HEIDENHAIN

Product Overview

Interface Electronics

October 2007

The interface electronics from HEIDENHAIN adapt the encoder signals to the interface of the subsequent electronics. They are used when the subsequent electronics cannot directly process the output signals from HEIDENHAIN encoders, or if additional interpolation of the signals is necessary.

Input signals of the interface electronics
Interface electronics from HEIDENHAIN can be connected to encoders with sinusoidal signals of 1 V_{PP} (voltage signals) or 11 μA_{PP} (current signals). The IK 220 PC expansion board can also process EnDat and SSI.

Output signals of the interface electronics
Interface electronics with the following interfaces to the subsequent electronics are available:

- TTL square-wave pulse trains
- EnDat 2.2
- Fanuc Serial Interface
- Mitsubishi High Speed Serial Interface
- PCI bus

Interpolation of the sinusoidal input signals
In addition to being converted, the sinusoidal encoder signals are also interpolated in the interface electronics. This results in finer measuring steps, leading to an increased positioning accuracy and higher control quality.

Formation of a position value
Some interface electronics have an integrated counting function. Starting from the last reference point set, an absolute position value is formed when the reference mark is traversed, and is output to the subsequent electronics.

Example of 5-fold interpolation

This catalog supersedes all previous editions, which thereby become invalid. The basis for ordering from HEIDENHAIN is always the catalog edition valid when the contract is made.

Standards (ISO, EN, etc.) apply only where explicitly stated in the catalog.

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Contents

IBV 100
EXE 100

EIB 192

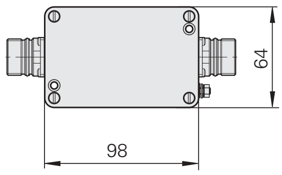
APE 371
EIB 392

Mechanical Design Types

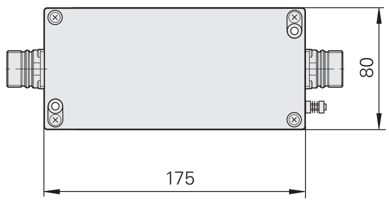
Box design
Because of their high degree of protection (IP 65), interface electronics with a box design are especially well suited for the rough industrial environment typically found where machine tools operate. The inputs and outputs are equipped with robust M23 and M12 connecting elements. The stable cast-metal housing offers protection against physical damage as well as against electrical interference.

The EXE/IBV 100 series distinguishes itself from the EXE/IBV 600 series primarily in its compact dimensions.

E.g. IBV 100



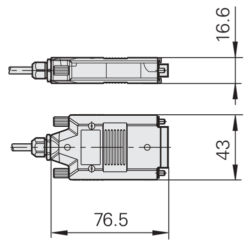
E.g. IBV 600



Plug design
The interface electronics with a plug design save a large amount of space: there is room for the entire interpolation and digitizing electronics in an extended D-sub connector housing. This offers protection against physical damage (degree of protection: IP 40) and electrical interference.

Appropriate accessory parts can be used to firmly attach the connecting elements, and stack several connectors on top of each other.

E.g. TS 371

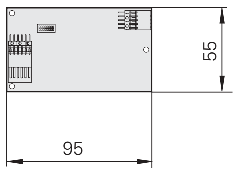


Version for integration
There are also versions of the interface electronics intended for integration in existing electronics. These pluggable boards must be protected against electrical and physical influences.

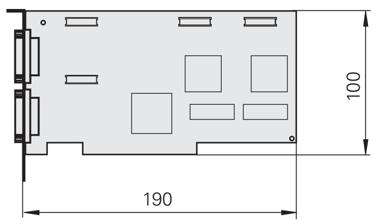
The **IDP** series consists of pure interpolation and digitizing electronics, and is intended for integration as input assemblies in non-HEIDENHAIN electronics.

The **IK 220** is a PC slot card with switchable input interfaces and a counting function for the incremental signals.

IDP 100



IK 220



Selection Guide

Output signal	Input signal	Design – protection class	Interpolation[1] or Subdivision	Model
⊓⊔TTL	∿ 1 V_{PP}	Box design – IP 65	5/10-fold	**IBV 101**
			20/25/50/100-fold	**IBV 102**
			Without interpolation	**IBV 600**
			25/50/100/200/400-fold	**IBV 660 B**
		Plug design – IP 40	5/10/20/25/50/100-fold	**APE 371**
		Version for integration – IP 00	5/10-fold	**IDP 181**
			20/25/50/100-fold	**IDP 182**
	∿ 11 μA_{PP}	Box design – IP 65	5/10-fold	**EXE 101**
			20/25/50/100-fold	**EXE 102**
			Without/5-fold	**EXE 602 E**
			25/50/100/200/400-fold	**EXE 660 B**
		Version for integration – IP 00	5-fold	**IDP 101**
2 x ⊓⊔TTL/∿ 1 V_{PP}[2]	∿ 1 V_{PP}	Box design – IP 65	2-fold	**IBV 606**
EnDat 2.2	∿ 1 V_{PP}	Box design – IP 65	≤ 16384-fold interpolation	**EIB 192**
		Plug design – IP 40	≤ 16384-fold interpolation	**EIB 392**
Fanuc Serial Interface	∿ 1 V_{PP}	Box design – IP 65	≤ 16384-fold interpolation	**EIB 192 F**
		Plug design – IP 40	≤ 16384-fold interpolation	**EIB 392 F**
Mitsubishi High Speed Serial Interface	∿ 1 V_{PP}	Box design – IP 65	≤ 16384-fold interpolation	**EIB 192 M**
		Plug design – IP 40	≤ 16384-fold interpolation	**EIB 392 M**
PCI bus	∿ 1 V_{PP}[3] ∿ 11 μA_{PP}[3] EnDat 2.1 / 01[3] SSI [3]	Version for integration – IP 00	≤ 4096-fold interpolation	**IK 220**

[1] Switchable
[2] Two outputs, interface can be set
[3] Two inputs, can be set via software

You can find more information and detailed specifications in the Product Information documents for each product.

