



HEIDENHAIN



Product Information

ECA 4000

Absolute Modular Angle
Encoder for Safety-Related
Applications

ECA 4410

Absolute angle encoder with high accuracy for safety-related applications

- Steel scale drum with centering collar
- Consists of scanning head and scale drum
- Fault exclusion for the loosening of the mechanical connection



Scanning head	AK ECA 4410	Functional Safety	Scale drum
Interface	EnDat 2.2		Measuring standard
Ordering designation	EnDat22		Coefficient of expansion
Clock frequency	≤ 16 MHz		Drum inside diameter*
Calculation time t_{cal}	≤ 5 µs		Drum outside diameter*
Functional safety for applications up to	<ul style="list-style-type: none"> • SIL 2 according to EN 61 508 (further basis for testing: EN 61 800-5-2) • Category 3, PL "d" as per EN ISO 13849-1:2015 		Safe position ^{4) 5)}
PFH	≤ $20 \cdot 10^{-9}$ (up to 6000 m above sea level)		Safety-related measuring step SM
Electrical connection	Cable, 1 m or 3 m with 8-pin M12 coupling (male) or 15-pin D-sub connector		Mechanically permissible speed
Cable length ¹⁾	≤ 100 m		Max. angular acceleration
Voltage supply	DC 3.6 V to 14 V		Elec. permissible speed
Power consumption (max.)	At 3.6 V: 700 mW At 14 V: 800 mW		Moment of inertia of rotor
Current consumption (typical)	At 5 V: 90 mA (without load)		Permissible axial movement
Vibration 55 Hz to 2000 Hz Shock 11 ms	≤ 200 m/s ² (EN 60 068-2-6) ≤ 200 m/s ² (EN 60 068-2-27)		Positions per revolution
Operating temperature	-10 °C to 70 °C ²⁾		Measuring step
Relative air humidity	≤ 93 % (at 40 °C/4d as per EN 60 068-2-78); without condensation		Signal periods
Protection EN 60 529 ³⁾	IP67		Accuracy of graduation
Mass Scanning head Connecting cable Coupling (M12) D-sub connector	18 g (without cable) 20 g/m 15 g 32 g		Position error per signal period RMS(18)
			Protection EN 60 529 ³⁾
			Mass

* Please select when ordering

¹⁾ With HEIDENHAIN cable; clock frequency ≤ 8 MHz

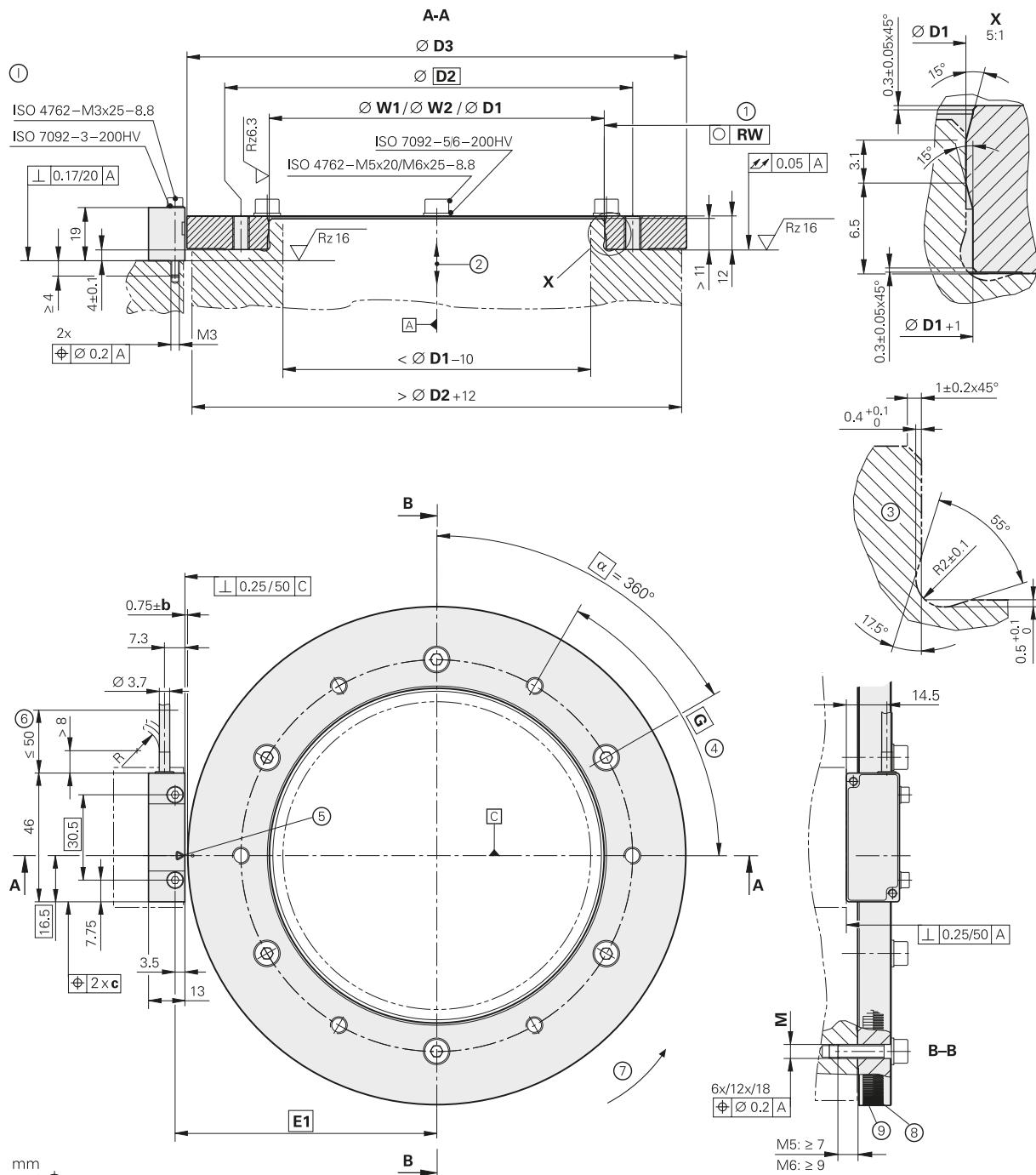
²⁾ With drum outside diameter 104.63 mm: 10 °C to 70 °C

