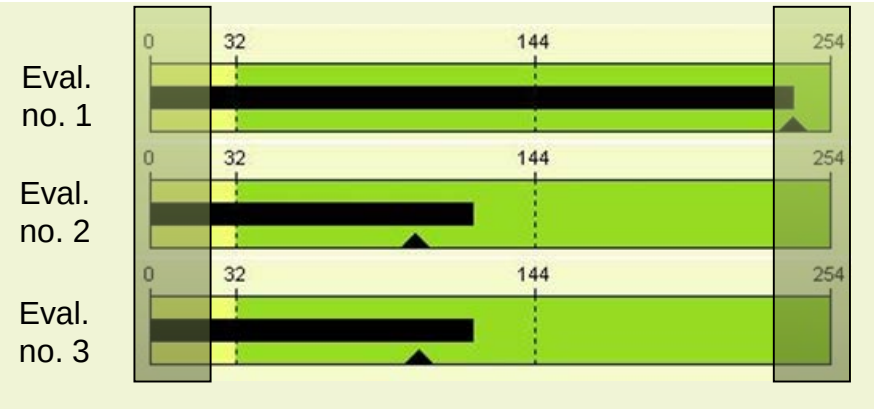
- In the factory default setting, the datum shift set by the encoder manufacturer is stored in the words for the datum shift and, for safety, also in words 22 and 23 of the encoder manufacturer's parameters.
  This makes it possible to check if the OEM has carried out a datum shift and to reset the encoder to the factory default settings.
- The value of the datum shift only becomes active after a reset is sent.
- See the specification for examples
- Further comments and the flow chart for shifting the datum to the current position are contained in the supplement to this document.
- Datum shift only affects position 1, not position 2 (valid for EIB and with encoders that support safety-related functionality).

- **The value must be stored as a two's complement.**
- **EnDat (with incremental signals): Calculation should be compatible with EnDat (datum shift only by complete signal periods). This is important for being able to associate the absolute and incremental information.**
- **EnDat (purely serial): The shift can be by any amount, since the position value is determined in the encoder (important with EQI and ECI, for example)**
- **Datum shift by OEM must be considered.**

Operating Parameters: Diagnosis

- The desired valuation numbers must be activated.
- The value (8 bits) is transmitted in additional datum 1.
- Values are output in a rolling request process; address + value.
- Information on which valuation numbers are supported is saved in EnDat 2.2 parameters.
- The diagnosis telegram can be transmitted during closed-loop operation.
- The performance and function reserves of an encoder can be determined through the valuation numbers.
- The scaling of the valuation numbers is the same for all encoders.
- The margin areas should be filtered out in the display (reserves).
- “System-specific data” → mounting interface (see the EnDat Application Note).

Example:



For details, see the EnDat Application Note

Operating Parameters: Diagnosis

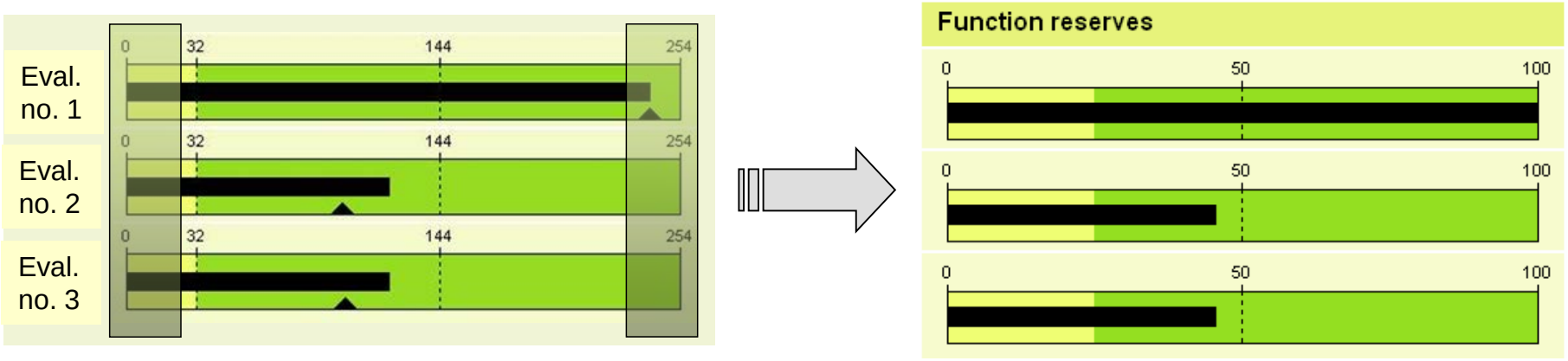
Example: ATS software from HEIDENHAIN

Display of the function reserve:

- Valuation number: 0 ... 29 ➔ Function reserve „0“ (Alarms can occur)
- Valuation number: 30 ... 230 ➔ Function reserve „0“ ... „100“ (Display of the function reserve)
- Valuation number: 231 ... 254 ➔ Function reserve „100“

Meaning of the function reserve:

- 0 … 25 (valuation number: 30 ... 80):
  The encoder is operating at its limits („yellow“) → Service is recommended
- 26 … 100 (valuation number: 81 ... 230 or 254):
  The encoder is operating in the specified range („green“)



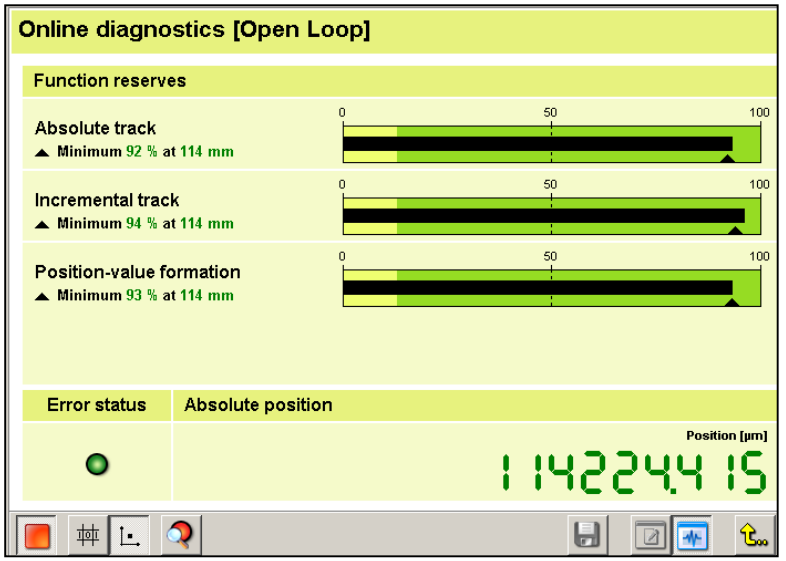
Industrial IoT: Data & Diagnostics

Commissioning data and process information

- Commissioning data for the control, the drive, and the sensors are stored by HEIDENHAIN in the encoder or can be stored by the OEM (electronic ID label).
- Mounting information is available from encoders that require mounting. For inductive rotary encoders, this includes, for example, the distance from the rotor and the stator.
- Process information can be saved in the encoder through the inverter during normal running operation (e.g., information such as speed ranges, motor currents, etc.)
  These data, in combination with diagnostics and mounting information, enable comprehensive system monitoring.

