Harmonic Gearhead

HARMONIC DRIVE

High Performance Gearheads for Servo and Stepper Motors

HarmonicPlanetary®

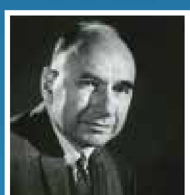
NEW HPGP / HPG / NEW HPN / HPF

HarmonicDrive®

NEW CSG-GH / CSF-GH

Revolutionary Technology for Evolving Industries

Harmonic Drive LLC engineers and manufactures precision servo actuators, gearheads and gear component sets. We work with industry-leading customers and companies of all sizes to provide both standard product and custom-engineered solutions to meet their mission critical application requirements. The majority of the products sold by HDLLC are proudly made at our US headquarters and manufacturing facility in Massachusetts. Affiliated companies in, Japan (Harmonic Drive Systems, Inc.) and Germany (Harmonic Drive AG) provide additional manufacturing capabilities.



1955

Walt Musser's Patent Application for Strain Wave Gearing

1963

Harmonic Drive® components used in inertial damping system for an unmanned helicopter

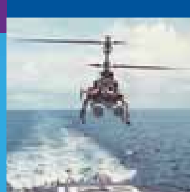


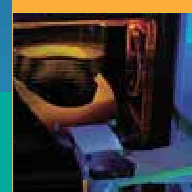
Photo credit: NASA

1971

Lunar Rover was first driven on the moon by Dave Scott. Each of the Rover's wheels were driven by a Hermetically Sealed Harmonic Drive® actuator

1977

Developed first mechatronic products (Servo Actuators) combining Harmonic Drive® gearing with servo motors and feedback sensors

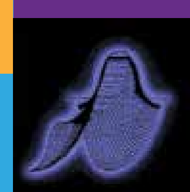


1986

First use of Harmonic Drive® gear used in semiconductor wafer handling robot

1988

"S" Tooth Profile was Patented providing double the torque, double the life and double the stiffness



1990

Began production of planetary gears

With over 50 years of experience, our expert engineering and production teams continually develop enabling technologies for the evolving motion control market. We are proud of our outstanding engineering capabilities and successful history of providing customer specific solutions to meet their application requirements.

Our high-precision, zero-backlash Harmonic Drive® gears and Harmonic Planetary® gears play critical roles in robotics, spaceflight applications, semiconductor manufacturing equipment, factory automation equipment, medical diagnostics and surgical robotics.

1998

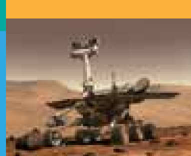
Market introduction of high precision HPG Harmonic Planetary® gearheads with low backlash for life

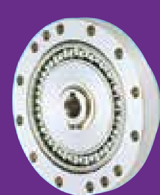
1999

Ultra-flat Harmonic Drive® gearing developed.

2004

Mars Exploration Rover Opportunity began a 90 day mission to explore the surface of Mars. 10 years later it is still operating and making new discoveries





2004

Market introduction of the CSG High Torque Harmonic Drive® gear with increased torque capacity and life

2011

Robonaut 2 launches on STS-133 and becomes the first permanent robotic crew member of the International Space Station

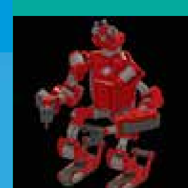
Photo credit: NASA

2011

Introduction of Hollow Shaft Harmonic Planetary® gear unit

2013

Harmonic Drive® products used by multiple teams competing in the DARPA Robotics Challenge



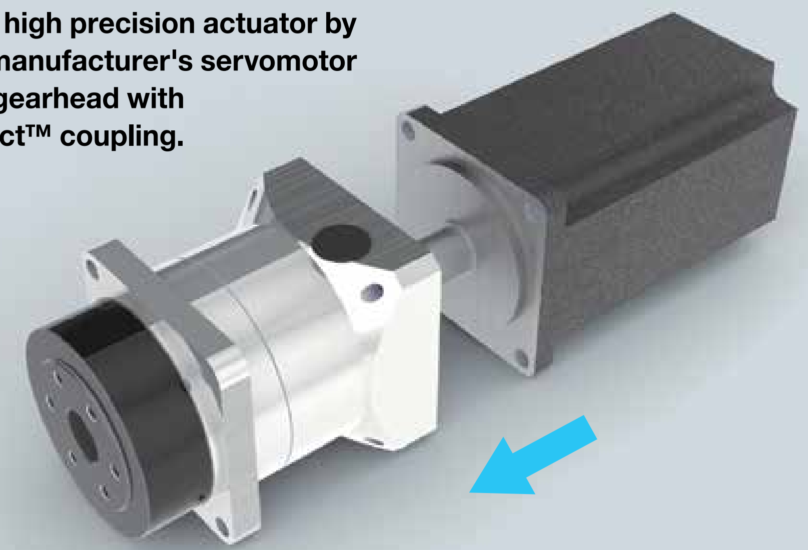
Innovative High Performance Gearheads for Servomotors

High Accuracy, High Torsional Stiffness, Long Life

Precision Harmonic Planetary® gearheads and Harmonic Drive® gearheads offer high performance for servomotors with a wide range of available gear ratios and torque capacities.

Building a high precision actuator can be easily achieved by coupling a servomotor to one of our precision Quick Connect™ gearheads.

You can create a high precision actuator by connecting any manufacturer's servomotor to our precision gearhead with our Quick Connect™ coupling.



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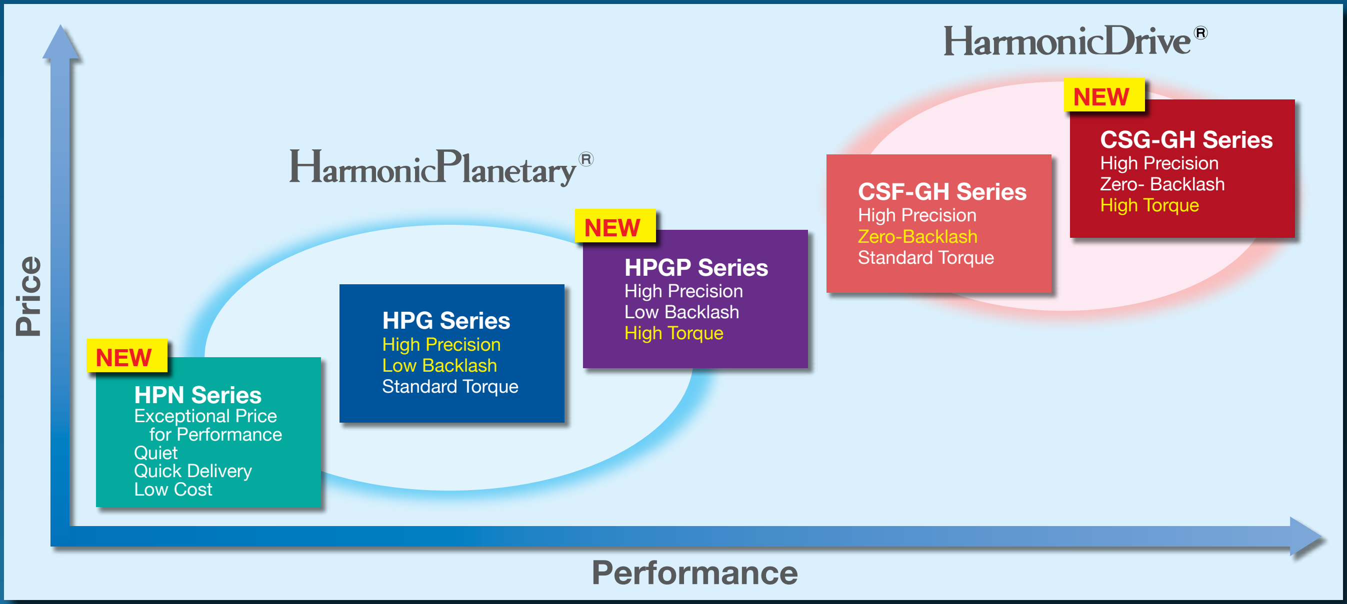
Product Lines



Product Line

Quick Connect Gearheads

HarmonicPlanetary®
HPGP High Torque Series
(Peak torque 12Nm to 3940Nm)

NEW

Size	Outline Dimension (mm)	Reduction ratio	Backlash*1		Motor power
			Standard	Reduced	
11	□40	5,21,37,45	≤ 3 arc-min	n/a	10W～200W
14,20,32	□60,□90,□120	5,11,15,21,33,45	≤ 3 arc-min	≤ 1 arc-min	30W～4kW
50	□170		≤ 3 arc-min	≤ 1 arc-min	500W～10kW
65	□230	4,5,12,15,20,25	≤ 3 arc-min	≤ 1 arc-min	1.3kW～15kW

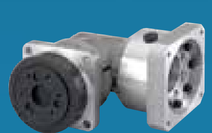
*1 For details of repeatability and transmission accuracy, refer to HPGP performance table on page 20.

HarmonicPlanetary®
HPG Standard Series
(Peak torque 5Nm to 3200Nm)

Size	Outline Dimension (mm)	Reduction ratio	Backlash*1		Motor power
			Standard	Reduced	
11	□40	5,9,21,37,45	≤ 3 arc-min	n/a	10W～100W
14,20,32	□60,□90,□120	3,5,11,15,21,33,45	≤ 3 arc-min	≤ 1 arc-min	30W～3.5kW
50	□170		≤ 3 arc-min	≤ 1 arc-min	500W～10kW
65	□230	4,5,12,15,20,25,40,50	≤ 3 arc-min	≤ 1 arc-min	1.3kW～15kW

*1 For details of repeatability and transmission accuracy, refer to HPG Performance table on page 32.

HarmonicPlanetary®
HPG Right Angle Series
(Peak torque 150Nm to 2200Nm)



Size	Outline Dimension (mm)	Reduction ratio	Backlash*1	Motor power
			Standard	
32,50	□120,□170	5,11,15,21,33,45	≤ 3 arc-min	500W～8kW
65	□230	5,12,15,20,25,40,50	≤ 3 arc-min	2kW～8kW

*1 For details of repeatability and transmission accuracy, refer to HPG Right Angle performance table on page 44.

HarmonicPlanetary®
HPN Standard Series
(Peak torque 9Nm to 752Nm)

NEW

Size	Outline Dimension (mm)	Reduction ratio *1	Backlash		Motor power
			One stage	Two stage	
11	□42	4,5,7,10,16,20,30	≤ 5 arc-min	≤ 7 arc-min	30W ～ 150W
14	□60	3,4,5,7,10,13,21,31			100W ～ 600W
20	□90				200W ～ 2kW
32	□115				400W ～ 7kW
40	□142				500W ～ 7.5kW

*1 One stage reduction ratio-3,4,5,7,10, two stage reduction ratio-13,16,20,21,30,31.

Gearhead Models

Size／Size (mm)	HarmonicPlanetary®			HarmonicDrive®
	HPGP Series	HPG Series	HPN Series	CSG/CSF-GH Series
	Gear Ratio			
11／□40 (HPN:□42)	5,21,37,45	5,9,21,37,45	4,5,7,10,16,20,30	-
14／□60	5,11,15,21,33,45	3,5,11,15,21,33,45	3,4,5,7,10,13,21,31	50,80,100
20／□90	5,11,15,21,33,45	3,5,11,15,21,33,45	3,4,5,7,10,13,21,31	50,80,100,120,160
32／□120 (HPN:□115)	5,11,15,21,33,45	3,5,11,15,21,33,45	3,4,5,7,10,13,21,31	50,80,100,120,160
40／□142	-	-	3,4,5,7,10,13,21,31	-
HPG/HPGP:50／□170 CSG/CSF:45／□170	5,11,15,21,33,45	3,5,11,15,21,33,45	-	50,80,100,120,160
65／□230	4,5,12,15,20,25	4,5,12,15,20,25,40,50	-	80,100,120,160

HarmonicDrive®
CSG-GH High Torque Series
(Peak torque 23Nm to 3419Nm)
Zero-Backlash

NEW

Size	Outline Dimension (mm)	Reduction ratio	Repeatability (arc sec)*1	Transmission Accuracy (arc min)*1	Motor power
14	□60	50,80,100	±10	1.5	30W~100W
20	□90	50,80,100,120,160	±8	1.0	100W~400W
32	□120		±6		300W~1.5kW
45	□170		±5		450W~2kW
65	□230	80,100,120,160	±4		850W~5kW

*1 For details of repeatability and transmission accuracy, refer to CSG-GH performance table on page 68.

HarmonicDrive®
CSF-GH Standard Series
(Peak torque 18Nm to 2630Nm)
Zero-Backlash

Size	Outline Dimension (mm)	Reduction ratio	Repeatability (arc sec)*1	Transmission Accuracy (arc min)*1	Motor power
14	□60	50,80,100	±10	1.5	30W~100W
20	□90	50,80,100,120,160	±8	1.0	100W~200W
32	□120		±6		300W~1kW
45	□170		±5		450W~2kW
65	□230	80,100,120,160	±4		850W~5kW

*1 For details of repeatability and transmission accuracy, refer to CSF-GH performance table on page 78.

