

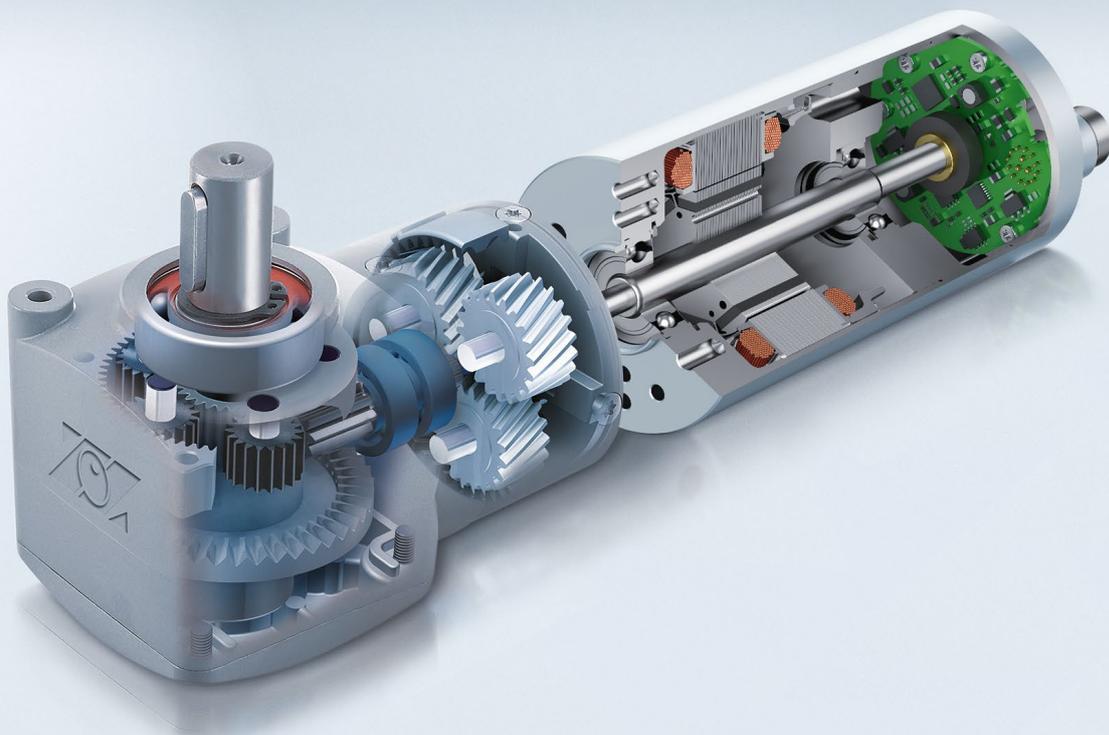
Brushless internal rotor motors ECI series

Drive solutions | Industrial drive engineering 2017-05

ebmpapst

The engineer's choice





Modular drive systems.
Motors with integrated logic and power
electronics – optional gearhead, encoder and brake.

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About ebm-papst.

As technological leader for ventilation and drive engineering, ebm-papst is in demand as an engineering partner in many industries. With over 15,000 different products, we provide the right solution for just about any challenge. Our fans and drives are reliable, quiet and energy-efficient.

Six reasons that make us the ideal partner:

Our systems expertise.

You want the best solution for every project. The interrelationships between ventilation and drive engineering must thus be considered as a whole. And that's what we do – with **motor technology** that sets standards, sophisticated **electronics** and **aerodynamic designs** – all from a single source and perfectly matched. These system solutions release unique synergies worldwide. And in particular – they relieve you of a lot of work, so that you can concentrate on your core competency.

The ebm-papst spirit of invention.

In addition to our wide range of products, we are always able to develop customized solutions for you. A diversified team of 600 engineers and technicians works at our three locations in Germany: Mulfingen, Landshut and St. Georgen. Contact us to discuss your next project.

Our lead in technology.

As pioneer and trail-blazer for developing highly efficient EC technology, we are way ahead of other motor manufacturers. Almost all our products are also available with GreenTech EC technology. The list of benefits is long: higher efficiency, maintenance-free, longer service life, sound reduction, intelligent control characteristics and unrivalled energy efficiency with savings of up to 80 % compared to conventional AC technology. Let our technology be your competitive advantage as you lead in your industry.

Closeness to our customers.

ebm-papst has 25 production locations worldwide (including facilities in Germany, China and the USA), together with 49 sales offices, each of which has a dense network of sales representatives. You will always have a local contact, someone who speaks your language and knows your market.

Our standard of quality.

Of course you can rely on the highest standards of quality with our products. Our quality management is uncompromising, at every step in every process. This is underscored by our certification according to international standards including DIN EN ISO 9001, TS declaration of conformity and DIN EN ISO 14001.

Our sustainable approach.

Assuming responsibility for the environment, for our employees and for society is an integral part of our corporate philosophy. We develop products with an eye to maximum environmental compatibility, in particular resource-preserving production methods. We promote environmental awareness among our young staff and are actively involved in sports, culture and education. That's what makes us a leading company – and an ideal partner for you.

Our success story to becoming market leader and technological innovator.

- 1963** Elektrobau Mulfingen **GmbH & Co. KG founded by** Gerhard Sturm and Heinz Ziehl.
- 1965** Development of the first compact fan in the field of EC-/DC-technology.
- 1966** The ebm-papst success story started to take off with the release of the new 68 motor.
- 1972** The first foreign subsidiary was founded in Sweden.
- 1988** Gerhard Sturm receives the German Cross of Merit.
- 1990** The sixty millionth external rotor fan was produced.
- 1992** Acquisition of **PAPST Motoren GmbH** in St. Georgen.
- 1997** Purchase of the **Landshut** plant (mvl).
- 2003** Change of name to **ebm-papst**.
- 2007** Introduction of the gearhead "**EtaCrown®**".
- 2010** **GreenTech** – our symbol for energy-efficiency and resource conservation.
- 2012** Introduction of a new generation control electronics (**K4**) for BLDC motors.
- 2013** ebm-papst acquires the gear specialist, **Zeitlauf**, and wins the **German Sustainability Award**.
- 2014** Launch of the BLDC internal rotor motor, **ECI 80**.
- 2015** Introduction of the overload-capable planetary gear "**Optimax 63**".
- 2016** Expansion of the electronic production plant, St. Georgen Hagenmoos.





ECI motors.



ECI-42.20-K1	14
ECI-63.XX-K1	16
ECI-63.XX-K3	20
ECI-63.XX-K4	24
ECI-63.XX-K5	28
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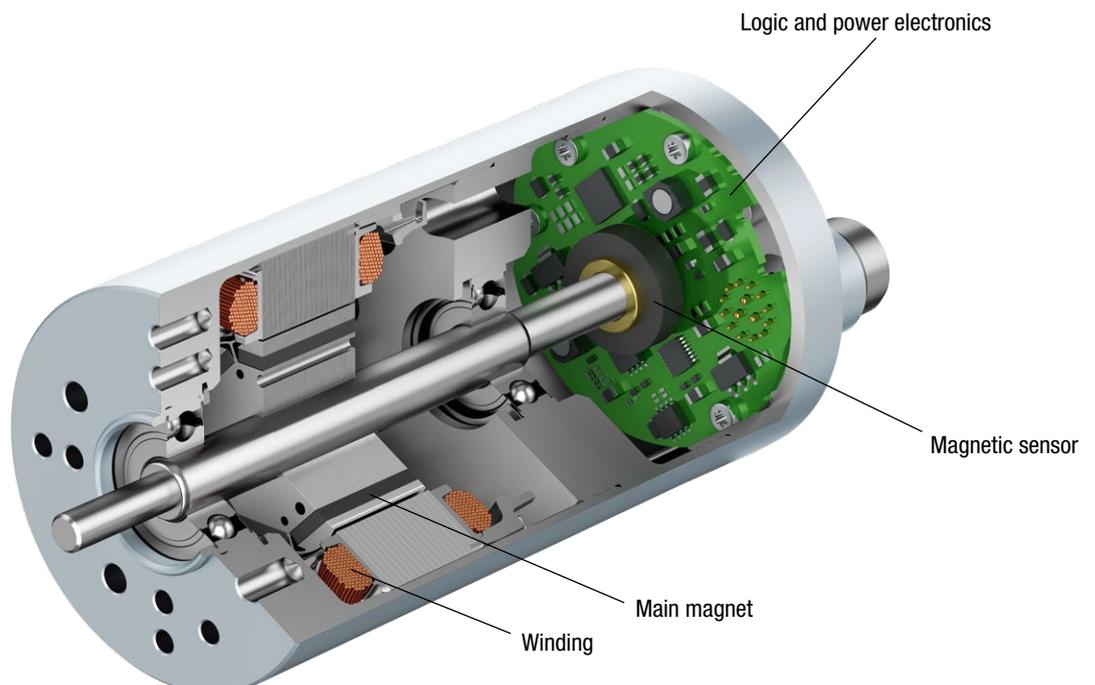
Information for ECI motors.

Key figures

- 3-phase, electronically commutated internal rotor motor with high-performance magnet
 - Power range between 30 and 750 watts
 - High power density realized in a compact design
 - High overload capacity
 - Long service life
 - Very quiet operation
 - Detection of rotor position via Hall sensors
 - Customer-specific winding layouts
 - Winding insulation as per insulation class E
 - Protection class IP 54 as per EN 60 034-5: up to IP 65
-
- Various motor types which can be combined with planetary and crown gearheads
 - Optional integrated control electronics
 - Optional encoder and brake modules

Approvals

- Support with the accreditation of products in different economic areas and markets
- As an experienced and competent partner we would be happy to support you
- Possible approvals include CE, CCC, UL, CSA, EAC
- Additional approvals on request



The data in this catalog contain product specifications, but are not a guarantee of particular properties.

All information is based on the measuring conditions mentioned below. Operation of motors using reference electronics at an **ambient temperature of max. 40°C** when attached (thermally conductive) to a free-standing steel plate of the following size:
Steel plate 105 x 105 x 10 mm

The **nominal operating point** is the basis for the electromagnetic design of the motor from the point of view of the maximum possible continuous output of the motor and is specified by the nominal values described here.

The values mentioned are typical values for the design in question and are also subject to the tolerances included in the specifications or drawings. Unless otherwise stated, the supplements and safety notes contained in the relevant operating and assembly instructions must be kept at all times. Subject to availability and technical alterations.

Nominal output power P_N [W]

The output power which the motor can produce continuously; it is calculated from nominal torque and nominal speed. For the electromagnetic design of the motor the determination of the nominal operating point is based on the fact that the nominal output power is close the maximum output power of the motor.

Nominal voltage U_{BN} , U_N , U_B [V DC]

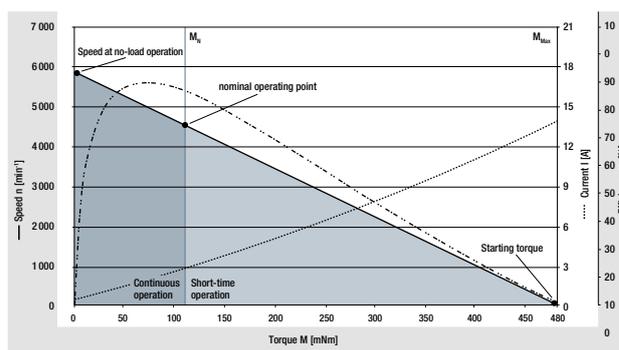
The DC voltage (i.e. DC voltage range) that is applied to the commutation electronics as a system supply voltage. All nominal values listed in the technical tables of the individual motors refer to this voltage. Motor applications are, however, not restricted to this voltage.

Nominal speed n_N [rpm]

The speed at which the motor may be operated continuously while delivering nominal torque at an ambient temperature of 40°C and nominal output torque. It is an operating point on the max. motor curve based on an ideal electronics with negligible losses.

Nominal torque M_N [mNm]

The torque that the motor can deliver continuously at an ambient temperature of 40°C and nominal speed.



The illustrated curves are idealized representations based on the figures in the tables.

Nominal current I_{BN}

The current that is drawn from the system supply when the motor delivers nominal torque at nominal speed.

Speed at no-load operation n_L [rpm]

The speed that takes effect at the nominal voltage and with unloaded motor. The theoretical possible speed at no-load operation can, in some cases, be limited by the mechanical ceiling speed.

No-load current I_{BL} [A]

Is established with nominal voltage and unloaded motor; is largely influenced by the bearing friction. For drive systems that have a separate supply for power and logic, the no-load current is called I_L . This no-load current is the sum of the power supply (I_{zK}) and the low-power logic supply (I_b).

Permanent stall torque M_{BN0} [mNm]

Is the maximum permissible torque with which the motor may be permanently loaded when the rotor is locked.

Permissible eff. continuous stall current I_{noeff} [A]

Is the maximum permissible current which at a stalled motor is allowed to flow into the motor lead as an effective value.

Definitions for ECI motors.

Continuous stall power P_{Bn0} [W]

Is an approximate value for the voltage-independent maximum permitted output ($P=U \times I$) that can be taken from the DC voltage source in holding status.

Permissible peak torque short-term M_{max} [mNm]

Is the torque which the motor can usually deliver in a short time.

Permissible peak current, motor lead I_{max} [A]

Is the current that must flow in to the motor lead as a peak value to achieve the short-time peak torque.

Induced voltage U_{max} [V/1 000 rpm]

Maximum value of the induced voltage between two motor leads at 1 000 rpm. It is a dimension for the electromagnetic utilization of the motor.

Connection resistance R_v [Ohm]

The winding resistance that is measured at 20°C between any two of three winding terminations.

Connection inductance L_v [mH]

The average inductance that is measured at 20°C between any two of three winding terminations using a sinusoidal wave measuring frequency of 1 kHz.

Rotor moment of inertia J_r [kgm²x10⁻⁶]

The mass moment of inertia of the rotor and necessary dimension for the dynamic characteristics of the motor.

Protection class

Information on the protection class; it describes protection against foreign particles (Point 1) and water (Point 2).

Permissible ambient temperature range T_v [°C]

Defines the minimum and maximum permissible ambient temperature to which the mentioned performance values apply when the motor is in operation. The permissible winding temperature in the motor (115°C for insulation Class E, as per EN 60 034-1) </1125 should not be exceeded.

Weight m [kg]

Weight of the delivered unit without additional units or packaging.

Max. shaft load F_{radial}/F_{axial} [N]

The permissible forces are divided into radial and axial load values. They are based on the maximum permissible values for the motor bearing during operation at normal rating and a defined service life expectancy L_{10} .

Service life L_{10}

The values for the L_{10} service life specified in conjunction with the permitted bearing loads have been calculated to DIN ISO 281. In addition to the specified values, this calculation is based on operation of the motor at nominal conditions (nominal torque, nominal speed) and an ambient temperature of max. 40°C. Therefore, the service life information is explicitly not a guarantee of service life, but strictly a theoretical quality figure.

Max. reverse voltage [V DC]

When the braking function is activated and when the set value step change is negative, the motor operates in controlled braking mode. In this operating state, the large part of the braking energy is fed back to the intermediate circuit until the max. reverse voltage is reached and the electronics prevent a further increase beyond this value by chopped braking. This behavior should be given special consideration when selecting the system supply.

Set value input

Speed setting via an analogue interface for DC voltage.

Depending on the drive design, the set speed can be configured in a range from 0 ... n_{max} , where the minimum possible speed value (with limited control quality) is about 0 rpm (sine commutation)

or approx. 50 to 100 rpm (block commutation). (Relevant only for drives with integrated operating electronics).

Recommended speed range [rpm]

Speed control range within which the speed control accuracy stipulated in the system specification is complied with.

Starting torque [mNm]

Is the torque that can be delivered over a short time when the motor is started based on the electromagnetic motor characteristics and the set current limitation.

Effective torque M_{eff} [mNm]

For cycle operation (e.g. "S5" operating mode – intermittent duty with the effect of the startup losses and the losses due to electrical braking on the heating), the effective torque corresponding to continuous operation ("S1" operating mode) is determined according to the following formula:

$$M_{\text{eff}} = \sqrt{\frac{M_A^2 \cdot t_A + M_L^2 \cdot t_B + M_{Br}^2 \cdot t_{Br}}{t_A + t_B + t_{Br} + t_{St}}}$$

M_A	Starting torque	M_{Br}	Braking
t_A	Acceleration time	t_{Br}	Braking time
M_L	Load torque	t_{St}	Standstill time
t_B	Load period		

At an ambient temperature of 40°C this effective torque must not be greater than the nominal torque M_N listed in the catalog for the selected motor. For intermittent operation (operating mode S3 with t_r = relative on period) the following permissible load moment applies:

$$M_L = M_N \cdot \sqrt{\frac{100}{t_r}}$$

System selection

When selecting a motor and operating for a drive system, consideration should be given to the fact that the values permitted for the motor should not be exceeded by the electronics. Likewise, the relationship shown in the commutation sequences between the sequence of Hall signals and the corresponding switching times and switching states of the output stage at the phase supply lines must be observed in order to attain optimum operation of the motor.

Please contact the manufacturer if the products are operated or stored under non standard environmental conditions.

ECI motor.

ECI-42.XX-K1



- Highly dynamic 3-phase internal rotor motor with EC technology
- Low cogging torque
- Robust, noise-optimized ball bearing system for a long service life
- High efficiency and high power density realized in a compact design
- Basic motor with electronic module K1 for operation with external control electronics
- Mechanical design and interfaces designed for modular flexibility
- Protection class IP 40 (higher on request) and connection by wires

Nominal data

Type		ECI-42.20-K1-B00	ECI-42.20-K1-D00	ECI-42.40-K1-B00	ECI-42.40-K1-D00
Nominal voltage (U_N)	V DC	24	48	24	48
Nominal speed (n_N)**	rpm	4 000			
Nominal torque (M_N)**	mNm	110	110	220	220
Nominal current (I_N)**	A	2.50	1.30	5.10	2.60
Nominal output power (P_N)**	W	46	46	92	92
Starting torque (M_{ms})	mNm	480	480	960	960
Permissible peak current (I_{max})***	A	14	7	21	11
Speed at no-load operation (n_0)	rpm	5 900	5 900	5 700	5 700
No-load current (I_0)	A	0.33	0.10	0.40	0.20
Permanent stall torque (M_{NO})	mNm	100	100	200	200
Recommended speed control range	rpm	0 ... 5 000			
Rotor moment of inertia (J_R)	kgm ² x10 ⁻⁶	3.42	3.42	6.70	6.70
Motor constant (K_V)	mVs/rad	40.9	84.2	42.8	83.9
Connection resistance (R_V)	Ω	0.85	3.20	0.39	1.50
Connection inductance (L_V)	mH	1.10	4.50	0.50	1.84
Overload protection		To be implemented via the control electronics			
Permissible ambient temperature range (T_U)	°C	0 ... +40			
Weight	kg	0.33	0.33	0.48	0.48
Order no. (wire interface)*	IP 40	932 4220 122	932 4220 123	932 4240 122	932 4240 123

Subject to alterations

* Classification of protection class refers to installed state with sealing on the flange side

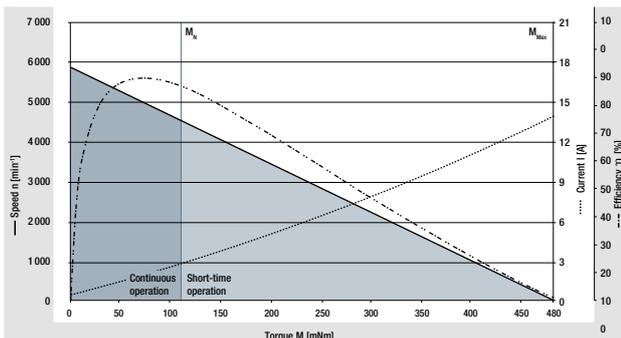
** At T_U max. 40°C

*** Permissible time for peak current: max. 1 sec. – to be repeated only after complete cool down

Preferred type: ready to ship in 48 hours

Characteristic curve

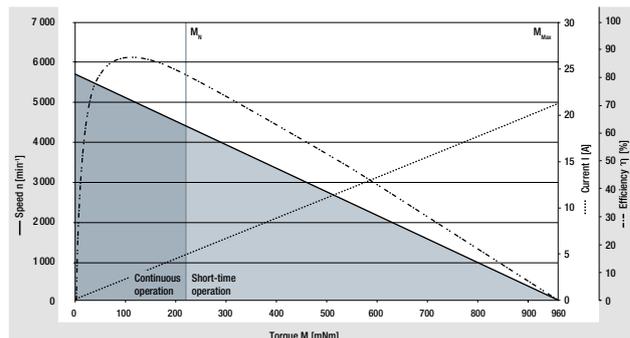
ECI-42.20, 24 V (at 25°C)



¹⁾ Nominal data, see table

Characteristic curve 48 V on request

ECI-42.40, 24 V (at 25°C)

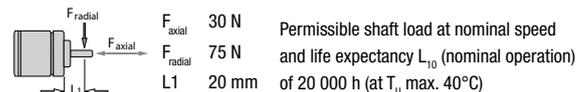
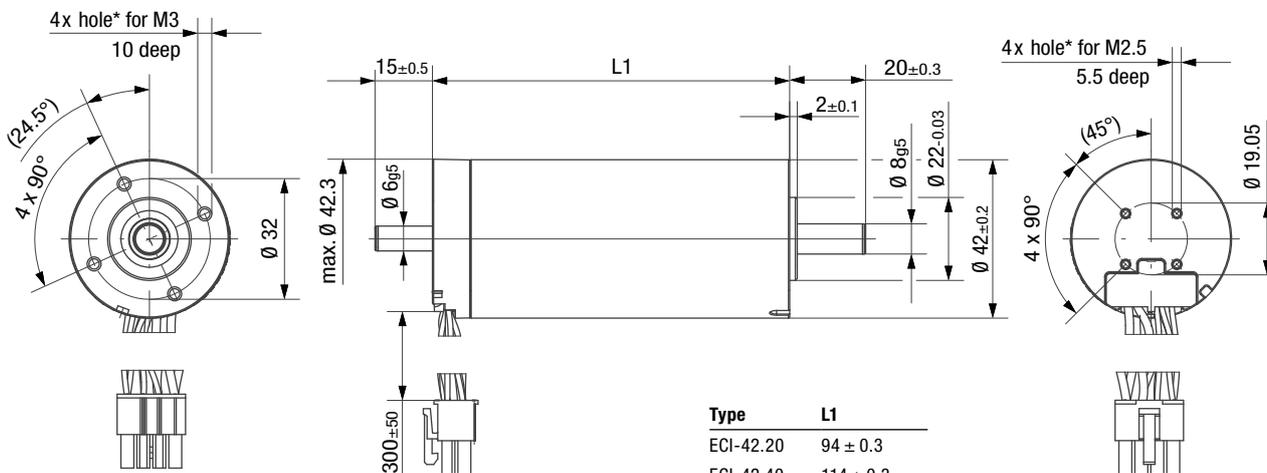


¹⁾ Nominal data, see table

Characteristic curve 48 V on request

Technical drawing

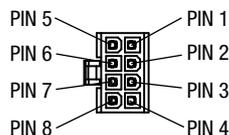
All dimensions in mm



* For thread-rolling screws according to DIN 7500

Electrical connection

Supply wire		
No.	Color	Function
1	yellow	Phase W
5	violet	Phase V
6	brown	Phase U



Molex pin no. 39-01-2085

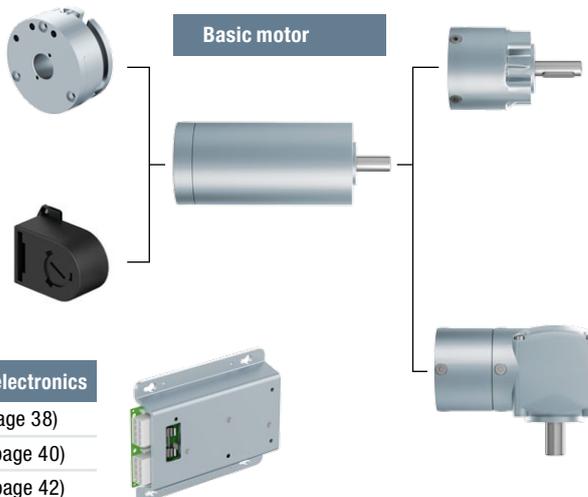
Signal wire		
No.	Color	Function
4	green	Hall A
3	white	Hall B
8	gray	Hall C
2	red	U_B
7	black	GND

Modular construction kit

Brake system	
Spring-applied brake	BFK 457-01 (page 76)

Encoder system	
Optical incremental encoder	HEDS 5500 (page 78)

Recommended external control electronics	
VTD-XX.XX-K3	Speed (page 38)
VTD-XX.XX-K4S	Position (page 40)
VTD-60.13-K5SB	Position (page 42)



Planetary gearheads	
NoiselessPlus 42	(page 50)
Performax® 42	(page 54)
Performax®Plus 42	(page 58)

Crown gearheads	
EtaCrown® 52	(page 64)
EtaCrown®Plus 42	(page 68)

For motor-gearbox combinations, depending on the choice of the single components, the maximum allowable torque (gearbox) can be exceeded or respectively not reached.

