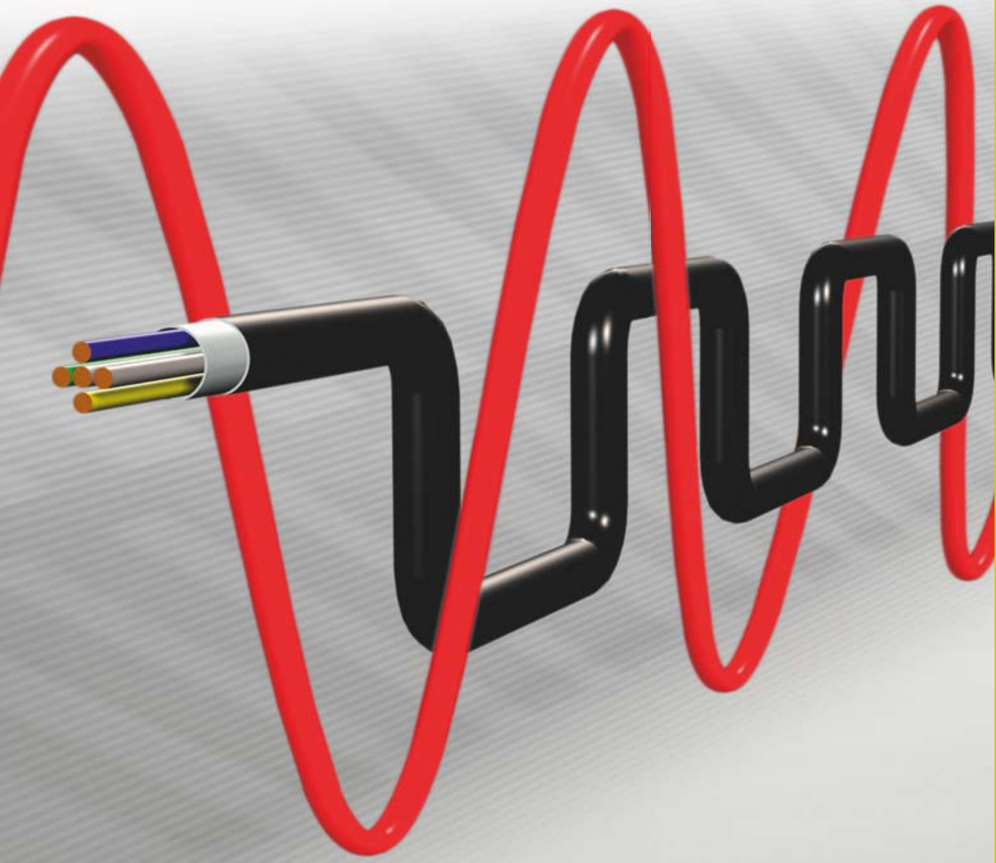
HEIDENHAIN



Interfaces

of HEIDENHAIN Encoders

July 2013

Interfaces

As defined transitions between encoders and subsequent electronics, interfaces ensure the reliable exchange of information.

HEIDENHAIN offers encoders with interfaces for many common subsequent electronics. The interface possible in each respective case depends, among other things, on the measuring method used by the encoder.

Note
Specialized encoders can have other interface properties, such as regarding the shielding.

Measuring methods
In the **incremental measuring method** the position information is obtained **by counting** the individual increments (measuring steps) from some point of origin. Since an absolute reference is necessary in order to determine the positions, a reference-mark signal is output as well. As a general rule, encoders that operate with the incremental measuring method output **incremental signals.** Some incremental encoders with integrated interface electronics also have a counting function: Once the reference mark is traversed, an absolute position value is formed and output via a serial interface.

With the **absolute measuring method** the absolute position information is gained directly **from the graduation of the measuring standard.** The position value is available from the encoder immediately upon switch-on and can be called at any time by the subsequent electronics.

Encoders that operate with the absolute measuring method output **position values.** Some interfaces provide incremental signals as well.

Absolute encoders do not require a reference run, which is advantageous particularly in concatenated manufacturing systems, transfer lines, or machines with numerous axes. Also, they are more resistant to EMC interferences.

Interface electronics
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.

You can find more detailed information in the *Interface Electronics* Product Overview.

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.

Contents

Incremental signals
∿ 1 V_{PP} sinusoidal signals

HEIDENHAIN encoders with ∿ 1 V_{PP} interface provide voltage signals that can be highly interpolated.

The sinusoidal **incremental signals** A and B are phase-shifted by 90° elec. and have an amplitude of typically 1 V_{PP}. The illustrated sequence of output signals—with B lagging A—applies for the direction of motion shown in the dimension drawing.

The **reference mark signal** R has a usable component G of approx. 0.5 V. Next to the reference mark, the output signal can be reduced by up to 1.7 V to a quiescent level H. This must not cause the subsequent electronics to overdrive. Even at the lowered signal level, signal peaks with the amplitude G can also appear.

The data on **signal amplitude** apply when the supply voltage given in the specifications is connected to the encoder. They refer to a differential measurement at the 120 ohm terminating resistor between the associated outputs. The signal amplitude decreases with increasing frequency. The **cutoff frequency** indicates the scanning frequency at which a certain percentage of the original signal amplitude is maintained:

- –3 dB ≙ 70 % of the signal amplitude
- –6 dB ≙ 50 % of the signal amplitude

The data in the signal description apply to motions at up to 20 % of the –3 dB cutoff frequency.

Interpolation/resolution/measuring step
The output signals of the 1 V_{PP} interface are usually interpolated in the subsequent electronics in order to attain sufficiently high resolutions. For **velocity control,** interpolation factors are commonly over 1000 in order to receive usable information even at low rotational or linear velocities.

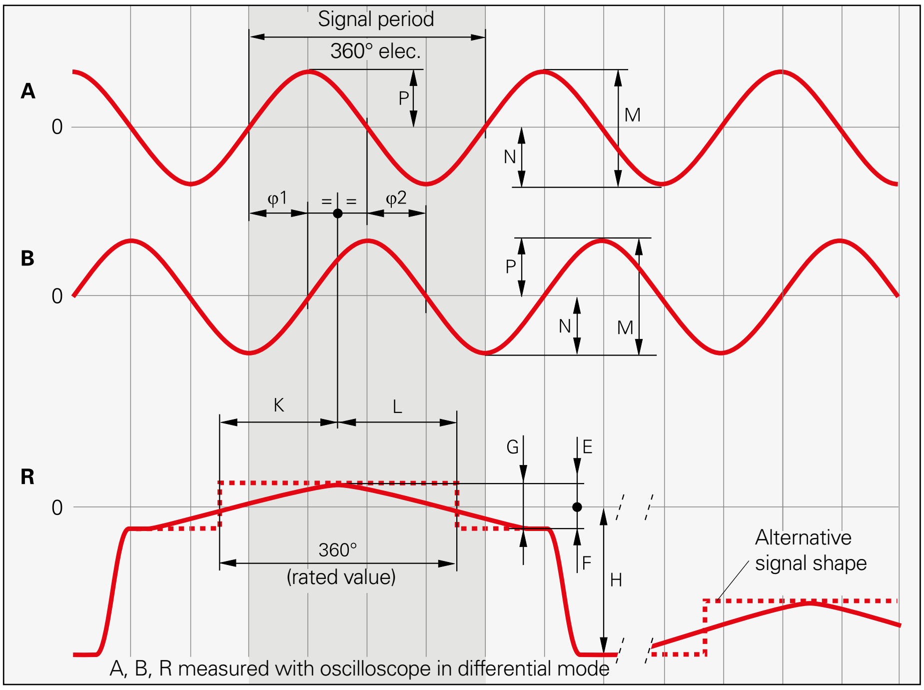
Measuring steps for **position measurement** are recommended in the specifications. For special applications, other resolutions are also possible.

Short-circuit stability
A temporary short circuit of one signal output to 0 V or U_P (except encoders with U_{Pmin} = 3.6 V) does not cause encoder failure, but it is not a permissible operating condition.

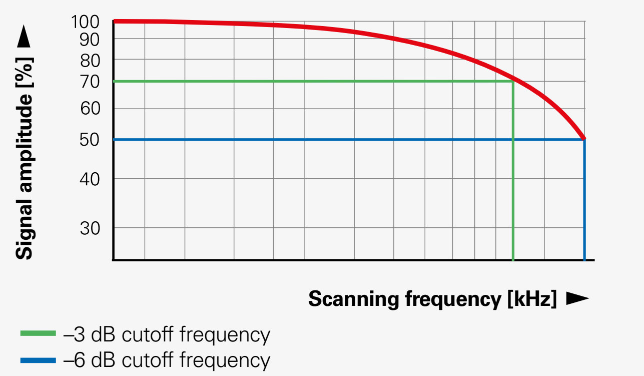
Short circuit at	20 °C	125 °C
One output	< 3 min	< 1 min
All outputs	< 20 s	< 5 s

Interface	Sinusoidal voltage signals ∿ **1 V_{PP}**	
Incremental signals	**Two nearly sinusoidal signals A and B**	
	Signal amplitude M:	0.6 to 1.2 V_{PP}; typically 1 V_{PP}
	Asymmetry |P – N|/2M:	≤ 0.065
	Amplitude ratio M_A/M_B:	0.8 to 1.25
	Phase angle |φ1 + φ2|/2:	90° ± 10° elec.
Reference mark signal	**One or several signal peaks R**	
	Usable component G:	≥ 0.2 V
	Quiescent value H:	≤ 1.7 V
	Switching threshold E, F:	0.04 V to 0.68 V
	Zero crossovers K, L:	180° ± 90° elec.
Connecting cable	Shielded HEIDENHAIN cable	
	For example PUR [4(2 x 0.14 mm^2) + (4 x 0.5 mm^2)]	
Cable length	Max. 150 m at 90 pF/m distributed capacitance	
Propagation time	6 ns/m	

These values can be used for dimensioning of the subsequent electronics. Any limited tolerances in the encoders are listed in the specifications. For encoders without integral bearing, reduced tolerances are recommended for initial operation (see the mounting instructions).



Cutoff frequency
Typical signal amplitude curve with respect to the scanning frequency (depends on encoder)

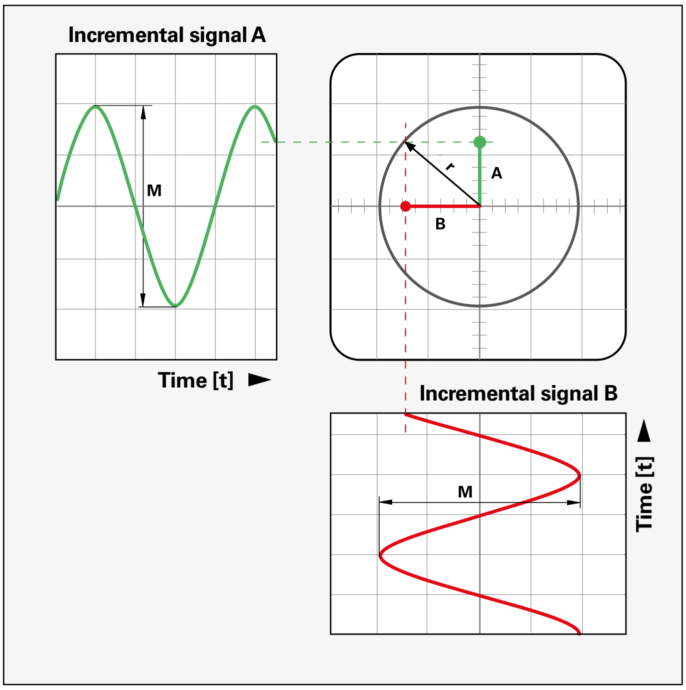


Monitoring of the incremental signals
The following sensitivity levels are recommended for monitoring the signal amplitude M:
Lower threshold: 0.30 V_{PP}
Upper threshold: 1.35 V_{PP}

The height of the incremental signals can be monitored, for example by the length of the resulting position indicator: The oscilloscope shows the output signals A and B as a Lissajous figure in the XY graph. Ideal sinusoidal signals produce a circle with the diameter M. In this case the position indicator *r* shown corresponds to ½M. The formula is therefore

$$r = \sqrt{(A^2 + B^2)}$$

with the condition 0.3 V < 2r < 1.35 V.



Input circuitry of subsequent electronics

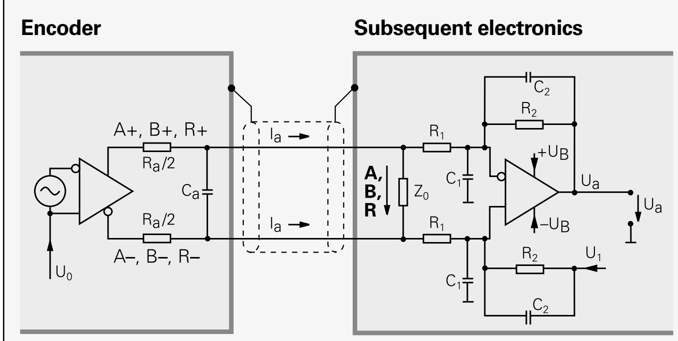
Dimensioning
Operational amplifier, e.g. MC 34074
$Z_0 = 120\ \Omega$
$R_1 = 10\ k\Omega$ and $C_1 = 100$ pF
$R_2 = 34.8\ k\Omega$ and $C_2 = 10$ pF
$U_B = \pm 15$ V
U_1 approx. U_0

–3 dB cutoff frequency of circuitry
Approx. 450 kHz
Approx. 50 kHz with $C_1 = 1000$ pF
and $C_2 = 82$ pF
The circuit variant for 50 kHz does reduce the bandwidth of the circuit, but in doing so it improves its noise immunity.

Circuit output signals
$U_a = 3.48\ V_{PP}$ typically
Gain 3.48

Incremental signals
Reference mark signal

$R_a < 100\ \Omega$,
typically 24 Ω
$C_a < 50$ pF
$\Sigma I_a < 1$ mA
$U_0 = 2.5\ V \pm 0.5\ V$
(relative to 0 V of the supply voltage)



Input circuitry of subsequent electronics for high signal frequencies

For encoders with high signal frequencies (e.g. LIP 281), a special input circuitry is required.

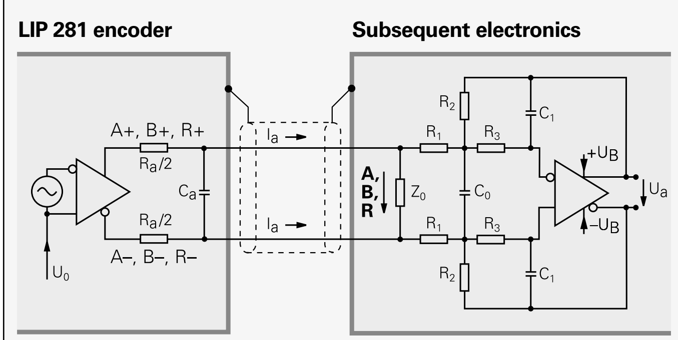
Dimensioning
Operational amplifier, e.g. AD 8138
$Z_0 = 120\ \Omega$
$R_1 = 681\ \Omega$; $R_2 = 1\ k\Omega$; $R_3 = 464\ \Omega$
$C_0 = 15$ pF; $C_1 = 10$ pF
$+U_B = 5$ V; $-U_B = 0$ V or –5 V

–3 dB cutoff frequency of circuitry
Approx. 10 MHz

Circuit output signals
$U_a = 1.47\ V_{PP}$ typically
Gain 1.47

Incremental signals
Reference mark signal

$R_a < 100\ \Omega$,
typically 24 Ω
$C_a < 50$ pF
$\Sigma I_a < 1$ mA
$U_0 = 2.5\ V \pm 0.5\ V$
(relative to 0 V of the supply voltage)



Incremental signals

∿ 11 µApp sinusoidal signals

HEIDENHAIN encoders with ∿ 11 µApp interface provide current signals. They are intended for connection to ND position display units or EXE pulse-shaping electronics from HEIDENHAIN.