HarmonicPlanetary® Gear Units

HarmonicPlanetary®
HPF Hollow Shaft Series
(Peak torque 100Nm to 220Nm)

NEW

Size	Outline Dimension (mm)	Hollow shaft diameter	Reduction ratio	Backlash*1
25	Ø136	Ø25	11	≤ 3 arc-min
32	Ø167	Ø30		

*1 For details of repeatability and transmission accuracy, refer to HPF Hollw shaft performance table on page 95.

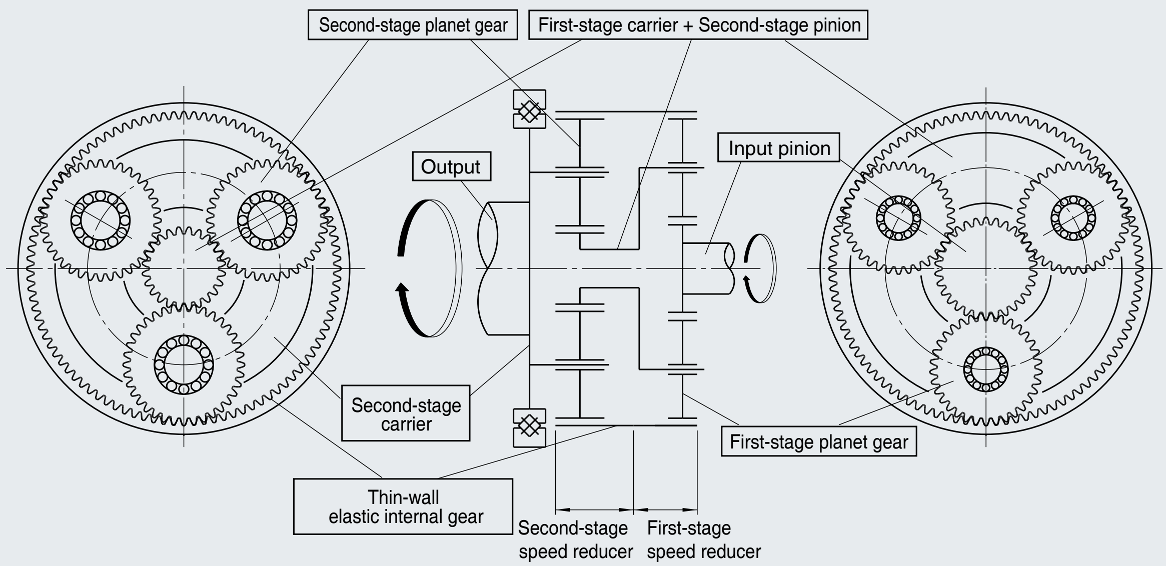
HarmonicPlanetary®
HPG Input Shaft Series
(Peak torque 3.9Nm to 2200Nm)

Size	Outline Dimension (mm)	Reduction ratio	Backlash*1	
			Standard	Reduced
11	□40	5,9,21,37,45	≤ 3 arc-min	n/a
14,20,32	□60,□90,□120	3,5,11,15,21,33,45	≤ 3 arc-min	≤ 1 arc-min
50	□170		≤ 3 arc-min	≤ 1 arc-min
65	□230	4,5,12,15,20,25,40,50	≤ 3 arc-min	≤ 1 arc-min

*1 For details of repeatability and transmission accuracy, refer to HPG Input shaft performance table on page 102.

Operating Principle HarmonicPlanetary® Gearheads

Example of a two-stage planetary speed reducer (reduction ratios 11 and higher) is illustrated.
A single-stage planetary speed reducer (reduction ratios 10 and below) utilizes the second-stage only.



First-stage

A planetary speed reducer with three planet gears.

Rotation of the input pinion transfers revolution motion to the first-stage planet gears that mesh with it. The revolution motion is then transferred to the first-stage carrier through the planetary shaft to the second-stage pinion.

The direction of rotation is the same as the input pinion.

Second-stage

A planetary speed reducer with three or four planet gears.

The second-stage pinion gear is driven by the first-stage carrier and provides the input to the second-stage planet gears. Similar to the case of the first-stage speed reducer, the rotation is then transferred to the second-stage carrier. The internal ring of the cross roller bearing serves as both the second stage carrier and as the gear output flange.

The direction of rotation is the same as the input of the first stage.

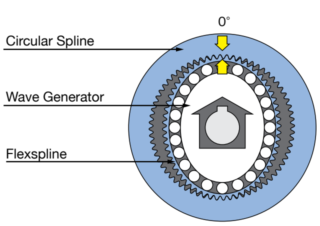
Operating Principle — HarmonicDrive® Gearheads

A simple three element construction combined with the unique operating principle puts extremely high reduction ratio capabilities into a very compact and lightweight package. The high performance attributes of this gearing technology including zero backlash, high torque, compact size, and excellent positional accuracy are a direct result of the unique operating principles.

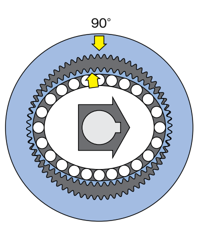
Wave Generator
The Wave Generator is a thin raced ball bearing fitted onto an elliptical hub. This serves as a high efficiency torque converter and is generally mounted onto the input or motor shaft.

Flexspline
The Flexspline is a non-rigid, thin cylindrical cup with external teeth on the open end of the cup. The Flexspline fits over the Wave Generator and takes on its elliptical shape. The Flexspline is generally used as the output of the gear.

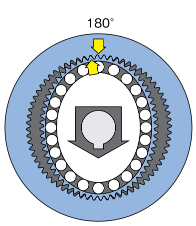
Circular Spline
The Circular Spline is a rigid ring with internal teeth. It engages the teeth of the Flexspline across the major axis of the Wave Generator ellipse. The Circular Spline has two more teeth than the Flexspline and is generally mounted onto a housing.



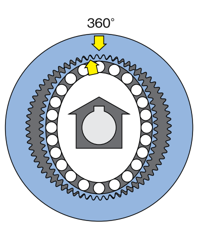
The Flexspline is slightly smaller in diameter than the Circular Spline and usually has two fewer teeth than the Circular Spline. The elliptical shape of the Wave Generator causes the teeth of the Flexspline to engage the Circular Spline at two opposite regions across the major axis of the ellipse.



As the Wave Generator rotates the teeth of the Flexspline engage with the Circular Spline at the major axis.



For every 180 degree clockwise movement of the Wave Generator the Flexspline rotates counterclockwise by one tooth in relation to the Circular Spline.



Each complete clockwise rotation of the Wave Generator results in the Flexspline moving counter-clockwise by two teeth from its original position relative to the Circular Spline. Normally, this motion is taken out as output.

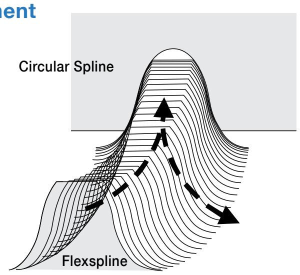
Direction of Rotation

The output rotational direction of CSG/CSF-GH series is reverse of the input rotational direction.

Input: Wave Generator (Motor shaft mounting)
Fixed: Circular Spline (Casing)
Output: Flexspline (Cross roller bearing)

Tooth behavior and engagement

The Harmonic Drive® gear utilizes a unique gear tooth profile for optimized tooth engagement. Unlike an involute tooth profile, this tooth profile (“S tooth”) enables about 30% of the total number of teeth to be engaged simultaneously. This technological innovation results in high torque, high torsional stiffness, long life and smooth rotation.



Model & Code

■Harmonic Planetary® Gearheads

HPGP - 11 A - 05 - BL3 - D - F0 - Motor Code

Model Name	Size	Design Revision	Reduction Ratio	Backlash	Input Side Bearing	Output Configuration	Input Configuration & Options
HarmonicPlanetary® HPGP High Torque	11	A	5, 21, 37, 45	BL1: Backlash less than 1 arc-min (Sizes 14 to 65) BL3: Backlash less than 3 arc-min	D: Input side contact sealed bearing (DDU) Z: Input side bearing with double non-contact shields	F0: Flange output J20: Shaft output without key J60: Shaft output with key and center tapped hole	This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.
	14		5, 11, 15, 21, 33, 45			F0: Flange output J2: Shaft output without key J6: Shaft output with key and center tapped hole (J2, J6 for Size 65 is also available)	
	20						
	32						
	50						
	65		4, 5, 12, 15, 20, 25				

HPG - 20 A - 05 - BL3 - D - F0 - Motor Code

Model Name	Size	Design Revision	Reduction Ratio	Backlash	Input Side Bearing	Output Configuration	Input Configuration & Options
HarmonicPlanetary® HPG Standard	11	B	5, 9, 21, 37, 45	BL1: Backlash less than 1 arc-min (Sizes 14 to 65) BL3: Backlash less than 3 arc-min	D: Input side contact sealed bearing (DDU) Z: Input side bearing with double non-contact shields	F0: Flange output J20: Shaft output without key J60: Shaft output with key and center tapped hole	This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.
	14	A	3, 5, 11, 15, 21, 33, 45			F0: Flange output J2: Shaft output without key J6: Shaft output with key and center tapped hole (J2, J6 for Size 65 is also available)	
	20						
	32						
	50						
	65		4, 5, 12, 15, 20, 25, 40, 50				

HPG - 32 A - 05 - J2 - RA3 - Motor Code

Model Name	Size	Design Revision	Reduction Ratio	Output Configuration	Right Angle Type	Input Configuration
HarmonicPlanetary® HPG Right Angle	32	A	5, 11, 15, 21, 33, 45	F0: Flange output J2: Shaft output without key J6: Shaft output with key and center tapped hole (J2, J6 for Size 65 is also available)	Right angle specification, RA3 or RA5.	This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.
	50					
	65		5, 12, 15, 20, 25, 40, 50			

HPN - 14 A - 05 - J6 - Motor Code

Model Name	Size	Design Revision	Reduction Ratio	Output Configuration	Input Configuration
HarmonicPlanetary® HPN High Torque	11	A	4, 5, 7, 10, 16, 20, 30	J6: Shaft output with key and center tapped hole J8: Shaft output with center tapped hole	This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.
	14		3, 4, 5, 7,1 0, 13, 21, 31		
	20				
	32				
	40				

Model & Code

Harmonic Drive® Gearheads

CSG - 20 - 100 - GH - F0 - Motor Code

Model Name	Size	Reduction Ratio	Model	Output Configuration	Input Configuration
HarmonicDrive™ CSG High Torque	14	50, 80, 100	GH: Gearhead	F0: Flange output J2: Shaft output without key J6: Shaft output with key and center tapped hole	This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.
	20	50, 80, 100, 120, 160			
	32				
	45				
	65	80, 100, 120, 160			

CSF - 20 - 100 - GH - F0 - Motor Code

Model Name	Size	Reduction Ratio	Model	Output Configuration	Input Configuration
HarmonicDrive® CSF Standard	14	50, 80, 100	GH: Gearhead	F0: Flange output J2: Shaft output without key J6: Shaft output with key and center tapped hole	This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.
	20	50, 80, 100, 120, 160			
	32				
	45				
	65	80, 100, 120, 160			

Harmonic Planetary® Gear Units

HPF - 25 A - 11 - F0 U1 - SP1

Model Name	Size	Design Revision	Reduction Ratio	Output Configuration	Input Configuration	Options
HarmonicPlanetary® HPF Hollow Shaft	25	A	11	F0: Flange output	U1: Hollow input shaft	None: Standard item SP: Special specification
	32					

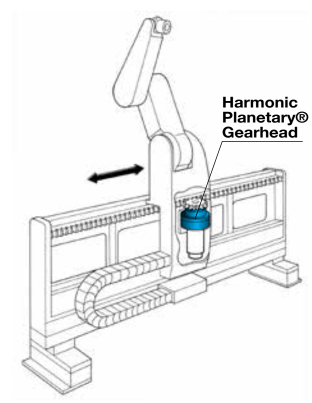
HPG - 20 A - 05 - BL3 - J2 U1 - SP1

Model Name	Size	Design Revision	Reduction Ratio	Backlash	Output Configuration	Input Configuration	Options
HarmonicPlanetary® HPG Input Shaft	11	B	5, 9, 21, 37, 45	BL1: Backlash less than 1 arc-min (Sizes 14 to 65) BL3: Backlash less than 3 arc-min	F0: Flange output J20: Shaft output without key J60: Shaft output with key and center tapped hole	U1: Input shaft (with key; no center tapped hole)	None: Standard item SP: Special specification
	14	A	3, 5, 11, 15, 21, 33, 45		F0: Flange output J2: Shaft output without key J6: Shaft output with key and center tapped hole (J2, J6 for Size 65 is also available)	U1: Input shaft (with key and center tapped hole)	
	20						
	32						
	50						
	65		4, 5, 12, 15, 20, 25, 40, 50				

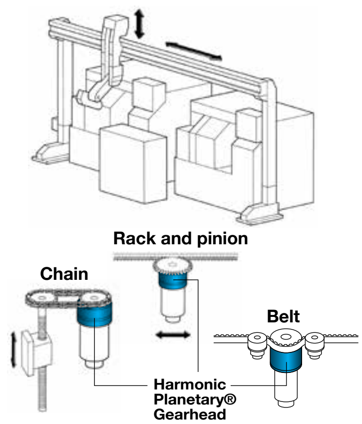
Application Examples for Harmonic Planetary® Gearheads

The Harmonic Planetary® gearheads are especially suitable for a wide range of high technology fields requiring precision motion control such as semiconductor or LCD manufacturing equipment, robot and machine tools.

