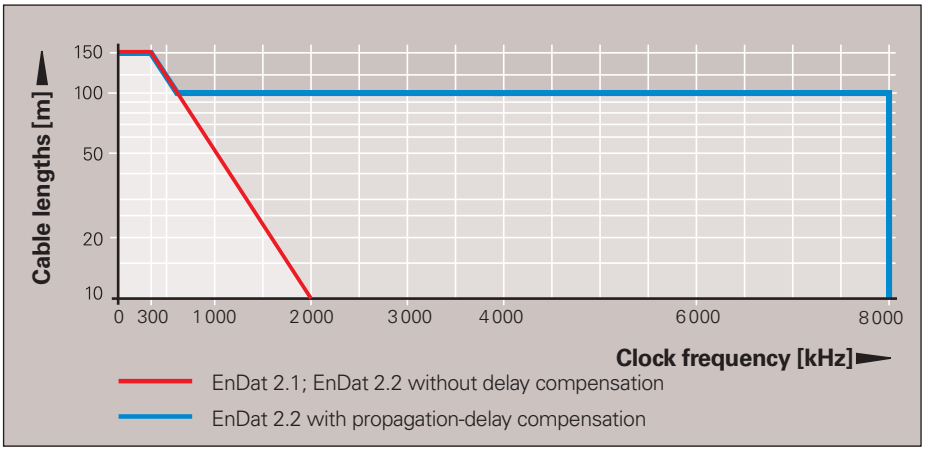
Interfaces

EnDat Absolute Position Values

The EnDat interface is a digital, **bidirectional** interface for encoders. It is capable of transmitting **position values** from both absolute and—with EnDat 2.2—incremental encoders, as well as reading and updating information stored in the encoder, or of saving new information. Thanks to the **serial transmission method** only **four signal lines** are required. The data are transmitted **in synchronism** with the clock signal from the subsequent electronics. The type of transmission (position values, parameters, diagnostics, etc.) is selected by mode commands that the subsequent electronics send to the encoder.

Interface	**EnDat** serial bidirectional
Data transfer	Absolute position values, parameters and additional information
Data input	Differential line receiver according to EIA standard RS 485 for CLOCK, $\overline{\text{CLOCK}}$, DATA and $\overline{\text{DATA}}$ signals
Data output	Differential line driver according to EIA standard RS 485 for the DATA and $\overline{\text{DATA}}$ signals
Code	Pure binary code
Position values	Ascending in traverse direction indicated by arrow (see Dimensions)
Incremental signals	~ 1 V_{PP} (see *1 V_{PP} Incremental Signals*) depending on unit
Connecting cable With Incremental Without signals	HEIDENHAIN cable with shielding PUR [(4 x 0.14 mm^2) + 4(2 x 0.14 mm^2) + (4 x 0.5 mm^2)] PUR [(4 x 0.14 mm^2) + (4 x 0.34 mm^2)]
Cable lengths	Max. 150 m
Propagation time	Max. 10 ns; approx. 6 ns/m

