	Incremental			
	ROD 426	**ROD 466**	**ROD 436**	**ROD 486**
Interface	⊓⊔ TTL		⊓⊔ HTL	∿ 1 V_{PP}[1]
Line counts*	50 100 150 200 250 360 **500** 512 720			–
	1000 **1024** **1250** 1500 1800 **2000** **2048** **2500** **3600** **4096** **5000**			
	6000[2] 8192[2] 9000[2] 10 000[2]		–	
Reference mark	One			
Cutoff frequency –3 dB	–			≥ 180 kHz
Scanning frequency	≤ 300 kHz/≤ 150 kHz[2]			–
Edge separation a	≥ 0.39 µs/≥ 0.25 µs[2]			–
System accuracy	1/20 of grating period			
Electrical connection*	• **Flange socket** M23, radial and axial • **Cable 1 m/**5 m, with or **without M23 coupling**			
Voltage supply	DC 5 V ±0.5 V	DC 10 V to 30 V	DC 10 V to 30 V	DC 5 V ±0.5 V
Current consumption without load	≤ 120 mA	≤ 100 mA	≤ 150 mA	≤ 120 mA
Shaft	Solid shaft ∅ 6 mm			
Mech. permiss. speed n	≤ 16 000 rpm			
Starting torque	≤ 0.01 Nm (at 20 °C)			
Moment of inertia of rotor	$\leq 2.7 \times 10^{-6}$ kgm^2			
Shaft load[3]	*Axial:* ≤ 40 N; *radial:* ≤ 60 N at shaft end			
Vibration 55 Hz to 2000 Hz	≤ 300 m/s^2 (EN 60 068-2-6)			
Shock 6 ms	≤ 2000 m/s^2 (EN 60 068-2-27)			
Max. operating temp.[4]	100 °C	70 °C	100 °C[5]	
Min. operating temp.	*Flange socket or fixed cable:* –40 °C; *moving cable:* –10 °C			
Protection EN 60 529	IP67 at housing, IP64 at shaft inlet (IP66 upon request)			
Mass	≈ 0.3 kg			
Valid for ID	376846-xx	376866-xx	376836-xx	376886-xx[6]

Bold: This preferred version is available on short notice.

* Please select when ordering

[1] Restricted tolerances: signal amplitude 0.8 V_{PP} to 1.2 V_{PP}

[2] Signal periods; generated by integrated 2-fold interpolation (TTL x 2)

[3] See also *Mechanical design types and mounting*

[4] For the correlation between operating temperature and the shaft speed or supply voltage, see *General mechanical information*

[5] 80 °C for ROD 486 with 4096 or 5000 lines

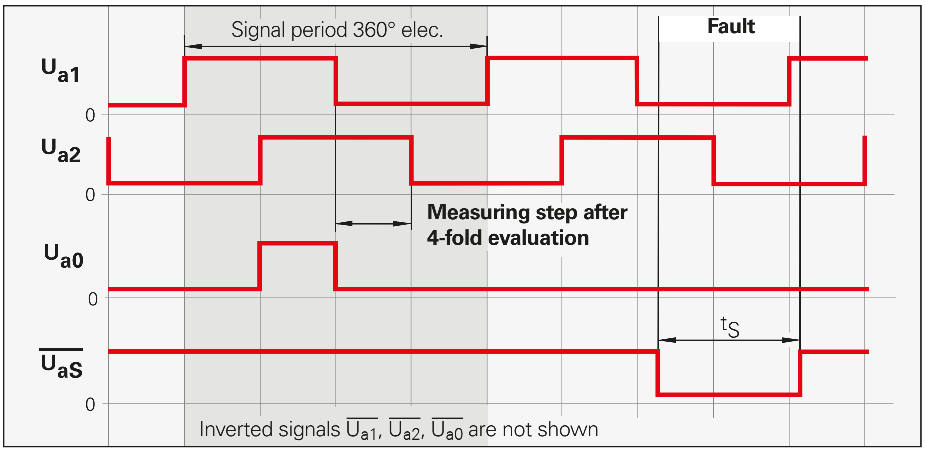
[6] Mechanical fault exclusion available; for restrictions on specifications and for special mounting information, see the *Fault Exclusion* customer information document

Incremental signals ⊓⊔TTL

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

The **fault detection signal** $\overline{U_{aS}}$ indicates fault conditions such as an interruption in the supply lines, failure of the light source, etc.