Interfaces
⊓⊔ TTL Incremental Signals

The IBV, EXE, APE and IDP interpolation and digitalizing electronics from HEIDENHAIN convert the sinusoidal output signals from HEIDENHAIN encoders, with or without interpolation, into ⊓⊔TTL square-wave signals.

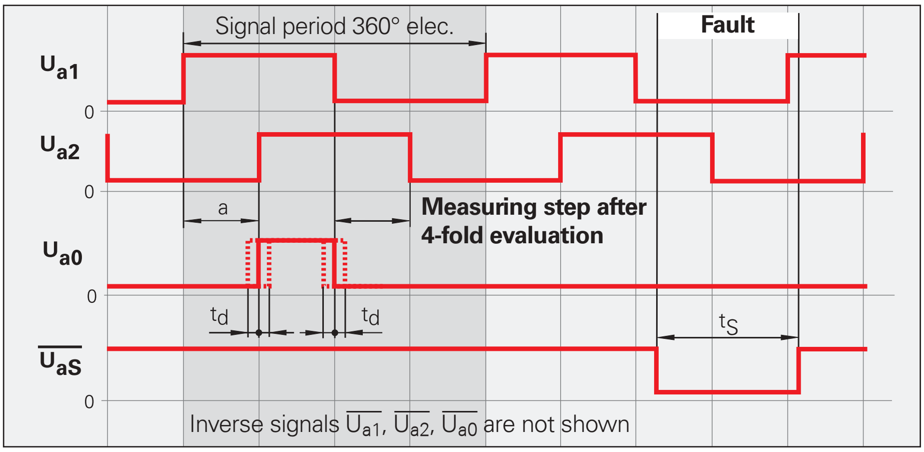
The **incremental signals** are transmitted as the square-wave pulse trains U_{a1} and U_{a2}, phase-shifted by 90° elec. The **reference mark signal** consists of one or more reference pulses U_{a0}, which are gated with the incremental signals. In addition, the integrated electronics produce their **inverse signals** $\overline{U_{a1}}$, $\overline{U_{a2}}$ and $\overline{U_{a0}}$ for noise-proof transmission.

The illustrated sequence of output signals—with U_{a2} lagging U_{a1}—applies for the direction of motion shown in the dimension drawing.

The **fault-detection signal** $\overline{U_{aS}}$ indicates fault conditions such as breakage of the power line or failure of the light source. It can be used for such purposes as machine shut-off during automated production.

The distance between two successive edges of the incremental signals U_{a1} and U_{a2} through 1-fold, 2-fold or 4-fold evaluation is one **measuring step.**

Interface	**⊓⊔TTL** square-wave signals
Incremental signals	**2 TTL square-wave signals U_{a1}, U_{a2}** and their inverted signals **$\overline{U_{a1}}$, $\overline{U_{a2}}$**
Reference-mark signal Pulse width Delay time	**1 or more TTL square-wave pulses U_{a0}** and their inverted pulses **$\overline{U_{a0}}$** 90° elec. (can be switched to 270° elec.) $\lvert t_d \rvert \le 50$ ns
Fault-detection signal Pulse width	**1 TTL square-wave pulse $\overline{U_{aS}}$** Improper function: LOW (can be switched to three-state: U_{a1}/U_{a2} high impedance) Proper function: HIGH $t_S \ge 20$ ms *EXE 602 E:* $t_S \ge 250$ µs can be switched to 40 ms
Signal level	Differential line driver as per EIA standard RS 422 $U_H \ge 2.5$ V at $-I_H = 20$ mA $U_L \le 0.5$ V at $I_L = 20$ mA
Permissible load	$Z_0 \ge 100\ \Omega$ between associated outputs $\lvert I_L \rvert \le 20$ mA max. load per output $C_{Load} \le 1000$ pF with respect to 0 V Outputs protected against short circuit to 0 V
Switching times (10% to 90%)	$t_+ / t_- \le 30$ ns (typically 10 ns) with 1 m cable and recommended input circuitry
Connecting cable Cable length Propagation time	Shielded HEIDENHAIN cable PUR [4(2 × 0.14 mm²) + (4 × 0.5 mm²)] Max. 100 m ($\overline{U_{aS}}$ max. 50 m) with 90 pF/m distributed capacitance 6 ns/m



The subsequent electronics must be designed to detect each edge of the square-wave pulse. The minimum **edge separation a** listed in the *Specifications* applies for the illustrated input circuitry with a cable length of 1 m, and refers to a measurement at the output of the differential line receiver. Cable-dependent differences in the propagation times additionally reduce the edge separation by 0.2 ns per meter of cable. To prevent counting error, design the subsequent electronics to process as little as 90 % of the resulting edge separation.

The max. permissible **shaft speed** or **traversing velocity** must never be exceeded.

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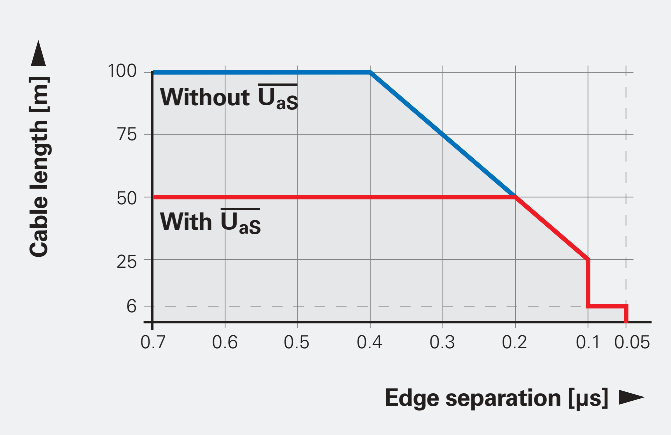
Clocked EXE/IBV
For electronics with clocked output signals, the clock frequency f_T specifies the edge separation, which in turn specifies the maximum input frequency. This means that the given values for the maximum input frequency represent an absolute limit to the correct operation. At reduced input frequency the edge separation can be increased provided that it remains an integral multiple of a_{min}.