Diagnostics

- Error messages for the recognition of encoder-specific malfunctions
- Warning messages for minimizing maintenance times
- Valuation numbers for evaluating the functional reserve of the encoder (access to the valuation numbers during normal running operation)



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

The functions for bus operation are currently not yet supported!

Operating Parameters: Temperature Warning Threshold

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 ≙ 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 ≙ $EF7_{hex}$

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.

An incorrect value could destroy the encoder.

Operating Parameters: Cycle Time or I/O

Important points:

- Future encoder functions require the indication of the cycle time.
- Words 9 to 15 are needed for future development, and may not be written to.
- I/O functionality in operating status 2 moved.

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.

EnDat 2.2 Seminar – Basics

- Demands on a modern encoder interface
- General information and documentation
- Interface physics and timing
- Power-on behavior
- Position value formation
- Mode commands
- Additional datum
- **Memory areas: Operating status**
- Error handling

Operating Status: Error Messages

- Error messages show that the position value is no longer reliable.
- EnDat 2.2 supports two error messages that are transmitted inverted to each other.
- It is possible to reset the error word. It is not possible to reset individual error bits (see the specification).
- Not every encoder supports all errors. The errors that are supported can be read out from the encoder (masking out).
  This also makes it possible to check whether the encoder is suitable for the application.
- Procedure after power-on: see Power-on Behavior.

Bit		= 0	= 1
2^0	Light source	OK	Failure ①
2^1	Signal amplitude	OK	Erroneous ①
2^2	Position value	OK	Erroneous ①
2^3	Over voltage	No	Yes ①
2^4	Under voltage	No	Under voltage supply ①
2^5	Over current	No	Yes ①
2^6	Battery	OK	Change the battery ②
•	Currently not assigned Expansion planned		
•			
•			
2^{15}			

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

⚠ Wird eine unterstützte Fehlermeldung zwangsdynamisiert, dann wird bis die Zwangsdynamisierung zurückgesetzt wird das zugehörige Fehlerbit gesetzt.

- **In the future, additional error messages may be used by HEIDENHAIN!**
- **Error messages that are not supported must be masked out!**

Operating Status: Extended Error Register

Increase in existing error messages:

- Additional features for detailed alarm interrogation were implemented to increase the alarm handling possibilities (also during controlled operation).
- The extended error register (operating status error sources) can be accessed via additional datum 2. Information about the meaning of the individual bits of the error register is contained in the specifications of the encoder.
- The operating status error sources that are supported can be read out from the encoder.

Clock ⏲	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
	Status			Information			A7/D7	...	A0/D0
							D7	...	D0
Operating status error sources	M Battery	M Overflow/Underflow	M ALL Power down	M System	M Pos2	M Pos1	S ALL Power down	S System	S Pos2	Temperature exceeded	Over current	Under voltage	Over voltage	S Pos1	Signal amplitude	Light Source

⚠ Operating Status Error Sources can not be individually force sampled. Through forced dynamic sampling of the error messages, more than one operating status error sources can indicate an error state.

Operating Status: Warnings

- Warnings indicate that the function reserves of the encoder have been reached.
- The group bit "warning (WRN)" is transmitted in the additional datum.
- Warnings can be reset; individual warning bits cannot be reset (see specification).
- Not every encoder supports all warnings. The warnings that are supported can be read out from the encoder (masking out).
  This also makes it possible to check whether the encoder is suitable for the application.
- Procedure after power-on: see Power-on Behavior.

Bits		= 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 points	Reached	Not reached ③
2^5	Cyclic mode	Cyclic	Acyclic
2^6	Limit position (see 3.9.30)	Not reached	Reached
2^7	Readiness	Yes	None
2^8	Diagnostics	OK	Below threshold value
•	Currently not allocated Extension planned		
•			
•			
2^{15}			

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

- **In the future, additional warnings may be used by HEIDENHAIN!**
- **Warnings that are not supported must be masked out!**

Operating Status: Write Protection

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 to n ①	No protection	Protection activated
•	Currently not allocated Extension planned		
•			
•			
2^{15}			

① n ≙ Number of blocks

Once write-protection has been activated, it cannot be rescinded.

Operating Status: Function Initialization

- Not every encoder supports all of the functions. The functions that are supported can be read out from the encoder.
- A reset command must be sent to the encoder for the selected function to be activated.
- The reduced Recovery Time (for explanation, see "Timing" section) may only be used if the clock pulse is greater than 1 MHz. The reduced Recovery Time is only valid for EnDat 2.2 commands. EnDat 2.1 commands < 1 MHz can be cancelled after power-on until the first call of an EnDat 2.2 command. For switching over to EnDat 2.1 mode commands < 1 MHz, an EnDat 2.1 mode command > 1 MHz has to be sent once.
- For further details see the Application Note

Bit	Information	= 0	= 1
2^0	Recovery time I t_m ①	10 µs ≤ t_m ≤ 30 µs	1.25 µs ≤ t_m ≤ 3.75 µs
2^1	Recovery time I t_m ①	1.25 µs ≤ t_m ≤ 3.75 µs	10 µs ≤ t_m ≤ 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 ≤ t_m ≤ 30 µs
Recovery time I can only be changed to 1.25 µs ≤ t_m ≤ 3.75 µs for type 2.2 mode commands. With clock pulse frequencies of ≤ 1 MHz the recovery time I must be set to 10 µs ≤ t_m ≤ 30 µs.

The subsequent electronics must initiate the activation / deactivation of the individual functions.

Operating Status: Handling of Temperature Sensors

Future encoder generations provide a switchover function for the evaluation of the temperature sensor,

e. g. KTY 84, PT 1000, …

In addition, the type of temperature sensor actually connected can also be stated.

This makes it possible to either calculate the temperature value directly in the encoder or by the external control on the basis of defined conversion polynomials.

Word 9:

- The evaluation of the external temperature sensors can be activated in word 9.

Words 10 and 11:

- In word 10 and word 11 you can define the type of temperature sensor connected to the external sensor inputs. The parameter shows which type of temperature sensor is actually connected and provides information to the user and the application software in the control, for example. The parameter is for information only and therefore does not influence the encoder-internal processing of the sensor data.

For further information see EnDat Application Notes

Operating Status 2: General

Important points:

- New MRS code!
- The functions are required for future encoder functions.

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.

⚠ For EnDat 2.1, value changes in the "operating parameter 2" range become effective at the latest when the acknowledgement is received in the subsequent electronics and for EnDat 2.2, when the BUSY bit in the additional data is reset (BUSY = 0).

⚠ 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 parameter 2	r/w	10111011

3.10.1 Overview of operating parameter 2

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

Operating Status 2: Resetting the RM bit

Important points:

- With incremental encoders this function enables a new reference run.
- The function is normally not supported.