The sinusoidal **incremental signals** I_1 and I_2 are phase-shifted by 90° elec. and have signal levels of approx. 11 µApp. The illustrated sequence of output signals—with I_2 lagging I_1—applies to the direction of motion shown in the dimension drawing, and for retracting plungers of length gauges.

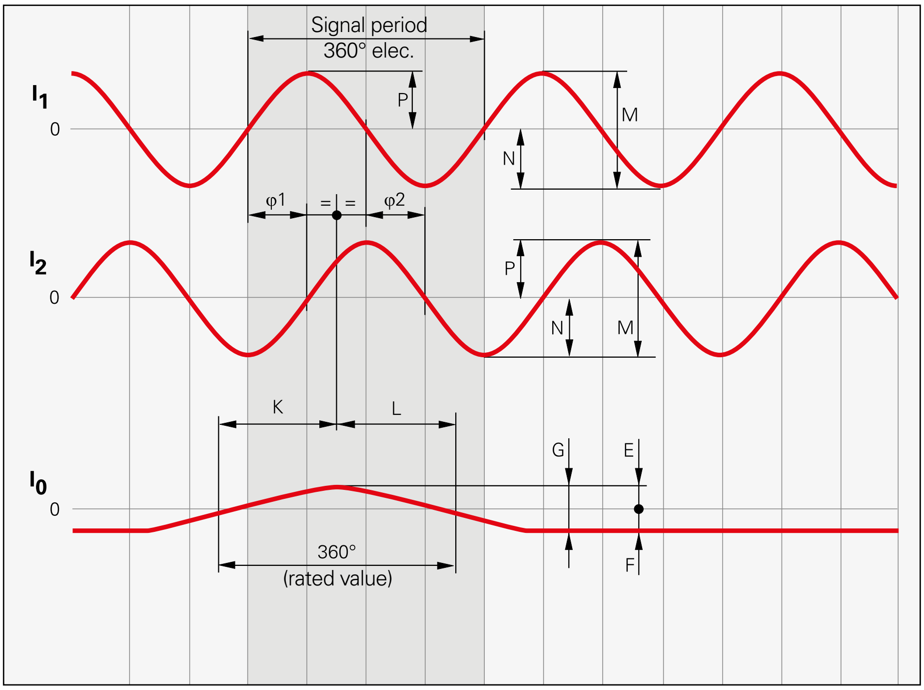
The **reference mark signal** I_0 has a usable component G of approx. 5.5 µA.

The data on **signal amplitude** apply when the supply voltage given in the *Specifications* is connected at the encoder. They refer to a differential measurement between the associated outputs. The signal amplitude decreases with increasing frequency. The **cutoff frequency** indicates the scanning frequency at which a certain percentage of the original signal amplitude is maintained:

- –3 dB cutoff frequency: 70 % of the signal amplitude
- –6 dB cutoff frequency: 50 % of the signal amplitude

Interpolation/resolution/measuring step
The output signals of the 11 µApp interface are usually interpolated in the subsequent electronics—ND position displays or EXE pulse-shaping electronics from HEIDENHAIN— in order to attain sufficiently high resolutions.

Interface	Sinusoidal current signals ∿ **11 µApp**	
Incremental signals	**Two nearly sinusoidal signals I_1 and I_2**	
	Signal amplitude M:	7 to 16 µApp/typically 11 µApp
	Asymmetry IP – NI/2M:	≤ 0.065
	Amplitude ratio M_A/M_B:	0.8 to 1.25
	Phase angle $\lvert\varphi 1 + \varphi 2\rvert/2$:	90° ± 10° elec.
Reference mark signal	**One or more signal peaks I_0**	
	Usable component G:	2 µA to 8.5 µA
	Switching threshold E, F:	≥ 0.4 µA
	Zero crossovers K, L:	180° ± 90° elec.
Connecting cable	Shielded HEIDENHAIN cable PUR [3(2 · 0.14 mm^2) + (2 · 1 mm^2)]	
Cable length	Max. 30 m with 90 pF/m distributed capacitance	
Propagation time	6 ns/m	



⊓⊔TTL square-wave signals

HEIDENHAIN encoders with ⊓⊔TTL interface incorporate electronics that digitize sinusoidal scanning signals with or without interpolation.

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 **inverted 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 to the direction of motion shown in the dimension drawing.

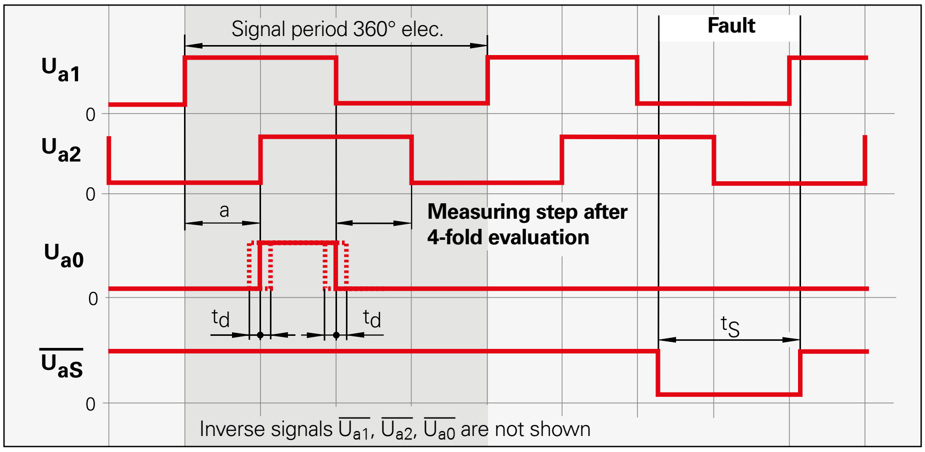
The **fault-detection signal** $\overline{U_{aS}}$ indicates fault conditions such as breakage of the power line or failure of the light source. It can be used for such purposes as machine shut-off during automated production.

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.**

The subsequent electronics must be designed to detect each edge of the square-wave pulse. The minimum **edge separation a** stated in the Specifications applies for the specified input circuit with a cable length of 1 m and refers to a measurement at the output of the differential line receiver.

Note
Not all encoders output a reference mark signal, fault-detection signal, or their inverted signals. Please see the connector layout for this.

Interface	Square-wave signals **⊓⊔TTL**
Incremental signals	**Two 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	**One or more TTL square-wave pulses U_{a0}** and their inverted pulses **$\overline{U_{a0}}$** 90° elec. (other widths available on request) $\lvert t_d \rvert \leq 50$ ns
Fault-detection signal Pulse width	**One TTL square-wave pulse $\overline{U_{aS}}$** Improper function: LOW (upon request: U_{a1}/U_{a2} high impedance) Proper function: HIGH $t_S \geq 20$ ms
Signal amplitude	Differential line driver as per EIA standard RS-422
Permissible load	$Z_0 \geq 100\ \Omega$ Between associated outputs $\lvert I_L \rvert \leq 20$ mA Max. load per output (*ERN 1x23:* 10 mA) $C_{load} \leq 1000$ pF With respect to 0 V Outputs protected against short circuit to 0 V
Switching times (10 % to 90 %)	$t_+ / t_- \leq 30$ ns (typically 10 ns) with 1 m cable and recommended input circuitry
Connecting cable Cable length Propagation time	Shielded HEIDENHAIN cable For example PUR [4(2 × 0.14 mm²) + (4 × 0.5 mm²)] Max. 100 m ($\overline{U_{aS}}$ max. 50 m) at distributed capacitance 90 pF/m Typically 6 ns/m



Clocked output signals are typical for encoders and interpolation electronics with 5-fold interpolation (or greater). They derive the edge separation a from an internal clock source. At the same time, the clock frequency determines the permissible input frequency of the incremental signals (1 V_{PP} or 11 μA_{PP}) and the resulting maximum permissible traversing velocity or shaft speed:

$$a_{nom} = \frac{1}{4 \cdot IPF \cdot fe_{nom}}$$

a_{nom} nominal edge separation
IPF interpolation factor
fe_{nom} nominal input frequency

The tolerances of the internal clock source have an influence on the edge separation a of the output signal and the input frequency f_e, thereby influencing the traversing velocity or shaft speed.

The data for edge separation already takes these tolerances into account with 5 %: Not the nominal edge separation is indicated, but rather the minimum edge separation a_{min}.

On the other hand, the maximum permissible input frequency must consider a tolerance of at least 5 %. This means that the maximum permissible traversing velocity or shaft speed are also reduced accordingly.

Encoders and interpolation electronics without interpolation in general **do not have 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.

Cable-dependent differences in the propagation time additionally reduce the edge separation by 0.2 ns per meter of cable. To prevent counting errors, a safety margin of 10 % must be considered, and the subsequent electronics so designed that they can process as little as 90 % of the resulting edge separation.

Please note:
The max. permissible **shaft speed** or **traversing velocity** must never be exceeded, since this would result in an irreversible counting error.

Calculation example 1
LIDA 400 linear encoder
Requirements: display step 0.5 µm, traversing velocity 1 m/s, output signals TTL, cable length to subsequent electronics 25 m.
What minimum edge separation must the subsequent electronics be able to process?

Selection of the interpolation factor

20 µm grating period : 0.5 µm display step =	40-fold subdivision
Evaluation in the subsequent electronics	4-fold
Interpolation	**10-fold**

Selection of the edge separation

Traversing velocity	60 m/min (corresponds to 1 m/s)
+ tolerance value 5 %	63 m/min
Select in specifications:	
Next LIDA 400 version	120 m/min (from specifications)
Minimum edge separation	**0.22 µs** (from specifications)

Determining the edge separation that the subsequent electronics must process

Subtract cable-dependent differences in the propagation time	0.2 ns per meter
For cable length = 25 m	5 ns
Resulting edge separation	0.215 µs
Subtract 10 % safety margin	0.022 µs
Minimum edge separation for the subsequent electronics	**0.193 µs**

Calculation example 2
ERA 4000 angle encoder with 32 768 lines
Requirements: measuring step 0.1", output signals TTL (IBV external interface electronics necessary), cable length from IBV to subsequent electronics = 20 m, minimum edge separation that the subsequent electronics can process = 0.5 µs (input frequency = 2 MHz).
What rotational speed is possible?

Selection of the interpolation factor

32 768 lines corresponds to	40" signal period
Signal period 40" : measuring step 0.1" =	400-fold subdivision
Evaluation in the subsequent electronics	4-fold
Interpolation in the IBV	**100-fold**

Calculation of the edge separation

Permissible edge separation of the subsequent electronics	0.5 µs
This corresponds to 90 % of the resulting edge separation	
This leads to: Resulting edge separation	0.556 µs
Subtract cable-dependent differences in the propagation time	0.2 ns per meter
For cable length = 20 m	4 ns
Minimum edge separation of IBV 102	**≥ 0.56 µs**

Selecting the input frequency
According to the Product Information, the input frequencies and therefore the edge separations a of the IBV 102 can be set.

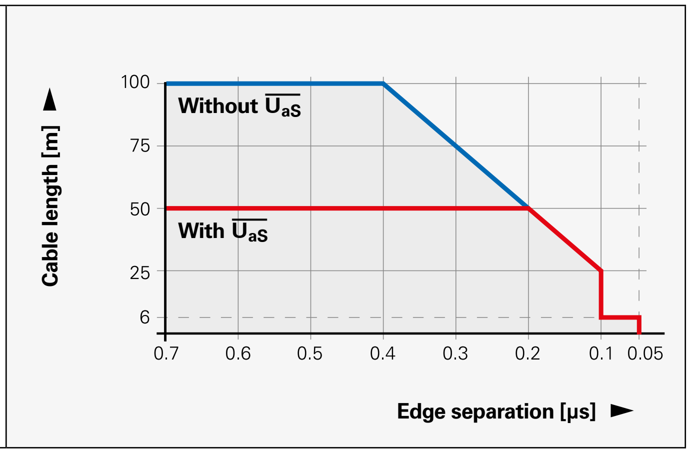
Next suitable edge separation	0.585 µs
Input frequency at 100-fold interpolation	**4 kHz**

Calculating the permissible shaft speed
Subtract 5 % tolerance 3.8 kHz
This is 3800 signals per second or 228 000 signals per minute.
Meaning for 32 768 lines of the ERA 4000:
Max. permissible rotational speed **6.95 rpm**

The permissible **cable length** for transmission of the TTL square-wave signals to the subsequent electronics depends on the edge separation a. It is at most 100 m, or 50 m for the fault detection signal. This requires, however, that the voltage 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 control system (remote sense voltage supply).

Greater cable lengths can be provided upon consultation with HEIDENHAIN.

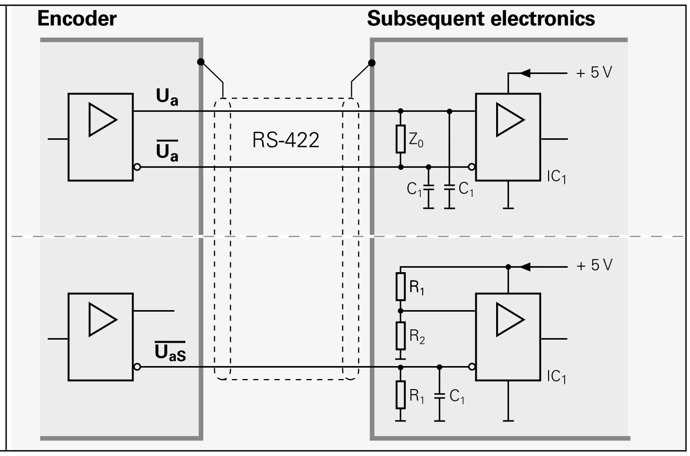
Permissible cable length
with respect to the edge separation



Input circuitry of subsequent electronics

Incremental signals
Reference mark signal

Fault-detection signal



Dimensioning

IC_1 = Recommended differential line receiver
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
HTL square-wave signals

HEIDENHAIN encoders with HTL interface incorporate electronics that digitize sinusoidal scanning signals with or without interpolation.

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 **inverted signals** $\overline{U_{a1}}$, $\overline{U_{a2}}$ and $\overline{U_{a0}}$ for noise-proof transmission (does not apply to HTLs).

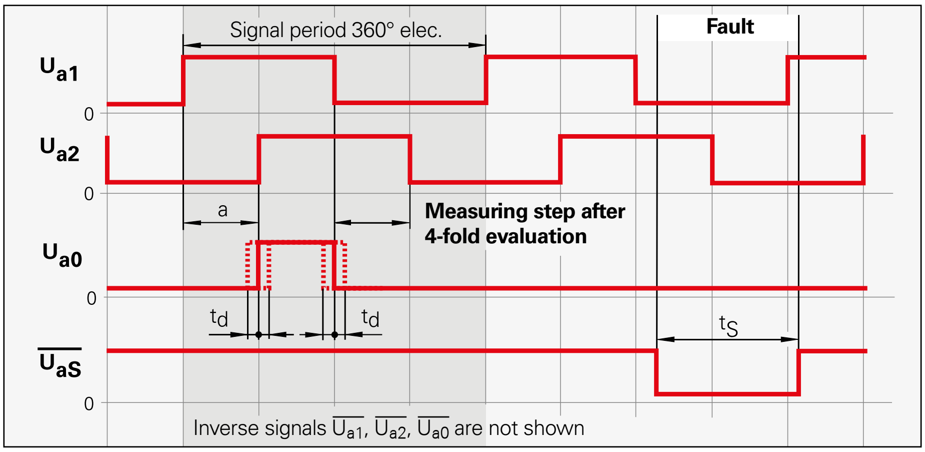
The illustrated sequence of output signals—with U_{a2} lagging U_{a1}—applies to the direction of motion shown in the dimension drawing.

