

Engineering Data
Harmonic Planetary Gears HPN



Harmonic
Drive AG



More information on our planetary gears can be found [HERE!](#)

Contact us today!

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1. General

About this documentation

This document contains safety instructions, technical data and operation rules for products 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 products 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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1.1 Description of Safety Alert Symbols

Symbol	Meaning
	Indicates an imminent hazardous situation. If this is not avoided, death or serious injury could occur.
	Indicates a possible hazard. Care should be taken or death or serious injury may result.
	Indicates a possible hazard. Care should be taken or slight or minor injury may result.
	Describes a possibly harmful situation. Care should be taken to avoid damage to the system and surroundings.
	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

The contents, images and graphics contained in this document are protected by copyright. In addition to the copyright, logos, fonts, company and product names can also be protected by brand law or trademark law. The use of text, extracts or graphics requires the permission of the publisher or rights holder.

We have checked the contents of this document. Since errors cannot be ruled out entirely, we do not accept liability for mistakes which may have occurred. Notification of any mistake or suggestions for improvements will be gratefully received and any necessary correction will be included in subsequent editions.

2. Safety and Installation Instructions

Please take note of the information and instructions in this document. Specially designed models may differ in technical detail. If in doubt, we recommend to 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 EN 50110-1 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 auxiliary 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 products 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 heart pacemaker, implants or similar. Vulnerable individuals must not be in the close proximity of the product.



DANGER

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



DANGER

Danger of injury due to improper handling of batteries.

Observing of the battery safety rules:

- do not insert batteries in reverse. Observe the + and - marks on the battery and on the electrical device
- do not short circuit
- do not recharge
- do not open or deform
- do not expose to fire, water or high temperature
- do not leave discharged batteries in the electrical device
- keep batteries out of reach of children. In case of ingestion of a battery, seek medical assistance promptly.

 **WARNING**

The successful and safe operation of products requires proper transport, storage and assembly as well as correct operation and maintenance.



ATTENTION

Use suitable lifting equipment to move and lift products 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

Harmonic Drive® Products are intended for industrial or commercial applications.

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

The products may only be operated within the operating ranges and environmental conditions shown in the documentation (altitude, degree of protection, temperature range, etc).

Before commissioning of plants and machinery including Harmonic Drive® Products, the compliance with the Machinery Directive must be established.

2.3 Non Intended Purpose

The use of products outside the areas of application mentioned above or beyond the operating areas or environmental conditions described in the documentation is considered as non-intended purpose.

2.4 Use in Special Application Areas

The use of the products in one of the following application areas requires a risk assessment and approval by Harmonic Drive AG.

- 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
- Household devices
- Medical equipment
- Devices which interact directly with the human body
- Machines or equipment for transporting or lifting people
- Special devices for use in annual markets or leisure parks

2.5 Declaration of Conformity

2.5.1 Gears

Harmonic Drive® Gears are components for installation in machines as defined by the Machinery Directive. Commissioning is prohibited until the end product conforms to the provisions of this directive.

Essential health and safety requirements were considered in the design and manufacture of these gear component sets. This simplifies the implementation of the Machinery Directive by the end user for the machinery or the partly completed machinery. Commissioning of the machine or partly completed machine is prohibited until the end product conforms to the Machinery Directive.

2.5.2 Servo Actuators and Motors

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 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.

According to the EMC directive Harmonic Drive® Servo Actuators and Motors are inherently benign equipment, unable to generate electromagnetic disturbance or to be affected by such disturbance.

The conformity to the EU directives of equipment, plant and machinery in which Harmonic Drive® Servo Actuators and Motors are installed must be provided by the user before taking the device into operation.

Equipment, plant and machinery with inverter driven motors must satisfy the protection requirements of the EMC directive. It is the responsibility of the user to ensure that the installation is carried out correctly.

3. Technical Description

3.1 Product Description

Affordability combined with precision

The HPN Series Planetary Gears are available in five sizes with thirteen gear ratios between 3 and 50. Offering repeated peak torque from 9 to 752 Nm with a backlash of just 5 (single-stage) to 7 (double-stage) arcmin, this gear series is ideal for low backlash applications. The outstanding price to performance ratio offers a precision gear solution where low backlash and cost represent a combined value.

HPN Series is built around a helical gearing concept that exhibits very smooth running and is extremely quiet. To support your application load, the gears are provided with two widely spaced bearings on the output side. The gears are available with standard flanges for various motor types.

Based on a combination of high torque capacity and low backlash, HPN Planetary Gears offer a compact solution for your application. Standard servo motors can be simply coupled to the lifetime lubricated gears.

With the introduction of the new HPN Series we extend our portfolio to supply additional customer cost benefits.

3.2 Ordering Code

Table 9.1

Series	Size	Ratio													Version	Code for motor adaption	
		3	4	5	7	10	15	20	25	30	35	40	45	50			
HPN	11A														J6, J8	xx.xx	
	14A	3	4	5	7	10	15	20	25	30	35	40	45	50			
	20A	3	4	5	7	10	15	20	25	30	35	40	45	50			
	32A	3	4	5	7	10	15	20	25	30	35	40	45	50			
	40A	3	4	5	7	10	15	20	25	30	35	40	45	50			
Ordering code																	
HPN	-	11A	-	4	-	J6											BH-AF1

Table 9.2

Output	
Ordering code	Description
J6	Output shaft with key
J8	Output shaft without key

Table 9.3

Version	
Code for motor adaption	Description
xx.xx	Depending on motor type

Clarification of the technical data can be found in the Glossary

3.3 Technical Data

3.3.1 General Technical Data

Table 10.1

	Symbol [Unit]	HPN-11A											
		single stage				double stage							
Number of stages													
Ratio	i []	4	5	7	10	15	20	25	30	35	40	45	50
Repeated peak torque	T_R [Nm]	14	16	11	9	24	24	24	26	26	26	26	26
Rated torque	T_N [Nm]	14	14	11	9	18	22	20	25	26	26	26	26
Momentary peak torque	T_M [Nm]	40	40	40	40	40	40	40	40	40	40	40	40
Maximum input speed (grease lubrication)	$n_{in(max)}$ [rpm]	10000											
Average input speed (grease lubrication)	$n_{av(max)}$ [rpm]	3000											
Weight	m [kg]	0.44				0.57							
Backlash	[arcmin]	≤ 5				≤ 7							
Torsional stiffness	K_3 [$\cdot 10^3$ Nm/rad]	2											
Ambient operating temperature	[°C]	0 ... 40											
Output bearing¹⁾													
Dynamic radial load	$F_{R\ dyn(max)}$ [N]	480											
Dynamic axial load	$F_{A\ dyn(max)}$ [N]	640											

¹⁾ Calculated for an L_{50} life time of 20000 hours operating at an output speed of 100 rpm

Table 10.2

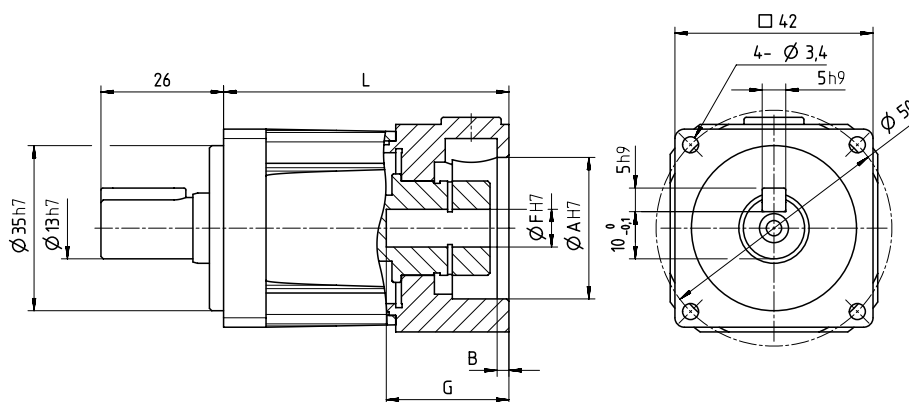
	Symbol [Unit]	HPN-14A												
		single stage				double stage								
Number of stages														
Ratio	i []	3	4	5	7	10	15	20	25	30	35	40	45	50
Repeated peak torque	T_R [Nm]	25	50	50	37	18	43	49	38	48	49	38	38	26
Rated torque	T_N [Nm]	22	28	29	30	18	30	30	30	40	40	30	30	26
Momentary peak torque	T_M [Nm]	89	110	107	100	79	97	100	102	98	99	100	100	94
Maximum input speed (grease lubrication)	$n_{in(max)}$ [rpm]	6000												
Average input speed (grease lubrication)	$n_{av(max)}$ [rpm]	3000												
Weight	m [kg]	0.95				1.3								
Backlash	[arcmin]	≤ 5				≤ 7								
Torsional stiffness	K_3 [$\cdot 10^3$ Nm/rad]	9,3												
Ambient operating temperature	[°C]	0 ... 40												
Output bearing¹⁾														
Dynamic radial load	$F_{R\ dyn(max)}$ [N]	840												
Dynamic axial load	$F_{A\ dyn(max)}$ [N]	900												

¹⁾ Calculated for an L_{50} life time of 20000 hours operating at an output speed of 100 rpm

3.3.2 Dimensions

Illustration 11.1

HPN-11A [mm]