The edge separation can be set in stages for adaptation to the subsequent electronics. The maximum permissible input frequency then changes correspondingly.

Non-clocked EXE/IBV
For electronics without clocked output signals, the minimum edge separation a_{min} that occurs at the maximum possible input frequency is stated in the specifications. If the input frequency is reduced, the edge separation increases correspondingly.

The permissible **cable length** for transmission of the TTL square-wave signals to the subsequent electronics depends on the edge separation a. It is max. 100 m, or 50 m for the fault detection signal. This requires, however, that the power supply (see *Specifications*) be ensured at the encoder. The sensor lines can be used to measure the voltage at the encoder and, if required, correct it with an automatic system (remote sense power supply).

Permissible cable length
with respect to the edge separation



Input Circuitry of the Subsequent Electronics

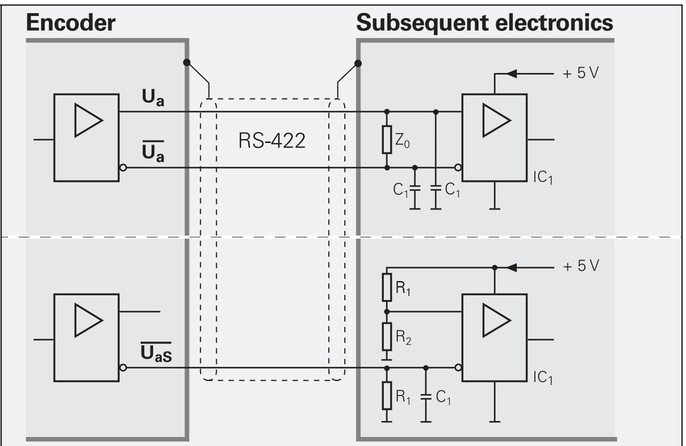
Dimensioning

IC_1 = Recommended differential line receivers
DS 26 C 32 AT
Only for a > 0.1 µs:
AM 26 LS 32
MC 3486
SN 75 ALS 193

R_1 = 4.7 kΩ
R_2 = 1.8 kΩ
Z_0 = 120 Ω
C_1 = 220 pF (serves to improve noise immunity)

Incremental signals Reference-mark signal

Fault-detection signal



Interfaces

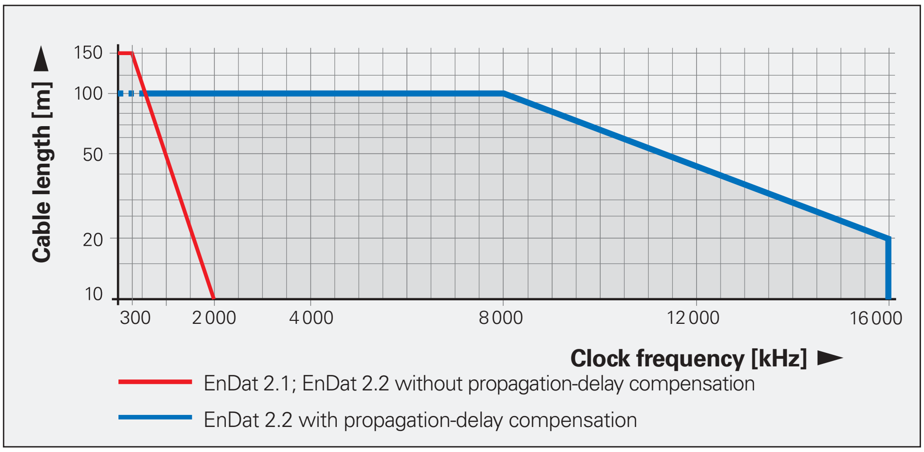
EnDat Absolute Position Values

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.

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 **16 MHz** at cable lengths up to a maximum of 100 m ($f_{CLK} \leq 8$ MHz) are possible. The maximum clock frequency is mainly determined by the cables and connecting elements used. To ensure proper function at clock frequencies above 2 MHz, use only original ready-made HEIDENHAIN cables.

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 $\overline{\text{DATA}}$
Data output	Differential line driver according to EIA standard RS 485 for the DATA and $\overline{\text{DATA}}$
Code	Pure binary code
Position values	Ascending during traverse in direction of arrow (see dimensions of the encoders)
Incremental signals	∿ 1 V_{PP} (see *Incremental Signals 1 V_{PP}*) depending on unit
Connecting cable With Incremental Without signals	Shielded HEIDENHAIN cable 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 length	Max. 150 m
Propagation time	Max. 10 ns; approx. 6 ns/m



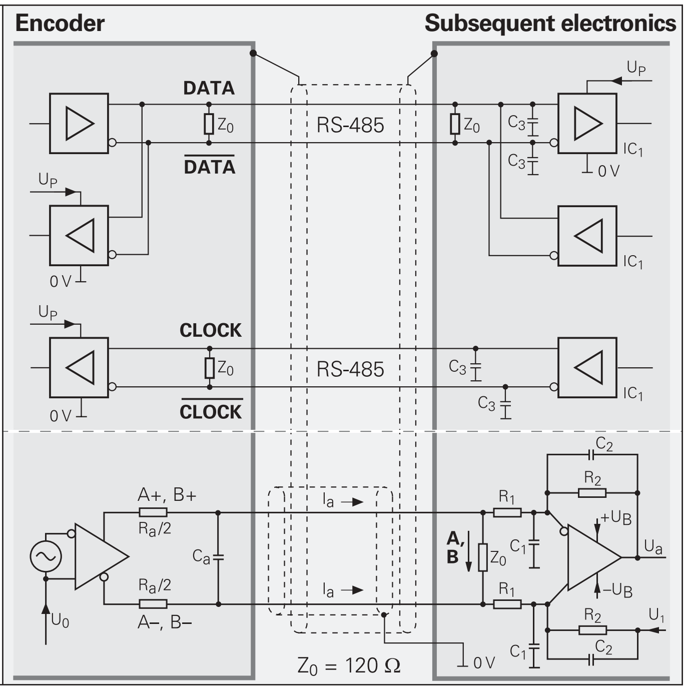
Input Circuitry of the Subsequent Electronics

Dimensioning
IC_1 = RS 485 differential line receiver and driver

C_3 = 330 pF
Z_0 = 120 Ω

Data transfer

Incremental signals
Depending on encoder



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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 checks.
- **Datum shift** for faster commissioning.

