

	<b>Incremental</b>											
	<b>ROD 426</b>	<b>ROD 466</b>	<b>ROD 436</b>	<b>ROD 486</b>								
<b>Interface</b>	□ □ TTL			□ □ HTL	~ 1 V <sub>PP</sub> <sup>1)</sup>							
Line counts*	50	100	150	200	250	360	<b>500</b>	512	720	-		
	<b>1000</b>	<b>1024</b>	<b>1250</b>	1500	1800	<b>2000</b>	<b>2048</b>	<b>2500</b>	<b>3600</b>	<b>4096</b>	<b>5000</b>	
	6000 <sup>2)</sup>			8192 <sup>2)</sup>			9000 <sup>2)</sup>			10000 <sup>2)</sup>		
Reference mark	One											
Cutoff frequency -3 dB	-									≥ 180 kHz		
Scanning frequency	≤ 300 kHz/≤ 150 kHz <sup>2)</sup>									-		
Edge separation a	≥ 0.39 μs/≥ 0.25 μs <sup>2)</sup>									-		
<b>System accuracy</b>	1/20 of grating period											
<b>Electrical connection*</b>	<ul style="list-style-type: none"> <li>• <b>Flange socket</b> M23, radial and axial</li> <li>• <b>Cable 1 m/5 m</b>, with or <b>without M23 coupling</b></li> </ul>											
Voltage supply	<b>DC 5 V ±0.5 V</b>			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		
<b>Shaft</b>	Solid shaft Ø 6 mm											
Mech. permiss. speed n	≤ 16000 rpm											
Starting torque	≤ 0.01 Nm (at 20 °C)											
Moment of inertia of rotor	≤ 2.7 × 10 <sup>-6</sup> kgm <sup>2</sup>											
Shaft load <sup>3)</sup>	<i>Axial</i> : ≤ 40 N; <i>radial</i> : ≤ 60 N at shaft end											
<b>Vibration</b> 55 Hz to 2000 Hz	≤ 300 m/s <sup>2</sup> (EN 60068-2-6)											
<b>Shock</b> 6 ms	≤ 2000 m/s <sup>2</sup> (EN 60068-2-27)											
<b>Max. operating temp.</b> <sup>4)</sup>	100 °C			70 °C			100 °C <sup>5)</sup>					
<b>Min. operating temp.</b>	<i>Flange socket or fixed cable</i> : -40 °C; <i>moving cable</i> : -10 °C											
<b>Protection</b> EN 60 529	IP67 at housing, IP64 at shaft inlet (IP66 upon request)											
<b>Mass</b>	≈ 0.3 kg											
<b>Valid for ID</b>	376846-xx			376866-xx			376836-xx			376886-xx <sup>6)</sup>		

**Bold:** This preferred version is available on short notice.

\* Please select when ordering

1) Restricted tolerances: signal amplitude 0.8 V<sub>PP</sub> to 1.2 V<sub>PP</sub>

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

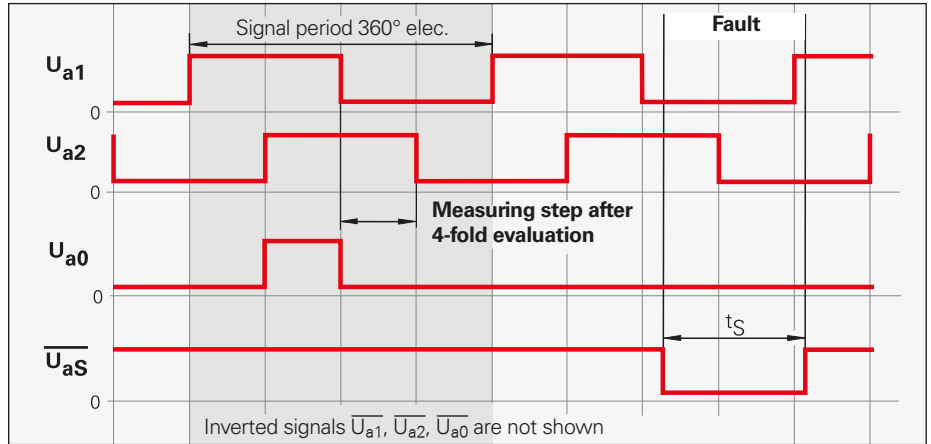
6) Mechanical fault exclusion available; for restrictions on specifications and for special mounting information, see the *Fault Exclusion* customer information document