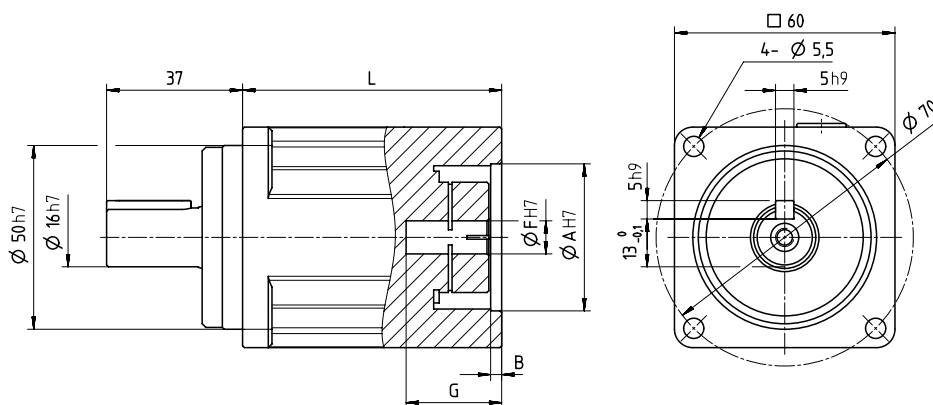
A, B, F, G and L depends on the motor type

Table 11.2

Length	Unit	single stage	double stage
L	[mm]	60	80

Illustration 11.3

HPN-14A [mm]



A, B, F, G and L depends on the motor type

Table 11.4

Length	Unit	single stage		double stage	
		min	max	min	max
L	[mm]	70	75	95	100

Table 12.1

	Symbol [Unit]	HPN-20A												
		single stage					double stage							
Number of stages														
Ratio	i []	3	4	5	7	10	15	20	25	30	35	40	45	50
Repeated peak torque	T_R [Nm]	74	130	149	113	54	129	147	114	139	112	112	112	75
Rated torque	T_N [Nm]	51	80	80	80	54	80	80	80	80	80	80	80	75
Momentary peak torque	T_M [Nm]	226	256	256	256	216	256	256	256	250	256	256	256	216
Maximum input speed (grease lubrication)	$n_{in(max)}$ [rpm]	6000												
Average input speed (grease lubrication)	$n_{av(max)}$ [rpm]	3000												
Weight	m [kg]	2.6					3.2							
Backlash	[arcmin]	≤ 5					≤ 7							
Torsional stiffness	$K_3 \cdot 10^3$ Nm/rad]	26												
Ambient operating temperature	[°C]	0 ... 40												
Output bearing¹⁾														
Dynamic radial load	$F_{R dyn(max)}$ [N]	1800												
Dynamic axial load	$F_{A dyn(max)}$ [N]	2200												

¹⁾ Calculated for an L_{50} life time of 20000 hours operating at an output speed of 100 rpm

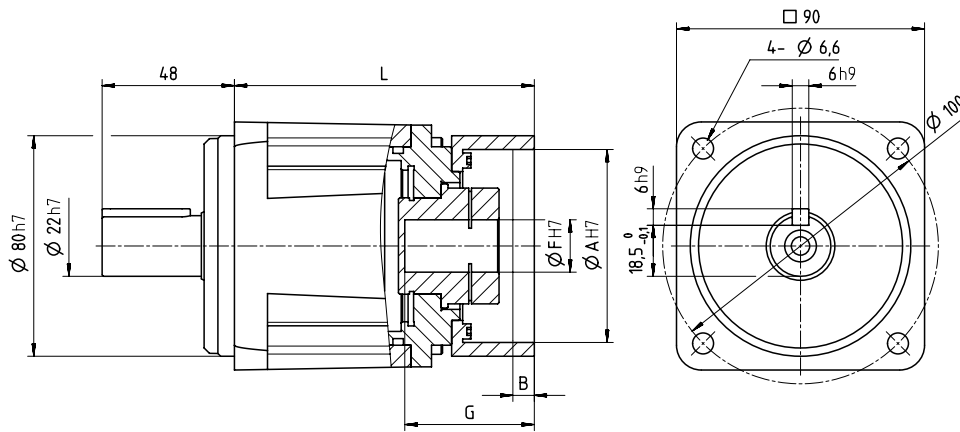
Table 12.2

	Symbol [Unit]	HPN-32A												
		single stage					double stage							
Number of stages														
Ratio	i []	3	4	5	7	10	15	20	25	30	35	40	45	50
Repeated peak torque	T_R [Nm]	254	376	376	376	185	376	376	376	376	376	376	376	251
Rated torque	T_N [Nm]	153	198	200	200	185	200	200	200	250	250	300	300	251
Momentary peak torque	T_M [Nm]	625	625	625	625	625	625	625	625	625	625	625	625	625
Maximum input speed (grease lubrication)	$n_{in(max)}$ [rpm]	6000												
Average input speed (grease lubrication)	$n_{av(max)}$ [rpm]	3000												
Weight	m [kg]	6.5					7.2							
Backlash	[arcmin]	≤ 5					≤ 7							
Torsional stiffness	$K_3 \cdot 10^3$ Nm/rad]	94												
Ambient operating temperature	[°C]	0 ... 40												
Output bearing¹⁾														
Dynamic radial load	$F_{R dyn(max)}$ [N]	3900												
Dynamic axial load	$F_{A dyn(max)}$ [N]	3800												

¹⁾ Calculated for an L_{50} life time of 20000 hours operating at an output speed of 100 rpm

Illustration 13.1

HPN-20A [mm]



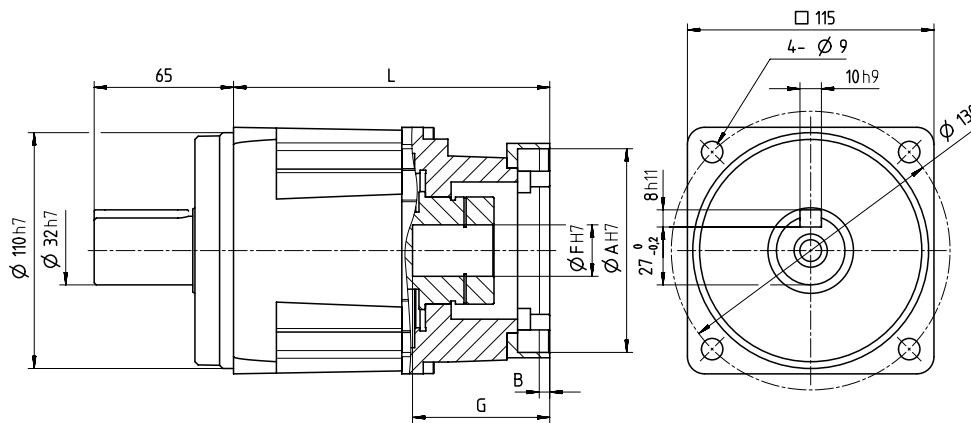
A, B, F, G and L depends on the motor type

Table 13.2

Length	Unit	single stage		double stage	
		min	max	min	max
L	[mm]	104	122	126	144

Illustration 13.3

HPN-32A [mm]



A, B, F, G and L depends on the motor type

Table 13.4

Length	Unit	single stage		double stage	
		min	max	min	max
L	[mm]	130	169	167	190

3.3.3 Accuracy

Table 15.1

		Unit	HPN-11A	HPN-14A	HPN-20A	HPN-32A	HPN-40A
Backlash	single stage	[arcmin]	< 5				
	double stage	[arcmin]	< 7				
Transmission accuracy	single stage	[arcmin]	< 8				
	double stage	[arcmin]	< 10				

3.3.4 Torsional Stiffness

Table 15.2

		Symbol [Unit]	HPN-11A	HPN-14A	HPN-20A	HPN-32A	HPN-40A
Torsional stiffness	single stage	K_3 [$\cdot 10^3$ Nm/rad]	2	9,3	26	94	143
	double stage	K_3 [$\cdot 10^3$ Nm/rad]	2	9,3	26	94	143

3.3.5 Materials Used

The ambient medium should not have any corrosive effects on the materials listed below.

Blank aluminium, lacquered aluminium, blank steel(output shaft). Adapter flange: high-strength aluminium

Screws: black phosphated

3.3.6 Bearings

Performance Data for the Output Bearing

HPN Planetary Gears are equipped with a highly stressable output bearing out of deep groove ball bearing in O-alignment. This specially developed bearing can withstand high axial and radial forces as well as high tilting moments. The reduction gear is thus protected from external loads, so ensuring a long service life and consistent performance. The integration of an output bearing also serves to reduce subsequent design and production costs, by removing the need for additional output bearings in most applications. Furthermore, installation and assembly of the reduction gear is greatly simplified. Table 16.1 ... 16.5 lists the performance data of the output bearing.

Output bearing

The HPN Series uses deep groove ball bearings to support the output shaft.
The graphs show the possible axial and radial load at different load coefficients f_w .