3.10.5 Referencing of incremental encoders

By writing to **word 11** of operating parameter 2, the RM bit in incremental encoders can be reset.

11

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 the RM bit on incremental encoders via EnDat command	Deactivated	Activated①
2^1		Activated①	Deactivated
2^2 • • • 2^{15}	Currently not assigned Extension planned		

① When the RM bit is reset, the warning "Reference point not reached" is also set (see Warnings). The position value and position value 2 are not influenced by this.

EnDat 2.2 Seminar – Basics

- Demands on a modern encoder interface
- General information and documentation
- Interface physics and timing
- Power-on behavior
- Position value formation
- Mode commands
- Additional datum
- **Memory areas: OEM memory area**
- Error handling

OEM Memory Area

Important points:

- Saving the so-called "electronic ID label."
- The memory is divided into 4 areas (OEM 1..4 or compensation values 1..4).
- The EnDat 2.1 parameters indicate whether an OEM area is supported and which addresses can be addressed within an available area.

- **The areas and addresses that are supported must be read out from the encoder before accessing the OEM memory.**
- **The OEM memory areas supported vary depending on the encoder family.**
- **The subsequent electronics should therefore use addresses that are relative with respect to the values determined, and not absolute addresses.**

OEM Memory Area

Example of EQN 1337, ID 678921-03:

- Entry in word 9: 5053 h
- Entry in word 10: FF50 h

Word 9: 5053 h corresponds to: 0101 0000 0101 0011

OEM 2: 0 .. 255 OEM 1: 64 .. 255

Word 10: FF50 h corresponds to: 1111 1111 0101 0000

OEM 4: not available OEM 3: 0 .. 255

Starting and ending addresses	Bit combination
0	0000
31	0001
63	0010
64	0011
127	0100
255	0101
Not available	1111

OEM Memory Area: Section 2

Important points:

- The section 2 memory area is organized blockwise; one block contains 256 EnDat words (16 bits).
- A separate MRS code is assigned to the section 2 memory area.
- The block address is transmitted together with the MRS code.
- A maximum of 256 blocks can be addressed.
- A write protection can be set for the blocks.
- The number of available blocks is stored in the EnDat 2.2 parameters.

The section 2 memory area is currently not yet supported.

EnDat 2.2 Seminar – Basics

- Demands on a modern encoder interface
- General information and documentation
- Interface physics and timing
- Power-on behavior
- Position value formation
- Mode commands
- Additional datum
- **Memory areas: EnDat 2.1 parameters**
- Error handling

Overview

Important points:

- The meanings of some of the parameters vary depending on the encoder model.
- The parameters can be read out with EnDat 2.1 and EnDat 2.2 commands.
- The MRS code can be selected with EnDat 2.1 and EnDat 2.2 commands.
- The parameter range is divided into three MRS code ranges.
- After the MRS code has been set, a parameter is accessed via the address.

3.5.1 Overview of Parameters of the Encoder Manufacturer

Word	Content	Unit for: Linear encoders	Unit for: Rotary / angle encoders	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 (transfer format)	—										0D
14	Encoder model	—										0E
15	Signal period length or signal periods per revolution	nm	—									0F
16	for incremental output signals											00
17	Distinguishable revolutions (only for multiturn encoders)	—	—									01
18	Nominal increment of reference marks	mm	Signal periods									02
19	Position of the first reference mark	mm										03
20	Measuring step length or measuring steps per revolution with	nm										04
21	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												08
25	ID number	—	—									09
26												0A
27												0B
28	Serial number	—	—									0C
29												0D
30	Direction of rotation or traverse	—	—									0E
31	Status of configuration diagnostics	—	—									0F
32	Maximum mechanically permissible linear velocity or shaft speed	m/min	rpm									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 (only for linear encoders) ②	—	—									06
39	Maximum processing time position value	—	—									07
40	EnDat ordering designation	—	—									08
41												09
42												0A
43	Manufacturer-specific data											0B
44												0C
45												0D
46												0E
47	CHECKSUM											0F

① The higher-valued byte contains the division factor relative to the maximum permissible linear velocity or shaft speed up to which this accuracy is valid.

② Is not supported by all linear encoders. Word 0 is the default value.

Commissioning Diagnosis

Important points:

- Word 31 indicates whether the encoder supports the commissioning diagnosis.
- The commissioning diagnosis is usually not supported by EnDat 2.2 encoders. EnDat 2.1 stopped supporting it around 1999.
- The commissioning diagnosis has been moved to the EnDat Application Note.

3.5.2 Configuration Diagnostics for Encoders with Gray-Code Scanning

For machines subject to certain safety requirements, it is possible to check the encoder components responsible for position detection at standstill (such as light source, photovoltaic cells, and triggers). This, together with the "Error in position value" message (→ see section 3.4.1), makes it possible to check the accuracy of the position values very thoroughly. Word 31 in the memory area for the encoder manufacturer indicates whether an encoder supports configuration diagnostics.

Encoder-specific data (40 bits) required for configuration diagnostics is stored in **words 4 to 6.** Using this data, parameters are assigned to an algorithm with which the encoder can be checked.

Version

Important points:

- The value "2" is stored for EnDat 2.1 and EnDat 2.2 encoders.

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	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}

* Always set to logical High for EEPROM checking

Digits after the decimal point in the version of the documentation are not stored in this word, because they are always backward compatible and have no influence upon older hardware and software in the subsequent electronics. For version 1.2, for example, word 8 stores only the value 1.

OEM Memory Allocation

Important points:

- See slide: "Memory Areas: OEM Memory Area"
- The memory areas vary depending on the encoder model.
- Addressing must be implemented relative to the start addresses.

	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	

Starting and ending addresses	Bit combination
0	0000
31	0001
63	0010
64	0011
127	0100
255	0101
Not available	1111

Compensation Values

Important points:

- The compensation value range can be accessed only by the encoder manufacturer.

	Compensation values of 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 of 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	

Starting and ending addresses	Bit combination
0	0000
31	0001
63	0010
64	0011
127	0100
255	0101
Not available	1111

Manipulation of the compensation value ranges causes malfunctions in the encoder.

Transmission Format

Important points:

- This parameter must be read out before the first position-value request for the subsequent electronics to be able to correctly determine the number of clock pulses to be sent.
- The parameter must be read out with EnDat 2.1 commands.

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 $\hat{=}$ 25 clock pulse periods
25 bit $\hat{=}$ 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.

Encoder Type

- Has to be read out because the parameters have to be interpreted differently depending on the encoder type
  (e.g. "Signal period or signal periods per revolution").
- EIB: Conversion 1 Vpp → EnDat 2.2 (with integrated 14-bit interpolation)
- EIB: Definition of measuring step must be considered.