# Incremental signals $\square$ TTL

HEIDENHAIN encoders with  $\square$ 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  $90^\circ$  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 1/4" – 18UNEF			
Voltage supply				Incremental signals				Other signals			
M23				M23				1 1/4"			
12 2 10 11				5 6 8 1 3 4				7 9			
H F K M				A N C R B P				S D/E/G/J/L/T			
Up Sensor Up 0V Sensor 0V				Ua1 Ua1 Ua2 Ua2 Ua0 Ua0				UaS <sup>1)</sup> Vacant <sup>2)</sup>			
Brown/Green Blue White/Green White				Brown Green Gray Pink Red Black				Violet Yellow			

**Shield** on housing; **Up** = Power supply voltage

**Sensor:** The sensor line is connected in the encoder with the corresponding power line.

<sup>1)</sup> ERO 14xx: vacant

<sup>2)</sup> Exposed linear encoders: TTL/11  $\mu$ App switchover for PWT

## HR pin layout

Screw-terminal connection						
Voltage supply		Incremental signals				
<b>Connection</b>	+	-	A	A	B	B
<b>Signal</b>	Up 5V	Un 0V	Ua1	Ua1	Ua2	Ua2

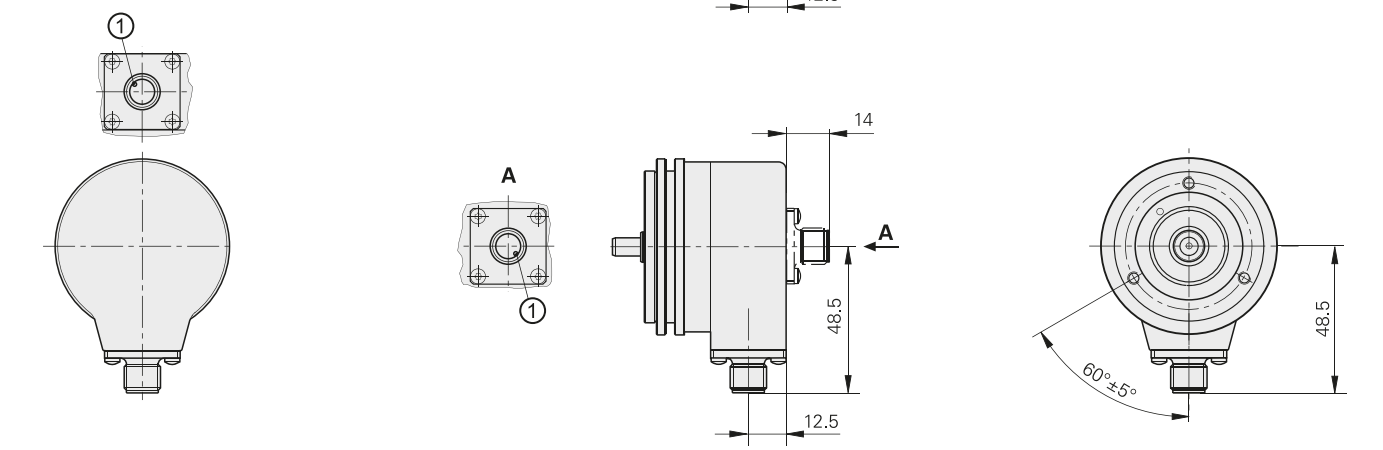
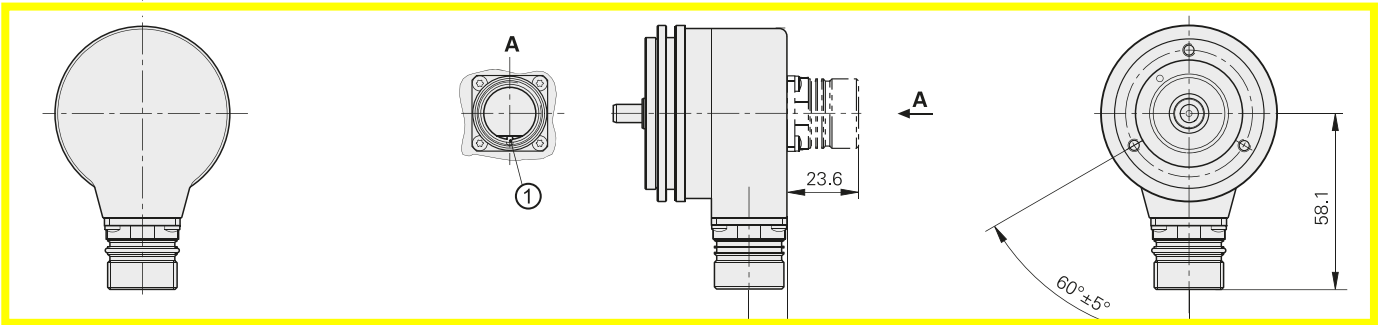
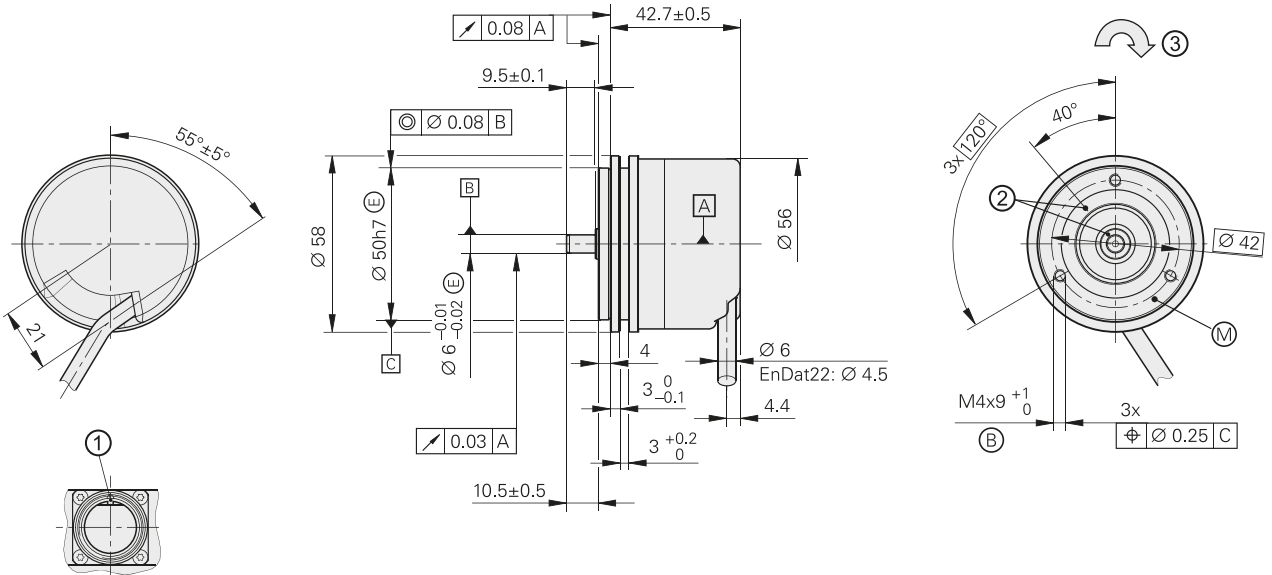
A shielded cable with a cross section of at least  $0.5 \text{ mm}^2$  is recommended when connecting the handwheel to the power supply.