Table 16.1

HPN-11A

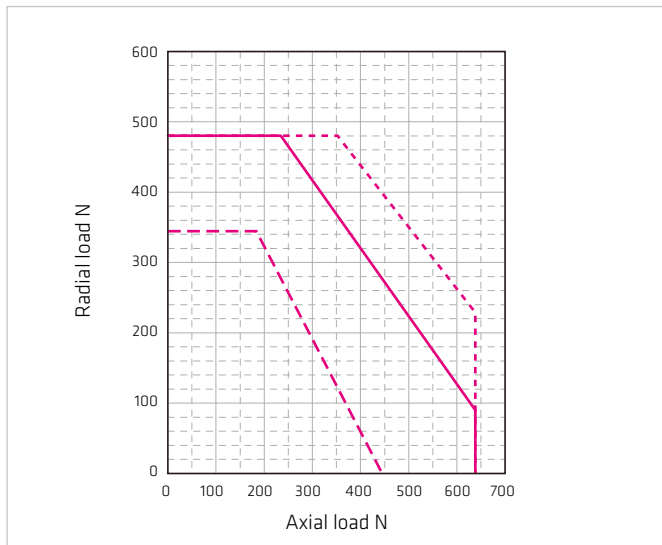


Table 16.2

HPN-14A

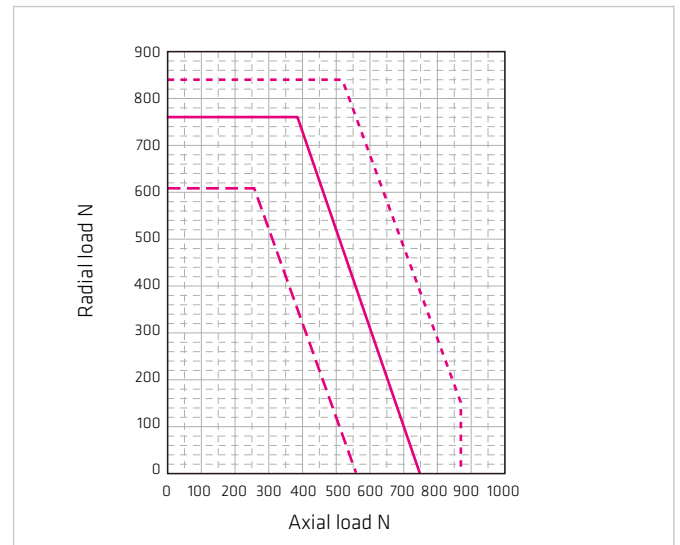


Table 16.3

HPN-20A

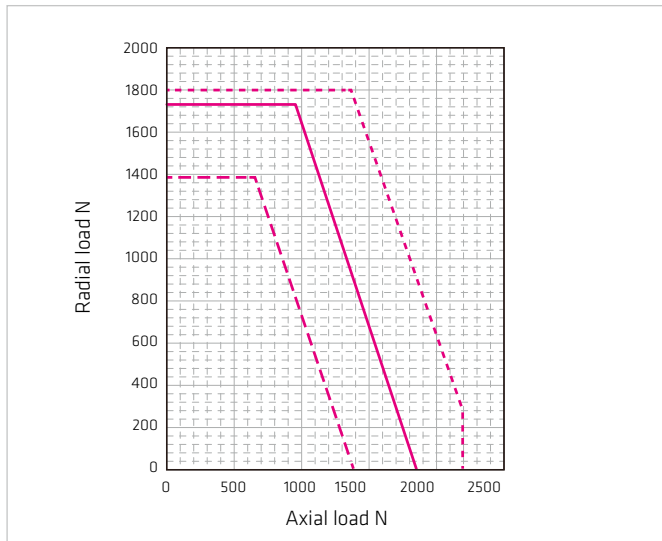


Table 16.4

HPN-32A

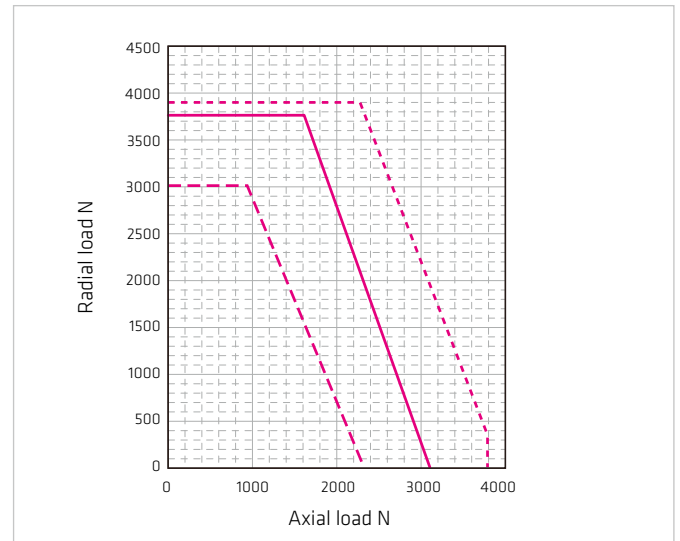
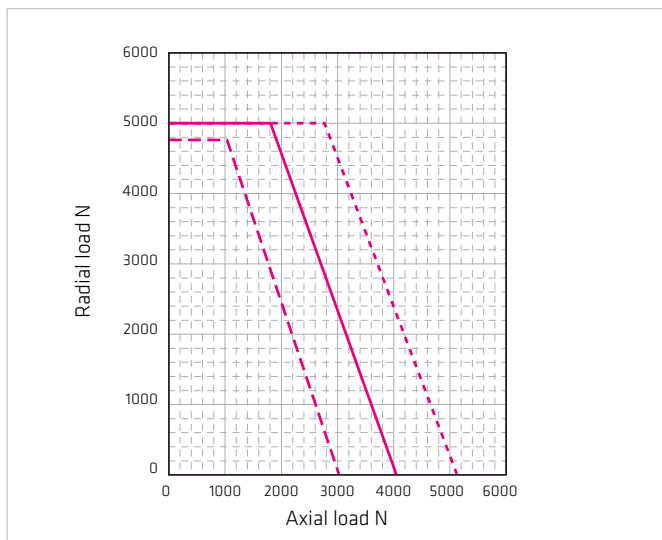


Table 16.5

HPN-40A



The graph shows the allowable load for an output shaft rotation speed of 100 rpm and bearing life of 20.000 hours.

Definition load point:

Radial load: load distribution at the center of the shaft
Axial load: load distribution at the axial center

f_w : Load coefficient

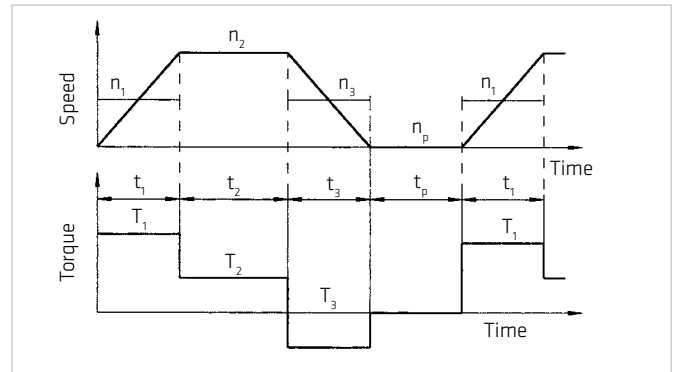
--- $f_w = 1$ — $f_w = 1,2$ - · - $f_w = 1,5$

4. Actuator Selection Procedure

4.1 Selecting Harmonic Drive® Planetary Gears

Torques	$T_1 \dots T_n$	[Nm]
during the load phases	$t_1 \dots t_n$	[s]
during the pause time	t_p	[s]
and output speeds	$n_1 \dots n_n$	[rpm]
Emergency stop/momentary peak torque	T_k	[Nm]

Illustration 17.1

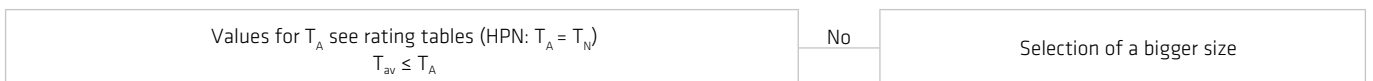


Equation 17.2

Load limit 1,
Calculation of the average output torque T_{av}

$$T_{av} = \sqrt[10/3]{\frac{|n_1 \cdot t_1| \cdot T_1^{10/3} + |n_2 \cdot t_2| \cdot T_2^{10/3} + \dots + |n_n \cdot t_n| \cdot T_n^{10/3}}{|n_1| \cdot t_1 + |n_2| \cdot t_2 + \dots + |n_n| \cdot t_n}}$$

Equation 17.3



Equation 17.4

Calculation of the average output speed

$$n_{out\ av} = \frac{|n_1| \cdot t_1 + |n_2| \cdot t_2 + \dots + |n_n| \cdot t_n}{t_1 + t_2 + \dots + t_n + t_p}$$

Equation 17.5

Average input speed

$$n_{in\ av} = i \cdot n_{out\ av}$$

Equation 17.6

Permissible maximum input speed

$$n_{in\ max} = n_{out\ max} \cdot i \leq \text{Maximum input speed (see rating table)}$$

Equation 17.7

Load limit 2, T_R

$$T_{max} \leq T_R$$

Equation 17.8

Load limit 3, T_M

$$T_k \leq T_M$$

Equation 17.9

Allowable number of momentary peak torques

$$N_{k\ max} = 10^x$$

$$x = 8.5 - 1.5 \cdot \frac{T_k}{T_R}$$

$$T_k > T_R$$

Equation 17.10

Life

$$L_{10} = 20000\ h \cdot \frac{\text{Rated input speed}}{n_{in\ av}} \cdot \left(\frac{T_N}{T_{av}}\right)^{10/3}$$

Output data

$T_1 = 40 \text{ Nm}$	$t_1 = 0.3 \text{ s}$	$n_1 = 250 \text{ rpm}$
$T_2 = 32 \text{ Nm}$	$t_2 = 3.0 \text{ s}$	$n_2 = 500 \text{ rpm}$
$T_3 = 20 \text{ Nm}$	$t_3 = 0.4 \text{ s}$	$n_3 = 250 \text{ rpm}$
	$t_p = 4.0 \text{ s}$	
$T_k = 200 \text{ Nm}$		
Ratio $i = 5$		

Equation 18.1

Load limit 1, Calculation of the average output torque T_{av}
$T_{av} = \sqrt[10/3]{\frac{250 \text{ rpm} \cdot 0.3 \text{ s} (40 \text{ Nm})^{10/3} + 500 \text{ rpm} \cdot 3 \text{ s} \cdot (32 \text{ Nm})^{10/3} + 250 \text{ rpm} \cdot 0.4 \cdot (20 \text{ Nm})^{10/3}}{250 \text{ rpm} \cdot 0.3 \text{ s} + 500 \text{ rpm} \cdot 3 \text{ s} + 250 \text{ rpm} \cdot 0.4 \text{ s}}}$

