maxon DC motor – Comments regarding motor data (pages 37-84)

Line 1 **Assigned power rating** P_{2T} [W]

● This figure represents the maximum power output when operating within the recommended output power range. It is dependent on motor type and can be correlated with the presentation in our Selection Guide (Please refer also to pages 37-81 under «Operating Ranges»).

Line 2 **Nominal voltage** U [V]

All nominal values refer to operation at this voltage. It was chosen such as not to exceed the maximum recommended speed in no load condition. Motor application is of course not limited to this voltage. To reach the assigned power rating (Line 1) higher operating voltages are permissible. Maximum power output (Line 12) will increase respectively, (see also page 30 «Important considerations» - bottom of right hand side).

Line 3 **No load speed** n_o [rpm]

This is the speed at which the motor turns at nominal voltage and without load. For practical purposes, this speed is proportional to the voltage applied.

Line 4 **Stall torque** M_H [mNm]

This is the torque produced by the motor in a standstill condition, also called starting torque. The rapidly rising rotor temperature leads to a corresponding decrease in stall torque (see also «Technology – short and to the point»).

Line 5 **Speed/torque gradient** $\Delta n/\Delta M$ [rpm/mNm]

This gradient says a lot about the power capability of a motor. The flatter the gradient, the less speed variation is experienced during load variations.
The speed/torque gradient is calculated at 25°C winding temperature.

Line 6 **No load current** I_o [mA]

This is the current the unloaded motor draws. It depends on brush and bearing friction and varies slighty with varying speed.

Line 7 **Starting current** I_A [mA], [A]

❍ is the quotient «Voltage at terminals/DC-resistance» and is proportional to stall torque.

Line 8 **Terminal resistance** R [Ohm]

is the resistance at the terminals at 25°C and determines the starting current at a given voltage.
In the case of graphite brushes it must be noted that contact resistance varies depending on the load.

Line 9 **Maximum permissible speed** n_{max} [rpm]

This speed should not be exceeded during normal operation. Commutation problems may be expected at higher speeds, in turn, this could lead to premature motor failure.

Line 10 **Maximum continuous current** $I_{permiss.}$ [mA],[A]

Operating the motor continuously at this current level and at 25°C ambient will cause the winding to ultimately reach the specified max. winding temperature. This assumes no heat sinking. Depending how the motor is mounted, this value can be increased substantially.

Line 11 **Max. continuous torque** M_{perm} [mNm]

is the torque that can be supplied continuously or on an average, thereby heating up the winding to the maximum permissible temperature; based on an ambient temperature of 25°C.

Line 12 **Maximum power output** P_{max} [mW], [W]

is the theoretical maximum output at 25°C rotor temperature. Permissible limits are frequently below this level (see max. continuous current and max. permissible speed).

Line 13 **Maximum efficiency** η_{max} [%]

Efficiency is derived from the relationship between no load and starting current.

The higher the efficiency, the nearer to no load speed the operating point will be. Maximum efficiency is usually at approximately $^1/_7$th of stall torque.
Operating at this point is not necessarily synonymous to operating at the motor's optimum load point.

Line 14 **Torque constant** k_M [mNm/A]

This may also be referred to as «specific torque» and represents the quotient from generated torque and applicable current.

Line 15 **Speed constant** k_n [rpm/V]

shows the specific speed per volt of applied voltage, disregarding any frictional losses. The reciprocal of the speed constant is known as the voltage constant or back-EMF constant.

Line 16 **Mechanical time constant** τ_m [ms]

is the time required by the rotor to accelerate from standstill to 63% of its no load speed. In 4τ the rotor will have reached more than 99% of no load speed.

Line 17 **Moment of inertia** J_R [gcm^2]

is the polar mass moment of inertia of the rotor.

Line 18 **Terminal inductance** L [mH]

is the winding inductance when stationary and measured at 1 kHz, sinusoidal.

Line 19 **Thermal resistance** R_{th2} [K/W]

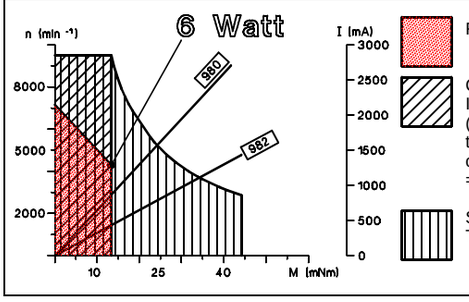
from housing to ambient air. Characteristic value of thermal contact resistance without additional heat sinking. The sum of lines 19 and 20 define the max. admissible power loss. Heat sinking may substantially reduce this value.