Other benefits of EnDat 2.2

- **A single interface** for all absolute and incremental encoders.
- **Additional information** (limit switch, temperature, acceleration)
- **Quality improvement:** Position value calculation in the encoder permits shorter sampling intervals (25 µs).
- **Online diagnostics** through valuation numbers that indicate the encoder's current functional reserves and make it easier to plan the machine servicing.
- **Safety techniques** for setting up safety oriented control systems consisting of safe controls and safe encoders based on the IEC 61 508 and DIN EN ISO 13 849-1 standards

Advantages of purely serial transmission specifically for EnDat 2.2 encoders

- Cost optimization through **simple subsequent electronics** with EnDat receiver component and **simple connection technology:** Standard connecting element (M12; 8-pin), single-shielded standard cable and low wiring cost.
- **Minimized transmission times** through **high clock frequencies** up to 16 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.

Order designation	Command set	Incremental signals	Clock frequency	Power supply
EnDat 01	EnDat 2.1 or EnDat 2.2	With	≤ 2 MHz	See Specifications of the encoder
EnDat 21		without		
EnDat 02	EnDat 2.2	With	≤ 2 MHz	Extended range 3.6 to 5.25 V or 14 V
EnDat 22	EnDat 2.2	without	≤ 16 MHz	

Specification of the EnDat interface (bold print indicates standard versions)

Versions

The extended EnDat interface version 2.2 is compatible in its communication, command set 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.

Order designation
Indicated on the ID label and can be read out via parameter.

Command set
The command set is the sum of all available mode commands. (See "Selection of transition type"). The EnDat 2.2 command set includes EnDat 2.1 mode commands. When a mode command from the EnDat 2.2 command set is transmitted to EnDat-01 subsequent electronics, the encoder or the subsequent electronics may generate an error message.

Incremental signals
EnDat 2.1 and EnDat 2.2 are both available with or without incremental signals. EnDat 2.2 encoders feature a high internal resolution. Therefore, depending on the control technology being used, interrogation of the incremental signals is not necessary. To increase the resolution of EnDat 2.1 encoders, the incremental signals are interpolated and evaluated in the subsequent electronics.

Power supply
Encoders with ordering designations EnDat 02 and EnDat 22 have an extended power supply range.

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 the Memory Range Select (MRS) code. Other functions such as *Read parameter* and *Write parameter* can also be called after the memory area and address have been selected. Through simultaneous transmission with the position value, additional information can also be requested of axes in the feedback loop, and functions executed with them.

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 is selected.

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

Servicing diagnostics make 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 *EnDat 2.2 Technical Information* document or on the Internet at www.endat.de.

Selecting the Transmission Type

Transmitted data are identified 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 redundant). 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.

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). The subsequent electronics continues to transmit clock pulses and observes the data line to detect the start bit. The **start bit** starts data transmission from the encoder to the subsequent electronics. Time t_{cal} is the smallest time duration time after which the position value can be read by the encoder. The subsequent **error messages,** error 1 and error 2 (only with EnDat 2.2 commands), are group signals for all monitored functions and serve as failure monitors.

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 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.

Mode commands

<table>
<tr><td>• Encoder transmit position value
• Selection of memory area
• Encoder receive parameters
• Encoder transmit parameters
• Encoder receive reset[1]
• Encoder transmit test values
• Encoder receive test command</td><td>EnDat 2.1</td><td rowspan="2">EnDat 2.2</td></tr>
<tr><td colspan="2">• 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]</td></tr>
</table>

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

The time absolute linear encoders need for calculating the position values t_{cal} differs depending on whether EnDat 2.1 or EnDat 2.2 mode commands are transmitted (see *Specifications* in the *Linear Encoders for Numerically Controlled Machine Tools* brochure). If the incremental signals are evaluated for axis control, then the EnDat 2.1 mode commands should be used. Only in this manner can an active error message be transmitted synchronously with the currently requested position value. EnDat 2.1 mode commands should not be used for purely serial position-value transfer for axis control.

		Without delay compensation	With delay compensation
Clock frequency	f_c	100 kHz ... 2 MHz	100 kHz ... 16 MHz
Calculation time for **Position value** **Parameters**	 t_{cal} t_{ac}	 See *Specifications* 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} t_{LO}	0.2 to 10 µs 0.2 to 50 ms/30 µs (with LC)	Pulse width fluctuation HIGH to LOW max. 10%