ECI motor.

ECI-63.XX-K1



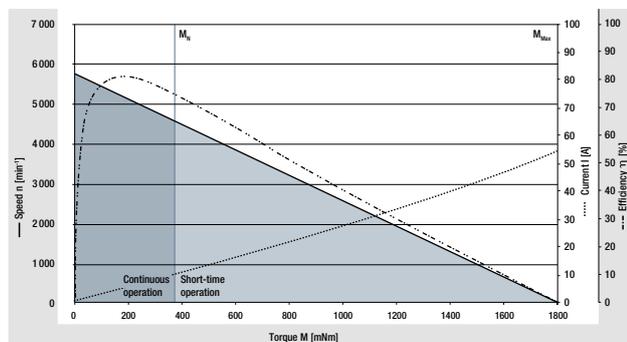
- Highly dynamic 3-phase internal rotor motor with EC technology
- Low cogging torque
- Robust, noise-optimized ball bearing system for a long service life
- High efficiency and high power density realized in a compact design
- Basic motor with electronic module K1 for operation with external control electronics
- Mechanical design and interfaces designed for modular flexibility
- Protection class IP 40 / IP 54 and connection by connector system

Nominal data

Type		ECI-63.20-K1 -B00	ECI-63.20-K1 -D00	ECI-63.40-K1 -B00	ECI-63.40-K1 -D00	ECI-63.60-K1 -B00	ECI-63.60-K1 -D00
Nominal voltage (U_N)	V DC	24	48	24	48	24	48
Nominal speed (n_N)**	rpm	4 000					
Nominal torque (M_N)**	mNm	360	360	670	670	800	880
Nominal current (I_N)**	A	8.50	4.50	14.0	6.50	17.6	8.50
Nominal output power (P_N)**	W	150	150	280	280	335	370
Starting torque (M_{max})	mNm	1 800	1 800	3 300	3 300	5 300	4 400
Permissible peak current (I_{max})***	A	55	30	95	45	150	57
Speed at no-load operation (n_0)	rpm	5 800	6 800	5 900	5 900	6 100	6 000
No-load current (I_0)	A	0.50	0.30	0.70	0.32	1.30	0.45
Recommended speed control range	rpm	0 ... 5 000					
Rotor moment of inertia (J_R)	kgm ² x10 ⁻⁶	19	19	38	38	57	57
Motor constant (K_E)	mVs/rad	41.4	73.3	40.4	83.8	40.4	83.8
Connection resistance (R_c)	Ω	0.14	0.42	0.08	0.24	0.04	0.15
Connection inductance (L_c)	mH	0.26	0.88	0.14	0.57	0.09	0.33
Overload protection		To be implemented via the control electronics					
Permissible ambient temperature range (T_U)	°C	0 ... +40					
Weight	kg	0.90	0.90	1.20	1.20	1.50	1.50
Order no. (wire interface)*	IP 40	932 6320 103	932 6320 105	932 6340 103	932 6340 105	932 6360 106	932 6360 108
Order No. (connector interface)*	IP 54	932 6320 100	932 6320 102	932 6340 100	932 6340 102		932 6360 102
Subject to alterations		* Classification of protection class refers to installed state with sealing on the flange side The wave geometry for the IP54 version differs from the illustrated drawing					
Preferred type: ready to ship in 48 hours		** At T_U max. 40°C *** Permissible time for peak current: max. 1 sec. – to be repeated only after complete cool down					

Characteristic curve

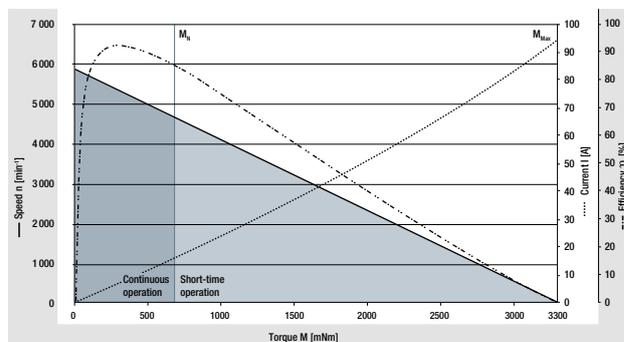
ECI-63.20-K1, 24 V (at 25°C)



¹⁾ Nominal data, see table

Characteristic curve 48 V on request

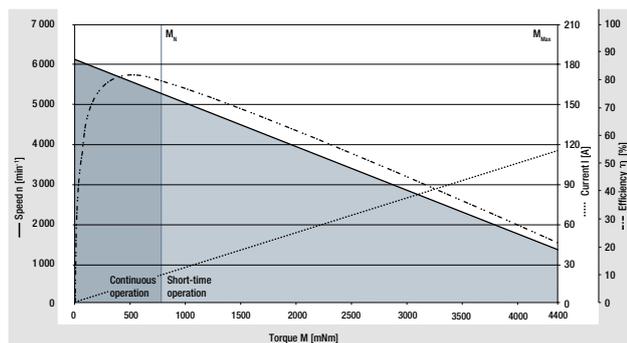
ECI-63.40-K1, 24 V (at 25°C)



¹⁾ Nominal data, see table

Characteristic curve 48 V on request

ECI-63.60-K1, 24 V (at 25°C)



¹⁾ Nominal data, see table

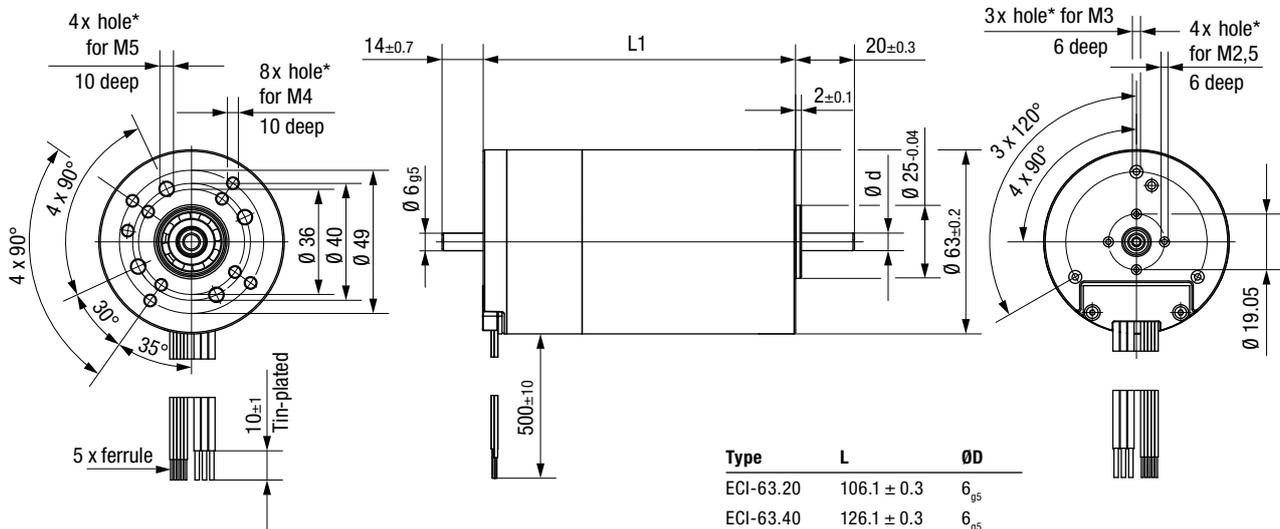
Characteristic curve 48 V on request

ECI motor.

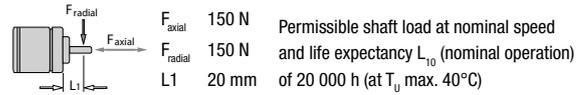
ECI-63.XX-K1

Technical drawing Strand design

All dimensions in mm



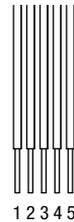
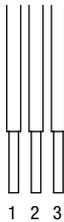
* For thread-rolling screws according to DIN 7500



Electrical connection

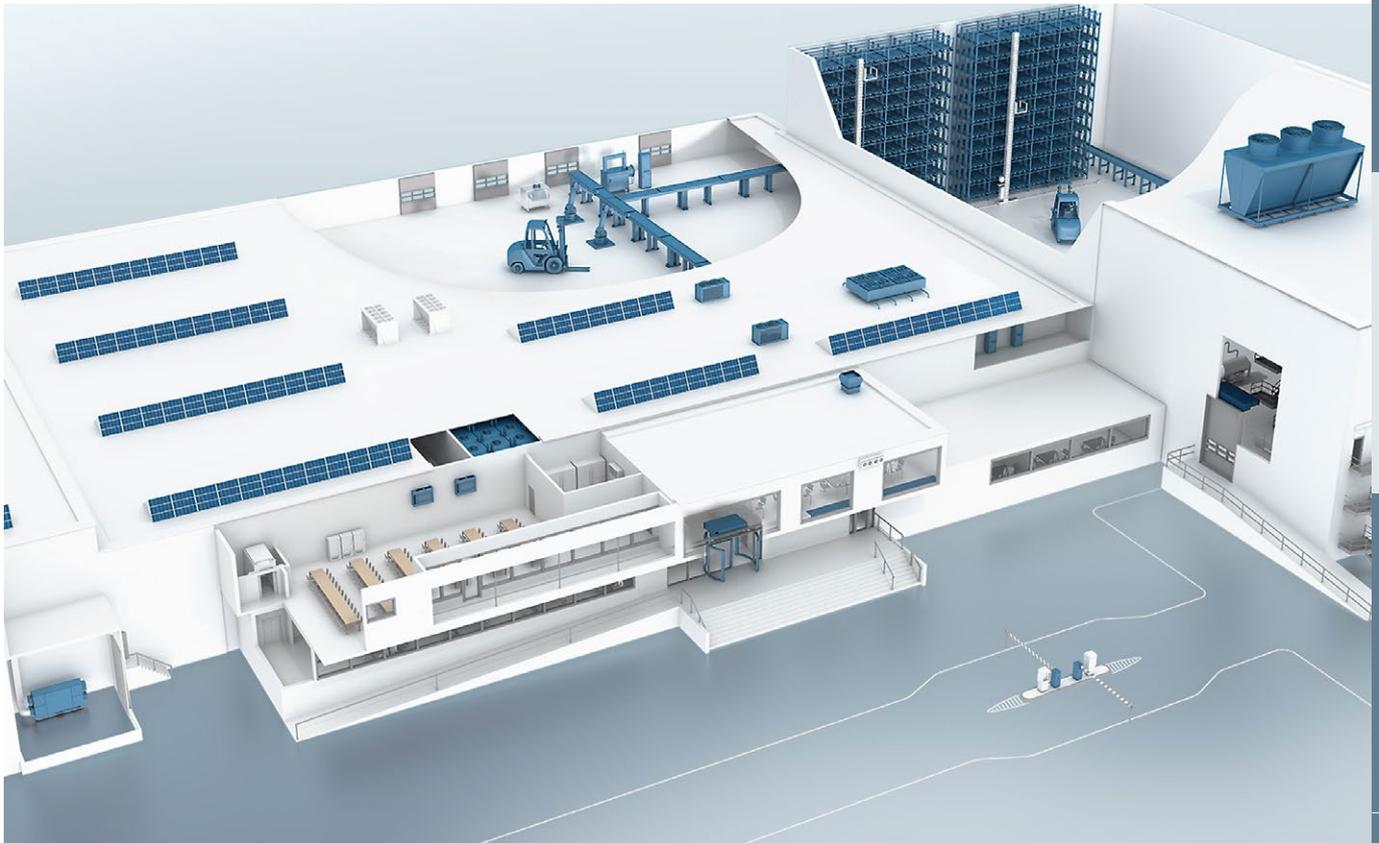
Supply wire

Wire	Color	Function
1	yellow	Phase W
2	violet	Phase V
3	brown	Phase U



Signal wire

Wire	Color	Function
4	green	Hall A
5	white	Hall B
6	gray	Hall C
7	red	U_B
8	black	GND



Factory building

Modular construction kit

Brake system
 Spring-applied brake
 BFK 457-03 (page 76)



Encoder system
 Optical incremental encoder
 HEDS 5500 (page 78)



Basic motor



Planetary gearheads
 NoiselessPlus 63 (page 55)
 Performax® 63 (page 56)
 Performax®Plus 63 (page 60)
 Optimax 63 (page 62)



Recommended external control electronics

VTD-XX.XX-K4S	Speed (page 40)
VTD-60.13-K5SB	Position (page 42)
VTD-60.35-K5SB	Position (page 44)



Crown gearheads
 EtaCrown® 75 (page 66)
 EtaCrown®Plus 63 (page 70)



For motor-gearbox combinations, depending on the choice of the single components, the maximum allowable torque (gearbox) can be exceeded or respectively not reached.

ECI motor.

ECI-63.XX-K3

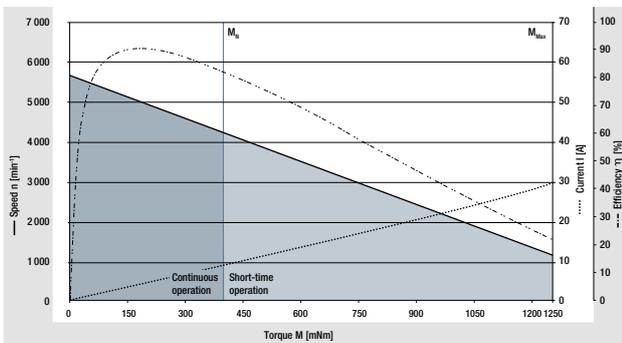


- Drive with completely integrated K3 operation and control electronics
- Integrated speed control
- Interface with analog and digital control inputs
- Output stage enabled via digital hardware enabling
- Field-oriented closed-loop control
- 15-pole plug

Nominal data						
Type		ECI-63.20-K3 -B00	ECI-63.20-K3 -D00	ECI-63.40-K3 -B00	ECI-63.40-K3 -D00	ECI-63.60-K3 -D00
Nominal voltage (U_n)	V DC	24	48	24	48	48
Permissible supply voltage range (U_{zk})	V DC	18 ... 30	18 ... 53	18 ... 30	18 ... 53	18 ... 53
Max. reverse voltage	V DC	35	58	35	58	58
Nominal speed (n_n)	rpm	4 000				
Nominal torque (M_n)**	mNm	425	450	600	750	850
Nominal current (I_n)**	A	8.50	5.40	12.3	7.20	8.60
Nominal output power (P_n)**	W	178	188	251	314	356
Starting torque (M_{max})	mNm	1 480	1 890	1 500	3 000	2 550
Speed at no-load operation (n_l)	rpm	5 800	5 800	5 900	5 800	6 000
No-load current (I_l)	A	0.50	0.50	0.90	0.50	0.60
Recommended speed control range	rpm	0 ... 5 000				
Set value input		analog (0 ... 10 V)				
Rotor moment of inertia (J_R)	kgm ² x10 ⁻⁶	19	19	38	38	57
Function for motor protection at stall		thermal				
Overload protection		integrated				
Permissible ambient temperature range (T_U)	°C	0 ... +40				
Weight	kg	0.85	0.85	1.15	1.15	1.50
Order no. (wire interface)*	IP 40	932 6320 303	932 6320 305	932 6340 303	932 6340 305	932 6360 305
Order no. (connector interface)*	IP 54	932 6320 300	932 6320 302	932 6340 300	932 6340 302	932 6360 302
Subject to alterations		* Classification of protection class refers to installed state with sealing on the flange side				
Preferred type: ready to ship in 48 hours		** At T_U max. 40°C				

Characteristic curve

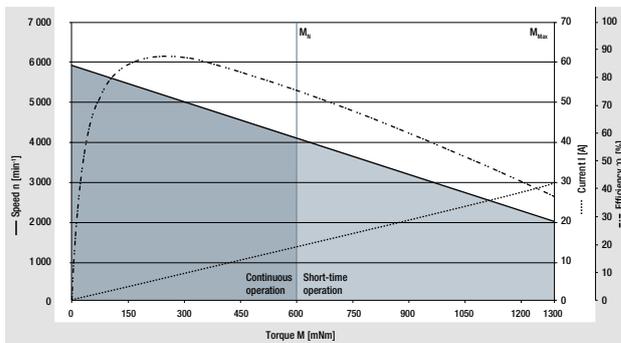
ECI-63.20-K3, 24 V (at 25°C)



¹⁾ Nominal data, see table

Characteristic curve 48 V on request

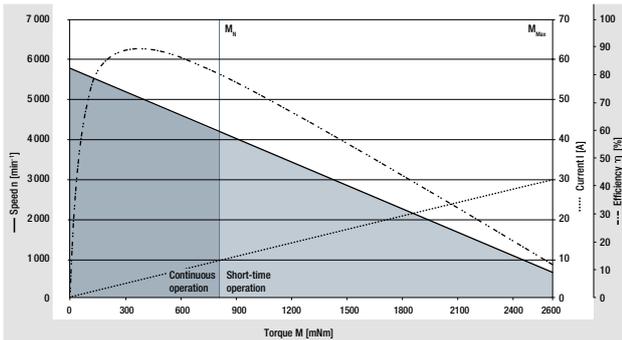
ECI-63.40-K3, 24 V (at 25°C)



¹⁾ Nominal data, see table

Characteristic curve 48 V on request

ECI-63.60-K3, 48 V (at 25°C)



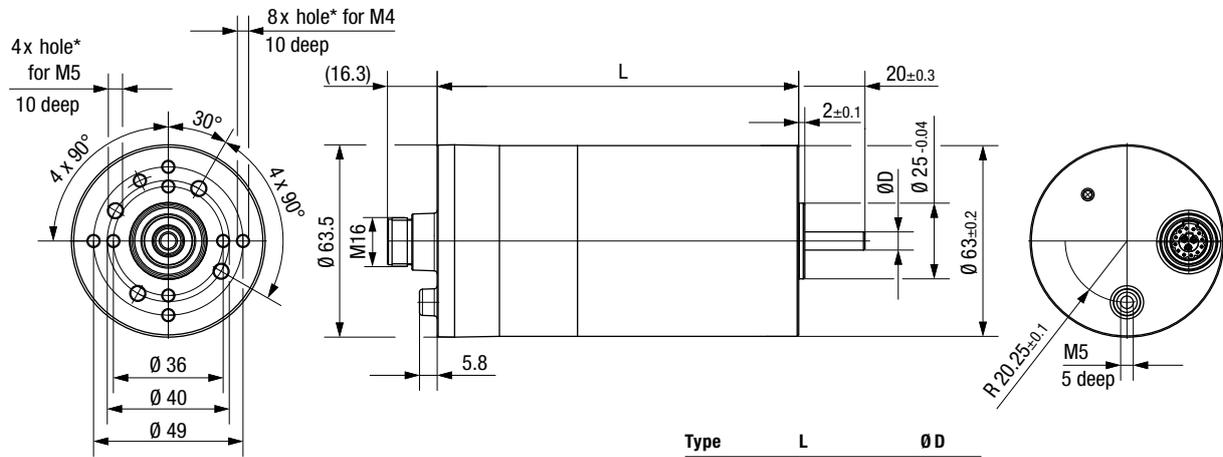
¹⁾ Nominal data, see table

ECI motor.

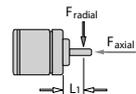
ECI-63.XX-K3

Technical drawing

All dimensions in mm



Type	L	$\varnothing D$
ECI-63.20	118.5 \pm 0.3	6 _{g5}
ECI-63.40	138.5 \pm 0.3	6 _{g5}
ECI-63.60	158.5 \pm 0.3	10 _{g5}

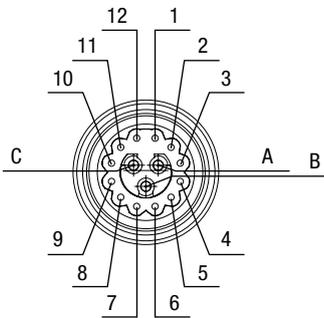


Permissible shaft load at nominal speed and life expectancy L_{10} (nominal operation) of 20 000 h (at T_u max. 40°C)

F_{axial}	150 N
F_{radial}	150 N
$L1$	20 mm

* For thread-rolling screws according to DIN 7500

Electrical connection

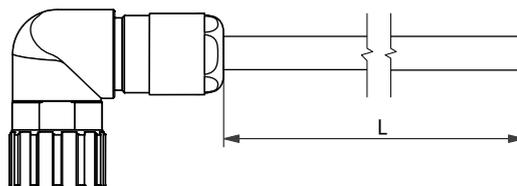
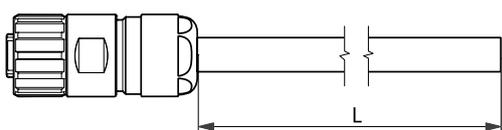


	Wire color	Pin	Configuration	Function	Recommended AWG
Signal	white	1	D-IN-A	NPN 24 V	24
	brown	2	D-IN-B	NPN 24 V	
	green	3	D-IN-1	NPN 24 V	
	yellow	4	D-IN-2	NPN 24 V / analog 0 ... 10 V / brake	
	gray	5	D-OUT-1	PNP 24 V	
	pink	6	D-OUT-2	PNP 24 V	
	blue	7	D-OUT-3	PNP 24 V	
	red	8	A-IN-1	0 ... 10 V (differential)	
	black	9	A-IN-GND	GND for analog IN 1 (differential)	
	violet	10	RS485 A (+)	Progr. bus	
	gray / pink	11	RS485 B (-)	Progr. bus	
	red / blue	12	U_{Logic}	Logic power supply (24 V)	
Power	gray	A	Ballast	Ballast resistor	16
	brown	B	U_{ZK}	Power supply	
	black	C	GND	Power / signal GND	

Cable

Type	Length L (mm)	Order no.
Cable (12+3 Pins)	1 000 ±30	992 0160 034
Cable (12+3 Pins)	3 000 ±30	992 0160 035

Type	Length L (mm)	Order no.
Cable (12+3 Pins)	1 000 ±30	992 0160 036
Cable (12+3 Pins)	3 000 ±30	992 0160 037



For self-assembly, cables can be obtained from Hummel:

Hummel cable connector M16 for cable \varnothing 8-11 mm, Tightening torque: 5 Nm (Order no. 7.810.500.000)

Hummel crimp insert series M16, socket 12+3 with special coding (Order no. 7K11886034)

Hummel crimp contact socket 3 x, power, crimp range 0.5 - 1.5 mm² (Order no. 7.010.981.202)

Hummel crimp contact socket 12 x, signal, crimp range 0.08 - 0.34 mm² (Order no. 7.010.980.802)

Modular construction kit

Brake system

Spring-applied brake, integrated
Brake module ECI 63-K4 (p. 76)



Basic motor



Planetary gearheads

NoiselessPlus 63 (page 52)

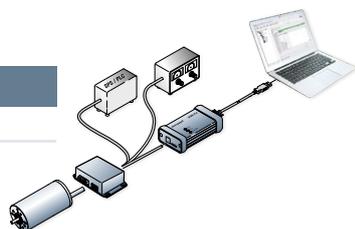
Performax® 63 (page 56)

Performax®Plus 63 (page 60)

Optimax 63 (page 62)

Commissioning tool

"Kickstart" (page 74)



Crown gearheads

EtaCrown® 75 (page 66)

EtaCrown®Plus 63 (page 70)

Cable

Connection cables have to be ordered separately

For motor-gearbox combinations, depending on the choice of the single components, the maximum allowable torque (gearbox) can be exceeded or respectively not reached.

ECI motor.