Line 20 **Thermal resistance** R_{th1} [K/W]

from rotor to housing.

Operating Ranges

Comments (Example from page 59)

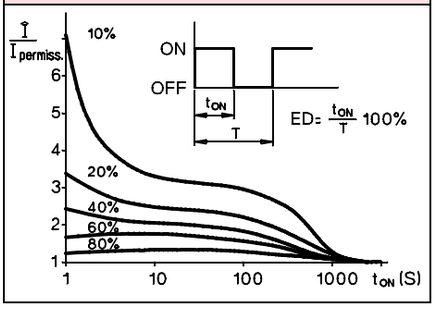


Recommended operating range

Continuous operation
In observation of above listed thermal resistances (lines 19 and 20) the maximum permissible rotor temperature will be reached during continuous operation at 25°C ambient.
= Thermal limit

Short term operation
The motor may be briefly overloaded (recurring).

Short Term Operation



Speed (n), torque (M), current (I):
The outer edges of the values depicted represent limits for continuous and short term motor operation. Values listed in the tables (lines 3, 4, 6, 7, 12 and 13) are valid for operation at nominal voltage (line 2). These are therefore values which are only reached when operating the motor at higher voltages.

● Assigned Power Rating P_{2T} (W) (Line 1)

❍ Starting current I_A at nominal voltage (Line 7) as well as related stall torque

M_H (mNm) (Line 4) $I_A = \frac{U}{R} \cdot 10^3$ (mA)

980 Winding Number with related current curve. Low resistance winding (Ref. line 8)

982 Winding Number with related current curve. High resistance winding (Ref. line 8)

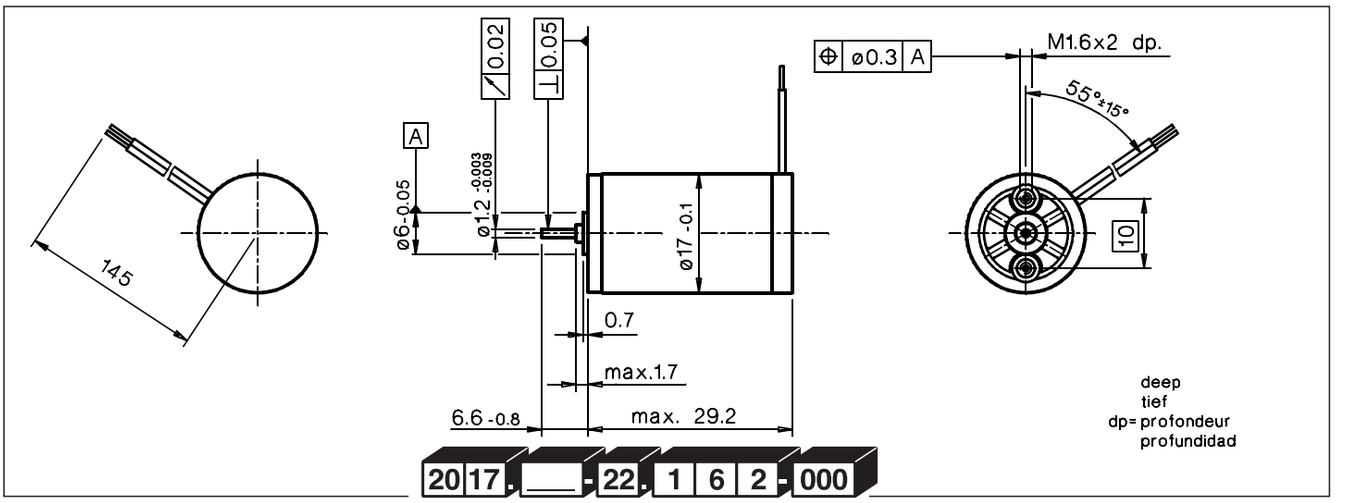
ON Motor in operation
OFF Motor inoperative
Î max. peak current
$I_{permiss.}$ max. permissible continuous current Line 10
t_{ON} ON time
T cycle time $t_{ON} + t_{OFF}$
DCy Duty Cycle in percent of the Cycle Time T. The motor may be overloaded by the relationship $\hat{I}/I_{permiss.}$ during X% of the total Cycle Time.