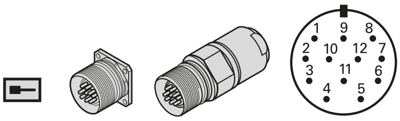
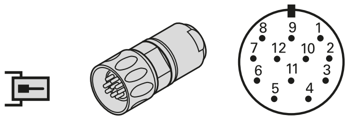
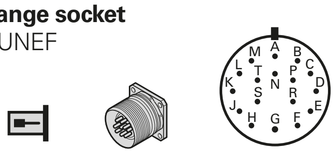


The distance between two successive edges of the incremental signals U_{a1} and U_{a2} through 1-fold, 2-fold or 4-fold evaluation is one **measuring step.**

Further information:

Comprehensive descriptions of all available interfaces as well as general electrical information are included in the *Interfaces of HEIDENHAIN Encoders* brochure.

ERN, ROD pin layout

12-pin flange socket or coupling, M23	**12-pin connector,** M23	**17-pin flange socket** 1 ¼" – 18UNEF
		

	Voltage supply				Incremental signals						Other signals	
M23	**12**	**2**	**10**	**11**	**5**	**6**	**8**	**1**	**3**	**4**	**7**	**9**
1 ¼"	**H**	**F**	**K**	**M**	**A**	**N**	**C**	**R**	**B**	**P**	**S**	**D/E/G/J/L/T**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**U_{a1}**	**$\overline{U_{a1}}$**	**U_{a2}**	**$\overline{U_{a2}}$**	**U_{a0}**	**$\overline{U_{a0}}$**	**$\overline{U_{aS}}$**[1]	**Vacant**[2]
	Brown/ Green	Blue	White/ Green	White	Brown	Green	Gray	Pink	Red	Black	Violet	Yellow

Shield on housing; **U_P** = Power supply voltage
Sensor: The sensor line is connected in the encoder with the corresponding power line.

[1] **ERO 14xx:** vacant

[2] **Exposed linear encoders:** TTL/11 µAPP switchover for PWT

HR pin layout

Screw-terminal connection

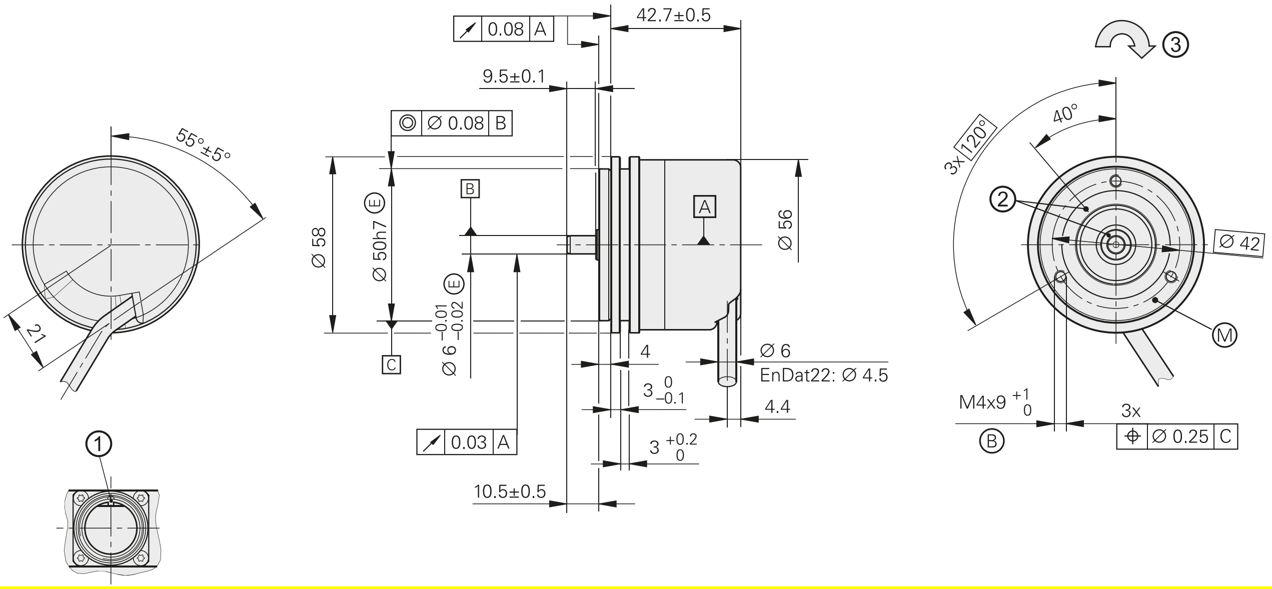
	Voltage supply		Incremental signals			
Connection	**+**	**–**	**A**	**$\overline{A}$**	**B**	**$\overline{B}$**
Signal	**U_P** 5 V	**U_N** 0 V	**U_{a1}**	**$\overline{U_{a1}}$**	**U_{a2}**	**$\overline{U_{a2}}$**