	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

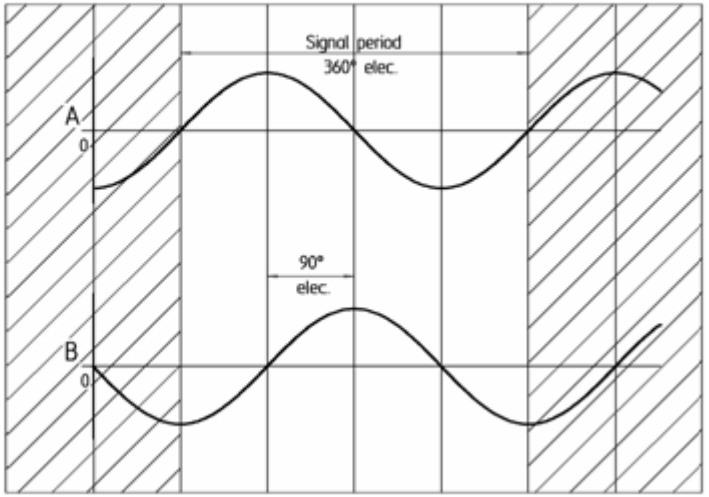
Future extension possible.

Signal Period

Important points:

- Since the bit length of the position value is adapted to the EnDat requirements, this parameter can also be used for analyzing the composition of the position value.
- Determination of the “significance” of the LSB for the interpolation value.
- The value "0" is stored for EnDat 2.1 and EnDat 2.2 encoders with pure serial transmission (order designation EnDat 21 or EnDat22); The EIB is an exception.

Words 15 and **16** supply the **signal period of the incremental output signals.**



Rotary or angle encoders
The information is given in **signal periods per revolution** (P/rev).

Linear encoders
The information is given in **nm** (0.001 µm).

Distinguishable Revolutions

Important points:

- The value "0" is stored for singleturn rotary encoders.
- The number might not be sufficient for battery-buffered multiturn rotary encoders. Word 34 in the EnDat 2.2 range must then be considered. In this case, "111..111" is stored in word 17.

3.5.9 Number of Distinguishable Revolutions

For **multiturn encoders,** the number of distinguishable revolutions is indicated in **word 17.**
A maximum of 65 535 revolutions 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
$2048 \triangleq 0800_{hex}$

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: In a singleturn encoder, word 17 contains 0000_{hex}.

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.

Distance of Reference Marks

Important points:

- Word 14 "encoder model" indicates whether the reference marks are distance-coded or equidistant.
- Rotary encoders: The information is given in signal periods (P).
- Linear encoders: The information is given in mm.

3.5.10 Increment of Reference Marks

In encoders with distance-coded reference marks, **word 18** indicates the **nominal increment of associated reference marks.** In absolute encoders without reference marks, 0000_{hex} is saved in this word.
In linear encoders without distance-coded reference marks, word 18 indicates the distance between two adjacent reference marks.
The information is given 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

Position of the First Reference Mark

Important points:

- Selectable reference marks are supported, for example, by LS 48x encoders.
- Is usually not supported by EnDat encoders.

3.5.11 Position of the First Reference Mark

For **linear encoders without distance-coded reference marks, word 19** indicates the **position of the first reference mark** with respect to the end position. The information is given in **mm.** Zero is saved in word 19 for encoders with selectable reference marks. See the encoder specifications for more detailed information.

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

$20 \triangleq 14_{hex}$

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}

Measuring Step

- Rotary encoders: The information is given in measuring steps per revolution.
- Linear encoders: The information is given in nm.
- The information is used for evaluating the LSB of the transferred position value.
- With the EIB, for example, the permanently set 14-bit interpolation together with the usual signal periods result in a measuring step value that cannot be indicated in nm. New parameters were therefore implemented in the EnDat 2.2 range.

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.

Datum Shift by Encoder Manufacturer

Important points:

- The information is given in measuring steps or measuring steps per revolution.
- Also see slide: "Operating Parameters: Datum Shift"

3.5.13 Datum Shift of the Encoder Manufacturer

Words 22 and **23** indicate 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.

Words 22 and 23 are located in a write-protected memory area and can only be changed by the encoder manufacturer.

The value is shown as a two's complement, where bit 2^{31} in word 23 indicates the direction. For a datum shift in linear encoders to be in compliance with EnDat (assignment of the zero position to a signal period), the value of the datum shift must be a multiple of the measuring steps per signal period. For absolute rotary or angle 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.

The value does not become valid until the mode command "Encoder to receive reset" is transmitted.

Part Number and Serial Number

Important points:

- This information is stored in the encoder for information and inspection purposes.

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 each stored in binary code in ASCII format (→ also see Appendix A6).

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.

Direction of Rotation

Important points:

- The direction of rotation cannot be influenced actively.
- The positive direction of rotation can be taken from the respective dimension drawing in the documentation

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.

Commissioning Diagnosis

Important points:

- Also see slide: "Word 4..7 Commissioning Diagnosis"
- The commissioning diagnosis is usually not supported by EnDat 2.2 encoders.

3.5.17 External Configuration Diagnostics

Word 31 indicates whether the encoder supports external commissioning diagnosis.

31

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}

* Always set to logical High for EEPROM checking

Bit		= 0	= 1
2^0	External configuration diagnostics	Is supported	Is **not** supported
2^1 • • •	Currently not assigned Expansion planned		
2^{15}		EEPROM error	—

Max. Perm. Linear Velocity or Shaft Speed

Important points:

- This information is also associated with words 33 and 34.

3.5.18 Maximum Permissible Mechanical Velocity or Shaft Speed

Word 32 contains the maximum permissible mechanical velocity v_{max} or shaft speed n_{max}.

	1/0	1/0	1/0	1/0	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 **rpm**

Linear encoders

Example: Maximum permissible mechanical velocity v_{max} 120 m/min
120 $\hat{=}$ 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}

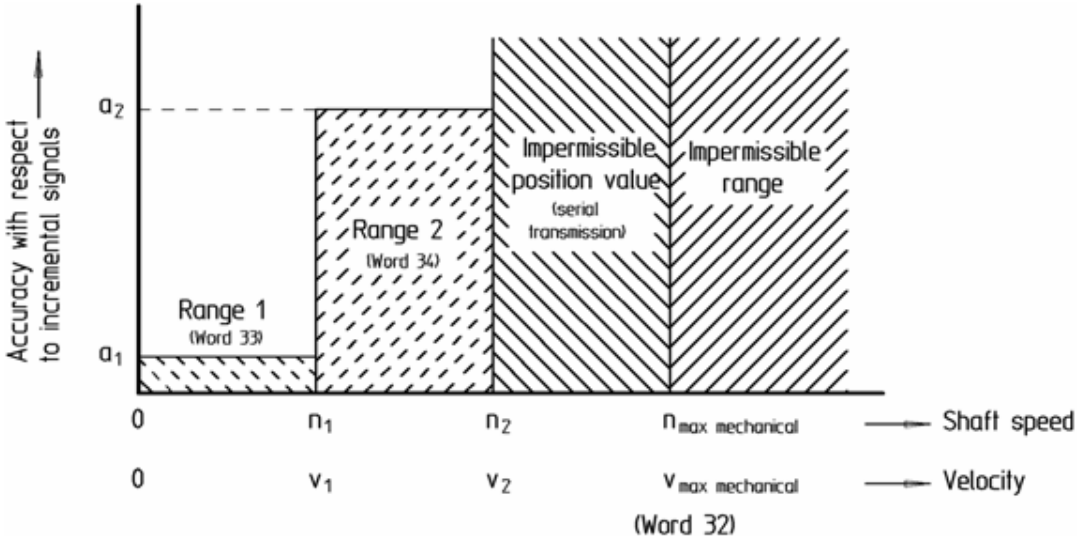
Rotary or angle encoders

Example: Maximum permissible mechanical speed n_{max} 15 000 rpm
15 000 $\hat{=}$ $3A98_{hex}$