The **fault-detection signal** $\overline{U_{aS}}$ indicates fault conditions such as 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.**

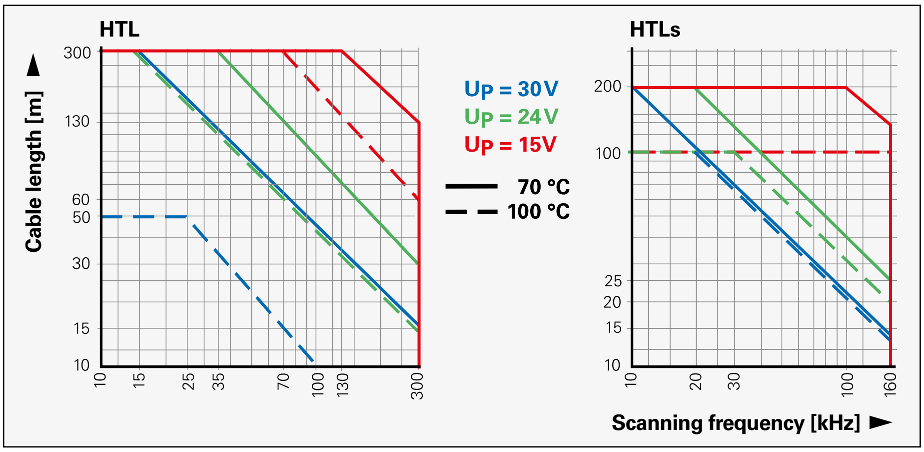
The subsequent electronics must be designed to detect each edge of the square-wave pulse. The minimum **edge separation a** listed in the *Specifications* refers to a measurement at the output of the given differential input circuitry. To prevent counting errors, the subsequent electronics should be designed so that they can process as little as 90% of the edge separation a.
The maximum permissible **shaft speed** or **traversing velocity** must never be exceeded.

Interface	Square-wave signals **HTL, HTLs**
Incremental signals	**Two HTL square-wave signals U_{a1}, U_{a2}** and their inverted signals $\overline{U_{a1}}$, $\overline{U_{a2}}$ (*HTLs* without $\overline{U_{a1}}$, $\overline{U_{a2}}$)
Reference mark signal Pulse width Delay time	**One or more HTL square-wave pulses U_{a0}** and their inverted pulses $\overline{U_{a0}}$ (*HTLs* without $\overline{U_{a0}}$) 90° elec. (other widths available on request) $\|t_d\| \leq 50$ ns
Fault-detection signal Pulse width	**One HTL square-wave pulse $\overline{U_{aS}}$** Improper function: LOW Proper function: HIGH $t_S \geq 20$ ms
Signal levels	$U_H \geq 21$ V at $-I_H = 20$ mA; $U_L \leq 2.8$ V at $I_L = 20$ mA — With voltage supply of $U_P = 24$ V, without cable
Permissible load	$\|I_L\| \leq 100$ mA — Max. load per output, (except $\overline{U_{aS}}$) $C_{load} \leq 10$ nF — With respect to 0 V Outputs short-circuit proof for max. 1 minute to 0 V and U_P (except $\overline{U_{aS}}$)
Switching times (10 % to 90 %)	$t_+/t_- \leq 200$ ns (except $\overline{U_{aS}}$) with 1 m cable and recommended input circuitry
Connecting cable Cable length Propagation time	HEIDENHAIN cable with shielding e.g. PUR [4(2 × 0.14 mm²) + (4 × 0.5 mm²)] Max. 300 m (*HTLs* max. 100 m) at distributed capacitance 90 pF/m 6 ns/m



The permissible **cable length** for incremental encoders with HTL signals depends on the scanning frequency, the effective supply voltage, and the operating temperature of the encoder.

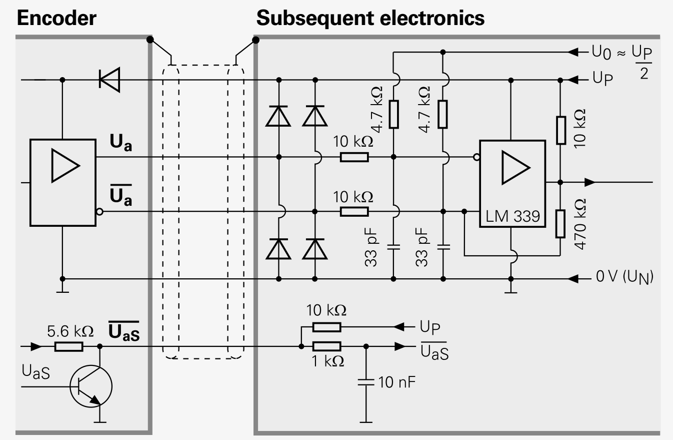
The **current requirement** of encoders with HTL output signals depends on the output frequency and the cable length to the subsequent electronics.



Input circuitry of subsequent electronics HTL

Incremental signals
Reference mark signal

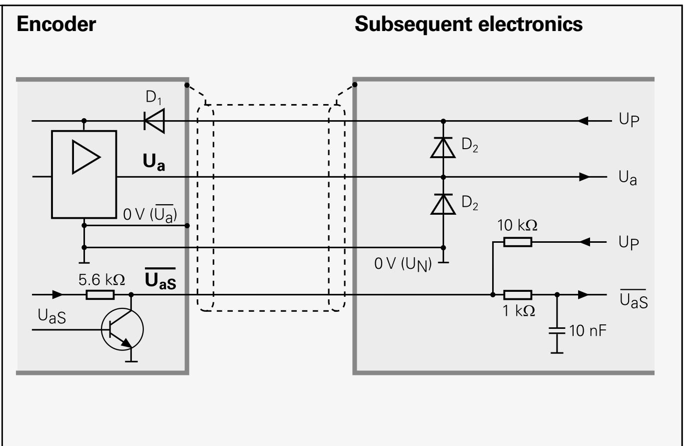
Fault-detection signal



HTLs

Incremental signals
Reference mark signal

Fault-detection signal



Position values
EnDat serial interface

Interface	**EnDat** serial bidirectional
Data transfer	Position values, parameters and additional data
Data input	Differential line receiver according to EIA standard RS 485 for the signals CLOCK, $\overline{\text{CLOCK}}$, DATA and $\overline{\text{DATA}}$
Data output	Differential line driver according to EIA standard RS 485 for the signals DATA and $\overline{\text{DATA}}$
Position values	Ascending during traverse in direction of arrow (see dimensions of the encoders)
Incremental signals	Depends on encoder ∼ 1 V_{PP}, TTL, HTL (see the respective Incremental signals)

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

History and compatibility
The EnDat 2.1 interface available since the mid-90s has since been upgraded to the EnDat 2.2 version (recommended for new applications). EnDat 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 data (e.g. sensor values, diagnostics, etc.) with the position value without sending a separate request for it. This permits support of additional encoder types (e.g. with battery buffer, incremental encoders, etc.). The interface protocol was expanded and the time conditions (clock frequency, processing time, recovery time) were optimized.

Supported encoder types
The following encoder types are currently supported by the EnDat 2.2 interface (this information can be read out from the encoder's memory area):
- Incremental linear encoder
- Absolute linear encoder
- Rotational incremental singleturn encoder
- Rotational absolute singleturn encoder
- Multiturn rotary encoder
- Multiturn rotary encoder with battery buffer

In some cases, parameters must be interpreted differently for the various encoder types (see EnDat Specifications) or EnDat additional data must be processed (e.g. incremental or battery-buffered encoders).

Order designations
The order designations define the central specifications and give information about:
- Typical power supply range
- Command set
- Availability of incremental signals
- Maximum clock frequency

The second character of the order designation identifies the interface generation. For encoders of the current generation the order designation can be read out from the encoder memory.

Incremental signals
Some encoders also provide incremental signals. These are usually used to increase the resolution of the position value, or to serve a second subsequent electronics unit. Current generations of encoders have a high internal resolution, and therefore no longer need to provide incremental signals. The order designation indicates whether an encoder outputs incremental signals:
- EnDat 01 with 1 V_{PP} incremental signals
- EnDat Hx with HTL incremental signals
- EnDat Tx with TTL incremental signals
- EnDat 21 without incremental signals
- EnDat 02 with 1 V_{PP} incremental signals
- EnDat 22 without incremental signals

Notes on EnDat 01, 02:
The signal period is stored in the encoder memory

Notes on EnDat Hx, Tx:
The encoder-internal subdivision of the incremental signal is indicated by the order designation:
Ha, Ta: 2-fold interpolation
Hb, Tb: No interpolation
Hc: Scanning signals x 2

Voltage supply
The typical voltage supply of the encoders depends on the interface:

EnDat 01 EnDat 21	5 V ± 0.25 V
EnDat 02 EnDat 22	3.6 V to 5.25 V or 14 V
EnDat Hx	10 V to 30 V
EnDat Tx	4.75 V to 30 V

Exceptions are documented in the Specifications.

Command set
The command set describes the available mode commands, which define the exchange of information between the encoder and the subsequent electronics. The EnDat 2.2 command set includes all EnDat 2.1 mode commands. In addition, EnDat 2.2 permits further mode commands for the selection of additional data, and makes memory accesses possible even in a closed control loop. When a mode command from the EnDat 2.2 command set is transmitted to an encoder that only supports the EnDat 2.1 command set, an error message is generated. The supported command set is stored in the encoder's memory area:
- EnDat 01, 21, Hx, Tx Command set 2.1 or 2.2
- EnDat 02, 22 Command set 2.2

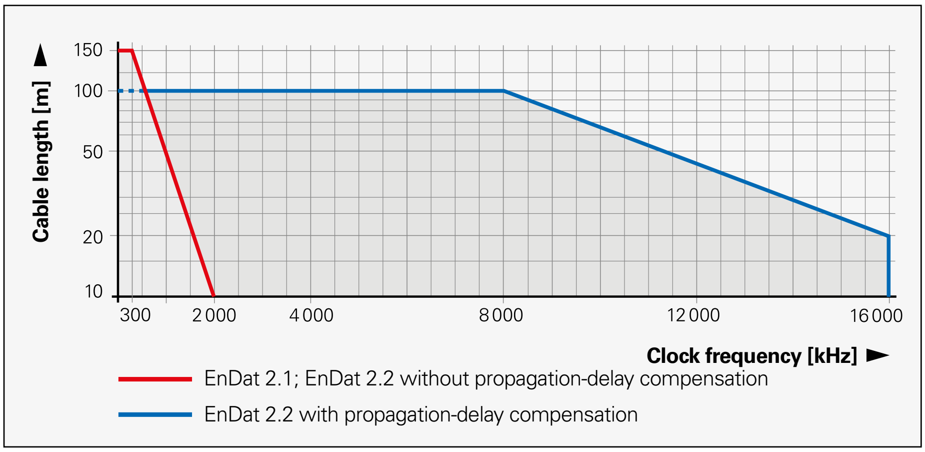
For more information, refer to the *EnDat* Technical Information sheet or visit *www.endat.de*.

Clock frequency
The clock frequency is variable—depending on the cable length (max. 150 m)—between 100 kHz and 2 MHz. With propagation-delay compensation in the subsequent electronics, either clock frequencies up to 16 MHz are possible or cable lengths up to 100 m. For EnDat encoders with order designation EnDat x2 the maximum clock frequency is stored in the encoder memory. For all other encoders the maximum clock frequency is 2 MHz. Propagation-delay compensation is provided only for order designations EnDat 21 and EnDat 22; for EnDat 02, see the notes below.

EnDat 01 EnDat Tx EnDat Hx	≤ 2 MHz (see "without propagation-delay compensation" in the diagram)
EnDat 21	≤ 2 MHz
EnDat 02	≤ 2 MHz or ≤ 8 MHz or 16 MHz (see notes)
EnDat 22	≤ 8 MHz or 16 MHz

Transmission frequencies up to 16 MHz in combination with large cable lengths place high technological demands on the cable. Due to the data transfer technology, the adapter cable connected directly to the encoder must not be longer than 20 m. Greater cable lengths can be realized with an adapter cable no longer than 6 m and an extension cable. As a rule, the entire transmission path must be designed for the respective clock frequency.

Notes on EnDat 02
EnDat 02 encoders typically have a pluggable cable assembly (e.g. LC 415). In choosing the version of the adapter cable, the customer also decides whether the encoder will be operated with incremental signals or without them. This also affects the maximum possible clock frequency. For adapter cables with incremental signals the clock frequency is limited to at most 2 MHz; see EnDat 01. For adapter cables without incremental signals the clock frequency can be up to 16 MHz. The exact values are stored in the encoder's memory.



Under certain conditions, cable lengths up to 300 m are possible after consultation with HEIDENHAIN

Position values can be transmitted with or without additional data. The EnDat 2.2 interface can interrogate the position and additional data, and also perform functions (e.g. read/write parameters, reset error messages, etc.), all within the closed loop.

Functional safety – Basic principle
EnDat 2.2 strictly supports the use of encoders in safety-related applications. The DIN EN ISO 13 849-1 (previously EN 954-1), EN 61 508 and EN 61 800-5-2 standards serve as the foundation for this. These standards describe the assessment of safety-oriented systems, for example based on the failure probabilities of integrated components and subsystems. The modular approach helps manufacturers of safety-related systems to implement their complete systems, because they can begin with prequalified subsystems.

Memory areas

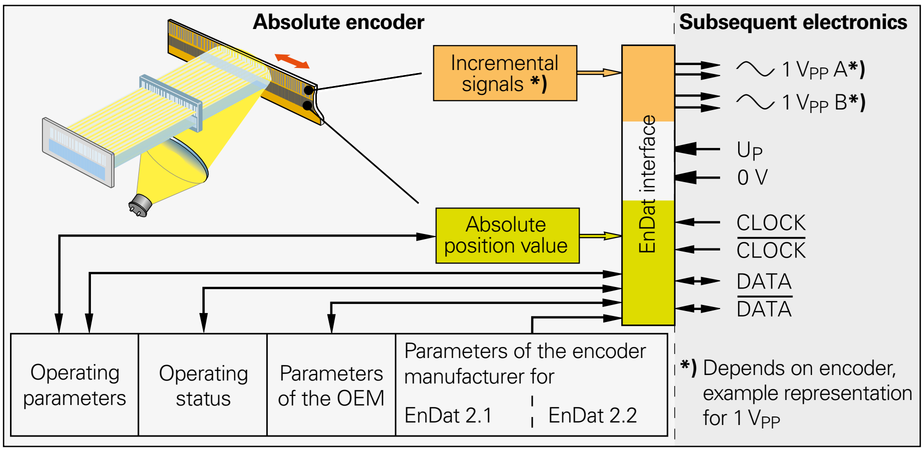
The encoder provides several memory areas for parameters. These can be read from by the subsequent electronics, and some can be written to by the encoder manufacturer, the OEM, or even the end user. The parameter data are stored in a permanent memory, which permits approximately 100 000 write-accesses. Certain memory areas can be write-protected (this can only be reset by the encoder manufacturer).