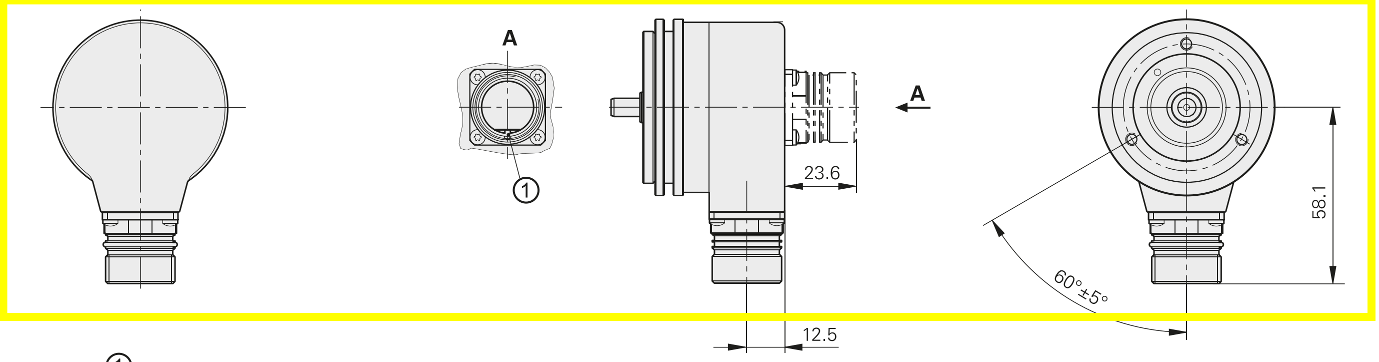
A shielded cable with a cross section of at least 0.5 mm^2 is recommended when connecting the handwheel to the power supply.

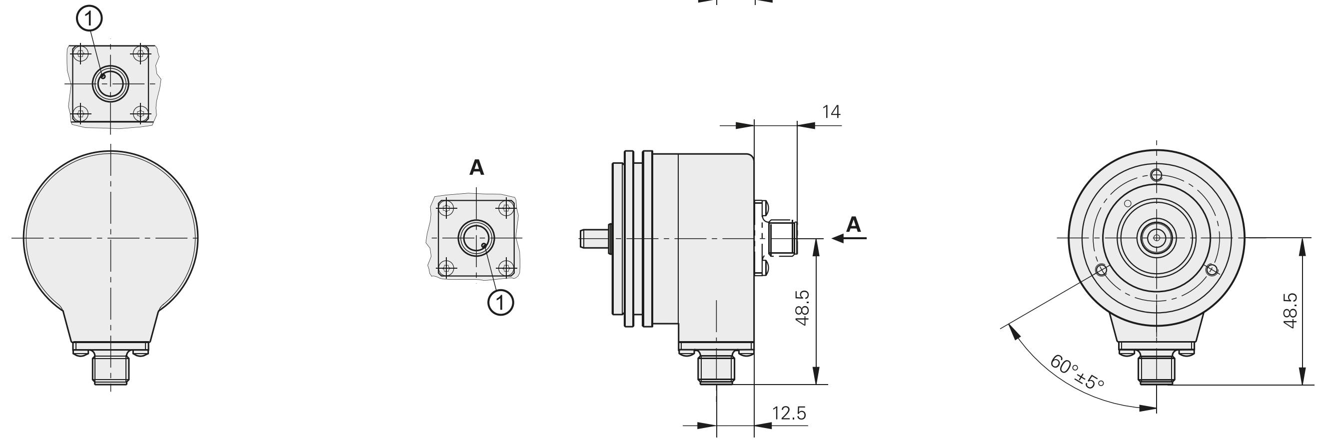
The handwheel is connected electrically via screw terminals. The appropriate wire end sleeves must be attached to the wires.

