Engineering Data
Direct Drive TorkDrive®

Harmonic Drive AG

QUICKLINK
www.harmonicdrive.de/1090

Contents

1. General

About this documentation
This document contains safety instructions, technical data and operation rules for servo actuators and servo motors of Harmonic Drive AG.
The documentation is aimed at planners, project engineers, commissioning engineers and machine manufacturers, offering support during selection and calculation of the servo actuators, servo motors and accessories.

Rules for storage
Please keep this document for the entire life of the product, up to its disposal. Please hand over the documentation when re-selling the product.

Additional documentation
For the configuration of drive systems using the products of Harmonic Drive AG, you may require additional documents. Documentation is provided for all products offered by Harmonic Drive AG and can be found in pdf format on the website.

www.harmonicdrive.de

Third-party systems
Documentation for parts supplied by third party suppliers, associated with Harmonic Drive® components, is not included in our standard documentation and should be requested directly from the manufacturers.

Before commissioning servo actuators and servo motors from Harmonic Drive AG with servo drives, we advise you to obtain the relevant documents for each device.

Your feedback
Your experiences are important to us. Please send suggestions and comments about the products and documentation to:

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E-Mail: info@harmonicdrive.de

1.1 Description of Safety Alert Symbols

Symbol	Meaning
DANGER	Indicates an imminent hazardous situation. If this is not avoided, death or serious injury could occur.
WARNING	Indicates a possible hazard. Care should be taken or death or serious injury may result.
ATTENTION	Indicates a possible hazard. Care should be taken or slight or minor injury may result.
ADVICE	Describes a possibly harmful situation. Care should be taken to avoid damage to the system and surroundings.
INFORMATION	This is not a safety symbol. This symbol indicates important information.
	Warning of a general hazard. The type of hazard is determined by the specific warning text.
	Warning of dangerous electrical voltage and its effects.
	Beware of hot surfaces.
	Beware of suspended loads.
	Precautions when handling electrostatic sensitive components.

1.2 Disclaimer and Copyright

2. Safety and Installation Instructions

Please take note of the information and instructions in this document. Specialy designed models may differ in technical detail. If in doubt, we strong recommend that you contact the manufacturer, giving the type designation and serial number for clarification.

2.1 Hazards

⚠ DANGER

Electric servo actuators and motors have dangerous live and rotating parts. All work during connection, operation, repair and disposal must be carried out by qualified personnel as described in the standards EN50110-1 and IEC 60364! Before starting any work, and especially before opening covers, the actuator must be properly isolated. In addition to the main circuits, the user also has to pay attention to any auxilliary circuits.

Observing the five safety rules:

- Disconnect mains
- Prevent reconnection
- Test for absence of harmful voltages
- Ground and short circuit
- Cover or close off nearby live parts

The measures taken above must only be withdrawn when the work has been completed and the device is fully assembled. Improper handling can cause damage to persons and property. The respective national, local and factory specific regulations must be adhered to.

⚠ ATTENTION

The surface temperature of gears, motors and actuators can exceed 55 degrees Celsius. The hot surfaces should not be touched.

ADVICE

Cables must not come into direct contact with hot surfaces.

DANGER

Electric, magnetic and electromagnetic fields are dangerous, in particular for persons with pacemakers, implants or similiar. Vulnerable groups must not be in the immediate vicinity of the products themselves.

DANGER

Built-in holding brakes alone are not functional safe. Particularly with unsupported vertical axes, the functional safety and security can only be achieved with additional, external mechanical brakes.

WARNING

The successful and safe operation of gears, servo actuators and motors requires proper transport, storage and assembly as well as correct operation and maintenance.

ADVICE

Use suitable lifting equipment to move and lift gears, servo actuators and motors with a weight > 20 kg.

INFORMATION

Special versions of products may differ in the specification from the standard. Further applicable data from data sheets, catalogues and offers of the special version have to be considered.

2.2 Intended Purpose

The Harmonic Drive® servo actuators and motors are intended for industrial or commercial applications. They comply with the relevant parts of the harmonised EN 60034 standards series.

Typical areas of application are robotics and handling, machine tools, packaging and food machines and similar machines.

The servo actuators and motors may only be operated within the operating ranges and environmental conditions shown in the documentation (altitude, degree of protection, temperature range etc).
Before plant and machinery which have Harmonic Drive® servo actuators and motors built into them are commissioned, the compliance must be established with the Machinery Directive, Low Voltage Directive and EMC guidelines.

Plant and machinery with inverter driven motors must satisfy the protection requirements in the EMC guidelines. It is the responsibility of the installer to ensure that installation is undertaken correctly.
Signal and power lines must be shielded. The EMC instructions from the inverter manufacturer must be observed in order that installation meets the EMC regulations.

2.3 Non Intended Purpose

The use of servo actuators and motors outside the areas of application mentioned above or, inter alia, other than in the operating areas or environmental conditions described in the documentation is considered as non-intended purpose.

ADVICE

Direct operating from the mains supply is not allowed.

The following areas of application are, inter alia, those considered as non-intended purpose:

- Aerospace
- Areas at risk of explosion
- Machines specially constructed or used for a nuclear purpose whose breakdown might lead to the emission of radio-activity
- Vacuum
- Machines for domestic use
- Medical equipment which comes into direct contact with the human body
- Machines or equipment for transporting or lifting people
- Special devices for use in annual markets or leisure parks

2.4 Declaration of Conformity

The Harmonic Drive® servo actuators and motors described in the engineering data comply with the Low Voltage Directive. In accordance with the Machinery Directive , Harmonic Drive® servo actuators and servo motors are electrical equipment for the use within certain voltage limits as covered by the Low Voltage Directive and thus excluded from the scope of the Machinery Directive. Commissioning is prohibited until the final product conforms to the Machinery Directive.

Multi-pole direct drive

TorkDrive® Series Direct Drives are normally supplied as kit motors comprising of a rotor and stator, which upon customer request, can also be delivered as integrated drive solutions. Due to the multi-pole design of the motor components, the Drives transmit high torques at low to medium rotational speeds.

They are available in five sizes offering a maximum torque from 19 to 600 Nm.

The large hollow shaft can be used to feed through supply lines or services for further drive axes. In the standard version, the Drives are designed for water cooling, thus increasing power density and minimising heat input into the machine.

3.2 Ordering Code

Table 9.1

Series	Size	Length of iron core	Motor winding	Cooling jacket	Special design
TorkDrive	100A 140A 210A 290A 370A	30 50 70	AA EA	C O	According to customer requirements
Ordering Code					
TorkDrive - 100A - 30 - AA - C - SP					

Table 9.2

Length of iron core	
Ordering Code	**Description**
30	30 mm
50	50 mm
70	70 mm

Table 9.3

Motor winding	
Ordering Code	**Maximum DC bus voltage**
AA	680 VDC
EA	48 VDC

Table 9.4

Cooling jacket	
Ordering Code	**Description**
C	with
O	without

Explanation of the technical data can be found in the Glossary.

Combinations

Table 10.1

Size		100A	140A	210A	290A	370A
Length of iron core	30	●	●	●	●	●
	50	●	●	●	●	●
	70	●	●	●	●	●
Motor winding	AA	●	●	●	●	●
	EA	○	○	○	–	–
Cooling jacket	C	●	●	●	●	●
	O	●	●	●	●	●

● available ○ on request – not available

3.3 Technical Data

3.3.1 General Technical Data

Table 11.1

Insulation class (EN 60034-1)		F
Insulation resistance (2000VDC)	GΩ	1
Insulation voltage (10s)	V_{rms}	2500
Degree of protection (EN 60034-5)		IP00
Ambient operating temperature	°C	-10 ... 40
Ambient storage temperature	°C	-20 ... 60
Altitude (a. s. l.)	m	< 1000
Relative humidity (without condensation)	%	20 ... 80
Vibration resistance (DIN IEC 68 Part 2-6, 10 ... 500 Hz)	g	5
Shock resistance (DIN IEC 68 Part 2-27, 18 ms)	g	30
Temperature Sensors		2 x KTY 84-130 // 3 x PTC 130° C

3.3.2 Actuator Data

Table 12.1

	Symbol [Unit]	TorkDrive-100A			TorkDrive-100A		
		30-AA	50-AA	70-AA	30-AA	50-AA	70-AA
Cooling method		Water			Convection		
Maximum output torque	T_{max} [Nm]	19	38	50	7	20	20
Maximum output speed	n_{max} [rpm]	2000			2000		
Maximum power	P_{max} [kW]	1.8	3.6	6.8	1.1	3.0	3.7
Continuous stall torque	T_0 [Nm]	7.1	12.2	18.2	2.5	4.1	4.8
Rated torque	T_N [Nm]	10	17	26	3	6	7
Rated speed	n_N [rpm]	1400	1500	1700	1800	1800	2000
Rated power	P_N [kW]	1.5	2.7	4.6	0.6	1.1	1.4
Maximum current	I_{max} [A_{rms}]	6	12	18	2	6	6
Rated current	I_N [A_{rms}]	3	5	8	1.1	1.7	2.0
Continuous stall current	I_0 [A_{rms}]	2.1	3.5	5.7	0.7	1.1	1.4
Torque constant (at motor)	k_{TM} [Nm/A_{rms}]	3.3	3.5	3.2	3.6	3.6	3.4
AC voltage constant (L-L, 20° C, at motor)	k_{EM} [V_{rms}/1000 rpm]	220	220	205	220	220	205
Maximum DC bus voltage	U_{DCmax} [V_{DC}]	720			720		
Motor terminal voltage (fundamental wave only)	U_M [V_{rms}]	430	430	430	430	430	430
Electrical time constant (20° C)	t_e [ms]	1	1	1	1	1	1
Mechanical time constant (20° C)	t_m [ms]	2	1	1	1	1	1
Resistance (L-L, 20° C)	R_{L-L} [Ω]	29.1	18.1	7.8	29.1	18.1	7.8
Inductance (L-L)	L_{L-L} [mH]	22	13	8	22	13	8
Number of pole pairs	p [ ]	11			11		
Weight stator	m [kg]	1.0	1.6	2.2	1.0	1.6	2.2
Weight stator with cooling jacket	m [kg]	1.5	2.1	2.9	-	-	-
Weight rotor	m [kg]	0.3	0.6	0.8	0.3	0.6	0.8
Cable length	l [mm]	approx. 300			approx. 300		

Moment of Inertia

Table 12.2

	Symbol [Unit]	TorkDrive-100A			TorkDrive-100A		
Moment of inertia	J [kgm^2]	0.00039	0.00064	0.00090	0.00039	0.00064	0.00090

Data for main motor cooler

Table 12.3

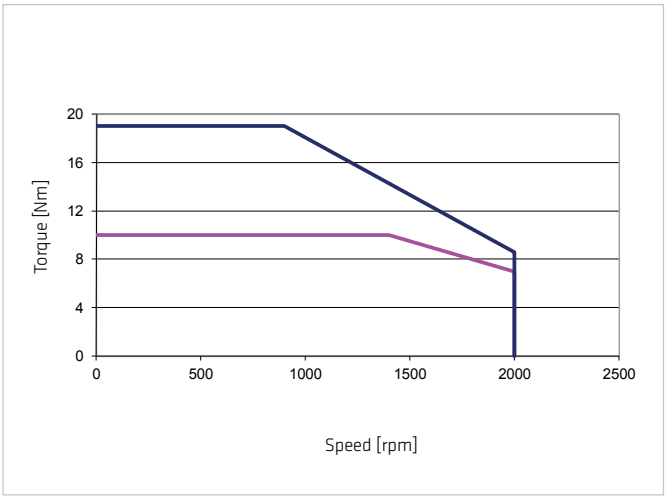
	Symbol [Unit]	TorkDrive-100A			TorkDrive-100A		
		30-AA	50-AA	70-AA	30-AA	50-AA	70-AA
Motor constant	K_{MV} [Nm/√W]	0.43	0.65	0.79	0.38	0.58	0.62
Power loss at rated conditions	$P_{V\,N}$ [kW]	0.55	0.70	1.07	0.07	0.10	0.12
Maximum power loss	$P_{V\,max}$ [kW]	2.2	3.9	5.2	0.25	1.00	0.62
Input temperature of cooling medium	$\Theta_{W\,Vorl}$ [°C]	15 ... 25			-		
Temperature increase of cooling medium	$\Delta\Theta_W$ [K]	10			-		
Minimum volume flow	$V_{W\,min}$ [l/min]	1	2	2	-	-	-

Performance Characteristics

The performance curves shown below are valid for the specified ambient operating temperature if the motor terminal voltage is higher or equal to the values given in the ratings table.

Cooling method: Water

Illustration 13.1 TorkDrive-100-30



Cooling method: Convection

Illustration 13.2 TorkDrive-100-30

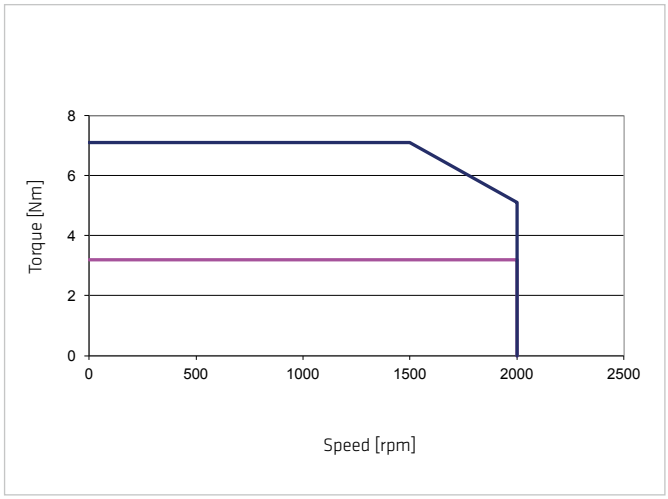


Illustration 13.3 TorkDrive-100-50

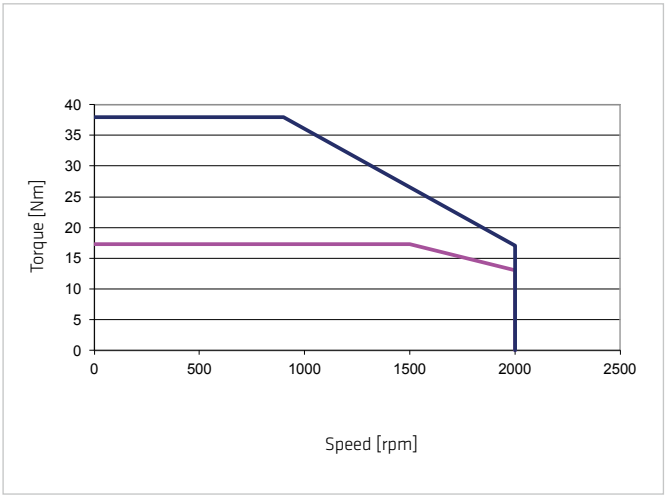


Illustration 13.4 TorkDrive-100-50

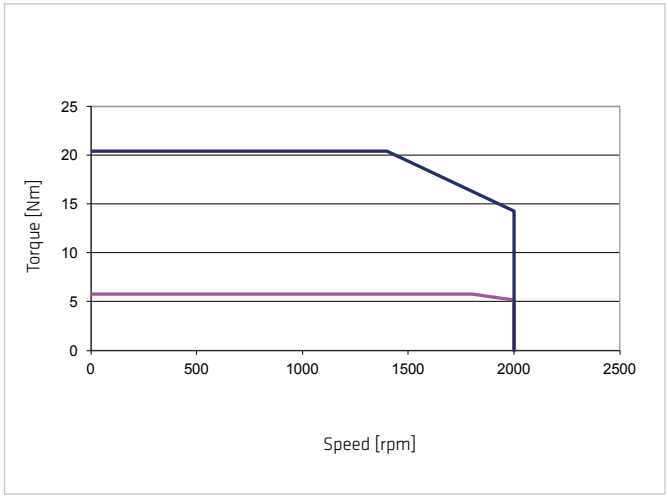


Illustration 13.5 TorkDrive-100-70

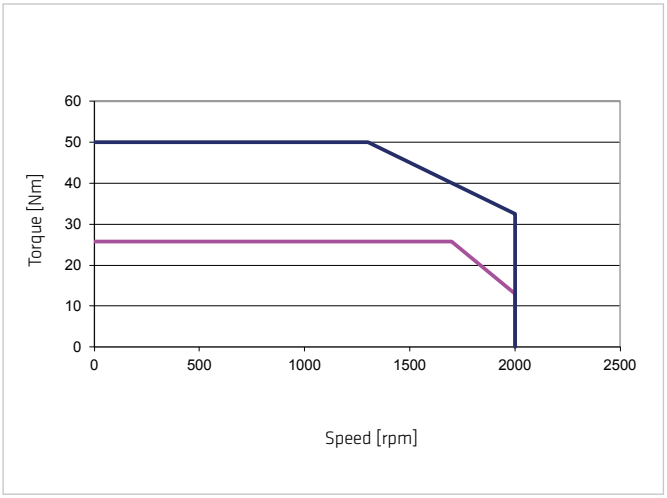
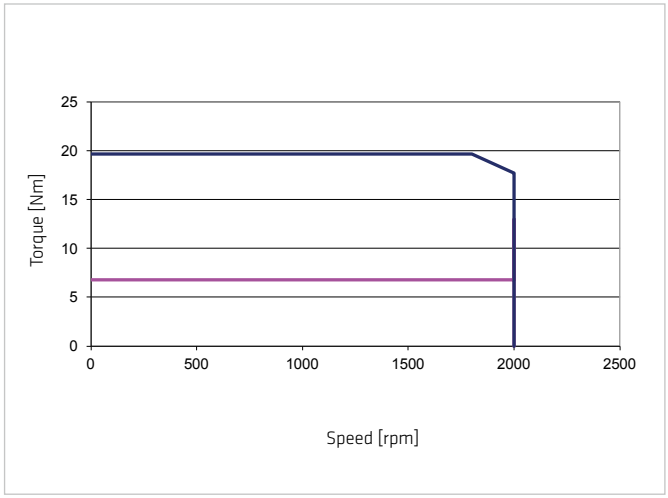