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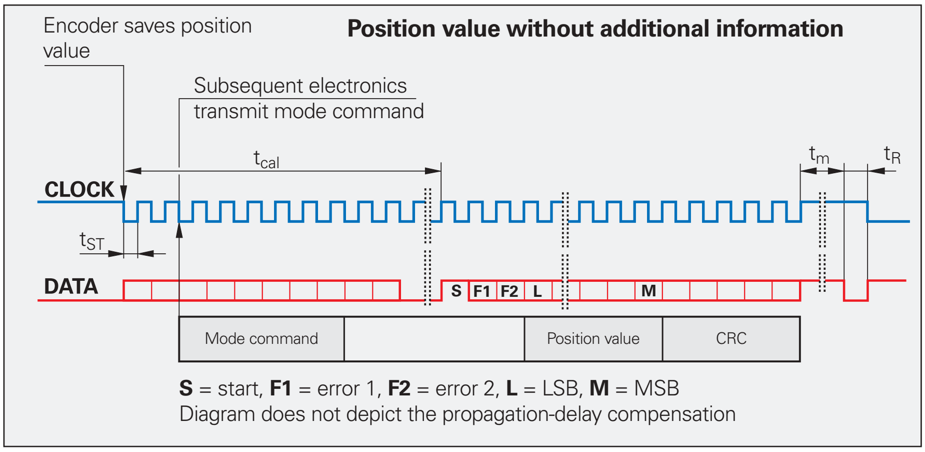
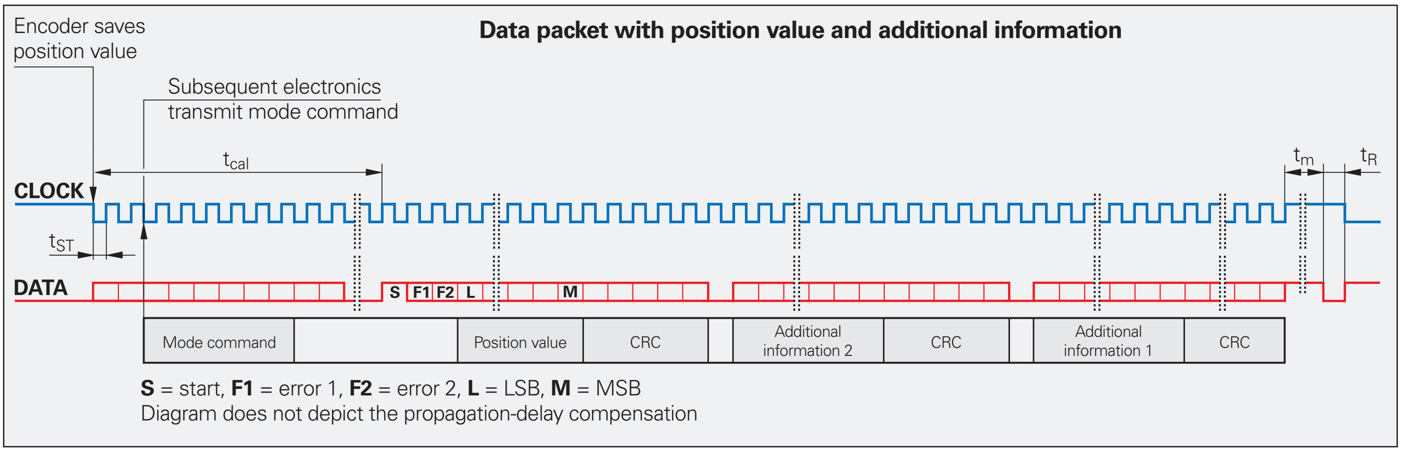
EnDat 2.2 – Transmission of Position Values

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



Position value without additional information

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



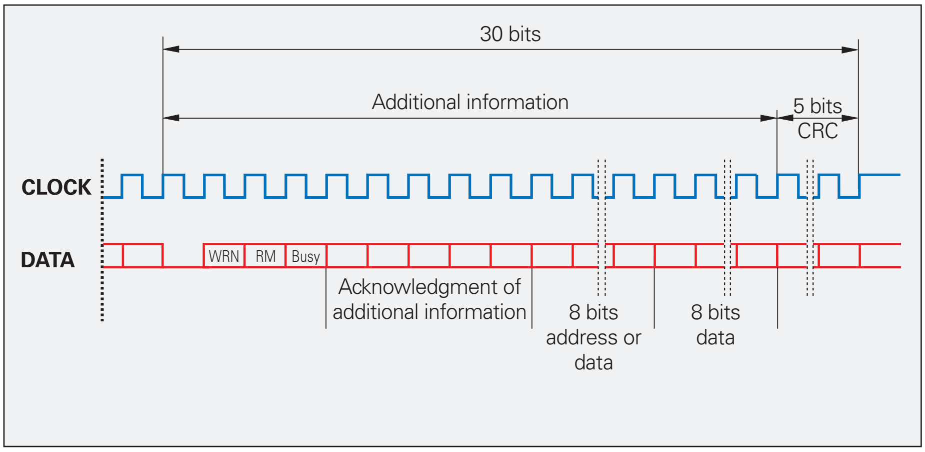
Data packet with position value and additional information

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

Additional information

With EnDat 2.2, one or two pieces of additional information can be appended to the position value. Each additional information is 30 bits long with LOW as first bit, and ends 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 information always begins with:	The additional information can contain the following data:	
Status data Warning – WRN Reference mark – RM Parameter request – busy **Acknowledgment** of additional information	**Additional information 1** Diagnosis (valuation numbers) Position value 2 Memory parameters MRS-code acknowledgment Test values Encoder temperature External temperature sensors Sensor data	**Additional information 2** Commutation Acceleration Limit position signals Operating status error sources

EnDat 2.1—Transmission of Position Values

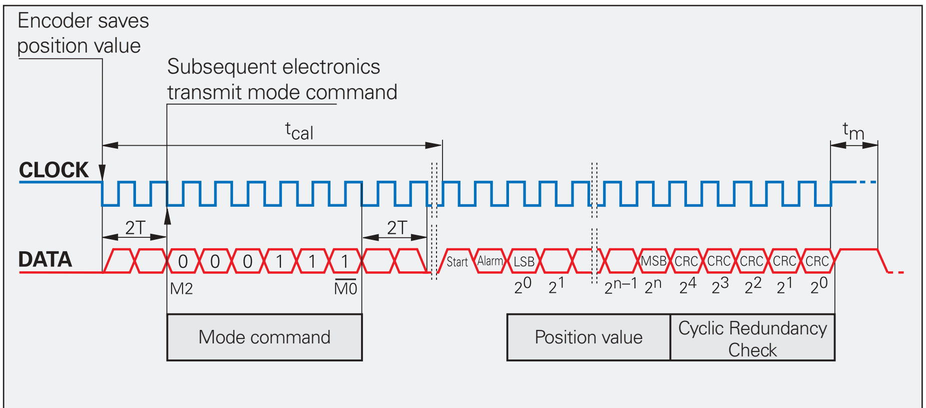
EnDat 2.1 can transmit position values with interrupted clock pulse (as in EnDat 2.2) or continuous clock pulse.

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. A new data transmission can then begin when started by the clock.