Equation 18.2

$T_{av} = 32 \text{ Nm} \leq T_A = 80 \text{ Nm}$

Selected size
HPN-20-5

Equation 18.3

Calculation of the average output speed
$n_{out\ av} = \frac{250 \text{ rpm} \cdot 0.3 \text{ s} + 500 \text{ rpm} \cdot 3 \text{ s} + 250 \text{ rpm} \cdot 0.4 \text{ s}}{0.3 \text{ s} + 3 \text{ s} + 0.4 \text{ s} + 4 \text{ s}} = 218 \text{ rpm}$

Equation 18.4

Average input speed
$n_{in\ av} = 5 \cdot 218 \text{ rpm} = 1090 \text{ rpm}$

Equation 18.5

Permissible maximum input speed
$n_{in\ max} = 500 \text{ rpm} \cdot 5 = 2500 \text{ rpm} \leq 6000 \text{ rpm}$

Equation 18.6

Load limit 2, T_R
$T_{max} = 40 \text{ Nm} \leq T_R = 149 \text{ Nm}$

Equation 18.7

Load limit 3, T_M
$T_k = 200 \text{ Nm} \leq T_M = 256 \text{ Nm}$

Equation 18.8

Permissible average input speed
$N_{k\ max} = 10^x$ $x = 8.5 - 1.5 \cdot \frac{200 \text{ Nm}}{149 \text{ Nm}} = 6.49$ $N_{k\ max} = 10^{6.49} = 3090295$

Equation 18.9

Operating life
$L_{10} = 20000 \text{ h} \cdot \frac{3000 \text{ rpm}}{1090 \text{ rpm}} \cdot \left(\frac{80 \text{ Nm}}{32 \text{ Nm}} \right)^{10/3} = 1167324 \text{ h}$

$\text{min}^{-1} \hat{=} \text{rpm}$

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

4.2 Efficiency Versus Load

4.2.1 Efficiency Calculations

The efficiency curves are mean values, which are valid for the following conditions:

Input Speed: $n = 3000$ rpm
Ambient Temperature: $25\text{ }^{\circ}\text{C}$
Lubrication: Grease PYRONOC UNIVERSAL 00

4.2.2 Efficiency Tables

Size 11

Illustration 19.1

HPN-11A-04

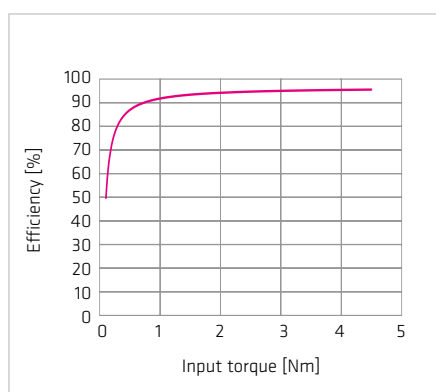


Illustration 19.2

HPN-11A-05

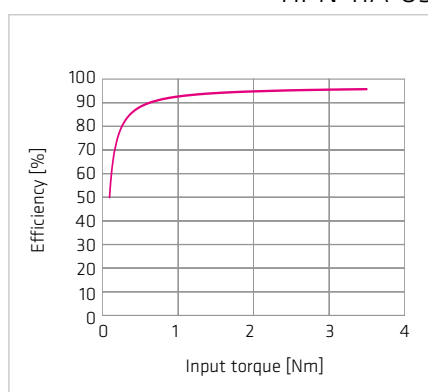


Illustration 19.3

HPN-11A-07

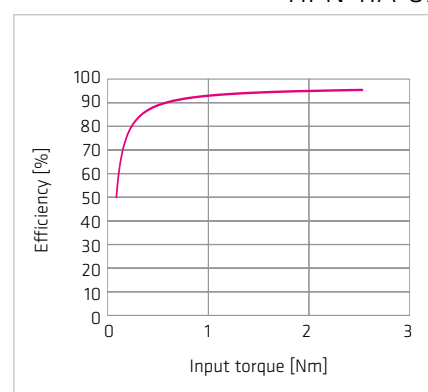


Illustration 19.4

HPN-11A-10

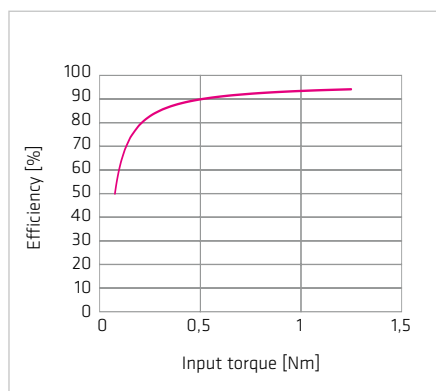


Illustration 19.5

HPN-11A-15

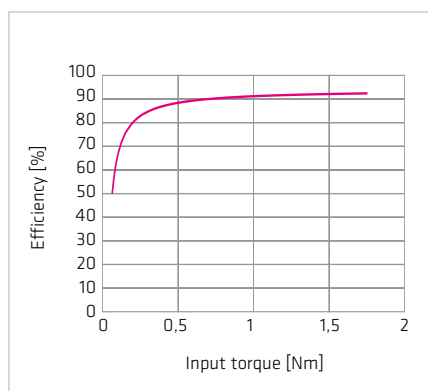


Illustration 19.6

HPN-11A-20/25

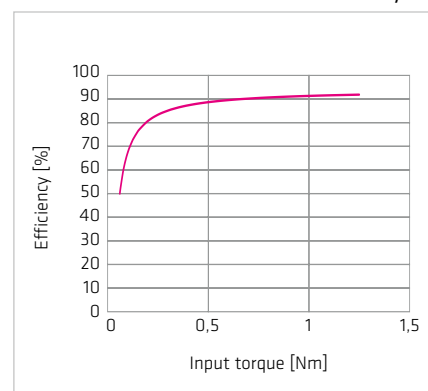


Illustration 19.7

HPN-11A-30/35

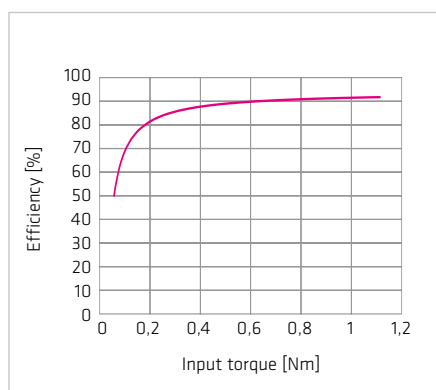
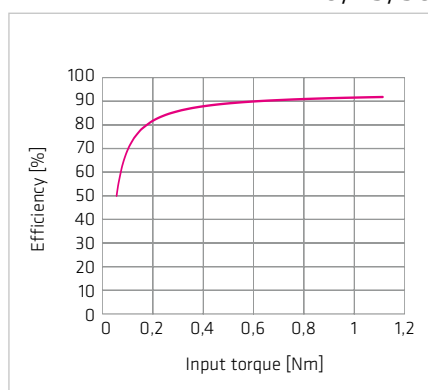