Illustration 13.6 TorkDrive-100-70



Legend

Intermittent duty — U_M = 430 VAC

Continuous duty

Table 14.1

	Symbol [Unit]	TorkDrive-140A			TorkDrive-140A		
		30-AA	50-AA	70-AA	30-AA	50-AA	70-AA
Cooling method		Water			Convection		
Maximum output torque	T_{max} [Nm]	32	53	73	15	25	34
Maximum output speed	n_{max} [rpm]	1500			1500		
Maximum power	P_{max} [kW]	5.0	8.3	10.7	2.4	3.9	5.3
Continuous stall torque	T_0 [Nm]	14.8	24.7	33.9	5.5	9.2	12.7
Rated torque	T_N [Nm]	21	35	48	8	13	18
Rated speed	n_N [rpm]	1500	1500	1500	1500	1500	1500
Rated power	P_N [kW]	3.3	5.5	7.5	1.2	2.0	2.8
Maximum current	I_{max} [A_{rms}]	18	36	36	6	12	12
Rated current	I_N [A_{rms}]	9	18	18	3	6	6
Continuous stall current	I_0 [A_{rms}]	6.4	12.7	12.7	2.1	4.2	4.2
Torque constant (at motor)	k_{TM} [Nm/A_{rms}]	2.3	1.9	2.9	2.6	2.2	2.9
AC voltage constant (L-L, 20° C, at motor)	k_{EM} [V_{rms}/1000 rpm]	157	130	177	157	130	177
Maximum DC bus voltage	U_{DCmax} [V_{DC}]	720			720		
Motor terminal voltage (fundamental wave only)	U_M [V_{rms}]	430	430	430	430	430	430
Electrical time constant (20° C)	t_e [ms]	2	3	3	2	3	3
Mechanical time constant (20° C)	t_m [ms]	1	1	1	1	1	1
Resistance (L-L, 20° C)	R_{L-L} [Ω]	4.6	1.4	1.7	4.6	1.4	1.7
Inductance (L-L)	L_{L-L} [mH]	9	4	5	11	5	6
Number of pole pairs	p [ ]	11			11		
Weight stator	m [kg]	2.8	4.0	5.2	2.8	4.0	5.2
Weight stator with cooling jacket	m [kg]	3.4	4.8	6.2	-	-	-
Weight rotor	m [kg]	0.7	1.1	1.6	0.7	1.1	1.6
Cable length	l [mm]	approx. 400			approx. 400		

Moment of Inertia

Table 14.2

	Symbol [Unit]	TorkDrive-140A			TorkDrive-140A		
Moment of inertia	J [kgm^2]	0.00100	0.00173	0.00242	0.00100	0.00173	0.00242

Data for main motor cooler

Table 14.3

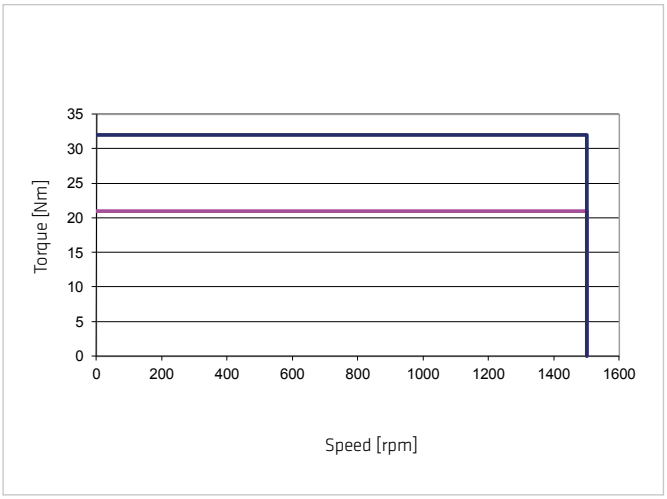
	Symbol [Unit]	TorkDrive-140A			TorkDrive-140A		
		30-AA	50-AA	70-AA	30-AA	50-AA	70-AA
Motor constant	K_{MV} [Nm/√W]	0.76	1.10	1.00	0.71	1.03	1.27
Power loss at rated conditions	$P_{V N}$ [kW]	0.77	0.97	1.16	0.12	0.16	0.20
Maximum power loss	$P_{V max}$ [kW]	2.98	4.19	3.49	0.36	0.46	0.56
Input temperature of cooling medium	$\Theta_{W Vorl}$ [°C]	15 ... 25			-		
Temperature increase of cooling medium	$\Delta\Theta_W$ [K]	10			-		
Minimum volume flow	$V_{W min}$ [l/min]	2	2	2	-	-	-

Performance Characteristics

The performance curves shown below are valid for the specified ambient operating temperature if the motor terminal voltage is higher or equal to the values given in the ratings table.

Cooling method: Water

Illustration 15.1 TorkDrive-140-30



Cooling method: Convection

Illustration 15.2 TorkDrive-140-30

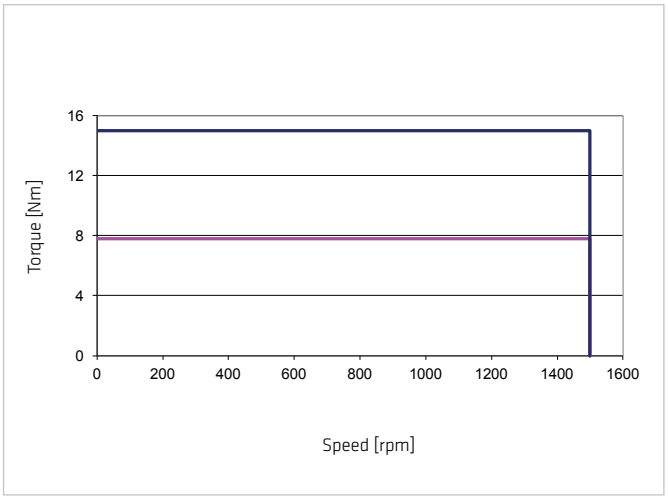


Illustration 15.3 TorkDrive-140-50

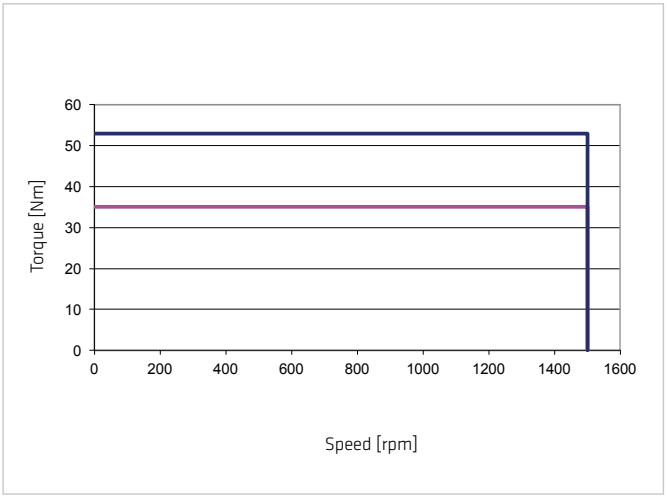


Illustration 15.4 TorkDrive-140-50

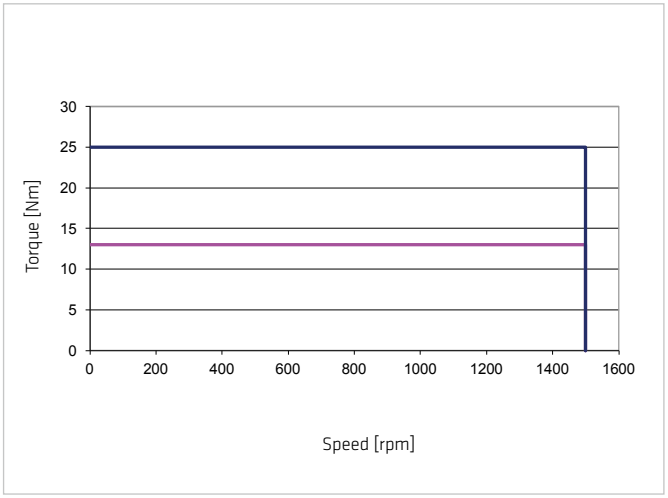


Illustration 15.5 TorkDrive-140-70

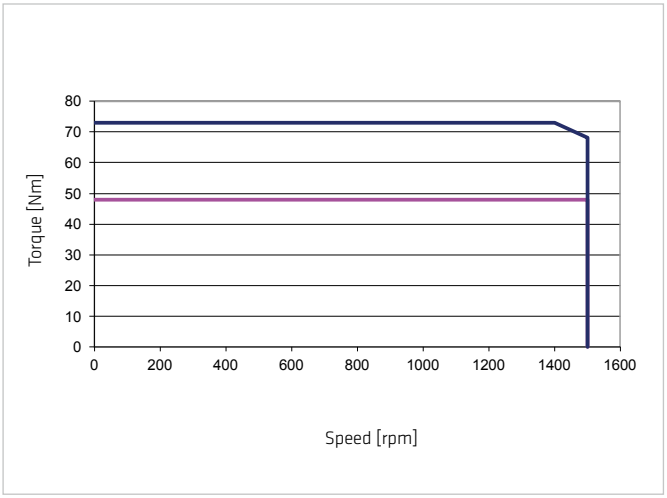
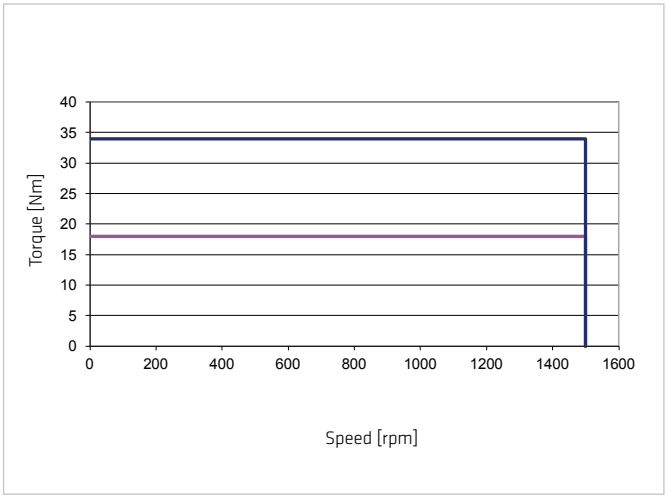


Illustration 15.6 TorkDrive-140-70



Legend

Intermittent duty — U_M = 430 VAC

Continuous duty

Table 16.1

	Symbol [Unit]	TorkDrive-210A			TorkDrive-210A		
		30-AA	50-AA	70-AA	30-AA	50-AA	70-AA
Cooling method		Water			Convection		
Maximum output torque	T_{max} [Nm]	104	170	220	43	69	83
Maximum output speed	n_{max} [rpm]	1000			1000		
Maximum power	P_{max} [kW]	10.9	12.5	23.0	4.5	5.1	8.7
Continuous stall torque	T_0 [Nm]	43	71	94	13	25	30
Rated torque	T_N [Nm]	61	100	133	19	35	42
Rated speed	n_N [rpm]	1000	1000	1000	1000	1000	1000
Rated power	P_N [kW]	6.4	10.5	13.9	2.0	3.7	4.4
Maximum current	I_{max} [A_{rms}]	36	36	56	12	12	18
Rated current	I_N [A_{rms}]	18	18	30	5.2	6.0	9.0
Continuous stall current	I_0 [A_{rms}]	12.7	12.7	21.2	3.7	4.2	6.4
Torque constant (at motor)	k_{TM} [Nm/A_{rms}]	3.4	5.6	4.4	3.7	5.8	4.7
AC voltage constant (L-L. 20° C. at motor)	k_{EM} [V_{rms}/1000 rpm]	219	353	282	219	353	282
Maximum DC bus voltage	U_{DCmax} [V_{DC}]	720			720		
Motor terminal voltage (fundamental wave only)	U_M [V_{rms}]	430	430	430	430	430	430
Electrical time constant (20° C)	t_e [ms]	1	1	3	1	1	3
Mechanical time constant (20° C)	t_m [ms]	3	2	2	2	2	2
Resistance (L-L. 20° C)	R_{L-L} [Ω]	2.0	2.4	1.0	2.0	2.4	1.0
Inductance (L-L)	L_{L-L} [mH]	2.4	3.9	1.8	2.6	4.2	1.9
Number of pole pairs	p [ ]	22			22		
Weight stator	m [kg]	3.6	5.4	7.2	3.6	5.4	7.2
Weight stator with cooling jacket	m [kg]	4.8	6.8	8.8	-	-	-
Weight rotor	m [kg]	1.6	2.4	3.0	1.6	2.4	3.0
Cable length	l [mm]	approx. 500			approx. 500		

Moment of Inertia

Table 16.2

	Symbol [Unit]	TorkDrive-210A			TorkDrive-210A		
Moment of inertia	J [kgm^2]	0.010	0.016	0.022	0.010	0.016	0.022

Data for main motor cooler

Table 16.3

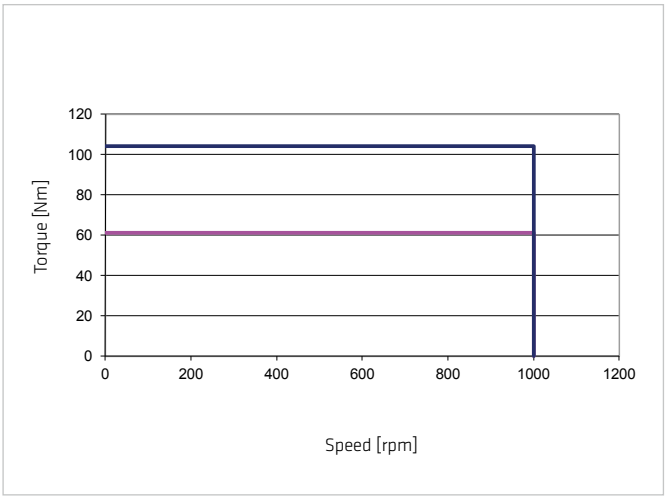
	Symbol [Unit]	TorkDrive-210A			TorkDrive-210A		
		30-AA	50-AA	70-AA	30-AA	50-AA	70-AA
Motor constant	K_{MV} [Nm/√W]	1.6	2.4	3.0	1.4	2.1	2.4
Power loss at rated conditions	$P_{V N}$ [kW]	1.4	1.7	2.0	0.18	0.29	0.31
Maximum power loss	$P_{V max}$ [kW]	5.5	6.5	6.4	0.68	0.83	0.80
Input temperature of cooling medium	$\Theta_{W Vorl}$ [°C]	15 ... 25			-		
Temperature increase of cooling medium	$\Delta\Theta_W$ [K]	10			-		
Minimum volume flow	$V_{W min}$ [l/min]	3	3	3	-	-	-

Performance Characteristics

The performance curves shown below are valid for the specified ambient operating temperature if the motor terminal voltage is higher or equal to the values given in the ratings table.