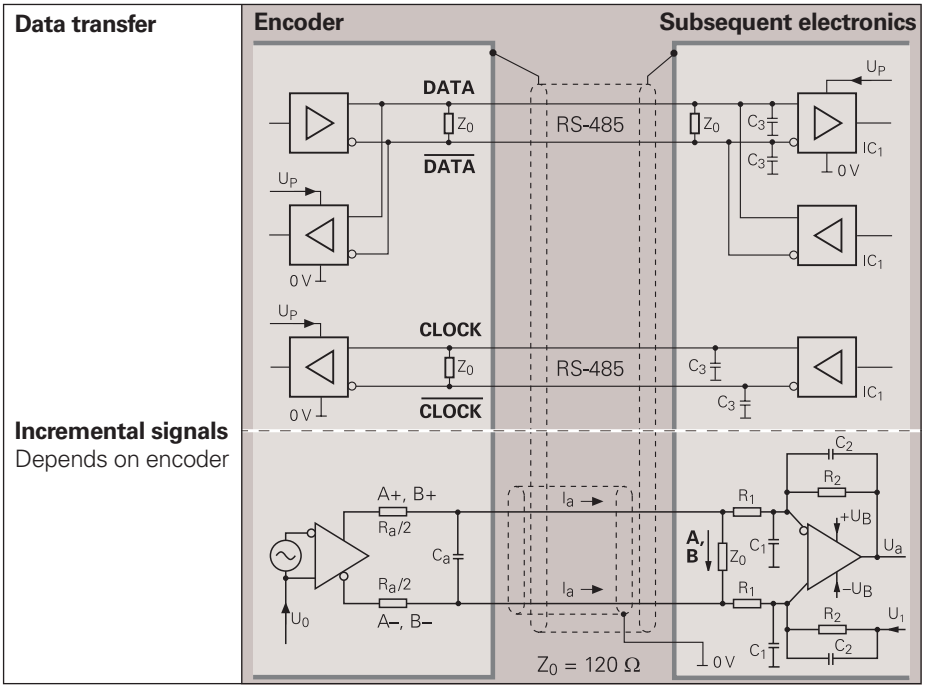
Clock frequency and cable length
Without propagation-delay compensation, the **clock frequency**—depending on the cable length—is variable between **100 kHz** and **2 MHz.** Because large cable lengths and high clock frequencies increase the signal run time to the point that they can disturb the unambiguous assignment of data, the delay can be measured in a test run and then compensated. With this **propagation-delay compensation** in the subsequent electronics, clock frequencies up to **8 MHz** at cable lengths up to a maximum of 100 m are possible. To ensure proper function at clock frequencies above 2 MHz, use only original HEIDENHAIN cables.



Input circuitry of the subsequent electronics

Dimensioning
IC_1 = RS 485 differential line receiver and driver

C_3 = 330 pF
Z_0 = 120 Ω



Versions

The extended EnDat interface version 2.2 is compatible in its communication, command set (i.e. the available mode commands) and time conditions with version 2.1, but also offers significant advantages. It makes it possible, for example, to transfer additional information with the position value without sending a separate request for it. The interface protocol was expanded and the time conditions (clock frequency, processing time, recovery time) were optimized.

Both EnDat 2.1 and EnDat 2.2 are available in versions with or without incremental signals. On EnDat 2.2 encoders, the variant without incremental signals is standard due to its high internal resolution. To increase the resolution of EnDat 2.1 encoders, the incremental signals are evaluated in the subsequent electronics.

EnDat 2.2 (includes EnDat 2.1)
- Position values for incremental and absolute encoders
- Additional information on position value
  - Diagnostics and test values
  - Absolute position values after reference run of incremental encoders
  - Parameter upload/download
  - Commutation
  - Acceleration
  - Limit position signal
  - Temperature of the encoder PCB
  - Temperature evaluation of an external temperature sensor (e.g. in the motor winding)

EnDat 2.1
- Absolute position values
- Parameter upload/download
- Reset
- Test command and test values

Interface	Version	Clock frequency	Ordering information
EnDat 2.1	**With incremental signals**	≤ 2 MHz	EnDat 01
	Without incremental signals		EnDat 21
EnDat 2.2	With incremental signals	≤ 2 MHz	EnDat 02
	Without incremental signals	≤ 8 MHz	EnDat 22

Bold: Standard version

Benefits of the EnDat Interface

- **Automatic self-configuration:** All information required by the subsequent electronics is already stored in the encoder
- **High system security** through alarms and messages for monitoring and diagnosis
- **High transmission reliability** through cyclic redundancy checking
- Faster configuration during installation: **Datum shifting** through offsetting by a value in the encoder

Other benefits from EnDat 2.2
- **A single interface** for all absolute and incremental encoders
- **Additional informationen** (limit switch, temperature, acceleration)
- **Quality improvement:** Position value calculation in the encoder permits shorter sampling intervals (25 µs)

Advantages of purely serial transmission specifically for EnDat 2.2 encoders
- **Simple subsequent electronics** with EnDat receiver chip
- **Simple connection technology:** Standard connecting elements (M12: 8-pin) single shielded standard cable and low wiring costs
- **Minimized transmission times** through adaptation of the data word length to the resolution of the encoder
- **High clock frequencies** up to 8 MHz. Position values available in the subsequent electronics after only approx. 10 µs
- **Support for state-of-the-art machine designs** e.g. direct drive technology

Functions

The EnDat interface transmits absolute position values or additional physical quantities (only EnDat 2.2) in an unambiguous time sequence and serves to read from and write to the encoder's internal memory. Some functions are available only with EnDat 2.2 mode commands.