Parameters are saved in various memory areas, e.g.:

- Encoder-specific information
- Information of the OEM (e.g. "electronic ID label" of the motor)
- Operating parameters (datum shift, instruction, etc.)
- Operating status (alarm or warning messages)

Monitoring and diagnostic functions of the EnDat interface make a detailed inspection of the encoder possible.

- Error messages
- Warnings
- Online diagnostics based on valuation numbers (EnDat 2.2)
- Mounting interface



Additional data

One or two items of additional data can be appended to the position value, depending on the type of transmission (selection via MRS code). The additional data supported by the respective encoder is saved in the encoder parameters.
The additional data contains:

Status information, addresses and data

- WRN—warnings
- RM—reference marks
- Busy—parameter request

Additional data 1

- Diagnosis
- Position value 2
- Memory parameters
- MRS-code acknowledgment
- Test values
- Temperature
- Additional sensors

Additional data 2

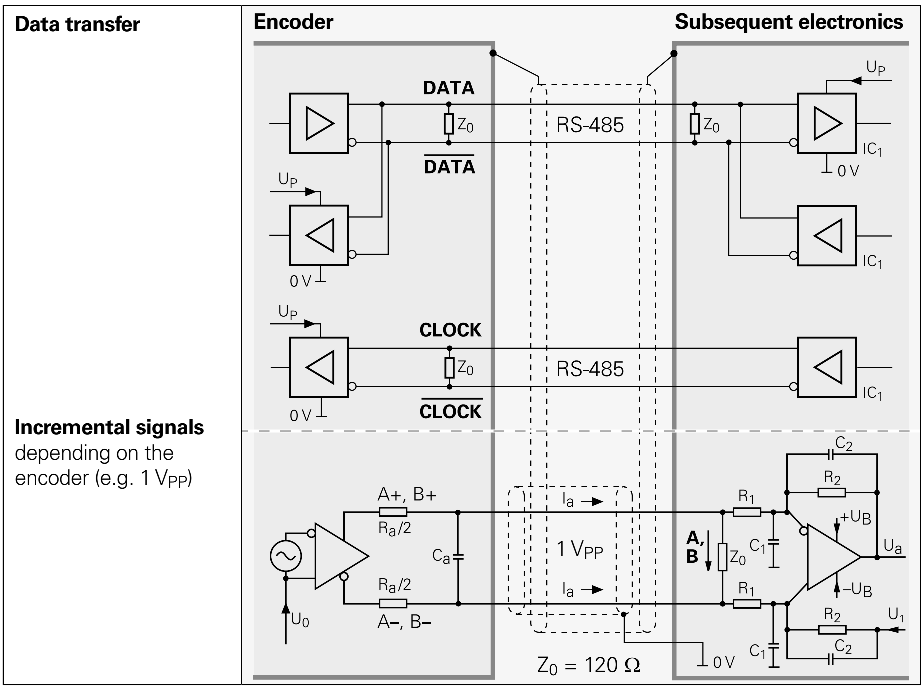
- Commutation
- Acceleration
- Limit position signals
- Asynchronous position value
- Operating status error sources
- Timestamp

Input circuitry of subsequent electronics

Dimensioning

IC_1 = RS 485 differential line receiver and driver

$Z_0 = 120\ \Omega$



Company-specific serial interfaces

Siemens

HEIDENHAIN encoders with the code letter S after the model designation are suited for connection to Siemens controls with

- **DRIVE-CLiQ interface**
  Order designation DQ 01

Fanuc

HEIDENHAIN encoders with the code letter F after the model designation are suited for connection to Fanuc controls with

- **Fanuc Serial Interface – α interface**
  Order designation Fanuc 02
  normal and high speed, two-pair transmission
- **Fanuc Serial Interface – αi interface**
  Order designation Fanuc 05
  high speed, one-pair transmission
  includes α interface (normal and high speed, two-pair transmission)

Mitsubishi

HEIDENHAIN encoders with the code letter M after the model designation are suited for connection to Mitsubishi controls with

Mitsubishi high speed interface

- Order designation Mitsu 01
  two-pair transmission
- Order designation Mit 02-4
  Generation 1, two-pair transmission
- Order designation Mit 02-2
  Generation 1, one-pair transmission
- Order designation Mit 03-4
  Generation 2, two-pair transmission

Yaskawa

HEIDENHAIN encoders with the code letter Y after the model designation are suited for connection to Yaskawa controls with

- **Yaskawa Serial Interface**
  Order designation YASK 01

DRIVE-CLiQ is a registered trademark of Siemens Aktiengesellschaft

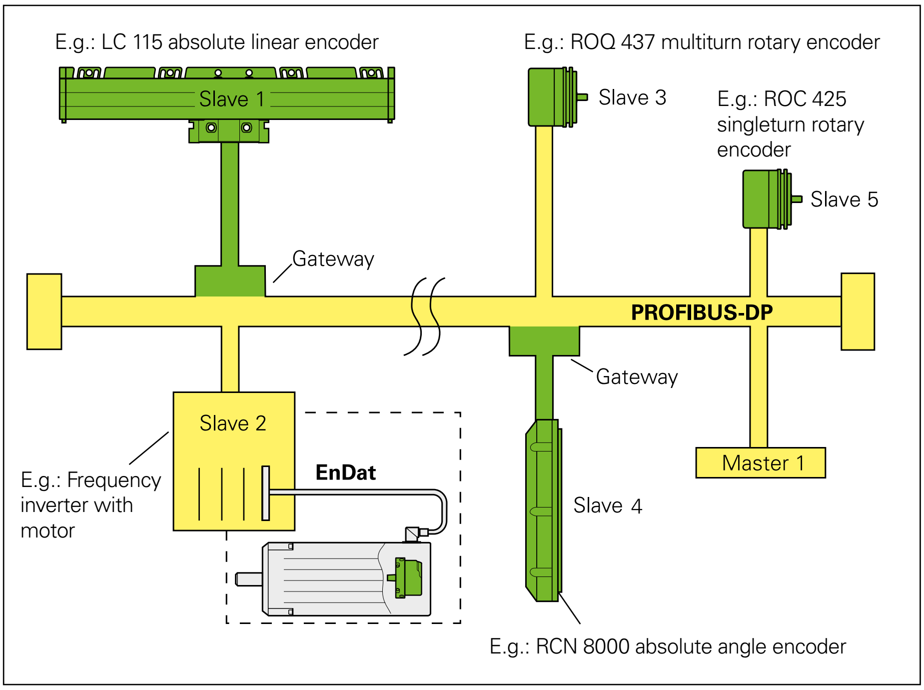
Position values

PROFIBUS-DP serial interface

PROFIBUS-DP
PROFIBUS is a nonproprietary, open fieldbus in accordance with the international EN 50 170 standard. The connecting of sensors through fieldbus systems minimizes the cost of cabling and reduces the number of lines between encoder and subsequent electronics.

Topology and bus assignment
The PROFIBUS-DP is designed as a linear structure. It permits transfer rates up to 12 Mbit/s. Both mono-master and multi-master systems are possible. Each master can serve only its own slaves (polling). The slaves are polled cyclically by the master. Slaves are, for example, sensors such as absolute rotary encoders, linear encoders, or also control devices such as motor frequency inverters.

Physical characteristics
The electrical features of the PROFIBUS-DP comply with the RS-485 standard. The bus connection is a shielded, twisted two-wire cable with active bus terminations at each end.



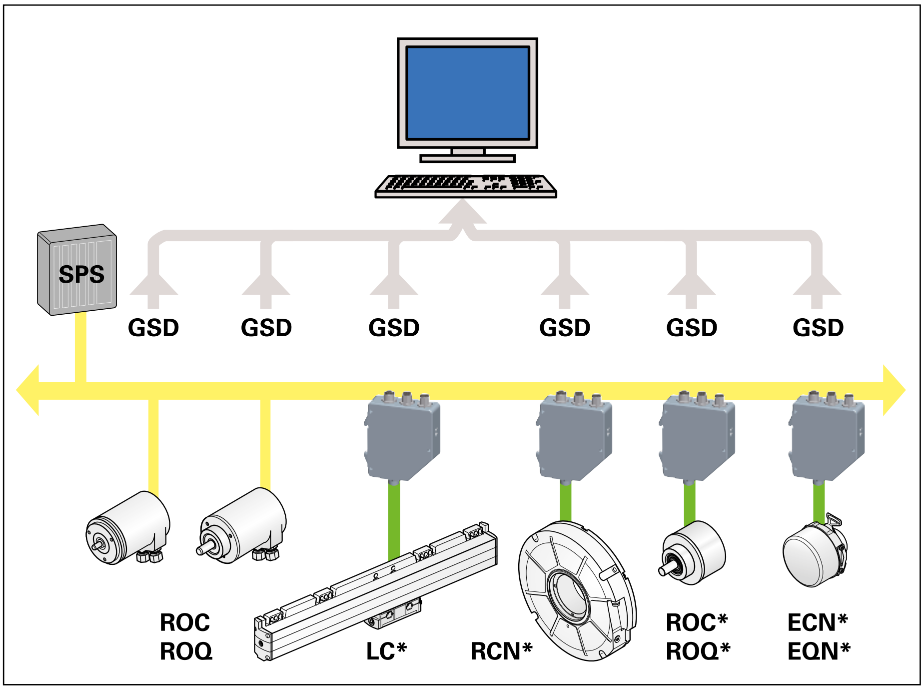
Bus structure of PROFIBUS-DP

Initial configuration
The characteristics of HEIDENHAIN encoders required for system configuration are included as "electronic data sheets"—also called device identification records (GSD)—in the gateway. These device identification records (GSD) completely and clearly describe the characteristics of a unit in an exactly defined format. This makes it possible to integrate the encoders into the bus system in a simple and application-friendly way.

Configuration
PROFIBUS-DP devices can be configured and the parameters assigned to fit the requirements of the user. Once these settings are made in the configuration tool with the aid of the GSD file, they are saved in the master. It then configures the PROFIBUS devices every time the network starts up. This simplifies exchanging of the devices: There is no need to edit or reenter the configuration data.

Two different GSD files are available for selection:

- GSD file for the DP-V0 profile
- GSD file for the DP-V1 and DP-V2 profile



* With EnDat interface

PROFIBUS-DP profile
The PNO (PROFIBUS user organization) has defined standard, nonproprietary profiles for the connection of absolute encoders to the PROFIBUS-DP. This ensures high flexibility and simple configuration on all systems that use these standardized profiles.

DP-V0 profile
This profile can be obtained from the Profibus user organization (PNO) in Karlsruhe, Germany, under the order number 3.062. There are two classes defined in the profile, where class 1 provides minimum support, and class 2 allows additional, in part optional functions.

DP-V1 and DP-V2 profile
This profile can be obtained from the Profibus user organization (PNO) in Karlsruhe, Germany, under the order number 3.162. This profile also distinguishes between two device classes:

- Class 3 with the basic functions and
- Class 4 with the full range of scaling and preset functions.

Optional functions are defined in addition to the mandatory functions of classes 3 and 4.

Supported functions
Particularly important in decentralized fieldbus systems are the **diagnostic functions** (e.g. warnings and alarms), and the **electronic ID label** with information on the type of encoder, resolution, and measuring range. But programming functions such as counting direction reversal, **preset/zero shift** and **changing the resolution (scaling)** are also possible. The **operating time** and the velocity of the encoder can also be recorded.

Encoders with PROFIBUS-DP
Absolute encoders with **integrated PROFIBUS-DP interface** are connected directly to the PROFIBUS. LEDs on the rear of the encoder display the voltage supply and bus status **operating states.**

The coding switches for the addressing (0 to 99) and for selecting the terminating resistor are easily accessible under the bus housing. The terminating resistor is to be activated if the rotary encoder is the last participant on the PROFIBUS-DP and the external terminating resistor is not used.

Functions of the DP-V0 class

Feature *Data word width*	**Class**	**Rotational encoders** *≤ 16 bits*	 *≤ 31 bits*[1]	**Linear encoders** *≤ 31 bits*[1]
Pos. value, pure binary code	1.2	✓	✓	✓
Data word length	1.2	16	32	32
Scaling function Measuring steps/rev Total resolution	 2 2	 ✓ ✓	 ✓ ✓	 – –
Reversal of counting direction	1.2	✓	✓	–
Preset (output data 16 or 32 bits)	2	✓	✓	✓
Diagnostic functions Warnings and alarms	 2	 ✓	 ✓	 ✓
Operating time recording	2	✓	✓	✓
Velocity	2	✓[2]	✓[2]	–
Profile version	2	✓	✓	✓
Serial number	2	✓	✓	✓

[1] With data word width > 31 bits, only the upper 31 bits are transferred
[2] Requires a 32-bit configuration of the output data and 32+16-bit configuration of the input data

Functions of the DP-V1, DP-V2 classes

Feature *Data word width*	**Class**	**Rotational encoders** *≤ 32 bits*	 *> 32 bits*	**Linear encoders**
Telegram	3.4	81-84	84	81-84
Scaling function	4	✓	✓	–
Reversal of counting direction	4	✓	✓	–
Preset/Datum shift	4	✓	✓	✓
Acyclic parameters	3.4	✓	✓	✓
Channel-dependent diagnosis via alarm channel	3.4	✓	✓	✓
Operating time recording	3.4	✓[1]	✓[1]	✓[1]
Velocity	3.4	✓[1]	✓[1]	–
Profile version	3.4	✓	✓	✓
Serial number	3.4	✓	✓	✓

[1] Not supported by DP V2

Position values
PROFINET IO serial interface

PROFINET IO
PROFINET IO is the open Industrial Ethernet Standard for industrial communication. It builds on the field-proven function model of PROFIBUS-DP, but uses fast Ethernet technology as physical transmission medium and is therefore tailored for fast transmission of I/O data. It offers the possibility of transmission for required data, parameters and IT functions at the same time.

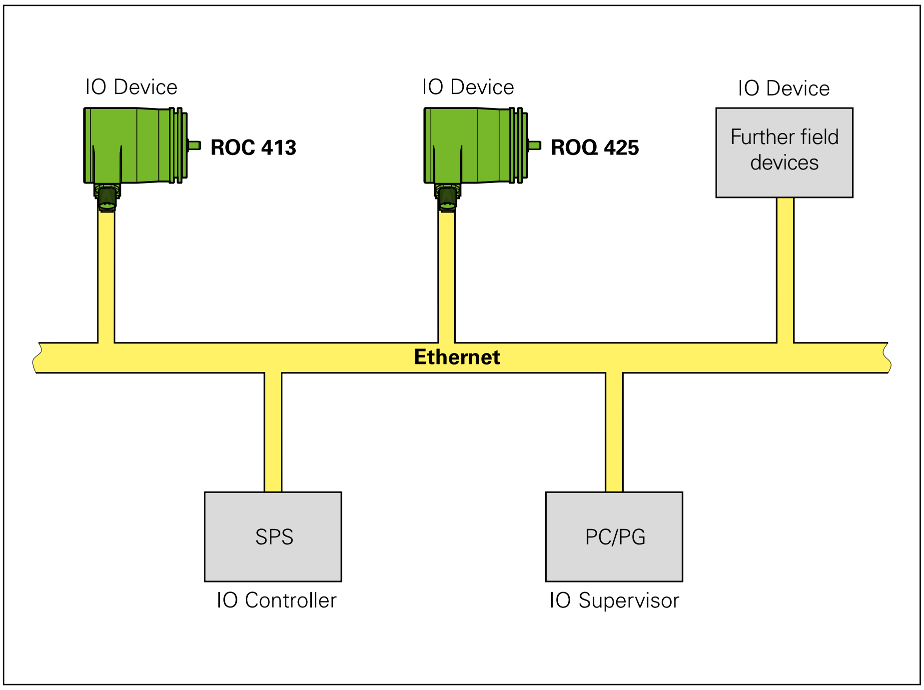
PROFINET makes it possible to connect local field devices to a controller and describes the data exchange between the controller and the field devices, as well as the parameterization and diagnosis. The PROFINET technique is arranged in modules. Cascading functions can be selected by the user himself. These functions differ essentially in the type of data exchange in order to satisfy high requirements on velocity.