Cooling method: Water

Illustration 17.1 TorkDrive-210-30



Cooling method: Convection

Illustration 17.2 TorkDrive-210-30

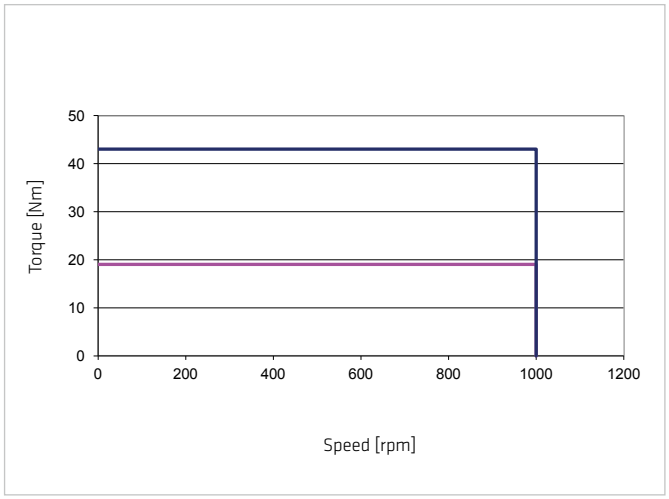


Illustration 17.3 TorkDrive-210-50

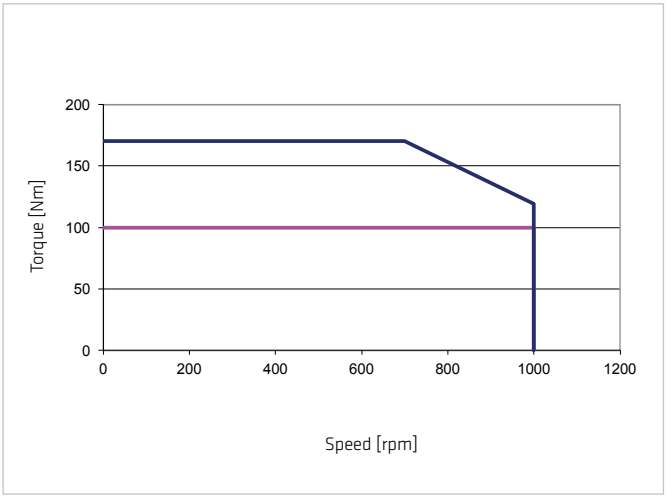


Illustration 17.4 TorkDrive-210-50

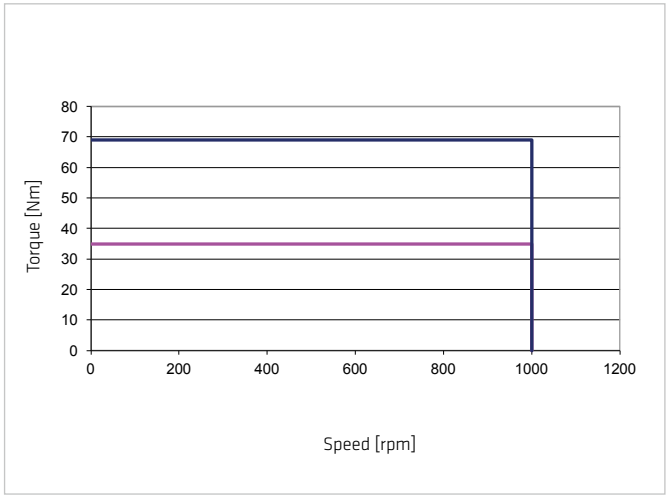


Illustration 17.5 TorkDrive-210-70

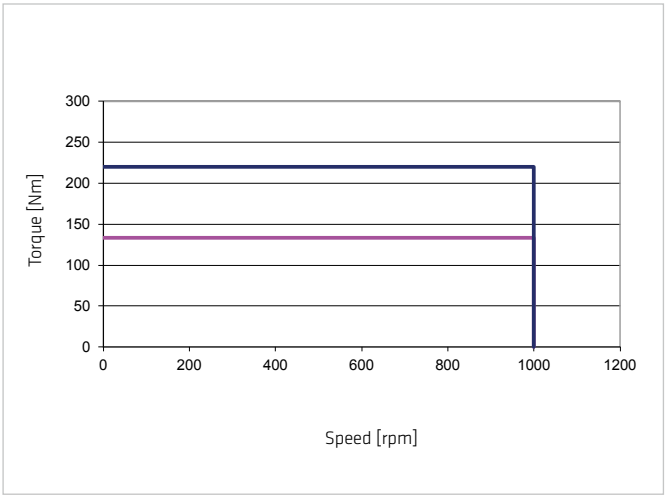
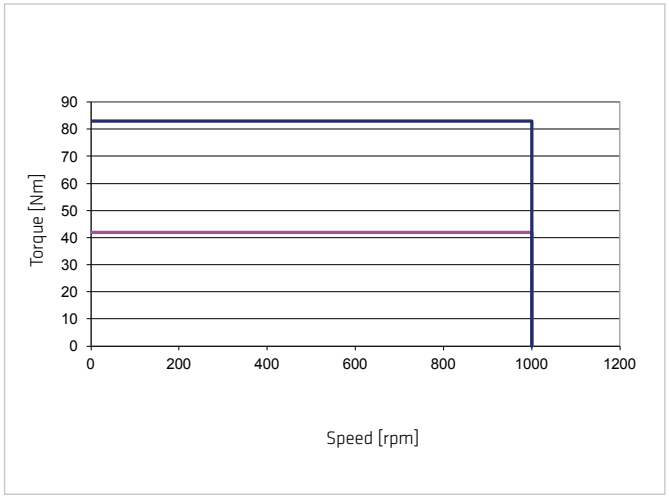


Illustration 17.6 TorkDrive-210-70



Legend

Intermittent duty — U_M = 430 VAC

Continuous duty

Table 18.1

	Symbol [Unit]	TorkDrive-290A			TorkDrive-290A		
		30-AA	50-AA	70-AA	30-AA	50-AA	70-AA
Cooling method		Water			Convection		
Maximum output torque	T_{max} [Nm]	177	296	404	53	88	117
Maximum output speed	n_{max} [rpm]	800			800		
Maximum power	P_{max} [kW]	14.8	19.2	21.3	4.4	7.4	9.8
Continuous stall torque	T_0 [Nm]	85	141	189	18	31	41
Rated torque	T_N [Nm]	120	200	267	26	44	58
Rated speed	n_N [rpm]	800	750	800	800	730	670
Rated power	P_N [kW]	10.1	15.7	22.4	2.2	3.4	4.1
Maximum current	I_{max} [A_{rms}]	56	56	85	12	12	18
Rated current	I_N [A_{rms}]	30	30	45	6.0	6.0	9.0
Continuous stall current	I_0 [A_{rms}]	21.2	21.2	31.8	4.2	4.2	6.4
Torque constant (at motor)	k_{TM} [Nm/A_{rms}]	4.0	6.7	5.9	4.3	7.3	6.4
AC voltage constant (L-L. 20° C. at motor)	k_{EM} [V_{rms}/1000 rpm]	265	441	390	265	441	390
Maximum DC bus voltage	U_{DCmax} [V_{DC}]	720			720		
Motor terminal voltage (fundamental wave only)	U_M [V_{rms}]	430	430	430	430	430	430
Electrical time constant (20° C)	t_e [ms]	4	4	5	5	4	6
Mechanical time constant (20° C)	t_m [ms]	2	2	1	2	1	1
Resistance (L-L. 20° C)	R_{L-L} [Ω]	0.7	1.4	0.5	0.7	1.4	0.5
Inductance (L-L)	L_{L-L} [mH]	1.4	2.4	1.3	1.6	2.7	1.5
Number of pole pairs	p [ ]	33			33		
Weight stator	m [kg]	9.6	12.6	16.7	9.6	12.6	16.7
Weight stator with cooling jacket	m [kg]	14.8	18.8	23.8	-	-	-
Weight rotor	m [kg]	2.0	3.2	4.6	2.0	3.2	4.6
Cable length	l [mm]	approx. 500			approx. 500		

Moment of Inertia

Table 18.2

	Symbol [Unit]	TorkDrive-290A			TorkDrive-290A		
Moment of inertia	J [kgm^2]	0.024	0.039	0.056	0.010	0.016	0.022

Data for main motor cooler

Table 18.3

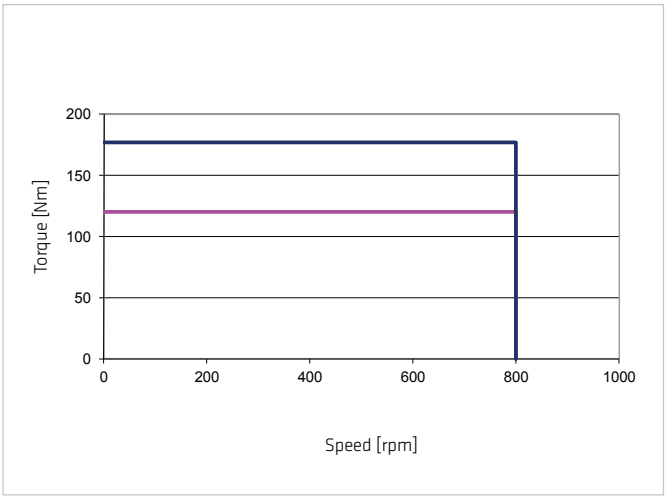
	Symbol [Unit]	TorkDrive-290A			TorkDrive-290A		
		30-AA	50-AA	70-AA	30-AA	50-AA	70-AA
Motor constant	K_{MV} [$Nm/\sqrt{W}$]	3.0	4.3	5.4	1.7	2.5	2.9
Power loss at rated conditions	$P_{V N}$ [kW]	1.6	2.1	2.4	0.23	0.32	0.39
Maximum power loss	$P_{V max}$ [kW]	5.1	6.6	7.4	0.38	0.56	0.73
Input temperature of cooling medium	$\Theta_{W Vorl}$ [°C]	15 ... 25			-		
Temperature increase of cooling medium	$\Delta\Theta_W$ [K]	10			-		
Minimum volume flow	$V_{W min}$ [l/min]	4	4	4	-	-	-

Performance Characteristics

The performance curves shown below are valid for the specified ambient operating temperature if the motor terminal voltage is higher or equal to the values given in the ratings table.

Cooling method: Water

Illustration 19.1 TorkDrive-290-30



Cooling method: Convection

Illustration 19.2 TorkDrive-290-30

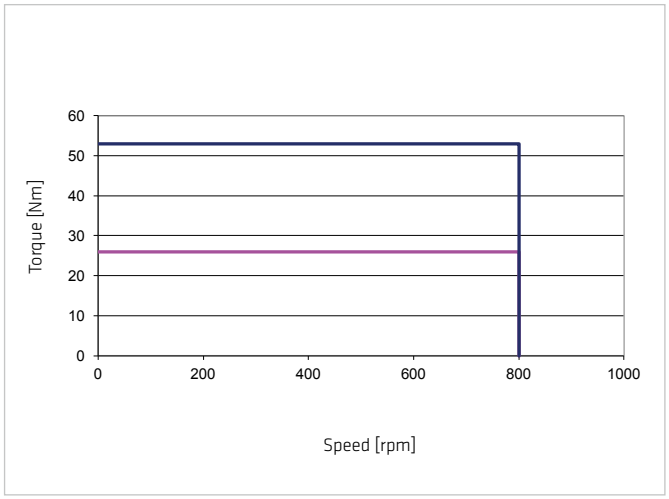


Illustration 19.3 TorkDrive-290-50

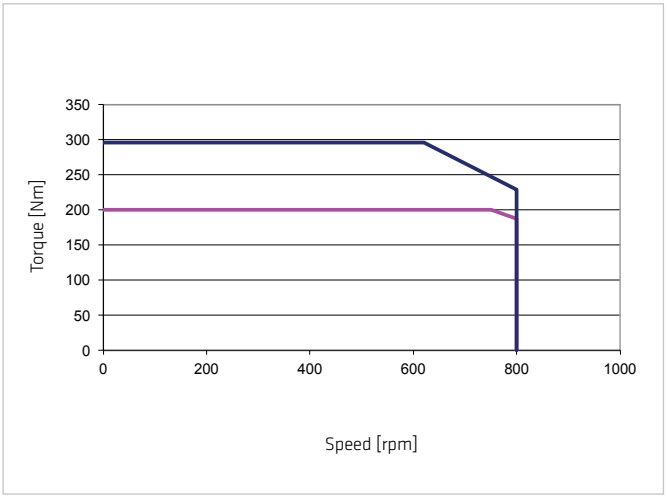


Illustration 19.4 TorkDrive-290-50

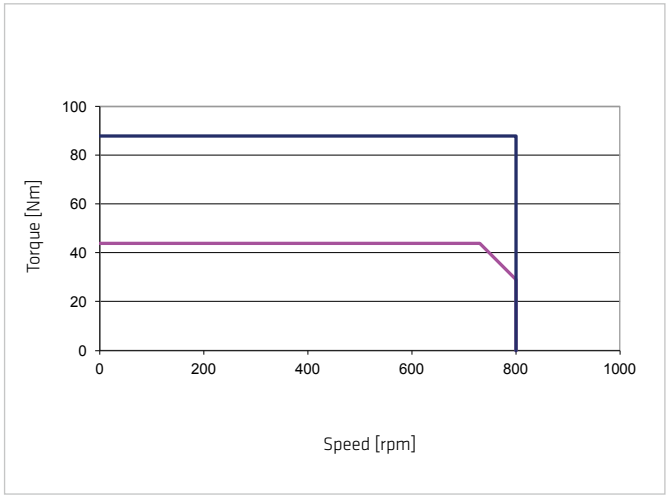


Illustration 19.5 TorkDrive-290-70

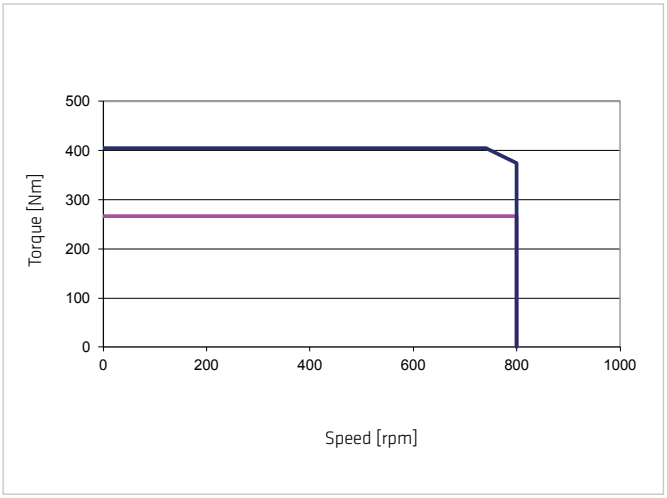
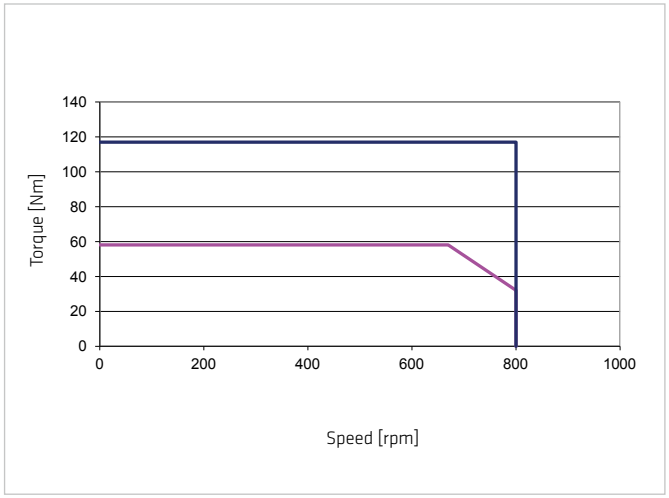