Illustration 19.8

HPN-11A-40/45/50



Size 14

Illustration 20.1

HPN-14A-03

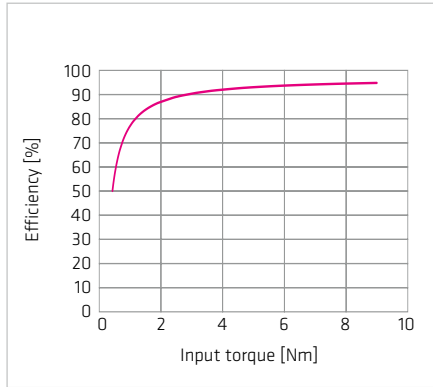


Illustration 20.2

HPN-14A-04

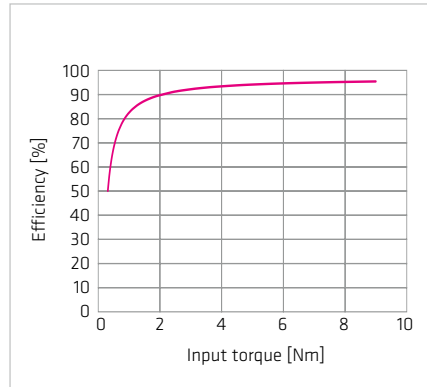


Illustration 20.3

HPN-14A-05

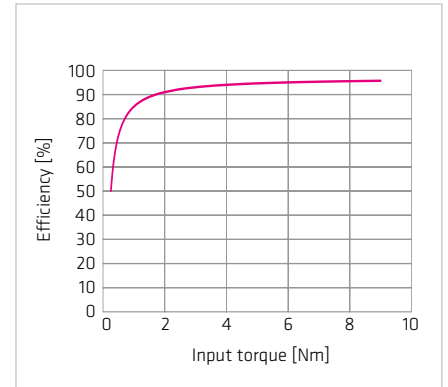


Illustration 20.4

HPN-14A-07

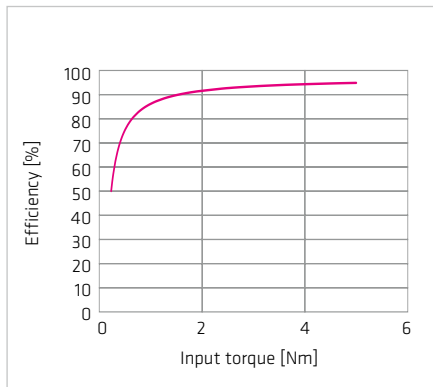


Illustration 20.5

HPN-14A-10

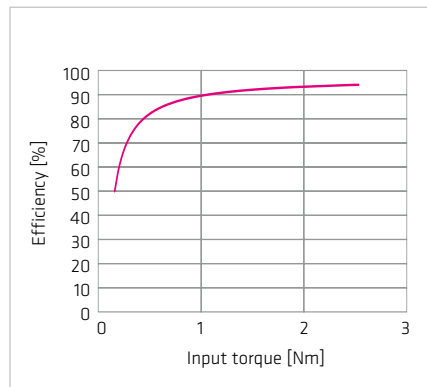


Illustration 20.6

HPN-14A-15

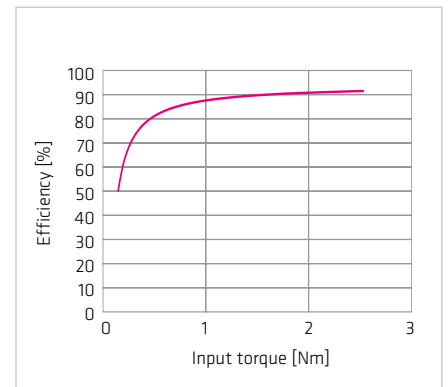


Illustration 20.7

HPN-14A-20/25

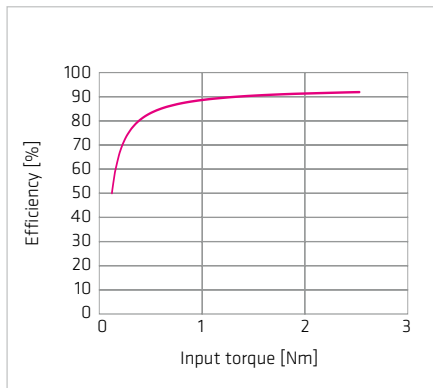


Illustration 20.8

HPN-14A-30/35

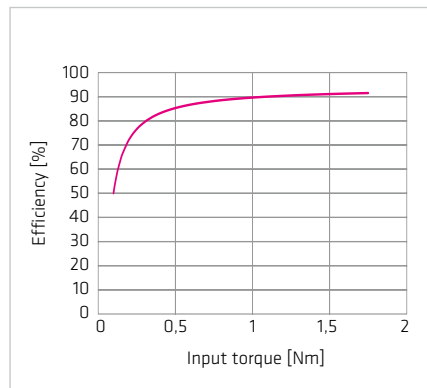
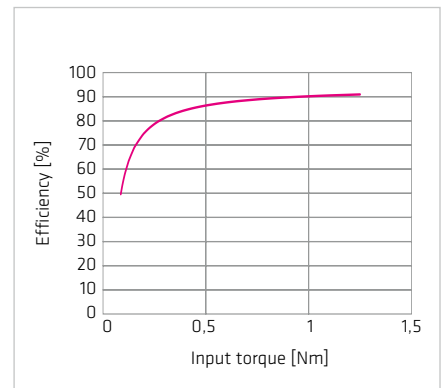


Illustration 20.9

HPN-14A-40/45/50



Size 20

Illustration 21.1 HPN-20A-03

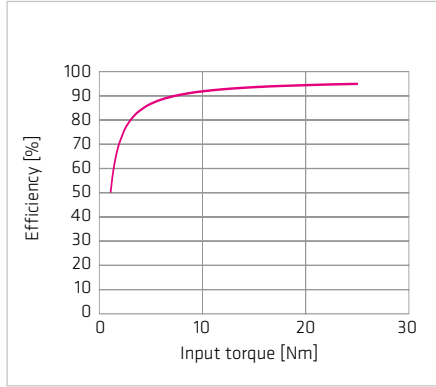


Illustration 21.2 HPN-20A-04

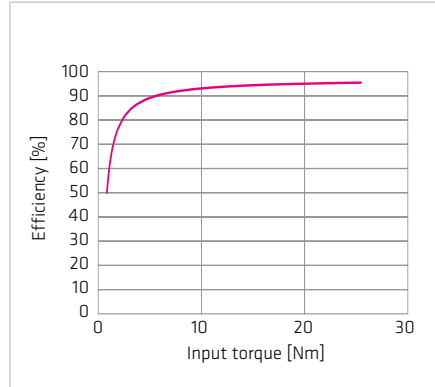


Illustration 21.3 HPN-20A-05

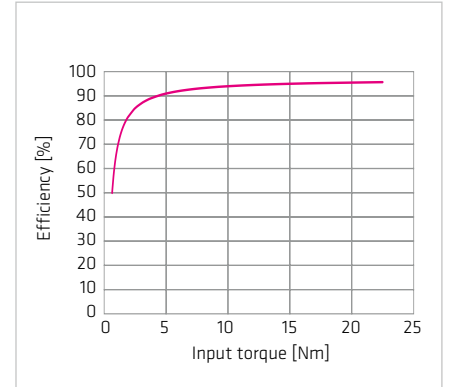


Illustration 21.4 HPN-20A-07

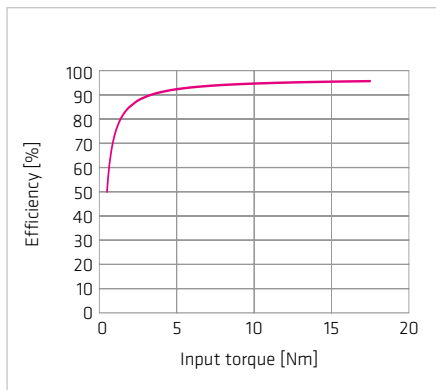


Illustration 21.5 HPN-20A-10

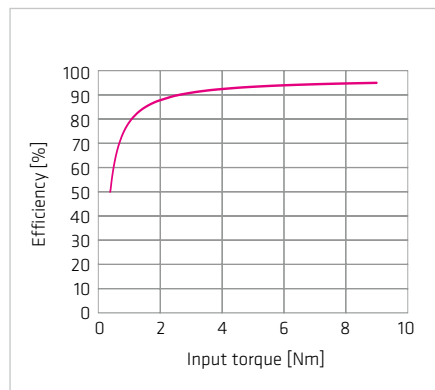


Illustration 21.6 HPN-20A-15

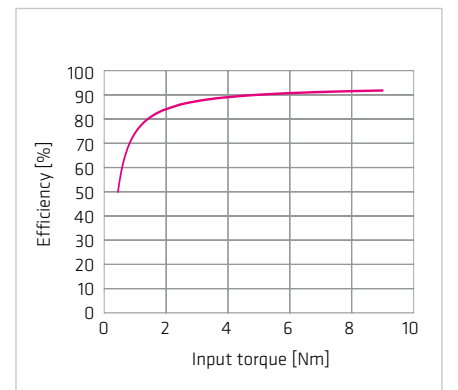


Illustration 21.7 HPN-20A-20/25

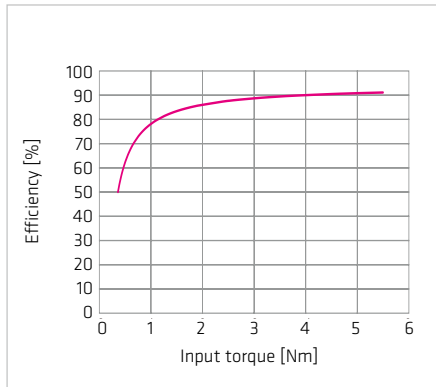


Illustration 21.8 HPN-20A-30/35

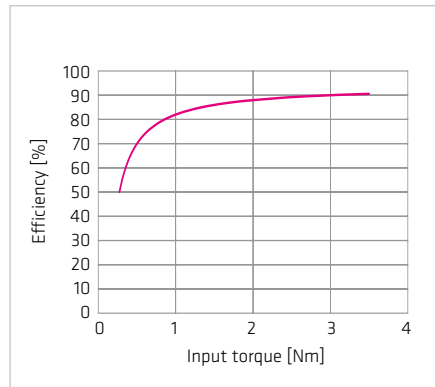
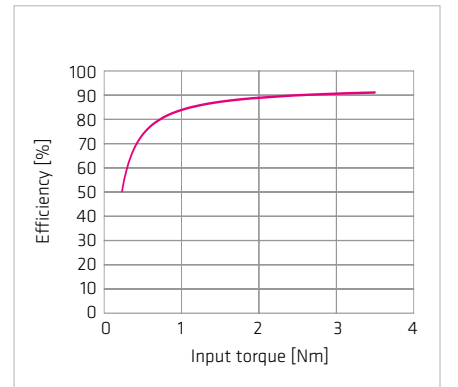