CLL1.5 Watt

CE approved

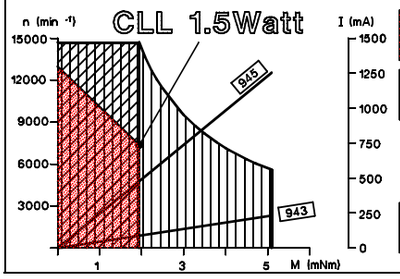
A-Motor 20 17 . . . .

Precious Metal Brushes



Motor Data	Winding Number (Order Number)	930	931	932	933	934	945	935	936	937	938	939	940	941	942	943
1	Assigned power rating W	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
2	Nominal voltage Volt	2.00	2.40	2.40	3.60	3.6	4.50	6.00	7.20	9.00	12.00	12.00	15.00	18.00	24.00	30.00
3	No load speed rpm	12400	12900	11300	13700	11200	10400	13400	13300	13400	14800	11800	12000	11200	11300	12800
4	Stall torque mNm	4.95	4.86	4.00	4.82	3.73	3.74	4.99	4.82	4.81	5.21	4.12	4.06	3.84	3.83	4.03
5	Speed/torque gradient rpm/mNm	2550	2690	2880	2890	3050	2830	2720	2800	2840	2880	2910	3010	2980	3020	3250
6	No load current mA	48.0	42.4	34.4	31.3	22.4	16.0	18.0	14.9	12.1	10.6	7.34	6.06	4.52	3.45	3.38
7	Starting current mA	3270	2770	2010	1950	1230	920	1180	946	765	681	431	347	255	193	184
8	Terminal resistance Ohm	0.611	0.865	1.19	1.85	2.92	4.89	5.08	7.61	11.8	17.6	27.8	43.3	70.6	124	163
9	Max. permissible speed rpm	14700	14700	14700	14700	14700	14700	14700	14700	14700	14700	14700	14700	14700	14700	14700
10	Max. continuous current mA	500	500	500	500	500	486	477	390	313	256	204	163	128	96.4	84.1
11	Max. continuous torque mNm	0.76	0.88	1.00	1.24	1.52	1.97	2.01	1.99	1.97	1.96	1.95	1.91	1.93	1.91	1.84
12	Max. power output at nominal voltage mW	1600	1630	1180	1720	1080	1010	1740	1670	1680	2000	1260	1270	1120	1130	1340
13	Max. efficiency %	78.0	77.6	76.4	77.1	75.7	76.1	77.6	77.3	77.2	77.4	76.4	76.1	76.0	75.9	75.6
14	Torque constant mNm/A	1.51	1.75	1.99	2.47	3.03	4.06	4.22	5.10	6.29	7.65	9.56	11.7	15.1	19.8	21.9
15	Speed constant rpm/V	6310	5450	4800	3870	3160	2350	2260	1870	1520	1250	999	816	634	481	436
16	Mechanical time constant ms	23.7	23.3	23.2	22.9	22.9	22.5	22.4	22.4	22.4	22.4	22.4	22.6	22.5	22.5	22.8
17	Rotor inertia gcm²	0.886	0.827	0.770	0.757	0.718	0.760	0.785	0.764	0.754	0.744	0.746	0.715	0.722	0.713	0.671
18	Terminal inductance mH	0.03	0.04	0.05	0.08	0.12	0.21	0.23	0.33	0.51	0.75	1.18	1.76	2.92	5.06	6.17
19	Thermal resistance housing-ambient K/W	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
20	Thermal resistance rotor-housing K/W	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10	12.10

Operating Range



Comments

(Details on page 36)

Recommended operating range

Continuous operation
In observation of above listed thermal resistances (lines 19 and 20) the maximum permissible rotor temperature will be reached during continuous operation at 25°C ambient.
= Thermal limit.

Short term operation
The motor may be briefly overloaded (recurring).