Illustration 19.6 TorkDrive-290-70



Legend

Intermittent duty — U_M = 430 VAC

Continuous duty

Table 20.1

	Symbol [Unit]	TorkDrive-370A			TorkDrive-370A		
		30-AA	50-AA	70-AA	30-AA	50-AA	70-AA
Cooling method		Water			Convection		
Maximum output torque	T_{max} [Nm]	255	425	600	87	145	295
Maximum output speed	n_{max} [rpm]	800			800		
Maximum power	P_{max} [kW]	21.4	24.0	31.4	7.3	12.0	21.6
Continuous stall torque	T_0 [Nm]	130	216	308	30	51	110
Rated torque	T_N [Nm]	184	306	435	43	72	155
Rated speed	n_N [rpm]	800	640	600	800	710	485
Rated power	P_N [kW]	15.4	20.5	27.3	3.6	5.4	7.9
Maximum current	I_{max} [A_{rms}]	85	85	113	18	18	36
Rated current	I_N [A_{rms}]	45	45	60	9.0	9.0	18.0
Continuous stall current	I_0 [A_{rms}]	31.8	31.8	42.4	6.4	6.4	12.7
Torque constant (at motor)	k_{TM} [Nm/A_{rms}]	4.1	6.8	7.3	4.8	8.0	8.6
AC voltage constant (L-L. 20° C. at motor)	k_{EM} [V_{rms}/1000 rpm]	289	482	518	289	482	518
Maximum DC bus voltage	U_{DCmax} [V_{DC}]	720			720		
Motor terminal voltage (fundamental wave only)	U_M [V_{rms}]	430	430	430	430	430	430
Electrical time constant (20° C)	t_e [ms]	3	4	4	4	5	6
Mechanical time constant (20° C)	t_m [ms]	2	2	1	2	1	1
Resistance (L-L. 20° C)	R_{L-L} [Ω]	0.4	0.5	0.4	0.4	0.5	0.4
Inductance (L-L)	L_{L-L} [mH]	1.3	2.1	1.7	1.3	2.1	1.7
Number of pole pairs	p [ ]	33			33		
Weight stator	m [kg]	14.0	19.2	24.3	14.0	19.2	24.3
Weight stator with cooling jacket	m [kg]	20.4	26.7	33.0	-	-	-
Weight rotor	m [kg]	2.9	4.9	6.9	2.9	4.9	6.9
Cable length	l [mm]	approx. 500			approx. 500		

Moment of Inertia

Table 20.2

	Symbol [Unit]	TorkDrive-370A			TorkDrive-370A		
Moment of inertia	J [kgm^2]	0.058	0.098	0.138	0.058	0.098	0.138

Data for main motor cooler

Table 20.3

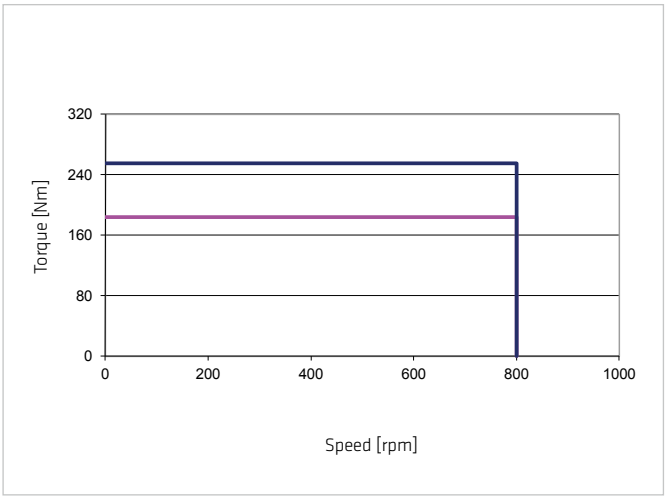
	Symbol [Unit]	TorkDrive-370A			TorkDrive-370A		
		30-AA	50-AA	70-AA	30-AA	50-AA	70-AA
Motor constant	K_{MV} [Nm/√W]	4.1	6.2	7.7	2.5	3.6	7.0
Power loss at rated conditions	P_{VN} [kW]	2.0	2.4	3.2	0.30	0.41	0.49
Maximum power loss	$P_{V max}$ [kW]	6.5	7.9	10.5	0.49	0.73	1.50
Input temperature of cooling medium	$\Theta_{W Vorl}$ [°C]	15 ... 25			-		
Temperature increase of cooling medium	$\Delta\Theta_W$ [K]	10			-		
Minimum volume flow	$V_{W min}$ [l/min]	3	4	5	-	-	-

Performance Characteristics

The performance curves shown below are valid for the specified ambient operating temperature if the motor terminal voltage is higher or equal to the values given in the ratings table.

Cooling method: Water

Illustration 21.1 TorkDrive-370-30



Cooling method: Convection

Illustration 21.2 TorkDrive-370-30

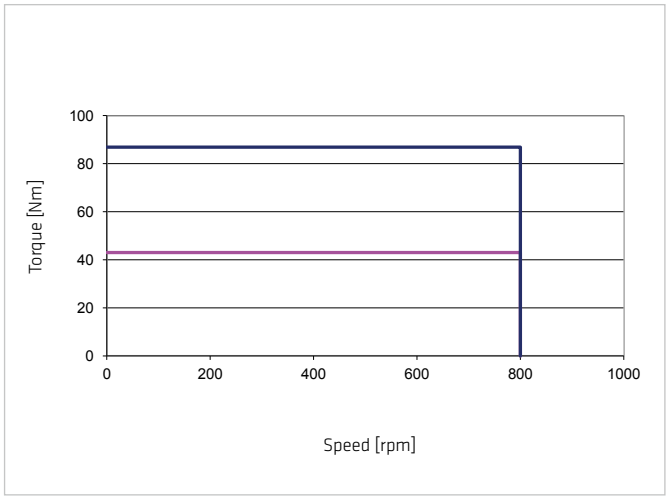


Illustration 21.3 TorkDrive-370-50

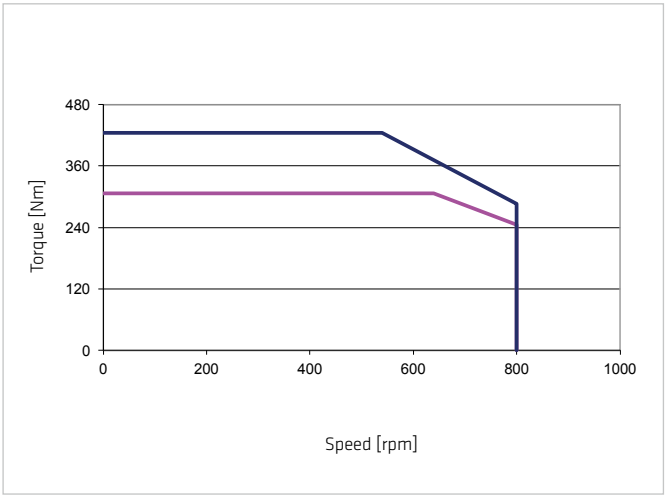


Illustration 21.4 TorkDrive-370-50

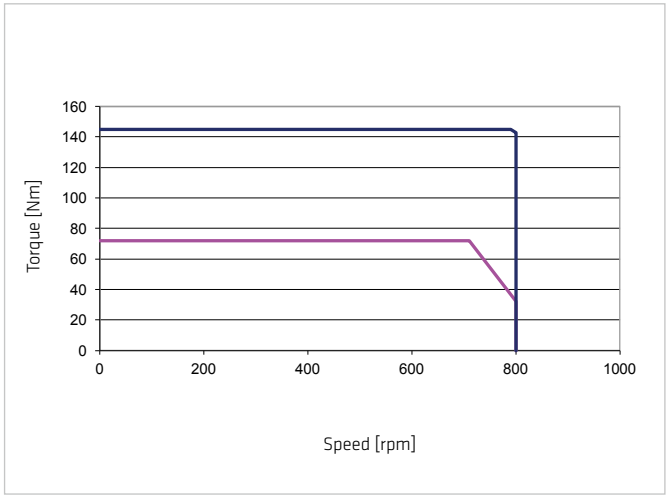


Illustration 21.5 TorkDrive-370-70

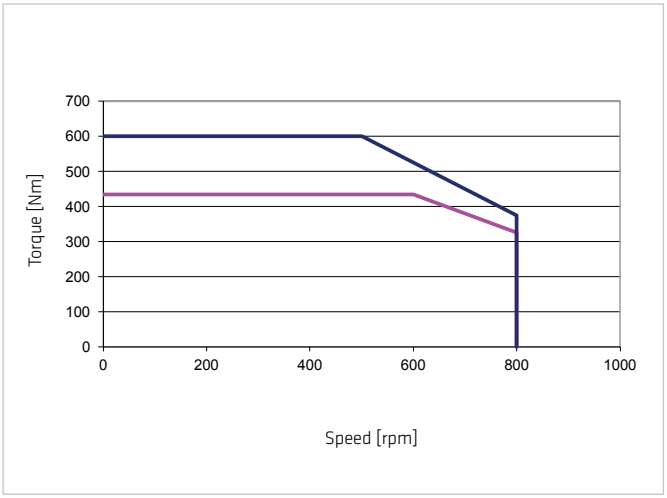
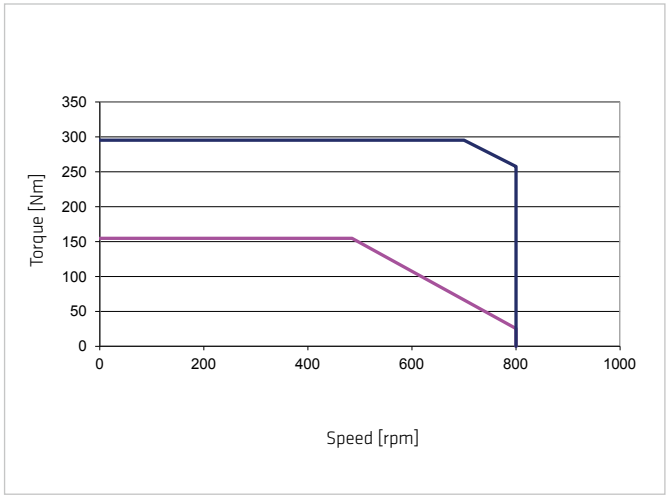


Illustration 21.6 TorkDrive-370-70



Legend

Intermittent duty — U_M = 430 VAC

Continuous duty

3.3.3 Dimensions

Detailed 2D drawings and 3D models can be found at the following Quicklink:
QUICKLINK **www.harmonicdrive.de/CAD1090**

Illustration 22.1 TorkDrive-100A [mm]

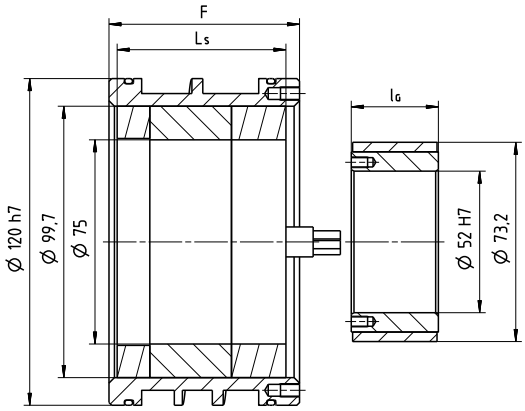


Illustration 22.2 TorkDrive-140A [mm]

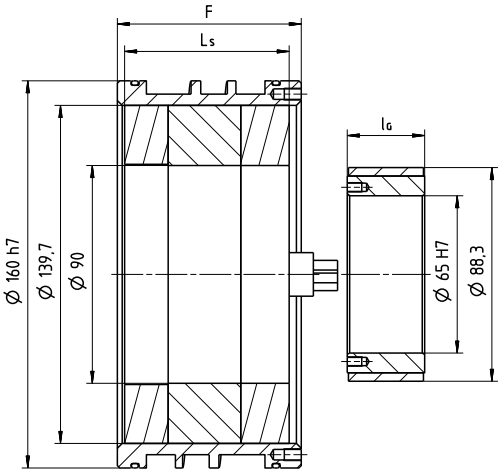


Table 22.3

	Symbol [Unit]	TorkDrive-100A			TorkDrive-140A		
		30	50	70	30	50	70
Length cooling jacket	F [mm]	70	90	110	76	96	116
Length stator	Ls [mm]	62	82	102	68	88	108
Length rotor	l_G [mm]	32	52	72	32	52	72
Stator outer diameter	Ø D1 [mm]	$99.7\ ^{0}_{-0.022}$			$139.7\ ^{0}_{-0.025}$		

Illustration 22.4 TorkDrive-210A [mm]

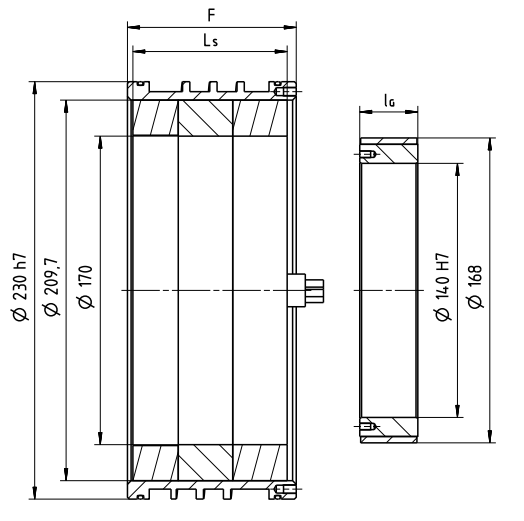


Illustration 22.5 TorkDrive-290A [mm]

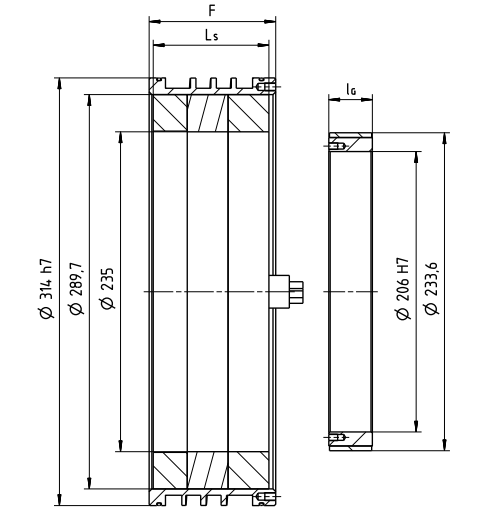


Table 22.6

	Symbol [Unit]	TorkDrive-210A			TorkDrive-290A		
		30	50	70	30	50	70
Length cooling jacket	F [mm]	93	113	133	93	113	133
Length stator	Ls [mm]	85	105	125	85	105	125
Length rotor	l_G [mm]	32	52	72	32	52	72
Stator outer diameter	Ø D1 [mm]	$209.7\ ^{0}_{-0.029}$			$289.7\ ^{0}_{-0.032}$		

Illustration 23.1

TorkDrive-370A [mm]

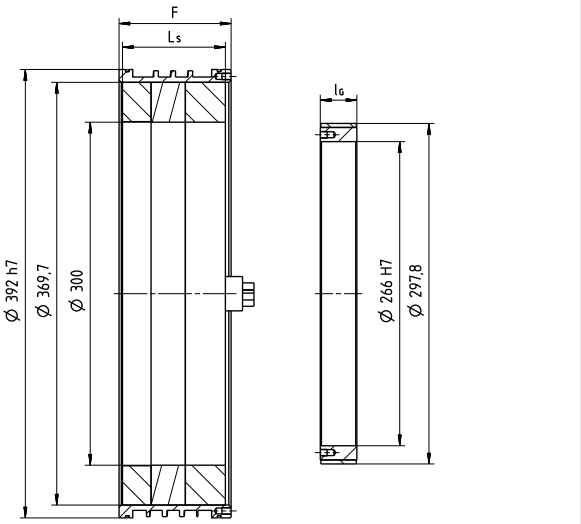


Table 23.2

	Symbol [Unit]	TorkDrive-370A		
		30	**50**	**70**
Length cooling jacket	F [mm]	98	118	138
Length stator	Ls [mm]	85	105	125
Length rotor	l_G [mm]	32	52	72
Stator outer diameter	Ø D1 [mm]	$369.7\ ^{0}_{-0.036}$		

3.3.4 Bearings

The Harmonic Drive AG TorkDrive® series are build in motors for direct rotary axis.