ROC/ROQ/ROD 400 and RIC/RIQ 400 series

Absolute and incremental rotary encoders
- **Synchro flange**
- **Solid shaft for separate shaft coupling**







mm
Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

Cable radial, also usable axially
A = Bearing
Ⓑ = Threaded mounting hole
Ⓜ = Measuring point for operating temperature
1 = Connector coding
2 = ROD reference mark position on shaft and flange ±30°
3 = Direction of shaft rotation for output signals as per the interface description

⊓⊔TTL square-wave signals

HEIDENHAIN encoders with the ⊓⊔TTL interface contain electronics that digitalize sinusoidal scanning signals either with or without interpolation.

The **incremental signals** are output 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 generate the **inverted signals** $\overline{U_{a1}}$, $\overline{U_{a2}}$, and $\overline{U_{a0}}$ for noise-immune transmission. The illustrated sequence of output signals—with U_{a2} lagging U_{a1}—applies to the direction of motion shown in the dimension drawing.

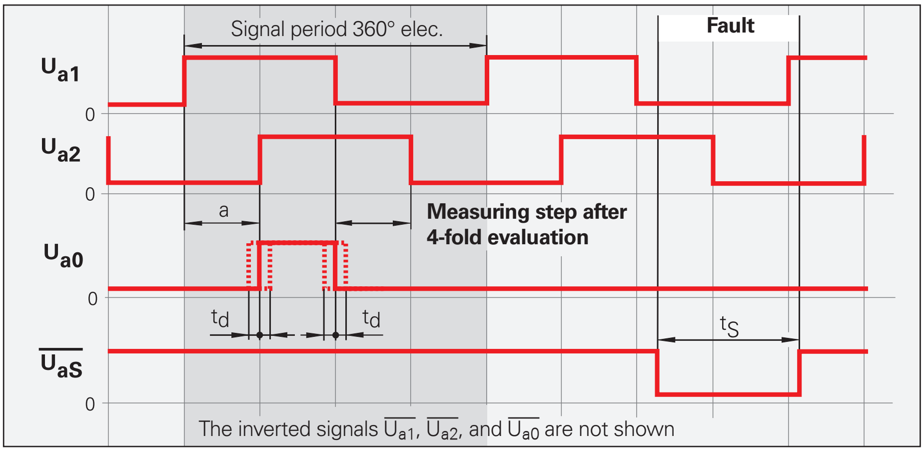
The **fault-detection signal** $\overline{U_{aS}}$ indicates malfunctions such as breakage of the power lines or failure of the light source. In automated manufacturing, for example, it can be used for machine switch-off.

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 is valid for the input circuit shown in conjunction with a cable length of 1 m, and is based on a measurement at the output of the differential line receiver.

Note:
Not all encoders output a reference-mark signal, fault-detection signal, and inverted signals. Please see the pin layout for this.

Interface	⊓⊔ **TTL** square-wave signals
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 upon request) $\lvert t_d \rvert \leq 50$ ns
Fault-detection signal Pulse width	**One TTL square-wave pulse $\overline{U_{aS}}$** Fault detection: LOW (upon request: high-impedance U_{a1}/U_{a2}) Proper functioning: 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 $C_{load} \leq 1000$ pF To 0 V Outputs are protected against a short to 0 V
Switching times (10 % to 90 %)	$t_+/t_- \leq 30$ ns (typ. 10 ns) with 1 m cable and specified input circuit
Connecting cable Cable length Propagation time	HEIDENHAIN shielded cables; e.g., PUR [4(2 × 0.14 mm^2) + (4 × 0.5 mm^2)] Max. 100 m ($\overline{U_{aS}}$ max. 50 m) Typ. 6 ns/m



The inverted signals $\overline{U_{a1}}$, $\overline{U_{a2}}$, and $\overline{U_{a0}}$ are not shown

Clocked output signals are typical of encoders and interpolation electronics with 5-fold interpolation (or higher). The edge separation *a* of these signals is derived 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 thus the resulting maximum permissible shaft speed or traversing 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 speed or shaft speed.