Position values can be transmitted with or without additional information. The additional information types are selectable via Memory Range Select (MRS) code. Other functions such as parameter reading and writing can also be called after the memory area and address have been selected. Through simultaneous transmission with the position value, axes in the feedback loop can also request additional information and execute functions.

Parameter reading and writing is possible both as a separate function and in connection with the position value. Parameters can be read or written after the memory area and address are selected.

Reset functions serve to reset the encoder in case of malfunction. Reset is possible instead of or during position value transmission.

Servicing diagnosis makes it possible to inspect the position value even at a standstill. A test command has the encoder transmit the required test values.

You can find more information in the *Technical Information for EnDat 2.2* document or on the Internet at www.endat.de.

Selecting the Transmission Type

Transmitted data are distinguished as either position values, position values with additional information, or parameters. The type of information to be transmitted is selected by mode commands. **Mode commands** define the content of the transmitted information. Every mode command consists of three bits. To ensure reliable transmission, every bit is transmitted redundantly (inverted or double). If the encoder detects an erroneous mode transmission, it transmits an error message. The EnDat 2.2 interface can also transfer parameter values in the additional information together with the position value. This makes the current position values constantly available for the control loop, even during a parameter request.

Mode commands

• Encoder transmit position values • Selection of the memory area • Encoder receive parameters • Encoder transmit parameters • Encoder receive reset [1] • Encoder transmit test values • Encoder receive test commands	EnDat 2.1
• Encoder transmit position value with additional information • Encoder transmit position value and receive selection of memory area [2] • Encoder transmit position value and receive parameters [2] • Encoder transmit position value and transmit parameters [2] • Encoder transmit position value and receive error reset [2] • Encoder transmit position value and receive test command [2] • Encoder receive communication command [3]	EnDat 2.2

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

Control Cycles for Transfer of Position Values

The transmission cycle begins with the first falling **clock edge.** The measured values are saved and the position value calculated. After two clock pulses (2T), to **select the type of transmission** the subsequent electronics transmit the mode command *Encoder transmit position value* (with/without additional information).

After successful calculation of the absolute position value (t_{cal}—see table), the **start bit** begins the data transmission from the encoder to the subsequent electronics. The subsequent **error messages,** error 1 and error 2 (only with EnDat 2.2 commands), are group signals for all monitored functions and serve for failure monitoring.

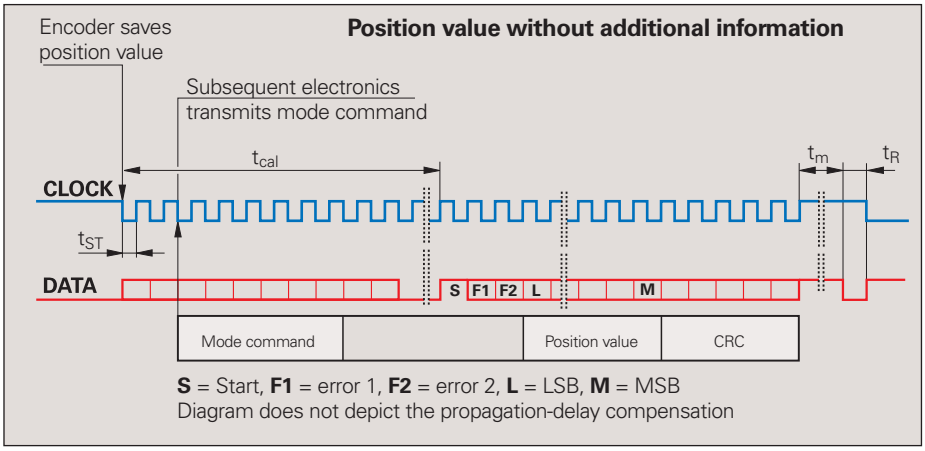
Beginning with the LSB, the encoder then transmits the absolute **position value** as a complete data word. Its length depends on the encoder being used. The number of required clock pulses for transmission of a position value is saved in the parameters of the encoder manufacturer. The data transmission of the position value is completed with the **Cyclic Redundancy Check** (CRC).