ECI-63.XX-K4

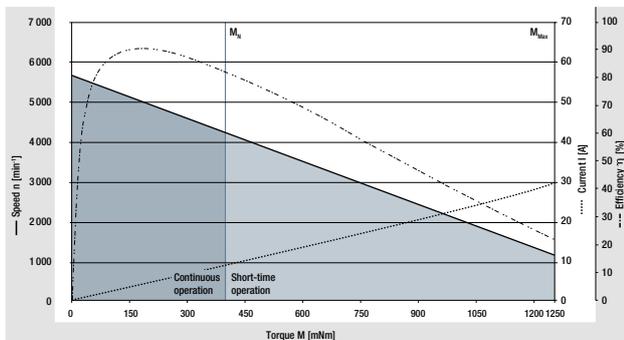


- Drive with completely integrated 4Q operation and control electronics
- Speed, torque or position mode possible
- Selection of operating modes and parameter setting via RS485
- Extensive interface with various inputs and outputs
- Output stage enabled via digital input
- Integrated brake chopper
- Speed set values from $n=0$ with holding torque up to 5 000 rpm
- Excellent control behavior via field-oriented control with sine commutation
- High efficiency and high power density realized in a compact design
- User-friendly parameter setting with “Kickstart” PC software

Nominal data						
Type		ECI-63.20-K4 -B00	ECI-63.20-K4 -D00	ECI-63.40-K4 -B00	ECI-63.40-K4 -D00	ECI-63.60-K4 -D00
Nominal voltage (U_n)	V DC	24	48	24	48	48
Permissible supply voltage range (U_{zk})	V DC	18 ... 30	18 ... 53	18 ... 30	18 ... 53	18 ... 53
Max. reverse voltage	V DC	35	58	35	58	58
Nominal speed (n_n)	rpm	4 000				
Nominal torque (M_n)**	mNm	425	450	600	750	850
Nominal current (I_n)**	A	8.50	5.40	12.3	7.20	8.60
Nominal output power (P_n)**	W	178	188	251	314	356
Starting torque (M_{max})	mNm	1 480	1 890	1 500	3 000	2 550
Speed at no-load operation (n_l)	rpm	5 800	5 800	5 900	5 800	6 000
No-load current (I_l)	A	0.50	0.50	0.90	0.50	0.60
Recommended speed control range	rpm	0 ... 5 000				
Set value input		analog / PWM / frequency / digital				
Rotor moment of inertia (J_R)	kgm ² x10 ⁻⁶	19	19	38	38	57
Function for motor protection at stall		thermal				
Overload protection		integrated				
Permissible ambient temperature range (T_u)	°C	0 ... +40				
Weight	kg	0.85	0.85	1.15	1.15	1.50
Order no. (wire interface)*	IP 40	932 6320 403	932 6320 405	932 6340 403	932 6340 405	932 6360 405
Order no. (connector interface)*	IP 54	932 6320 400	932 6320 402	932 6340 400	932 6340 402	932 6360 402
Subject to alterations		* Classification of protection class refers to installed state with sealing on the flange side				
Preferred type: ready to ship in 48 hours		** At T_u max. 40°C				

Characteristic curve

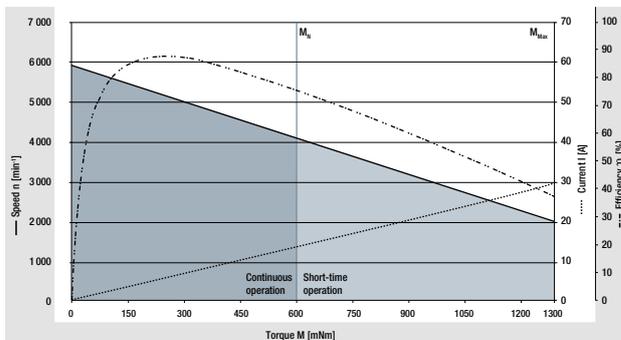
ECI-63.20-K4, 24 V (at 25°C)



¹⁾ Nominal data, see table

Characteristic curve 48 V on request

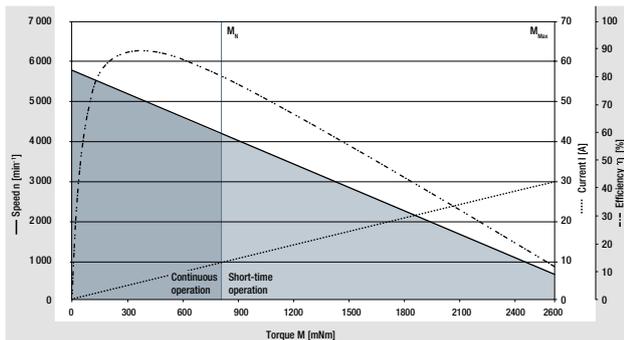
ECI-63.40-K4, 24 V (at 25°C)



¹⁾ Nominal data, see table

Characteristic curve 48 V on request

ECI-63.60-K4, 48 V (at 25°C)



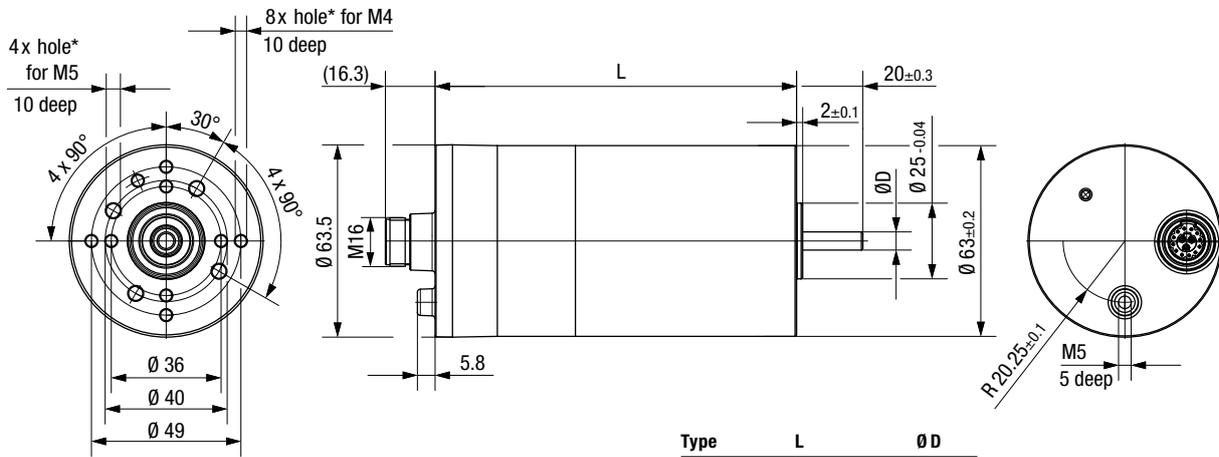
¹⁾ Nominal data, see table

ECl motor.

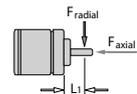
ECl-63.XX-K4

Technical drawing

All dimensions in mm



Type	L	$\varnothing D$
ECl-63.20	118.5 \pm 0.3	6 _{g5}
ECl-63.40	138.5 \pm 0.3	6 _{g5}
ECl-63.60	158.5 \pm 0.3	10 _{g5}

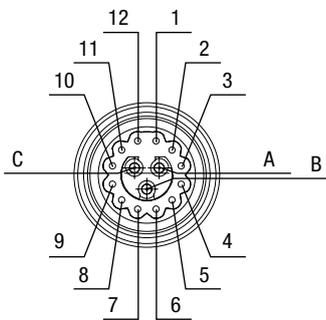


Permissible shaft load at nominal speed and life expectancy L_{10} (nominal operation) of 20 000 h (at T_u max. 40°C)

F_{axial}	150 N
F_{radial}	150 N
$L1$	20 mm

* For thread-rolling screws according to DIN 7500

Electrical connection



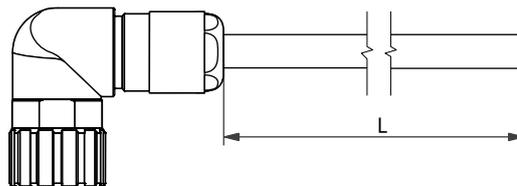
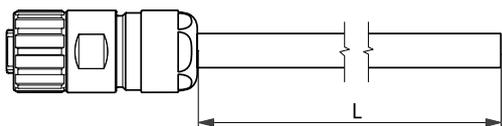
	Wire color	Pin	Configuration	Function	Recommended AWG
Signal	white	1	D-IN-A	NPN 24 V	24
	brown	2	D-IN-B	NPN 24 V	
	green	3	D-IN-1	NPN 24 V	
	yellow	4	D-IN-2	NPN 24 V / analog 0 ... 10 V / brake	
	gray	5	D-OUT-1	PNP 24 V	
	pink	6	D-OUT-2	PNP 24 V	
	blue	7	D-OUT-3*	PNP 24 V	
	red	8	A-IN-1	0 ... 10 V (differential)	
	black	9	A-IN-GND	GND for analog IN 1 (differential)	
	violet	10	RS485 A (+)	Progr. bus	
	gray / pink	11	RS485 B (-)	Progr. bus	
	red / blue	12	U_{Logic}	Logic power supply (24 V)	
Power	gray	A	Ballast	Ballast resistor	16
	brown	B	U_{ZK}	Power supply	
	black	C	GND	Power / signal GND	

* Output (OUT 3) is only available on ECl-63.XX-K4

Cable

Type	Length L (mm)	Order no.
Cable (12+3 Pins)	1 000 ±30	992 0160 034
Cable (12+3 Pins)	3 000 ±30	992 0160 035

Type	Length L (mm)	Order no.
Cable (12+3 Pins)	1 000 ±30	992 0160 036
Cable (12+3 Pins)	3 000 ±30	992 0160 037



For self-assembly, cables can be obtained from Hummel:

Hummel cable connector M16 for cable \varnothing 8-11 mm, Tightening torque: 5 Nm (Order no. 7.810.500.000)

Hummel crimp insert series M16, socket 12+3 with special coding (Order no. 7K11886034)

Hummel crimp contact socket 3 x, power, crimp range 0.5 - 1.5 mm² (Order no. 7.010.981.202)

Hummel crimp contact socket 12 x, signal, crimp range 0.08 - 0.34 mm² (Order no. 7.010.980.802)

Modular construction kit

Brake system

Spring-applied brake, integrated
Brake module ECI 63-K4 (p. 76)



Basic motor

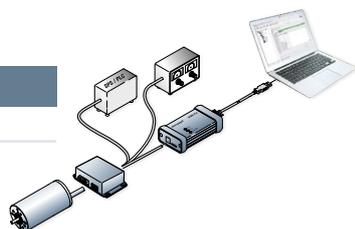


Planetary gearheads

NoiselessPlus 63 (page 52)
Performax® 63 (page 56)
Performax®Plus 63 (page 60)
Optimax 63 (page 62)

Commissioning tool

"Kickstart" (page 74)



Crown gearheads

EtaCrown® 75 (page 66)
EtaCrown®Plus 63 (page 70)

Cable

Connection cables have to be ordered separately

For motor-gearbox combinations, depending on the choice of the single components, the maximum allowable torque (gearbox) can be exceeded or respectively not reached.

ECI motor.

ECI-63.XX-K5



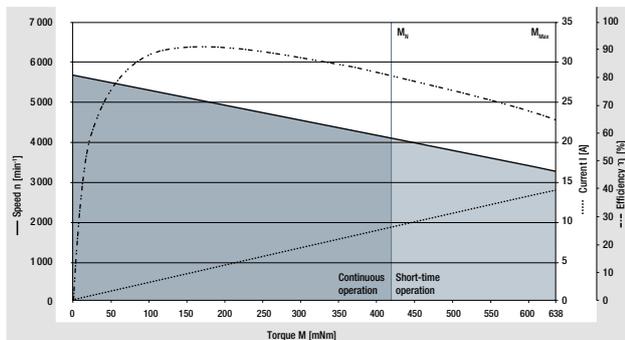
- Drive with integrated K5 operation and control electronics with CANopen communication interface
- Sine commutation of the drives with field-oriented control
- Speed control range down to $n = 0$ rpm with holding torque up to 5 000 rpm possible
- Different operating modes according to DSP 402 (speed, torque, positioning) possible via software
- Electronics in safely sealed housing
- Connectors M16 and M12 in sealed industry standard
- Interface with analog and digital control inputs

Nominal data

Type		ECI-63.20-K5 -B00	ECI-63.20-K5 -D00	ECI-63.40-K5 -B00	ECI-63.40-K5 -D00	ECI-63.60-K5 -D00
Nominal voltage (U_n)	V DC	24	48	24	48	48
Permissible supply voltage range (U_{zk})	V DC	18 ... 30	18 ... 52	18 ... 30	18 ... 52	18 ... 52
Max. reverse voltage	V DC	35	58	35	58	58
Nominal speed (n_n)**	rpm	4 000				
Nominal torque (M_n)**	mNm	425	450	600	750	850
Nominal current (I_n)**	A	8.50	5.40	12.3	7.20	8.60
Nominal output power (P_n)**	W	178	188	251	314	356
Starting torque (M_{max})	mNm	1 275	1 350	1 500	2 250	2 550
Speed at no-load operation (n_l)	rpm	5 800	5 800	5 900	5 800	6 000
No-load current (I_l)	A	0.50	0.20	0.90	0.46	0.48
Recommended speed control range	rpm	0 ... 4 000				
Rotor moment of inertia (J_r)	kgm ² x10 ⁻⁶	19	19	38	38	57
Function for motor protection at stall		thermal				
Overload protection		integrated				
Permissible ambient temperature range (T_u)	°C	0 ... +40				
Weight	Kg	0.95	0.95	1.25	1.25	1.55
Order no. (connector interface)*	IP 54	932 6320 550	932 6320 552	932 6340 550	932 6340 552	932 6360 552
Subject to alterations Series planned 2nd q/2017		* Classification of protection class refers to installed state with sealing on the flange side ** At T_u max. 40°C				

Characteristic curve

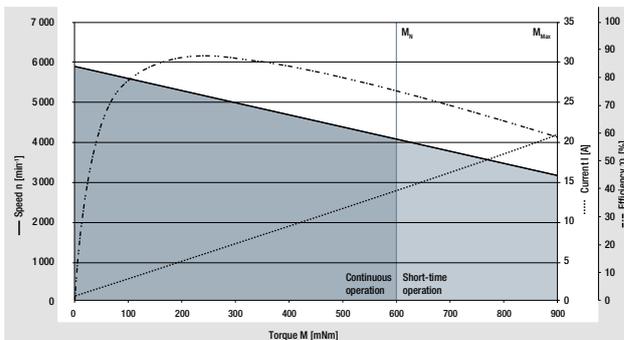
ECI-63.20-K5, 24 V (at 25°C)



¹⁾ Nominal data, see table

Characteristic curve 48 V on request

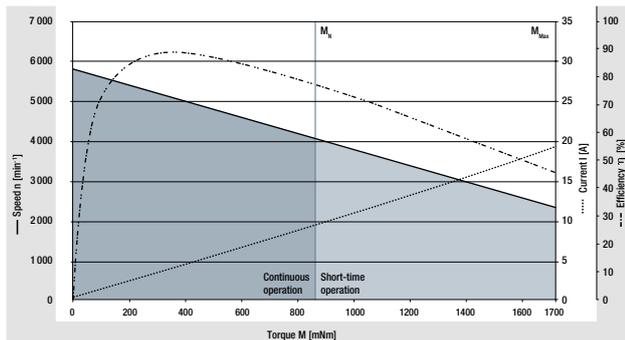
ECI-63.40-K5, 24 V (at 25°C)



¹⁾ Nominal data, see table

Characteristic curve 48 V on request

ECI-63.60-K5, 48 V (at 25°C)



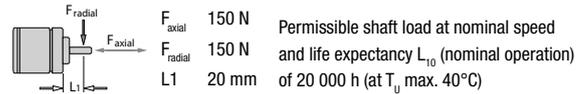
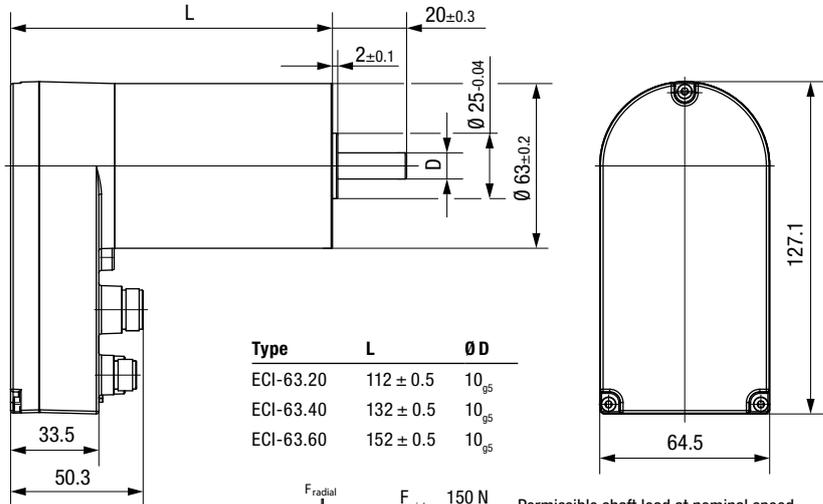
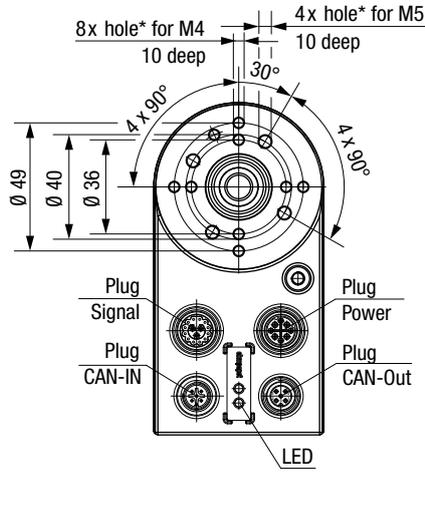
¹⁾ Nominal data, see table

ECI motor.

ECI-63.XX-K5

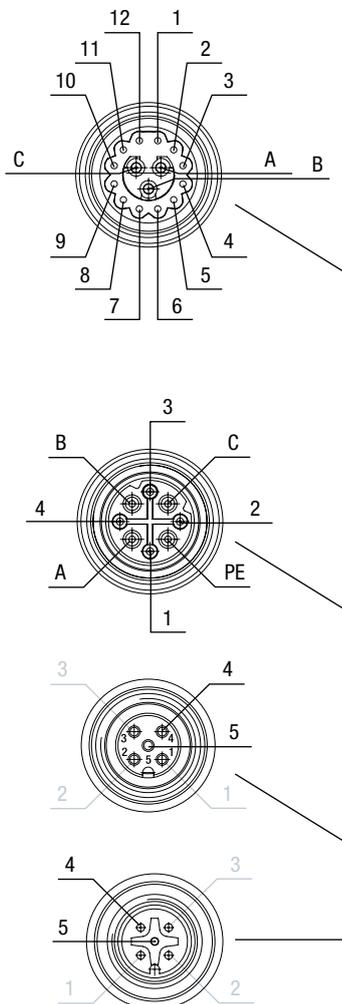
Technical drawing

All dimensions in mm



* For thread-rolling screws according to DIN 7500

Electrical connection

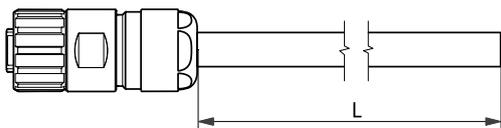


	Wire color	Pin	Configuration	Function	Recommended AWG
Plug Signal	white	1	D-IN-1	Digital input 1	24
	brown	2	D-IN-2	Digital input 2	
	green	3	D-IN-3	Digital input 3	
	yellow	4	D-IN-4	Digital input 4	
	gray	5	D-IN-5	Digital input 5	
	pink	6	D-IN-6	Digital input 6	
	blue	7	D-IN-7	Digital input 7	
	red	8	D-OUT-1	Digital output 1	
	black	9	D-OUT-2	Digital output 2	
	violet	10	Enable	Enable input	
	gray / pink	11	A-IN-1+	Analog input 1	
	red / blue	12	A-IN-2	Analog input 2	
Plug Power	gray	A	A-IN-1-	Analog input 1 GND	18
	brown	B	U_{Logic}	Power supply for electronics	
	black	C	GND	Ground and reference for A-IN-2	
	brown	Pin A	U_{ZK}	Power supply (ballast)	
Plug CAN Out	gray	Pin B	Ballast	Ballast resistor	16
	black	Pin C	GND power	Power supply	
	blue	Pin FE	FE	Functional earth	
	white	Pin 1	CAN H	CAN Bus high signal	
Plug CAN-IN	brown	Pin 2	CAN L	CAN Bus low signal	24
	green	Pin 3	Enable	24 V	
	yellow	Pin 4	U_{Logic}	NPN / PNP 24 V	
		Pin 4	CAN H	CAN Bus high signal	
	Pin 5	CAN L	CAN Bus low signal		
		Pin 4	CAN H	CAN Bus high signal	24
		Pin 5	CAN L	CAN Bus low signal	

Cable All dimensions in mm

Type	Length L (mm)	Order no.
Cable Signal (12+3 Pins)	1 000 ±30	992 0160 059
Cable Signal (12+3 Pins)	3 000 ±30	992 0160 060
Cable Power (4+3+FE)*	1 000 ±30	992 0160 055
Cable Power (4+3+FE)*	3 000 ±30	992 0160 056

* Wires Pin1, Pin2 (CAN_H, CAN_L) not executed.

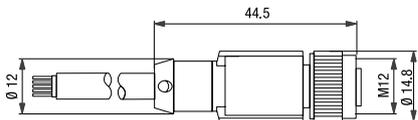


For self-assembly, cables can be obtained from Hummel:

- Signal (straight)**
- 1x cable connector M16 for cable Ø 8-11 mm, Order no. 7.810.500.000
 - 1x crimp insert series M16, socket 12+3 with special coding, Order no. 7K11886034
 - 3x crimp contact socket power crimp range 0.5-1.5mm², Order no. 7.010.981.202
 - 12x crimp contact socket signal crimp range 0.08-0.34mm², Order no. 7.010.980.802

- Power (straight)**
- 1x cable connector M16 for cable Ø 8-11 mm, Order no. 7.810.500.000
 - 1x crimp insert series M16, socket 4+3+PE, Order no. 7.003.943.102
 - 4x crimp contact 1.6 mm² / crimp range 0.34-1.5mm², Order no. 7.010.981.602
 - 2x crimp contact 0.8 mm² / crimp range 0.08-0.34mm², Order no. 7.010.980.802

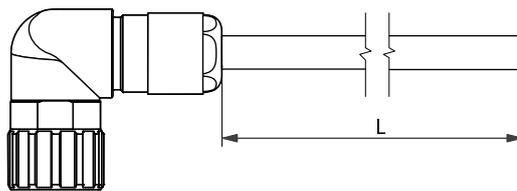
Length L (mm)	Order no.
5 000 ±30	992 0160 018 (CANopen socket)



Length L (mm)	Order no.
2 000 ±30	992 0160 019 (CANopen connecting cable)

Type	Length L (mm)	Order no.
Cable Signal (12+3 Pins)	1 000 ±30	992 0160 061
Cable Signal (12+3 Pins)	3 000 ±30	992 0160 062
Cable Power (4+3+FE)*	1 000 ±30	992 0160 057
Cable Power (4+3+FE)*	3 000 ±30	992 0160 058

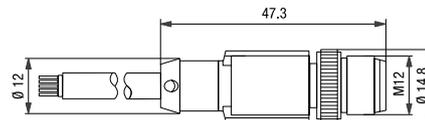
* Wires Pin1, Pin2 (CAN_H, CAN_L) not executed.



- Signal (angled)**
- 1x cable connector M16 for cable Ø 8-11 mm, Order no. 7.831.500.000
 - 1x crimp insert series M16, socket 12+3 with special coding, Order no. 7K11886034
 - 3x crimp contact socket power crimp range 0.5-1.5mm², Order no. 7.010.981.202
 - 12x crimp contact socket signal crimp range 0.08-0.34mm², Order no. 7.010.980.802

- Power (angled)**
- 1x cable connector M16 for cable Ø 8-11 mm, Order no. 7.831.500.000
 - 1x crimp insert series M16, socket 4+3+PE, Order no. 7.003.943.102
 - 4x crimp contact 1.6 mm² / crimp range 0.34-1.5mm², Order no. 7.010.981.602
 - 2x crimp contact 0.8 mm² / crimp range 0.08-0.34mm², Order no. 7.010.980.802

Length L (mm)	Order no.
5 000 ±30	992 0160 018 (CANopen plug)



Modular construction kit

<p>Brake system On request</p>		<p>Planetary gearheads</p> <ul style="list-style-type: none"> NoiselessPlus 63 (page 52) Performax® 63 (page 56) Performax®Plus 63 (page 60) Optimax 63 (page 62)
<p>Commissioning tool “EP-Tools” (page 75)</p>		<p>Crown gearheads</p> <ul style="list-style-type: none"> EtaCrown® 75 (page 66) EtaCrown®Plus 63 (page 70)
<p>Cable Connection cables have to be ordered separately</p>		

For motor-gearbox combinations, depending on the choice of the single components, the maximum allowable torque (gearbox) can be exceeded or respectively not reached.