³⁾ In the application the device must be protected from contamination by solids and liquids. If necessary, use a suitable enclosure with seal and sealing air

⁴⁾ Further tolerances may occur in subsequent electronics after position value comparison (contact manufacturer of subsequent electronics)

⁵⁾ Mechanical connection: fault exclusions for loosening of the scanning head and scale drum (page 6)

TTR ECA 4400 scale drum								
								
Steel drum $\alpha_{\text{therm}} \approx 10.4 \cdot 10^{-6} \text{ K}^{-1}$								
70 mm	80 mm	120 mm	120 mm	150 mm	180 mm	270 mm	425 mm	512 mm
104.63 mm	127.64 mm	148.2 mm	178.55 mm	208.89 mm	254.93 mm	331.31 mm	484.07 mm	560.46 mm
$\pm 0.88^\circ$		$\pm 0.44^\circ$				$\pm 0.22^\circ$		$\pm 0.11^\circ$
0.352° (10 bits)		0.176° (11 bits)				0.088° (12 bits)		0.044° (13 bits)
$\leq 8500 \text{ rpm}$	$\leq 6250 \text{ rpm}$	$\leq 5250 \text{ rpm}$	$\leq 4500 \text{ rpm}$	$\leq 4250 \text{ rpm}$	$\leq 3250 \text{ rpm}$	$\leq 2500 \text{ rpm}$	$\leq 1800 \text{ rpm}$	$\leq 1500 \text{ rpm}$
14 000 rad/s ²	6600 rad/s ²	7900 rad/s ²	2700 rad/s ²	1800 rad/s ²	1000 rad/s ²	1300 rad/s ²	900 rad/s ²	1200 rad/s ²
$\leq 7000 \text{ rpm}$	$\leq 5750 \text{ rpm}$	$\leq 4400 \text{ rpm}$	$\leq 3000 \text{ rpm}$	$\leq 2550 \text{ rpm}$	$\leq 2100 \text{ rpm}$	$\leq 900 \text{ rpm}$	$\leq 600 \text{ rpm}$	$\leq 550 \text{ rpm}$
$0.81 \cdot 10^{-3} \text{ kgm}^2$	$1.9 \cdot 10^{-3} \text{ kgm}^2$	$2.3 \cdot 10^{-3} \text{ kgm}^2$	$7.1 \cdot 10^{-3} \text{ kgm}^2$	$12 \cdot 10^{-3} \text{ kgm}^2$	$28 \cdot 10^{-3} \text{ kgm}^2$	$59 \cdot 10^{-3} \text{ kgm}^2$	$195 \cdot 10^{-3} \text{ kgm}^2$	$258 \cdot 10^{-3} \text{ kgm}^2$
$\leq \pm 0.4 \text{ mm}$ (scale drum relative to the scanning head)								
134217728 (27 bits)					268435456 (28 bits)		536870912 (29 bits)	
0.0097"					0.0048"		0.0024"	
8195	10 010	11 616	14 003	16 379	19 998	25 993	37 994	44 000
$\pm 3.7''$	$\pm 3.0''$	$\pm 2.8''$	$\pm 2.5''$	$\pm 2.5''$	$\pm 2.5''$	$\pm 2.5''$	$\pm 2.0''$	$\pm 2.0''$
$\pm 0.20''$ 0.040"	$\pm 0.16''$ 0.032"	$\pm 0.14''$ 0.028"	$\pm 0.12''$ 0.023"	$\pm 0.10''$ 0.020"	$\pm 0.08''$ 0.016"	$\pm 0.06''$ 0.012"	$\pm 0.04''$ 0.009"	$\pm 0.04''$ 0.007"
IP00								
$\approx 0.40 \text{ kg}$	$\approx 0.68 \text{ kg}$	$\approx 0.51 \text{ kg}$	$\approx 1.2 \text{ kg}$	$\approx 1.5 \text{ kg}$	$\approx 2.3 \text{ kg}$	$\approx 2.6 \text{ kg}$	$\approx 3.8 \text{ kg}$	$\approx 3.6 \text{ kg}$