Illustration 21.9 HPN-20A-40/45/50



Size 32

Illustration 22.1 HPN-32A-03

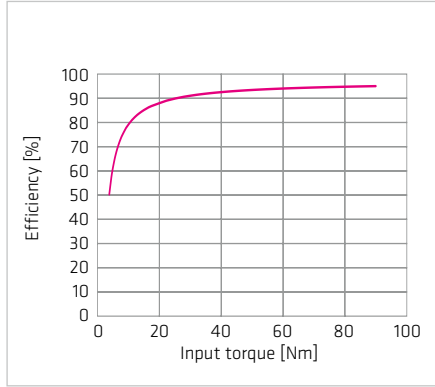


Illustration 22.2 HPN-32A-04

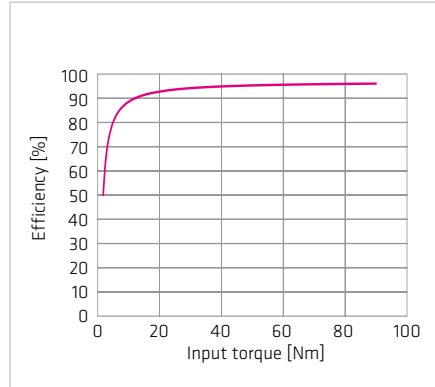


Illustration 22.3 HPN-32A-05

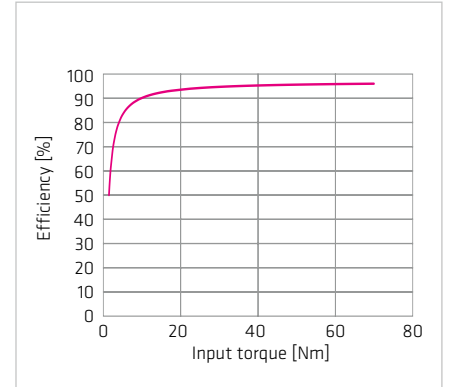


Illustration 22.4 HPN-32A-07

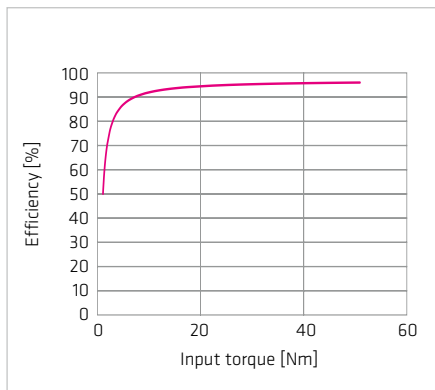


Illustration 22.5 HPN-32A-10

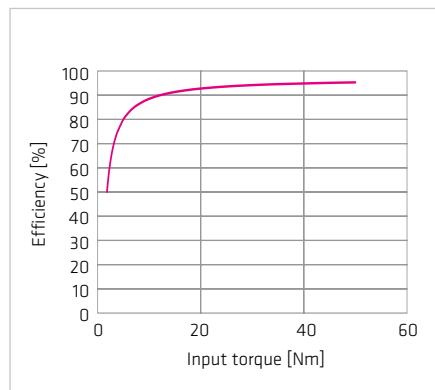


Illustration 22.6 HPN-32A-15

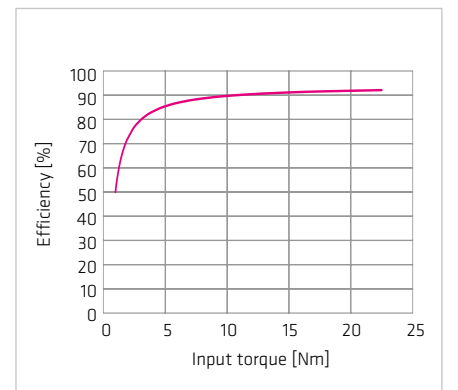


Illustration 22.7 HPN-32A-20/25

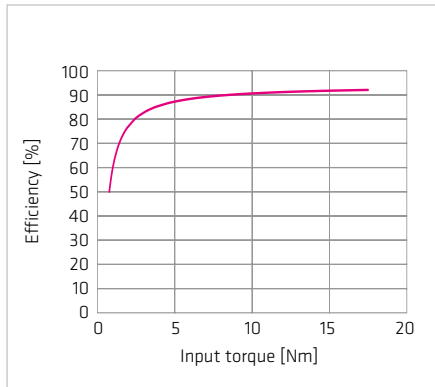


Illustration 22.8 HPN-32A-30/35

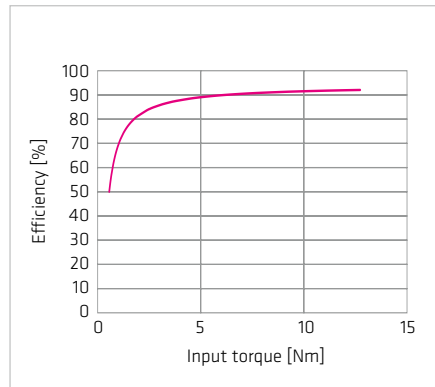
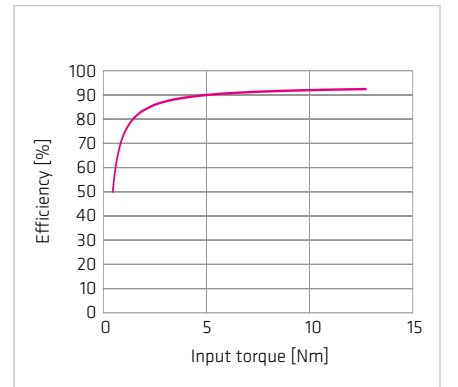


Illustration 22.9 HPN-32A-40/45/50



Size 40

Illustration 23.1 HPN-40A-03

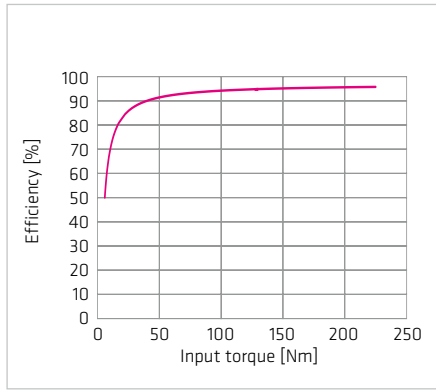


Illustration 23.2 HPN-40A-04

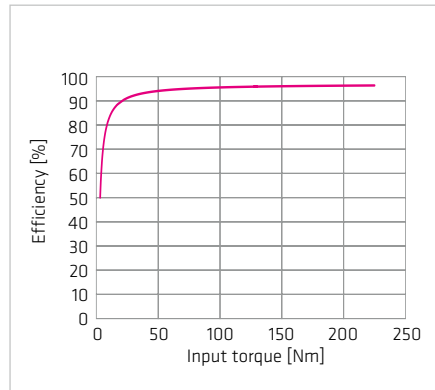


Illustration 23.3 HPN-40A-05

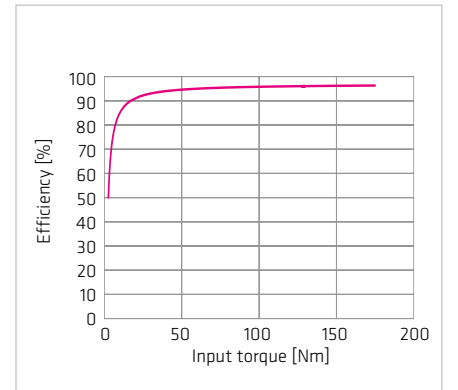


Illustration 23.4 HPN-40A-07

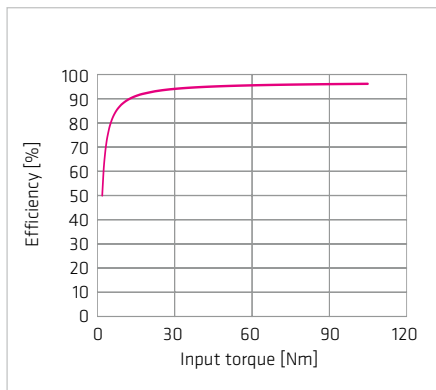


Illustration 23.5 HPN-40A-10

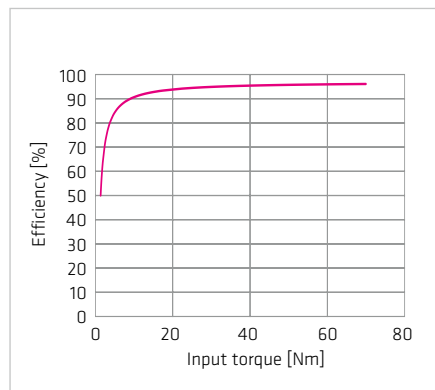


Illustration 23.6 HPN-40A-15

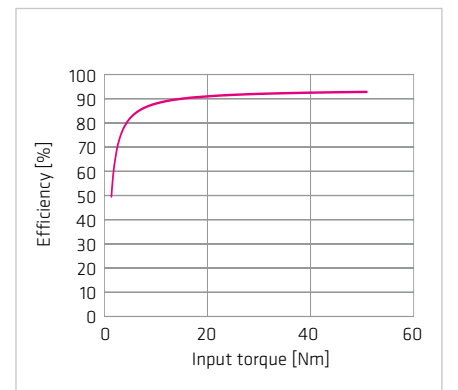


Illustration 23.7 HPN-40A-20/25

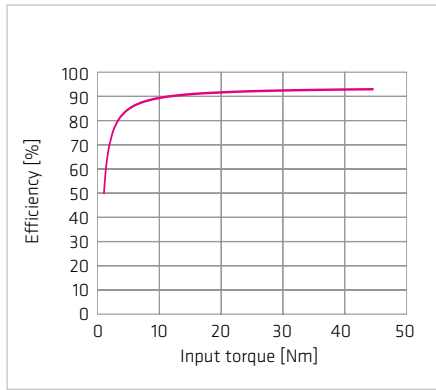


Illustration 23.8 HPN-40A-30/35

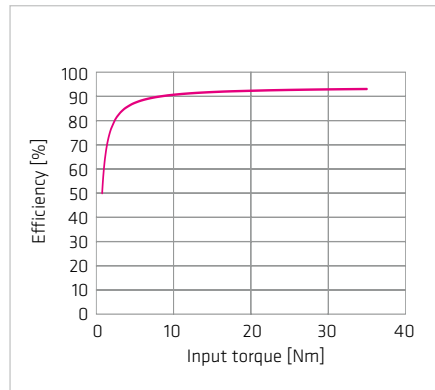
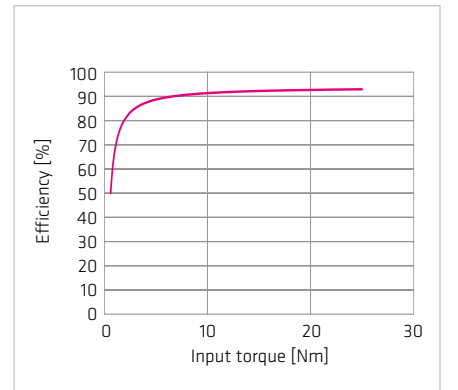


Illustration 23.9 HPN-40A-40/45/50



4.3 Lubrication

HPG Planetary Gears are delivered grease-packed. An additional grease lubrication is not necessary, either during assembly or during operation.