Topology and bus assignment
A PROFINET-IO system consists of:
- **IO controller** (control/PLC, controls the automation task)
- **IO device** (local field device, e.g. rotary encoder)
- **IO supervisor** (development or diagnostics tool, e.g. PC or programming device)

PROFINET IO functions according to the provider-consumer model, which supports communication between Ethernet peers. An advantage is that the provider transmits its data without any prompting by the communication partner.

Physical characteristics
HEIDENHAIN encoders are connected according to 100BASE-TX (IEEE 802.3 Clause 25) through one shielded, twisted wire pair per direction to PROFINET. The transmission rate is 100 Mbit/s (Fast Ethernet).

PROFINET profile
HEIDENHAIN encoders fulfill the definitions as per Profile 3.162, Version 4.1. The device profile describes the encoder functions. Class 4 (full scaling and preset) functions are supported. More detailed information on PROFINET can be ordered from the PROFIBUS user organization PNO.



Supported functions	Class	Rotary encoder	
		Singleturn	Multiturn
Position value	3.4	✓	✓
Isochronous mode	3.4	✓	✓
Functionality of class 4	4	✓	✓
Scaling function	4	✓	✓
Measuring units per revolution	4	✓	✓
Total measuring range	4	✓	✓
Cyclic operation (binary scaling)	4	✓	✓
Noncyclic operation	4	✓	✓
Preset	4	✓	✓
Code sequence	4	✓	✓
Preset control G1_XIST1	4	✓	✓
Compatibility mode (encoder profile V.3.1)	3.4	✓	✓
Operating time	3.4	✓	✓
Velocity	3.4	✓	✓
Profile version	3.4	✓	✓
Permanent storage of the offset value	4	✓	✓
Identification & maintenance (I & M)		✓	✓
External firmware upgrade		✓	✓

Initial configuration
To put an encoder with a PROFINET interface into operation, a device identification record (GSD) must be downloaded and imported into the configuration software. The GSD contains the execution parameters required for a PROFINET-IO device.

Configuration
Profiles are predefined configurations of available functions and performance characteristics of PROFINET for use in certain devices or applications such as rotary encoders. They are defined and published by the workgroups of PROFIBUS & PROFINET International (PI).

Profiles are important for openness, interoperability and exchangeability so that the end user can be sure that similar devices from different manufacturers function in a standardized manner.

Encoders with PROFINET
Absolute encoders with integrated PROFIBUS interface are connected directly to the network. Addresses are distributed automatically over a protocol integrated in PROFINET. A PROFINET-IO field device is addressed within a network through its physical device MAC address.

On their rear faces, the encoders feature two double-color LEDs for diagnostics of the bus and the device.

A terminating resistor for the last participant is not necessary.

Position values
SSI serial interface

The **absolute position value** beginning with the Most Significant Bit (MSB first) is transferred on the DATA lines in synchronism with a CLOCK signal transmitted by the control. The SSI standard data word length for singleturn absolute encoders is 13 bits, and for multiturn absolute encoders 25 bits. In addition to the absolute position values, **incremental signals** can be transmitted. See *Incremental signals* for a description of the signals.

For the ECN/EQN 4xx and ROC/ROQ 4xx rotary encoders, the following **functions** can be activated via the programming inputs of the interfaces by applying the supply voltage U_P:

- **Direction of rotation**
  Continuous application of a HIGH level to pin 2 reverses the direction of rotation for ascending position values.

- **Zeroing** (datum setting)
  Applying a positive edge (t_{min} > 1 ms) to pin 5 sets the current position to zero.

Note: The programming inputs must always be terminated with a resistor (see "Input circuitry of the subsequent electronics").

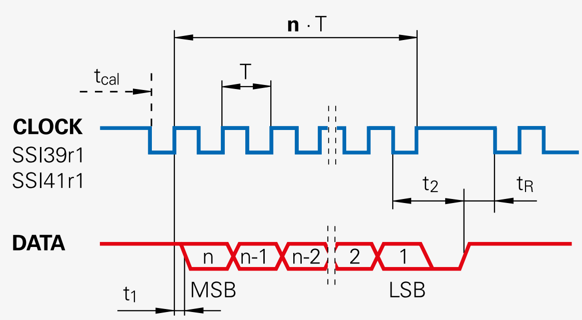
Interface	**SSI** serial
Ordering designation	*Singleturn:* SSI 39r1 *Multiturn:* SSI 41r1
Data transfer	Absolute position values
Data input	Differential line receiver according to EIA standard RS 485 for the CLOCK and $\overline{\text{CLOCK}}$ signals
Data output	Differential line driver according to EIA standard RS 485 for the signals DATA and $\overline{\text{DATA}}$
Code	Gray
Ascending position values	With clockwise rotation viewed from flange side (can be switched via interface)
Incremental signals	Depends on encoder ∿ 1 V_{PP}, TTL, HTL (see the respective Incremental signals)
Programming inputs Inactive Active Switching time	Direction of rotation and zero reset (for ECN/EQN 4xx, ROC/ROQ 4xx) LOW < 0.25 x U_P HIGH > 0.6 x U_P t_{min} > 1 ms
Connecting cable Cable length Propagation time	HEIDENHAIN cable with shielding e.g. PUR [(4 x 0.14 mm^2) + 4(2 x 0.14 mm^2) + (4 x 0.5 mm^2)] Max. 100 m at 90 pF/m distributed capacitance 6 ns/m

Control cycle for complete data format
When not transmitting, the clock and data lines are on high level. The internally and cyclically formed position value is stored on the first falling edge of the clock. The stored data is then clocked out on the first rising edge.
After transmission of a complete data word, the data line remains low for a period of time (t_2) until the encoder is ready for interrogation of a new value. Encoders with the SSI 39r1 or SSI 41r1 interface additionally require a subsequent clock pause t_R. If another data-output request (CLOCK) is received within this time (t_2 or t_2+t_R), the same data will be output once again.
If the data output is interrupted (CLOCK = High for t ≥ t_2), a new position value will be stored on the next falling edge of the clock. With the next rising clock edge the subsequent electronics adopts the data.

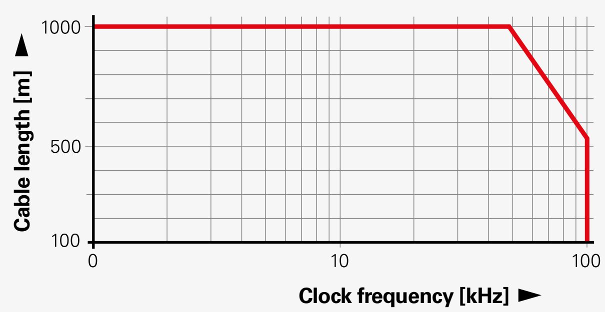
Data transfer

T = 1 to 10 µs
t_{cal} See *Specifications*
t_1 ≤ 0.4 µs (without cable)
t_2 = 17 to 20 µs
t_R ≥ 5 µs
n = Data word length
13 bits for ECN/ROC
25 bits for EQN/ROQ

$\overline{\text{CLOCK}}$ and $\overline{\text{DATA}}$ not shown



Permissible clock frequency with respect to cable lengths



Incremental signals
Some encoders also provide incremental signals. These are usually used to increase the resolution of the position value, or to serve a second subsequent electronics unit. In general these are 1 V_{PP} incremental signals. Exceptions can be seen from the order designation:

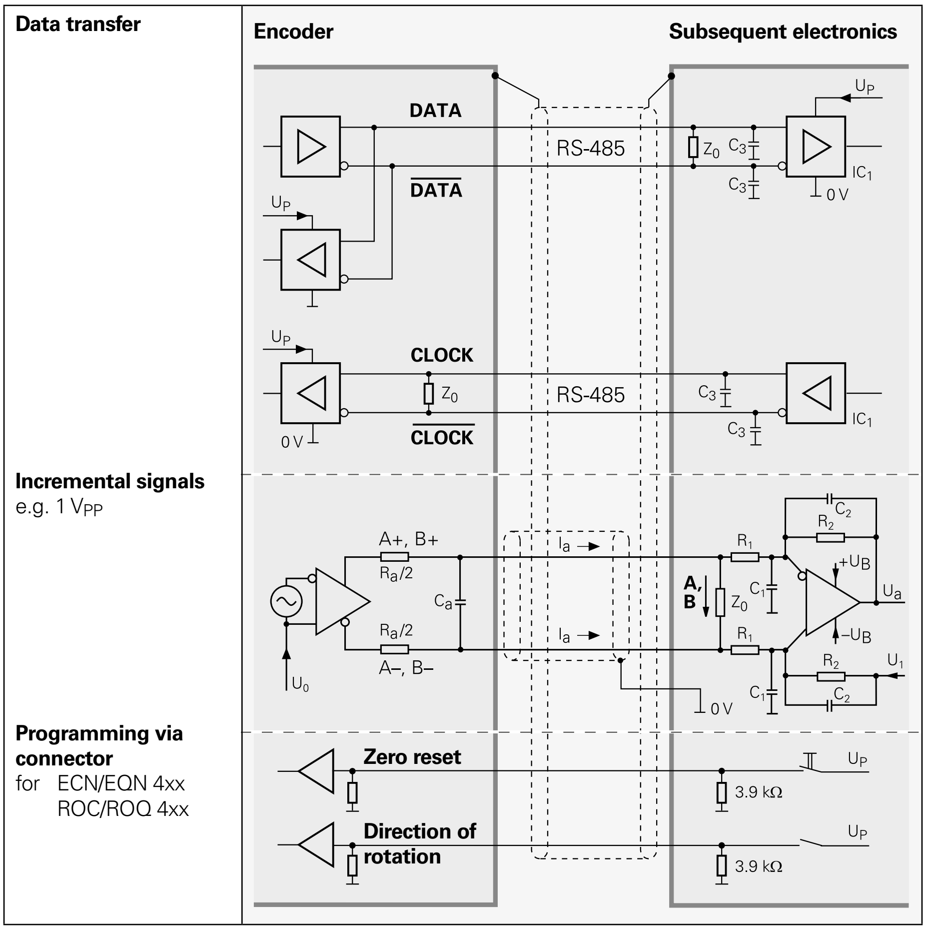
- SSI41 Hx with HTL incremental signals
- SSI41 Tx with TTL incremental signals

For these the encoder-internal subdivision of the incremental signal is indicated by the order designation:
Ha, Ta: 2-fold interpolation
Hb, Tb: No interpolation
Hc: Scanning signals x 2

Input circuitry of subsequent electronics

Dimensioning
IC_1 = Differential line receiver and driver
E.g. SN 65 LBC 176
LT 485

Z_0 = 120 Ω
C_3 = 330 pF (serves to improve noise immunity)

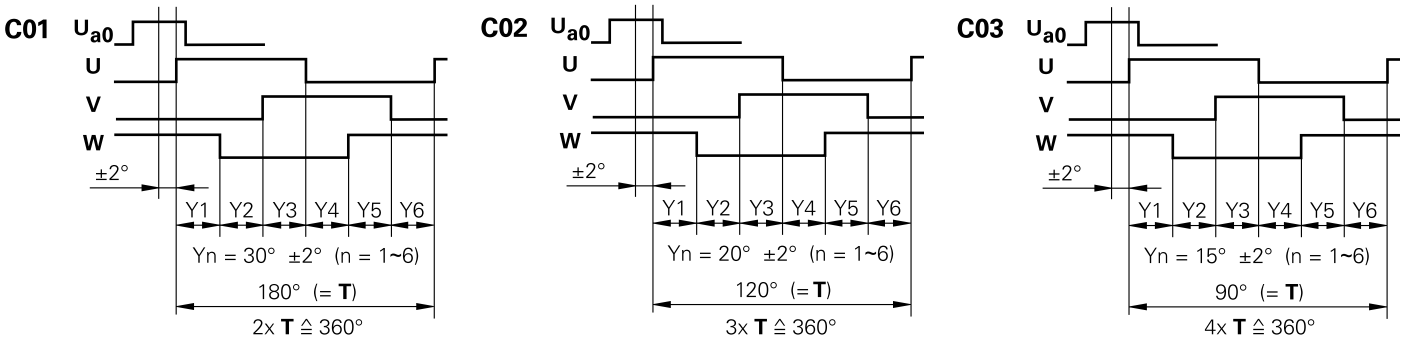


Other signals
Commutation signals for block commutation

The **block commutation signals U, V and W** are derived from three separate tracks. They are transmitted as square-wave signals in TTL levels.

Interface	Square-wave signals ⊓⊔ **TTL**
Commutation signals	Three square-wave signals U, V, W and their inverse signals $\overline{U}$, $\overline{V}$, $\overline{W}$
Width	2x180° mech., 3x120° mech. or 4x90° mech. (other versions upon request)
Signal levels	See *Incremental signals* ⊓⊔ *TTL*
Incremental signals	See *Incremental signals* ⊓⊔ *TTL*
Connecting cable	Shielded HEIDENHAIN cable E.g. PUR [6(2 x 0.14 mm^2) + (4 x 0.5 mm^2)]
Cable length	Max. 100 m
Propagation time	6 ns/m

Commutation signals
(Values in mechanical degrees)

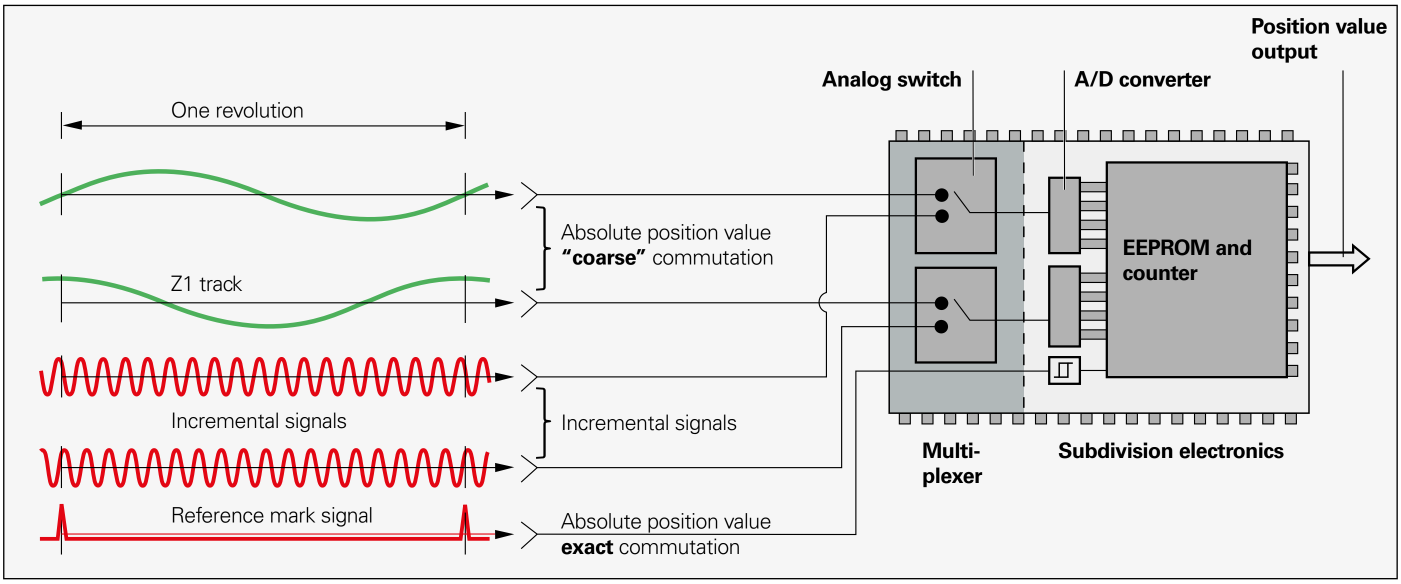


Commutation signals for sinusoidal commutation

The **commutation signals C and D** are taken from the Z1 track and form one sine or cosine period per revolution. They have a signal amplitude of typically 1 V_{PP} at 1 kΩ. The input circuitry of the subsequent electronics is the same as for the ∿ 1 V_{PP} interface. The required terminating resistor of Z_0, however, is 1 kΩ instead of 120 Ω.