Stock program

Standard program

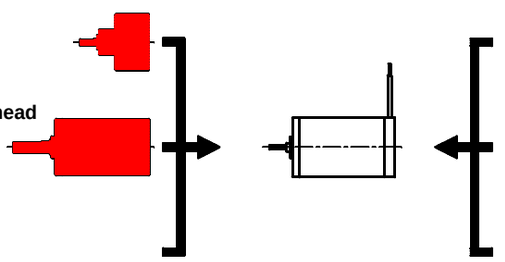
Special program (on request!)

- Axial play 0.1 - 0.2 mm
- Max. **sleeve bearing** loads
  - axial (dynamic) 0.2 N
  - radial (5 mm from flange) 0.5 N
  - Press-fit force (static) 20 N
- Radial play/**sleeve bearings** 0.014 mm
- Ambient temperature range -20/+65°C
- Max. rotor temperature +85°C
- Number of commutator segments 5
- Weight of motor 26 g
- Values listed in the table are nominal. For applicable tolerances (see page 33) and additional details please request our computer printout.
- CLL = Capacitor Long Life

maxon Modular System

Spur Gearhead
Ø16 mm
0.015 Nm
Details page 108

Planetary Gearhead
0.06-0.3Nm
Ø16 mm
page 110/111



maxon gear – Important considerations

When selecting a gear-motor, please keep the following suggestions in mind: Reduce the motor speed by dividing by the reduction ratio. Increase the motor torque by multiplying times gearhead ratio times gearhead efficiency. The maximum efficiency is stated in the table. It is dependent on the number of stages and is measured at maximum continuous torque and nominal speed. The efficiency is reduced for lower torque requirements. This must be taken into consideration when selecting a gear-motor.
To keep noise and gearhead wear low it is advisable not to exceed the max. recommended input speed. Also, the permissible output torque must be observed with a clear distinction between short-term and continuous operation. We will gladly assist you with any gearmotor problem you might have.

Important:

- Primary consideration should be given speed and torque at the output shaft when determining a gear-motor combination.
- An extensive adaption to desired output requirements is achieved by taking advantage of the various windings available with maxon motors as well as the wide selection of gear reduction ratios.
- The recommended maximum gearhead input speed should, if possible, not be exceeded (see gearhead pages, «Technical Data»).
- When ordering a gearhead, state maxon motor or give details of the mounting.
- You will find spur and planetary gearheads on page 104 up to 134 sorted by diameter.

Spur gearheads:

Output torques up to 0.6 Nm. Reduction ratios from 4:1 to 3000:1. One or several stages. Each pair of gear wheels represents one stage, whereas the first gear wheel (pinion) is mounted on the motor shaft. Normally, gearhead output shaft bearings are the sinter sleeve type.

Planetary gearheads:

Output torques up to 180 Nm. Reduction ratios from 4:1 to 6285:1. Planetary gearheads are particularly suitable for the transmission of high torque. Gearheads 22 mm in diameter and larger are equipped with ball bearings.

Sequence of steps in determining the components of a gearmotor combination:

1. Power requirement estimate

$$P_L = M \cdot \omega = M_L \cdot \frac{\pi}{30} \cdot n_L$$

2. Gearhead selection
Choose the one gearhead from the gearhead pages that just meets the application's torque requirements.

3. Determination of the theoretical reduction ratio:

$$i_{theor} = \frac{n_{Gear\ permiss}}{n_L}$$

4. Determination of motor speed
based on the nearest available gearhead reduction ratio.

$$n_{Mot} = i \cdot n_L$$

5. Gearhead efficiency

$$\eta_{Gear} = (\eta_{Stage})^s = \eta_1 \cdot \eta_2 \cdot \eta_3 \cdot \ldots$$

6. Calculation of necessary motor torque

$$M_{Mot} = \frac{M_L\ [Nm] \cdot 1000}{i \cdot \eta_{Gear}} = [mNm]$$

7. Choice of motor type
The gearhead data pages indicate the motor types compatible with the chosen gearhead. Choose a type that meets power requirements and other prerequisites such as dimensions, tacho option, etc.