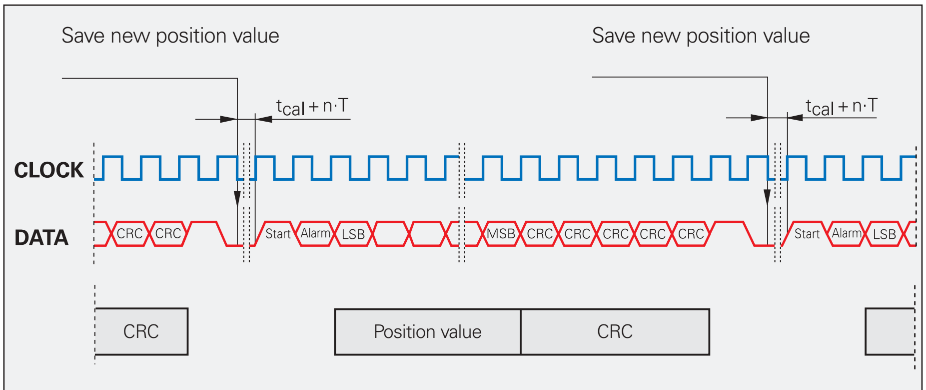
Continuous clock
For applications that require fast acquisition of the measured value, the EnDat interface can have the clock run continuously. Immediately after the last CRC bit has been sent, the data line is switched to high for one clock cycle, and then to low. The new position value is saved with 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 transmit 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 the A/D converters for subdividing the sinusoidal incremental signals in the subsequent electronics.

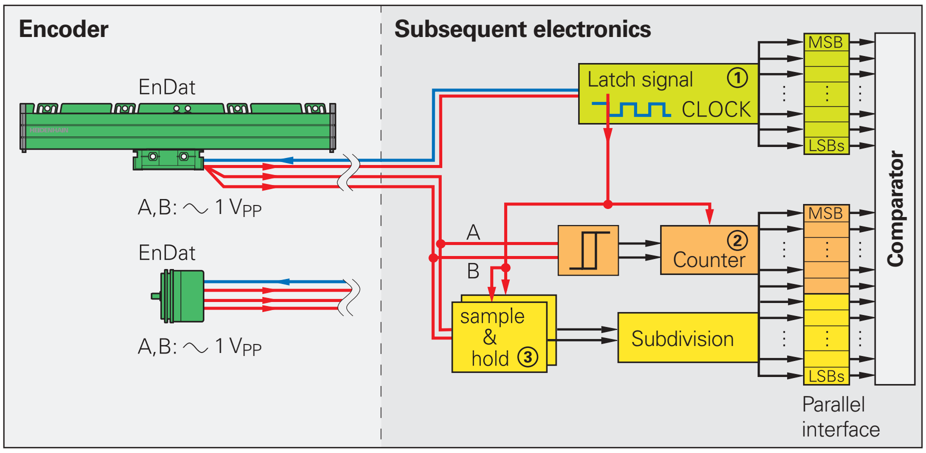
The code value transmitted over the serial interface unambiguously identifies one incremental signal period. The position value is absolute within one sinusoidal period of the incremental signal. The subdivided incremental signal can therefore be appended in the subsequent electronics to the serially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



Interrupted clock



Continuous clock



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 systems.

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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.

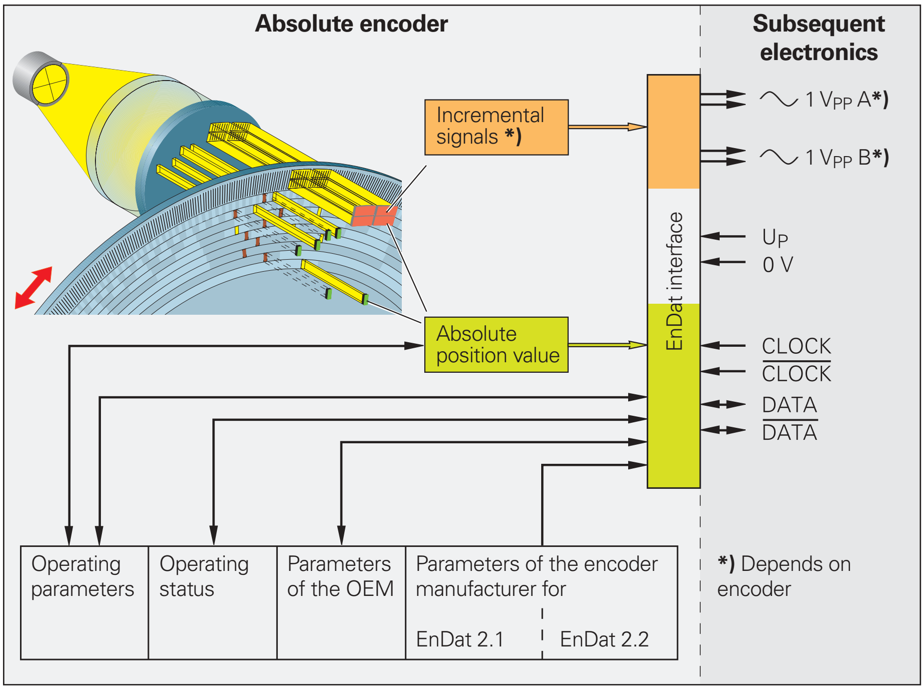
The parameters, which in most cases are set by the OEM, largely define the function of the encoder and the EnDat interface. When the encoder is exchanged, it is therefore essential that its parameter settings are correct. Attempts to configure machines without including OEM data can result in malfunctions. 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, 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 to interrogate their status. Once activated, **the write protection** cannot be reversed.



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.

Error message
An error message becomes active if a **malfunction of the encoder** might result in incorrect position values. The exact cause of the disturbance is saved in the encoder's "operating status" memory. It is also possible to interrogate over the additional information "operating status error sources." 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.

Online diagnostics
Encoders with pure serial interfaces do not provide incremental signals for evaluation of encoder function. EnDat 2.2 encoders can therefore cyclically transmit so-called valuation numbers from the encoder. The valuation numbers provide the current state of the encoder and ascertain the encoder's "functional reserves." The identical scale for all HEIDENHAIN encoders allows uniform valuation. This makes it easier to plan machine use and servicing.