	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}

Accuracy Range 1 or 2

- Internal propagation times, etc. may result in a difference between absolute and incremental value → Definition of accuracy ranges
- Range 1: In this velocity range, association of absolute and incremental values is usually implemented with power-on.
- Range 2: Must be considered when the absolute value is compared to the incremental value during operation.
- EnDat 2.2 encoders generate until max. shaft speed / velocity of a valid absolute value (due to internal interpolation, is stored with most EnDat 2.2 encoders in the words “11...11”; In this case the EnDat 2.2 parameters must be considered).



$= \frac{v_{max}}{c_i}$ bzw. $n_i = \frac{n_{max}}{c_i}$ $i = 1,2$

Supported Error Message 1

Important Points:

- Varies depending on the encoder.
- Bits that are not supported should be masked out for safety, when the error message is read out.
- Enables cross-testing of application ↔ encoder

Bit		= 0	= 1
2^0	Light source	Is not supported	Is supported
2^1	Signal amplitude	Is not supported	Is supported
2^2	Position error	Is not supported	Is supported
2^3	Overvoltage	Is not supported	Is supported
2^4	Undervoltage	Is not supported	Is supported
2^5	Overcurrent	Is not supported	Is supported
2^6	Battery failure	Is not supported	Is supported
• • • 2^{15}	Currently not assigned Expansion planned		

In the future, additional error messages may be used by HEIDENHAIN!

Supported Warnings

Important Points:

- Varies depending on the encoder.
- Bits that are not supported should be masked out for safety, when the warning is read out.

Bits		= 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 points	Reached	Not reached ③
2^5	Cyclic mode	Cyclic	Acyclic
2^6	Limit position (see 3.9.30)	Not reached	Reached
2^7	Readiness	Yes	None
2^8	Diagnostics	OK	Below threshold value
•	Currently not allocated Extension planned		
•			
•			
2^{15}			

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

In the future, additional warnings might be used by HEIDENHAIN!

EnDat Command Set

Important Points:

- Currently “command set type 2.2” and “safety-related applications” are supported.
- Whether an encoder supports EnDat 2.2 or not must be requested via this parameter. This however does not automatically mean that 8 MHz clock frequency is also possible.
- The maximum clock frequency supported by the encoder can be interrogated via: “Parameter encoder manufacturer for EnDat 2.2, word 25”

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

① Only for encoders in which word 37 bit 2^0 = 1 and at the same time word 37 bit 2^1 = 0 are the functions of versions ≥ 2.2 supported.

Measuring Length

Important Points:

- Default value "0" is stored in most of the encoders, since the position range must already be considered for the mechanical design of the system.

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.

38

Measuring length unit			Measuring length														
1/0	1/0	1/0	1/0	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

Max. Calculation Time

Important Points:

- Can be used for the monitoring functions, e.g. for safety applications

3.5.24 Maximum calculation time

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

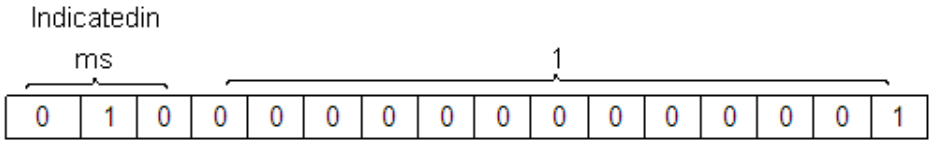
The calculation time t_{CAL} ① must pass before the encoder can send the position value.

39

Unit of time			Calculation time													
1/0	1/0	1/0	1/0	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}	Calculation time
0	0	0	Display of calculation time is not supported
0	0	1	In microseconds
0	1	0	In milliseconds
0	1	1	In nanoseconds
1	0	0	tbd

Example: Linear encoder with calculation time of 1 ms



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

Order Designation

Important Points:

- The ordering designation in also on the ID label. However, only the last two numerals are shown in the parameter
- If the value 0000hex is saved, the parameter is not yet supported by the encoder.

	Binary coded ASCII								Binary coded ASCII							
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
	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 following information can be derived from the order designation:

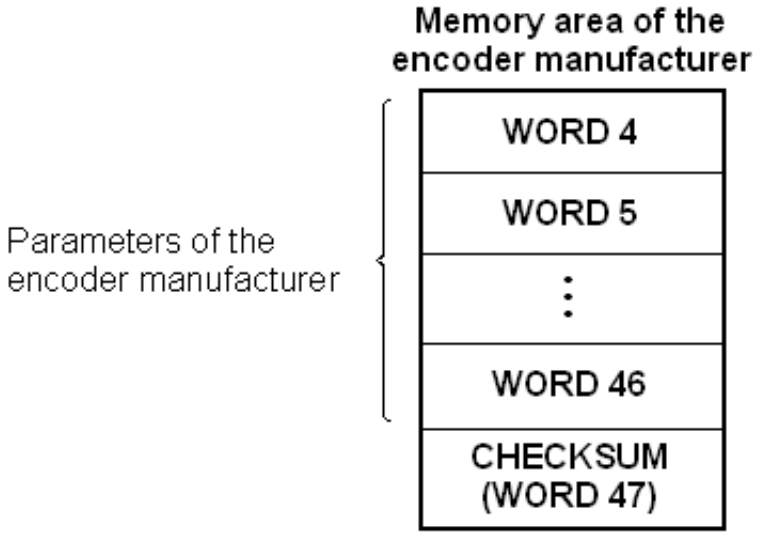
Ordering designation	Interface type
EnDat01	With incremental signal output
EnDat21	Without incremental signal output
EnDat02	With incremental signal output
EnDat22	Without incremental signal output

Checksum

Important Points:

- The overflow is disregarded

The checksum is stored in **word 47** of the encoder manufacturer 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 wordwise, whereby the overflow is disregarded:

CHECKSUM = WORD (4) + WORD (5) + ... + WORD (46)

EnDat 2.2 Seminar – Basics

- Demands on a modern encoder interface
- General information and documentation
- Interface physics and timing
- Power-on behavior
- Position value formation
- Mode commands
- Additional datum
- **Memory areas: EnDat 2.2 parameters**
- Error handling

Overview

Important Points:

- The meanings of some of the parameters vary depending on the encoder model.
- The MRS code can be selected only with EnDat 2.2 commands.
- Reading out the parameters can be executed with EnDat 2.1 or EnDat 2.2 mode commands.
- The parameter range requires only one MRS code.
- After the MRS code has been set, a parameter is accessed via the address.