Applied lubricant:

PYRONOC UNIVERSAL 00

Ambient temperature range: -10 °C bis +40 °C

Maximum operating temperature: +80 °C

5. Installation and Operation

5.1 Transport and Storage

Gears should be transported in the original packaging. If the gear is not put into service immediately on receipt, it should be stored in a dry area in the original packaging. The permissible storage temperature range is -20° C to +60° C.

5.2 Gear Condition at Delivery

The gears are generally delivered according to the dimensions indicated in the confirmation drawing.

Gears with Grease Lubrication

Units are supplied with grease lubricant as standard.

5.3 Assembly Information

ADVICE

Screws which have been tightened by the gear manufacturer must not be loosened.

5.4 Assembly Instructions

A motor shaft without key groove should be used. For motor shafts with key groove the groove can be filled with a half key to prevent imbalance.

Contact between sharp-edged or abra-sive objects (cutting chips, splinters, metallic or mineral dust etc.) and the output shaft seal must be prevented.

In addition, permanent contact between the output shaft seal and a permanent liquid covering should be prevented. Please note that the changing operating temperature of a completely sealed actuator can lead to a pressure differential between the environment and the inside of the actuator. This can cause liquid covering the output shaft seal to be drawn into the gear housing, which can lead to 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 gear by applying dry filtered air at a pressure of not more than 10^4 Pa. Please contact Harmonic Drive AG for further advice.

5.4.1 Preparation for Assembly

Assembly preparation

The gear assembly must be carried out very carefully and within a clean environment. Please make sure that during the assembly procedure no foreign particles enter the gear.

General information

Clean, degrease and dry all mating surfaces to ensure an adequate coefficient of friction. The values given in table 8 are valid for 12.9 quality screws which must be tightened by means of a torque wrench. Locking devices such as spring washers or toothed washers should not be used.

Auxiliary materials for assembly

For the assembly, we recommend the application of the following auxiliary materials or the use of those with similar characteristics. Please pay attention to the application guidelines given by the manufacturer. Auxiliary materials must not enter the gear.

Surface sealing

- Loctite 5203
- Loxeal 28-10

Recommended for all mating surfaces, if the use of O-ring seals is not intended. Flanges provided with O-ring grooves must be sealed with sealing compound when a proper seal cannot be achieved using the O-ring alone.

Screw fixing

- Loctite 243

This adhesive ensures that the screw is fixed and also provides a good sealing effect. Loctite 243 is recommended for all screw connections.

Assembly paste

- Klüber Q NB 50

Recommended for O-rings which may come out of the groove during the assembly procedure. Before starting with the assembly you should spread some grease (which you can take from the gear) on all other O-rings.

Adhesives

- Loctite 638

Apply Loctite 638 to the connections between motor shaft and Wave Generator. You should make use of it only if this is specified in the confirmation drawing.

5.5 Assembly

Screws which have been tightened by the gear manufacturer must not be loosened.

5.5.1 Motor Assembly

To connect a motor to a HPN Series gear please follow the following instructions:

- Turn the coupling on the input side so that the head of the bolt aligns with the bore for the rubber cap.
- Gently insert the motor vertically into the gear.
- Fix the motor and gear by tightening the bolts on the flange (see table 26.1).
- Fasten the bolt on the input coupling (see table 26.2).
- Finally, insert the rubber cap provided.

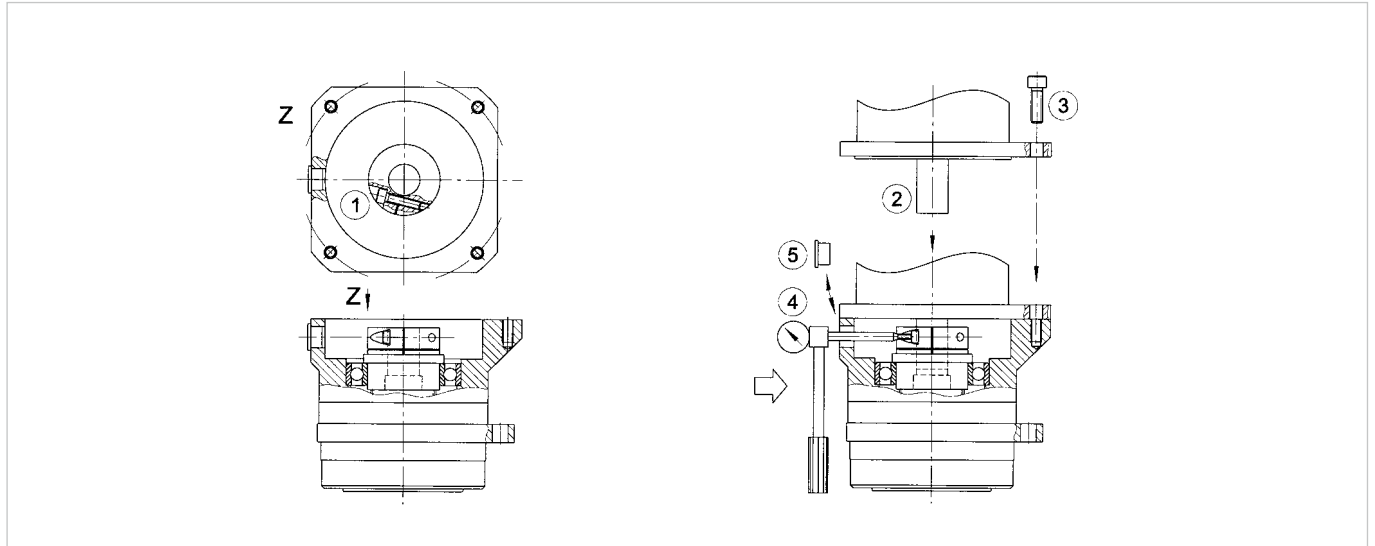
Table 26.1

Bolt Size	Unit	M3	M4	M5	M6h	M8	M10	M12
Tightening Torque	[Nm]	1.28	3.0	5.9	10.1	24.6	48.0	84.0

Table 26.2

Gear	Unit	HPN-11A	HPN-14A	HPN-14A	HPN-20A	HPN-32A	HPN-32A	HPN-40A
Bolt Size		M3	M3	M4	M4	M4	M6	M6
Tightening Torque	[Nm]	1.8	1.8	4,6	4.6	4.6	14.9	14.9

Illustration 26.3



5.5.2 Assembly of the Gear

First connect the unit housing to the machine housing. Then the load should be connected to the output flange. It is important to obey this sequence when the output bearing of the unit must support large tilting moments, radial or axial forces.

When installing the HPN in a machine, please ensure that the assembly surfaces are flat and the tapped holes are free of burrs. Fix the flange by tightening the bolts on the housing flange.

Table 271

Size	Unit	HPN-11A	HPN-14A	HPN-20A	HPN-32A	HPN-40A
Number of Bolts		4	4	4	4	4
Bolt Size		M3	M5	M6	M8	M10
Bolt pitch diameter	[mm]	50	70	100	130	165
Tightening Torque	[Nm]	1.4	6.3	10.1	26.1	51.5

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} [$V_{rms} / 1000 \text{ rpm}$]

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. The applications average input speed must be lower than the permitted average input speed of the gear.

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

Maximum permissible average gear input speed for oil lubrication. The applications average input speed must be lower than the permitted average input speed of the gear.

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 O 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}]

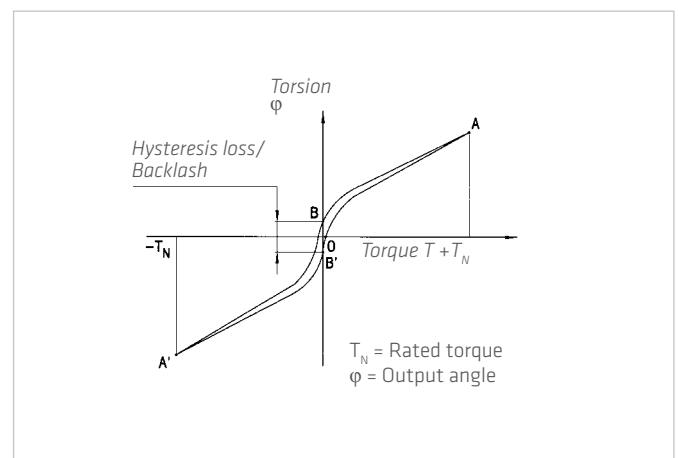
Current required to open the brake.

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. This value is not based on the equation for lifetime calculation of the output bearing but on the maximum allowable deflection of the Harmonic Drive® Component Set. This value must not be exceeded even if the lifetime calculation of the bearing permits higher values.

Electrical time constant τ_e [s]

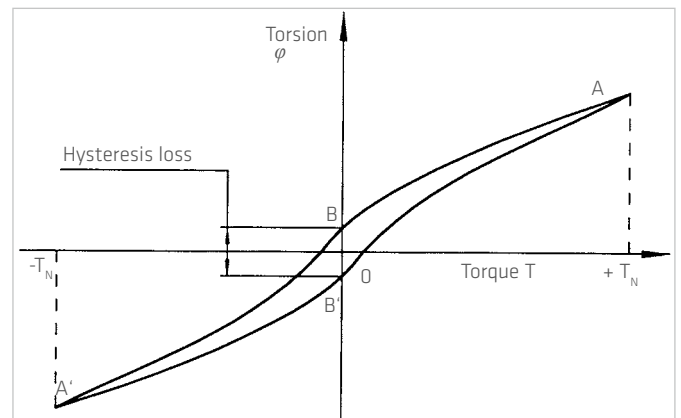
The electrical time constant is the time required for the current to reach 63 % of its final value.