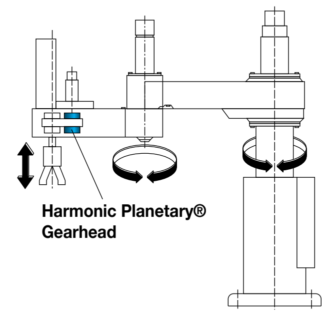
Linear axis for robots (Racks and pinion)



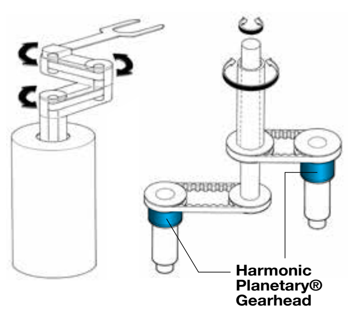
Gantry Robots



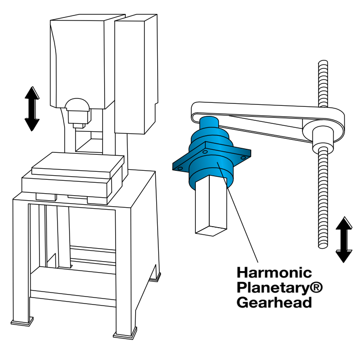
Primary axes of SCARA robots



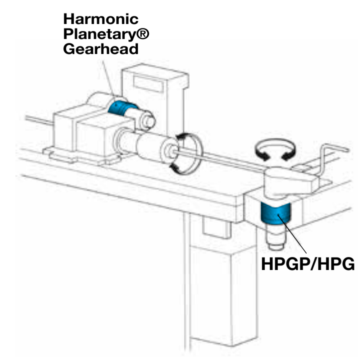
Wafer transfer robots



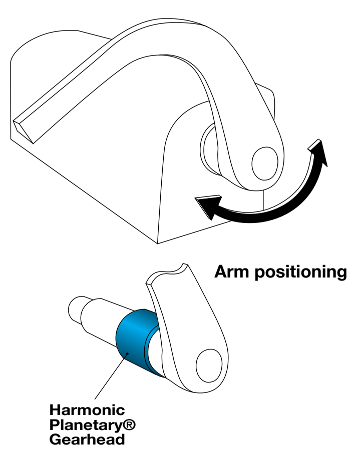
Electric presses



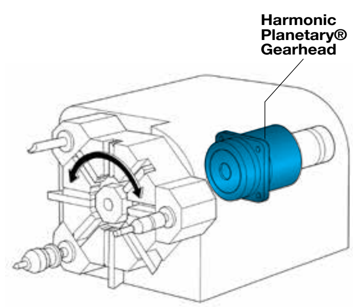
Pipe benders



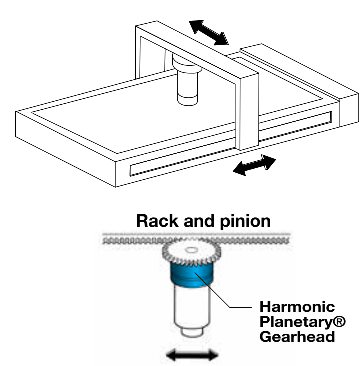
Injection molding unloading robots



Machine tool turrets



X-Y axes of machine tools



Application Examples for Harmonic Planetary® Gearheads

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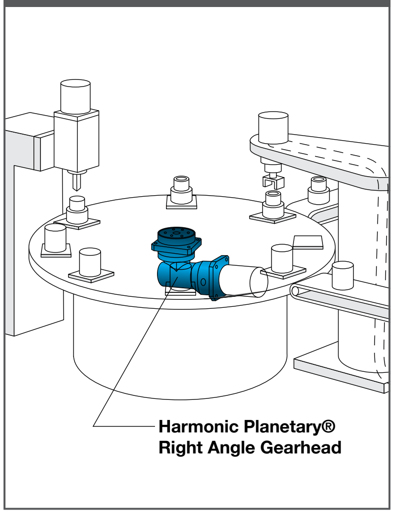
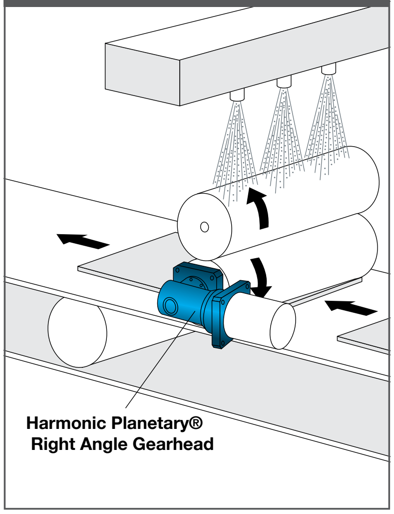
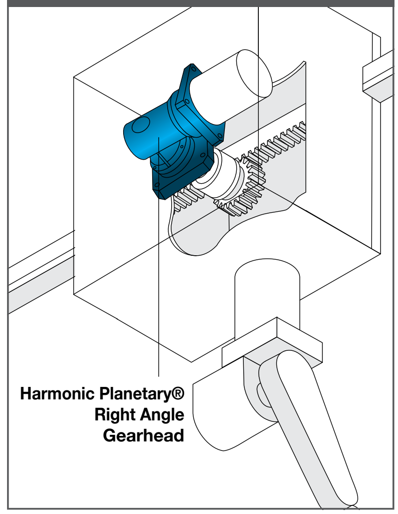


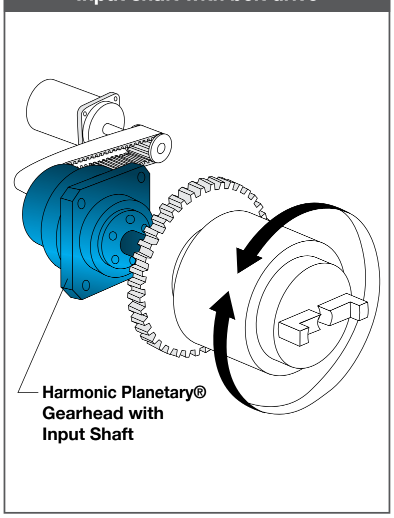
Roller Drive



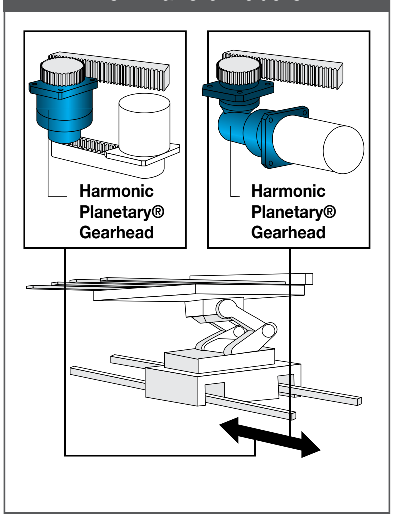
Linear Axis Drive



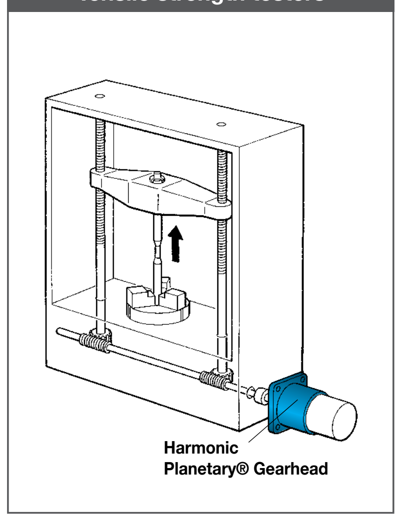
Input shaft with belt drive



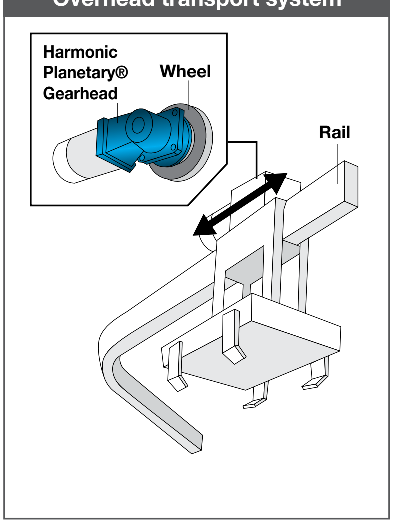
LCD transfer robots



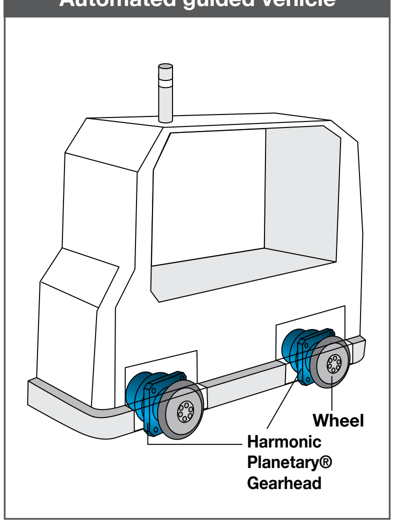
Tensile strength testers



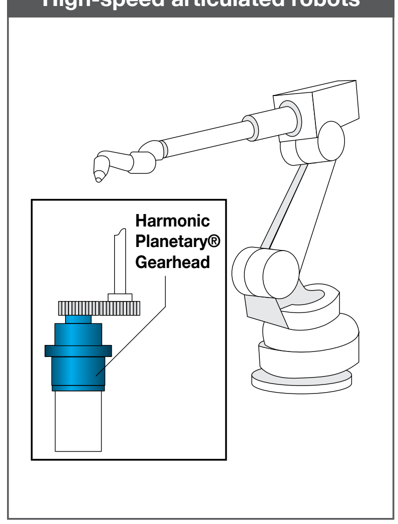
Overhead transport system



Automated guided vehicle



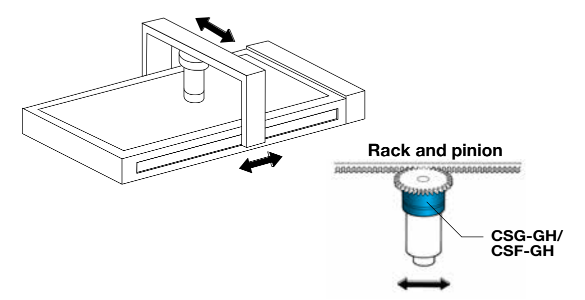
High-speed articulated robots



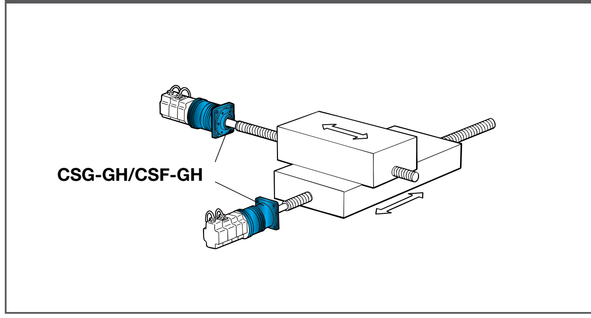
Application Examples for Harmonic Drive® Gearheads

The Harmonic Drive® gearheads series is especially suitable for a wide range of high technology applications requiring precision motion control such as semiconductor or LCD manufacturing equipment, robots and machine tools.