For the stated edge separation, these tolerances are already taken into account at 5 %; in each case, it is not the nominal edge separation that is stated, but rather the minimum edge separation a_{min}.

For the maximum permissible input frequency, however, a tolerance of at least 5 % must be taken into account. This means that the maximum permissible traversing speed or shaft speed is also reduced accordingly.

As a rule, encoders and interpolation electronics without interpolation have **unclocked output signals.** The minimum edge separation a_{min} at the maximum permissible input frequency is stated in the specifications. If the input frequency is reduced, then the edge separation correspondingly increases.

Cable-dependent differences in the propagation time additionally reduce the edge separation by 0.2 ns per meter of cable. In order to avoid counting errors, a safety margin of 10 % must be taken into account. The subsequent electronics must also be designed to process 90 % of the resulting edge separation.

Please note:
The maximum permissible **shaft speed** or **traversing speed** must not be exceeded—even temporarily—because this will cause irreversible counting errors.

Example calculation 1
LIDA 400 linear encoder
Requirements: display step: 0.5 µm; traversing speed: 1 m/s;
output signals: TTL; cable length to subsequent electronics: 25 m.
What is the minimum edge separation that the subsequent electronics must 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 speed	60 m/min (equivalent to 1 m/s)
+ tolerance value: 5 %	63 m/min
Select in the specifications:	
Next LIDA 400 version	120 m/min (from the specifications)
Minimum edge separation	**0.22 µs** (from the specifications)

Determining the edge separation that the subsequent electronics must process

Subtract cable-dependent differences in propagation time	0.2 ns per meter
For cable length of 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**

Example calculation 2
ERA 4000 angle encoder with 32 768 lines
Requirements: measuring step of 0.1″; TTL output signals (IBV external interface required); 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 shaft speed is possible?

Selection of the interpolation factor

32 768 lines corresponds to	a signal period of 40″
Signal period of 40″: measuring step of 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	
Therefore: resulting edge separation	0.556 µs
Subtract cable-dependent differences in the propagation time	0.2 ns per meter
For cable length of 20 m	4 ns
Minimum edge separation IBV 102	**≥ 0.56 µs**

Selecting the input frequency
With the IBV 102, the input frequencies and thus the edge separation a *are adjustable as per the Production Information document.*

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

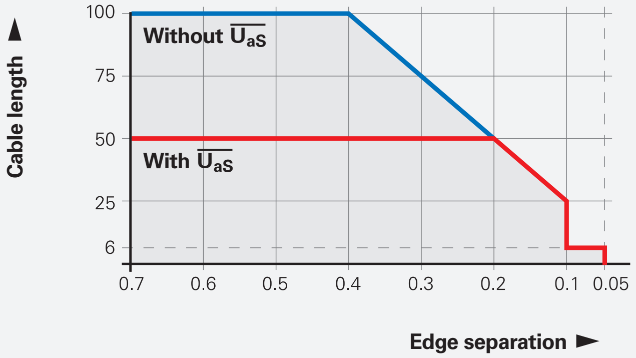
Calculating the permissible shaft speed

Subtract 5 % tolerance	3.8 kHz
This is 3800 signals per second, or 228 000 signals per minute.	
With the 32 768 lines of the ERA 4000, the following applies:	
Maximum permissible shaft speed	**6.95 rpm**

The permissible **cable length** for transmission of the TTL square-wave signals to the subsequent electronics is dependent on the edge separation *a*. The maximum cable length is 100 m, or 50 m for the fault detection signal. The required supply voltage must be applied at the encoder (see the specifications). Over the sense lines, the voltage at the encoder can be monitored and adjusted as needed by a suitable regulating device (remote sense power supply).

Greater cable lengths can be provided upon consultation with HEIDENHAIN.

Permissible cable length as a function of the edge separation



Input circuit of the subsequent electronics

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
Reference mark signal

Fault-detection signal