Word	Contents	Unit: Linear encoder	Unit: Rotary encoder/ Angle encoder	MRS code C7	C6	C5	C4	C3	C2	C1	C0	Address HEX
0	Status of additional datum 1	—	—	1	0	1	1	1	1	0	1	00
1	Status of additional datum 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	Forced sampling status	—	—									07
8	Forced 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 for 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	min^{-1}									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 position											27
40												28
41	Non-safety-relevant subdivision of the absolute position											29
42												2A
43	Generation of a warning message through limit position signals											2B
44	Support of touch probe statuses											2C
45	Timestamp unit of measure											2D
46	Referencing of incremental encoders											2E
47	Support of I/Os											2F

Supported Additional Datum

Important Points:

- Must be read out, since not every encoder supports all of the functions

Bits		= 0	= 1
2^0	Position value 2	is not supported	is supported
2^1	Test values	are not supported	are supported
2^2	Temperature sensor 1 (external)	is not supported	is supported
2^3	Temperature sensor 2 (on board)	is not supported	is supported
2^4	Additional sensors	are not supported	are supported
•	Currently not allocated Extension planned		
•			
•			
2^{15}			

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

In the future, further additional data bits can be used by HEIDENHAIN!

Additional Functions

Important Points:

- Reference pulse initialization
  Position of reference mark is automatically detected and compensated.
  Supported only by EIB (connection of incremental encoders).
- Adjustable recovery time: See "Operating Status: Function Initialization"
- Multiturn switch-off is used with buffer battery backup devices.
- All other functions are currently not yet supported!

Bits		= 0	= 1
2^0	Reference pulse initialization	is not supported	is supported
2^1	Settable recovery time t_m	is not supported	is supported
2^2	Oversampling	is not supported	is supported
2^3	Time-triggered operation	is not supported	is supported
2^4	Multiturn overflow error message can be disabled	is not supported	is supported
2^5	Multiturn overflow latch can be disabled	is not supported	is supported
2^6	Multiturn error message can be disabled ①	is not supported	is supported
2^7	Multiturn counter reset	is not supported	is supported
2^8	EnDat2.2 cyclic operation	is not supported	is supported
•	Currently not allocated Extension planned		
•			
•			
2^{15}			

① With the exception of multiturn overflow error message bit 2^4

In the future, further additional function bits can be used by HEIDENHAIN!

- **May be used in future for other scaling**

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.

Different scaling for temperature sensor 1 and 2 as well as for additional sensors.

Diagnosis-Status

Important Points:

- Also see „Operating Parameters“

3.9.7 Diagnostic status

The diagnostics values supported depend on the encoder.
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}	

Bits		= 0	= 1
2^0	Valuation number 1	is not supported	is supported
2^1	Valuation number 2	is not supported	is supported
2^2	Valuation number 3	is not supported	is supported
2^3	Valuation number 4	is not supported	is supported
2^4	Valuation number 5	is not supported	is supported
2^5	Valuation number 6	is not supported	is supported
•	Currently not allocated Extension planned		
•			
2^{15}	System-specific data	are not supported	are supported

In the future, further valuation numbers may be used by HEIDENHAIN.

Supported Error Messages 2

Important Points:

- Error bit 2 is only output with EnDat 2.2 mode commands.
- Cross-testing: Application ⇔ encoder

3.9.8 Support of Error Messages 2

Depending on the encoder, different error bits are supported in word 0 of the operating status memory. **Word 6** indicates whether a particular encoder function is monitored and whether a malfunction will activate the corresponding error bit in word 0.

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	Light source	Is not supported	Is supported
2^1	Signal amplitude	Is not supported	Is supported
2^2	Position error	Is not supported	Is supported
2^3	Overvoltage	Is not supported	Is supported
2^4	Undervoltage	Is not supported	Is supported
2^5	Overcurrent	Is not supported	Is supported
2^6	Battery failure	Is not supported	Is supported
• • • 2^{15}	Currently not assigned Expansion planned		

In the future, additional error messages may be used by HEIDENHAIN

Dynamization Status

Important Points:

- Serves to check the alarm generation of the encoder.
- The mode commands “Receive test command” and “Encoder to send position values and receive test command” can be used for forced sampling. However, the ports set are uncoupled from each other!
- The error message (< 1 ms) transmitted in one of the following cycles must be processed and interpreted by the subsequent electronics.

3.9.9 Forced 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 to send parameters 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	×	×	×	×	×	×	×	×	×	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	×	×	×	×	×	×	×	×	×	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}	

Measuring Steps for Position 2

Important Points:

- Position value 2 is used for transmitting the absolute position value of incremental encoders (after the reference mark has been traversed) and for outputting the redundant position value of encoders supporting the safety concept.
- Also see word 0: Supported additional datum 1

3.9.10 Measuring Step or Measuring Steps per Revolution of Position Value 2

Words 9 and **10** contain the resolution of the position value, depending on the scaling factor from word 27 of "Parameters of the encoder manufacturer for 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)

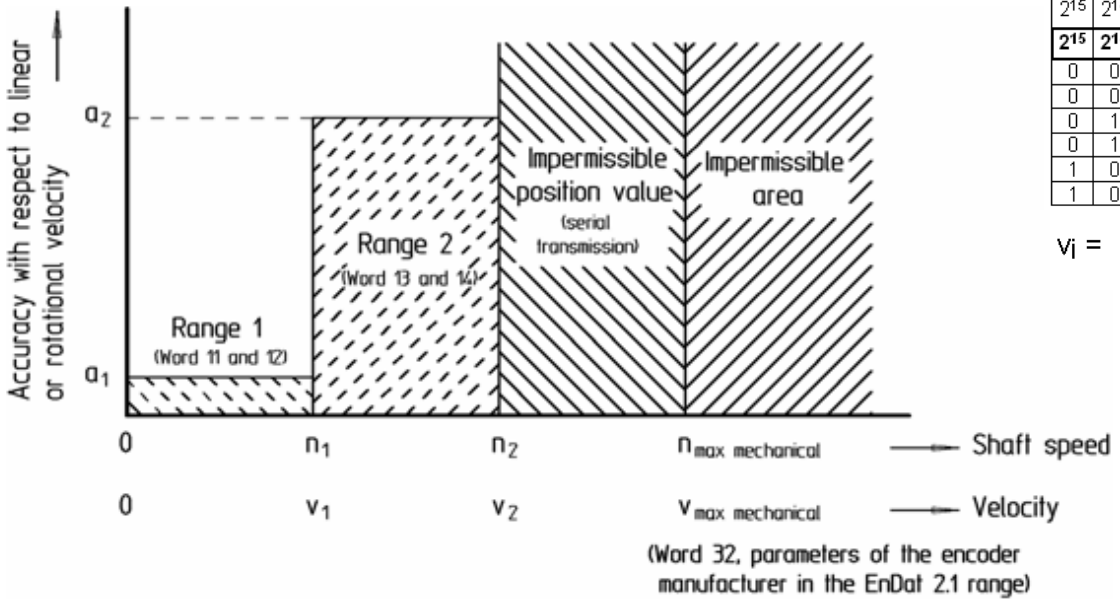
1) Depending on the scaling factor

Word 27 „Scaling factor“

2^{10}	2^{9}	2^{8}	Scaling factor for words 9 and 10 or 31 to 33
0	0	0	Entry in nm or measuring steps per revolution
0	0	1	Subdivision values of one grating period
0	1	0	Entry in measuring steps per revolution in powers of 2
0	1	1	Entry of the measuring steps in pm

Accuracy between position 1 and position 2: Range 1 or 2

- Indicates the accuracy of the incremental signals between position 1 and position 2.
- Separate accuracy information for position 1 and 2 is not necessary. The higher of each of the two values is indicated. In principle, the values of position 1 and position 2 are very similar.2
- Internal propagation times, etc. may result in a difference between position value 1 and position value 2.
- One word is provided for each the dividing factor and the accuracy; scaling factors must be considered.