8. Motor choice, a cursory assessment

$$n_{Mot} < n_{limit}$$
$$M_{Mot} < M_{permiss}$$

9. Choice of winding number
a) Determination of the motor's no load speed

$$n_i = n_{Mot} + \left(\frac{\Delta n}{\Delta M} \cdot M_{Mot} \right)$$

b) Calculation of theoretical speed constant

$$k_{ni} = \frac{n_i}{U}$$

c) Effective speed constant
The speed constant of the motor selected under item 7 can be obtained from line 15 of the motor data sheet.

d) Choice of winding

$$k_{ni} \approx k_{nMot}$$

10. Verification of calculated values
Compare gearmotor speed of the unit assembled using the components selected with the initial requirements. The procedure may need to be repeated with other motor and gearhead data, if necessary.

Definition of abbreviations:

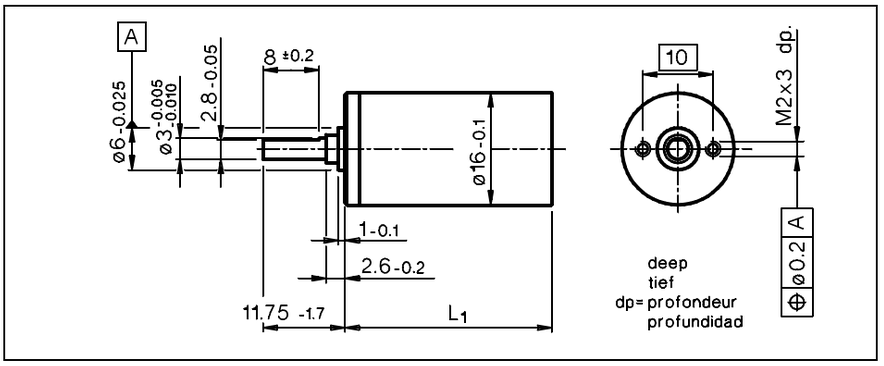
i	=	Actual gearhead reduction
i_{theor}	=	theoretical gearhead reduction
$I_{permiss}$	=	Max. permissible continuous current (Line 10) [mA]
k_M	=	Torque constant (Line 14) [mNm/A]
k_{ni}	=	Theoretical speed constant [rpm/V]
k_{nMot}	=	Actual motor speed constant (Line 15) [rpm/V]
M_L	=	Output torque [Nm]
M_{Mot}	=	Motor torque [mNm]
$M_{permiss}$	=	Max. permissible continuous torque (Line 11) [mNm]
	=	$k_M \cdot I_{permiss}/1000$
$n_{Gear\ perm}$	=	Recommended input speed [rpm]
n_i	=	Theoretical no load speed [rpm]
nL	=	Output speed under load [rpm]
n_{limit}	=	Max. permissible speed [rpm] (Line 9)
n_{Mot}	=	Motor speed [rpm]
P_L	=	Output power [W]
s	=	Number of gearhead stages
U	=	Available voltage [V]
U_N	=	Nominal voltage (Line 2) [V]
$\Delta n / \Delta M$	=	Speed/torque gradient (Line 5) [rpm/mNm]
η_{gear}	=	Gearhead efficiency
η_{stage}	=	Efficiency per gearhead stage

Note: Line .... references above pertain to motor data pages.

Planetary Gearhead

∅16 mm, 0.1-0.3 Nm

METAL *VERSION*
Plastic version see page 111



Technical Data

Planetary gearhead	straight teeth
Bearing at output	sleeve bearing
Radial play, 6 mm from flange	max. 0.06 mm
Axial play	0.02 - 0.10 mm
Max. perm. radial load, 6 mm from flange	36 N
Max. perm. axial load	8 N
Max. permissible force for press fits	100 N
Average backlash no load per stage	< 1°
Recommended input speed	< 6000 rpm
Recommended temperature range	-15/+65°C