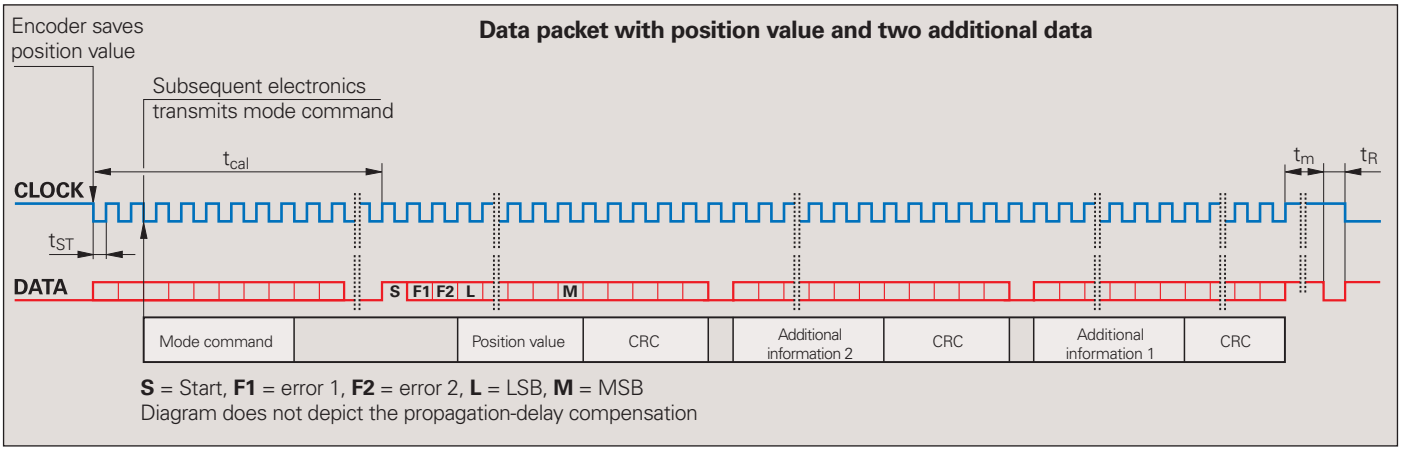
In EnDat 2.2, this is followed by the additional information 1 and 2, each also concluded with a CRC. With the end of the data word, the clock must be set to HIGH. After 10 to 30 µs or 1.25 to 3.75 µs (with EnDat 2.2 parameterizable recovery time t_m) the data line falls back to LOW. Then a **new data transmission** can begin by starting the clock.

		Without delay compensation	**With delay compensation**
Clock frequency	f_c	100 kHz ... 2 MHz	100 kHz ... 8 MHz
Calculation time for			
Position value	t_{cal}	See *Specifications*	
Parameters	t_{ac}	Max. 12 ms	
Recovery time	t_m	*EnDat 2.1:* 10 to 30 µs *EnDat 2.2:* 10 to 30 µs or 1.25 to 3.75 µs ($f_c \geq 1$ MHz) (parameterizable)	
	t_R	Max. 500 ns	
	t_{ST}	–	2 to 10 µs
Data delay time	t_D	(0.2 + 0.01 x cable length in m) µs	
Pulse width	t_{HI}	0.2 to 10 µs	Pulse width fluctuation HIGH to LOW max. 10%
	t_{LO}	0.2 to 50 ms/30 µs (with LC)	

EnDat 2.2 – Transfer of Position Values

EnDat 2.2 can transmit position values selectably with or without additional information.