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

W1 = Without mechanical fault exclusion
W2 = With mechanical fault exclusion

①, ⑪ = Mounting options

Ⓐ = Bearing

W = Mating diameter (shaft)

② = Circularity of mating diameter (shaft)

③ = Permissible axial motion of measured shaft: $\leq \pm 0.4$ mm

④ = Design proposal for undercut

⑤ = Back-off thread, not permitted for drum fastening

⑥ = Optical centerline

⑦ = Cable support

⑧ = Positive direction of rotation

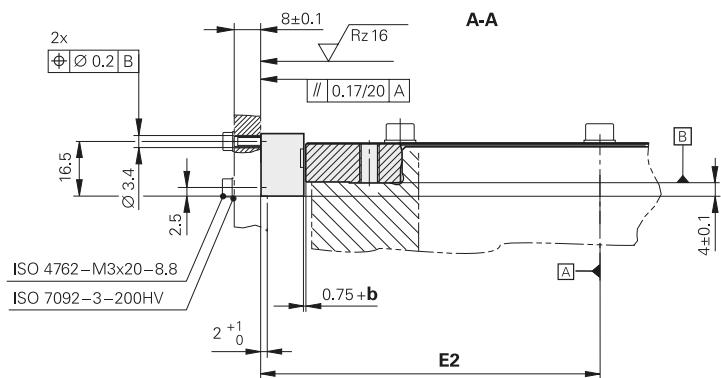
⑨ = Incremental track

⑩ = Code track

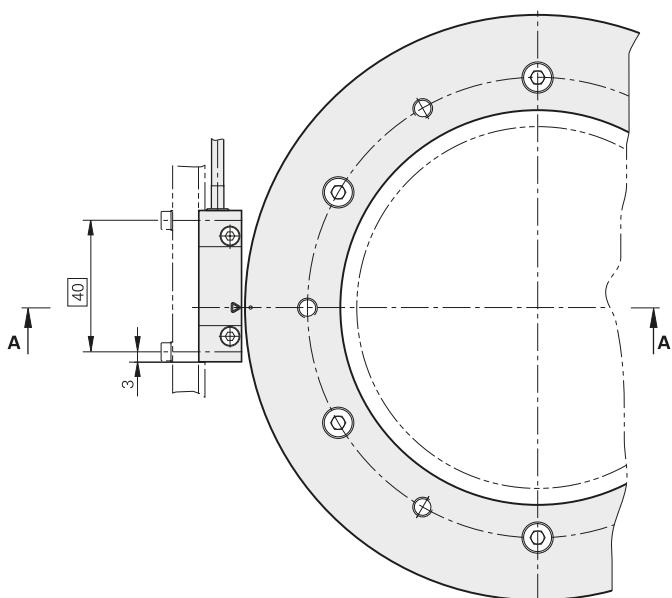
⑪ = Space for mounting aid

	b [mm]	c [mm]
∅ 70	± 0.05	0.3
∅ 80	± 0.07	0.3
∅ 120	± 0.07	0.3
∅ 120	± 0.10	0.3
∅ 150	± 0.12	0.5
∅ 180	± 0.12	0.5
∅ 270	± 0.15	1.0
∅ 425	± 0.15	1.0
∅ 512	± 0.15	1.0