ECI motor.

ECI-80.XX-K1



- Highly dynamic 3-phase internal rotor motor with EC technology
- Low cogging torque
- Robust, noise-optimized ball bearing system for a long service life
- High efficiency and high power density realized in a compact design
- Protection class IP 40/IP 54 and connection by connector system
- Basic motor with electronic module K1 for operation with external control electronics
- Mechanical design and interfaces designed for modular flexibility

Nominal data

Type		ECI-80.20-K1 -B00	ECI-80.20-K1 -D00	ECI-80.40-K1 -B00	ECI-80.40-K1 -D00	ECI-80.60-K1 -D00
Nominal voltage (U_N)	V DC	24	48	24	48	48
Nominal speed (n_N)*	rpm	4 000				
Nominal torque (M_N)*	mNm	700	700	1 200	1 200	1 800
Nominal current (I_N)*	A	13.5	7.50	25.0	12.0	18.0
Nominal output power (P_N)*	W	293	293	503	503	754
Starting torque (M_{max})	mNm	2 400	2 500	3 900	5 000	5 600
Permissible peak current (I_{max})**	A	100	60	100	100	100
Permanent stall torque (M_{NO})	mNm	700	700	1 200	1 200	1 800
Speed at no-load operation (n_0)	rpm	1.00	0.70	1.50	0.90	1.00
No-load current (I_0)	A	0 ... 4 000				
Speed at no-load operation (n_0)	rpm	4 800	4 800	4 700	4 850	6 100
Rotor moment of inertia (J_R)	kgm ² x10 ⁻⁶	54	54	104	104	155
Motor constant (K_E)	mVs/rad	47.2	94.1	48.2	96.0	72.15
Connection resistance (R_c)	Ω	0.07	0.30	0.03	0.10	0.04
Connection inductance (L_c)	mH	0.30	1.30	0.20	0.60	0.20
Overload protection		integrated				
Permissible ambient temperature range (T_U)	°C	-30 ... +40				
Weight	kg	1.40	1.40	2.10	2.10	2.70
Order no. (wire interface)***	IP 40	932 8020 103	932 8020 105	932 8040 103	932 8040 105	932 8060 105
Order no. (cable routing)***	IP 54	On request				

Subject to alterations

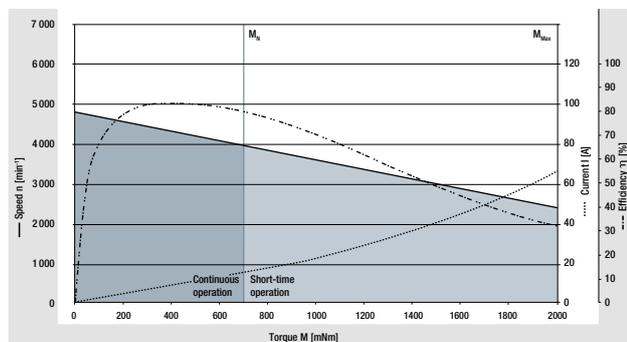
* At T_U max. 40°C

** Permissible time for peak current: max. 5 sec. – to be repeated only after complete cool down

*** Classification of protection class refers to installed state with sealing on the flange side

Characteristic curve

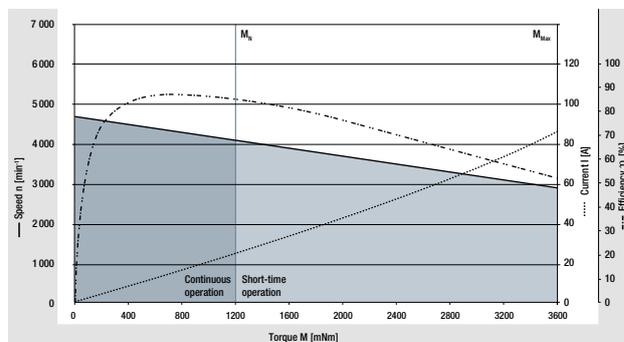
ECI-80.20-K1, 24 V (at 25°C)



¹⁾ Nominal data, see table

Characteristic curve 48 V on request

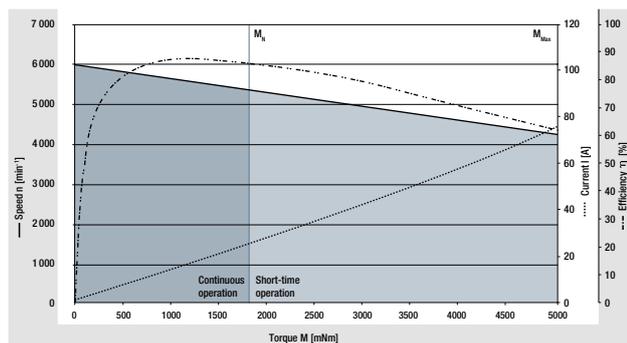
ECI-80.40-K1, 24 V (at 25°C)



¹⁾ Nominal data, see table

Characteristic curve 48 V on request

ECI-80.60-K1, 48 V (at 25°C)



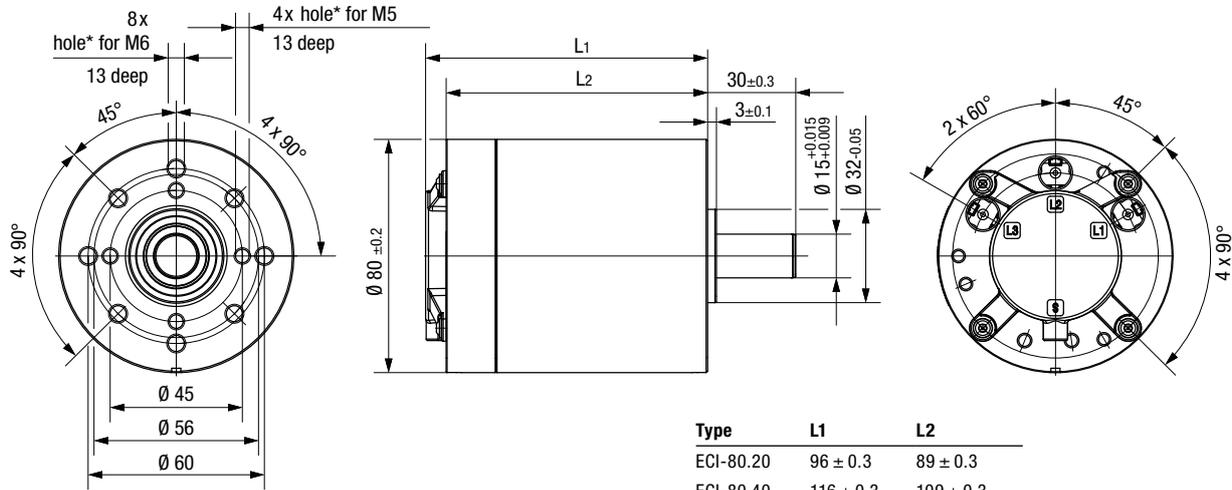
¹⁾ Nominal data, see table

ECl motor.

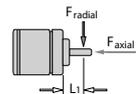
ECl-80.XX-K1

Technical drawing

All dimensions in mm



Type	L1	L2
ECl-80.20	96 ± 0.3	89 ± 0.3
ECl-80.40	116 ± 0.3	109 ± 0.3
ECl-80.60	136 ± 0.3	129 ± 0.3



F_{axial}	30 N	Permissible shaft load at nominal speed and life expectancy L_{10} (nominal operation) of 20 000 h (at T_u max. 40°C)
F_{radial}	75 N	
$L1$	20 mm	

* For thread-rolling screws according to DIN 7500

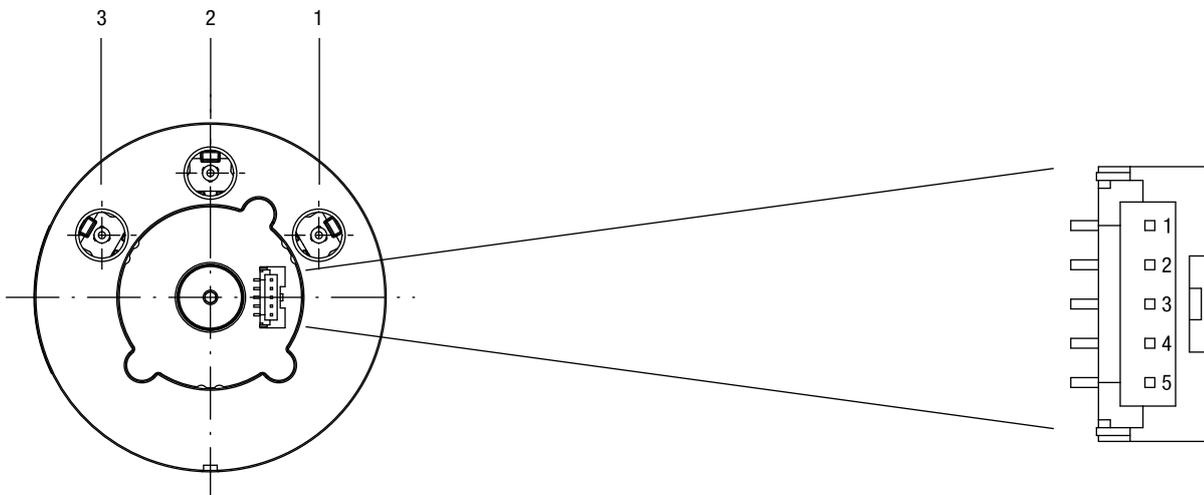
Electrical connection

Supply wire

No.	Color	Function
1	brown	Phase L1
2	violet	Phase L2
3	yellow	Phase L3

Signal wire

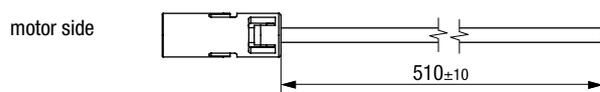
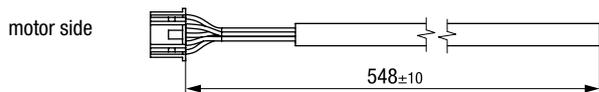
No.	Color	Function
1	red	U_B
2	black	GND
3	green	Hall A
4	white	Hall B
5	gray	Hall C



Cable All dimensions in mm

Sensor cable with wires and plug AWG 24 (0.22 mm ²)	
Type	Order number
Sensor cable	992 0800 001

Winding connector AWG 12 (4 mm ²)		
Type	Color	Order number
Power wire L1	brown	992 0800 012
Power wire L2	violet	992 0800 011
Power wire L3	yellow	992 0800 010



Modular construction kit

Brake system
On request



Basic motor



Planetary gearheads
Performax®Plus 63 (page 60)
Optimax 63 (page 62)

Encoder system
On request



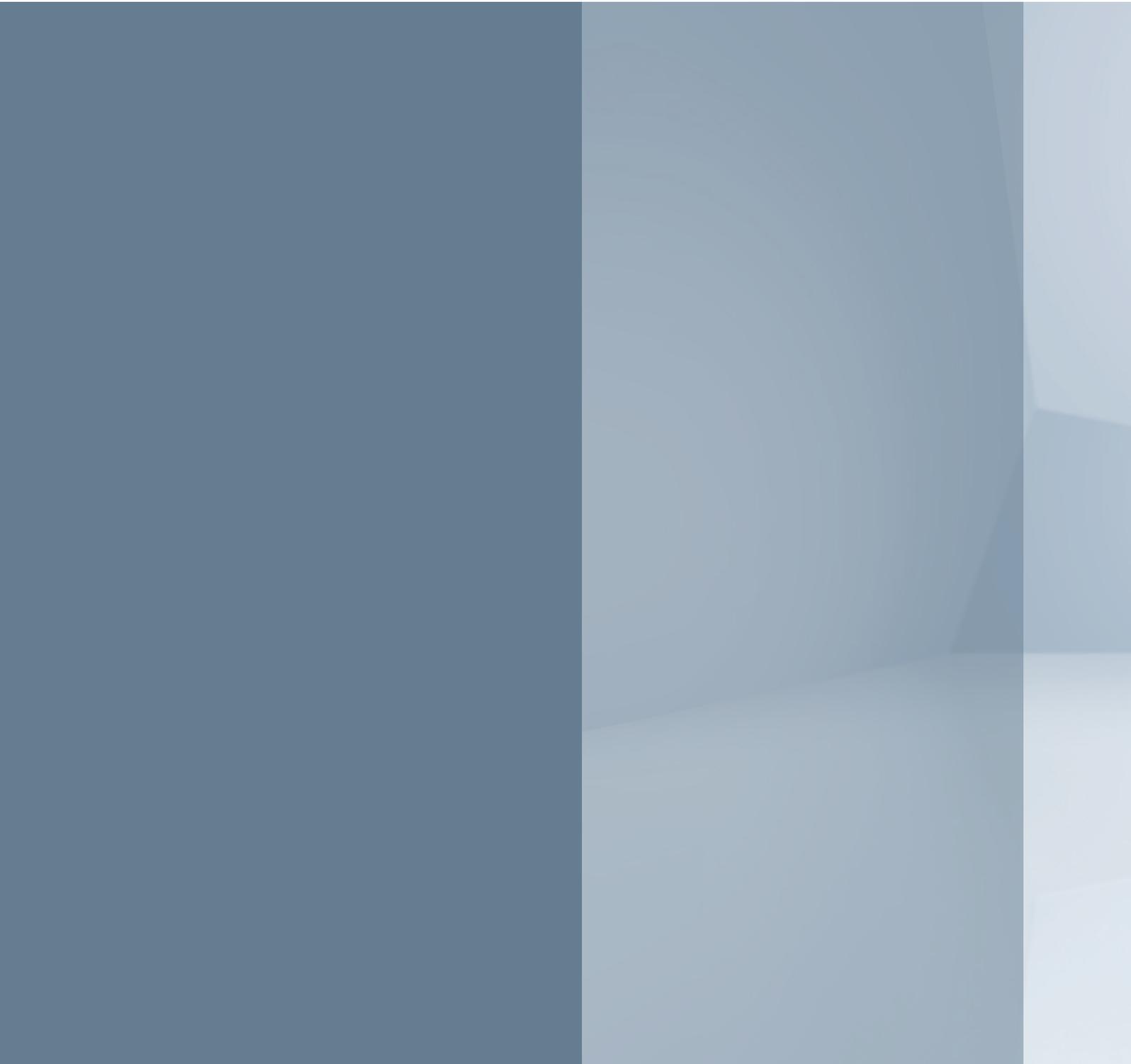


Recommended external control electronics

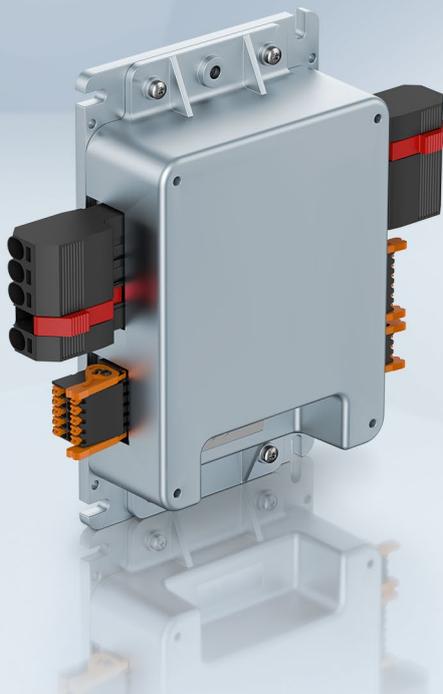
VTD-XX.XX-K4S	Speed (page 40)
VTD-60.35-K5SB	Position (page 44)



For motor-gearbox combinations, depending on the choice of the single components, the maximum allowable torque (gearbox) can be exceeded or respectively not reached.



Control electronics.



VTD-XX.XX-K3 (speed)	38
VTD-XX.XX-K4S (position)	40
VTD-60.13-K5SB (CANopen)	42
VTD-60.35-K5SB (CANopen)	44

Control electronics.

VTD-XX.XX-K3



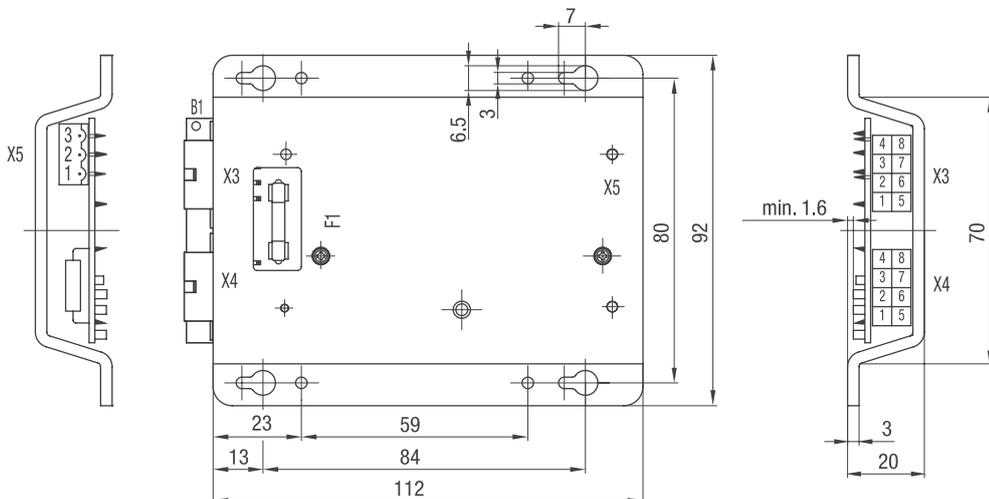
Operating electronics for driving 3-phase BLDC motors from the ECI-42.XX-K1 and ECI-63.20-K1 series. Design in digital technology for use as OEM electronics in series applications

- Motor commutation and speed control via microcontroller
- Control parameters are each specifically designed for the motor
- Four-quadrant controller
- Speed setting via analog nominal value 0 ... 10 V DC
- Speed actual value processing and output
- Setting of the operating mode via 2 control inputs
- Monitoring function for output current and voltage

Nominal data			
Type		VTD-24.XX-K3	VTD-48.XX-K3
Nominal voltage (Power supply U_N)	V DC	24	48
Permissible supply voltage range (U)	V DC	18 ... 30	30 ... 52
Permissible continuous output current*	A	3 - 12 depending on model	3 - 6 depending on model
Maximum commutation frequency	kHz		2
Switching frequency	kHz		20
Minimum connection inductance	mH		0.1
Digital inputs	Number		2
Digital outputs	Number		1
Analog inputs	Number		1
Efficiency (in optimum working range)	%		95
Permissible ambient temperature range (T_U)	°C		0 ... +40
Permissible ambient humidity**	%		5 ... 93
Protection class			IP 00
Weight	kg		0.2
Order number		On request	On request
Subject to alterations	Commutation: block commutation (by means of 3 digital Hall sensors)		
	* Applicable at rated temperature $T_U = 40^\circ\text{C}$		
	** Condensation not permitted		

Technical drawing

All dimensions in mm



Electrical connection

Pin	Control plug X3		Motor plug X4		Capacitor plug X5	
1	A	Operating mode	L3	Motor phase	U+	Capacitor connector
2	+U _B	Operating voltage	+U-Hall	Hall sensor supply	U-	Capacitor connector
3	n.c.	Not allocated	RLG2	Hall signal 2	BR	Braking resistor
4	S+	Set value input	RLG1	Hall signal 1		
5	B	Operating mode	L2	Motor phase 2		
6	Actual	Actual speed value	L1	Motor phase 1		
7	GND	Ground	GND Hall	Ground Hall sensor supply		
8	S-	Ground set value input	RLG3	Hall signal 3		

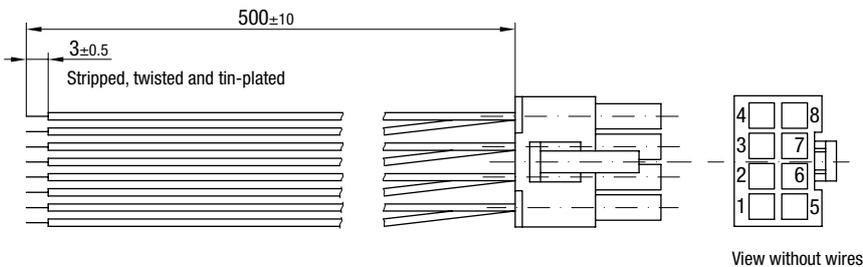
Accessories

Cable connector X3

Type	Order no.
X3 Control plug	194 0017 000

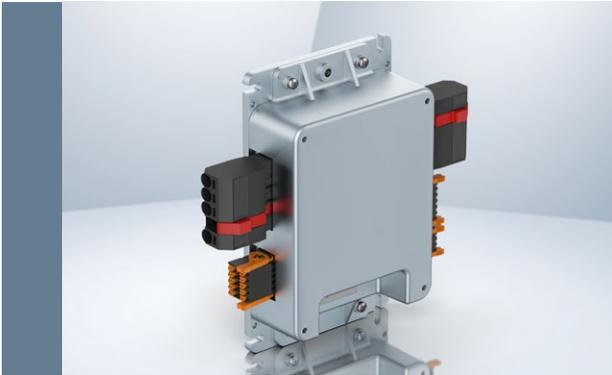
Color assignment

No.	Color	Function
1	white (AWG 20)	A
2	red (AWG 18)	+U _B
3	violet (AWG 20)	n.c.
4	green (AWG 20)	S+
5	gray (AWG 20)	B
6	yellow (AWG 20)	Actual
7	black (AWG 18)	GND
8	brown (AWG 20)	S-



Control electronics.

VTD-XX.XX-K4S



- Operating electronics for driving 3-phase BLDC motors up to 1 000 watt output power
- Four-quadrant controller
- Speed, torque and positioning mode
- Selection of operating modes and parameter setting via RS 485
- User-friendly parameter setting with “Kickstart” PC software
- Integrated brake ballast-control
- Device status notification by 2 LEDs

Nominal data			
Type		VTD-24.40-K4S	VTD-48.20-K4S
Nominal voltage (power supply U_v)	V DC	24	48
Permissible supply voltage range (U)	V DC	18 ... 30	18 ... 53
Maximum output current (max. 5 sec)*	A	100	
Permissible continuous output current*	A	40 ± 10%	20 ± 10%
Nominal voltage (Logic supply U_l)	V DC	24	
Logic current draw** (at 24 V DC)	mA	< 100	
Maximum commutation frequency	kHz	2	
Switching frequency	kHz	20	
Minimum connection inductance	mH	0.10	
Digital inputs	Number	4	
Digital outputs	Number	3	
Analog inputs	Number	1	
Parameterization interface		RS 485	
Efficiency (in optimum working range)	%	> 95	
Permissible ambient temperature range (T_v)	°C	-30 ... +40	
Permissible ambient humidity***	%	5 ... 85	
Protection class		IP 20	
Weight	kg	approx. 0.50	
Order number (IP 20)		994 2440 000	994 4820 000
Subject to alterations	* Applicable at rated temperature $T_v = 25^\circ\text{C}$, Derating at deviating (higher) temperatures		
	** Current draw without current requirement of digital outputs		
	*** Condensation not permitted		
Series planned for 2nd q/2017			

Control electronics.