(Word 32, parameters of the encoder manufacturer in the EnDat 2.1 range)

Conversion factor for maximum mechanically permissible linear or rotational velocity 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
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}	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

$v_i = \frac{v_{max}}{c_i}$ bzw. $n_i = \frac{n_{max}}{c_i}$ $i = 1,2$

Distinguishable Revolutions for Position 2

Important Points:

- Unlike with the EnDat 2.1 parameter, the scaling factor in word 34 must always be considered for this parameter.

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 manufacture for EnDat 2.2".

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

Direction of Rotation for Position 2

Important Points:

- The direction of rotation cannot be influenced actively.

3.9.13 Direction of Rotation or Traverse for Position Value 2

In rotary and angle encoders, **word 16** defines whether increasing or decreasing position values are output over the serial interface when the encoder shaft rotates clockwise (viewed from the flange side). In linear encoders, word 16 defines whether traverse toward the right (viewed from ID-label side) outputs increasing or decreasing position values over the serial interface.

16

1*	×	×	×	×	×	×	×	×	×	×	×	×	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 EEPROM checking

Bit		= 0	= 1
2^0	Measuring direction ①	Increasing position values	Decreasing position values
•	Currently not assigned Expansion planned		
•			
•			
2^{15}		EEPROM error	—

① Does not affect the complementary output of incremental signals.

Encoder Designation / Instructions

3.9.14 Encoder Identification

Words 17, 18, 19 and **20** are intended for identification of the encoder. The identification is saved binary-coded in ASCII format (→ also see Appendix A6).

3.9.15 Support of Instructions

Depending on the encoder, not all instructions are supported. Specify in **word 21** 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	Is not supported	Is supported
2^1	Data driver at high-impedance	Is not supported	Is supported
2^2	No updating of position values	Is not supported	Is supported
• • •	Currently not assigned Expansion planned		
2^{15}			

Bus operation, currently not supported

In the future, additional instruction bits may be used by HEIDENHAIN !

Encoder Temperature / Max. Acceleration / Section 2 Words

- Also see memory areas for "OEM Section 2."
- Not supported by all encoders; default value "0"

3.9.16 Maximum Permissible Encoder Temperature

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

Must be considered for setting the warning threshold (see operating parameters).

3.9.17 Maximum Permissible Mechanical Acceleration

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

- **If the value is exceeded, the encoder may be destroyed.**
- **Not indicated for all encoders; default value "0"**

3.9.18 Number of Blocks for Section 2 Memory Area

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

Max. Clock Frequency / Number of Bits for Position Comparison

3.9.19 Maximum Clock Frequency

The maximum possible clock frequency in kHz for EnDat 2.2 transmissions is entered in **word 25.**

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}	

This information applies for the properties of the encoder without connecting cable; the max. possible clock frequency is also determined by the cable assembly.

3.9.20 Number of Bits for Position Comparison

The number of bits relevant for comparison of Pos1 and Pos2 is entered 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}	

Important for safety applications

Scaling Factor for Resolution

- 9/10:
  Measuring Step Pos 2
- 28/29:
  Measuring Step Pos 1

3.9.21 Scalingfactor for Resolution

A scaling factor for words 9 and 10 or 31 to 33 or 28 and 29 is entered in **word 27**
(⇒ see section 3.5.12

	Scaling factor																
27	×	×	×	×	×	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}	
						absolute Position								relative Position			
						Pos. 2								Pos. 1			

2^{10}	2^{9}	2^{8}	Scaling factor for words 9 and 10 or 31 to 33
0	0	0	Entry in nm or measuring steps per revolution
0	0	1	Subdivision values of one grating period
0	1	0	Entry in measuring steps per revolution in powers of 2
0	1	1	Entry of the measuring steps in pm

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 one grating period
0	1	0	Entry of the measuring steps or measuring steps per revolution in powers of 2
0	1	1	Entry of the measuring steps in pm

It is absolutely necessary to read out and consider the scaling factor. Future increase in scaling factors possible.

Measuring Steps

Important Points:

- These words are used when no information can be entered in the EnDat 2.1 range (words 20 and 21), e.g. EIB.
- The scaling factor in word 27 must be considered

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}	

Max. Speed for Constant Code Value

Important information: Example RCN 729

- EnDat 2.1 word 32 n_{max}, mechanical = 1000 1/min
- EnDat 2.2 word 30 n_{max}, electrical = 300 1/min

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 rpm for the constant code value is not stored in all encoders. Default value ≙ 0

If the specified speed is exceeded, malfunctions will occur.

Offset between Position 1 and Position 2

3.9.24 Offset between position value and position value 2

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

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}	

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}	

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}	

Important for safety applications

Scaling Factor for Revolutions

Wichtige Punkte:

- Must always be considered for the "number of distinguishable revolutions for position 2."

3.9.25 "Number of Distinguishable Revolutions" with Scaling Factor

Only if the value 65535 is saved in **Word 17** of the "Parameters of the encoder manufacturer for EnDat 2.1" range, are 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
	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}	**Scaling factor**
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	Entered as $2^{\text{Number of distinguishable revolutions}}$

Future increase in scaling factors possible.

Support of operating status error sources

Important Points:

- The exact meaning of the error states can befound in the encoder`s specification

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

Parameters for Position Comparison

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.

3.9.28 Non-safety-relevant subdivision of the position

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

3.9.29 Non-safety-relevant subdivision of position value 2

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

Important for safety applications

Warning Message for Limit Position Signals

Important Points:

- Limit position signals are currently only supported by open linear encoders such as LIF, LIDA.

3.9.30 Generation of a warning message through limit position signals

The limit-position signal leading to a warning message is stored 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	is not supported	is supported
2^1	Warning message for limit position signal L2	is not supported	is supported
•	Currently not assigned Extension planned		
•			
2^{15}			

Important Points:

- See the product information for specification of touch probe functionality.
- The touch probe transfers a timestamp that transfers the probe time relative to the EnDat interrogation time.

3.9.31 Support of touch probe statuses

The touch probe functions that are supported are stored in **word 44**.

	Status of 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 stored in **word 45**. In combination with the value of the timestamp, the trigger time of an encoder can be determined.