For the set up of a compleate motor a bearing between the rotor and the stator is required as well as a suitable motor feedback sytem or a suitable positioning measurement system.

Please consider the following requirements when selecting the motor bearing.

- Accuracy
- Load capacity
- Stiffness
- Maximum output speed
- Geometric requirements
- Lifetime

3.3.5 Motor Feedback Systems

Design and Operation

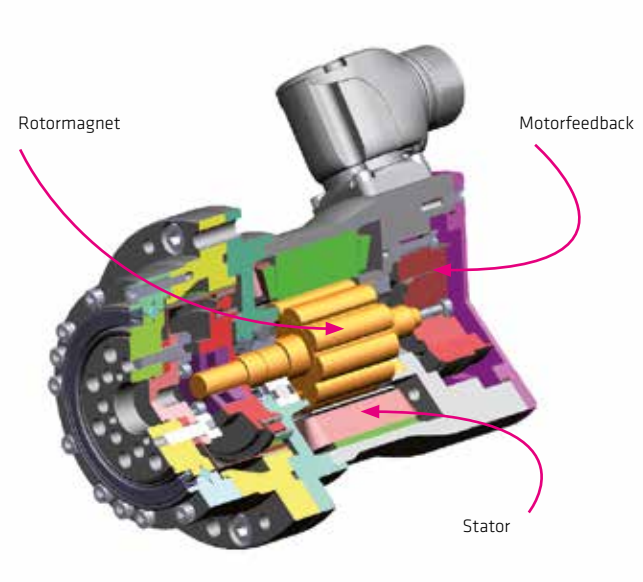
For accurate position setting, the servo motor and its control device are fitted with a measuring device (feedback), which determines the current position (e.g. the angle of rotation set for a starting position) of the motor.

This measurement is effected via a rotary encoder, e.g. a resolver, an incremental encoder or an absolute encoder. The position controller compares the signal from this encoder with the pre-set position value. If there is any deviation, then the motor is turned in the direction which represents a shorter path to the set value which leads to the deviation being reduced. The procedure repeats itself until the value lies incrementally or approximately within the tolerance limits. Alternatively, the motor position can also be digitally recorded and compared by computer to a set value.

Servo motors and actuators from Harmonic Drive AG use various motor feedback systems which are used as position transducers to fulfil several requirements.

Commutation

Commutation signals or absolute position values provide the necessary information about the rotor position, in order to guarantee correct commutation.



Actual Speed

The actual speed is obtained in the servo controller suing the feedback signal, from the cyclical change in position information.

Actual Position

Incremental encoder
The actual signal value needed for setting the position is formed by adding up the incremental position changes. Where incremental encoders have square wave signals, definition of the edge evaluation can be quadrupled (quad counting).
Where incremental encoders have SIN / COS signals, then the definition can be increased by interpolation in the control device.

Absolute encoder
Absolute encoders deliver absolute position information about one (single turn) or several (multi-turn) rotations. This information can on the one hand provide the rotor position for commutation and on the other hand possibly a reference of travel.
Where absolute encoders have additional incremental signals, then typically the absolute position information can be read at power up and the incremental signals then evaluated to determine the rotation and actual position value.
Fully digital absolute encoders as motor feedback systems have such a high definition of the absolute value that there is no need for additional incremental signals.

The compatibitlity to the selected servo drive as well as the required positioning accuracy according to the application has to be considred when selecting the motor feedback system.

Positioning accuracy, speed requirements and dynamic requirements must be observed.

Motor feedback systems and positiong measurement systems of differend manuacturers are available at the market.

Below is a selection of some manufacturers
- Dr. Johannes Heidenhain GmbH
- Renishaw GmbH
- AMO GmbH
- Sick Stegmann GmbH

3.3.6 Temperature Sensors

Temperature sensors are incorporated into the coil windings to protect it against thermal overload and to monitor the winding temperature during operation. A PTC temperature sensor is used for each of the three motor phases and conected in series. The PTC sensores are set to operate at a temperature of 130° C. Additionally, two KTY-84-130 temperature sensors are used to provide an analogue temperature output.

Illustration 26.1

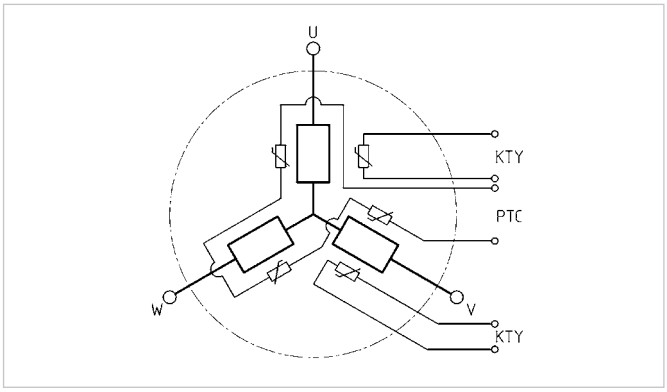


Table 26.2

Sensortyp	Kennwert	T_{Nat} [°C]
PTC	Rated operating temperature	130

PTC thermistors, because of their very high positive temperature coefficient at nominal operating temperature (Tnat), are ideally suited for motor winding protection.

Due to their principle, the PTC sensors should only be used to monitor the winding temperature.

Illustration 26.3

Diagram PTC

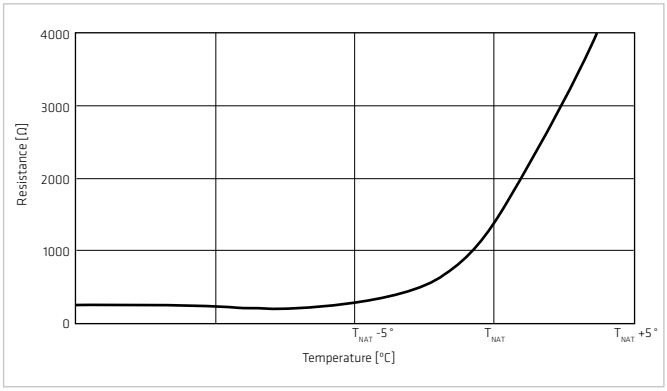


Table 26.4

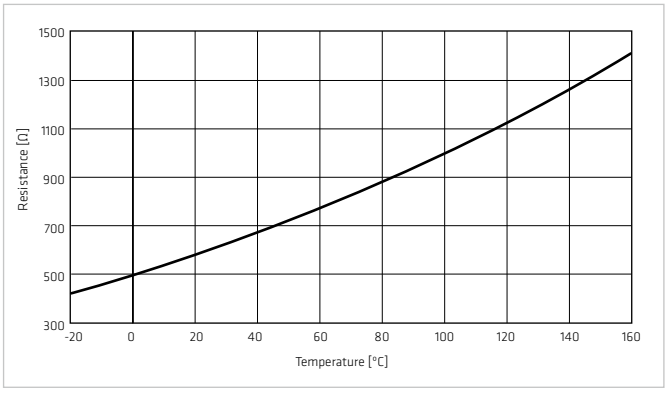
Sensor type	Parameter	Symbol [Unit]	Warning	Shutdown
KTY 84-130	Temperature	T [°C]	100	130
	Resistance	R [Ω]	1000 ± 3%	1194 ± 3%

The KTY sensor is used for temperature measurement and monitoring the motor winding.

Temperature sensors used in the TorkDrive® Series meet the requirements for safe separation according to EN50178.

Illustration 26.5

Diagram KTY 84-130



3.3.7 Electrical Connections

Table 27.1

	Symbol [Unit]	TorkDrive®								
Motor phase		U	V	W	Temp PTC	Temp PTC	Temp+ KTY1	Temp- KTY1	Temp+ KTY2	Temp- KTY2
Colour		brown	blue	black	blue	blue	brown	white	brown	white
Cross section	[mm²]	Table 27.2 / 27.3			0.25					
Diameter	[mm]				1.2					

Table 27.2

Antrieb	Symbol [Unit]	TorkDrive-100			TorkDrive-140			TorkDrive-210		
		30-AA	50-AA	70-AA	30-AA	50-AA	70-AA	30-AA	50-AA	70-AA
Cross section U. V . W	[mm²]	0.5	0.5	0.75	0.75	1	1	1	1	2.5
Diameter U. V . W	[mm]	1.5	1.5	1.8	1.8	2	2	2	2	2.8

Table 27.3

Antrieb	Symbol [Unit]	TorkDrive-290			TorkDrive-370		
		30-AA	50-AA	70-AA	30-AA	50-AA	70-AA
Cross section U. V . W	[mm²]	2.5	2.5	6	6	6	10
Diameter U. V . W	[mm]	2.8	2.8	4.1	4.1	4.1	5.5

4. Actuator Selection Procedure

4.1. Selection Procedure and Calculation Example

ADVICE

We will be pleased to make a gear calculation and selection on your behalf. Please contact our application engineers.

Flowchart for actuator selection

Equation 28.1

$$T_1 = T_L + \frac{2\pi}{60} \cdot \frac{(J_{out} + J_L) \cdot n_2}{t_1}$$

Equation 28.2

$$T_2 = T_L$$

$$T_3 = T_L \cdot (T_1 - T_L)$$

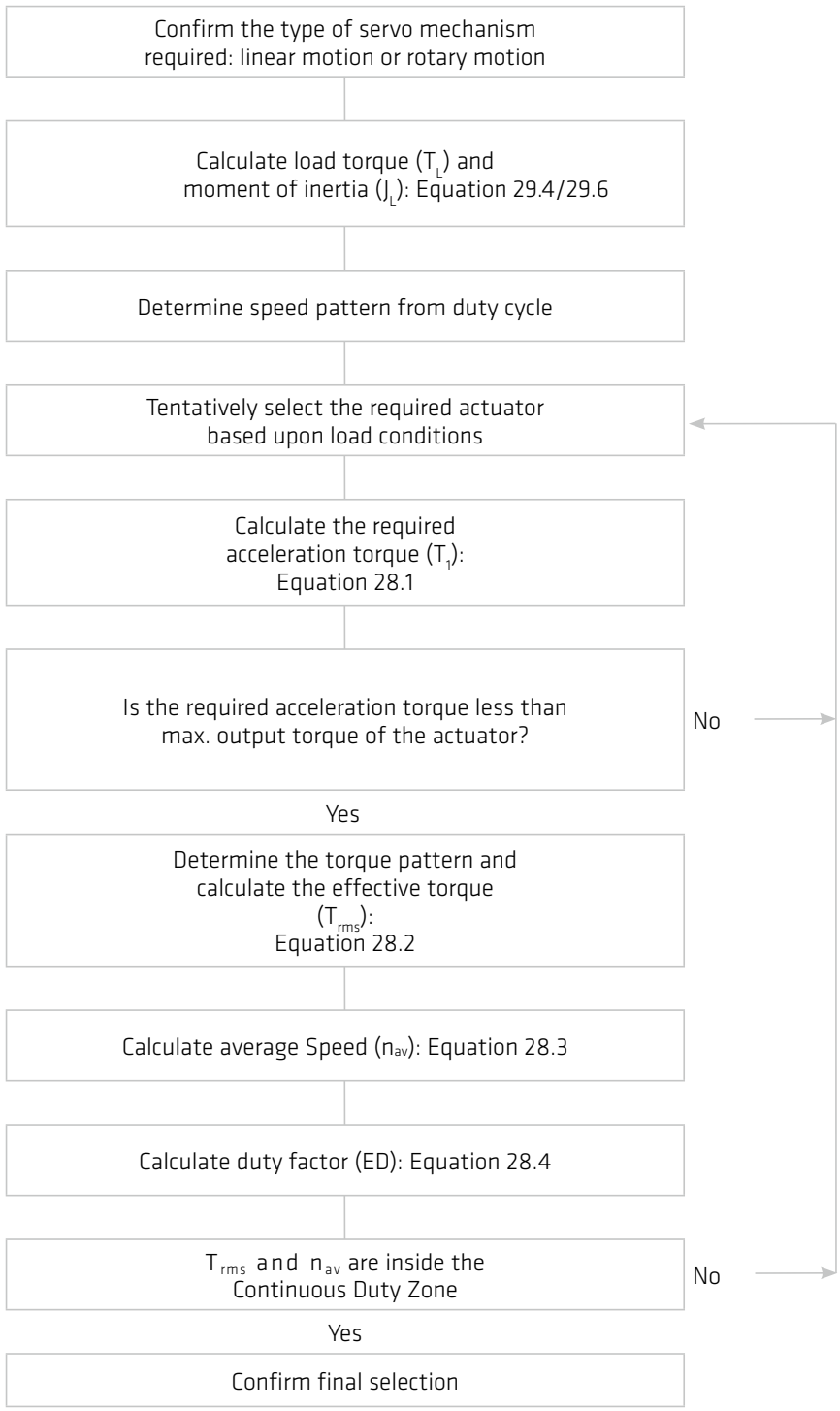
$$T_{rms} = \sqrt{\frac{T_1^2 \cdot t_1 + T_2^2 \cdot t_2 + T_3^2 \cdot t_3}{t_1 + t_2 + t_3 + t_p}}$$

Equation 28.3

$$n_{av} = \frac{\frac{n_2}{2} \cdot t_1 + n_2 \cdot t_2 + \frac{n_2}{2} \cdot t_3}{t_1 + t_2 + t_3 + t_p}$$

Equation 28.4

$$ED = \frac{t_1 + t_2 + t_3}{t_1 + t_2 + t_3 + t_p} \cdot 100\ \%$$



Pre selection conditions

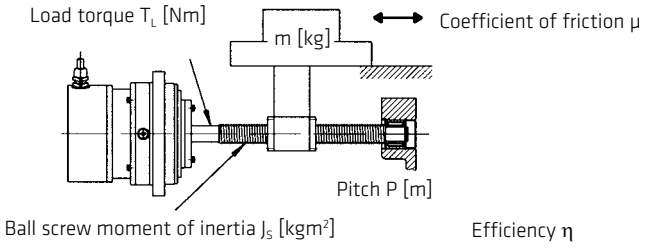
Table 29.1

Load	Confirmation	Catalogue value	Unit
Load max. rotation speed (n_2)	≤ n_{max}	Max. output speed	[rpm]
Load moment of inertia (J_L)	≤ $3J_{Out}$ [1)]	Moment of inertia	[kgm²]

[1)] $J_L \leq 3 \cdot J_{Out}$ is recommended for highly dynamic applications (high responsiveness and accuracy).