VTD-60.13-K5SB

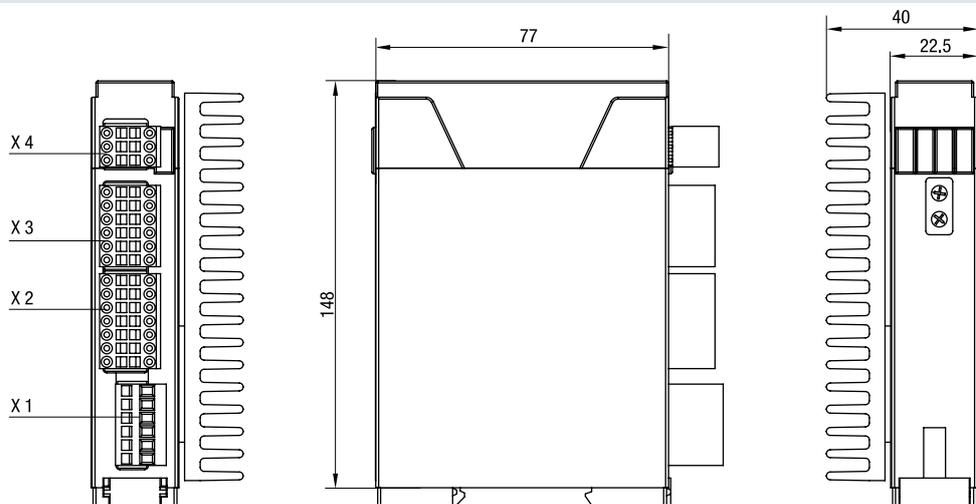


- Compact four-quadrant controller for BLDC motors
- CANopen interface (Protocol DS301, Device profile DS402)
- Integrated digital inputs
- Integrated digital outputs
- Integrated analog inputs
- Overvoltage, undervoltage and overtemperature monitoring
- Device status notification by 3 LEDs (Power, Status, Error)
- Hex switch for setting the device node ID
- Freely programmable due to built in MPU (Motion Process Unit)

Nominal data			
Type		VTD-60.13-K5SB	
Nominal voltage (Power supply U_N)	V DC	24	48
Permissible supply voltage range (U)	V DC	9 ... 60	
Maximum output current*	A	50	
Permissible continuous output current*	A	12.5 (at 24 V)	12.5 (at 24 V)
Nominal voltage (Logic supply U_L)	V DC	9 ... 30	
Logic current draw** (at 24 V DC)	mA	60	
Maximum commutation frequency	kHz	2	
Switching frequency	kHz	32	
Minimum connection inductance	mH	0.20	
Digital inputs	Number	8	
Digital outputs	Number	2	
Analog inputs	Number	2	
Parameterization interface		CANopen	
Efficiency (in optimum working range)	%	95	
Permissible ambient temperature range (T_U)	°C	0 ... +70	
Permissible ambient humidity***	%	5 ... 85	
Protection class		IP 20	
Weight	kg	0.31	
Order number (IP 20)		994 6013 000	
Subject to alterations	Commutation: block commutation (by means of 3 digital Hall sensors)		
	* Applicable at rated temperature $T_U = 25^\circ\text{C}$, Derating at deviating (higher) temperatures		
	** Current draw without current requirement of digital outputs		
	*** Condensation not permitted		

Technical drawing

All dimensions in mm



Mating connectors are included in delivery

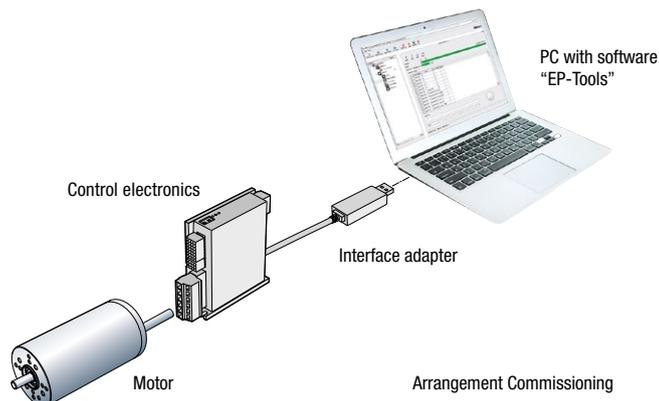
Electrical connection

Pin	X1	Motor	X2	Hall sensors and encoder	X3	I/O's and CAN	X4	I/O's
1	FE	Functional earth	H1	Hall sensor signal 1	U _{Logic}	Power supply Electronics	A-IN-1	Analog input 1
2	+Up	Power supply Power	H2	Hall sensor signal 2	A-IN-0 +	Analog input 0, plus	D-IN-4	Digital input 4
3	GND	Ground for power supply voltage	H3	Hall sensor signal 3	D-IN-0	Digital input 0	D-IN-5	Digital input 5
4	Ma	Motor phase A	A	Incremental encoder – A channel	D-IN-1	Digital input 1	D-IN-6	Digital input 6
5	Mb	Motor phase B	B	Incremental encoder – B channel	D-IN-2	Digital input 2	D-OUT-1	Digital output 1
6	Mc	Motor phase C	Inx	Incremental encoder – index channel	D-IN-3	Digital input 3	D-IN-7	Digital input 7
7			+U _{sv}	5V auxiliary voltage (Hall and encoder)	GND	Ground for electronic supply voltage		
8			/H1	Hall sensor signal 1 inverted	A-IN-0 -	Analog input 0, minus		
9			/H2	Hall sensor signal 2 inverted	D-OUT-0	Digital output 0		
10			/H3	Hall sensor signal 3 inverted	CAN Hi	CAN High		
11			/A	Incremental encoder – A channel inverted	CAN Lo	CAN Low		
12			/B	Incremental encoder – B channel inverted	CAN GND	CAN Ground		
13			/Inx	Incremental encoder – index channel inverted				
14			GND	Ground for auxiliary voltage				

Accessories

Commissioning tool

“EP-Tools” (page 75)



Control electronics.

VTD-60.35-K5SB

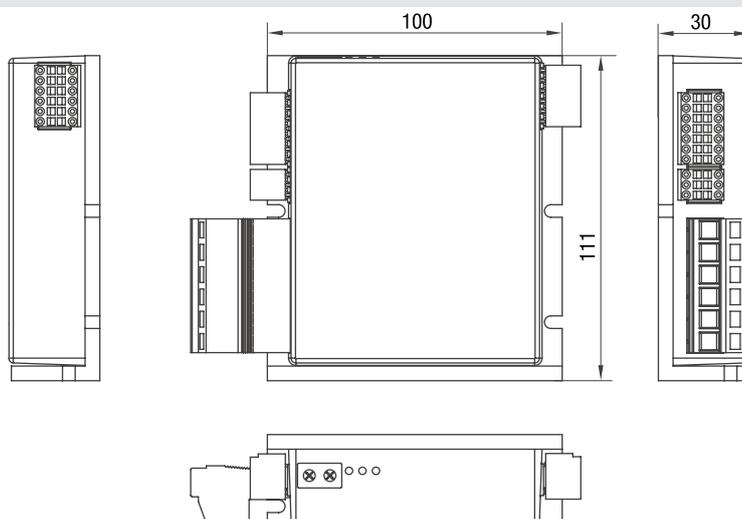


- Motor controller up to 100 A
- Compact four-quadrant controller for BLDC motors
- CANopen interface (Protocol DS301, Device profile DS402)
- Integrated digital inputs
- Integrated digital outputs
- Integrated analog inputs
- Overvoltage, undervoltage and overtemperature monitoring
- Device status notification by 3 LEDs (Power, Status, Error)
- Hex switch for setting the device node ID
- Freely programmable due to built in MPU (Motion Process Unit)

Nominal data			
Type		VTD-60.35-K5SB	
Nominal voltage (Power supply U_N)	V DC	24	48
Permissible supply voltage range (U)	V DC	9 ... 60	
Maximum output current*	A	100	
Permissible continuous output current*	A	35 (at 24 V)	26 (at 48 V)
Nominal voltage (Logic supply U_L)	V DC	9 ... 30	
Logic current draw** (at 24 V DC)	mA	70	
Maximum commutation frequency	kHz	2	
Switching frequency	kHz	32	
Minimum connection inductance	mH	0.2	
Digital inputs	Number	8	
Digital outputs	Number	2	
Analog inputs	Number	2	
Parameterization interface		CANopen	
Efficiency (in optimum working range)	%	95	
Permissible ambient temperature range (T_U)	°C	0 ... +70	
Permissible ambient humidity***	%	5 ... 85	
Protection class		IP 20	
Weight	kg	0.38	
Order number (IP 20)		994 6035 000	
Subject to alterations	Commutation: block commutation (by means of 3 digital Hall sensors)		
Series planned for 2nd q/2017	* Applicable at rated temperature $T_U = 25^\circ\text{C}$, Derating at deviating (higher) temperatures ** Current draw without current requirement of digital outputs *** Condensation not permitted		

Technical drawing

All dimensions in mm



Mating connectors are included in delivery

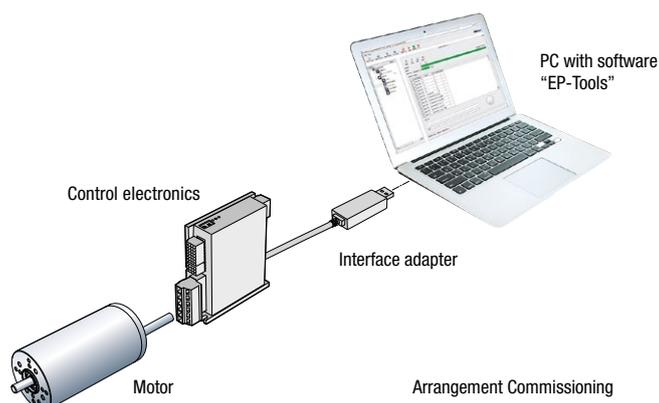
Electrical connection

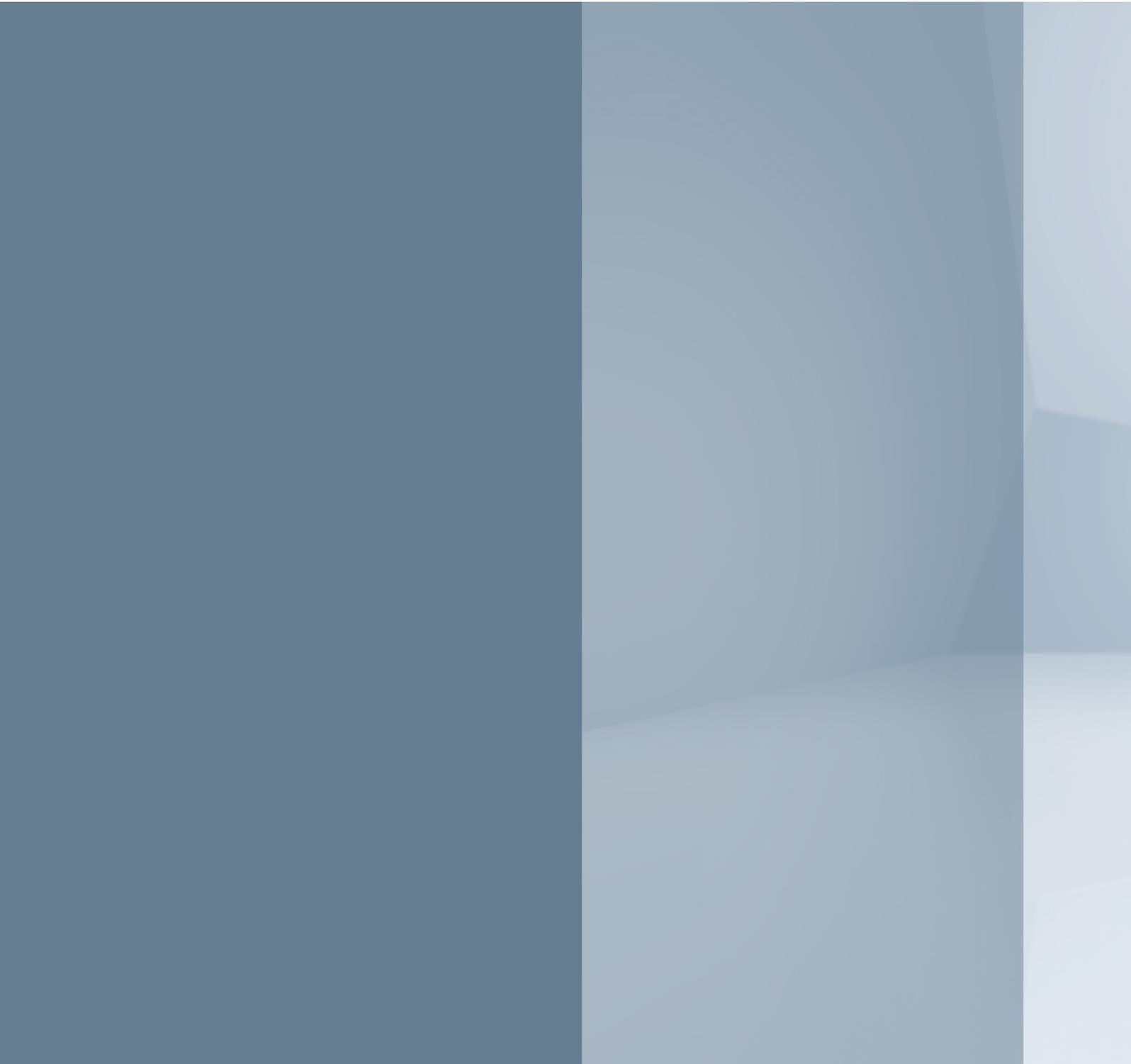
Pin	X1	Motor	X2	Hall sensors and encoder	X3	I/O's and CAN	X4	I/O's
1	FE	Functional earth	H1	Hall sensor signal 1	U_{Logic}	Power supply Electronics	A-IN-1	Analog input 1
2	+Up	Power supply Power	H2	Hall sensor signal 2	A-IN-0 +	Analog input 0, plus	D-IN-4	Digital input 4
3	GND	Ground for power supply voltage	H3	Hall sensor signal 3	D-IN-0	Digital input 0	D-IN-5	Digital input 5
4	Ma	Motor phase A	A	Incremental encoder – A channel	D-IN-1	Digital input 1	D-IN-6	Digital input 6
5	Mb	Motor phase B	B	Incremental encoder – B channel	D-IN-2	Digital input 2	D-OUT-1	Digital output 1
6	Mc	Motor phase C	Inx	Incremental encoder – index channel	D-IN-3	Digital input 3	D-IN-7	Digital input 7
7			+U _{sv}	5V auxiliary voltage (Hall and encoder)	GND	Ground for electronic supply voltage		
8			/H1	Hall sensor signal 1 inverted	A-IN-0 -	Analog input 0, minus		
9			/H2	Hall sensor signal 2 inverted	D-OUT-0	Digital output 0		
10			/H3	Hall sensor signal 3 inverted	CAN Hi	CAN High		
11			/A	Incremental encoder – A channel inverted	CAN Lo	CAN Low		
12			/B	Incremental encoder – B channel inverted	CAN GND	CAN Ground		
13			/Inx	Incremental encoder – index channel inverted				
14			GND	Ground for auxiliary voltage				

Accessories

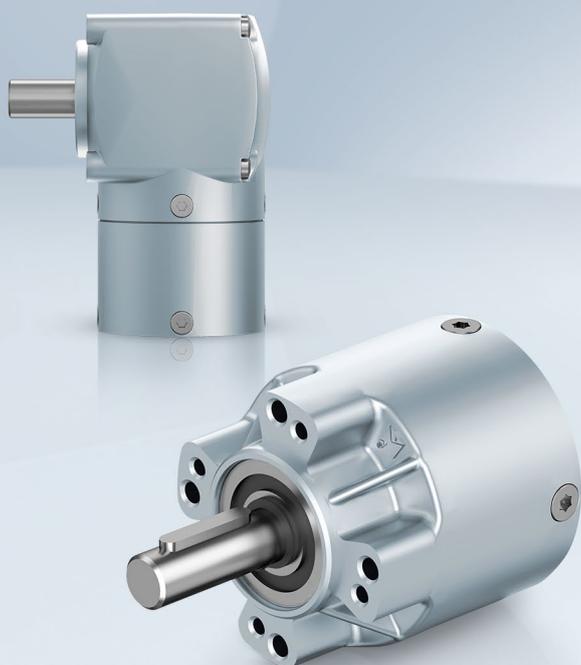
Commissioning tool

"EP-Tools" (page 75)





Gearheads.



NoiselessPlus 42 (planetary gearhead)	50
NoiselessPlus 63 (planetary gearhead)	52
Performax® 42 (planetary gearhead)	54
Performax® 63 (planetary gearhead)	56
Performax®Plus 42 (planetary gearhead)	58
Performax®Plus 63 (planetary gearhead)	60
Optimax 63 (planetary gearhead)	62
EtaCrown® 52 (crown gearhead)	64
EtaCrown® 75 (crown gearhead)	66
EtaCrown®Plus 42 (crown gearhead)	68
EtaCrown®Plus 63 (crown gearhead)	70
Information on operating factor, lifetime, efficiency	82

Information for gearheads.

In the gearbox product range, we offer three types of transmission technologies. These include planetary gearing, crown gearhead units and spur gears, all individually adapted to the requirements of the customer according to the modular principle. Deciding which of these technologies will render the best results for the respective application, ultimately depends on the application itself.

Characteristics of the individual transmission technologies:

Planetary gearheads

- Higher reduction ratios within first and second stage
- Very quiet operation
- Extremely high performance
- Compact design
- No offset axle
- Comprehensive range of products with three model types
 - Noiseless Plus – unique quiet operation
 - Performax® – extreme performance
 - Optimax – robust and long lifetime



Crown gearheads

- Outstanding efficiency
- Large reduction ratio range
- No self-locking
- Highest power density
- No offset axle
- Two different model ranges
 - EtaCrown®
 - EtaCrown® Plus



The comprehensive range of **planetary gearbox** products is used when the application does not allow axle misalignment.

When it comes to achieving high efficiency with minimal noise, the **NoiselessPlus** is the impressive obvious choice. Exemplary smooth running is achieved thanks to extremely sturdy, low-wear plastic planetary wheels in an aluminium housing with bevelled teeth. Double ball bearing output shafts efficiently absorb the forces acting on the shaft at high radial loads. The output shafts of the NoiselessPlus gearheads are made of hardened and ground case-hardened steel and are thus particularly durable.

Performax® is an innovative, patent-pending concept of high-performance **planetary gearheads**.

With its pioneering design, Performax® gearheads are popular for their outstanding power density, ultimate smoothness and unique reduction ranges. Transmissions of up to 17:1 in one stage allow the use of single-stage gearheads, whereas competitors' products already require a two-stage design. The design features of the series include helical plastic gear wheels in the first stage and in the second stage, straight toothing in the zinc diecast casting with case-hardened planetary wheels. Another special standard feature of Performax® gearheads is the planetary wheels of the second stage.

These have needle bearings, which really sets the series apart from the regular planetary gearheads available on the market.

EtaCrown® is the name of the innovative **angular gear** with crown gearhead technology.

Our vision of making crown gearheads smaller, more powerful and more efficient, and above all to manufacture them more economically, is now a reality. EtaCrown® significantly improves energy efficiency and cost-effectiveness of drive solutions. The modular design can be flexibly adapted for any drive task. Characteristic is its very compact design and space-saving geometry with a symmetrical structure and maximum performance density. Transmissions of 4:1 to 113:1 are available as standard. Also standard is jolt-free start-up due to rolling tooth gripping. Smooth running due to intelligent gear-tooth technology and gearhead design, while maximum radial load thanks to double-sided support of the drive shaft are also part of its features.

A special feature among angular drives is the self-locking capacity, which does not exist in the technology. In contrast to other gearbox technologies, this offers optimal protection against vandalism.

Planetary gearheads.

NoiselessPlus 42



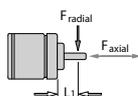
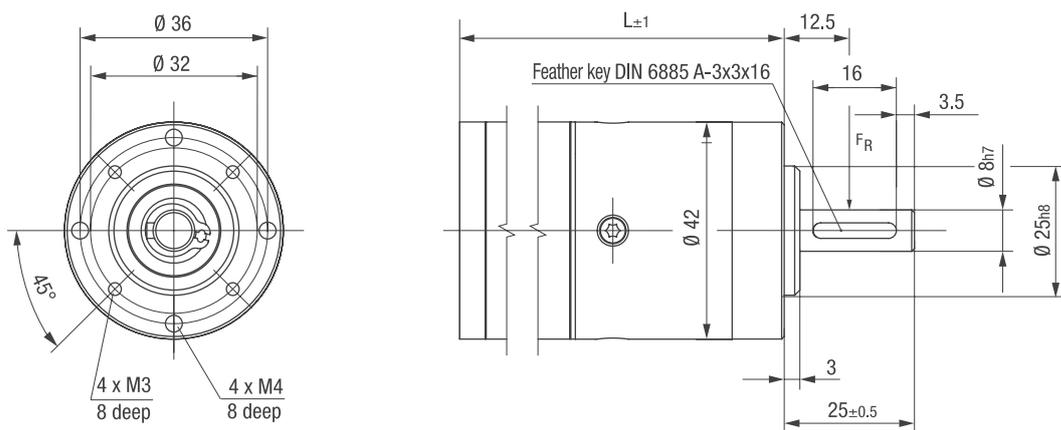
Image of 1-stage gearhead

- Very quiet operation due to helical-tooth gear stages
- Toothed parts made of plastic with optimized sliding properties ensure smooth operation
- Higher reduction ratios within first and second gear stage
- High radial loads due to double ball bearing in the output shaft
- Flexible connection to customer applications (shaft variants, centering and fastening)

Nominal data										
Gearheads		NoiselessPlus 42.1					NoiselessPlus 42.2			
Reduction ratio		4.30	6.00	11.0	21.0	26.0	47.6	66.0	121	231
No. of stages		1					2			
Efficiency		0.90					0.81			
Max. input speed (n_i)	rpm	6 000					6 000			
Rated output torque (M_{ab})	Nm	2.52	1.96	1.10	0.38	4.00	4.28	4.94	3.02	3.66
Short-term torque (M_{max})	Nm	6.30	4.90	2.75	0.95	10.0	10.7	12.4	7.55	9.15
Gear play	°	0.2 ... 0.5					0.2 ... 0.5			
Permissible operating temperature (T_{v})	°C	-20 ... +80					-20 ... +80			
Operating mode		S1					S1			
Protection class		IP 50					IP 50			
Weight	kg	0.22					0.25			
Shaft load radial / axial	N	50 / 350	80 / 350	175 / 350	220 / 350	250 / 350	520 / 350	680 / 350	900 / 350	1 000 / 350
Service life	h	10 000					10 000			
Lubrication		Maintenance-free grease lubrication for life								
Installation position		any								
Subject to alterations										
Preferred type: ready to ship in 48 hours		on request								

Technical drawing

Image of 1-stage gearhead / All dimensions in mm



F_{axial} 350 N
 F_{radial} see table
 L_1 12.5 mm

Permissible shaft load at nominal speed and life expectancy L_{10} (nominal operation) and operating factor $C_b = 1$ (see page 82) of 10 000 h (at T_u 40°C).

Length of the possible motor / gearhead combinations

Motor / gearhead		L - 1-stage	L - 2-stage
ECI-42.20-NP42	mm	135	162
ECI-42.40-NP42	mm	115	182

Subject to alterations

Planetary gearheads.