	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 unit of measure**
0	0	0	Indication of 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

Re-referencing of Incremental Encoders

Important Points:

- This function is only intended for incremental encoders.
- This function is not supported in standard cases.

3.9.33 Referencing of incremental encoders

For incremental encoders, **word 46** specifies whether the encoder supports resetting of the RM bit and thus re-referencing via EnDat command or whether re-referencing is only possible by switching the power supply off and on again.

46

x	x	x	x	x	x	x	x	x	x	x	x	x	x	1	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 the RM bit on incremental encoders via EnDat command	is not supported	is supported
2^{1}	Currently not assigned Extension planned	:	:
•		:	:
•		:	:
•		:	:
2^{15}		:	:

I/O Functions

Important Points:

- I/O are currently not yet supported.

3.9.34 Support of I/Os

The I/Os that are available depend on the encoder, and are documented in **word 47** according to the following table.

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}	

3.9.36 Unterstützung Temperatursensortyp

In **Wort 50** wird hinterlegt, für welche Temperatursensortypen eine Auswertung im Messgerät implementiert ist.

50

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	Reserviert	wird nicht unterstützt	wird unterstützt
2^1	KTY 84-130	wird nicht unterstützt	wird unterstützt
2^2	PT1000	wird nicht unterstützt	wird unterstützt
2^3	PT 100	wird nicht unterstützt	wird unterstützt
2^4	KTY 83/110	wird nicht unterstützt	wird unterstützt
2^5	derzeit nicht belegt Erweiterung in Planung	:	:
•		:	:
2^7		:	:
2^8	Nicht verfügbar		
•			
2^{14}			
2^{15}	Unterstützung Einstellung	wird nicht unterstützt	wird unterstützt

Ist Bit 15 (Unterstützung Einstellung) mit 0 belegt, so kann der Anwender den Typ des Temperatursensors nicht einstellen und es wird nur die Standardeinstellung KTY 84-130 unterstützt.

For further information see EnDat Application Notes

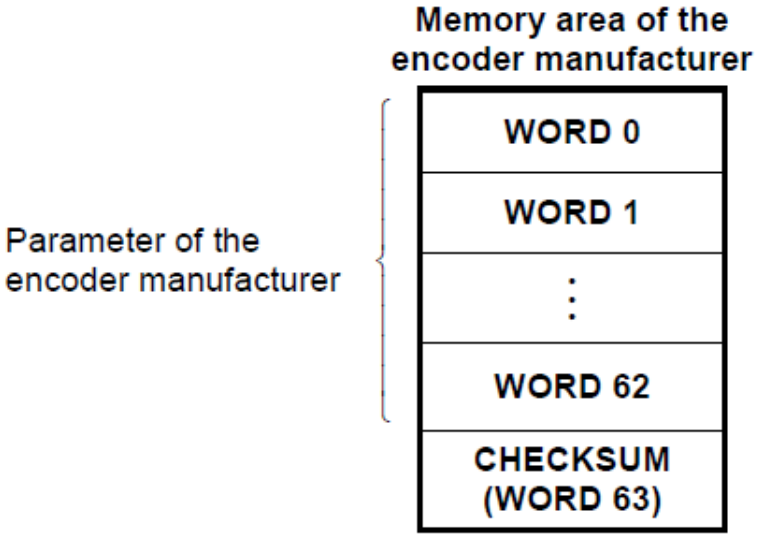
Checksum

Important Points:

- The overflow is disregarded

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.



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

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

EnDat 2.2 Seminar – Basics

- Demands on a modern encoder interface
- General information and documentation
- Interface physics and timing
- Power-on behavior
- Position value formation
- Mode commands
- Additional datum
- Memory areas: EnDat 2.1 parameters
- **Error handling**

Error Type I

Error type I (noise during transmission):

- The encoder needs a defined hardware reset, i.e. the clock pulse line must be kept at high level.
  → This corresponds to the elapsing of the recovery time and therefore an internal reset of the encoder.
- If a transmission does not conclude, then the error message is contained in the subsequent transmission.

1	Faulty transmission of mode command. M0 M1 M2 ≠ (M0) (M1) (M2) and M0 M1 M2 ≠ $(\overline{\mathbf{M0}})$ $(\overline{\mathbf{M1}})$ $(\overline{\mathbf{M2}})$	**Type I**
2	Faulty frame during MRS code transmission. C7 C6 C5 C0 ≠ 1011 C7 C6 C5 ≠ 010 (permitted for type 2.2 mode command) C7 C6 C5 ≠ 011 (permitted for type 2.2 mode command)	
3	A transmission was not completed. (busy error)	
4	**010010 received,** but **not permissible.**	
5	EnDat encoders that are not yet initialized (Extended Interface Box EIB).	
6	Communication command → high-impedance data driver deactivated with 0_{hex} address.	

Error Type II

Error type II (error during addressing):

- The address or parameter is returned in inverted form.
- The subsequent electronics must detect this and determine the further procedure.

7	A currently impermissible memory area was selected C4 C3 C2 C1 1 1 0 1 1 1 1 0 1 1 1 1 } (permitted for type 2.2 mode command)	**Type II**
8	Selection of an impermissible or inaccessible address during reading or writing of parameters, EnDat reset or with an active busy bit that is still set	
9	Writing of parameters into write-protected memory area	
10	Writing 0 to a bit with write-protected status after activation of the write-protection	
11	Impermissible block address was selected	
12	Communication command → The activated encoder receives a communication command with an unknown address Access to operating parameter 2 address that is currently not assigned or supported	

Error Type III

Error type III (noise during selection of additional data):

- Es wird ein Default-Wert für die Adresse der Zusatzinformation zurückgesendet
- Die Folgeelektronik muss dies erkennen und das weitere Vorgehen bestimmen

13	Currently impermissible additional data is selected. I4 I3 I2 I1 I0 1 1 0 1 0 1 1 1 0 0 1 1 1 0 1 1 1 1 1 0	**Type III**
14	Selected additional data is not supported via configuration (word 0 and 1 in the area "Encoder manufacturer for EnDat 2.2").	
15	Several additional data with the same identifier I4 – I0 are simultaneously activated	

Error Type IV

4.2.4 Fehlerbehandlung nach Typ IV

Das Feld Information I[4:0] einer Zusatzinformation kennzeichnet den Inhalt der Zusatzinformation. Der Wert 0 bei Zusatzinformation 1 und der Wert 16 bei Zusatzinformation 2 bedeuten NOP (siehe Abschnitt 2.3.5).
Beim Lesen der Zusatzinformation wird so lange NOP als Information zur Folgeelektronik zurückgesendet, so lange die Zusatzinformation nicht aktualisiert werden konnte.
Die Daten der Bytes 1 und 2 der jeweiligen Zusatzinformation sind in diesem Fall ungültig!

16	Eine verfügbare Zusatzinformation konnte nicht aktualisiert werden. Dies kann auch einzelne Adressen der zusätzlichen Sensoren in Zusatzinformation 1 betreffen.	**nach Typ IV**