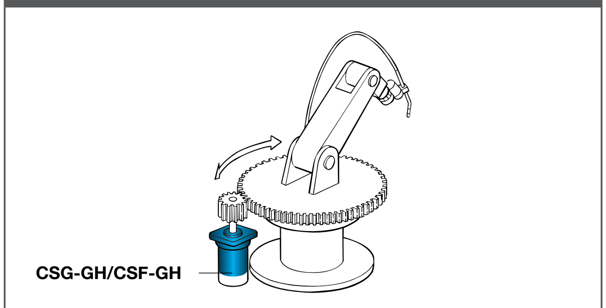
X-Y axes of machine tools



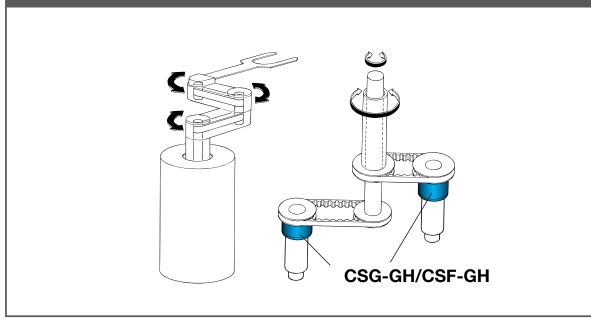
Linear Drive (XY table)



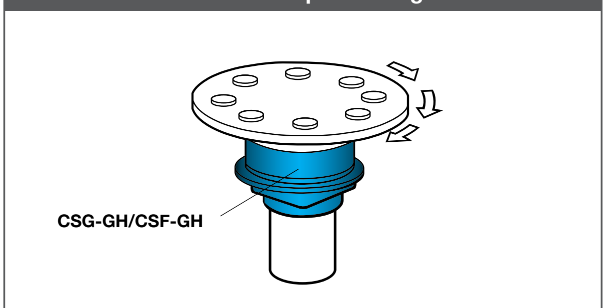
Rotation



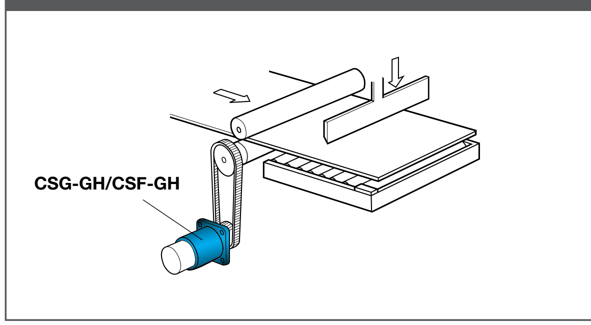
Transfer Robot



Index table positioning



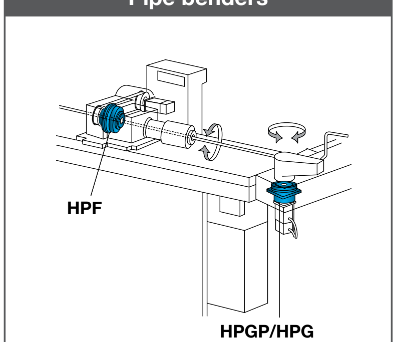
Roller drive



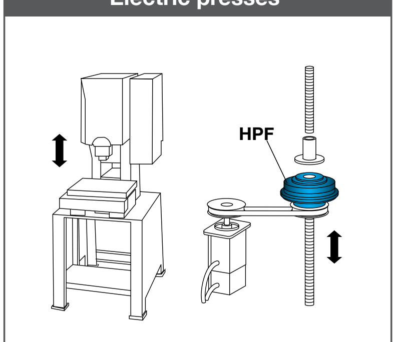
Application Examples for HPF Series Gearheads

The HPF Precision Hollow Shaft Planetary Gear is based on the HPG Harmonic Planetary® gearhead. The large coaxial hollow shaft allows cables, shafts, ball screws or lasers to pass directly through the axis of rotation. The HPF also incorporates a large output flange with an integrated Cross-Roller Bearing which can support high axial, radial and moment loads without the need for additional support bearings.

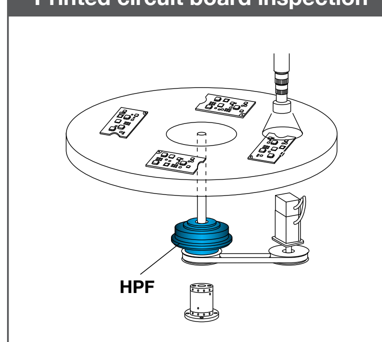
Pipe benders



Electric presses



Printed circuit board inspection



HarmonicPlanetary®

Gearheads for Servomotors

HPGP High Torque Series

HPG Standard Series

HPG Right Angle Series

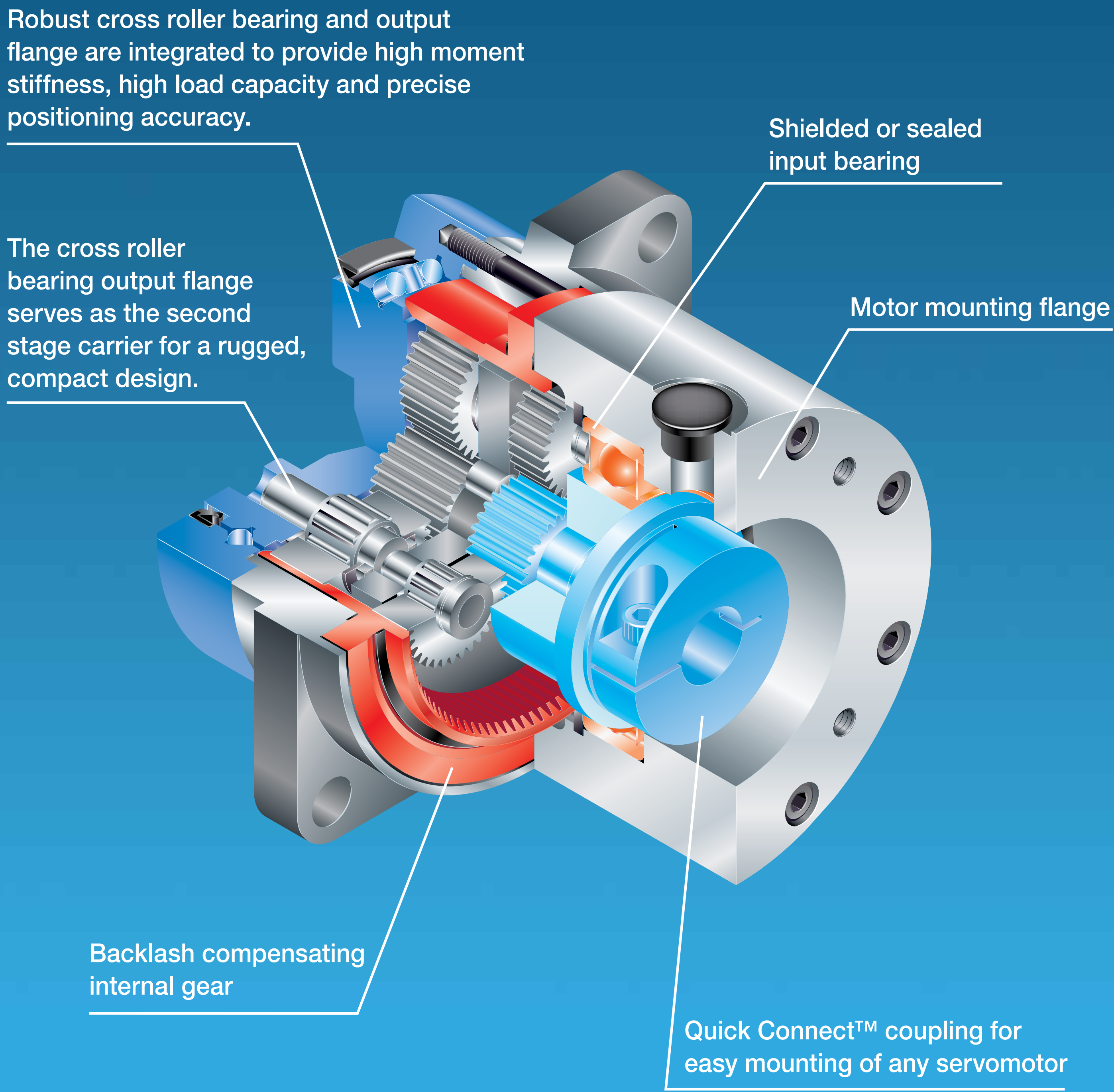
HPN Value Series

HarmonicPlanetary® HPGP ⁄ HPG Series

The thin wall flexible gear technology used for HarmonicDrive® gearing is applied to the internal gear of our planetary gear speed reducers. It allows the internal gear to deform elastically thus maintaining low backlash for the life of the gearhead, without the need for adjustment.

Planetary gears have simultaneous meshing between the sun gear and planet gears and between the planet gears and the internal gear. Some manufacturers try to reduce the backlash by controlling the dimensional precision of the parts, however this causes interference of meshing parts due to dimensional errors, resulting in uneven input torque and noise. Harmonic Planetary gears use a thin wall elastic internal gear which allows a preload of the gear and compensates for interference between meshing parts. The Harmonic Planetary® gear series incorporates this internal gear which maintains low backlash for the life of the speed reducer.

- **Low backlash: Less than 3 arc-min (Less than 1 arc-min also available)**
- **Low gear ratios, 3:1 to 50:1**
- **High efficiency**
- **High load capacity by integrating structure with cross roller bearing**
- **High-torque capacity**


Robust cross roller bearing and output flange are integrated to provide high moment stiffness, high load capacity and precise positioning accuracy.
Shielded or sealed input bearing
The cross roller bearing output flange serves as the second stage carrier for a rugged, compact design.
Motor mounting flange
Backlash compensating internal gear
Quick Connect™ coupling for easy mounting of any servomotor

HarmonicPlanetary®
HPGP High Torque Series

Size
6 Sizes

11, 14, 20, 32, 50, 65

Peak Torque

12Nm – 3940Nm

Reduction Ratio

Single Stage: 4:1 to 5:1, Two Stage: 11:1 to 45:1

Low Backlash

Standard: <3 arc-min Optional: <1 arc-min

Low Backlash for Life

Innovative ring gear automatically adjusts for backlash, ensuring consistent, low backlash for the life of the gearhead. The ring gear design automatically provides the optimum backlash in the planetary gear train and maintains the same low backlash for the life of the gearhead.

High Efficiency

Up to 95%

High Load Capacity Output Bearing

A Cross Roller bearing is integrated with the output flange to provide high moment stiffness, high load capacity and precise positioning accuracy.

Easy mounting to a wide variety of servomotors

Quick Connect™ coupling

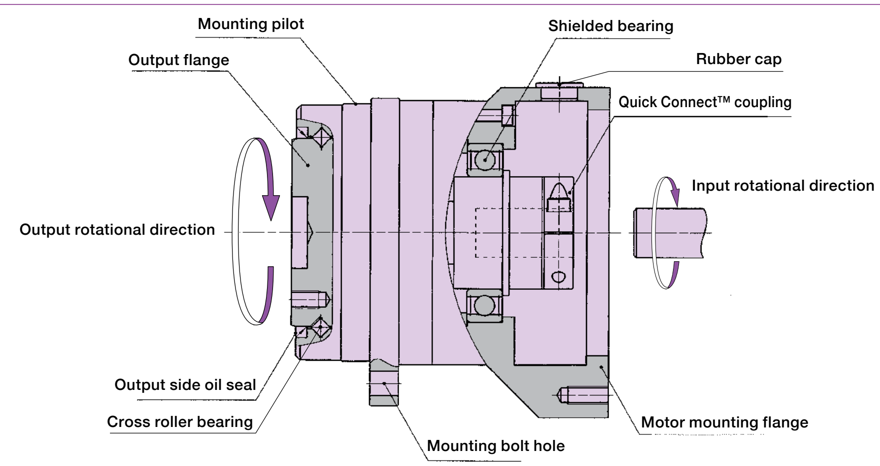
CONTENTS

HPGP - 11 A - 05 - BL3 - D - F0 - Motor Code

Model Name	Size	Design Revision	Reduction Ratio	Backlash	Input Side Bearing	Output Configuration	Input Configuration & Options
HarmonicPlanetary® HPGP High Torque	11	A	5, 21, 37, 45	BL1: Backlash less than 1 arc-min (Sizes 14 to 65)	D: Input side contact sealed bearing (DDU)	F0: Flange output J20: Shaft output without key J60: Shaft output with key and center tapped hole	This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.
	14		5, 11, 15, 21, 33, 45	BL3: Backlash less than 3 arc-min	Z: Input side bearing with double non-contact shields	F0: Flange output J2: Shaft output without key J6: Shaft output with key and center tapped hole (J2, J6 for Size 65 is also available)	
	20						
	32						
	50						
	65		4, 5, 12, 15, 20, 25				