NoiselessPlus 63



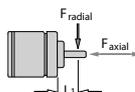
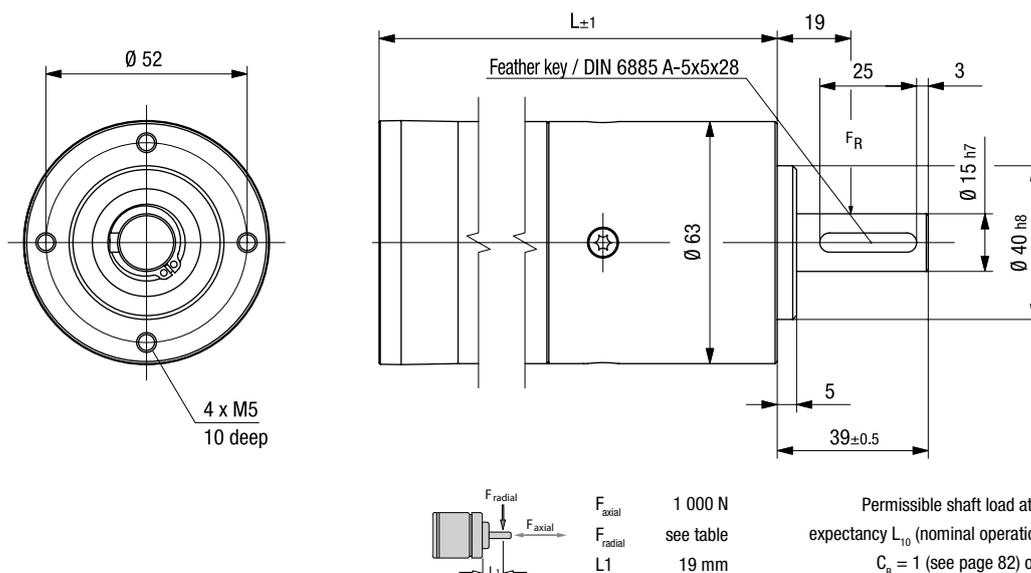
Image of 1-stage gearhead

- Very quiet operation due to helical-tooth gear stages
- Toothed parts made of plastic with optimized sliding properties ensure smooth operation
- Higher reduction ratios within first and second gear stage
- High radial loads due to double ball bearing in the output shaft
- Flexible connection to customer applications (shaft variants, centering and fastening)

Nominal data									
Gearheads		NoiselessPlus 63.1				NoiselessPlus 63.2			
Reduction ratio		4.30	6.00	11.0	21.0	26.0	47.0	66.0	121
No. of stages		1				2			
Efficiency		0.90				0.81			
Max. input speed (n_i)	rpm	6 000				6 000			
Rated output torque (M_{ab})	Nm	8.99	7.13	3.98	1.32	12.6	14.7	17.5	10.6
Short-term torque (M_{max})	Nm	22.5	17.8	9.95	3.30	31.5	36.8	43.8	26.5
Gear play	°	0.2 ... 0.5				0.2 ... 0.5			
Permissible operating temperature (T_{op})	°C	-20 ... +80				-20 ... +80			
Operating mode		S1				S1			
Protection class		IP 50				IP 50			
Weight	kg	0.56				0.80			
Shaft load radial / axial	N	50 / 1 000	50 / 1 000	50 / 1 000	100 / 1 000	780 / 1 000	1 000 / 1 000	1 100 / 1 000	1 550 / 1 000
Service life	h	10 000				10 000			
Lubrication		Maintenance-free grease lubrication for life							
Installation position		any							
Subject to alterations									
Preferred type: ready to ship in 48 hours		on request							

Technical drawing

Image of 1-stage gearhead / All dimensions in mm



F_{axial} 1 000 N
 F_{radial} see table
 L_1 19 mm

Permissible shaft load at nominal speed and life expectancy L_{10} (nominal operation) and operating factor $C_b = 1$ (see page 82) of 10 000 h (at T_u 40°C).

Length of the possible motor / gearhead combinations

Motor / gearhead		L - 1-stage	L - 2-stage
ECI-63.20-K1-NP63	mm	165	197
ECI-63.40-K1-NP63	mm	185	217
ECI-63.60-K1-NP63	mm	205	237
ECI-63.20-K3-NP63	mm	178	210
ECI-63.40-K3-NP63	mm	198	230
ECI-63.60-K3-NP63	mm	218	250
ECI-63.20-K4-NP63	mm	178	210
ECI-63.40-K4-NP63	mm	198	230
ECI-63.60-K4-NP63	mm	218	250
ECI-63.20-K5-NP63	mm	171	203
ECI-63.40-K5-NP63	mm	191	223
ECI-63.60-K5-NP63	mm	211	243

Subject to alterations

Planetary gearheads.

Performax® 42



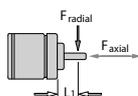
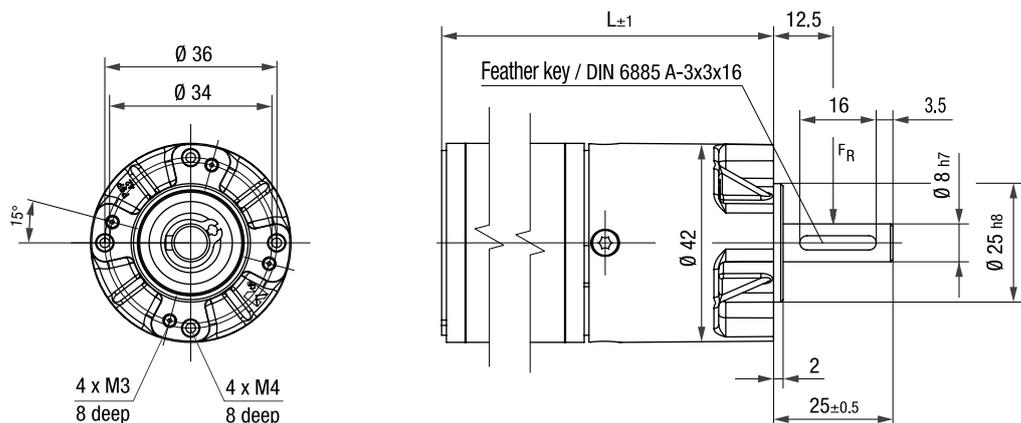
- High power density from compact dimensions
- Very quiet operation due to helical teeth in the first gear stage
- Planetary wheels made of plastic with optimized sliding properties in the first stage ensure smooth operation
- Large effective diameter thanks to radial screw connection
- Economical setup due to use of many individual parts which are readily available on the market

Image of 2-stage gearhead

Nominal data												
Gearheads		Performax® 42.1					Performax® 42.2					
Reduction ratio		3.20	5.00	9.00	17.0	21.3	30.0	38.3	54.0	72.3	102	204
No. of stages		1					2					
Efficiency		0.90					0.81					
Max. input speed (n_i)	rpm	6 000					6 000					
Rated output torque (M_{ab})	Nm	1.24	1.00	0.50	0.79	3.20	4.48	1.80	2.60	2.20	3.20	6.30
Short-term torque (M_{max})	Nm	3.10	2.50	1.25	1.98	8.00	11.2	4.50	6.50	5.50	8.00	15.8
Gear play	°	0.7 ... 1.2					0.7 ... 1.2					
Permissible operating temperature (T_v)	°C	-20 ... +80					-20 ... +80					
Operating mode		S1					S1					
Protection class		IP 50					IP 50					
Weight	kg	0.19					0.29					
Shaft load radial / axial	N	250 / 150					250 / 150					
Service life	h	5 000					5 000					
Lubrication		Maintenance-free grease lubrication for life										
Installation position		any										
Subject to alterations												
Preferred type: ready to ship in 48 hours		on request										

Technical drawing

Image of 1-stage gearhead / All dimensions in mm



F_{axial} 150 N
 F_{radial} 250 N
 L_1 12.5 mm

Permissible shaft load at nominal speed and life expectancy L_{10} (nominal operation) and operating factor $C_g = 1$ (see page 82) of 5 000 h (at T_u 40°C).

Length of the possible motor / gearhead combinations

Motor / gearhead		L - 1-stage	L - 2-stage
ECI-42.20-K1-P42	mm	129	145
ECI-42.40-K1-P42	mm	149	165

Subject to alterations

Planetary gearheads.

Performax® 63



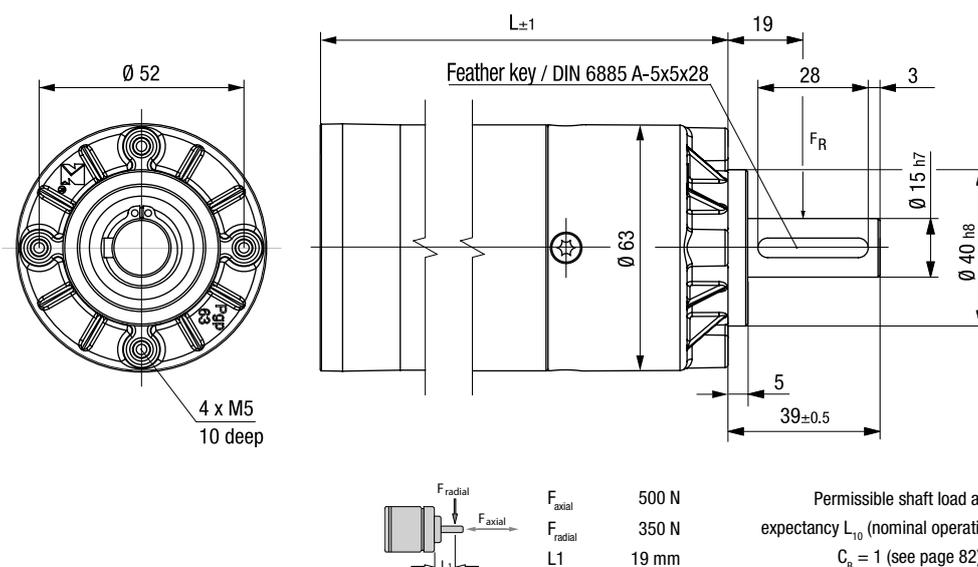
- High power density from compact dimensions
- Very quiet operation due to helical teeth in the first gear stage
- Planetary wheels made of plastic with optimized sliding properties in the first stage ensure smooth operation
- Large effective diameter thanks to radial screw connection
- Economical setup due to use of many individual parts which are readily available on the market

Image of 1-stage gearhead

Nominal data											
Gearheads		Performax® 63.1				Performax® 63.2					
Reduction ratio		5.00	9.00	17.0	21.25	30.0	38.25	54.0	72.3	102	204
No. of stages		1				2					
Efficiency		0.90				0.81					
Max. input speed (n_i)	rpm	6 000				6 000					
Rated output torque (M_{ab})	Nm	6.91	2.20	1.50	12.0	17	8.30	11.8	5.90	8.30	16.5
Short-term torque (M_{max})	Nm	17.3	5.50	3.75	30.0	42.5	20.8	29.5	14.8	20.8	41.3
Gear play	°	0.7 ... 1.2				0.7 ... 1.2					
Permissible operating temperature (T_{ν})	°C	-20 ... +80				-20 ... +80					
Operating mode		S1				S1					
Protection class		IP 50				IP 50					
Weight	kg	0.40				0.60					
Shaft load radial / axial	N	350 / 500				350 / 500					
Service life	h	5 000				5 000					
Lubrication		Maintenance-free grease lubrication for life									
Installation position		any									
Subject to alterations											
Preferred type: ready to ship in 48 hours		on request									

Technical drawing

Image of 1-stage gearhead / All dimensions in mm



Length of the possible motor / gearhead combinations

Motor / gearhead		L - 1-stage	L - 2-stage
ECI-63.20-K1-P63	mm	152	173
ECI-63.40-K1-P63	mm	172	193
ECI-63.60-K1-P63	mm	192	213
ECI-63.20-K3-P63	mm	164	186
ECI-63.40-K3-P63	mm	184	206
ECI-63.60-K3-P63	mm	204	226
ECI-63.20-K4-P63	mm	164	186
ECI-63.40-K4-P63	mm	184	206
ECI-63.60-K4-P63	mm	204	226
ECI-63.20-K5-P63	mm	158	179
ECI-63.40-K5-P63	mm	178	199
ECI-63.60-K5-P63	mm	198	219

Subject to alterations

Planetary gearheads.

Performax®Plus 42



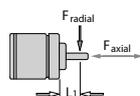
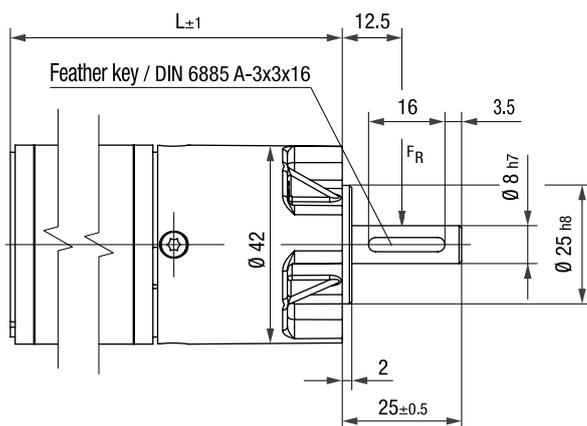
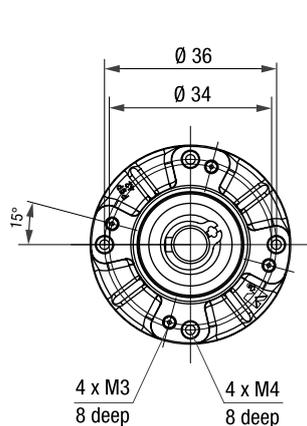
Image of 2-stage gearhead

- High torques thanks to large gearing width in the first gear stage
- Good shock resistance due to housing made of case-hardened steel with linear tooth profile in the output stage
- Very quiet operation due to helical teeth in the first gear stage
- Planetary wheels made of plastic with optimized sliding properties in the first stage ensure smooth operation
- Large effective diameter thanks to radial screw connection

Nominal data			
Gearheads		Performax®Plus 42.1	Performax®Plus 42.2
Reduction ratio		5.00	30.0
No. of stages		1	2
Efficiency		0.90	0.81
Max. input speed (n_i)	rpm	6 000	6 000
Rated output torque (M_{ab})	Nm	2.00	4.48
Short-term torque (M_{max})	Nm	5.00	11.2
Gear play	°	0.7 ... 1.2	0.7 ... 1.2
Permissible operating temperature (T_v)	°C	-20 ... +80	-20 ... +80
Operating mode		S1	S1
Protection class		IP 50	IP 50
Weight	kg	0.22	0.33
Shaft load radial / axial	N	250 / 150	250 / 150
Service life	h	5 000	5 000
Lubrication		Maintenance-free grease lubrication for life	
Installation position		any	
Subject to alterations			
Preferred type: ready to ship in 48 hours			

Technical drawing

Image of 1-stage gearhead / 2-stage design completely cylindrical / All dimensions in mm



F_{axial}	150 N
F_{radial}	250 N
$L1$	12.5 mm

Permissible shaft load at nominal speed and life expectancy L_{10} (nominal operation) and operating factor $C_g = 1$ (see page 82) of 5 000 h (at T_u 40°C).

Length of the possible motor / gearhead combinations

Motor / gearhead		L - 1-stage	L - 2-stage
ECI-42.20-K1-PP42	mm	133	149
ECI-42.40-K1-PP42	mm	153	169

Subject to alterations

Planetary gearheads.

Performax®Plus 63



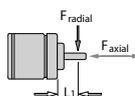
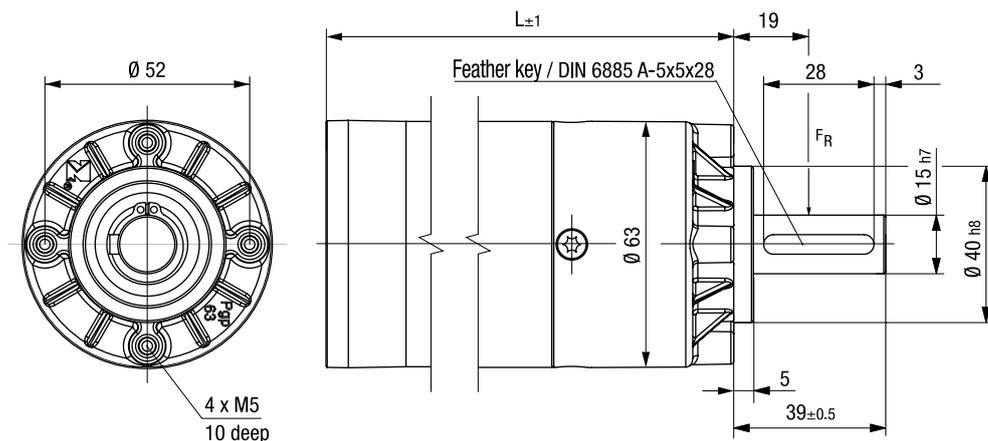
- High torques thanks to large gearing width in the first gear stage
- Good shock resistance due to housing made of case-hardened steel with linear tooth profile in the output stage
- Very quiet running due to helical teeth in the first gear stage
- Planetary wheels made of plastic with optimized sliding properties in the first stage ensure smooth operation
- Large effective diameter thanks to radial screw connection

Image of 2-stage gearhead

Nominal data												
Gearheads		Performax®Plus 63.1					Performax®Plus 63.2					
Reduction ratio		3.20	5.00	9.00	17.0	21.3	30.0	38.3	54.0	72.3	102	204
No. of stages		1					2					
Efficiency		0.90					0.81					
Max. input speed (n_i)	rpm	6 000					6 000					
Rated output torque (M_{ab})	Nm	6.50	11.9	7.60	4.40	45.2	64.0	28.9	41.0	16.9	23.9	27.4
Short-term torque (M_{max})	Nm	16.3	29.8	19.0	11.0	113	160	72.3	102.5	42.3	59.8	68.5
Gear play	°	0.7 ... 1.2					0.7 ... 1.2					
Permissible operating temperature (T_{ν})	°C	-20 ... +80					-20 ... +80					
Operating mode		S1					S1					
Protection class		IP 50					IP 50					
Weight	kg	0.66					1.20					
Shaft load radial / axial	N	350 / 500					350 / 500					
Service life	h	5 000					5 000					
Lubrication		Maintenance-free grease lubrication for life										
Installation position		any										
Subject to alterations												
Preferred type: ready to ship in 48 hours		on request										

Technical drawing

Image of 1-stage gearhead / 2-stage design completely cylindrical / All dimensions in mm



F_{axial}	500 N
F_{radial}	350 N
$L1$	19 mm

Permissible shaft load at nominal speed and life expectancy L_{10} (nominal operation) and operating factor $C_g = 1$ (see page 82) of 5 000 h (at T_u 40°C).

Length of the possible motor / gearhead combinations

Motor / gearhead		L - 1-stage	L - 2-stage
ECI-63.20-K1-PP63	mm	164	185
ECI-63.40-K1-PP63	mm	184	205
ECI-63.60-K1-PP63	mm	204	225
ECI-63.20-K3-PP63	mm	176	198
ECI-63.40-K3-PP63	mm	196	218
ECI-63.60-K3-PP63	mm	216	238
ECI-63.20-K4-PP63	mm	176	198
ECI-63.40-K4-PP63	mm	196	218
ECI-63.60-K4-PP63	mm	216	238
ECI-63.20-K5-PP63	mm	170	191
ECI-63.40-K5-PP63	mm	190	211
ECI-63.60-K5-PP63	mm	210	231
ECI-80.20-K1-PP63	mm	154	175
ECI-80.40-K1-PP63	mm	174	195
ECI-80.60-K1-PP63	mm	194	215

Subject to alterations

Planetary gearheads.

Optimax 63

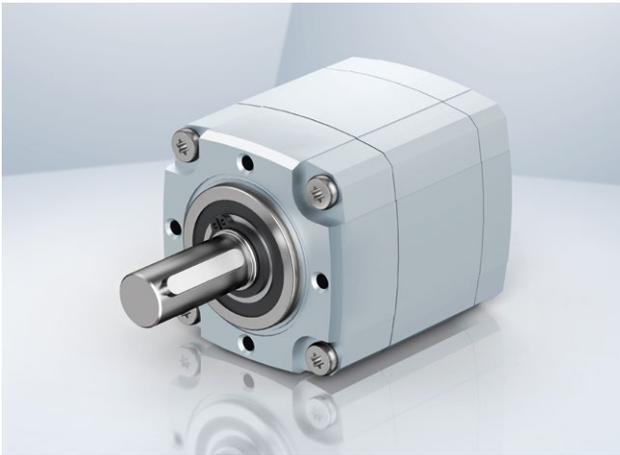


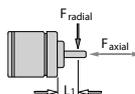
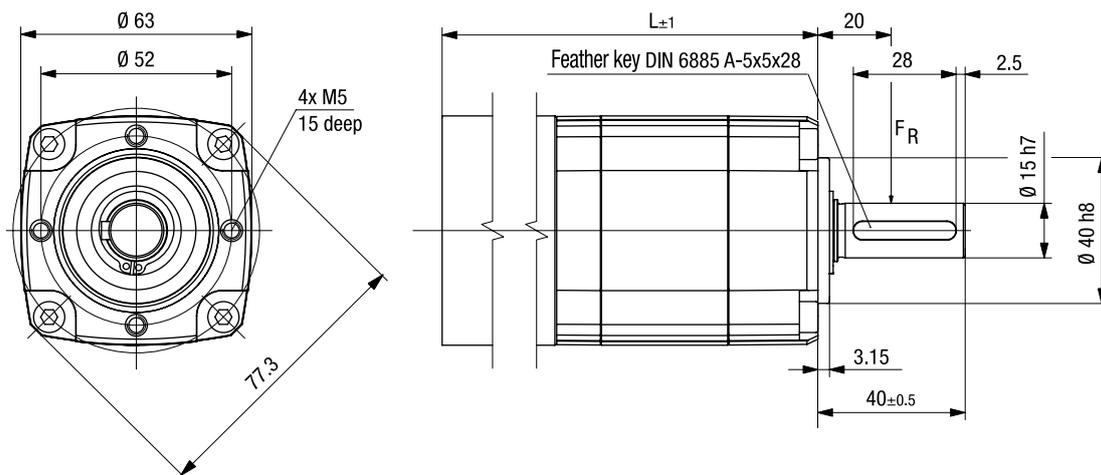
Image of 1-stage gearhead

- Extreme high overload capability to cope with peak torques
- Robust gearhead concept for extended service life
- Modular design and interfaces for maximum flexibility within ebm-papst modular system
- High efficiency realized in a compact design
- Noise optimized version with planetary wheels made from high-strength plastic
- Protection class IP 50 (optional IP 54)

Nominal data								
Gearheads		Optimax 63.1			Optimax 63.2			
Reduction ratio		3.0	5.0	9.0	9.0	15	25	45
No. of stages		1			2			
Efficiency		0.90			0.81			
Max. input speed (n_i)	rpm	6 000			6 000			
Rated output torque (M_{ab})*/**	Nm	40.0 (13.0)	40.0 (13.0)	25.0 (6.00)	68.0 (35.0)	68.0 (58.0)	68.0 (58.0)	58.0 (27.0)
Short-term torque (M_{max})**	Nm	120.0 (39.0)	120.0 (39.0)	75.0 (18.0)	150.0 (105.0)	150.0 (150.0)	150.0 (150.0)	150.0 (81.0)
Gear play	°	< 0.9			< 1.2			
Permissible operating temperature (T_{ij})	°C	-30 ... +90			-30 ... +90			
Operating mode		S1 / S3***			S1 / S3***			
Protection class		50			50			
Weight	kg	1.3			1.9			
Shaft load radial / axial	N	500 / 500			500 / 500			
Service life	h	10 000			10 000			
Lubrication		Maintenance-free grease lubrication for life						
Installation position		any						
Subject to alterations		* In S1 operation ** Value 1 applies to planetary gears (single stage) made from high-strength steel. Value 2 (in brackets) applies to planetary gears (single stage) made from high-strength plastic. *** $M_{eff} = M_{ab}$						
Preferred type: ready to ship in 48 hours		on request						

Technical drawing

Image of 1-stage gearhead / All dimensions in mm



F_{axial} 500 N
 F_{radial} 500 N
 L_1 20 mm

Permissible shaft load at nominal speed and life expectancy L_{10} (nominal operation) and operating factor $C_b = 1$ (see page 82) of 10 000 h (at T_u 40°C).

Length of the possible motor / gearhead combinations

Motor / gearhead		L - 1-stage	L - 2-stage
ECI-63.20-K1-O63	mm	177	208
ECI-63.40-K1-O63	mm	197	228
ECI-63.60-K1-O63	mm	217	248
ECI-63.20-K3-O63	mm	190	221
ECI-63.40-K3-O63	mm	210	241
ECI-63.60-K3-O63	mm	230	261
ECI-63.20-K4-O63	mm	190	221
ECI-63.40-K4-O63	mm	210	241
ECI-63.60-K4-O63	mm	230	261
ECI-63.20-K5-O63	mm	184	242
ECI-63.40-K5-O63	mm	204	235
ECI-63.60-K5-O63	mm	224	255
ECI-80.20-K1-O63	mm	168	199
ECI-80.40-K1-O63	mm	188	219
ECI-80.60-K1-O63	mm	208	239

Subject to alterations

Crown gearheads.