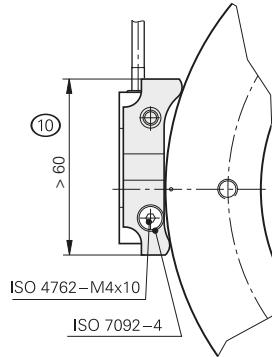
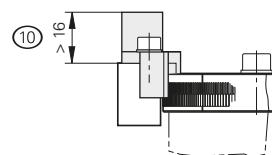
(II)



A-A



Accessory: Mounting aid



D1	W1	W2	RW	D2	D3	E1	E2	α	M	G
$\varnothing 70 -0.001/-0.005$	$\varnothing 70 +0.005$	$\varnothing 70 +0.007/+0.002$	0.001	$\varnothing 85$	$\varnothing 104.63$	56.57	66.07	$6 \times 60^\circ$	6x M5	6x M6
$\varnothing 80 -0.001/-0.005$	$\varnothing 80 +0.006$	$\varnothing 80 +0.009/+0.003$	0.0015	$\varnothing 95$	$\varnothing 127.64$	68.07	77.57	$6 \times 60^\circ$	6x M5	6x M6
$\varnothing 120 -0.001/-0.008$	$\varnothing 120 +0.008$	$\varnothing 120 +0.040/+0.022$	0.002	$\varnothing 134$	$\varnothing 148.20$	78.35	87.85	$6 \times 60^\circ$	6x M5	6x M6
$\varnothing 120 -0.001/-0.008$	$\varnothing 120 +0.008$	$\varnothing 120 +0.040/+0.022$	0.002	$\varnothing 140$	$\varnothing 178.55$	93.52	103.02	$6 \times 60^\circ$	6x M5	6x M6
$\varnothing 150 -0.001/-0.008$	$\varnothing 150 +0.008$	$\varnothing 150 +0.046/+0.028$	0.002	$\varnothing 165$	$\varnothing 208.89$	108.69	118.19	$6 \times 60^\circ$	6x M5	6x M6
$\varnothing 180 -0.001/-0.008$	$\varnothing 180 +0.010$	$\varnothing 180 +0.050/+0.030$	0.003	$\varnothing 200$	$\varnothing 254.93$	131.71	141.21	$6 \times 60^\circ$	6x M5	6x M6
$\varnothing 270 0/-0.01$	$\varnothing 270 +0.012$	$\varnothing 270 +0.067/+0.044$	0.003	$\varnothing 290$	$\varnothing 331.31$	169.90	179.40	$12 \times 30^\circ$	12x M5	12x M6
$\varnothing 425 0/-0.01$	$\varnothing 425 +0.015$	$\varnothing 425 +0.094/+0.067$	0.006	$\varnothing 445$	$\varnothing 484.07$	246.29	255.79	$12 \times 30^\circ$	12x M6	12x M6
$\varnothing 512 0/-0.015$	$\varnothing 512 +0.016$	$\varnothing 512 +0.109/+0.076$	0.007	$\varnothing 528$	$\varnothing 560.46$	284.48	293.98	$18 \times 20^\circ$	18x M6	12x M8

For CAD data go to cad.heidenhain.de

Functional safety

With the absolute angle encoder of the ECA 4410 series, HEIDENHAIN offers an ideal solution for position acquisition for rotational axes in safety-related applications. In conjunction with a safe control, the encoders can be used as single-encoder systems for applications with control category SIL 2 (as per EN 61 508) and performance level "d" (as per EN ISO 13 849).

Reliable transmission of the position is based on two independently generated absolute position values and on error bits, which are then provided to the safe control. The functions of the encoder can be used for numerous safety functions in the complete system as per EN 61 800-5-2.

The ECA 4410 angle encoder provides a safe absolute position value at all times—including immediately after switch-on. Purely serial data transfer takes place via the bidirectional EnDat 2.2 interface.

In addition to the data interface, the mechanical connection of the encoder to the motor is also relevant to safety. Table

D16 of the standard for electrical drives, EN 61 800-5-2, defines the loosening of the mechanical connection between the encoder and drive as a fault that requires consideration. Since it cannot be guaranteed that the control will detect such errors, a fault exclusion for the loosening of the mechanical connection is frequently required.