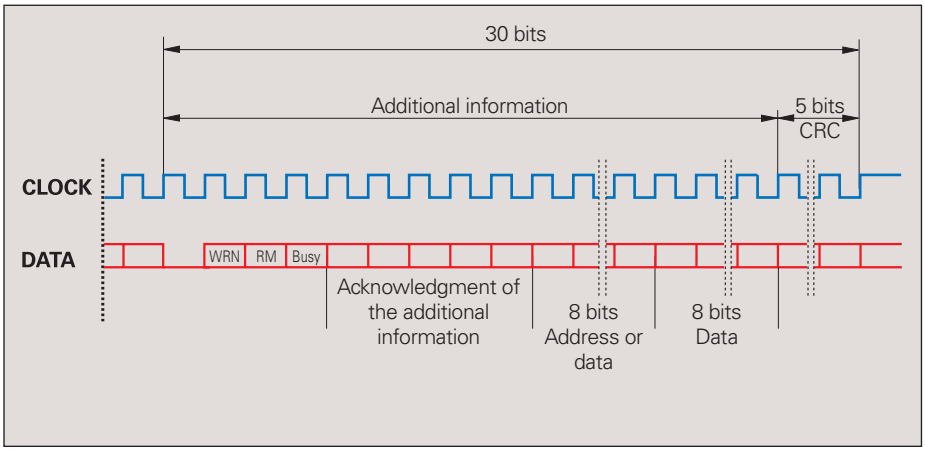




Additional information

With EnDat 2.2, one or two additional data can be appended to the position value. The additional data are each 30 bits in length with LOW as first bit, and end with a CRC check. The additional information supported by the respective encoder is saved in the encoder parameters.

The content of the additional information is determined by the MRS code and is transmitted in the next sampling cycle for additional information. This information is then transmitted with every sampling until a selection of a new memory area changes the content.



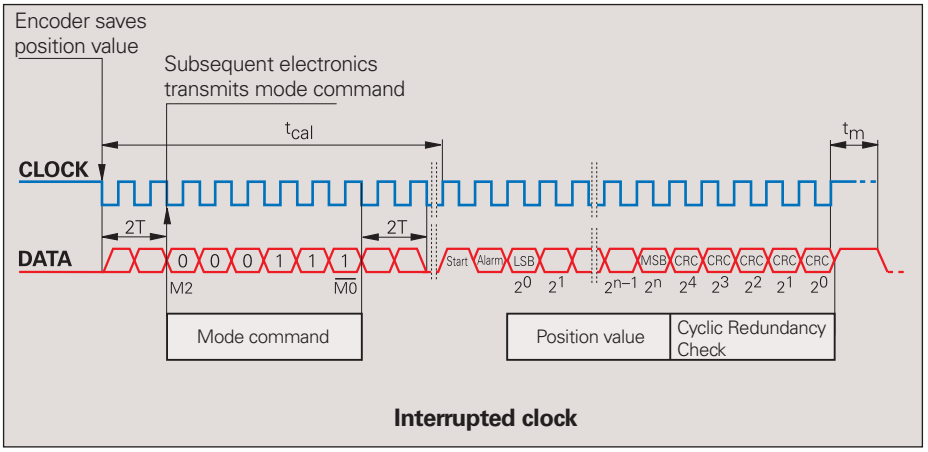
The additional data always begin with:	The additional data can contain the following information:	
Status data Warning—WRN Reference mark—RM Parameter request—busy **Acknowledgment** of additional information	**Additional information 1** Diagnosis Position value 2 Memory parameters MRS-code acknowledgment Test values Temperature	**Additional information 2** Commutation Acceleration Limit position signals

EnDat 2.1 – Transfer of Position Values

EnDat 2.1 can transmit position values selectably with interrupted clock pulse (as in EnDat 2.2) or continuous clock pulse.