Gearhead Construction

Figure 018-1



Rating Table

Table 019-1

<table>
<tr><th rowspan="3">Size</th><th rowspan="3">Ratio</th><th rowspan="2">Rated Torque *1</th><th rowspan="2">Limit for Repeated Peak Torque *2</th><th rowspan="2">Limit for Momentary Torque *3</th><th rowspan="2">Max. Average Input Speed *4</th><th rowspan="2">Max. Input Speed *5</th><th colspan="2">Mass *6</th></tr>
<tr><th>Shaft</th><th>Flange</th></tr>
<tr><th>Nm</th><th>Nm</th><th>Nm</th><th>rpm</th><th>rpm</th><th>kg</th><th>kg</th></tr>
<tr><td rowspan="4">11</td><td>5</td><td>6.6</td><td>12</td><td rowspan="4">20</td><td rowspan="4">3000</td><td rowspan="4">10000</td><td>0.18</td><td>0.14</td></tr>
<tr><td>21</td><td>10</td><td rowspan="3">13</td><td rowspan="3">0.24</td><td rowspan="3">0.20</td></tr>
<tr><td>37</td><td>12</td></tr>
<tr><td>45</td><td>13</td></tr>
<tr><td rowspan="6">14</td><td>5</td><td>15</td><td>39</td><td>56</td><td rowspan="6">3000</td><td rowspan="6">6000</td><td>0.54</td><td>0.42</td></tr>
<tr><td>11</td><td>20</td><td>38</td><td rowspan="5">63</td><td rowspan="5">0.63</td><td rowspan="5">0.51</td></tr>
<tr><td>15</td><td>21</td><td rowspan="4">39</td></tr>
<tr><td>21</td><td>23</td></tr>
<tr><td>33</td><td>27</td></tr>
<tr><td>45</td><td>29</td></tr>
<tr><td rowspan="6">20</td><td>5</td><td>50</td><td>133</td><td rowspan="6">217</td><td rowspan="6">3000</td><td rowspan="6">6000</td><td>1.6</td><td>1.2</td></tr>
<tr><td>11</td><td>59</td><td>156</td><td rowspan="3">1.9</td><td rowspan="3">1.5</td></tr>
<tr><td>15</td><td>70</td><td rowspan="2">142</td></tr>
<tr><td>21</td><td>78</td></tr>
<tr><td>33</td><td>72</td><td>156</td><td>2.0</td><td>1.6</td></tr>
<tr><td>45</td><td>98</td><td>142</td><td>1.9</td><td>1.5</td></tr>
<tr><td rowspan="6">32</td><td>5</td><td>150</td><td>400</td><td rowspan="6">650</td><td rowspan="6">3000</td><td rowspan="6">6000</td><td>4.4</td><td>3.0</td></tr>
<tr><td>11</td><td>160</td><td>440</td><td rowspan="3">5.1</td><td rowspan="3">3.7</td></tr>
<tr><td>15</td><td>220</td><td rowspan="2">400</td></tr>
<tr><td>21</td><td>240</td></tr>
<tr><td>33</td><td>200</td><td>440</td><td>5.4</td><td>4.0</td></tr>
<tr><td>45</td><td>280</td><td>400</td><td>5.1</td><td>3.7</td></tr>
<tr><td rowspan="6">50</td><td>5</td><td>380</td><td rowspan="2">1460</td><td>1850</td><td rowspan="6">2000</td><td rowspan="6">4500</td><td>13</td><td>10</td></tr>
<tr><td>11</td><td>450</td><td rowspan="5">2180</td><td rowspan="5">15</td><td rowspan="5">12</td></tr>
<tr><td>15</td><td>460</td><td>1500</td></tr>
<tr><td>21</td><td>490</td><td rowspan="2">1460</td></tr>
<tr><td>33</td><td>620</td></tr>
<tr><td>45</td><td>640</td><td>1360</td></tr>
<tr><td rowspan="6">65</td><td>4</td><td>1150</td><td>3520</td><td rowspan="6">4500</td><td rowspan="6">2000</td><td>2500</td><td rowspan="2">32 *7</td><td rowspan="2">22</td></tr>
<tr><td>5</td><td>1190</td><td rowspan="2">3790</td><td rowspan="5">3000</td></tr>
<tr><td>12</td><td>1350</td><td rowspan="4">47 *7</td><td rowspan="4">37</td></tr>
<tr><td>15</td><td>1670</td><td>3940</td></tr>
<tr><td>20</td><td>1520</td><td>3790</td></tr>
<tr><td>25</td><td>1900</td><td>3840</td></tr>
</table>

*1: Rated torque is based on L_{50} life of 20,000 hours at rated input speed.
*2: The limit for torque during start and stop cycles.
*3: The limit for torque during emergency stops or from external shock loads. Always operate below this value. Calculate the number of permissible events to ensure it meets required operating conditions.
*4: Maximum average input speed is limited by heat generation in the speed reducer assuming a continuous operating speed or the average input speed of a motion profile. The actual limit for average input speed depends on the operating environment.
*5: Maximum instantaneous input speed.
*6: The mass is for the gearhead only (without input shaft coupling & motor flange). Please contact us for the mass of your specific configuration.
*7: Flange output is standard for the size 65 gearhead. Shaft type (J2 & J6) is also available.

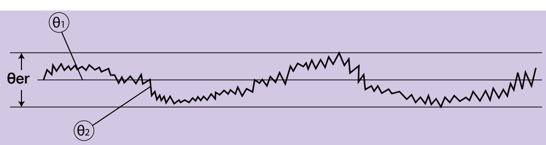
Performance Table

Table 020-1

Size	Ratio	Accuracy *1		Repeatability *2	Starting torque *3		Backdriving torque *4		No-load running torque *5	
		arc min	×10⁻⁴rad	arc sec	Ncm	kgfcm	Nm	kgfm	Ncm	kgfcm
11	5	5	14.5	±30	4.0	0.41	0.20	0.020	5.0	0.51
	21				2.9	0.29	0.60	0.061	1.3	0.13
	37				1.6	0.17		0.062	0.90	0.092
	45				1.4	0.15	0.64	0.066	0.80	0.082
14	5	4	11.6	±20	8.6	0.88	0.43	0.044	9.8	1.0
	11				8.0	0.82	0.90	0.092	4.9	0.50
	15				7.4	0.75	1.1	0.11	2.9	0.30
	21				5.2	0.53		0.12		
	33				3.3	0.34			2.0	0.20
	45				2.4	0.25				
20	5	4	11.6	±15	19	1.9	0.93	0.095	28	2.9
	11				15	1.6	1.7	0.17	15	1.5
	15				12	1.2	1.8	0.18	11	1.1
	21				9.3	0.95	2.0	0.20	8.8	0.90
	33				6.4	0.65	2.1	0.22	5.9	0.60
	45				4.7	0.48			4.9	0.50
32	5	4	11.6	±15	33	3.4	1.7	0.17	73	7.4
	11				27	2.7	2.9	0.30	38	3.9
	15				25	2.5	3.7	0.38	29	3.0
	21				22	2.3	4.7	0.48	24	2.4
	33				15	1.5	4.8	0.49	14	1.4
	45				11	1.2	5.1	0.52	13	1.3
50	5	3	8.7	±15	80	8.2	4.0	0.41	130	13
	11				45	4.6	5.0	0.51	60	6.1
	15				40	4.1	6.0	0.61	47	4.8
	21				36	3.7	7.6	0.78	40	4.1
	33				24	2.4	7.8	0.80	24	2.5
	45				20	2.0	8.9	0.91	20	2.0
65	4	3	8.7	±15	288	29	12	1.2	420	43
	5				240	24			360	37
	12				125	13	15	1.5	190	19
	15				110	11	17	1.7	160	16
	20				95	10	19	1.9	130	13
	25				84	8.6	21	2.1	110	11

*1: Accuracy values represent the difference between the theoretical angle and the actual angle of output for any given input. The values shown in the table are maximum values.

Figure 020-1

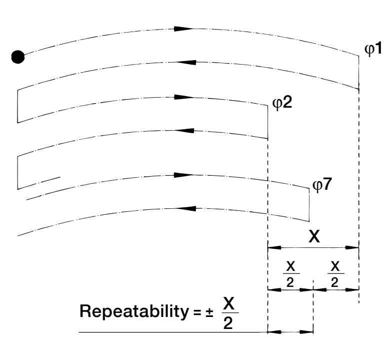


θer : Accuracy
θ1 : Input angle
θ2 : Actual output angle
R : Gear reduction ratio

$$\theta er = \theta_2 - \frac{\theta_1}{R}$$

*2: The repeatability is measured by moving to a given theoretical position seven times, each time approaching from the same direction. The actual position of the output shaft is measured each time and repeatability is calculated as the 1/2 of the maximum difference of the seven data points. Measured values are indicated in angles (arc-sec) prefixed with "±". The values in the table are maximum values.

Figure 020-2



*3: Starting torque is the torque value applied to the input side at which the output first starts to rotate. The values in the table are maximum values.

Table 020-2

Load	No load
HPGP speed reducer surface temperature	25°C

*4: Backdriving torque is the torque value applied to the output side at which the input first starts to rotate. The values in the table are maximum values.

Note: Never rely on these values as a margin in a system that must hold an external load. A brake must be used where back driving is not permissible.

Table 020-3

Load	No load
HPGP speed reducer surface temperature	25°C

*5: No-load running torque is the torque required at the input to operate the gearhead at a given speed under a no-load condition. The values in the table are average values.

Table 020-4

Input speed	3000 rpm
Load	No load
HPGP speed reducer surface temperature	25°C

Backlash and Torsional Stiffness

■ Gearhead - Standard backlash (BL3) (≤ 3 arc-min)

Table 21-1

Size	Ratio	Backlash arc min	Backlash x10⁻⁴rad	Torsion angle on one side at TR X 0.15 D arc min	Torsion angle on one side at TR X 0.15 D x10⁻⁴rad	Torsional stiffness A/B kgfm/arc min	Torsional stiffness A/B x100Nm/rad
11	5	3.0	8.7	2.5	7.3	0.065	22
	21, 37, 45			3.0	8.7		
14	5	3.0	8.7	2.2	6.4	0.14	47
	11, 15, 21, 33, 45			2.7	7.9		
20	5	3.0	8.7	1.5	4.4	0.55	180
	11, 15, 21, 33, 45			2.0	5.8		
32	5	3.0	8.7	1.3	3.8	2.2	740
	11, 15, 21, 33, 45			1.7	4.9		
50	5	3.0	8.7	1.3	3.8	14	4700
	11, 15, 21, 33, 45			1.7	4.9		
65	4, 5	3.0	8.7	1.3	3.8	38	13000
	12, 15, 20, 25			1.7	4.9		

■ Gearhead - Reduced backlash (BL1) (≤ 1 arc-min)

Table 021-2

Size	Ratio	Backlash arc min	Backlash x10⁻⁴rad	Torsion angle on one side at TR X 0.15 D arc min	Torsion angle on one side at TR X 0.15 D x10⁻⁴rad	Torsional stiffness A/B kgfm/arc min	Torsional stiffness A/B x100Nm/rad
11	not available						
14	5	1.0	2.9	1.1	3.2	0.14	47
	11, 15, 21, 33, 45			1.7	4.9		
20	5	1.0	2.9	0.6	1.7	0.55	180
	11, 15, 21, 33, 45			1.1	3.2		
32	5	1.0	2.9	0.5	1.5	2.2	740
	11, 15, 21, 33, 45			1.0	2.9		
50	5	1.0	2.9	0.5	1.5	14	4700
	11, 15, 21, 33, 45			1.0	2.9		
65	4, 5	1.0	2.9	0.5	1.5	38	13000
	12, 15, 20, 25			1.0	2.9		

Torsional stiffness curve

With the input of the gear locked in place, a torque applied to the output flange will torsionally deflect in proportion to the applied torque. We generate a torsional stiffness curve by slowly applying torque to the output in the following sequence:
(1) Clockwise torque to T_R, (2) Return to Zero, (3) Counter-Clockwise torque to $-T_R$, (4) Return to Zero and (5) again Clockwise torque to T_R.
A loop of (1) > (2) > (3) > (4) > (5) will be drawn as in Fig. 021-1.
The torsional stiffness in the region from "0.15 x T_R" to "T_R" is is calculated using the average value of this slope. The torsional stiffness in the region from "zero torque" to "0.15 x T_R" is lower. This is caused by the small amount of backlash plus engagement of the mating parts and loading of the planet gears under the initial torque applied.

Calculation of total torsion angle

The method to calculate the total torsion angle (average value) on one side when the speed reducer applies a load in a no-load state.

Formula 021-1

● Calculation formula

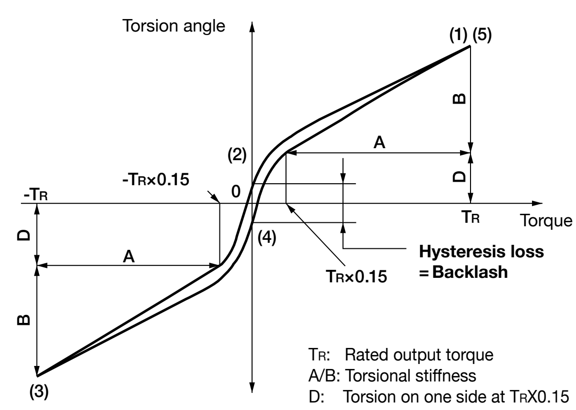
$$\theta = D + \frac{T - T_L}{\frac{A}{B}}$$

θ	Total torsion angle	——
D	Torsion angle on one side at output torque x 0.15 torque	See Fig. 021-1, Table 021-1, Table 021-2
T	Load torque	——
T_L	Output torque x 0.15 torque (=T_RX0.15)	See Fig. 021-1 See Fig. 021-1, Table 021-1 to 2
A/B	Torsional stiffness	

Backlash (Hysteresis loss)

The vertical distance between points (2) & (4) in Fig. 021-1 is called a hysteresis loss. The hysteresis loss between "Clockwise load torque T_R" and "Counter Clockwise load torque - T_R" is defined as the backlash of the HPGP series. Backlash of the HPGP series is less than 3 arc-min (1 arc-min is also available).