Fault exclusion for the loosening of the mechanical connection

The machine manufacturer is responsible for the dimensioning of mechanical connections in a drive system. The OEM should ideally consider the application conditions for the mechanical design. Providing objective evidence of a safe connection is time-consuming, however. For this reason, HEIDENHAIN has developed a mechanical fault exclusion for the ECA 4410 series and confirmed it by way of a type examination.

The qualification of the mechanical fault exclusion was performed for a broad application range of the encoders. This means that fault exclusion is ensured under the operating conditions listed below. The great range of temperatures in combination with the multitude of material characteristics, as well as the maximum permissible shaft speeds and accelerations require an interference fit of the drum. The dimensioning of the interference fit, taking into account all safety factors, makes it necessary to shrink-fit the scale drum and directly influences the required assembly temperatures.

Mounting with mechanical fault exclusion is to be seen as an option. If no mechanical fault exclusion is required for the safety strategy, the drum can also be fastened without interference fitting (see **W1** under *Dimensions*).

Both mounting options and the prerequisites are described in the documentation.

Mechanical connection	Fastening	Safe position for the mechanical coupling ³⁾	Restricted characteristic values ⁴⁾
Scale drum	Interference fit according to dimension drawing: Screw connection: ¹⁾ ²⁾ M5x20 ISO 4762 8.8 screws M6x25 ISO 4762 8.8 screws	Drum outside diameter 104.63 mm to 127.64 mm: $\pm 0.015^\circ$ Drum outside diameter 148.2 mm or more: $\pm 0.0^\circ$	See <i>Specifications</i> : • Vibration • Shock • Maximum angular acceleration • Operating temperature
Scanning head	Mounting option I: Screw connection: ²⁾ M3x25 ISO 4762 8.8 screws		See <i>Dimensions</i> : • Mounting tolerances
	Mounting option II: Screw connection: ²⁾ M3x20 ISO 4762 8.8 screws		See <i>Mounting</i> : • Usable materials • Mounting conditions

¹⁾ A material bonding anti-rotation lock is to be used for the screw connections of the scale drums (mounting or service)

²⁾ Friction class B according to VDI 2230

³⁾ Fault exclusions are given only for the mounting conditions explicitly stated

⁴⁾ Compared with ECA 44x2

Material

For the material of the mating shaft and stator, the data given in the table is to be observed.

Mounting temperature

All information on screw connections is given with respect to a mounting temperature of 15 °C to 35 °C.

Assembling the scale drum

An oversize of the shaft is required for fault exclusion. The ECA 4400 scale drum should preferably be shrunk thermally onto the mating shaft and additionally be fastened with screws. For this purpose, the scale drum must be heated slowly before mounting. Ideally, this is done using an oven or heating plate. The diagram shows the recommended minimum temperatures for the different drum diameters. The maximum temperature must not exceed 140 °C.

During shrink-fitting, make sure that the hole patterns of the scale drum and mating shaft are properly aligned. Appropriate centering aids (setscrews) can facilitate mounting. When the scale drum has cooled down, all mounting screws have to be tightened again with the correct torque. The mounting screws used for the assembly of the scanning head and scale drum must only be used to secure the scanning head and the scale drum. Do not additionally fasten any other components with these screws.

Removing the scale drum

The scale drum is disassembled using the corresponding back-off threads in the drum. To do so, fasten greased screws and tighten them in a row until the scale drum comes off the shaft.

Mounting the scanning head

Ensure that the diameter specifications for all components of the encoder (scale drum, scanning head, mounting aid) match. The relevant information is indicated on the ID labels. A mounting wizard in the ATS software helps to ensure that the scanning head and the scale drum are properly aligned.