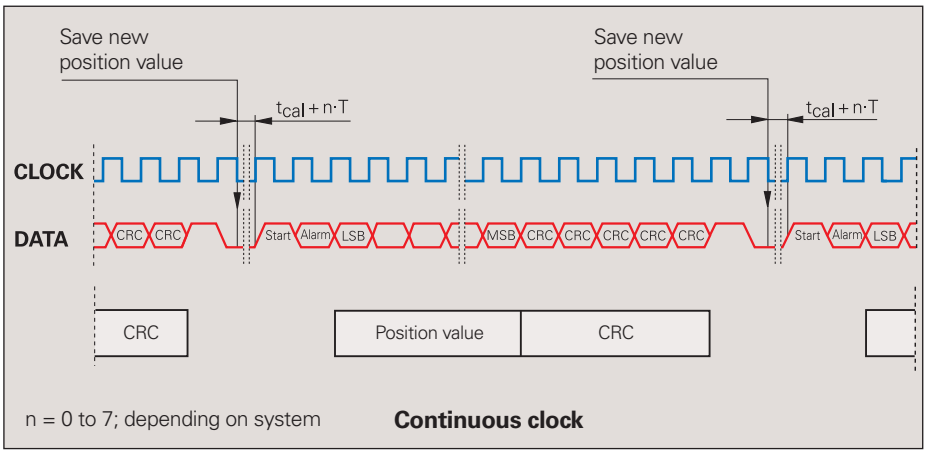
Interrupted clock

The interrupted clock is intended particularly for time-clocked systems such as closed control loops. At the end of the data word the clock signal is set to HIGH level. After 10 to 30 µs (t_m), the data line falls back to LOW. Then a new data transmission can begin by starting the clock.



Continuous clock

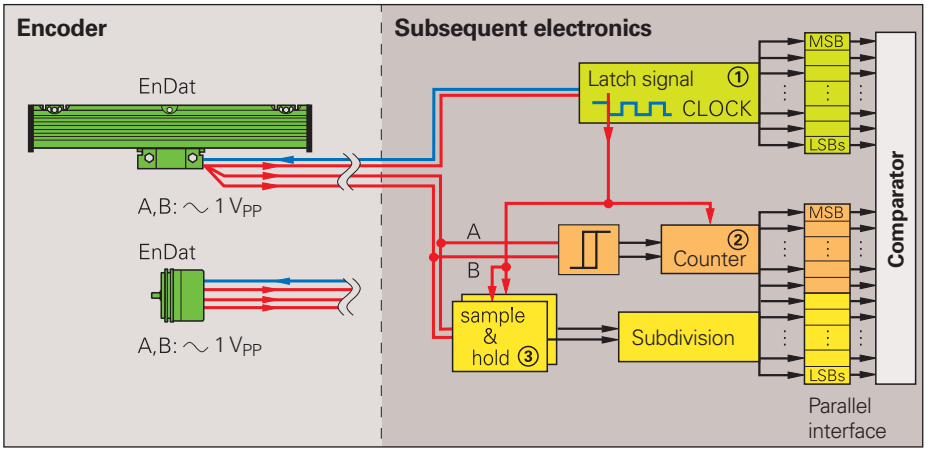
For applications that require fast acquisition of the measured value, the EnDat interface can have the clock run continuously. Immediately after the last CRC bit has been sent, the data line is switched to high for one clock cycle, and then to low. The new position value is saved with the very next falling edge of the clock and is output in synchronism with the clock signal immediately after the start bit and alarm bit. Because the mode command *Encoder transmits position value* is needed only before the first data transmission, the continuous-clock transfer mode reduces the length of the clock-pulse group by 10 periods per position value.



Synchronization of the serially transmitted code value with the incremental signal

Absolute encoders with EnDat interface can exactly synchronize serially transmitted absolute position values with incremental values. With the first falling edge (latch signal) of the CLOCK signal from the subsequent electronics, the scanning signals of the individual tracks in the encoder and counter are frozen, as are also the A/D converters for subdividing the sinusoidal incremental signals in the subsequent electronics.

The code value transmitted over the serial interface unambiguously identifies one incremental signal period. The position value is absolute within one sinusoidal period of the incremental signal. The subdivided incremental signal can therefore be appended in the subsequent electronics to the serially transmitted code value.



After power on and initial transmission of position values, two redundant position values are available in the subsequent electronics. Since encoders with EnDat interface guarantee a precise synchronization—regardless of cable length—of the serially transmitted absolute value with the incremental signals, the two values can be compared in the subsequent electronics. This monitoring is possible even at high shaft speeds thanks to the EnDat interface's short transmission times of less than 50 µs. This capability is a prerequisite for modern machine design and safety techniques.

Parameters and Memory Areas

The encoder provides several memory areas for parameters. These can be read from by the subsequent electronics, and some can be written to by the encoder manufacturer, the OEM, or even the end user. Certain memory areas can be write-protected.