Interface	Sinusoidal voltage signals ∿ **1 V_{PP}**
Commutation signals	**Two nearly sinusoidal signals C and D** See *Incremental signals* ∿ *1 V_{PP}*
Incremental signals	See *Incremental signals* ∿ *1 V_{PP}*
Connecting cable	Shielded HEIDENHAIN cable E.g. PUR [4(2 x 0.14 mm^2) + (4 x 0.14 mm^2) + (4 x 0.5 mm^2)]
Cable length	Max. 150 m
Propagation time	6 ns/m

Electronic commutation with Z1 track

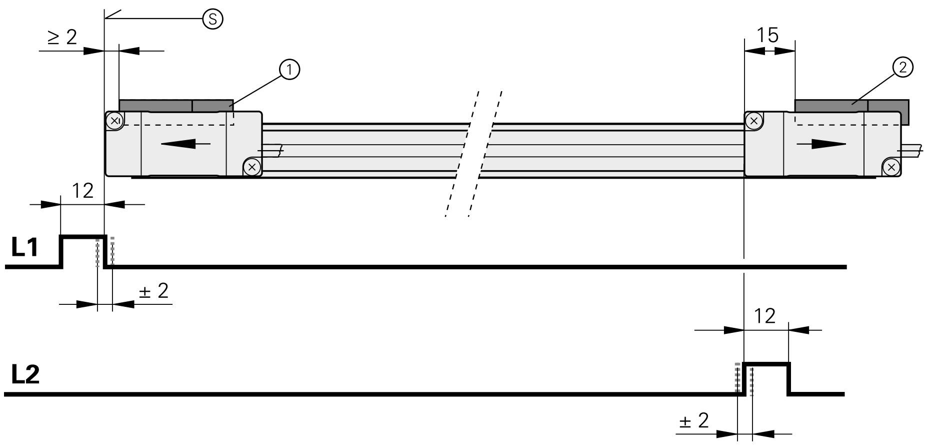


Other signals
Limit switches

Encoders with limit switches, such as LIDA 400, are equipped with two limit switches that make limit-position detection and the formation of homing tracks possible. The limit switches are activated by differing adhesive magnets to distinguish between the left or right limit. The magnets can be configured in series to form homing tracks.

The signals from the limit switches are sent over separate lines and are therefore directly available.

		LIDA 47x	LIDA 48x
Output signals		One TTL square-wave pulse from each limit switch L1 and L2; "active high"	
Signal amplitude		TTL from push-pull stage (e.g. 74 HCT 1G 08)	TTL from common-collector circuit with 10 kΩ load resistance against 5 V
Permissible load		$I_{aL} \le 4$ mA $I_{aH} \le 4$ mA	
Switching times (10 % to 90 %)	Rise time Fall time	$t_+ \le 50$ ns $t_- \le 50$ ns Measured with 3 m cable and recommended input circuitry	$t_+ \le 10$ µs $t_- \le 3$ µs Measured with 3 m cable and recommended input circuitry
Permissible cable length		Max. 20 m	



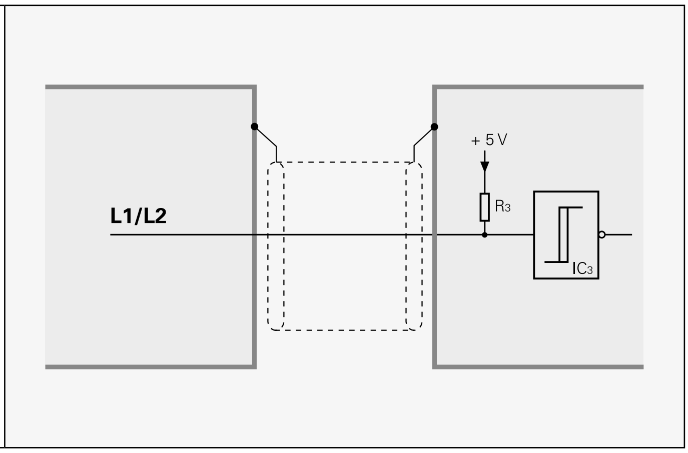
L1/L2 = Output signals of the limit switches 1 and 2
Tolerance of the switching point: ± 2 mm

Ⓢ = Beginning of measuring length (ML)
① = Magnet N for limit switch 1
② = Magnet S for limit switch 2

Input circuitry of subsequent electronics

Dimensioning
IC_3 e.g. 74AC14
R_3 = 1.5 kΩ

Limit switches LIDA 400

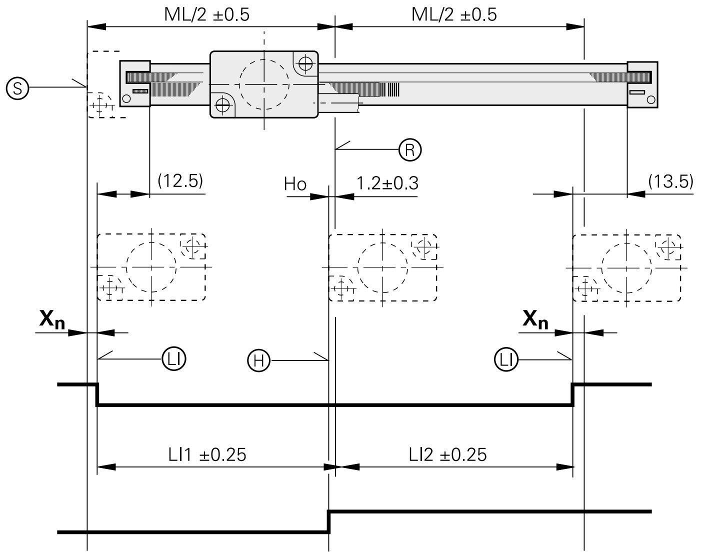


Position detection

In addition to the incremental graduation, encoders with position detection, such as the LIF 4x1, feature a homing track and limit switches for limit position detection.

The signals are transmitted in TTL levels over the separate lines H and L and are therefore directly available.

	LIF 4x1
Output signals	One TTL pulse each for homing track H and limit switch L
Signal amplitude	TTL $U_H \geq 3.8$ V at $-I_H = 8$ mA $U_L \leq 0.45$ V at $I_L = 8$ mA
Permissible load	$R \geq 680\ \Omega$ $\lvert I_L \rvert \leq 8$ mA
Permissible cable length	Max. 10 m



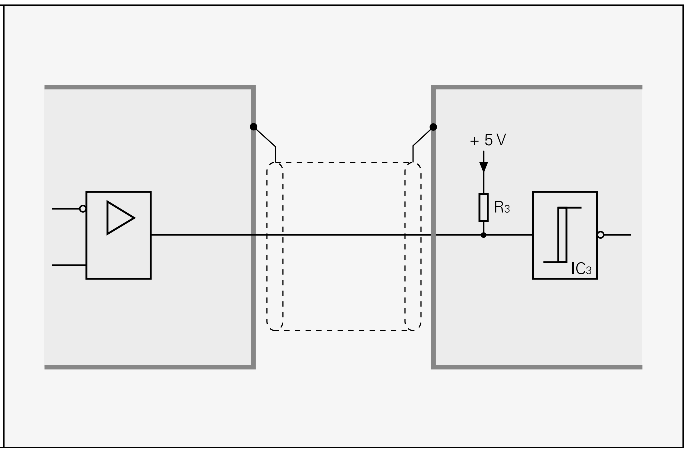
X_n =
Var. 01 X_1 = 2 mm
Var. 02 X_2 = 14 mm
Var. 03 X_3 = 22 mm

Ⓡ = Reference mark position
Ⓢ = Beginning of measuring length (ML)
Ⓛ = Limit mark, adjustable
Ⓗ = Switch for homing track
Ho = Trigger point for homing

Input circuitry of subsequent electronics

Dimensioning
IC_3 e.g. 74AC14
$R_3 = 4.7$ kΩ

Limit switches
Homing track
LIF 400



Further information
Interface electronics

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). Encoders with the serial interfaces EnDat or SSI can also be connected to various interface electronics.

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
- DRIVE-CLiQ
- Fanuc Serial Interface
- Mitsubishi high speed interface
- Yaskawa serial interface
- PCI bus
- Ethernet
- Profibus

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.

Measured value memory
Interface electronics with integrated measured value memory can buffer measured values:
IK 220: Total of 8192 measured values
EIB 74x: Per input typically 250000 measured values

Box design

Benchtop design

Plug design

Version for integration

Top-hat rail design

Outputs		Inputs		Design – degree of protection	Interpolation[1] or subdivision	Model
Interface	Qty.	Interface	Qty.			
⊓⊔TTL	1	∼ 1 V_{PP}	1	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}	1	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**
⊓⊔TTL/ ∼ 1 V_{PP} Adjustable	2	∼ 1 V_{PP}	1	Box design – IP 65	2-fold	**IBV 6072**
					5/10-fold	**IBV 6172**
					5/10-fold and 20/25/50/100-fold	**IBV 6272**
EnDat 2.2	1	∼ 1 V_{PP}	1	Box design – IP 65	≤ 16384-fold subdivision	**EIB 192**
				Plug design – IP 40	≤ 16384-fold subdivision	**EIB 392**
			2	Box design – IP 65	≤ 16384-fold subdivision	**EIB 1512**
DRIVE-CLiQ	1	EnDat 2.2	1	Box design – IP 65	–	**EIB 2391 S**
Fanuc Serial Interface	1	∼ 1 V_{PP}	1	Box design – IP 65	≤ 16384-fold subdivision	**EIB 192 F**
				Plug design – IP 40	≤ 16384-fold subdivision	**EIB 392 F**
			2	Box design – IP 65	≤ 16384-fold subdivision	**EIB 1592 F**
Mitsubishi high speed interface	1	∼ 1 V_{PP}	1	Box design – IP 65	≤ 16384-fold subdivision	**EIB 192 M**
				Plug design – IP 40	≤ 16384-fold subdivision	**EIB 392 M**
			2	Box design – IP 65	≤ 16384-fold subdivision	**EIB 1592 M**
Yaskawa serial interface	1	EnDat 2.2[2]	1	Plug design – IP 40	–	**EIB 3391Y**
PCI bus	1	∼ 1 V_{PP}; ∼ 11 μA_{PP} EnDat 2.1 / 01; SSI Adjustable	2	Version for integration – IP 00	≤ 4096-fold subdivision	**IK 220**
Ethernet	1	∼ 1 V_{PP} EnDat 2.1; EnDat 2.2 ∼ 11 μA_{PP} upon request Adjustable by software	4	Benchtop design – IP 40	≤ 4096-fold subdivision	**EIB 741** **EIB 742**
PROFIBUS-DP	1	EnDat	1	Top-hat rail design	–	**PROFIBUS Gateway**

[1] Switchable

[2] Only LIC 4100, measuring step 5 nm

Further information
HEIDENHAIN testing equipment

Overview		HEIDENHAIN measuring equipment		
Interface	**Output signals**	**PWM 20**	**PWM 9**	**PWT 1x**[1]
EnDat	Position value Incremental signals	Yes Yes	No Yes	No No
Fanuc	Position value	Yes	No	No
Mitsubishi	Position value	Yes	No	No
DRIVE-CLiQ	Position value	Yes	No	No
Yaskawa	Position value	Yes	No	No
SSI	Position value Incremental signals	Yes Yes	No Yes	No No
1 V_{PP}	Incremental signals	Yes	Yes	PWT 18
11 μA_{PP}	Incremental signals	Yes	Yes	PWT 10
TTL	Incremental signals	Yes	Yes	PWT 17
HTL	Incremental signals	No	Yes	No
Commutation	Block commutation Sinusoidal commutation	Being planned Yes	Yes Yes	No No

[1] The PWT is an aid for setting and adjustment

The **PWT** is a simple adjusting aid for HEIDENHAIN incremental encoders. In a small LCD window the signals are shown as bar charts with reference to their tolerance limits.

	PWT 10	PWT 17	PWT 18
Encoder input	∿ 11 µAPP	⊓⊔TTL	∿ 1 VPP
Functions	Measurement of signal amplitude Wave-form tolerance Amplitude and position of the reference mark signal		
Power supply	Via power supply unit (included)		
Dimensions	114 mm x 64 mm x 29 mm		

The **PWM 9** is a universal measuring device for checking and adjusting HEIDENHAIN incremental encoders. Expansion modules are available for checking the various types of encoder signals. The values can be read on an LCD monitor. Soft keys provide ease of operation.

	PWM 9
Inputs	Expansion modules (interface boards) for 11 µAPP; 1 VPP; TTL; HTL; EnDat*/SSI*/commutation signals *No display of position values or parameters
Functions	• **Measures** signal amplitudes, current consumption, operating voltage, scanning frequency • **Graphically displays** incremental signals (amplitudes, phase angle and on-off ratio) and the reference-mark signal (width and position) • **Displays symbols** for the reference mark, fault detection signal, counting direction • **Universal counter,** interpolation selectable from single to 1 024-fold • **Adjustment support** for exposed linear encoders
Outputs	• Inputs are connected through to the subsequent electronics • BNC sockets for connection to an oscilloscope
Power supply	10 V to 30 V DC, max. 15 W
Dimensions	150 mm × 205 mm × 96 mm

PWM 20

Together with the ATS adjusting and testing software, the PWM 20 phase angle measuring unit serves for diagnosis and adjustment of HEIDENHAIN encoders.

	PWM 20
Encoder input	• EnDat 2.1 or EnDat 2.2 (absolute value with/without incremental signals) • DRIVE-CLiQ • Fanuc Serial Interface • Mitsubishi high speed interface • Yaskawa serial interface • SSI • 1 V_{PP}/TTL/11 μA_{PP}
Interface	USB 2.0
Power supply	100 V to 240 V AC or 24 V DC
Dimensions	258 mm x 154 mm x 55 mm

	ATS
Languages	Choice between English and German
Functions	• Position display • Connection dialog • Diagnostics • Mounting wizard for EBI/ECI/EQI, LIP 200, LIC 4000 and others • Additional functions (if supported by the encoder) • Memory contents
System requirements and recommendations	PC (dual-core processor, > 2 GHz) RAM > 2 GB Windows operating systems XP, Vista, 7 (32-bit/64-bit), 8 200 MB free space on hard disk

DRIVE-CLiQ is a registered trademark of Siemens Aktiengesellschaft

The **APS 27** encoder diagnostic kit is necessary for assessing the mounting tolerances of the LIDA 27x with TTL interface. In order to examine it, the LIDA 27x is either connected to the subsequent electronics via the PS 27 test connector, or is operated directly on the PG 27 test unit.