Hollow shaft diameter d_H [mm]

Free inner diameter of the axial hollow shaft.

Hysteresis loss (Harmonic Drive® Gears)

When a torque is applied to the output of a Harmonic Drive® Gear with the input locked, the torque-torsion relationship measured at the output typically follows, starting from point 0, the successive points the hysteresis curve A-B-A'-B'-A (see figure). The value of the displacement B-B' is defined as the hysteresis loss.



T_N = Rated output torque
 φ = Output rotation angle

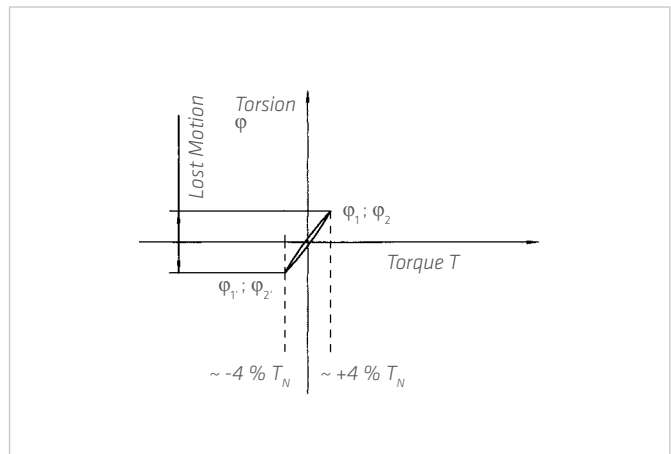
Inductance (L-L) L_{L-L} [mH]

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

Lost Motion (Harmonic Drive® Gears) [arcmin]

Harmonic Drive® Gears exhibit 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 $\pm 4\%$ 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 for short period. The maximum input speed can be applied as often as desired, as long as the application's average speed is lower than the permitted average input speed of the gear.

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

Maximum allowable input speed for gearing with oil lubrication for short period. The maximum input speed can be applied as often as desired, as long as the application's average speed is lower than the permitted average input speed of the gear.

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® Gear may be subjected to a brief momentary peak torque. The magnitude and frequency of this peak torque should be kept to a minimum and under no circumstances should the momentary peak torque occur during the normal operating cycle. The allowable number of momentary peak torque events can be calculated with the equations given in chapter "selection procedure".

Moment of inertia J [kgm²]

Mass moment of inertia at motor side.

Moment of inertia J_{in} [kgm²]

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

Moment of inertia J_{out} [kgm²]

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.

Nominal Service Life L_n [h]

When loaded with rated torque and running at rated speed the Wave Generator Bearing will reach the nominal service life L_n with 50 % probability of failure. For different load conditions the service life of the Wave Generator Bearing can be calculated using the equations in chapter "selection procedure".

Number of pole pairs p

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

Offset R [m]

Distance between output 's center plane and contact point of the load.

Pitch circle diameter d_p [m] or [mm]

Pitch circle diameter of the output bearing rolling element raceway.

Protection class 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], Servo

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

Rated speed n_N [rpm], Mechanical

The rated speed is a reference speed for the calculation of the gear life. When loaded with rated torque and running at rated speed the Wave Generator Bearing will reach the nominal service life L_n with 50 % probability of failure. The rated speed n_N is not used for the dimensioning of the gear.

Product series	Unit	n_N
CobaltLine®, HFUC, HFUS, CSF, CSG, CSD, SHG, SHD	[rpm]	2000
PMG size 5	[rpm]	4500
PMG size 8 to 14	[rpm]	3500
HPG, HPGP, HPN	[rpm]	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 rated torque and running at rated speed the Wave Generator Bearing will reach the nominal service life L_n with 50 % probability of failure. 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.

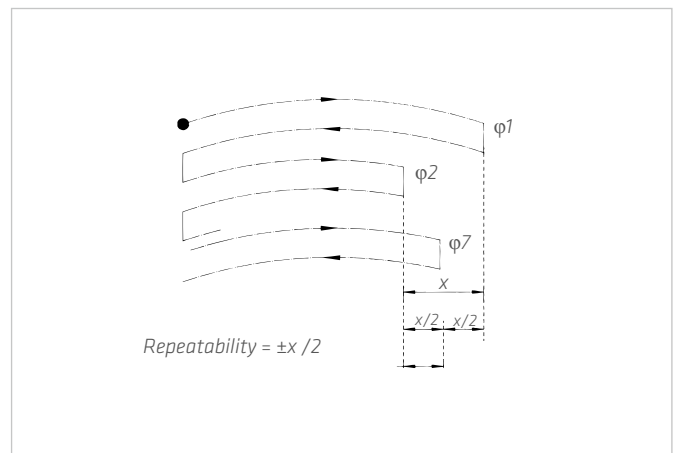
Ratio i []

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

Note for Harmonic Drive® Gears: In the standard drive arrangement, the Wave Generator is the drive element while the Flexspline is the driven 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 must 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.



Repeated peak torque T_R [Nm]

Specifies the maximum allowable acceleration and deceleration torque. During the normal operating cycle the repeated peak torque T_R must not be exceeded. The repeated peak torque can be applied as often as desired, as long as the application's average torque is lower than the permitted average torque of the gear.

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_o [N]

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

Static tilting moment M_o [Nm]

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

Synchronous inductance L_d [mH]

Sum of air gap inductance and leakage inductance in relation to the single-phase equivalent circuit diagram of the synchronous motor.

Tilting moment stiffness K_b [Nm/arcmin]

The ratio of the tilting angle of the output bearing and the 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}]

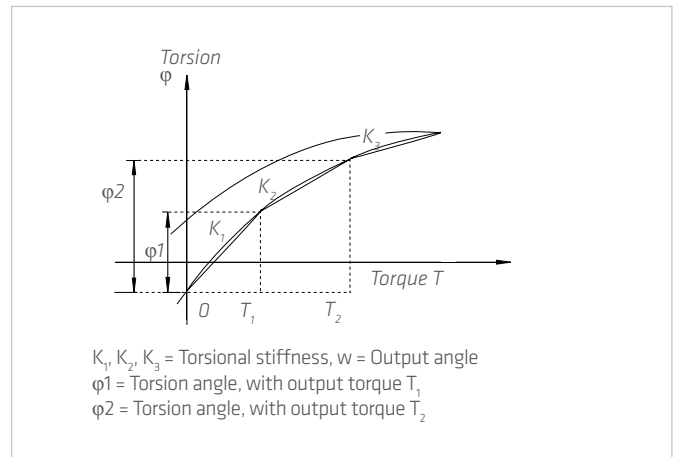
Quotient of stall torque and stall current, taking into account the transmission losses.

Torsional stiffness (Harmonic Drive® Gears) K_1, K_2, K_3 [Nm/rad]

The amount of elastic rotation at the output for a given torque with the Wave Generator blocked. The torsional stiffness may be evaluated by dividing the torque-torsion curve into three regions. The torsional stiffness values K_1, K_2 and K_3 are determined by linearization of the curve.

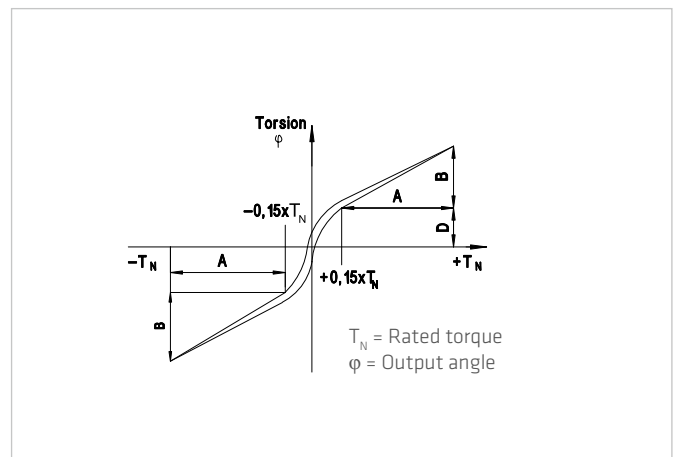
- K_1 : low torque region $0 \sim T_1$
- K_2 : middle torque region $T_1 \sim T_2$
- K_3 : high torque region $> T_2$

The values given for the torsional stiffness K_1, K_2 and K_3 are average values that have been determined during numerous tests. The limit torques T_1 and T_2 and an calculation example for the torsional angle can be found in chapter "torsional stiffness" and "calculation of the torsion angle" of this documentation.



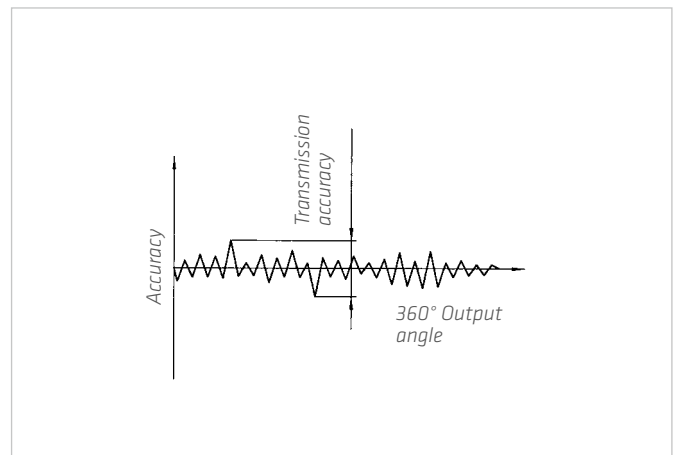
Torsional stiffness (Harmonic Planetary Gears) K_3 [Nm/rad]

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.



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 catalogue 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 the product meets the applicable requirements of the EU harmonization legislation.



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.