The parameters, which in most cases are set by the OEM, largely define the function of the encoder and the EnDat interface. When the encoder is exchanged, it is therefore essential that its parameter settings are correct. Attempts to configure machines without including OEM data can result in malfunctions. If there is any doubt as to the correct parameter settings, the OEM should be consulted.

Parameters of the encoder manufacturer
This write-protected memory area contains all **information specific to the encoder,** such as encoder type (linear/angular, singleturn/multiturn, etc.), signal periods, position values per revolution, transmission format of position values, direction of rotation, maximum speed, accuracy dependent on shaft speeds, support of warnings and alarms, part number and serial number. This information forms the basis for **automatic configuration.** A separate memory area contains the parameters typical for EnDat 2.2: Status of additional information, temperature, acceleration, support of diagnostic and error messages, etc.

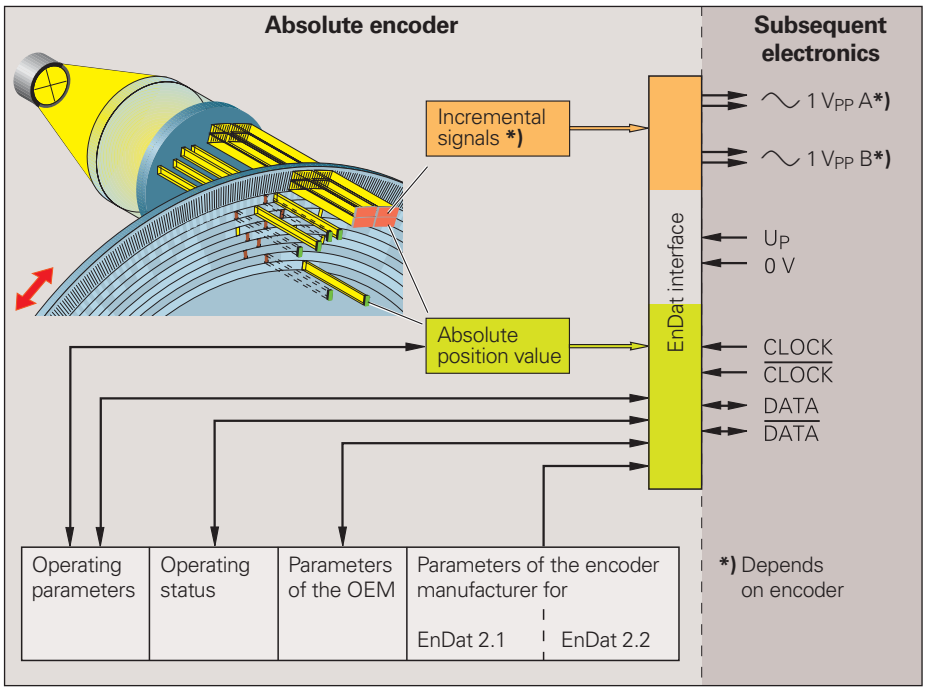
Parameters of the OEM
In this freely definable memory area, the OEM can store his information, e.g. the "electronic ID label" of the motor in which the encoder is integrated, indicating the motor model, maximum current rating, etc.

Operating parameters
This area is available for a **datum shift** and the configuration of diagnostics. It can be protected against overwriting.

Operating status
This memory area provides detailed alarms or warnings for diagnostic purposes. Here it is also possible to activate write protection for the OEM parameter and operating parameter memory areas and interrogate their status. Once **write protection** is activated, it cannot be removed.

Safety System

The safety system is in preparation. Safety-oriented controls are the planned application for encoders with EnDat 2.2 interface. Refer to the EN 61800 standard *Adjustable speed electrical power drive systems* Part 5-2.



Monitoring and Diagnostic Functions

The EnDat interface enables comprehensive monitoring of the encoder without requiring an additional transmission line. The alarms and warnings supported by the respective encoder are saved in the "parameters of the encoder manufacturer" memory area.

Diagnosis
Cyclic information on encoder function and additional diagnostic values are transmitted in the additional information.