Green LEDs for the incremental signals and reference pulse, respectively, indicate correct mounting. If they shine red, then the mounting must be checked again.

	APS 27
Encoder	LIDA 277, LIDA 279
Function	Good/bad detection of the TTL signals (incremental signals and reference pulse)
Power supply	Via subsequent electronics or power supply unit (included)
Items supplied	PS 27 test connector PG 27 test unit Power supply unit for PG 27 (110 V to 240 V, including adapter plug) Shading films

The **SA 27** adapter connector serves for tapping the sinusoidal scanning signals of the LIP 372 off the APE. Exposed pins permit connection to an oscilloscope through standard measuring cables.

	SA 27
Encoder	LIP 372
Function	Measuring points for the connection of an oscilloscope
Power supply	Via encoder
Dimensions	Approx. 30 mm x 30 mm

General electrical information

Voltage supply

Connect HEIDENHAIN encoders only to subsequent electronics whose supply voltage is generated from PELV systems (DIN EN 50178).

If HEIDENHAIN encoders are to be operated in accordance with DIN EN 61010-1, power must be supplied from a secondary circuit with current or power limitation as per DIN EN 61010-1:2011-07, section 9.4 or DIN EN 60950-1:2011-01, section 2.5 or a Class 2 secondary circuit as specified in UL1310.

The encoders require a **stabilized DC voltage U_P** as voltage supply. The required current consumption and power consumption are listed in the respective *Specifications*. 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

However, the limits of the supply voltage must not be violated by the ripple content.

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 available. If an adjustable power supply is not available, the voltage drop can be reduced by switching the sensor lines parallel to the corresponding supply wires.

The voltage U_P actually applied to the encoder is to be considered when **calculating the encoder's current and power consumption.** This voltage consists of the supply voltage U_E provided by the subsequent electronics minus the **voltage drop ΔU** in the supply wires.

For **encoders with an expanded supply voltage range**, the calculation of the voltage drop ΔU in the supply wires must consider the nonlinear current consumption (see next page).

For **encoders without expanded supply voltage range** (typical supply voltage 5 V) the voltage drop ΔU in the supply wires is calculated as follows:

$$\Delta U = 2 \cdot \frac{1.05 \cdot L_C}{56 \cdot A_P} \cdot I_M \cdot 10^{-3}$$

Where:
ΔU Line drop in V
L_C Cable length in m
A_P Cross section of supply wires in mm² (see cable)
I_M Current consumption in mA
2 Outgoing and incoming lines
1.05 Length factor due to twisted wires
56 Electrical conductivity of copper

If the value for the voltage drop is known, the parameters of voltage at the encoder, current consumption, as well as power consumption of the encoder and the power provided by the subsequent electronics can be calculated for the encoder and subsequent electronics.

Switch-on/off behavior of the encoders
After the switch-on time t_{SOT}, valid output signals are available. During the time t_{SOT}, the output signals reach the maximum voltage values given in the table. The switch-on time t_{SOT} depends on the interface.

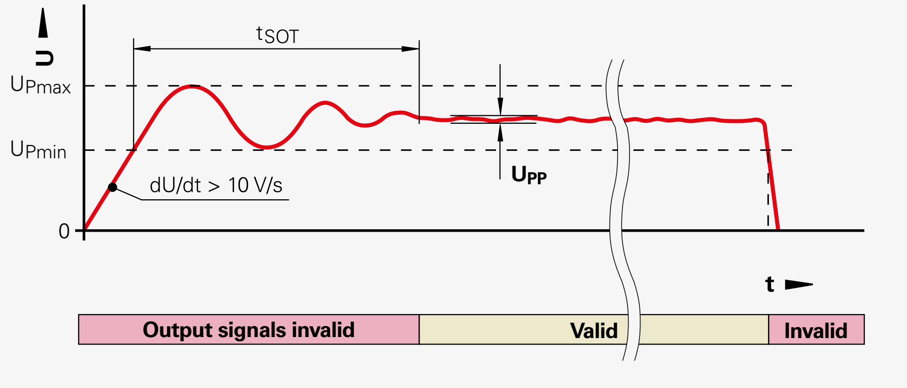
Interface	Switch-on time t_{SOT}	Maximum voltage
1 V_{PP}	1.3 s	5.5 V
11 µA_{PP}		
TTL		
HTL		U_{Pmax}
EnDat		5.5 V
PROFIBUS-DP	2 s	5.5 V
PROFINET	10 s	U_{Pmax}

If the power supply is switched off, or when the supply voltage falls below U_{Pmin}, the output signals are also invalid.

As before, the interface-specific switch-on/off characteristics must be considered. If interface electronics are inserted between the encoder and the subsequent electronics, the switch-on/off characteristics of the interface electronics must also be considered.

During restart, the voltage must remain below 0.2 V for the time t_{SOT} before power on. Other proprietary interfaces supported by HEIDENHAIN are not considered.

Transient response of supply voltage and switch-on/switch-off behavior

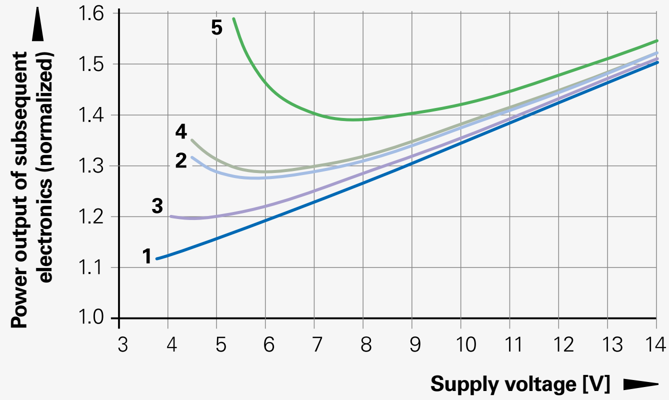


Encoders with expanded supply voltage range

For encoders with expanded supply voltage range, the current consumption has a nonlinear relationship with the supply voltage. On the other hand, the power consumption follows an approximately linear curve (see *Current and power consumption* diagram).
The maximum power consumption at minimum and maximum supply voltage is listed in the **Specifications**. The maximum power consumption accounts for:

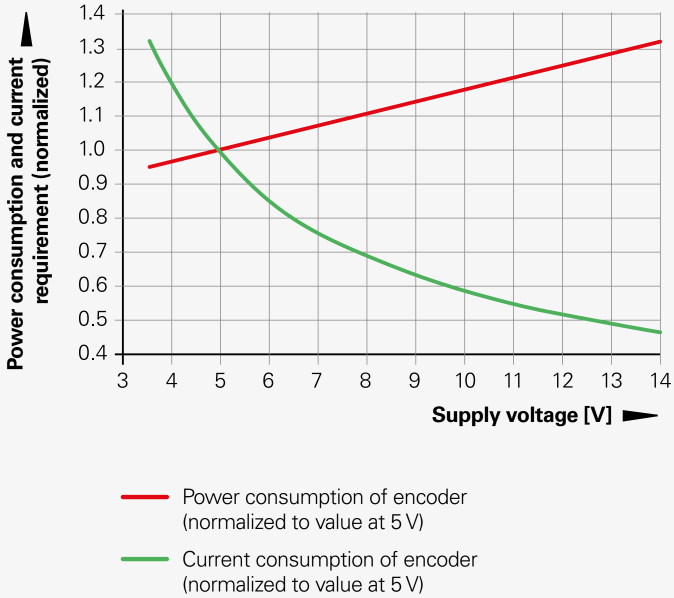
- Recommended receiver circuit
- Cable length 1 m
- Aging and influences of temperature
- Proper use of the encoder with respect to clock frequency and cycle time

For comparative and inspection purposes, the typical current or power consumption is additionally listed in typical ambient and operating conditions without load (only voltage supply connected) for the typical supply voltage or rated voltage. This information only has informative character; it is subject to change without notice. The maximum power consumption is to be used for dimensioning the voltage supply.



	Encoder cable/adapter cable	Connecting cable	Total
1	3 m	/	3 m
2	20 m	/	20 m
3	3 m	17 m	20 m
4	3 m	47 m	50 m
5	3 m	97 m	100 m

Influence of cable length on the power output of the subsequent electronics (example representation)



Current and power consumption with respect to the supply voltage (example representation)

The **actual power consumption** of the encoder and the required power output of the subsequent electronics are calculated, while taking the voltage drop on the supply wires into consideration, in four steps:

Step 1: **Resistance of the supply wires**
The resistance values of the supply wires (adapter cable and encoder cable) can be calculated with the following formula:

$$R_L = 2 \cdot \frac{1.05 \cdot L_C}{56 \cdot A_P}$$

Step 2: **Coefficients for calculation of the voltage drop**

$$b = -R_L \cdot \frac{P_{Mmax} - P_{Mmin}}{U_{Pmax} - U_{Pmin}} - U_E$$

$$c = P_{Mmin} \cdot R_L + \frac{P_{Mmax} - P_{Mmin}}{U_{Pmax} - U_{Pmin}} \cdot R_L \cdot (U_E - U_{Pmin})$$

Step 3: **Voltage drop based on the coefficients b and c**

$$\Delta U = -0.5 \cdot (b + \sqrt{b^2 - 4 \cdot c})$$

Step 4: **Parameters for subsequent electronics and the encoder**
Voltage at encoder:
$U_P = U_E - \Delta U$

Current requirement of encoder:
$I_M = \frac{\Delta U}{R_L}$

Power consumption of encoder:
$P_M = U_P \cdot I_M$

Power output of subsequent electronics:
$P_E = U_E \cdot I_M$

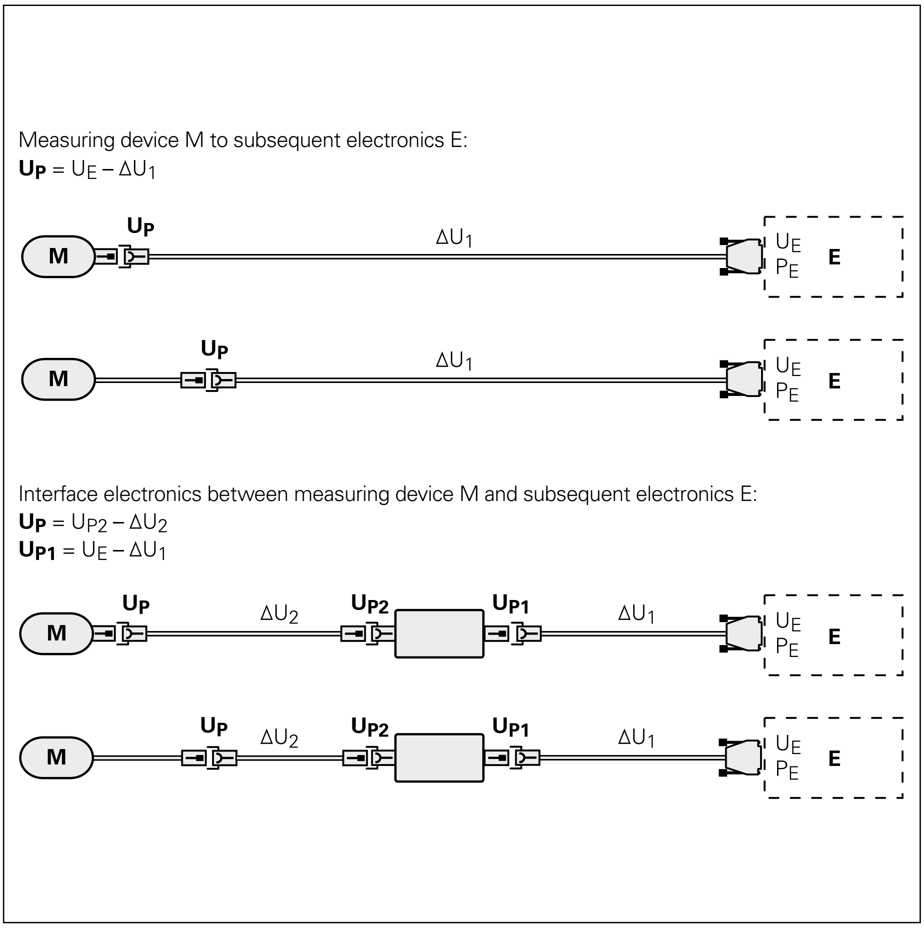
Where:

R_L	Cable resistance (for both directions) in ohms
L_C	Cable length in m
A_P	Cross section of supply wires in mm^2 (see cable)
2	Outgoing and incoming lines
1.05	Length factor due to twisted wires
56	Electrical conductivity of copper
P_{Mmin}, P_{Mmax}	Maximum power consumption at minimum or maximum power supply, respectively, in W
U_{Pmin}, U_{Pmax}	Minimum or maximum supply voltage of the encoder in V
U_E	Supply voltage at the subsequent electronics in V
ΔU	Voltage drop in the cable in V
U_P	Voltage at encoder in V
I_M	Current requirement of encoder in mA
P_M	Power consumption of encoder in W
P_E	Power output of subsequent electronics in W

If an encoder operates at a subsequent electronics unit via **interface electronics,** the power consumption of the encoder and of the interface electronics must be added to calculate the resulting power consumption.

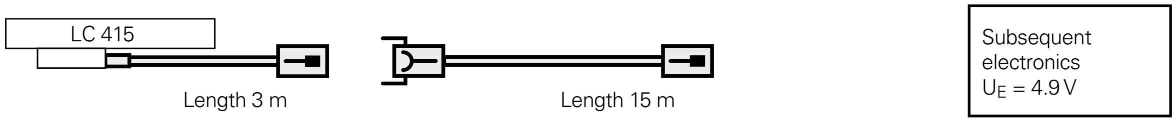
Depending on the interface electronics, a compensation factor for the efficiency of the interface electronics' switching power supply (see Product Information) may have to be considered.

Encoders with **DRIVE-CLiQ interface** are designed for a rated voltage of 24 V DC. The subsequent electronics manufacturer specifies 20.4 V to 28.8 V DC as the tolerance of the power supply. HEIDENHAIN encoders with DRIVE-CLiQ interface permit a greater voltage range (see Specifications). Operation is briefly allowed up to 36.0 V DC. Higher power consumption is to be expected in the range of 28.8 V to 36.0 V DC.