Linear horizontal motion

Illustration 29.2



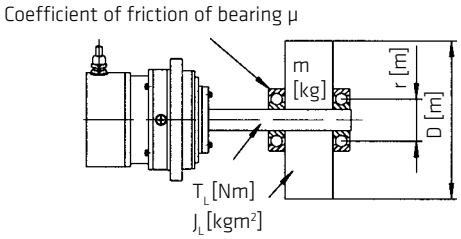
Equation 29.3

$$J_L = J_S + m \left(\frac{P}{2\pi}\right)^2 \text{ [kgm²]}$$

$$T_L = \frac{\mu \cdot m \cdot P \cdot g}{2\pi \cdot \eta} \text{ [Nm]}$$

Rotary motion

Illustration 29.4

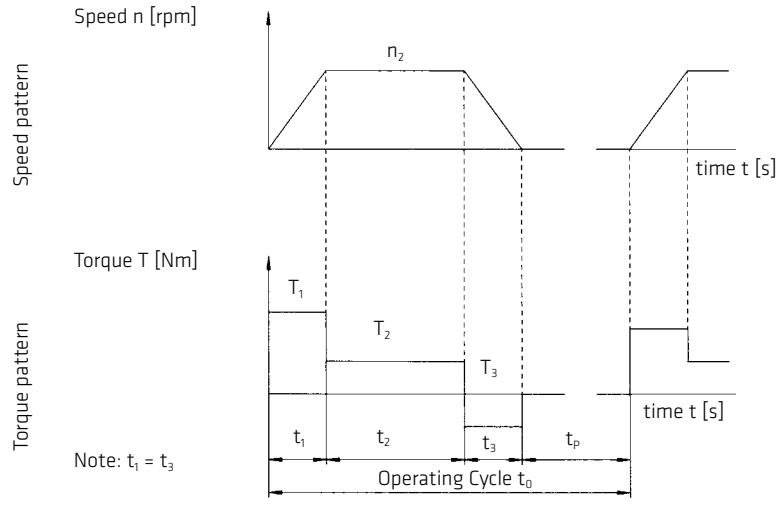


Equation 29.5

$$J_L = \frac{m}{8} \cdot D^2 \text{ [kgm²]}$$

$T_L = \mu \cdot m \cdot g \cdot r$ [Nm] $g = 9.81$ [m/s²]

Illustration 29.6



Example of actuator selection

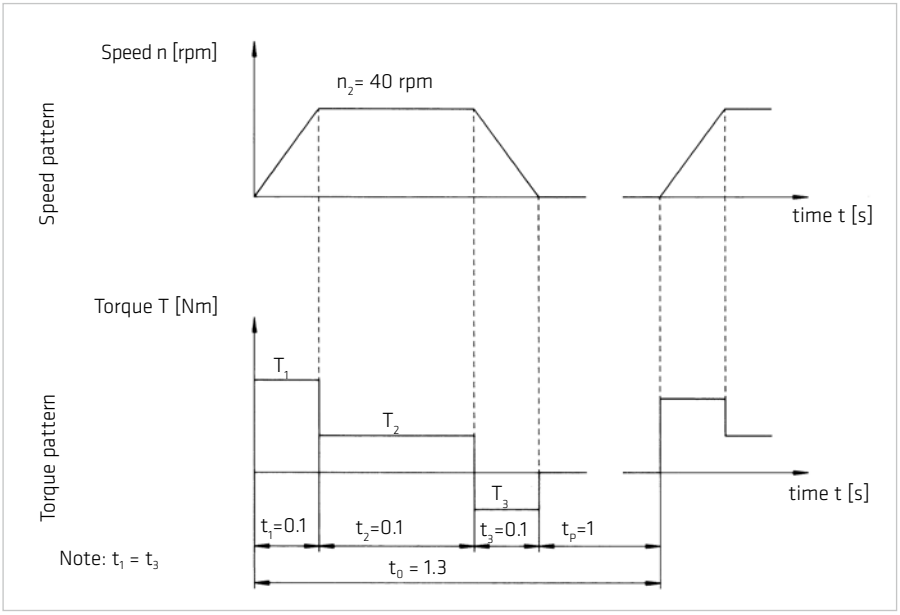
Load Conditions
Assume servo mechanism is used to cyclically position a mass with a horizontal axis of rotation.

Table 30.1

Load rotation speed	n_2 = 40 [rpm]
Load torque (e. g. friction)	T_L = 5 [Nm]
Load inertia	J_L = 1.3 [kgm²]
Speed pattern	
Acceleration; Deceleration	$t_1 = t_3$ = 0.1 [s]
Operate with rated speed	t_2 = 0.1 [s]
Stand still	t_p = 1 [s]
Total cycle time	t_0 = 1.3 [s]

Please note: Each characteristic value should be converted to the value at the output shaft of the actuator.

Illustration 30.2



Actuator data FHA-25C-50-L

Table 30.3

Max. Torque	T_{max} = 151 [Nm]
Max. output speed	n_{max} = 90 [rpm]
Moment of inertia	J_{Out} = 0.86 [kgm²]

Tentatively select a required actuator based upon load conditions. FHA-25C-50 meets the tentative selection requirements from catalogue value (see rating table)

$n_2 = 40\ rpm < n_{max} = 90\ rpm$
$J_L = 1.3\ kgm^2 < 3J_{out} = 2.58\ kgm^2$

Calculate required acceleration torque (T_1)

$$T_1 = 5 + \frac{2\pi}{60} \cdot \frac{(1.3 + 0.86) \cdot 40}{0.1} = 95\ Nm$$

Confirm: Is the required acceleration torque less than the maximum output torque of the actuator?

$T_1 = 95\ Nm < T_{max} = 151\ Nm$

No

Yes

Calculate effective torque (T_{rms})

$T_1 = 95\ Nm$
$T_2 = T_L = 5\ Nm$
$T_3 = T_L - (T_1 - T_L) = -85\ Nm$

$$T_{rms} = \sqrt{\frac{95^2 \cdot 0.1 + 5^2 \cdot 0.1 + (-85)^2 \cdot 0.1}{1.3}} = 35\ Nm$$

Calculation of the average speed

$$n_{av} = \frac{\frac{40}{2} \cdot 0.1 + 40 \cdot 0.1 + \frac{40}{2} \cdot 0.1}{1.3}$$

$n_{av} = 6\ rpm$

Calculation of the duty factor

$$ED = \frac{0.1 + 0.1 + 0.1}{1.3} \cdot 100\%$$

$ED = 23\,\%$

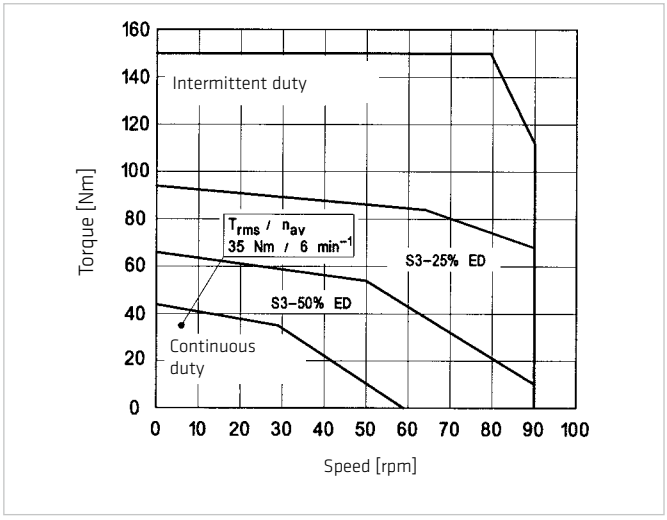
$T_{rms} = 35\ Nm$
$n_{av} = 6\ rpm$

Check according to the performance characteristics
T_{rms} and n_{av} are inside the continuous duty zone

Confirm final selection

Illustration 31.1

FHA-25C-50L



min^{-1} ≙ rpm

ED = 1 min.

5. Installation and Operation

5.1 Transport and Storage

The transportation of the servo actuators and motors should always be in the original packaging. If the servo actuators and motors are not put into operation immediately after delivery, they should be stored in a dry, dust and vibration-free environment. Storage should be for no longer than 2 years at room temperatures (between +5° C ... +40° C) so that the grease life is preserved.

INFORMATION

Tensile forces in the connecting cable must be avoided.

5.2 Installation

Check the performance and protection and check the suitability of the conditions at the installation site. Take suitable constructive measures to ensure that no liquid (water, drilling emulsion, coolant) can penetrate the output bearing or encoder housing.

ADVICE

The installation must be protected against impact and pressure on the gear.

The mounting must be such that heat loss can be adequately dissipated.

No radial forces and axial forces may act to the protection sleeve of the hollow shaft actuator.

During installation, the actuator must be fitted ensuring the machine housing can be rotated without terminals. Already low terminals may affect the accuracy of the gear and, should this be the case, the installation of the machine housing should be checked.

5.3 Mechanical Installation

5.3.1 Rotor

Illustration 33.1

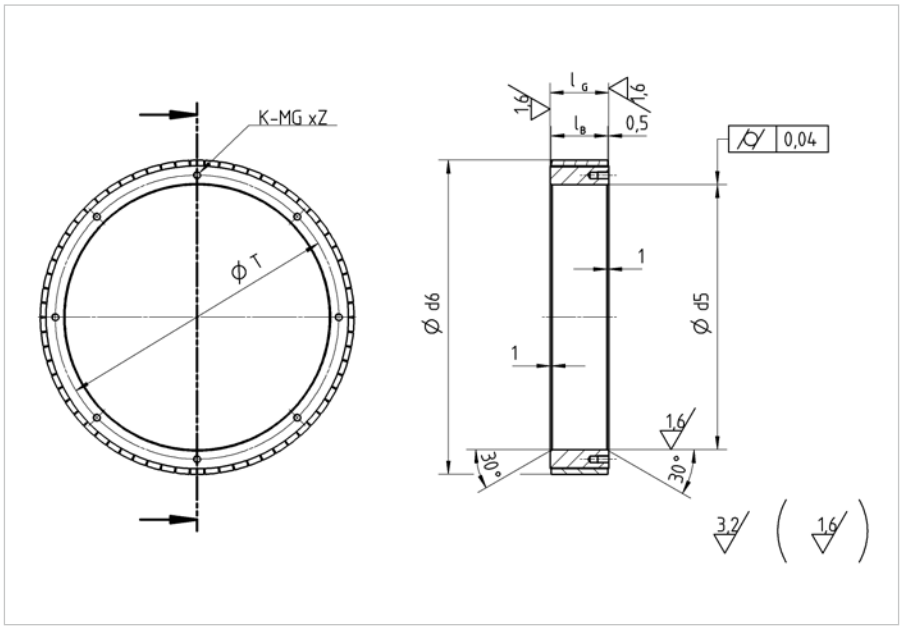


Table 33.2

Typ	Symbol [Unit]	TorkDrive-100A			TorkDrive-140A			TorkDrive-210A			TorkDrive-290A			TorkDrive-370A		
		30-AA	50-AA	70-AA	30-AA	50-AA	70-AA	30-AA	50-AA	70-AA	30-AA	50-AA	70-AA	30-AA	50-AA	70-AA
Rotor outer diameter	Ø d6 [mm]	73.2			88.3			168			233.6			297.8		
Rotor inner diameter	Ø d5 [mm]	52 H7			65 H7			140 H7			206 H7			266 H7		
Rotor length	l_G [mm]	32 ±0.1	52 ±0.1	72 ±0.1	32 ±0.1	52 ±0.1	72 ±0.1	32 ±0.1	52 ±0.1	72 ±0.1	32 ±0.1	52 ±0.1	72 ±0.1	32 ±0.1	52 ±0.1	72 ±0.1
Magnet length	l_B [mm]	31	51	71	31	51	71	31	51	71	31	51	71	31	51	71
Pitch circle diameter	Ø T [mm]	58.5 ±0.1			72 ±0.1			150 ±0.1			214 ±0.1			278 ±0.1		
Threaded hole	K-MGxZ [mm]	4 x M4 x 6			4 x M4 x 6			8 x M4 x 6			12 x M5 x 6.5			12 x M6 x 8		
Screw tightening torque	[Nm]	5,1			5,1			5,1			10			17,4		

5.3.2 Stator without cooling jacket

Illustration 34.1

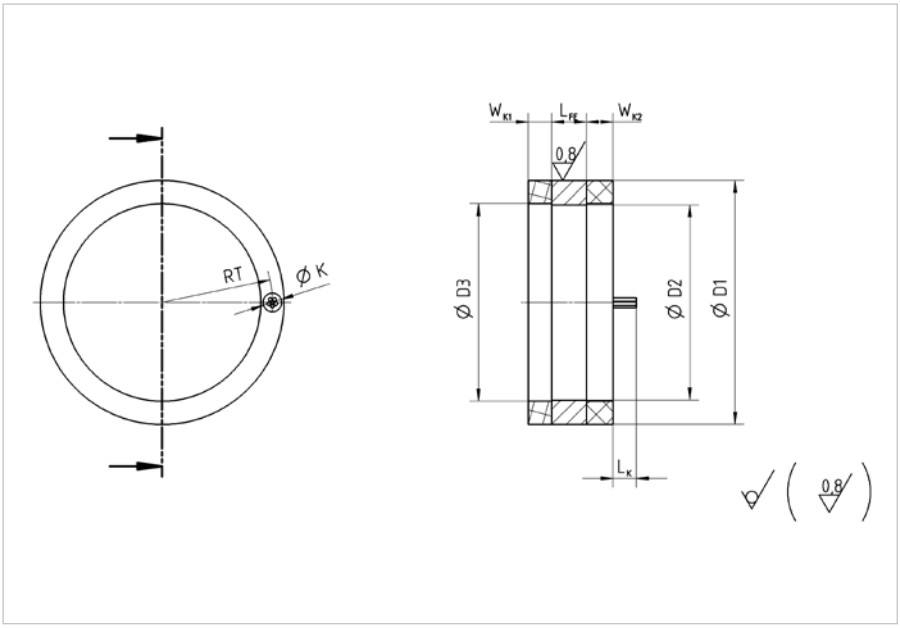


Table 34.2

Typ	Symbol [Unit]	TorkDrive-100A			TorkDrive-140A			TorkDrive-210A			TorkDrive-290A			TorkDrive-370A		
		30-AA	50-AA	70-AA	30-AA	50-AA	70-AA	30-AA	50-AA	70-AA	30-AA	50-AA	70-AA	30-AA	50-AA	70-AA
Stator outer diameter	Ø D1 [mm]	99.7 ^{0}			139.7 $^{0-0.025}$			209.7 $^{0-0.029}$			289.7 $^{0-0.032}$			369.7 $^{0-0.036}$		
Stator inner diameter	Ø D2 [mm]	75			90			170			235			300		
Winding inner diameter	Ø D3 [mm]	76			91			171			236			301		
Length iron core	L_{Fe} [mm]	30 $^{0-0.6}$	50 $^{0-0.6}$	70 $^{0-0.6}$	30 $^{0-0.6}$	50 $^{0-0.6}$	70 $^{0-0.6}$	30 $^{0-0.6}$	50 $^{0-0.6}$	70 $^{0-0.6}$	30 $^{0-0.6}$	50 $^{0-0.6}$	70 $^{0-0.6}$	30 $^{0-0.6}$	50 $^{0-0.6}$	70 $^{0-0.6}$
Length winding	W_{K1} [mm]	≤20			≤20			≤30			≤30			≤30		
Length winding	W_{K2} [mm]	12 $^{\pm0.2}$			18 $^{\pm0.2}$			25 $^{\pm0.2}$			25 $^{\pm0.2}$			25 $^{\pm0.2}$		
Length connecting cables	L_K [mm]	≥ 300			≥ 400			≥ 500			≥ 500			≥ 500		
Position of the connecting cables	Ø K [mm]	11			18			18			24			30		
	RT [mm]	44			57.5			95			132			168.5		