Torque-torsion angle diagram Figure 021-1

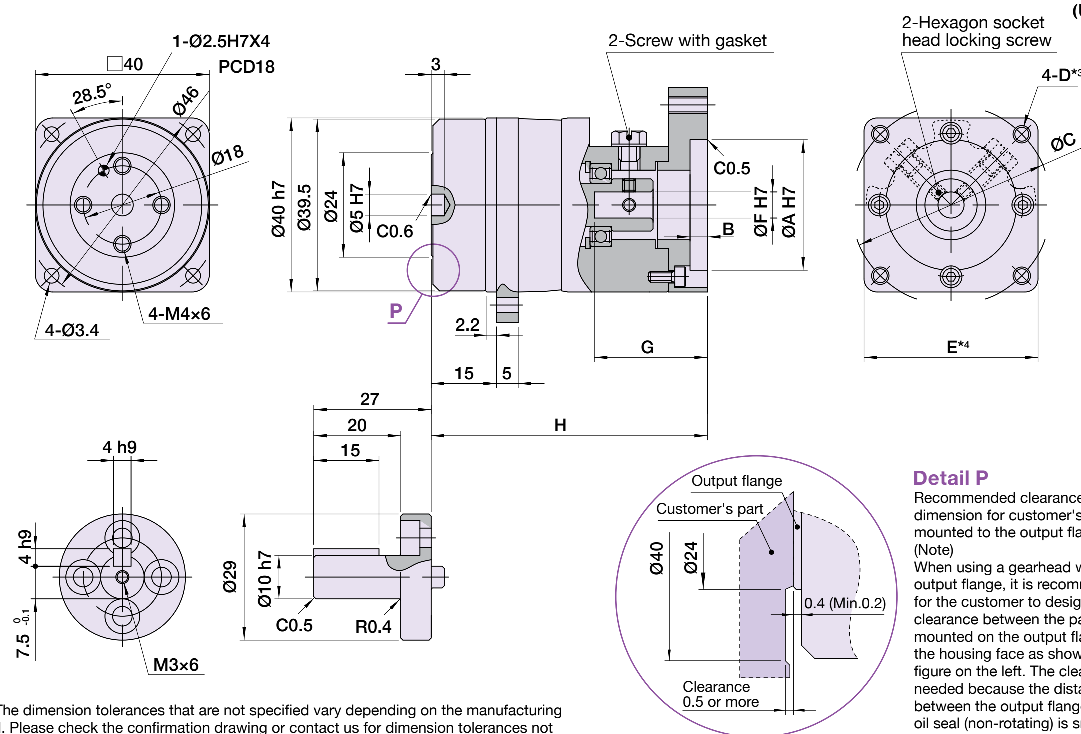


HPGP-11 Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.

Figure 022-1

(Unit: mm)



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

Detail P

Recommended clearance dimension for customer's part mounted to the output flange

(Note)

When using a gearhead with an output flange, it is recommended for the customer to design clearance between the part mounted on the output flange and the housing face as shown in the figure on the left. The clearance is needed because the distance between the output flange and the oil seal (non-rotating) is small (min. 0.2mm).

Dimension Table

(Unit: mm) Table 022-1

	Flange	Coupling	A (H7)		B	C		F (H7)		G		H *1	Mass (kg) *2	
			Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	Shaft	Flange
Single Stage	Type I	1	20	50	4	28	70	5	8	17.5	26	54.5	0.34	0.30
Two Stage	Type I	1	20	50	4	28	70	5	8	17.5	26	63.5	0.40	0.36

Refer to the confirmation drawing for detailed dimensions. Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.

*1 May vary depending on motor interface dimensions.

*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.

*3 Tapped hole for motor mounting screw.

*4 E dimension is dependent on motor selection.

Moment of Inertia

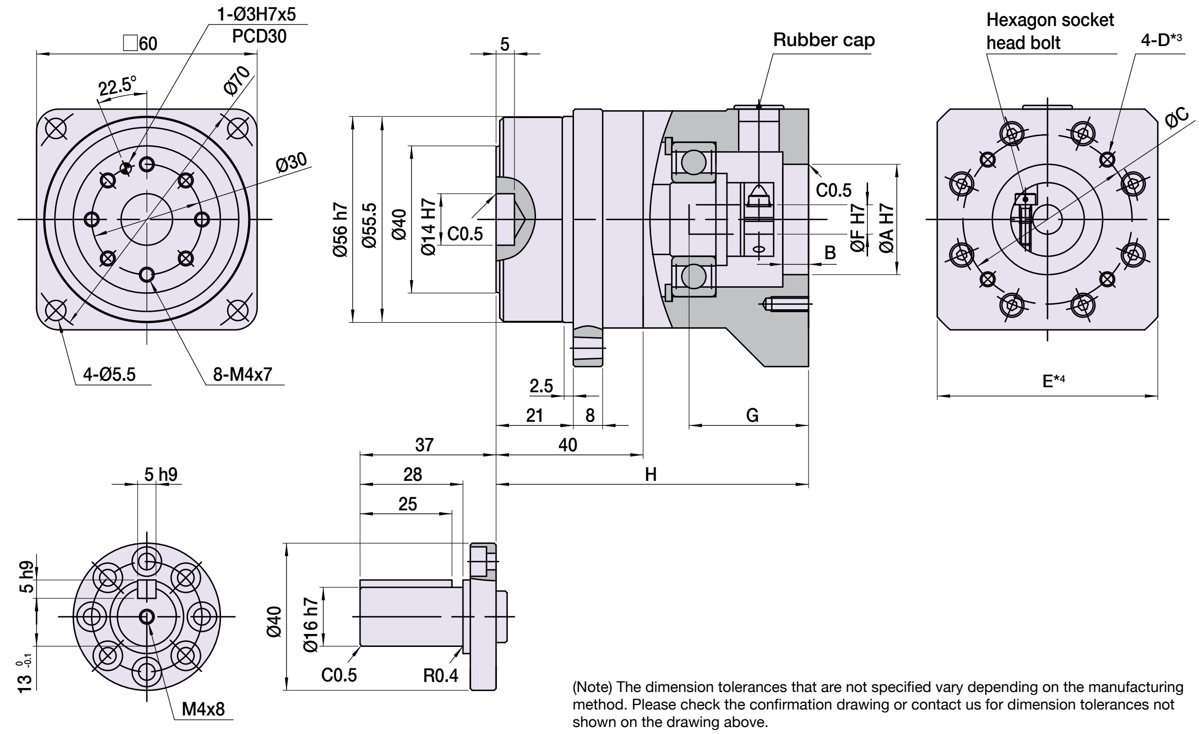
(10^{-4} kgm^2) Table 022-2

	Coupling \ Ratio	5	21	37	45
HPGP 11	1	0.006	0.004	0.0027	0.0025

HPGP-14 Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.

Figure 023-1



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

Dimension Table

(Unit: mm) Table 023-1

Flange	Coupling	A (H7)		B	C		F (H7)		G		H *1	Mass (kg) *2	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	Shaft	Flange
Type I	1	30	58	7	35	74	6.0	7.8	21.5	32.5	85	1.07	0.95
Type II	1	40	70	7	45	84	9.0	14.2	25.8	33.8	85	1.12	1.00

Refer to the confirmation drawing for detailed dimensions. Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.
*1 May vary depending on motor interface dimensions.
*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.
*3 Tapped hole for motor mounting screw.
*4 E dimension is dependent on motor selection.

Moment of Inertia

(10^{-4} kgm^2) Table 023-2

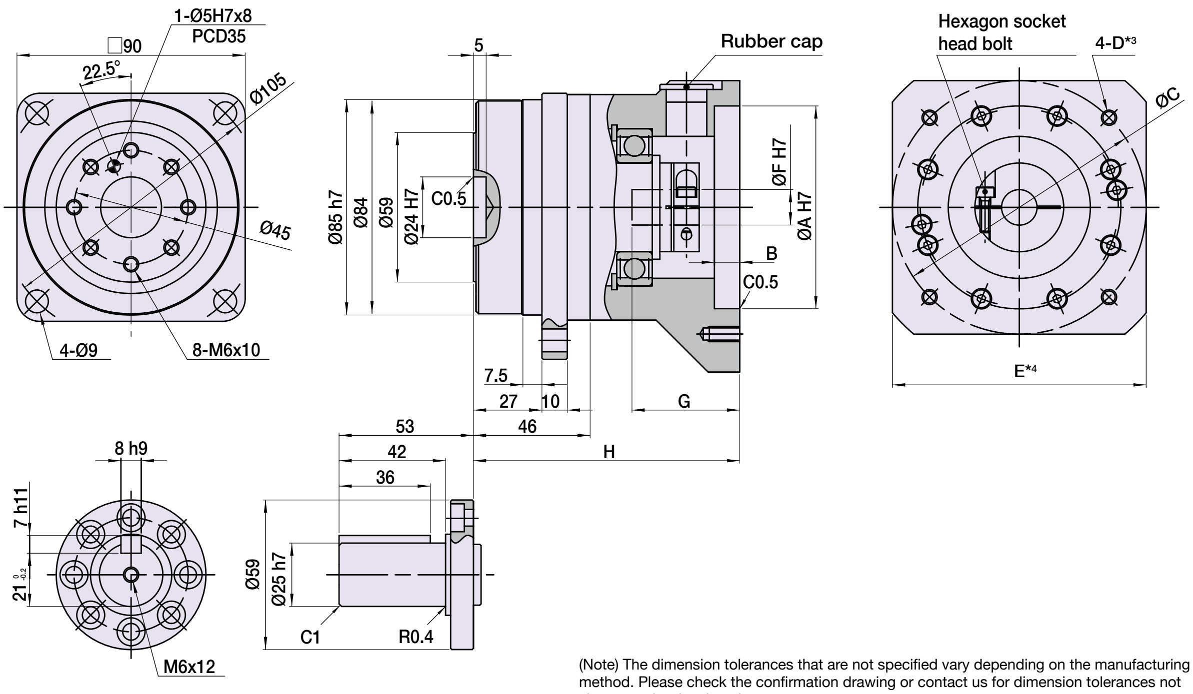
	Ratio / Coupling	5	11	15	21	33	45
HPGP 14	1	-	0.06	0.058	0.05	0.044	0.044
	2	0.204	0.197	0.195	-	-	-

HPGP-20 Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.

Figure 024-1

(Unit: mm)



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

Dimension Table

(Unit: mm) Table 024-1

	Flange	Coupling	A (H7)		B	C		F (H7)		G		H *1	Mass (kg) *2	
			Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	Shaft	Flange
	Type I	1	50	72	8	55	80	7.0	19.6	23.0	35.5	98.0	3.1	2.7
	Type II	1	80	98	10	90	120	7.0	19.6	30.0	42.5	105.0	3.3	2.9
	Type III	3	30	45	10	35	50	7.0	7.8	21.0	31.0	93.5	2.6	2.2
	Type IV	1	46	70	10	55	96	7.0	19.6	30.0	42.5	105.0	3.3	2.9
-33 Ratio	Type I	1	50	72	8	55	80	7.0	19.6	23.0	35.5	103.0	3.1	2.7
-33 Ratio	Type II	1	80	98	10	90	120	7.0	19.6	30.0	42.5	110.0	3.3	2.9
-33 Ratio	Type III	3	30	45	10	35	50	7.0	7.8	21.0	31.0	98.5	2.6	2.2
-33 Ratio	Type IV	1	46	70	10	55	96	7.0	19.6	30.0	42.5	103.0	3.3	2.9

Refer to the confirmation drawing for detailed dimensions. Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.

*1 May vary depending on motor interface dimensions.

*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.

*3 Tapped hole for motor mounting screw.

*4 E dimension is dependent on motor selection.

Moment of Inertia

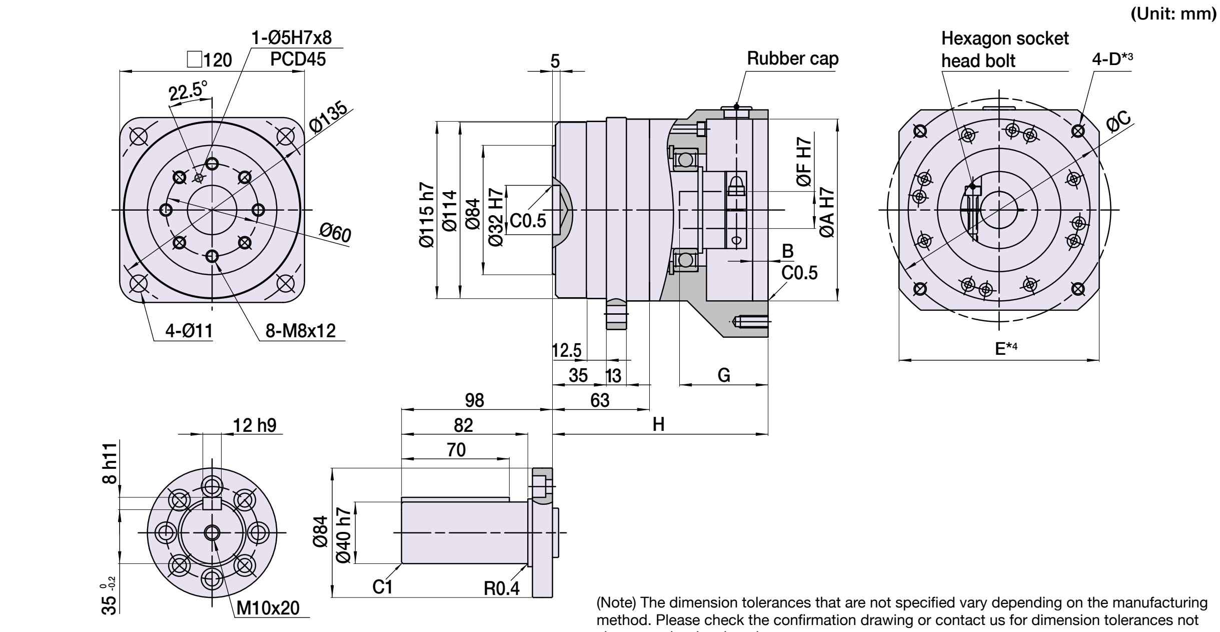
(10^{-4} kgm^2) Table 024-2

	Ratio / Coupling	5	11	15	21	33	45
HPGP 20	1	0.69	0.62	0.58	0.5	0.45	0.45
	2	-	-	-	0.12	0.071	0.063

HPGP-32 Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.