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:  $\pm 0.2$  mm

- Cable radial, also usable axially
- ▣ = Bearing
- ⊙ = Threaded mounting hole
- ⊙ = Measuring point for operating temperature
- 1 = Connector coding
- 2 = ROD reference mark position on shaft and flange  $\pm 30^\circ$
- 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.

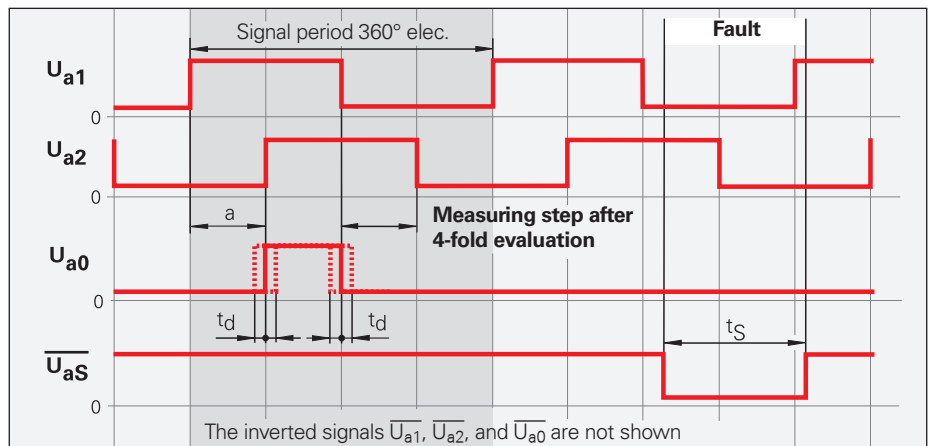
The distance between two successive edges of the incremental signals  $U_{a1}$  and  $U_{a2}$  through 1-fold, 2-fold, or 4-fold evaluation is one **measuring step**.