Illustration 35.1

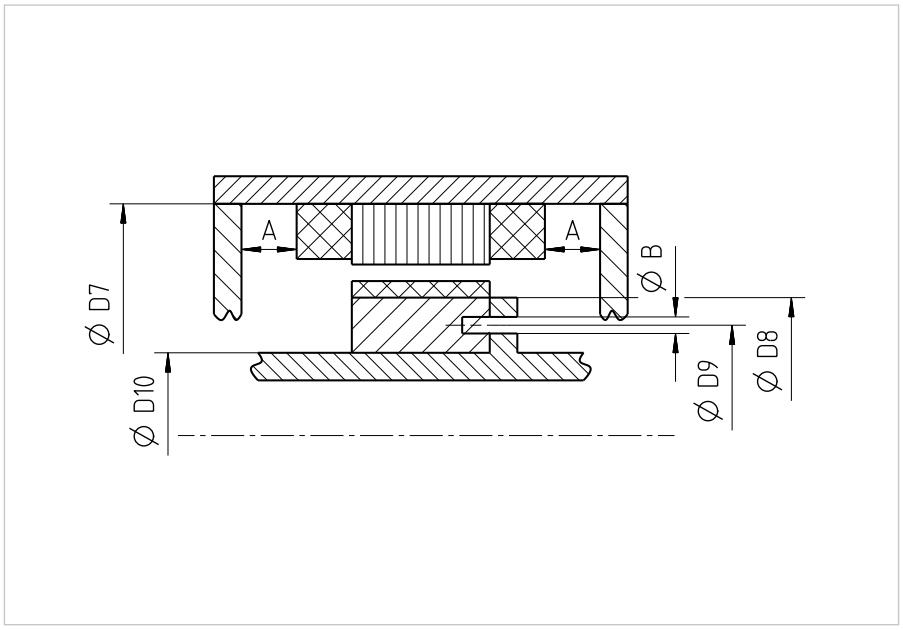


Table 35.2

Symbol [Unit]	TorkDrive-100A	TorkDrive-140A	TorkDrive-210A	TorkDrive-290A	TorkDrive-370A
Ø D7 [mm]	As a possible assembly method between motor stator and motor housing we recommend shrink connection or adhesive bond. The tolerances for the assembly are dependent on the selected process.				
	99.7 G6	139.7 G6	209.7 G6	289.7 G6	266 G6
			Loctite 638		
Ø D8 [mm]	65	79	160	222	250
Ø D9 [mm]	58.5 $^{\pm 0.1}$	72 $^{\pm 0.1}$	150 $^{\pm 0.1}$	214 $^{\pm 0.1}$	278 $^{\pm 0.1}$
Ø D10 [mm]	As a possible assembly method between motor stator and motor housing we recommend screw connection or adhesive bond. The tolerances for the assembly are dependent on the selected process.				
	52 g6	65 g6	140 g6	206 g6	266 g6
			Loctite 638		
Ø B [mm]	5	5	5	6	7
A [mm]	≥1	≥1	≥1	≥1	≥1

5.3.3 Stator with cooling jacket

Illustration 36.1

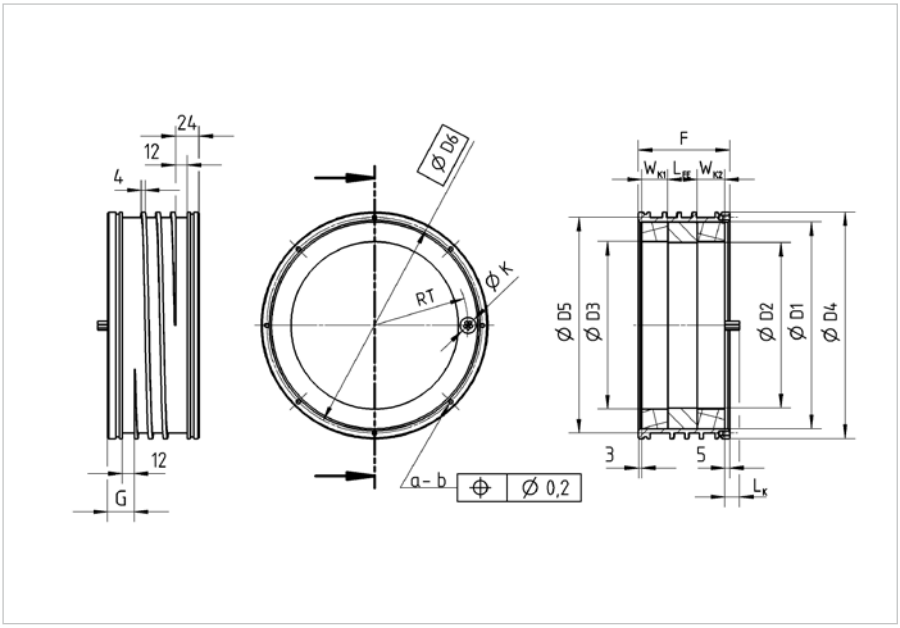


Table 36.2

Typ	Symbol [Unit]	TorkDrive-100A			TorkDrive-140A			TorkDrive-210A			TorkDrive-290A			TorkDrive-370A		
		30-AA	50-AA	70-AA	30-AA	50-AA	70-AA	30-AA	50-AA	70-AA	30-AA	50-AA	70-AA	30-AA	50-AA	70-AA
External diameter cooling jacket	Ø D4 [mm]	120 h7			160 h7			230 h7			314 h7			392 h7		
Length cooling jacket	F [mm]	70	90	110	76	96	116	93	113	133	93	113	133	98	118	138
Stator outer diameter	Ø D1 [mm]	99.7 $^{0-0.022}$			139.7 $^{0-0.025}$			209.7 $^{0-0.029}$			289.7 $^{0-0.032}$			369.7 $^{0-0.036}$		
Stator inner diameter	Ø D2 [mm]	75			90			170			235			300		
Winding inner diameter	Ø D3 [mm]	76			91			171			236			301		
Diameter of the cooling spiral	Ø D5 [mm]	109			149			219			299			379		
	G [mm]	27			27			27			29			29		
Length iron core	L_{Fe} [mm]	30 $^{0-0.6}$	50 $^{0-0.6}$	70 $^{0-0.6}$	30 $^{0-0.6}$	50 $^{0-0.6}$	70 $^{0-0.6}$	30 $^{0-0.6}$	50 $^{0-0.6}$	70 $^{0-0.6}$	30 $^{0-0.6}$	50 $^{0-0.6}$	70 $^{0-0.6}$	30 $^{0-0.6}$	50 $^{0-0.6}$	70 $^{0-0.6}$
Length winding	W_{K1} [mm]	≤20			≤20			≤30			≤30			≤30		
Length winding	W_{K2} [mm]	12 $^{\pm 0.2}$			18 $^{\pm 0.2}$			25 $^{\pm 0.2}$			25 $^{\pm 0.2}$			25 $^{\pm 0.2}$		
Length connecting cables	L_K [mm]	≥ 300			≥ 400			≥ 500			≥ 500			≥ 500		
Position of the connecting cables	Ø K [mm]	11			18			18			24			30		
	RT [mm]	44			57.5			95			132			168.5		
Pitch circle diameter	Ø D6 [mm]	109			149			219			301			380		
Thread hole	a	4			4			8			12			12		
	b	M5x7			M5x7			M5x7			M6x8			M6x8		
Screw tightening torque	[Nm]	10			10			10			17.4			17.4		
Material cooling jacket	-	Aluminium			Aluminium			Aluminium			Stahl			Stahl		

Illustration 37.1

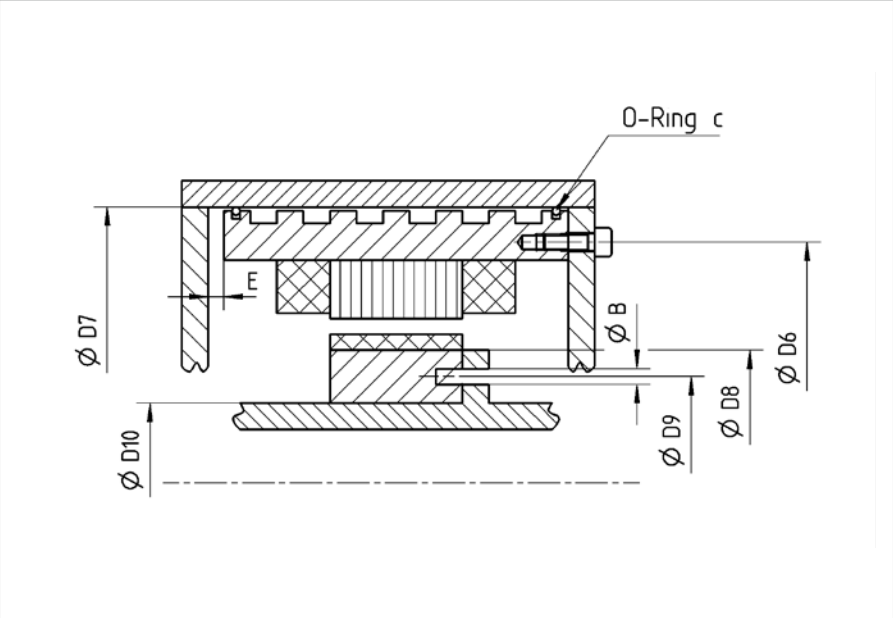


Table 37.2

Symbol [Unit]	TorkDrive-100A	TorkDrive-140A	TorkDrive-210A	TorkDrive-290A	TorkDrive-370A
Ø D6 [mm]	109	149	219	301	380
Ø D7 [mm]	120 G7	160 G7	230 G7	314 G7	392 G7
Ø D8 [mm]	65	79	160	222	250
Ø D9 [mm]	58.5 $^{\pm 0.1}$	72 $^{\pm 0.1}$	150 $^{\pm 0.1}$	214 $^{\pm 0.1}$	278 $^{\pm 0.1}$
Ø D10 [mm]	As a possible assembly method between motor shaft and motor rotor we recommend screw connection, shrink connection or adhesive bond. The tolerances for the assembly are dependent on the selected process.				
	52 g6	65 g6	140 g6	206 g6	266 g6
	Loctite 638				
Ø B [mm]	5	5	5	6	7
E [mm]	min. 0.1	min. 0.1	min. 0.1	min. 0.1	min. 0.1
c [mm]	112x2.5-NB 70	152x2.5-NB 70	215.57x2.62-NB 70	296x2.5-NB 70	375x2.5-NB 70

5.4 Electrical Installation

All work should be carried out with power off.

DANGER

Electric servo actuators and motors have dangerous live and rotating parts. All work during connection, operation, repair and disposal must be carried out only by qualified personnel as described in the standards EN50110-1 and IEC 60364! Before starting any work, and especially before opening covers, the actuator must be properly isolated. In addition to the main circuits, the user also has to pay attention to any auxilliary circuits.

Observing the five safety rules:
- Disconnect mains
- Prevent reconnection
- Test for absence of harmful voltages
- Ground and short circuit
- Cover or close off nearby live parts

The measures taken above must only be withdrawn when the work has been completed and the device is fully assembled. Improper handling can cause damage to persons and property. The respective national, local and factory specific regulations must be adhered to.

DANGER

Due to the fact that the motor contains permanent magnets, a voltage is generated at the motor terminals when the rotor is turned.

ADVICE

- The connecting leads should be suitable for the type of use, as well as the voltages and amperages concerned.
- The protective earth must be connected to the terminal marked PE.
- All cables used should be provided with a shield and in addition, the encoder cable should feature twisted pair leads.
- The power supply is switched off before connecting and disconnecting the power connection and signal connections.

ADVICE

Encoders and sensors contain electrostatically sensitive components, observe the ESD measures!

5.5 Commissioning

NOTE

Commissioning must be executed in accordance with the documentation of Harmonic Drive AG.

Before commissioning, please check that:
- The actuator is properly mounted,
- All electrical connections and mechanical connections are designed according to requirements,
- The protective earth is properly connected,
- All attachments (brakes, etc) are operational,
- Appropriate measures have been taken to prevent contact with moving and live parts,
- The maximum speed nmax is specified and cannot be exceeded,
- The set up of the drive parameters has been executed,
- The commutation is adjusted correctly.

⚠ ATTENTION

Check the direction of rotation of the load uncoupled.

In the event of changes in the normal operating behaviour, such as increased temperature, noise or vibration, switch the actuator off. Determine the cause of the problem and contact the manufacturer if necessary. Even if the actuator is only on test, do not put safety equipment out of operation.

This list may not be complete. Other checks may also be necessary.

ADVICE

Due to heat generation from the actuator itself, tests outside the final mounting position should be limited to 5 minutes of continuous running at a motor speed of less than 1000 rpm.

These values should not be exceeded in order to avoid thermal damage to the actuator.

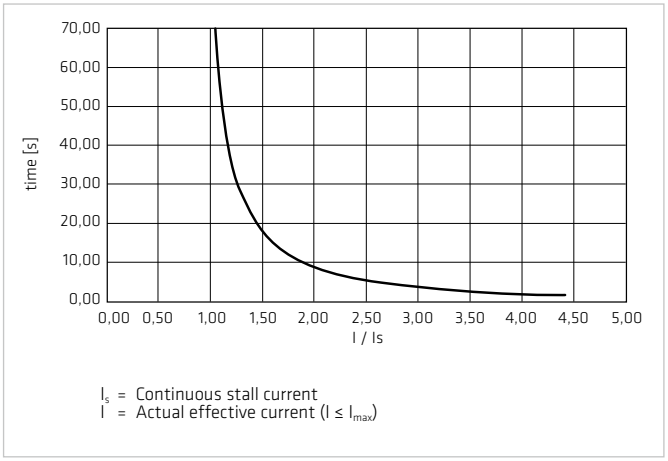
5.6 Overload Protection

Temperature sensors are integrated into the servo actuators and motors to protect them from.

To protect the servo actuators and motors from temperature overload sensors are integrated into the motor windings. The temperature sensors alone do not guarantee motor protection. Protection against overload of the motor winding is only possible only with an input speed > 0. For special applications (eg load at standstill or very low speed) is an additional overload protection by limiting the overload period.

The built specification of the integrated temperature sensors can be found in the technical data.

Illustration 39.1 Over load characteristic



In addition, it is recommended to protect the motor winding against overload by the use of I^2t monitoring integrated in the controller. The graph shows an example of the overload characteristic for the I^2t monitoring. The overload factor is the ratio between the actual RMS current and continuous stall current.

5.7 Protection against Corrosion and Penetration of Liquids and Debris

Table 40.1

	TorkDrive® without cooling jacket Variant O	TorkDrive® with cooling jacket Variant C	
		TorkDrive-100A ... 210A	TorkDrive-290A ... 370A
Corrosion protection	without	with	with
Cooling jacket material	-	Aluminium	Steel
Salt spray test	without	Hexavalent chromium free passivation	nickel plated

The product is fully protected provided that the connectors are correctly attached. Corrosion from the ambient atmosphere (condensation, liquids and gases) at the running surface of the output shaft seal is prevented.

Contact between sharp edged or abrasive objects (cutting chips, splinters, metallic or minerals dusts etc) and the output shaft seal must be prevented. Permanent contact between the output shaft seal and a permanent liquid covering should also be prevented.
A change in the operating temperature of a completely sealed actuator can lead to a pressure differential between the outside and the inside temperature of the actuator. This can cause any liquid covering the output shaft seal to be drawn into the housing which could cause corrosive damage.

As a countermeasure, we recommend the use of an additional shaft seal (to be provided by the user) or the maintenance of a constant pressure inside the actuator. Please contact Harmonic Drive AG for further information.

ADVICE

Specification sealing air: constant pressure in the actuator as described above; the supplied air must be dry and filtered with pressure at not more than 10^4 Pa.

5.8 Shutdown and Maintenance

In case of malfunctions or maintenance measures, or to shutdown the motors, proceed as follows:

1. Follow the instructions in the machine documentation.
2. Bring the actuator on the machine to a controlled standstill.
3. Turn off the power and the control voltage on the controller.
4. For motors with a fan unit; turn off the motor protection switch for the fan unit.
5. Turn off the mains switch of the machine.
6. Secure the machine against accidental movement and against unauthorised operation.
7. Wait for the discharge of electrical systems then disconnect all the electrical connections.
8. Secure the motor, and possibly the fan unit, before disassembly against falling or movement then pay attention to the mechanical connections.