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.

General Electrical Information

Power Supply

The encoders require a **stabilized dc voltage U_P** as power supply. The respective *Specifications* state the required power supply and the current consumption. The permissible ripple content of the dc voltage is:

- High frequency interference $U_{PP} < 250$ mV with $dU/dt > 5$ V/µs
- Low frequency fundamental ripple $U_{PP} < 100$ mV

The values apply as measured at the encoder, i.e., without cable influences. The voltage can be monitored and adjusted with the encoder's **sensor lines.** If a controllable power supply is not available, the voltage drop can be halved by switching the sensor lines parallel to the corresponding power lines.

Calculation of the **line drop:**

$$\Delta U = 2 \cdot 10^{-3} \cdot \frac{L_C \cdot I}{56 \cdot A_P}$$

where ΔU: Line drop in V
L_C: Cable length in m
I: Current consumption in mA
A_P: Cross section of power lines in mm^2

Switch-on/off behavior of the encoders

The output signals are valid no sooner than after switch-on time $t_{SOT} = 1.3$ s (2° s for PROFIBUS-DP) (see diagram). During time t_{SOT} they can have any levels up to 5.5 V (with HTL encoders up to U_{Pmax}). If an interpolation electronics unit is inserted between the encoder and the power supply, the unit's switch-on/off characteristics must also be considered. If the power supply is switched off, or when the supply voltage falls below U_{min}, the output signals are also invalid. This data applies to the encoders listed in the catalog—customized interfaces are not considered.

Encoders with new features and increased performance range may take longer to switch on (longer time t_{SOT}). If you are responsible for developing subsequent electronics, please contact HEIDENHAIN in good time.

Isolation

The encoder housings are isolated against internal circuits.
Rated surge voltage: 500 V
(preferred value as per VDE 0110 Part 1, overvoltage category II, contamination level 2)

Cables

HEIDENHAIN cables are mandatory for **safety-related applications.** The **cable lengths** listed in the *Specifications* apply only for HEIDENHAIN cables and the recommended input circuitry of the subsequent electronics.

Durability

All encoders have polyurethane (PUR) cables. PUR cables are resistant to oil, hydrolysis and microbes in accordance with **VDE 0472.** They are free of PVC and silicone and comply with UL safety directives. The **UL certification** AWM STY LE 20963 80 °C 30 V E63216 is documented on the cable.

Temperature range

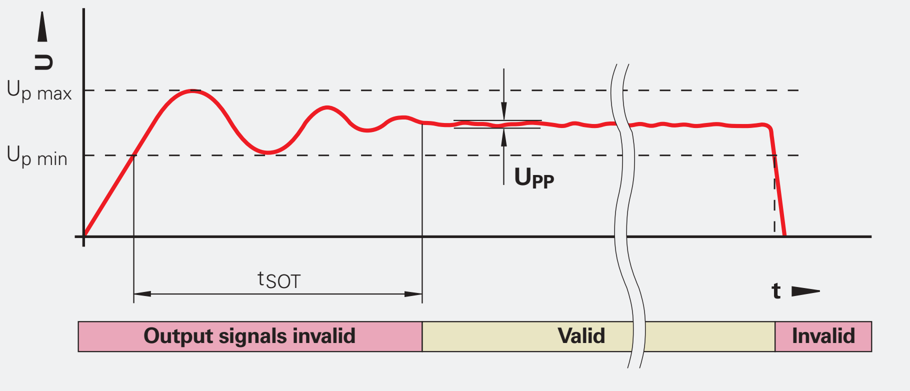
HEIDENHAIN cables can be used for
- rigid configuration –40 °C to 85 °C
- frequent flexing –10 °C to 85 °C

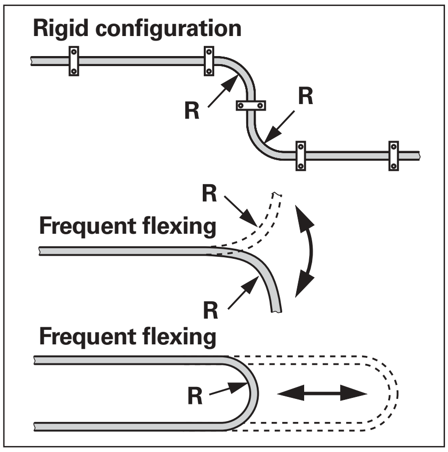
Cables with limited resistance to hydrolysis and microbes are rated for up to 100 °C.
If required, please ask for assistance from HEIDENHAIN Traunreut.

Bend radius

The permissible bend radii R depend on the cable diameter and the configuration:

Initial transient response of the supply voltage and switch-on/switch-off behavior





Connect HEIDENHAIN position encoders only to subsequent electronics whose power supply is generated through double or strengthened insulation against line voltage circuits. Also see **IEC 364-4-41:** 1992, modified Chapter 411 regarding "protection against both direct and indirect touch" (PELV or SELV). If position encoders or electronics are used in safety-related applications, they must be operated with protective extra-low voltage (PELV) and provided with overcurrent protection or, if required, with overvoltage protection.

Cables	**Cross section** of power supply lines A_P				**Bend radius R**	
	1 V_{PP}/TTL/HTL	**11 µA_{PP}**	**EnDat/SSI** 17-pin	**EnDat**[4] 8-pin	**Rigid configuration**	**Frequent flexing**
Ø 3.7 mm	0.05 mm^2	–	–	–	≥ 8 mm	≥ 40 mm
Ø 4.5 mm **Ø 5.1 mm**	0.14/0.05[2] mm^2	0.05 mm^2	0.05 mm^2	0.14 mm^2	≥ 10 mm	≥ 50 mm
Ø 6 mm **Ø 10 mm**[1]	0.19/0.14[3] mm^2	–	0.08 mm^2	0.34 mm^2	≥ 20 mm ≥ 35 mm	≥ 75 mm ≥ 75 mm
Ø 8 mm **Ø 14 mm**[1]	0.5 mm^2	1 mm^2	0.5 mm^2	1 mm^2	≥ 40 mm ≥ 100 mm	≥ 50 mm ≥ 100 mm

[1] Metal armor [2] Length gauges [3] LIDA 400 [4] Also Fanuc, Mitsubishi

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Electrically Permissible Speed/ Traversing Speed

The maximum permissible shaft speed or traversing velocity of an encoder is derived from

- the **mechanically** permissible shaft speed/traversing velocity (if listed in *Specifications*)
  and
- the **electrically** permissible shaft speed or traversing velocity.