Figure 025-1



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

Dimension Table

(Unit: mm) Table 025-1

	Flange	Coupling	A (H7)		B	C		F (H7)		G		H *1	Mass (kg) *2	
			Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	Shaft	Flange
	Type I	1	110	120	10	120	155	10.0	28.6	31.0	57.5	140	3.1	2.7
	Type II	1	70	100	7	80	112	10.0	28.6	30.0	56.5	139	3.3	2.9
	Type III	3	50	100	10	80	112	14.0	19.6	25.8	38.8	139	2.6	2.2
	Type IV	1	70	95	10	80	115	10.0	28.6	41.0	67.5	150	3.3	2.9
	Type V	1	70	110	10	80	155	10.0	28.6	45.0	71.5	154	3.3	2.9
-33 Ratio	Type I	1	110	120	10	120	155	10.0	28.6	31.0	57.5	145	3.1	2.7
-33 Ratio	Type II	1	70	100	7	80	112	10.0	28.6	30.0	56.5	144	3.3	2.9
-33 Ratio	Type III	3	50	100	10	80	112	14.0	19.6	25.8	38.8	144	2.6	2.2
-33 Ratio	Type IV	1	70	95	10	80	115	10.0	28.6	41.0	67.5	155	3.3	2.9
-33 Ratio	Type V	1	70	110	10	80	155	10.0	28.6	45.0	71.5	159	3.3	2.9

Refer to the confirmation drawing for detailed dimensions. Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.
*1 May vary depending on motor interface dimensions.
*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.
*3 Tapped hole for motor mounting screw.
*4 E dimension is dependent on motor selection.

Moment of Inertia

(10^{-4} kgm^2) Table 025-2

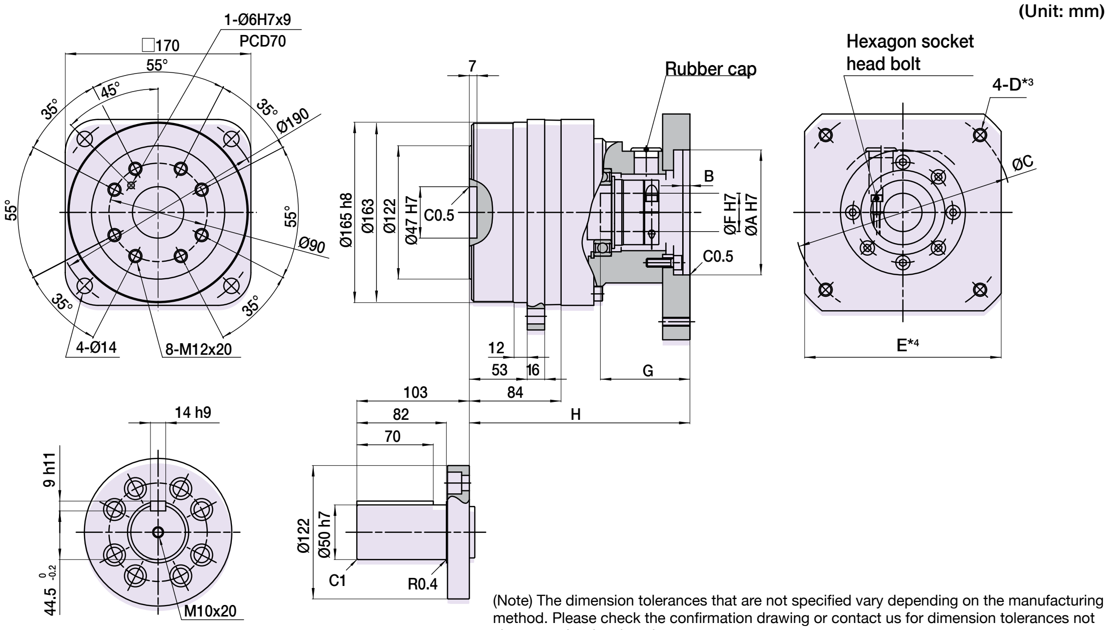
	Ratio / Coupling	5	11	15	21	33	45
HPGP 32	1	3.9	3.7	3.5	3	2.8	.8
	2	-	-	-	0.84	0.66	0.61

HPGP-50 Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.

Figure 026-1

(Unit: mm)



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

Dimension Table

(Unit: mm) Table 026-1

Flange	Coupling	A (H7)		B	C		F (H7)		G		H *1	Mass (kg) *2	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	Shaft	Flange
Type I	1	70	200	15	90	235	19.0	41.0	45.0	81.0	202	20.2	17.2
Type II	1	70	200	15	90	235	19.0	41.0	45.0	81.0	243.5	20.4	17.4
Type III	2	80	115	10	100	150	19.0	41.0	31.5	55.0	176	19.0	16.0
Type IV	1	70	200	15	90	235	19.0	41.0	45.0	81.0	202	27.5	24.5

Refer to the confirmation drawing for detailed dimensions. Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.

*1 May vary depending on motor interface dimensions.
*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.
*3 Tapped hole for motor mounting screw.
*4 E dimension for Flange Type I, II, and IV is dependent on motor selection.

Moment of Inertia

(10^{-4} kgm^2) Table 026-2

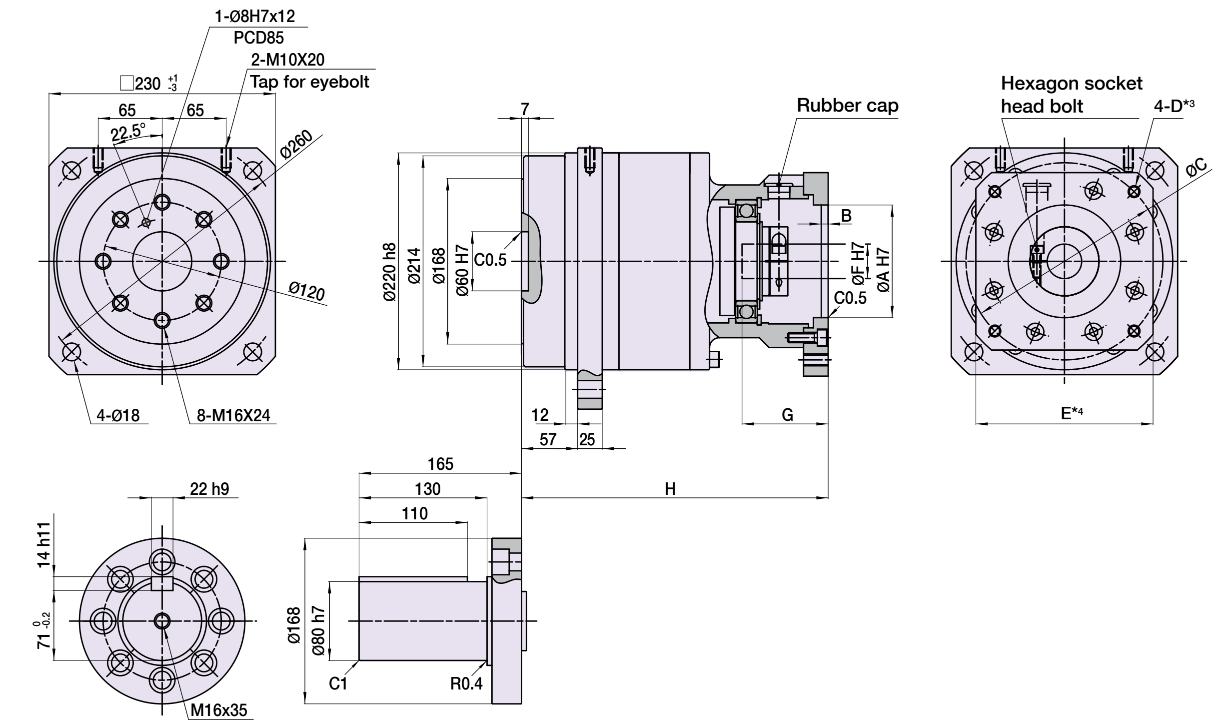
	Ratio / Coupling	5	11	15	21	33	45
HPGP 50	1	12	9.4	9.1	7	6.1	5.9
	2	-	-	8.3	5.8	4.9	4.7

HPGP-65 Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.

Figure 027-1

(Unit: mm)



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

Dimension Table

(Unit: mm) Table 027-1

	Flange	Coupling	A (H7)		B	C		F (H7)		G		H *1	Mass (kg) *2	
			Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	Shaft	Flange
Single Stage	Type I	1	125	230	15	150	265	35.0	43.9	63.0	87.5	241.5	48.0	38.0
Two Stage	Type I	1	125	230	15	150	265	35.0	43.9	63.0	87.5	311.5	52.0	42.0

Refer to the confirmation drawing for detailed dimensions. Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.

*1 May vary depending on motor interface dimensions.
*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.
*3 Tapped hole for motor mounting screw.
*4 E dimension is dependent on motor selection.

Moment of Inertia

(10^{-4} kgm^2) Table 027-2

	Ratio / Coupling	4	5	12	15	20	25
HPGP 65	1	-	-	28	27	15	15
	2	92	-	77	69	57	56

Product Sizing & Selection

To fully utilize the excellent performance of the HPGP HarmonicPlanetary® gearheads, check your operating conditions and, using the flowchart, select the appropriate size gear for your application.

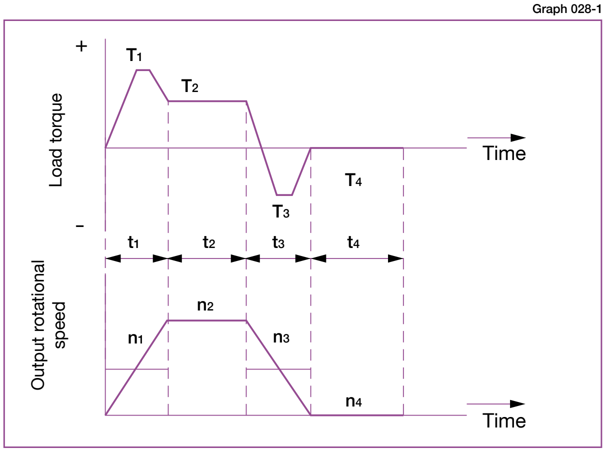
In general, a servo system rarely operates at a continuous load and speed. The input speed, load torque change and a comparatively large torque is applied during start and stop. Unexpected impact torques may also be applied.

Check your operating conditions against the following load torque pattern and select a suitable size based on the flowchart shown on the right. Also check the life and static safety coefficient of the cross roller bearing and input side main bearing (input shaft type only).

Checking the load torque pattern

Review the load torque pattern. Check the specifications shown in the figure below.

Graph 028-1



Obtain the value of each load torque pattern.

Load torque	T_1 to T_n (Nm)
Time	t_1 to t_n (sec)
Output rotational speed	n_1 to n_n (rpm)

<Normal operation pattern>

Starting	T_1, t_1, n_1
Steady operation	T_2, t_2, n_2
Stopping (slowing)	T_3, t_3, n_3
Idle	T_4, t_4, n_4

<Maximum rotational speed>

Max. output rotational speed	$n_{o\,max} \geqq n_1$ to n_n
Max. input rotational speed	$n_{i\,max}$ $n_1 \times R$ to $n_n \times R$
(Restricted by motors)	R: Reduction ratio

<Impact torque>

When impact torque is applied T_s

<Required life>

L_{50} = L (hours)

Flowchart for selecting a size

Please use the flowchart shown below for selecting a size. Operating conditions must not exceed the performance ratings.

Calculate the average load torque applied on the output side from the load torque pattern: T_{av} (Nm).

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

Calculate the average output speed based on the load torque pattern: no av (rpm)

$$n_{o\,av}=\frac{|n_1|\cdot t_1+|n_2|\cdot t_2+\cdots+|n_n|\cdot t_n}{t_1+t_2+\cdots+t_n}$$

Make a preliminary model selection with the following condition: $T_{av} \leqq$ Average load torque (Refer to rating table). — NG

OK

Determine the reduction ratio (R) based on the maximum output rotational speed (no *max*) and maximum input rotational speed (ni *max*).

$$\frac{n_{i\,max}}{n_{o\,max}} \geqq R$$

(A limit is placed on ni *max* by motors.)
Calculate the maximum input speed (ni *max*) from the maximum output speed (no *max*) and the reduction ratio (R).

$$n_{i\,max}=n_{o\,max}\cdot R$$

Calculate the average input speed (ni *av*) from the average output speed (no *av*) and the reduction ratio (R): $n_{i\,av} = n_{o\,av}\cdot R \leqq$ Max. average input speed (nr). — NG

OK

Check whether the maximum input speed is equal to or less than the values in the rating table.
$n_{i\,max} \leqq$ maximum input speed (rpm) — NG

OK

Check whether T1 and T3 are within peak torques (Nm) on start and stop in the rating table. — NG

OK

Check whether T_s is equal to or less than the momentary max. torque (Nm) value from the ratings. — NG

OK

Calculate the lifetime and check whether it meets the specification requirement.
Tr: Output torque
n_r: Max. average input speed

$$L_{50}=20{,}000\cdot\left(\frac{T_r}{T_{av}}\right)^{10/3}\cdot\left(\frac{n_r}{n_{i\,av}}\right)\ \text{(Hour)}$$

— NG

OK

The model number is confirmed.