* Option ball bearings

Order Number	Reduction	Reduction absolute	Order Number	Reduction	Reduction absolute	Order Number	Reduction	Reduction absolute	No. of stages	max. Torque Continuous [Nm]	max. Torque Intermittent [Nm]	Sense of direction	η max. [%]	Weight [g]	L1 max. [mm]	L2 max. [mm]	L3 max. [mm]	L4 max. [mm]	L5 max. [mm]	L6 max. [mm]	L7 max. [mm]	L8 max. [mm]
110321	4.4 : 1	$4^{5}/_{13}$	**118184**	5.4 : 1	$5^{2}/_{5}$				1	0.10	0.150	=	90	20	15.55	53.65	44.75	38.05	56.00	63.60	59.00	66.60
110322	19 : 1	$19^{38}/_{169}$	**134777**	24 : 1	$23^{44}/_{65}$	**118185**	29 : 1	$29^{4}/_{25}$	2	0.15	0.225	=	81	23	19.15	57.25	48.35	41.65	59.60	67.20	62.60	70.20
110323	84 : 1	$84^{645}/_{2197}$	**134778**	104 : 1	$103^{688}/_{845}$	**134779**	128 : 1	$127^{278}/_{325}$	3	0.20	0.300	=	73	27	22.75	60.85	51.95	45.25	63.20	70.80	66.20	73.80
118186	157 : 1	$157^{58}/_{125}$							3	0.20	0.300	=	73	27	22.75	60.85	51.95	45.25	63.20	70.80	66.20	73.80
110324	370 : 1	$369^{47}/_{79}$	**134780**	455 : 1	$455^{693}/_{3739}$	**134781**	561 : 1	$560^{2521}/_{4225}$	4	0.25	0.375	=	65	31	26.35	64.45	55.55	48.85	66.80	74.40	69.80	77.40
134782	690 : 1	$690^{681}/_{1625}$	**118187**	850 :1	$850^{191}/_{625}$				4	0.25	0.375	=	65	31	26.35	64.45	55.55	48.85	66.80	74.40	69.80	77.40
110325	1621 : 1	$1620^{3469}/_{6525}$	**134783**	1996 : 1	$1995^{6008}/_{7393}$	**134784**	2458 : 1	$2458^{8}/_{9349}$	5	0.30	0.450	=	59	35	29.95	68.05	59.15	52.45	70.40	78.00	73.40	81.00
134785	3027 : 1	$3027^{1493}/_{6722}$	**134786**	3728 : 1	$3728^{2137}/_{8125}$	**118188**	4592 : 1	$4591^{2032}/_{3125}$	5	0.30	0.450	=	59	35	29.95	68.05	59.15	52.45	70.40	78.00	73.40	81.00

Stock program Standard program Special program (on request!)

+ Motor Order Number

25 15 . ... - 6_ . 1 1 1 - 0 0 0
Basic motor **2515....-11.111-000**
Details see page 65

20 17 . ... - 6_ . 1 6 2 - 0 0 0
Basic motor **2017....-22.162-000**
Details see page 66

maxon DC motor RE ∅15 mm Metal Brushes CLL
1.6 Watt, sleeve bearings, 1 shaft
Details see page 47

maxon DC motor RE ∅16 mm Metal Brushes CLL
3.2 Watt, sleeve bearings, 1 shaft
Details see page 48

maxon DC motor RE ∅16 mm Metal Brushes CLL
3.2 Watt, sleeve bearings, 1 shaft
Details see page 48

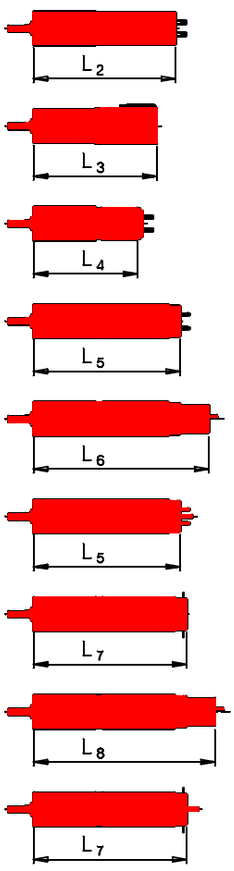
maxon DC motor RE ∅16 mm Metal Brushes CLL
3.2 Watt, sleeve bearings, 2 shafts
Details see page 48

maxon DC motor RE ∅16 mm Graphite Brushes
4.5 Watt, sleeve bearings, 1 shaft
Details see page 49

maxon DC motor RE ∅16 mm Graphite Brushes
4.5 Watt, sleeve bearings, 2 shafts
Details see page 49

maxon DC motor RE ∅16 mm Graphite Brushes
4.5 Watt, sleeve bearings, 2 shafts
Details see page 49

+ Tacho/Encoder



Digital Magnetic Encoder
∅13 mm, 16 CPT, 2 channels
Details see page 155

Digital Magnetic Encoder
∅13 mm, 16 CPT, 2 channels
Details see page 155