Error message
An error message becomes active if a **malfunction of the encoder** might result in incorrect position values. The exact cause of the trouble is saved in the encoder's "operating status" memory where it can be interrogated in detail. Errors include, for example,

- Light unit failure
- Signal amplitude too low
- Error in calculation of position value
- Power supply too high/low
- Current consumption is excessive

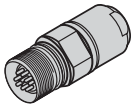
Here the EnDat interface transmits the error bits, error 1 and error 2 (only with EnDat 2.2 commands). These are group signals for all monitored functions and serve for failure monitoring. The two error messages are generated independently from each other.

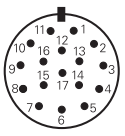
Warning
This collective bit is transmitted in the status data of the additional information. It indicates that certain **tolerance limits of the encoder** have been reached or exceeded—such as shaft speed or the limit of light source intensity compensation through voltage regulation—without implying that the measured position values are incorrect. This function makes it possible to issue preventive warnings in order to minimize idle time.

Cyclic Redundancy Check
To ensure **reliability of data transfer,** a cyclic redundancy check (CRC) is performed through the logical processing of the individual bit values of a data word. This 5-bit long CRC concludes every transmission. The CRC is decoded in the receiver electronics and compared with the data word. This largely eliminates errors caused by disturbances during data transfer.

Pin Layout EnDat

17-pin coupling M23

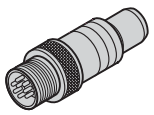




	Power supply					Incremental signals[1]				Absolute position values			
	7	**1**	**10**	**4**	**11**	**15**	**16**	**12**	**13**	**14**	**17**	**8**	**9**
	U_P	**Sensor** U_P	0 V	**Sensor** 0 V	**Inside shield**	**A+**	**A–**	**B+**	**B–**	**DATA**	**$\overline{\text{DATA}}$**	**CLOCK**	**$\overline{\text{CLOCK}}$**
	Brown/ Green	Blue	White/ Green	White	/	Green/ Black	Yellow/ Black	Blue/ Black	Red/ Black	Gray	Pink	Violet	Yellow

Shield on housing; **U_P** = Power supply voltage
Sensor: The sensor line is connected internally with the corresponding power line
Vacant pins or wires must not be used!
1) Not with EnDat 2.2, order information 22

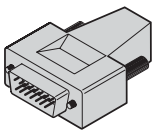
8-pin coupling M12

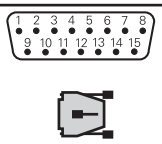


	Power supply				Absolute position values			
	2	**8**	**1**	**5**	**3**	**4**	**7**	**6**
	U_P [1]	**U_P**	**0 V**[1]	**0 V**	**DATA**	**$\overline{\text{DATA}}$**	**CLOCK**	**$\overline{\text{CLOCK}}$**
	Blue	Brown/Green	White	White/Green	Gray	Pink	Violet	Yellow

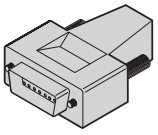
Shield on housing; **U_P** = Power supply voltage
1) for power lines configured parallel
Vacant pins or wires must not be used!

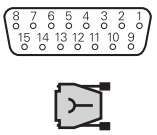
15-pin D-sub connector (male) for IK 115/IK 215





15-pin D-sub connector, female for HEIDENHAIN controls and IK 220





	Power supply					Incremental signals[1]				Absolute position values			
	4	**12**	**2**	**10**	**6**	**1**	**9**	**3**	**11**	**5**	**13**	**8**	**15**
	1	**9**	**2**	**11**	**13**	**3**	**4**	**6**	**7**	**5**	**8**	**14**	**15**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**Inside shield**	**A+**	**A–**	**B+**	**B–**	**DATA**	**$\overline{\text{DATA}}$**	**CLOCK**	**$\overline{\text{CLOCK}}$**
	Brown/ Green	Blue	White/ Green	White	/	Green/ Black	Yellow/ Black	Blue/ Black	Red/ Black	Gray	Pink	Violet	Yellow

Shield on housing; **U_P** = Power supply voltage
Sensor: The sensor line is connected internally with the corresponding power line
Vacant pins or wires must not be used!
[1] Not with EnDat 2.2, order information 22