EtaCrown® 52



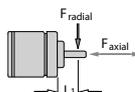
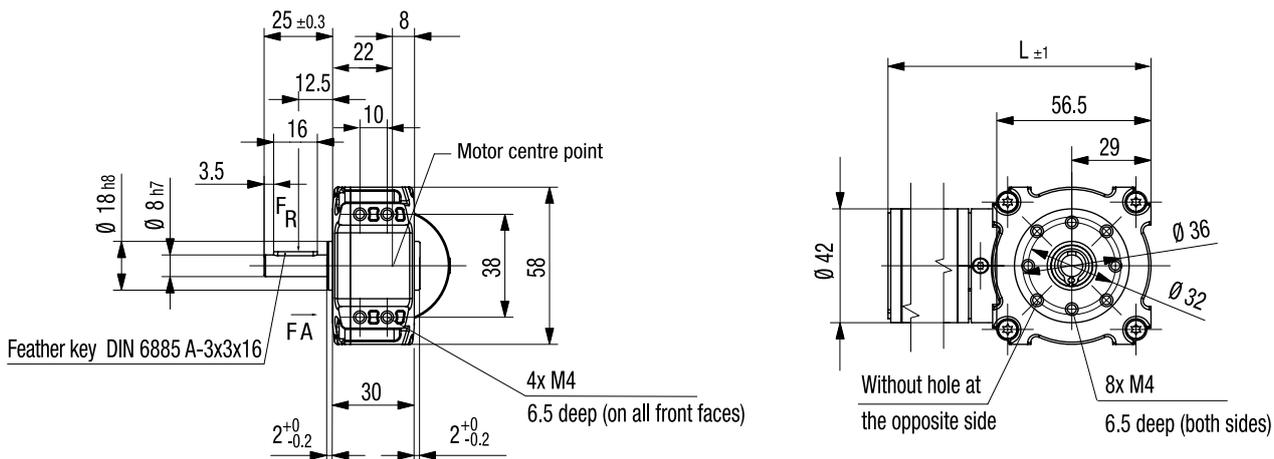
Image of 2-stage gearhead

- Maximum safety in design and operation, as well as optimal vandalism protection; no automatic lock due to high efficiency of the crown wheel technology
- Space-saving installation due to zero offset axle and symmetrical structure
- Flexible application possibilities with various optional shaft outlets and available shaft geometries
- Wide reduction range by means of upstream / downstream planetary stage
- High radial loads due to double ball bearing in the output shaft

Nominal data								
Gearheads		EtaCrown® 52.1			EtaCrown® 52.2			
Reduction ratio		4.10	6.70	10.1	21.2	33.3	60.0	113
No. of stages		1			2			
Efficiency		0.90			0.81			
Max. input speed (n _i)	rpm	6 000			6 000			
Rated output torque (M _{ab})	Nm	0.21	0.34	0.52	0.98	1.54	2.77	3.48
Short-term torque (M _{max})	Nm	0.53	0.85	1.30	2.45	3.85	6.93	8.70
Gear play	°	0.55 ... 1.1			0.55 ... 1.1			
Permissible operating temperature (T _v)	°C	-20 ... +80			-20 ... +80			
Operating mode		S1			S1			
Protection class		IP 50			IP 50			
Weight	kg	0.40			0.65			
Shaft load radial / axial	N	300 / 150	350 / 150	400 / 150	500 / 150	570 / 150	720 / 150	770 / 150
Service life	h	5 000			5 000			
Lubrication		Maintenance-free grease lubrication for life						
Installation position		any						
Subject to alterations								
Preferred type: ready to ship in 48 hours		on request						

Technical drawing

Image of 1-stage gearhead with left shaft end (W05) / All dimensions in mm



F_{axial} 150 N
 F_{radial} see table
 $L1$ 12.5 mm

Permissible shaft load at nominal speed and life expectancy L_{10} (nominal operation) and operating factor $C_g = 1$ (see page 82) of 5 000 h (at T_u 40°C).

Shaft end, right (W05) (standard)	Shaft end, left (W06)	Shaft end, both sides (W07)

Length of the possible motor / gearhead combinations

Motor / gearhead		L - 1-stage	L - 2-stage
ECI-42.20-K1-E52	mm	160	189
ECI-42.40-K1-E52	mm	180	209

Subject to alterations

Crown gearheads.

EtaCrown® 75



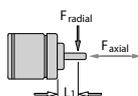
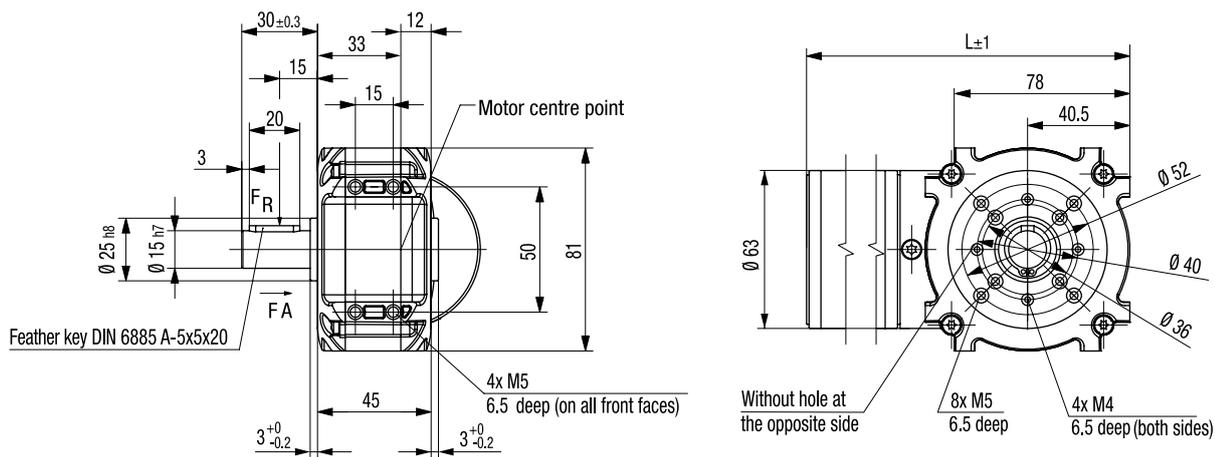
Image of 2-stage gearhead

- Maximum safety in design and operation, as well as optimal vandalism protection; no automatic lock due to high efficiency of the crown wheel technology
- Space-saving installation due to zero offset axle and symmetrical structure
- Flexible application possibilities with various optional shaft outlets and available shaft geometries
- Wide reduction range by means of upstream / downstream planetary stage
- High radial loads due to double ball bearing in the output shaft

Nominal data								
Gearheads		EtaCrown® 75.1			EtaCrown® 75.2			
Reduction ratio		4.10	6.70	10.1	20.3	33.3	60.0	113
No. of stages		1			2			
Efficiency		0.90			0.81			
Max. input speed (n_1)	rpm	6 000			6 000			
Rated output torque (M_{ab})	Nm	6.00	5.00	2.43	10.0	10.0	10.0	10.0
Short-term torque (M_{max})	Nm	15.0	12.5	6.08	25.0	25.0	25.0	25.0
Gear play	°	0.55 ... 1.1			0.55 ... 1.1			
Permissible operating temperature (T_{v})	°C	-20 ... +80			-20 ... +80			
Operating mode		S1			S1			
Protection class		IP 50			IP 50			
Weight	kg	0.9			1.3			
Shaft load radial / axial	N	150 / 500	250 / 500	400 / 500	550 / 500	800 / 500	1 100 / 500	1 300 / 500
Service life	h	5 000			5 000			
Lubrication		Maintenance-free grease lubrication for life						
Installation position		any						
Subject to alterations								
Preferred type: ready to ship in 48 hours		on request						

Technical drawing

Image of 1-stage gearhead with left shaft end (W05) / All dimensions in mm



F_{axial} 500 N
 F_{radial} see table
 $L1$ 15 mm

Permissible shaft load at nominal speed and life expectancy L_{10} (nominal operation) and operating factor $C_g = 1$ (see page 82) of 5 000 h (at T_u 40°C).

Shaft end, right (W05) (standard)	Shaft end, left (W06)	Shaft end, both sides (W07)	Hollow shaft (W08)
			 Hollow shaft \varnothing 10 mm

Length of the possible motor / gearhead combinations

Motor / gearhead		L - 1-stage	L - 2-stage
ECI-63.20-K1-E75	mm	197	233
ECI-63.40-K1-E75	mm	217	253
ECI-63.60-K1-E75	mm	237	273
ECI-63.20-K3-E75	mm	210	246
ECI-63.40-K3-E75	mm	230	266
ECI-63.60-K3-E75	mm	250	286
ECI-63.20-K4-E75	mm	210	246
ECI-63.40-K4-E75	mm	230	266
ECI-63.60-K4-E75	mm	250	286
ECI-63.20-K5-E75	mm	203	239
ECI-63.40-K5-E75	mm	223	259
ECI-63.60-K5-E75	mm	243	279

Subject to alterations

Crown gearheads.

EtaCrown®Plus 42



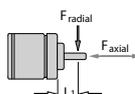
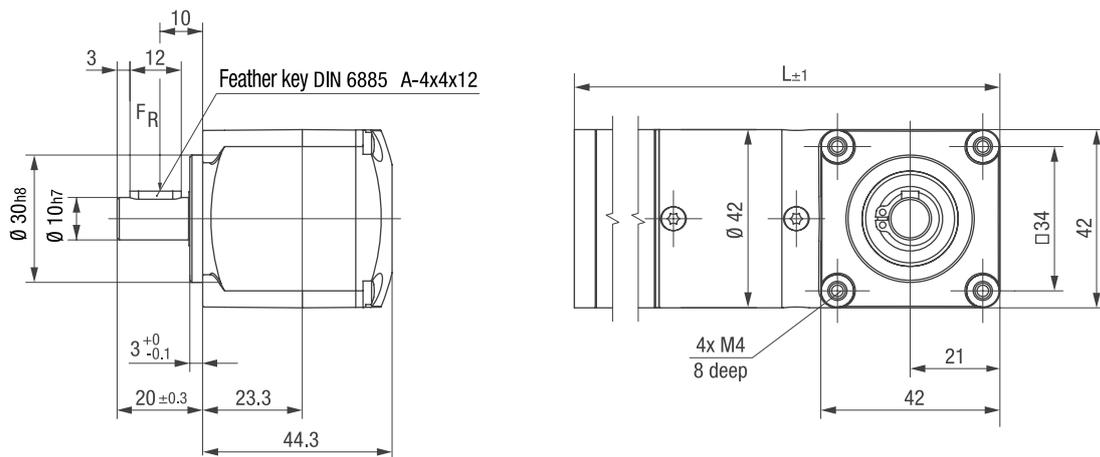
Image of 3-stage gearhead

- Compact design due to combination of the crown wheel and planetary stage in one housing
- No automatic lock due to high efficiency of the crown wheel technology
- High torques by using 5 straight toothed planetary gears made of case-hardened sintered steel in the integrated planetary gear stage
- Wide reduction range thanks to possibility of an upstream planetary stage
- Improved quiet operation thanks to the optimized design of the crown wheel stage when using an upstream helical planetary gear stage made of plastic with optimized sliding properties

Nominal data		EtaCrown®Plus 42.3			
Gearheads					
Reduction ratio		54.0	84.8	153	289
No. of stages		3			
Efficiency		0.73			
Max. input speed (n_i)	rpm	6 000			
Rated output torque (M_{ab})	Nm	10.0	10.0	6.70	8.40
Short-term torque (M_{max})	Nm	25.0	25.0	16.8	21.0
Gear play	°	0.7 ... 1.2			
Permissible operating temperature (T_{op})	°C	-20 ... +80			
Operating mode		S1			
Protection class		IP 50			
Weight	kg	0.45			
Shaft load radial / axial	N	300 / 200			
Service life	h	5 000			
Lubrication		Maintenance-free grease lubrication for life			
Installation position		any			
Subject to alterations					
Preferred type: ready to ship in 48 hours		on request			

Technical drawing

Image of 3-stage gearhead / All dimensions in mm



F_{axial} 200 N
 F_{radial} 300 N
 L_1 10 mm

Permissible shaft load at nominal speed and life expectancy L_{10} (nominal operation) and operating factor $C_g = 1$ (see page 82) of 5 000 h (at T_u 40°C).

Length of the possible motor / gearhead combinations

Motor / gearhead		L - 3-stage
ECI-42.20-K1-EP42	mm	174
ECI-42.40-K1-EP42	mm	194

Subject to alterations

Crown gearheads.

EtaCrown®Plus 63



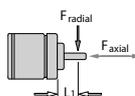
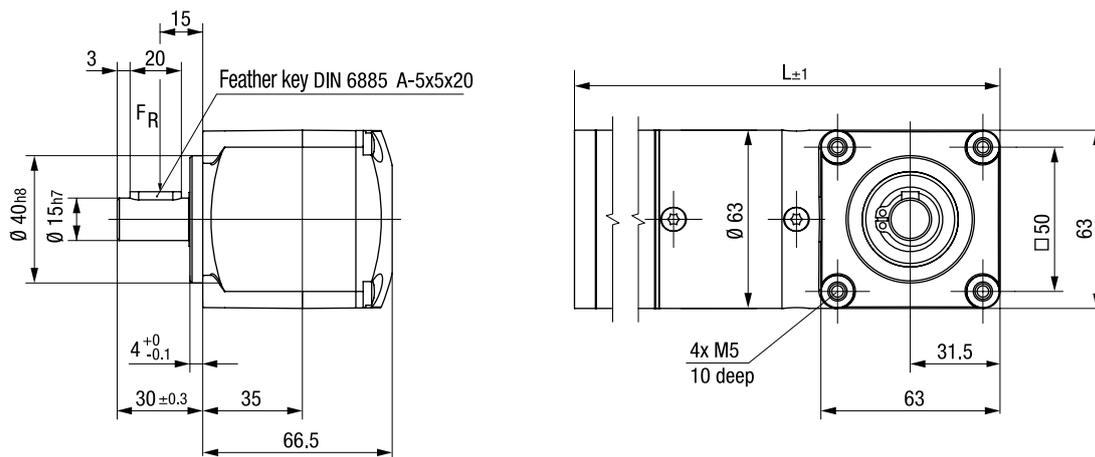
Image of 3-stage gearhead

- Compact design due to combination of the crown wheel and planetary stage in one housing
- No automatic lock due to high efficiency of the crown wheel technology
- High torques by using 5 straight toothed planetary gears made of case-hardened sintered steel in the integrated planetary gear stage
- Wide reduction range thanks to possibility of an upstream planetary stage
- Improved quiet operation thanks to the optimized design of the crown wheel stage when using an upstream helical planetary gear stage made of plastic with optimized sliding properties

Nominal data		EtaCrown®Plus 63.3			
Gearheads					
Reduction ratio		54.0	84.8	153	289
No. of stages		3			
Efficiency		0.73			
Max. input speed (n_i)	rpm	6 000			
Rated output torque (M_{ab})	Nm	40.0	40.0	30.1	29.1
Short-term torque (M_{max})	Nm	100	100	75.3	72.8
Gear play	°	0.7 ... 1.2			
Permissible operating temperature (T_{op})	°C	-20 ... +80			
Operating mode		S1			
Protection class		IP 50			
Weight	kg	1.0			
Shaft load radial / axial	N	600 / 300			
Service life	h	5 000			
Lubrication		Maintenance-free grease lubrication for life			
Installation position		any			
Subject to alterations					
Preferred type: ready to ship in 48 hours		on request			

Technical drawing

Image of 3-stage gearhead / All dimensions in mm



F_{axial} 300 N
 F_{radial} 600 N
 $L1$ 15 mm

Permissible shaft load at nominal speed and life expectancy L_{10} (nominal operation) and operating factor $C_g = 1$ (see page 82) of 5 000 h (at T_u 40°C).

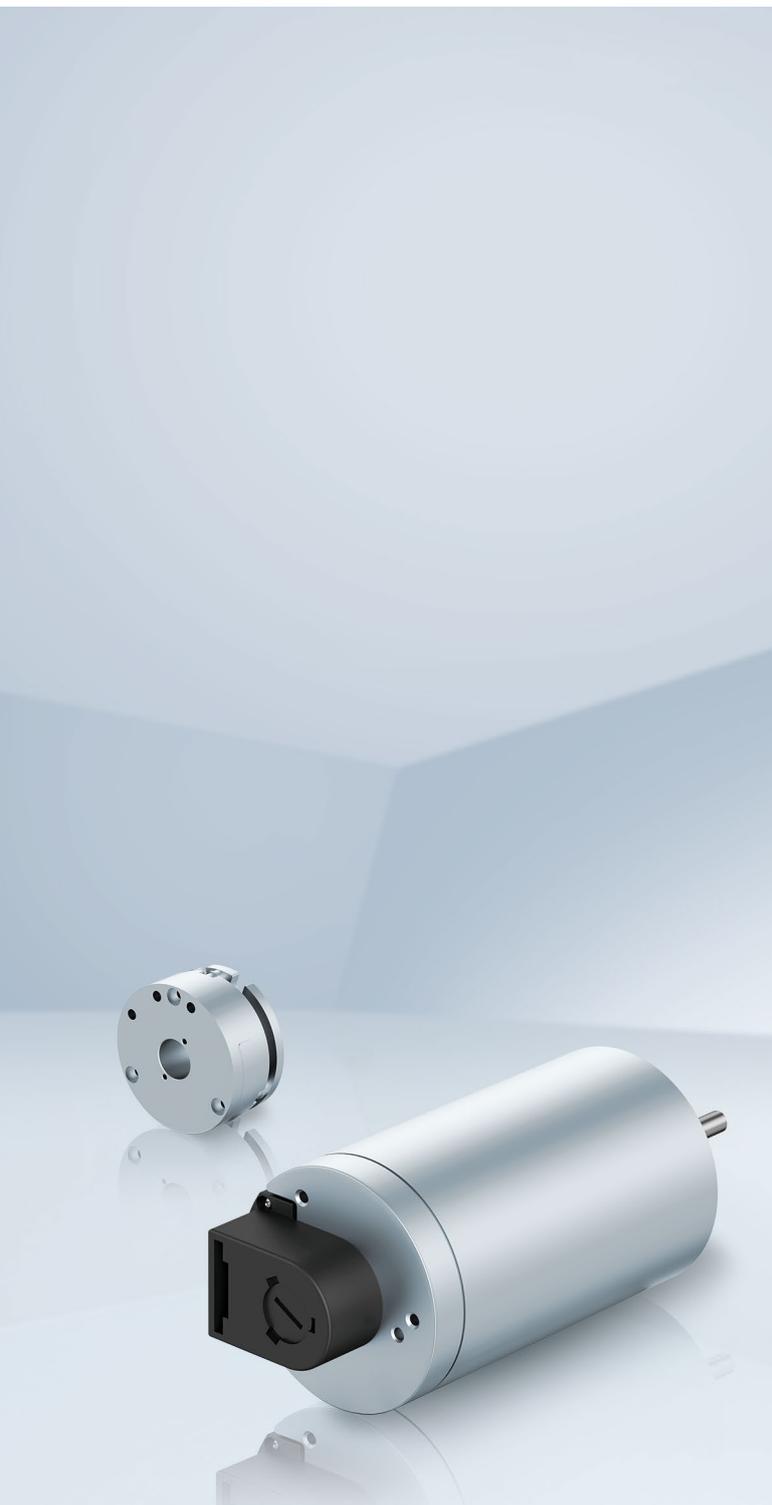
Length of the possible motor / gearhead combinations

Motor / gearhead	L - 3-stage	
ECl-63.20-K1-EP63	mm	222
ECl-63.40-K1-EP63	mm	242
ECl-63.60-K1-EP63	mm	262
ECl-63.20-K3-EP63	mm	235
ECl-63.40-K3-EP63	mm	255
ECl-63.60-K3-EP63	mm	275
ECl-63.20-K4-EP63	mm	235
ECl-63.40-K4-EP63	mm	255
ECl-63.60-K4-EP63	mm	275
ECl-63.20-K5-EP63	mm	228
ECl-63.40-K5-EP63	mm	248
ECl-63.60-K5-EP63	mm	268

Subject to alterations



Accessories.

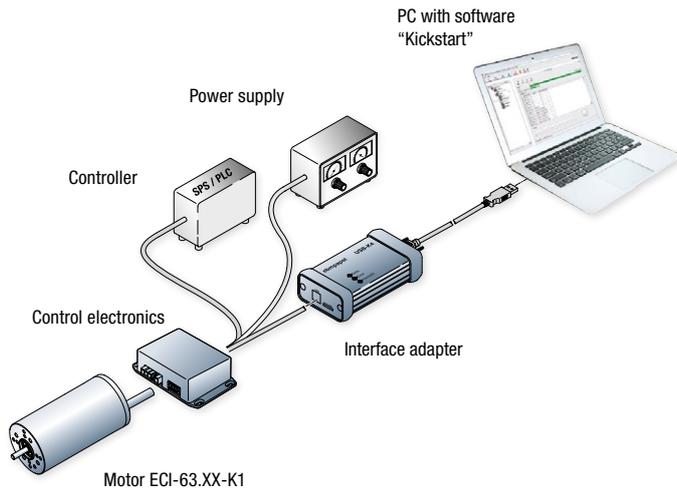


Commissioning tools	72
Brakes	74
Optical encoder system	76

Commissioning tools.

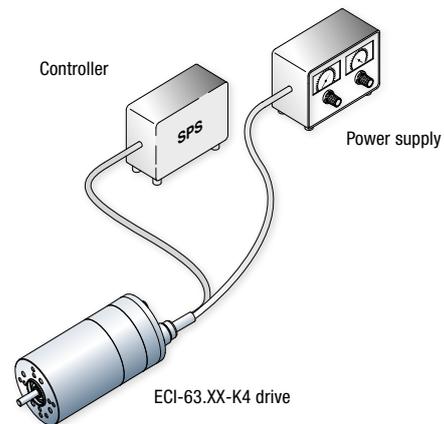
K4

Parameterization and commissioning



Automatic operation

Automatic operation with stored parameters and integrated control



Commissioning setup

The RS485 interface serves as an interface for parameterization and diagnosis. It can be operated using the freely available “Kickstart” PC software. This requires a PC and the ebmpapst USB-CAN-RS485 adapter. Load your detailed operating manual and the PC software “Kickstart” under www.ebmpapst.com.



Interface adapter for “Kickstart” PC software	Order no.
USB-CAN-RS485 adapter	914 0000 400

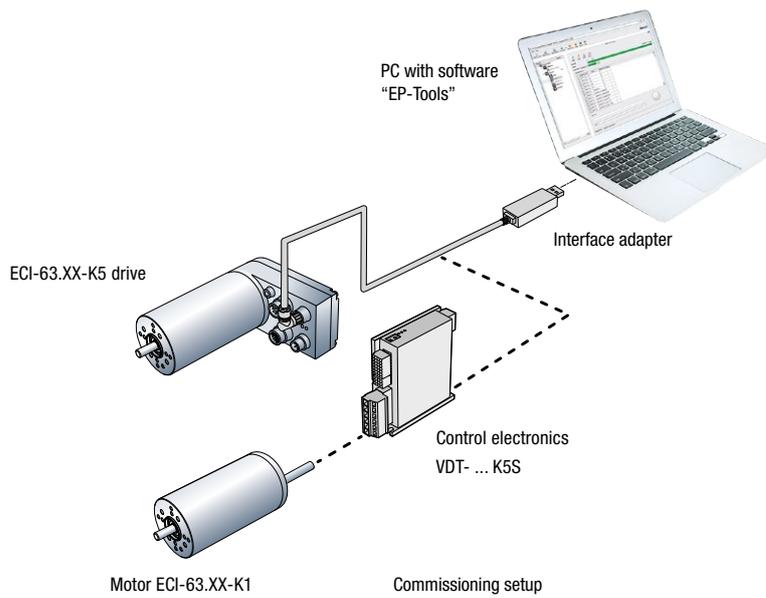
Functional description of the LED displays

LED name	Color	Function assignment
Data	red	No assignment.
	green	Active data transfer via the USB-CAN-RS485 adapter.
Error	red	No response following request to K4. Receipt of a faulty data package.
	green	Received data is OK.
microSD	red	No assignment.
	green	Access to the memory card.

Commissioning tools.

K5

Parameterization and commissioning



Commissioning tool for "EP-Tools" PC software

Order no.