Calculation example

This specific example is used to determine the relevant parameters for operating an encoder:



Encoder used

LC 415

- Supply voltage is 3.6 V to 14 V DC (from Specifications)
- Power consumption *at 14 V:* ≤ 1.5 W; *at 3.6 V:* ≤ 1.1 W (from Specifications)

Cables used

Adapter cable (L1)

- Length L_{C1} = 3 m
- Cable diameter 4.5 mm
- A_P = 0.14 mm^2 (from Connecting elements and cables)

Connecting cable (L2)

- Length L_{C2} = 15 m
- Cable diameter 4.5 mm
- A_P = 0.34 mm^2 (from Connecting elements and cables)

Constraints from subsequent electronics

- **Sensor lines** are used additionally for the power supply, doubling the cross-section
- **Supply voltage** of the subsequent electronics U_E = 4.9 V

Step 1: **Resistance of the supply lines**

$R = 2 \times (1.05 \times L_K)/(56 \times 2A_P)$
$R_{L1} = 0.402\ \Omega$
$R_{L2} = 0.827\ \Omega$
$\mathbf{R_L = 1.229\ \Omega}$

Step 2: **Coefficients for calculation of the voltage drop**

$$b = -R_L \cdot \frac{P_{Mmax} - P_{Mmin}}{U_{Pmax} - U_{Pmin}} - U_E$$

$b = -\ 1.229 \times (1.5 - 1.1)/(14 - 3.6) - 4.9$
b = – 4.947

$$c = P_{Mmin} \cdot R_L + \frac{P_{Mmax} - P_{Mmin}}{U_{Pmax} - U_{Pmin}} \cdot R_L \cdot (U_E - U_{Pmin})$$

$c = 1.1 \times 1.229 + (1.5 - 1.1)/(14 - 3.6) \times 1.229\ (4.9 - 3.6)]$
c = 1.413

Step 3: **Voltage drop based on the coefficients b and c**

$$\Delta U = -0.5 \cdot (b + \sqrt{b^2 - 4 \cdot c})$$

$\Delta U = -\ 0.5 \times [-4.947 + \sqrt{((-4.947)^2 - 4 \times 1.413)}]$
$\mathbf{\Delta U = 0.304\ V}$

Step 4: **Parameters for subsequent electronics and the encoder**

Voltage at encoder
$U_P = U_E - \Delta U$
$U_P = 4.9\ V - 0.304\ V$
$U_P = 4.596\ V$

The voltage at the encoder is greater than 3.6 V, and is therefore within the permissible range

Current requirement of the encoder
$I_M = \Delta U / R_L$
$I_M = 0.304\ V/1.229\ \Omega$
$I_M = 248\ mA$

Power consumption of encoder
$P_M = U_P \times I_M$
$P_M = 4.596\ V \times 248\ mA$
$P_M = 1138\ mW$

Power output of subsequent electronics
$P_E = U_E \times I_M$
$P_E = 4.9\ V \times 248\ mA$
$P_E = 1214\ mW$

Electrically permissible speed/ traversing velocity

The maximum permissible shaft speed or traversing velocity of an encoder is derived from
- the **mechanically** permissible shaft speed or traversing velocity and
- the **electrically** permissible shaft speed or traversing velocity.

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

For angle or rotary encoders

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

For linear encoders

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

Where:

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

Cables

Versions

The cables of almost all HEIDENHAIN encoders and adapter and connecting cables are sheathed in **polyurethane (PUR).** In addition, **special elastomer (EPG), special thermoplastic elastomer (TPE)** and **polyvinyl chloride (PVC)** are used. These cables are identified in the catalog as PUR, EPG, TPE or PVC.

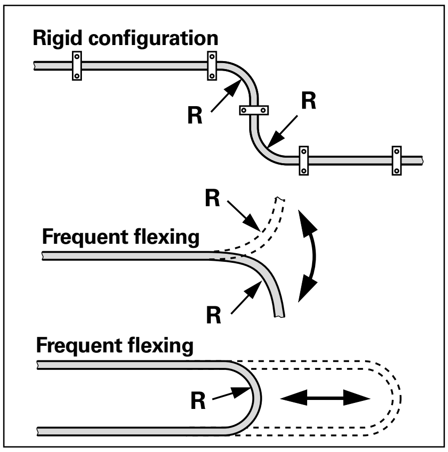
Durability

PUR cables are resistant to oil and hydrolysis in accordance with DIN EN 60811-2-1 and resistant to microbes in accordance with DIN EN 50363-10-2. They are free of PVC and silicone and comply with UL safety directives. The **UL certification** AWM STYLE 20963 80 °C 30 V E63216 is documented on the cable.

EPG cables are suitable for high temperatures and are resistant to oil in accordance with DIN EN 60811-2-1, hydrolysis in accordance with DIN EN 50363-10-2, and are free of PVC, silicone and halogens. In comparison with PUR cables, they are only somewhat resistant to media, frequent flexing and continuous torsion.

PVC cables are oil-resistant. The UL certification is documented on the cable with AWM E64638 STYLE20789 105C VW-1SC NIKKO.

TPE wires with braided sleeving are slightly oil-resistant.



Temperature range

	Rigid configuration	Frequent flexing
PUR	–40 °C to 80 °C	–10 °C to 80 °C
EPG	–40 °C to 120 °C	–
TPE	–40 °C to 120 °C	–
PVC	–20 °C to 90 °C	–10 °C to 90 °C

With limited hydrolytic and media exposure, PUR cables can be used up to 100 °C. If needed, please ask for assistance from HEIDENHAIN.

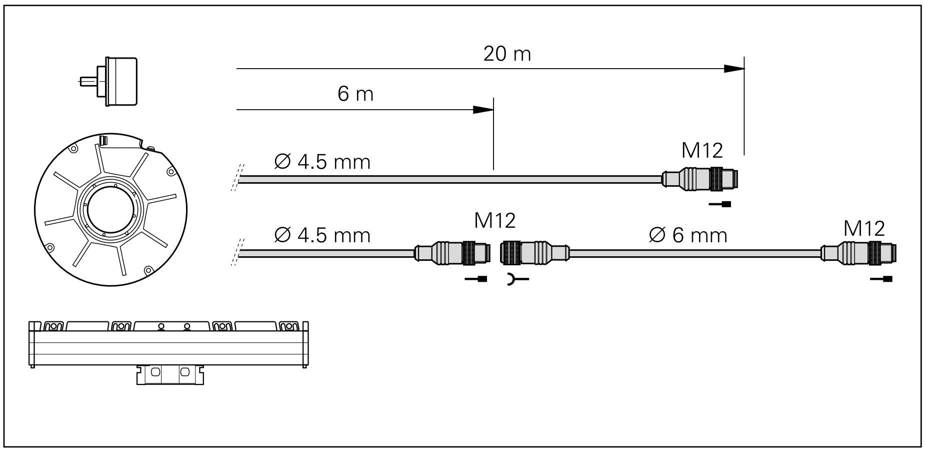
Cable	**Material**	**Bend radius R**	
		Rigid configuration	**Frequent flexing**
Ø 3.7 mm	**PUR**	≥ 8 mm	≥ 40 mm
Ø 4.3 mm		≥ 10 mm	≥ 50 mm
Ø 4.5 mm			
Ø 4.5 mm	**EPG**	≥ 18 mm	–
Ø 5.1 mm	**PUR**	≥ 10 mm	≥ 50 mm
Ø 5.5 mm	**PVC**	Upon request	Upon request
Ø 6 mm	**PUR**	≥ 20 mm	≥ 75 mm
Ø 6.8 mm			
Ø 8 mm		≥ 40 mm	≥ 100 mm
Ø 10 mm[1)]		≥ 35 mm	≥ 75 mm
Ø 14 mm[1)]		≥ 100 mm	≥ 100 mm
TPE wires with braided sleeving	**TPE**	≥ 10 mm	–

[1)] Metal armor

Lengths
The **cable lengths** listed in the *Specifications* apply only for HEIDENHAIN cables and the recommended input circuitry of subsequent electronics.

Attainable cable lengths for absolute linear and angle encoders
The interfaces for HEIDENHAIN linear encoders permit long cables, practical for real situations, sometimes even up to 150 m. However, long cable lengths also result in a large voltage drop on the supply lines. The magnitude of this depends on the wire cross-section of the supply lines, along with the usual criteria of the cable length and the current required by the encoder.

Particularly for long cables and encoders with a high current consumption (mainly absolute linear and angle encoders), the voltage drop can lead to the encoder's supply voltage falling below the minimum permissible level. Possible remedies:
- For long lengths, select cables with large wire cross-sections
- Keep thin cables, with small wire cross-sections, as short as possible
- For subsequent electronics without controllable power supply unit, connect the sensor lines parallel to the supply lines. This doubles the available cross-section.
- Select as high a supply voltage U_P as possible, e.g. 5.25 V DC



Notes
Due to the data transfer technology, the adapter cable connected directly to the encoder (e.g. Ø ≤ 4.5 mm) must not be longer than 20 m. Greater cable lengths can be realized with an adapter cable no longer than 6 m and an extension cable (Ø 6 mm).

Along with the voltage drop over the line, other criteria (e.g. clock frequency) can limit the maximum permissible cable length.

Transmission frequencies up to 16 MHz in combination with large cable lengths place high technological demands on the cable. HEIDENHAIN cables are equal to this task, not least because of a cable construction conceived specifically for this application. We recommend using original HEIDENHAIN cables.

Encoder	Supply voltage U_P of the subsequent electronics	Adapter cable Ø 4.5 mm	Connecting cable Ø 6 mm	Total cable length
RCN 8000	5 V DC	20 m/*17 m*[1)]	–	**20 m/*17 m***
		6 m/*6 m*	68 m/*26 m*	**74 m/*32 m***
		1 m/*1 m*	80 m/*39 m*	**81 m/*40 m***
	5.25 V DC	20 m/*20 m*	–	**20 m/*20 m***
		6 m/*6 m*	83 m/*34 m*	**89 m/*40 m***
		1 m/*1 m*	95 m/*46 m*	**96 m/*47 m***
	12 V DC	6 m/*6 m*	94 m/*94 m*	**max./*max.***

Encoder	Supply voltage U_P of the subsequent electronics	Adapter cable within motor	Connecting cable Ø 6 mm	Total cable length
ECN 1325 EQN 1337	5 V DC	0.3 m	max./*64 m*	**max./*64 m***
	5.25 V DC	0.3 m	max./*75 m*	**max./*75 m***

Encoder	Supply voltage U_P of the subsequent electronics	Encoder cable	Connecting cable Ø 6 mm	Total cable length
LIC 4000	5 V DC	3 m	max./*45 m*	**max./*48 m***
		1 m	max./*53 m*	**max./*54 m***
	5.25 V DC	3 m	max./*55 m*	**max./*58 m***
		1 m	max./*63 m*	**max./*64 m***

Cursive: Sensor lines are **not** connected in parallel
max.: No limiting to the cable length due to the line voltage drop
1) Due to the line voltage drop, the theoretically possible cable length cannot be used

DRIVE-CLiQ does permit a maximum cable length of 100 m, but this value is reduced by a number of influencing factors:

- Number of joints with DRIVE-CLiQ couplings
- Length factor of the MOTION-CONNECT signal line
- Pluggable adapter cable at the HEIDENHAIN encoder
- Length of the HEIDENHAIN adapter cable with compensation factor

The maximum permissible cable length is calculated as follows:

$$n_{MG} \cdot 5\,\text{m} + \frac{4}{3} \cdot L_{AC} + \sum_i k_i \cdot L_i + n_C \cdot 5\,\text{m} \leq 100\,\text{m}$$

k_i: Length compensation factor[1)] of signal line i
L_i: Total length[1)] of signal line i
n_C: Number of joints
n_{MG}: Influence of the encoder, e.g. by a pluggable adapter cable; n = 1
4/3: Length compensation factor for HEIDENHAIN adapter cables
L_{AC}: Length of the HEIDENHAIN adapter cable

1) See technical documentation of the subsequent electronics manufacturer

Electrical safety and electromagnetic compatibility

Electrical safety
The encoder housings are isolated against internal circuits. Rated surge voltage: 500 V as per DIN EN 60664-1.

Electromagnetic compatibility (EMC)
When properly installed, and when HEIDENHAIN cables are used, HEIDENHAIN encoders fulfill the requirements for electromagnetic compatibility according to **EMC directive 2004/108/EC** with respect to the generic standards for:

- **Immunity DIN EN 61000-6-2:**

Specifically the following basic standards:

– ESD	DIN EN 61000-4-2
– Electromagnetic fields	DIN EN 61000-4-3
– Burst	DIN EN 61000-4-4
– Surge	DIN EN 61000-4-5
– Conducted disturbances	DIN EN 61000-4-6
– Power frequency magnetic fields	DIN EN 61000-4-8
– Voltage dips, short interruptions	DIN EN 61000-4-11

- **Emission DIN EN 61000-6-4:**

Specifically the following product (family) standard:

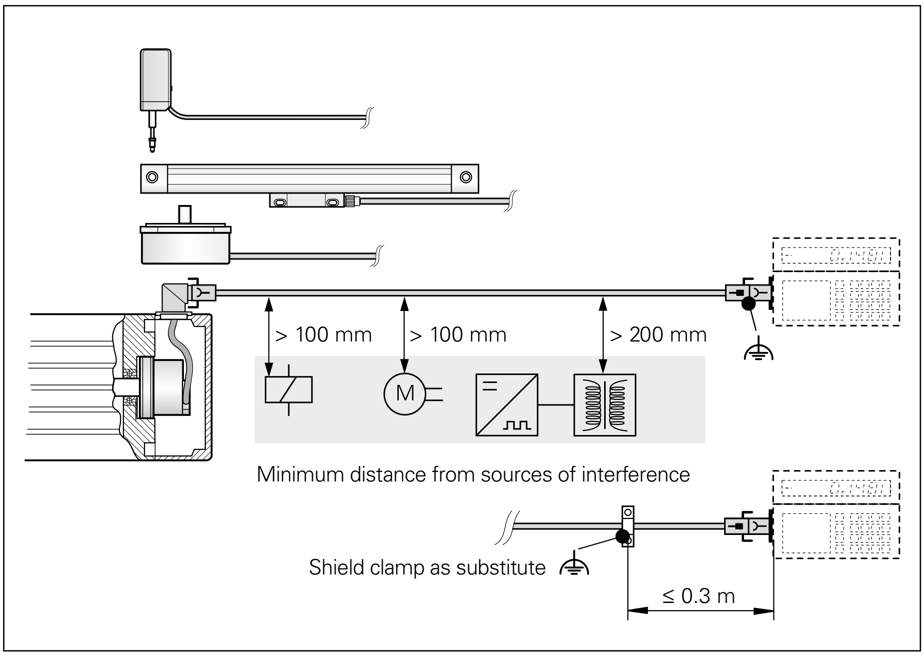
– For information technology equipment	DIN EN 55022

Sources of electrical interference
Electrical interference is caused mainly through capacitive or inductive transfer. Inductive transfer can be introduced into the system over signal lines and input or output terminals.
Typical sources for electrical interference include:

- 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 wires to the above devices

Measures
The following measures must be complied with for disturbance-free operation. If other actions are taken, specific measures regarding electrical safety and EMC are required.

- Use only original HEIDENHAIN cables. Consider the voltage drop in the supply wires.
- Use connecting elements (such as connectors or terminal boxes) with metal housings. Only the signals and voltage supply of the connected encoder may be routed through these elements (exception: hybrid motor cables from HEIDENHAIN).
- Connect the housings of the encoder, connecting elements and subsequent electronics through the shield of the cable. Ensure that the shield has complete contact over the entire surface (360°). For encoders with more than one electrical connection, refer to the documentation for the respective product.
- Cables with inner and outer shielding are to be kept spatially apart. Connect the inner shield to 0 V of the subsequent electronics. Do not connect the inner shield with the outer shield, neither in the encoder nor in the cable.
- Connect the (outer) shield to functional earth as per the mounting instructions.
- Prevent contact of the shield (e.g. connector housing) with other metal surfaces. Pay attention to this when installing cables.
- Do not install signal cables in the direct vicinity of interference sources (inductive consumers such as contactors, 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.
- If compensating currents are to be expected within the overall system, a separate equipotential bonding conductor must be provided. The shield does not have the function of an equipotential bonding conductor.
- Only provide power from PELV systems (see DIN EN 50178 for an explanation of the term) to position encoders, and provide high-frequency grounding with low impedance (see DIN EN 60204-1 Chapter EMC).
- For encoders with 11 µAPP interface: Use only HEIDENHAIN cable ID 244955-01 as extension cable. Overall length: max. 30 m.



Minimum distance from sources of interference

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