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.

<b>Interface</b>	□TTL square-wave signals
<b>Incremental signals</b>	Two TTL square-wave signals $U_{a1}$ , $U_{a2}$ , and their inverted signals $\overline{U_{a1}}$ , $\overline{U_{a2}}$
<b>Reference mark signal</b> Pulse width Delay time	<b>One or more TTL square-wave pulses <math>U_{a0}</math></b> and their inverted pulses $\overline{U_{a0}}$ 90° elec. (other widths upon request) $ t_d  \leq 50$ ns
<b>Fault-detection signal</b> Pulse width	<b>One TTL square-wave pulse <math>\overline{U_{aS}}</math></b> Fault detection: LOW (upon request: high-impedance $U_{a1}/U_{a2}$ ) Proper functioning: HIGH $t_s \geq 20$ ms
<b>Signal amplitude</b>	Differential line driver as per EIA standard RS-422
<b>Permissible load</b>	$Z_0 \geq 100 \Omega$ Between associated outputs $ I_L  \leq 20$ mA                      Max. load per output $C_{load} \leq 1000$ pF                To 0 V Outputs are protected against a short to 0 V
<b>Switching times</b> (10% to 90%)	$t_+/t_- \leq 30$ ns (typ. 10 ns) with 1 m cable and specified input circuit
<b>Connecting cable</b> Cable length Propagation time	HEIDENHAIN shielded cables; e.g., PUR [4(2 × 0.14 mm <sup>2</sup> ) + (4 × 0.5 mm <sup>2</sup> )] Max. 100 m ( $\overline{U_{aS}}$ max. 50 m) Typ. 6 ns/m



**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  $\mu A_{PP}$ ) 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 **unlocked 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  $\mu m$ ; 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  $\mu m$  grating period : 0.5  $\mu m$  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  $\mu s$**  (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  $\mu s$

Subtract 10% safety margin 0.022  $\mu s$

**Minimum edge separation for the subsequent electronics**

**0.193  $\mu s$**

**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  $\mu s$  (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  $\mu s$

This corresponds to 90% of the resulting edge separation

Therefore: resulting edge separation 0.556  $\mu s$

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**

**$\geq 0.56 \mu s$**

**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  $\mu s$

**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.

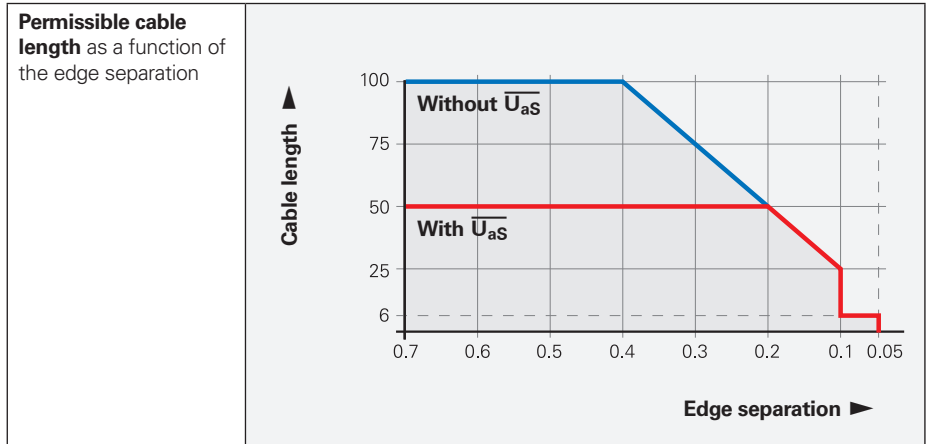
With the 32 768 lines of the ERA 4000, the following applies:

**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.



### Input circuit of the subsequent electronics

#### Dimensioning

IC<sub>1</sub> = Recommended differential line receiver:

- DS 26 C 32 AT
- Only for  $a > 0.1 \mu\text{s}$ :
- AM 26 LS 32
- MC 3486
- SN 75 ALS 193

$R_1 = 4.7 \text{ k}\Omega$

$R_2 = 1.8 \text{ k}\Omega$

$Z_0 = 120 \Omega$

$C_1 = 220 \text{ pF}$  (serves to improve noise immunity)