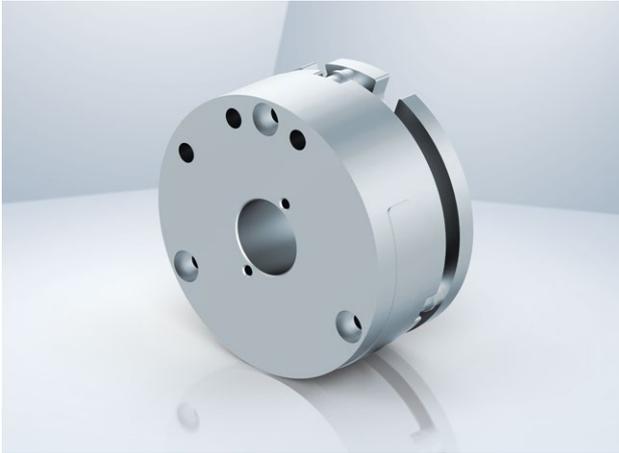
USB to CANStick

914 0000 401

Functional description of the LED displays

LED name	Color	Display	Function assignment
LED0 "Power"	green	lights up	Normal operation
		does not light up	No power supply
		flashes	Bootloader mode (no firmware)
LED1 "State"	yellow	does not light up	Normal operation
		flashes	Bootloader mode (flashes with incoming message)
LED2 "Error"	red	lights up	Error
		does not light up	No error (normal operation)
LED3 "Rx"	green	flashes	Flashes with incoming message
		does not light up	No incoming message
LED4 "Tx"	yellow	flashes	Flashes with outgoing message
		does not light up	No outgoing message

Brakes.



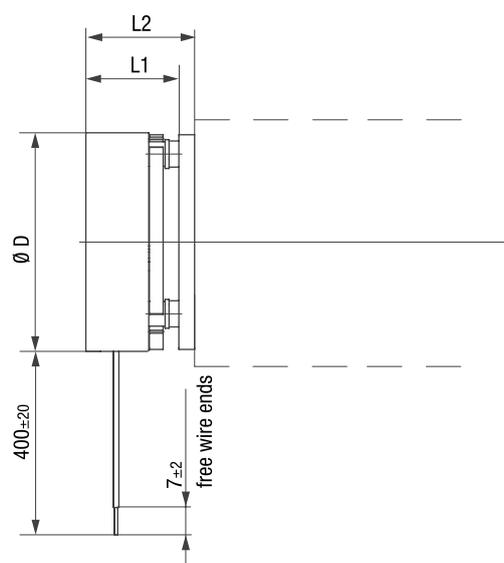
- Spring-applied brake
- Single-disk brakes with 2 friction contact surfaces
- Braking torque effective in powerless state
- Braking force is eliminated by electromagnetic force
- Holding brake with emergency stop function
- Currentless-operated brake with high power density
- Braking torque applied by spring force
- Reduced inertia for optimum dynamics

Brake system				
		external BFK 457-01 for ECI 42	external BFK 457-03 for ECI 63	integrated Brake module ECI 63-K4
Nominal voltage	V DC	24	24	24
Nominal power	W	5.00	9.00	10.00
Braking torque	Nm	0.12	1.00	1.00
Engagement time	ms	11.0	12.5	20.0
Disengagement time	ms	17.0	18.0	35.0
Subject to alterations				
Preferred type: ready to ship in 48 hours				

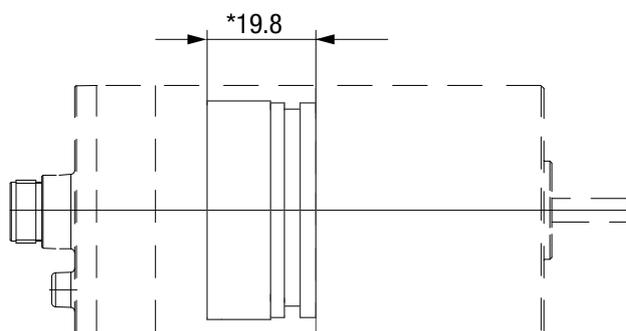
Technical drawing / external

All dimensions in mm

Brake mounted



Brake integrated



Brake type	Ø D	L1	L2
BFK 457-01 (ECI-42.XX)	37	31.3	35.3
BFK 457-03 (ECI-63.XX)	56	27.7	37.3

* Installing the brake module extends the length of the drive housing by 20 mm

Electrical connection

Connection cable

Color	Function
red	Power supply
black	GND

Optical encoder systems.

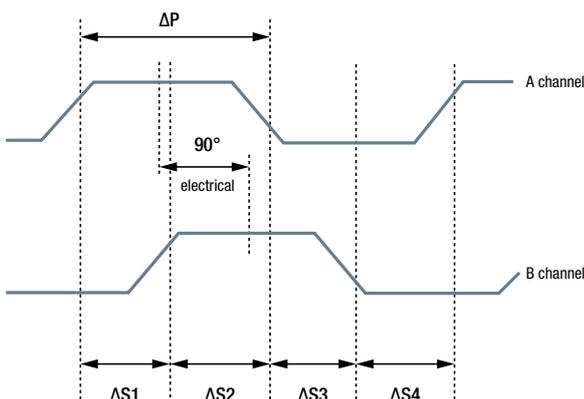


- Opto-electronic 2- and 3-channel incremental encoder.
- A corresponding evaluation in an external controller will achieve a resolution of max. 2048 increments per revolution
- The encoder is contactor-less and wear-free. The rotary angle resolution is achieved by means of an LED, a metallic encoder disk and a photo-diode array
- Electrical protection IP 40
- Temperature range -40°C to +100°C
- Additional resolutions and interfaces possible

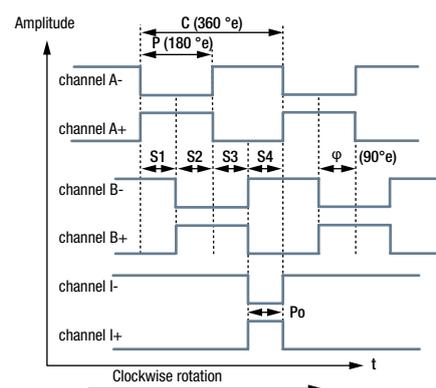
Important! Do not use in applications in which failure of the encoder interferes with the safety-relevant functions. If in doubt, consult the manufacturer.

Encoder systems		HEDS 5500	PWB AE30
No. of pulses Z		512 per revolution (channel A and B)	512 per revolution (channel A and B)
Output signal A, B		2 rectangular signals (90° phase offset; TTL-compatible)	3 rectangular signals, channel A, B (90° phase offset) and index
Reaction frequency [f]		100 kHz	100 kHz
Supply voltage [U _p]	V	+ 5 ± 10%	+ 5 ± 10%
Power consumption [I _p]	mA	type 17 max. 40	max. 110 mA
Deviation, pulse width [Δ _s]		type 5° (from electrical 90°)	type 5° (from electrical 90°)
Deviation, phase shift [Δ _p]		type 7° (between channel A and B from electrical 90°)	max. ± 20°
Index pulse width		-	90° ± 30° elec.
Electrical connection		AMP: 103686-4 or 600442-5	Molex 53048-0810
Connector type		Berg: 65039-032 with 4825X-000 terminals or 65801-034 Molex: 2695 with 2759 terminals	Molex: 51021-0800 with contact 50079-8000
Weight	kg	0.02	0.02
Subject to alterations			
Preferred type: ready to ship in 48 hours			

Signal processing HEDS 5500

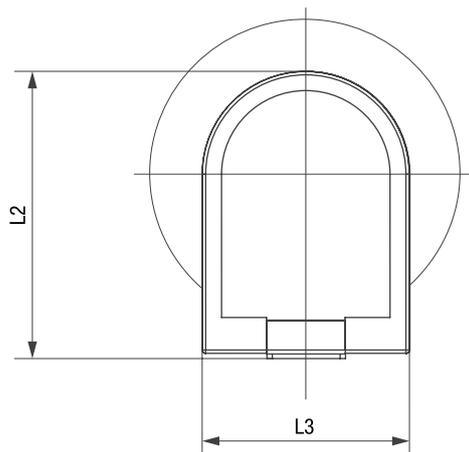
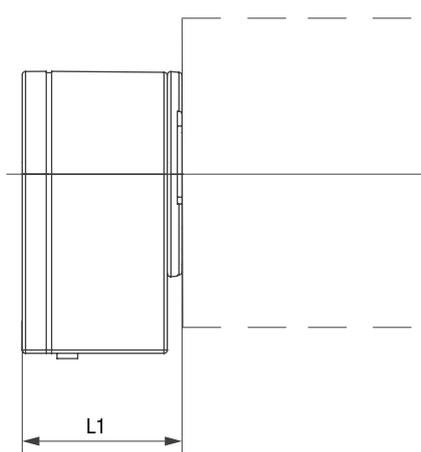


Signal processing PWB AE30



Technical drawing

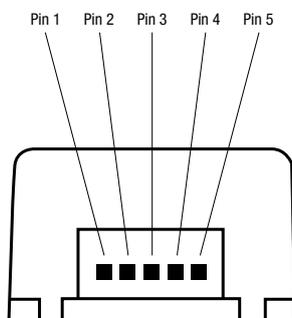
All dimensions in mm



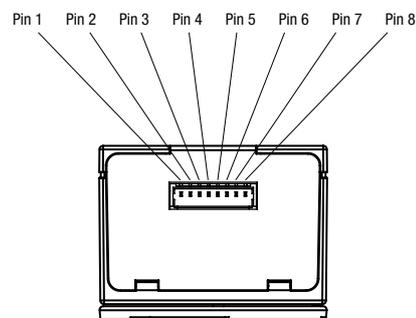
Encoder	L1	L2	L3
HEDS	18.3	41.1	30.0
PWM	23.9	42.5	31.0

Electrical connection

HEDS 5500



PWB AE30



Signal wire

Pin	Function
1	GND
2	n.c.
3	A
4	U_B
5	B

Signal wire

Pin	Function
1	GND
2	A-
3	A+
4	B-
5	B+
6	I-
7	I+
8	Vcc

Standards and guidelines.

Basic information on standards and guidelines for electrical small-power motors and drive systems operated with a DC voltage of max. 75 V DC (nominal voltage):

The ECI series described in this catalog are direct current motors in an electronically commutated design, which are designed and specified for a nominal voltage of max. 75 V DC. Thus the supply voltage of these drives is within the range of safety extra-low voltage (SELV). On this basis, ebm-papst would like to provide some information intended to help you understand the classification of the motors from the relevant EC Directives and the resulting consequences.

The CE label

In order to ensure a uniform safety level in the European internal market, the European commission has implemented a new approach for technical harmonization. This has been welcomed by all relevant parties and is visible in many products as a CE label giving proof of agreement with the harmonized provisions.



What does CE actually mean? Why don't all products bear the CE label?

CE is the abbreviation for "Communauté Européenne". The harmonized statutory provisions are a framework directive and belong to the so-called New Approach. This framework directive defines the basic requirements, putting in circulation and operation as well as the applicable conformity assessment process. The manufacturer of a product must now decide which framework directive applies to which product. For electrical small-powered motors the following framework directive can be applied:

- 1) Machinery Directive 2006/42/EC
- 2) Low Voltage Directive 2014/35/EU
- 3) EMC Directive 2014/30/EU

Based on these directives, ebm-papst St. Georgen GmbH & Co. KG does not mark the electric motors and drive systems described with the "CE" mark and does not issue an EC Declaration of Conformity. The reason for this is consideration of the relevant EC Directives and the definitions of the terms used, "Electric motor" and "Drive system", by ebm-papst St. Georgen GmbH & Co. KG.

Definition of the electric motor

An electric motor is a motor without electronics or a motor with integrated electronics of low complexity, such as commutation sensors, simple commutation electronics or commutation electronics with simple speed control with a voltage range of <75 V DC (nominal voltage) for use by customers who incorporate them into end devices.

According to this definition, electric motors include, for example, the ECI-XX.XX-K1 series.

Definition of drive systems

Drive systems are motors with built-in electronic control systems that have a certain degree of complexity. These include electronic control systems which, in addition to a speed control, offer other functions such as current control or position control. This also includes electronic control systems which, for example, have a CANopen interface or that can be operated via programmable sequential controls. For these drive systems, the voltage range of <75 V DC (nominal voltage) and the intended use by customers who will use the systems in end devices also apply. Drive systems include the ECI-XX.XX-K3, ECI-XX.XX-K4 and ECI-XX.XX-K5 series, for example.

Reasons according to the Machinery Directive 2006/42/EC

Electric motors are expressly exempt in Art. 1, Par. (2), lit. k) and thus are NOT given the CE mark.

According to the definition of the term in Art. 2, lit. g), a drive system is an "incomplete machine" and thus does not receive a CE mark, but falls under the process for incomplete machines according to Art. 13. Installation instructions to Annex IV and a Declaration of Incorporation to Annex II, Part 1, Section B are available for each drive system. The specific technical documents to Art. 13, Par. (1), lit. a) have been created in-house and are archived for the government agencies of the individual countries.

Based on this directive, the machine manufacturer is responsible for verifying and ensuring compliance with the basic requirements of the Machinery Directive.

Reasons according to the Low Voltage Directive 2014/35/EU

Due to the voltage ranges (nominal voltage), the specified electric motors and drive systems do not fall under the application area of the low voltage directive according to Art. 1.

Reasons according to the EMC Directive 2014/30/EU

Because they are sold exclusively to customers who incorporate them into end devices and not to the end user, the specified electric motors and drive systems do not fall under the application area of the EMC directive according to the definition of the term in Art. 3, Par. (2), 1: As the small motors are supplied to companies who incorporate them into end devices and not to the end user, ebm-papst has no control over further use of the pre-fabricated components in devices, machines or installations. Therefore, ebm-papst provides express notice that the system manufacturer must provide a suitable EMC circuit when selecting the power supply and must provide for EMC-compliant installation and use in the devices. For more information about EMC-compliant installation and EMC safety measures, refer to resources such as the IEC 61000-5-x series (Installation and Mitigation Guidelines).

Proper use

All drives in this catalog are determined for installation in permanently connected, stationary end devices and machines in the industrial area and must be operated on electricity only when in installed condition! Operation is prohibited until it has been ascertained that this product, along with the machine into which this product is to be installed, complies with the protective requirements of the Machinery Directive. If, when using our drives, market or application-specific product standards apply, compliance with these must be verified and ensured by the device manufacturer. This product is not intended for the end consumer.

RoHS **European Directive EC No. 2011/65/EU (RoHS)** **Legally regulated substances**

As an innovative company and trendsetter in the world of air technology and drive engineering, ebm-papst feels a special obligation towards the environment. Accordingly, under the GreenTech logo, we have implemented a comprehensive concept that extends from the origin to the use of our products. This includes, of course, protecting our environment and using natural resources in a way that conserves them. This applies equally to our manufacturing processes and to our products.

When developing our products, we already take into consideration any possible negative consequences they may have for the environment.

Our goal is to prevent such environmental impact-even beyond the extent mandated by law-or to reduce it to a minimum, and thus to ensure sustainable development of our products. Thus we ensure that our products are free of materials and substances that are prohibited by law.

Of course, all current products have been designed for conformity with European Directive 2011/65/EU (RoHS). All older products that do not yet conform to these directives or parts thereof will be consistently redesigned. Our suppliers are required to provide us only with goods that conform to the directives. Thus we can confirm that basically, all of our products listed in this catalog conform to the above-mentioned directive. We are also available to help with any other questions you may have on both these topics.

REACH Directive (EC No. 1907/2006)

The EU legal regulation for Registration, Evaluation, Authorization and Restriction of Chemical substances (REACH) entered into force on 1 June 2007. This is a chemicals law intended to provide maximum protection to health and the environment. As defined by the REACH directive, ebm-papst is a downstream user. The units you purchase from us are products as defined by REACH and thus do not require registration. However, in our own interest and to ensure a high degree of product safety, we track the implementation of REACH and the resulting requirements as part of our duty to provide information. To comply with the requirements of REACH, we are in contact with all suppliers from whom we obtain chemicals (substances), preparations and components that we use as part of our production process. Within this framework, ebm-papst fulfills the obligations set forth in the REACH regulation. If you have any other questions about the implementation of the REACH directive in our company, please do not hesitate to contact us.

Operating factor, lifetime, efficiency.

Operating factor c_b

To achieve a uniform lifetime for the gearheads and motors, the necessary torques M must be increased by the respective operating factor c_b under the various operating loads so as not to exceed the maximum permissible gearhead torque $M_{2,max}$ (see table below).

Operating modes									
	Load			Operating period in h/days					
	even	gradual	sudden	3 h	8 h	24 h	3 h	8 h	24 h
				up to 10 switching ops./h			over 10 switching ops./h		
One rotation direction	•			1.00	1.00	1.20	1.00	1.20	1.52
Rotation direction change	•			1.00	1.30	1.59	1.20	1.59	1.92
One rotation direction		•		1.11	1.30	1.59	1.30	1.52	1.82
Rotation direction change		•		1.41	1.72	2.00	1.59	1.89	2.33
One rotation direction			•	1.20	1.52	1.82	1.52	1.82	2.22
Rotation direction change			•	1.59	2.00	2.33	2.00	2.33	2.86

Operating mode

It is necessary to define the operating mode under which a gear motor can be operated with certain nominal values in order to avoid overloading the motor and/or the gearhead. The values stated in this catalog refer to S1 operation (continuous operation). This means that the gear motor can be constantly operated with the stated values, but can also have a higher load placed on it for a short time. Please contact us if you require more information about this.

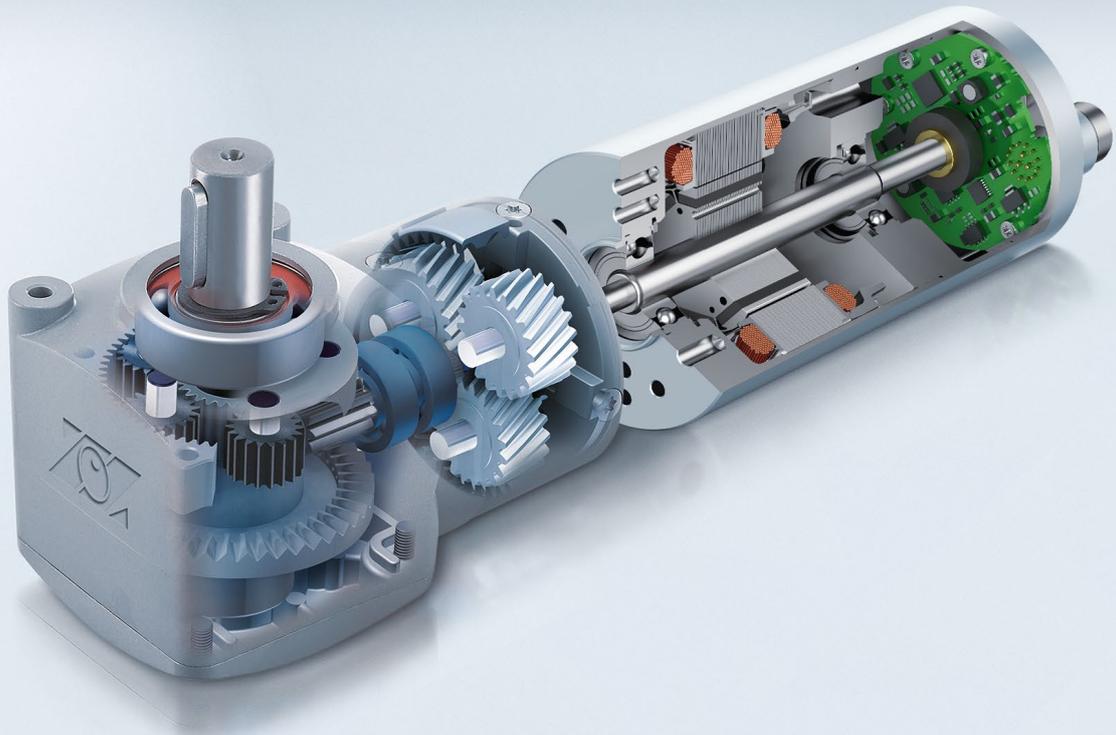
Lifetime

Lifetime is limited by the various components in the drive. If frequently overloaded, the gearhead components are subjected to more wear than under nominal load. Extreme ambient and operating conditions cause a reduction in the lifetime guaranteed for operation under operating ratio $c_b = 1$.

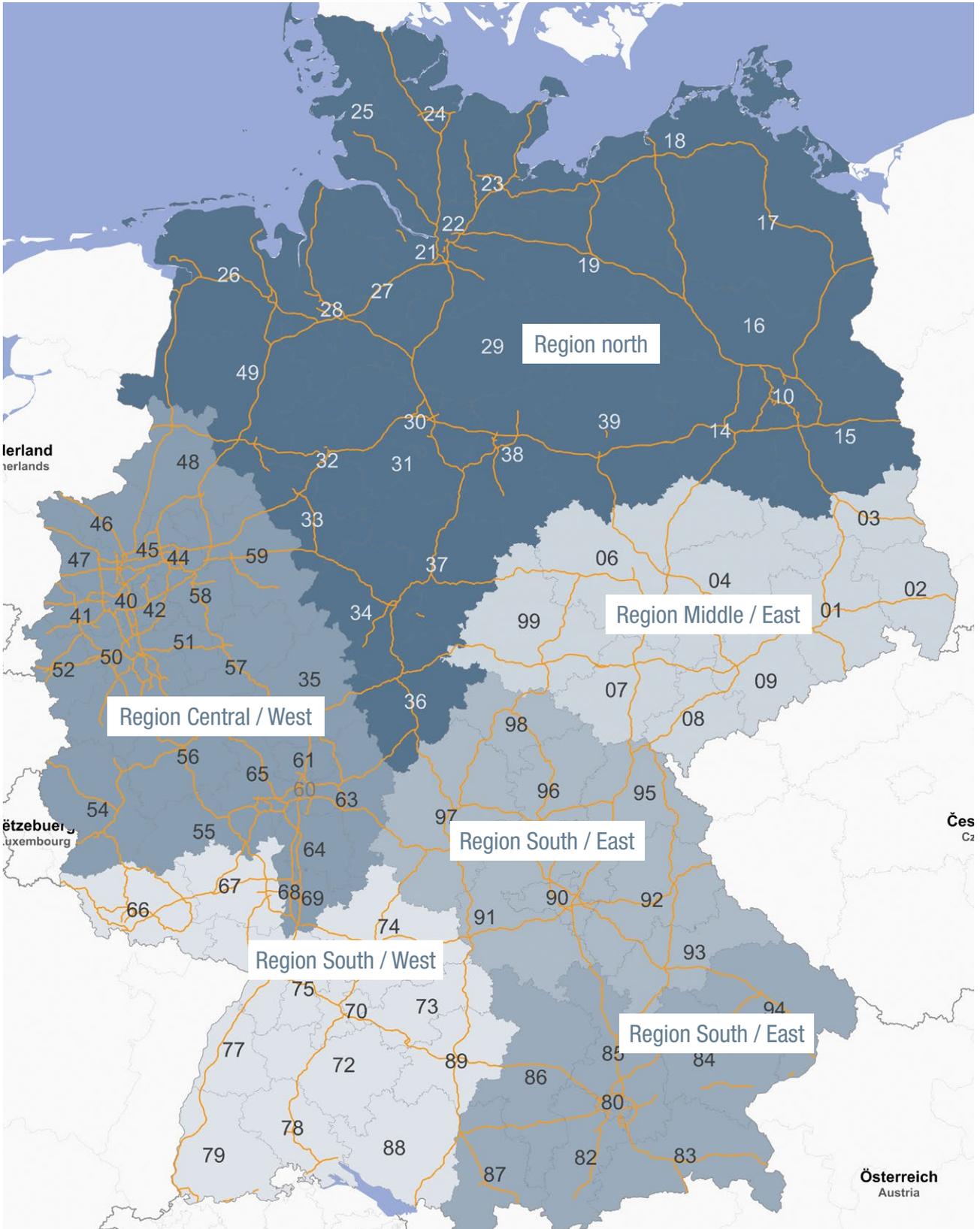
Efficiency η (eta)

The efficiency per gear stage is at least 90%. Depending on the tooth configuration and on the manufacturing quality, far better levels of efficiency can also be achieved. The following overall efficiencies were obtained for multi-stage gearheads:

Overall efficiency	
for 1-stage gearhead	$\eta = 0.9$
for 2-stage gearhead	$\eta = 0.9^2 = 0.81$
for 3-stage gearhead	$\eta = 0.9^3 = 0.73$
for 4-stage gearhead	$\eta = 0.9^4 = 0.66$
for 5-stage gearhead	$\eta = 0.9^5 = 0.59$



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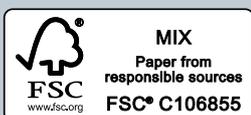
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