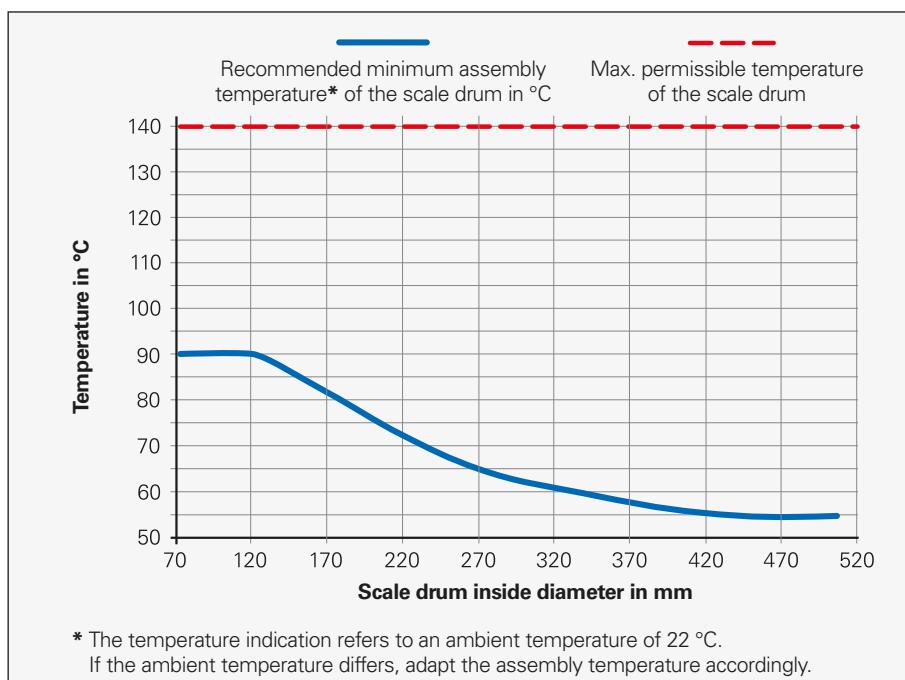
Accessory:

- Mounting aid (corresponding to drum diameter)
- Mounting wizard in ATS software

Mating shaft/mating stator

Material	Steel
Tensile strength R_m	$\geq 600 \text{ N/mm}^2$
Shear strength τ_m	$\geq 390 \text{ N/mm}^2$
Elastic modulus E	$\geq 200\,000 \text{ N/mm}^2$ to $215\,000 \text{ N/mm}^2$
Coefficient of thermal expansion α_{therm}	$(10 \text{ to } 13) \cdot 10^{-6} \text{ K}^{-1}$ ¹⁾

¹⁾ More available on request



Electrical connection

EnDat pin layout

8-pin coupling, M12				15-pin D-sub connector					
	Voltage supply				Absolute position values				
	8	2	5	1	3	4	7	6	
	4	12	2	10	5	13	8	15	
	U_P	Sensor U_P	0 V	Sensor 0 V	DATA	DATA	CLOCK	CLOCK	
	Brown/Green	Blue	White/Green	White	Gray	Pink	Violet	Yellow	

Cable shield connected to housing; **U_P** = Power supply voltage

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

Vacant pins or wires must not be used.

When engaged, the connections provide **protection** to IP67 (D-sub connector: IP50; EN 60529).

When not engaged, there is no protection.

EnDat connecting cables

PUR connecting cable	$[(4(2 \cdot 0.09 \text{ mm}^2))]; A_P = 0.09 \text{ mm}^2$		
PUR connecting cable	$[(4 \times 0.14 \text{ mm}^2) + (4 \times 0.34 \text{ mm}^2)]; A_P = 0.34 \text{ mm}^2$	$\varnothing 6 \text{ mm}$	$\varnothing 3.7 \text{ mm}^1)$
Complete with connector (female), and coupling (male), 8-pin		368330-xx	801142-xx
Complete with right-angle connector (female), and coupling (male), 8-pin		373289-xx	801149-xx
Complete with connector (female), 8-pin and D-sub connector (male), 15-pin, for PWM 20, EIB 74x etc.		524599-xx	801129-xx
Complete with right-angle connector (female), 8-pin and D-sub connector (male), 15-pin, for PWM 20, EIB 74x etc.		722025-xx	801140-xx
With one connector (female), 8-pin		634265-xx	-
With one right-angle connector (female), 8-pin		606317-xx	-

¹⁾ Max. total cable length 6 m

A_P: Cross section of power supply lines

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

Related documents: Comply with the information in the following documents to ensure the correct and intended operation of the encoder:

- Catalog: *Angle Encoders Without Integral Bearing* 606136-xx
- Catalog: *Interfaces of HEIDENHAIN Encoders* 1078628-xx
- *Safety-Related Position Measuring Systems* Technical Information: 596632-xx
- Specification for implementation in a safe control or inverter 533095-xx
- Mounting Instructions: *TTR ECA 4400 FS* 1177156-xx
- AK ECA 4410 FS* 1177157-xx
- Mounting wizard for ECA 44xx* 1126455-xx