⚠ DANGER

Risk of death by electric voltages. Work in the area of live parts is extremely dangerous.

- Work on the electrical system may only be performed by qualified electricians. The use of a power tool is absolutely necessary.

Observing the five safety rules:
- Disconnect mains
- Prevent reconnection
- Test for absence of harmful voltages
- Ground and short circuit
- Cover or close off nearby live parts

The measures taken above must only be withdrawn when the work has been completed and the device is fully assembled. Improper handling can cause damage to persons and property. The respective national, local and factory specific regulations must be adhered to.

⚠ ATTENTION

Burns from hot surfaces with temperatures of over 100° C

Let the motors cool down before starting work. Cooling times of up to 140 minutes may be necessary.
Wear protective gloves.
Do not work on hot surfaces!

⚠ WARNING

Persons and property during maintenance and operation

Never perform maintenance work on running machinery. Secure the system during maintenance against re-starting and unauthorised operation.

Cleaning

Excessive dirt, dust or chips may adversely affect the operation of the device and can, in extreme cases, lead to failure. At regular intervals you should therefore, clean the device to ensure a sufficient dissipation of the surface heat. Insufficient heat emissions can have undesirable consequences. The lifetime of the device is reduced if temperature overloads occures. Overtemperature can lead to the shutdown of the device.

Checking of electric connections

DANGER

Lethal electric shock by touching live parts!

In any case of defects of the cable sheath the system must be shut down immediately and the damaged cable should be replaced. Do not make any temporary repairs on the connection cables.

- Connection cord should be periodically checked for damage and replaced if necessary.
- Check optionally installed power chains (power chains) for defects.
- Protective conductor connections should be in a good condition and tightness checked at regular intervals. Replace if necessary.

Control of mechanical fasteners

The fastening screws and the load of the housing must be checked regularly.

6. Decommissioning and Disposal

The gears, servo actuators and motors from Harmonic Drive AG contain lubricants for bearings and gears as well as electronic components and printed circuit boards. Since lubricants (greases and oils) are considered hazardous substances in accordance with health and safety regulations, it is necessary to dispose of the products correctly. Please ask for safety data sheet where necessary.

7. Glossary

7.1 Technical Data

AC Voltage constant k_{EM} [V_{rms} / 1000 rpm]

Effective value of the induced motor voltage measured at the motor terminals at a speed of 1000 rpm and an operating temperature of 20° C.

Ambient operating temperature [° C]

The intended operating temperature for the operation of the drive.

Average input speed (grease lubrication) $n_{av\ (max)}$ [rpm]

Maximum permissible average gear input speed for grease lubrication.

Average input speed (oil lubrication) $n_{av\ (max)}$ [rpm]

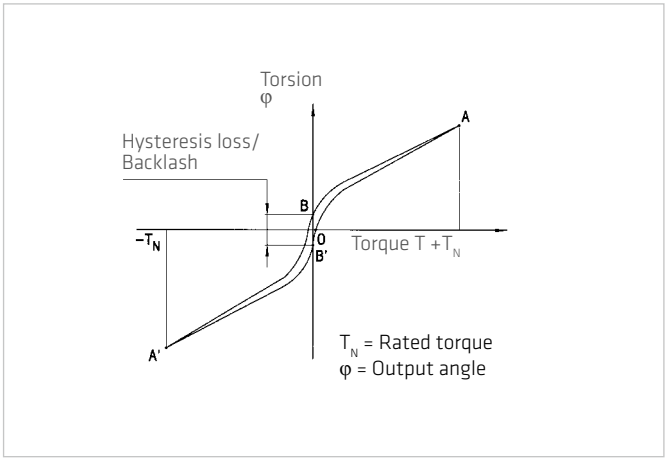
Maximum permissible average gear input speed for oil lubrication.

Average torque T_A [Nm]

When a variable load is applied to the gear, an average torque should be calculated for the complete operating cycle. This value should not exceed the specified T_A limit.

Backlash (Harmonic Planetary gears) [arcmin]

When subjected to the rated torque, Harmonic Planetary gears display characteristics shown in the hysteresis curve. When a torque is applied to the output shaft of the gear with the input shaft locked, the torque-torsion relationship can be measured at the output. Starting from point 0 the graph follows successive points A-B-A'-B'-A where the value B-B' is defined as the backlash or hysteresis.



Brake closing time t_C [ms]

Delay time to close the brake.

Brake current to hold I_{HBr} [A_{DC}]

Current for applying the brake.

Brake current to open I_{OBr} [A_{DC}]

Current required to open the brake.

Brake holding torque T_{BR} [Nm]

Torque the actuator can withstand when the brake is applied, with respect to the output.

Brake opening time t_O [ms]

Delay time for opening the brake.

Brake voltage U_{Br} [VDC]

Terminal voltage of the holding brake.

Continuous stall current I_0 [A_{rms}]

Effective value of the motor phase current to produce the stall torque.

Continuous stall torque T_0 [Nm]

Allowable actuator stall torque.

Demagnetisation current I_E [A_{rms}]

Current at which rotor magnets start to demagnetise.

Dynamic axial load $F_{A\ dyn\ (max)}$ [N]

With the bearing rotating, this is the maximum allowable axial load with no additional radial forces or tilting moments applied.

Dynamic load rating C [N]

Maximum dynamic load that can be absorbed by the output bearing before permanent damage may occur.

Dynamic radial load $F_{R\ dyn\ (max)}$ [N]

With the bearing rotating, this is the maximum allowable radial load with no additional axial forces or tilting moments applied.

Dynamic tilting moment $M_{dyn\ (max)}$ [Nm]

With the bearing rotating, this is the maximum allowable tilting moment with no additional axial forces or radial forces applied.

Electrical time constant τ_e [s]

The electrical time constant is the time required for the current to reach 63% of its final value.

Hollow shaft diameter d_H [mm]

Free inner diameter of the continuous axial hollow shaft.

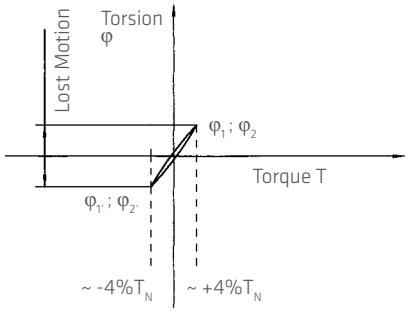
Inductance (L-L) L_{L-L} [mH]

Terminal inductance calculated without taking into account the magnetic saturation of the active motor parts.

Lost Motion (Harmonic Drive® Gearing) [arcmin]

Harmonic Drive® Gearing exhibits zero backlash in the teeth. Lost motion is the term used to characterise the torsional stiffness in the low torque region.

The illustration shows the angle of rotation φ measured against the applied output torque as a hysteresis curve with the Wave Generator locked. The lost motion measurement of the gear is taken with an output torque of about ± 4% of the rated torque.



Maximum current I_{max} [A]

The maximum current is the maximum current that can be applied for a short period.

Maximum DC bus voltage $U_{DC\ (max)}$ [VDC]

The maximum DC bus power supply for the correct operation of the actuator. This value may only be exceeded for a short period during the braking or deceleration phase.

Maximum hollow shaft diameter $d_{H\ (max)}$ [mm]

For gears with a hollow shaft, this value is the maximum possible diameter of the axial hollow shaft.

Maximum input speed (grease lubrication) $n_{in\ (max)}$ [rpm]

Maximum allowable input speed with grease lubrication.

Maximum input speed (oil lubrication) $n_{in\ (max)}$ [rpm]

Maximum allowable input speed for gearing with oil lubrication.

Maximum motor speed n_{max} [rpm]

The maximum allowable motor speed.

Maximum output speed n_{max} [rpm]

The maximum output speed. Due to heating issues, this may only be momentarily applied during the operating cycle. The maximum output speed can occur any number of times as long as the calculated average speed is within the permissible continuous operation duty cycle.

Maximum output torque T_{max} [Nm]

Specifies the maximum allowable acceleration and deceleration torques. For highly dynamic processes, this is the maximum torque available for a short period. The maximum torque can be parameterised by the control unit where the maximum current can be limited. The maximum torque can be applied as often as desired, as long as the calculated average torque is within the permissible continuous operation duty cycle.

Maximum power P_{max} [W]

Maximum power output.

Mechanical time constant τ_m [s]

The mechanical time constant is the time required to reach 63% of its maximum rated speed in a no-load condition.

Momentary peak torque T_M [Nm]

In the event of an emergency stop or collision, the Harmonic Drive® Gearing may be subjected to a brief collision torque. The magnitude and frequency of this collision torque should be kept to a minimum and under no circumstances should the collision torque occur during the normal operating cycle.

Moment of inertia J [kgm^2]

Mass moment of inertia at motor side.

Moment of inertia J_{in} [kgm^2]

Mass moment of inertia of the gearing with respect to the input.

Moment of inertia J_{out} [kgm^2]

Mass moment of inertia with respect to the output.

Motor terminal voltage (Fundamental wave only) U_M [V_{rms}]

Required fundamental wave voltage to achieve the specified performance. Additional power losses can lead to restriction of the maximum achievable speed.

Number of pole pairs p

Number of magnetic pole pairs on the rotor of the motor.

Offset R [mm]

Distance between output bearing and contact point of the load.

Pitch circle diameter d_p [mm]

Pitch circle diameter of the output bearing rolling elements.

Protection IP

The degree of protection according to EN 60034-5 provides suitability for various environmental conditions.

Rated current I_N [A]

RMS value of the sinusoidal current when driven at rated torque and rated speed.

Rated motor speed n_N [rpm]

The motor speed which can be continuously maintained when driven at rated torque T_N, when mounted on a suitably dimensioned heat sink.

Rated power P_N [W]

Output power at rated speed and rated torque.

Rated speed n_N [rpm], Mechanical

The rated speed is a reference speed for the calculation of the gear life. When loaded with the rated torque and running at rated speed the gear will reach the expected operating life L_{50}. The speed n_N is not used for dimensioning the gear.

[rpm]

Product series	**n_N**
CobaltLine®, HFUC, HFUS, CSF, CSG, CSD, SHG, SHD	2000
PMG size 5	4500
PMG size 8 to 14	3500
HPG, HPGP, HPN	3000

Rated torque T_N [Nm], Servo

The output torque which can be continuously transmitted when driven at rated input speed, when mounted on a suitably dimensioned heat sink.

Rated torque T_N [Nm], Mechanical

The rated torque is a reference torque for the calculation of the gear life. When loaded with the rated torque and running at rated speed the gear will reach the average life L_{50}. The rated torque T_N is not used for the dimensioning of the gear.

Rated voltage U_N [V_{rms}]

Supply voltage for operation with rated torque and rated speed.

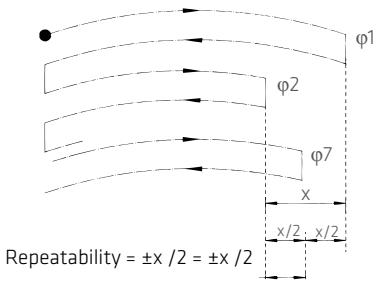
Ratio i [ ]

The ratio is the reduction of input speed to the output speed.

Note for Harmonic Drive® Gears: The standard version has the Wave Generator as the input element, the Flexspline as the output element and the Circular Spline is fixed to the housing. Since the direction of rotation of the input (Wave Generator) is opposite to the output (Flexspline), a negative ratio should be used for calculations in which the direction of rotation is to be considered.

Repeatability [arcmin]

The repeatability of the gear describes the position difference measured during repeated movement to the same desired position from the same direction. The repeatability is defined as half the value of the maximum difference measured, preceded by a ± sign.



Repeatable peak torque T_R [Nm]

Specifies the maximum allowable acceleration and braking torques. During the normal operating cycle the repeatable peak torque T_R should be not be exceeded.

Resistance (L-L, 20° C) R_{L-L} [Ω]

Winding resistance measured between two conductors at a winding temperature of 20° C.

Size

1) Actuators / Gears with Harmonic Drive® gears or Harmonic Planetary gears
The frame size is derived from the pitch circle diameter of the gear teeth in inches multiplied by 10.

2) CHM Servo motor series
The size of the CHM servo motors is derived from the stall torque in Ncm.

3) Direct drives from the TorkDrive® series
The size of the TorkDrive® series is the outer diameter of the iron core of the stator.

Static load rating C_0 [N]

Maximum static load that can be absorbed by the output bearing before permanent damage may occur.

Static tilting moment M_0 [Nm]

With the bearing stationary, this is the maximum allowable radial load with no additional axial forces or tilting moments applied.

Tilting moment stiffness K_B [Nm/arcmin]

Describes the relationship between the tilting angle of the output bearing and an applied moment load.

Torque constant (motor) k_{TM} [Nm/A_{rms}]

Quotient of stall torque and stall current.

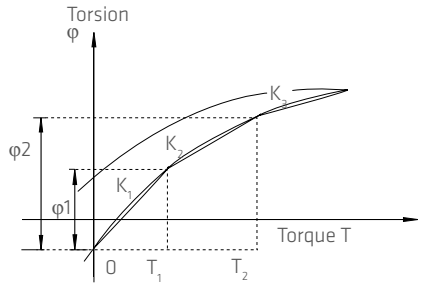
Torque constant (output) k_{Tout} [Nm/A_{rms}]

Quotient of stall torque and stall current, taking into account the transmission losses.

Torsional stiffness (Harmonic Drive® Gears) K_3 [Nm/rad]

The amount of elastic rotation at the output for a given torque with the Wave Generator blocked. The torsional stiffness K_3 describes the stiffness above a defined reference torque where the stiffness is almost linear.

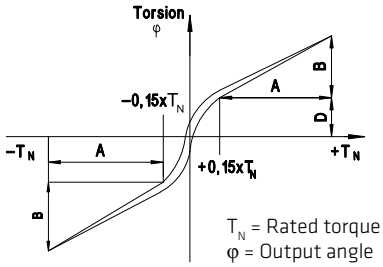
The value given for the torsional stiffness K_3 is an average that has been determined during numerous tests. The limit torques T_1 and T_2 and calculation example for the total torsional angle can be found in sections 3 and 4 of this documentation.



K_1, K_2, K_3 = Torsional stiffness, w = Output angle
$\varphi 1$ = Torsion angle, with output torque T_1
$\varphi 2$ = Torsion angle, with output torque T_2

Torsional stiffness (Harmonic Planetary gears) K [Nm/rad]

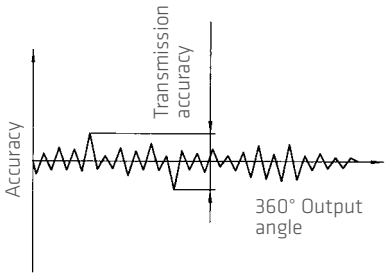
The amount of elastic rotation at the output for a given torque and blocked input shaft. The torsional rigidity of the Harmonic Planetary gear describes the rotation of the gear above a reference torque of 15% of the rated torque. In this area the torsional stiffness is almost linear.



T_N = Rated torque
φ = Output angle

Transmission accuracy [arcmin]

The transmission accuracy of the gear represents the linearity error between input and output angle. The transmission accuracy is measured for one complete output revolution using a high resolution measurement system. The measurements are carried out without direction reversal. The transmission accuracy is defined as the sum of the maximum positive and negative differences between the theoretical and actual output rotation angles.



Weight m [kg]

The weight specified in the catalog is the net weight without packing and only applies to standard versions.

7.2 Labelling, Guidelines and Regulations

CE-Marking

With the CE marking, the manufacturer or EU importer declares in accordance with EU regulation, that by affixing the CE mark the product meets the applicable requirements in the harmonization legislation established the Community.

REACH Regulation

REACH is a European Community Regulation on chemicals. REACH stands for Registration, Evaluation, Authorization and Restriction of Chemicals.

RoHS EU Directive

The RoHS EU Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment.

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Subject to technical changes

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