  For encoders with **sinusoidal output signals,** the electrically permissible shaft speed or traversing velocity is limited by the –3dB/ –6dB cutoff frequency or the permissible input frequency of the subsequent electronics.

  For encoders with **square-wave signals,** the electrically permissible shaft speed/ traversing velocity is limited by
  – the max. permissible scanning frequency f_{max} of the encoder
  and
  – the min. permissible edge separation a for the subsequent electronics.

For angular or rotary encoders

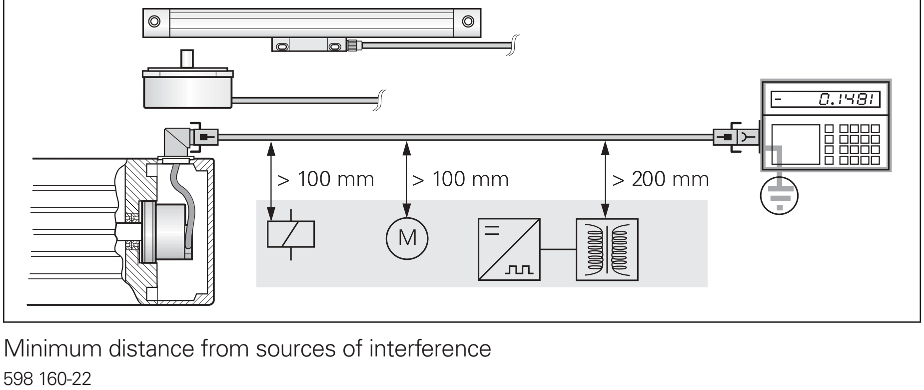
$$n_{max} = \frac{f_{max}}{z} \cdot 60 \cdot 10^3$$

For linear encoders

$$v_{max} = f_{max} \cdot SP \cdot 60 \cdot 10^{-3}$$

and:

n_{max}: Elec. permissible speed in min^{-1}
v_{max}: Elec. permissible traversing velocity in m/min
f_{max}: Max. scanning/output frequency of encoder or input frequency of subsequent electronics in kHz
z: Line count of the angle or rotary encoder per 360°
SP: Signal period of the linear encoder in µm



Minimum distance from sources of interference

Noise-Free Signal Transmission

Electromagnetic compatibility/ CE compliance
When properly installed, and when HEIDENHAIN connecting cables and cable assemblies are used, HEIDENHAIN encoders fulfill the requirements for electromagnetic compatibility according to 2004/108/EC with respect to the generic standards for:

- **Noise immunity EN 61 000-6-2:**
  Specifically:
  – ESD — EN 61 000-4-2
  – Electromagnetic fields — EN 61 000-4-3
  – Burst — EN 61 000-4-4
  – Surge — EN 61 000-4-5
  – Conducted disturbances — EN 61 000-4-6
  – Power frequency magnetic fields — EN 61 000-4-8
  – Pulse magnetic fields — EN 61 000-4-9
- **Interference EN 61 000-6-4:**
  Specifically:
  – For industrial, scientific and medical (ISM) equipment — EN 55 011
  – For information technology equipment — EN 55 022

Transmission of measuring signals— electrical noise immunity
Noise voltages arise mainly through capacitive or inductive transfer. Electrical noise can be introduced into the system over signal lines and input or output terminals.
Possible sources of noise are:

- Strong magnetic fields from transformers, brakes and electric motors
- Relays, contactors and solenoid valves
- High-frequency equipment, pulse devices, and stray magnetic fields from switch-mode power supplies
- AC power lines and supply lines to the above devices

Protection against electrical noise
The following measures must be taken to ensure disturbance-free operation:

- Use only HEIDENHAIN cables.
- Use connectors or terminal boxes with metal housings. Do not conduct any extraneous signals.
- Connect the housings of the encoder, connector, terminal box and evaluation electronics through the shield of the cable. Connect the shielding in the area of the cable outlets to be as induction-free as possible (short, full-surface contact).
- Connect the entire shielding system with the protective ground.
- Prevent contact of loose connector housings with other metal surfaces.
- The cable shielding has the function of an equipotential bonding conductor. If compensating currents are to be expected within the entire system, a separate equipotential bonding conductor must be provided. Also see **EN 50 178**/4.98 Chapter 5.2.9.5 regarding "protective connection lines with small cross section."
- Do not lay signal cables in the direct vicinity of interference sources (inductive consumers such as contacts, motors, frequency inverters, solenoids, etc.).
- Sufficient decoupling from interference-signal-conducting cables can usually be achieved by an air clearance of 100 mm or, when cables are in metal ducts, by a grounded partition.
- A minimum spacing of 200 mm to inductors in switch-mode power supplies is required. See also **EN 50 178**/4.98 Chapter 5.3.1.1, regarding cables and lines, as well as **EN 50 174-2**/09.01, Chapter 6.7, regarding grounding and potential compensation.
- When using **rotary encoders in electromagnetic fields** greater than 30 mT, HEIDENHAIN recommends consulting with the main facility in Traunreut.

Both the cable shielding and the metal housings of encoders and subsequent electronics have a shielding function. The housings must have the **same potential** and be connected to the main signal ground over the machine chassis or by means of a separate potential compensating line. Potential compensating lines should have a minimum cross section of 6 mm^2 (Cu).

For More Information

For more detailed information, mounting instructions, technical specifications and exact dimensions, as well as descriptions of interfaces, please refer to our brochures visit us on the Internet at *www.heidenhain.de*.

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IBV 100, EXE 100 Series

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