Refer to the Caution note below.

Review the operation conditions, size and reduction ratio.

Caution

If the expected operation will result in conditions where;
i) Actual average load torque (Tav) > Permissible maximum value of average load torque or
ii) Actual average input rotational speed (ni av) > Permissible average input rotational speed (nr),
then please check its effect on the speed reducer temperature rise or other factors. Consider selecting the next larger speed reducer, reduce the operating loads or take other means to ensure safe use of the gear. Exercise caution especially when the duty cycle is close to continuous operation.

Example of model number Selection

Value of each load torque pattern.

Load torque	T_n (Nm)
Time	t_n (sec)
Output rotational speed	n_n (rpm)

<Normal operation pattern>

Starting	T_1 = 70 Nm,	t_1 = 0.3 sec,	n_1 = 60 rpm
Steady operation	T_2 = 18 Nm,	t_2 = 3 sec,	n_2 = 120 rpm
Stopping (slowing)	T_3 = 35 Nm,	t_3 = 0.4 sec,	n_3 = 60 rpm
Idle	T_4 = 0 Nm,	t_4 = 5 sec,	n_4 = 0 rpm

<Maximum rotational speed>

Max. output rotational speed	no *max* = 120 rpm
Max. input rotational speed	ni *max* = 5,000 rpm (Restricted by motors)

<Impact torque>

When impact torque is applied T_s = 180 Nm

<Required life>

L_{50} = 30,000 (hours)

Calculate the average load torque applied to the output side based on the load torque pattern: T*av* (Nm).

$$T_{av} = \sqrt[10/3]{\frac{|60\text{rpm}|\cdot 0.3\text{sec}\cdot |70\text{Nm}|^{10/3} + |120\text{rpm}|\cdot 3\text{sec}\cdot |18\text{Nm}|^{10/3} + |60\text{rpm}|\cdot 0.4\text{sec}\cdot |35\text{Nm}|^{10/3}}{|60\text{rpm}|\cdot 0.3\text{sec} + 120\text{rpm}|\cdot 3\text{sec} + |60\text{rpm}|\cdot 0.4\text{sec}|}}$$

Calculate the average output speed based on the load torque pattern: no *av* (rpm)

$$no\ av = \frac{|60\text{rpm}|\cdot 0.3\text{sec} + |120\text{rpm}|\cdot 3\text{sec} + |60\text{rpm}|\cdot 0.4\text{sec} + |0\text{rpm}|\cdot 5\text{sec}}{0.3\text{sec}+3\text{sec}+0.4\text{sec}+5\text{sec}}$$

Make a preliminary model selection with the following conditions. T*av* = 30.2 Nm ≦ 72 Nm. (**HPGP-20A-33** is tentatively selected based on the average load torque (see the rating table) of size 20 and reduction ratio of 33.) — NG

OK

Determine a reduction ratio (R) from the maximum output speed (no *max*) and maximum input speed (ni *max*).

$$\frac{5{,}000\text{ rpm}}{120\text{ rpm}} = 41.7 \geqq 33$$

Calculate the maximum input speed (ni *max*) from the maximum output speed (no *max*) and reduction ratio (R): ni *max* = 120 rpm・33 = 3,960 rpm

Calculate the average input speed (ni *av*) from the average output speed (no *av*) and reduction ratio (R):
ni *av* = 46.2 rpm・33= 1,525 rpm ≦ Max average input speed of size 20 3,000 rpm — NG

OK

Check whether the maximum input speed is equal to or less than the values specified in the rating table.
ni *max* = 3,960 rpm ≦ 5,000 rpm (maximum input speed of size 20) — NG

OK

Check whether T_1 and T_3 are within peak torques (Nm) on start and stop in the rating table.
T_1 = 70 Nm ≦ 156 Nm (Limit for repeated peak torque, size 20)
T_3 = 35 Nm ≦ 156 Nm (Limit for repeated peak torque, size 20) — NG

OK

Check whether Ts is equal to or less than limit for momentary torque (Nm) in the rating table.
T_s = 180 Nm ≦ 217 Nm (momentary max. torque of size 20) — NG

OK

Calculate life and check whether the calculated life meets the requirement.

$$L_{50} = 20{,}000 \cdot \left(\frac{72\text{ Nm}}{30.2\text{ Nm}}\right)^{10/3} \cdot \left(\frac{3{,}000\text{ rpm}}{1{,}525\text{ rpm}}\right) = 712{,}251\text{ (hours)} \geqq 30{,}000\text{ (hours)}$$

— NG

OK

The selection of model number HPGP-20A-33 is confirmed from the above calculations.

Refer to the Caution note at the bottom of page 28.

Review the operation conditions, size and reduction ratio.

HarmonicPlanetary®
HPG Standard Series

Size
6 Sizes

11, 14, 20, 32, 50, 65

Peak torque
5Nm – 3200Nm

Reduction ratio
Single Stage: 3:1 to 9:1, Two Stage: 11:1 to 50:1

Low Backlash
Standard: <3 arc-min Optional: <1 arc-min

Low Backlash for Life

Innovative ring gear automatically adjusts for backlash, ensuring consistent, low backlash for the life of the gearhead. The ring gear design automatically provides the optimum backlash in the planetary gear train and maintains the same low backlash for the life of the gearhead.

High efficiency
Up to 95%

High Load Capacity Output Bearing
A Cross Roller bearing is integrated with the output flange to provide high moment stiffness, high load capacity and precise positioning accuracy.

Easy mounting to a wide variety of servomotors
Quick Connect™ coupling

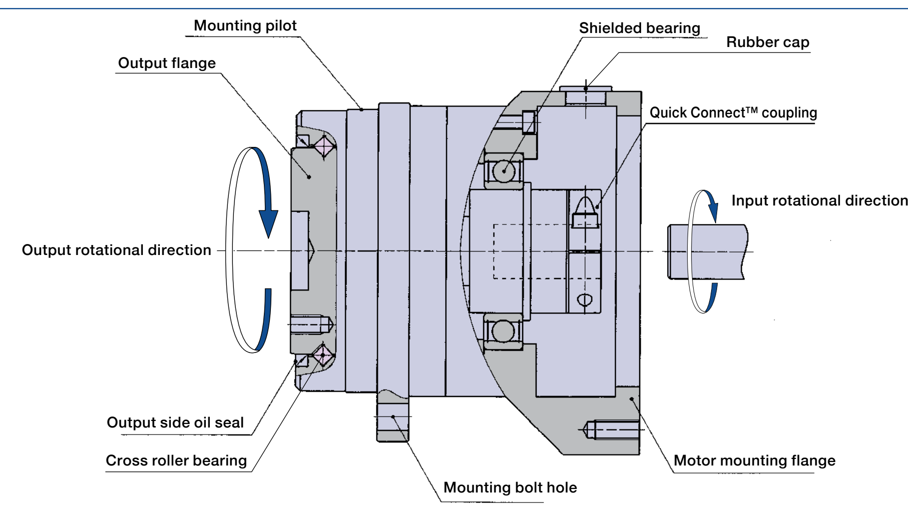
CONTENTS

HPG - 20 A - 05 - BL3 - D - F0 - Motor Code

Model Name	Size	Design Revision	Reduction Ratio	Backlash	Input Side Bearing	Output Configuration	Input Configuration & Options
HarmonicPlanetary® HPG Standard	11	B	5, 9, 21, 37, 45	BL1: Backlash less than 1 arc-min (Sizes 14 to 65) BL3: Backlash less than 3 arc-min	D: Input side contact sealed bearing (DDU) Z: Input side bearing with double non-contact shields	F0: Flange output J20: Shaft output without key J60: Shaft output with key and center tapped hole	This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.
	14	A	3, 5, 11, 15, 21, 33, 45			F0: Flange output J2: Shaft output without key J6: Shaft output with key and center tapped hole (J2, J6 for Size 65 is also available)	
	20						
	32						
	50						
	65		4, 5, 12, 15, 20, 25, 40, 50				

Gearhead Construction

Figure 030-1



Rating Table

Table 031-1

<table>
<tr><th rowspan="3">Size</th><th rowspan="3">Ratio</th><th>Rated Torque *1</th><th>Limit for Repeated Peak Torque *2</th><th>Limit for Momentary Torque *3</th><th>Max. Average Input Speed *4</th><th>Max. Input Speed *5</th><th colspan="2">Mass*6</th></tr>
<tr><th rowspan="2">Nm</th><th rowspan="2">Nm</th><th rowspan="2">Nm</th><th rowspan="2">rpm</th><th rowspan="2">rpm</th><th>Shaft</th><th>Flange</th></tr>
<tr><th>kg</th><th>kg</th></tr>
<tr><td rowspan="5">11</td><td>5</td><td rowspan="2">5</td><td>10</td><td rowspan="5">20</td><td rowspan="5">3000</td><td rowspan="5">10000</td><td rowspan="2">0.18</td><td rowspan="2">0.14</td></tr>
<tr><td>9</td><td>5</td></tr>
<tr><td>21</td><td>8</td><td rowspan="3">10</td><td rowspan="3">0.24</td><td rowspan="3">0.20</td></tr>
<tr><td>37</td><td>9</td></tr>
<tr><td>45</td><td>10</td></tr>
<tr><td rowspan="7">14</td><td>3</td><td>7</td><td>15</td><td>37</td><td rowspan="7">3000</td><td>5000</td><td rowspan="2">0.50</td><td rowspan="2">0.40</td></tr>
<tr><td>5</td><td>11</td><td rowspan="6">30</td><td>56</td><td rowspan="6">6000</td></tr>
<tr><td>11</td><td>15</td><td rowspan="5">63</td><td rowspan="5">0.60</td><td rowspan="5">0.50</td></tr>
<tr><td>15</td><td>16</td></tr>
<tr><td>21</td><td>17</td></tr>
<tr><td>33</td><td>20</td></tr>
<tr><td>45</td><td>22</td></tr>
<tr><td rowspan="7">20</td><td>3</td><td>17</td><td>64</td><td>124</td><td rowspan="7">3000</td><td>4000</td><td rowspan="2">1.6</td><td rowspan="2">1.2</td></tr>
<tr><td>5</td><td>38</td><td>100</td><td rowspan="6">217</td><td rowspan="6">6000</td></tr>
<tr><td>11</td><td>46</td><td>117</td><td rowspan="5">1.8</td><td rowspan="5">1.4</td></tr>
<tr><td>15</td><td>58</td><td rowspan="2">107</td></tr>
<tr><td>21</td><td>58</td></tr>
<tr><td>33</td><td>70</td><td>117</td></tr>
<tr><td>45</td><td>73</td><td>106</td></tr>
<tr><td rowspan="7">32</td><td>3</td><td>60</td><td>225</td><td>507</td><td rowspan="7">3000</td><td>3600</td><td rowspan="2">4.3</td><td rowspan="2">2.9</td></tr>
<tr><td>5</td><td>120</td><td>300</td><td rowspan="6">650</td><td rowspan="6">6000</td></tr>
<tr><td>11</td><td>160</td><td>330</td><td rowspan="5">4.9</td><td rowspan="5">3.5</td></tr>
<tr><td>15</td><td>170</td><td rowspan="2">300</td></tr>
<tr><td>21</td><td>190</td></tr>
<tr><td>33</td><td>200</td><td>330</td></tr>
<tr><td>45</td><td>240</td><td>300</td></tr>
<tr><td rowspan="7">50</td><td>3</td><td>160</td><td>850</td><td>1200</td><td rowspan="7">2000</td><td>3000</td><td rowspan="2">13</td><td rowspan="2">10</td></tr>
<tr><td>5</td><td>290</td><td>1110</td><td>1850</td><td rowspan="6">4500</td></tr>
<tr><td>11</td><td>340</td><td>1200</td><td rowspan="5">2180</td><td rowspan="5">15</td><td rowspan="5">12</td></tr>
<tr><td>15</td><td>400</td><td>1250</td></tr>
<tr><td>21</td><td>450</td><td rowspan="2">1140</td></tr>
<tr><td>33</td><td>470</td></tr>
<tr><td>45</td><td>560</td><td>1130</td></tr>
<tr><td rowspan="8">65</td><td>4</td><td>870</td><td>2890</td><td rowspan="8">4500</td><td rowspan="8">2000</td><td>2500</td><td rowspan="2">32*7</td><td rowspan="2">22</td></tr>
<tr><td>5</td><td>900</td><td rowspan="2">3100</td><td rowspan="7">3000</td></tr>
<tr><td>12</td><td>1020</td><td rowspan="6">47*7</td><td rowspan="6">37</td></tr>
<tr><td>15</td><td>1260</td><td>3200</td></tr>
<tr><td>20</td><td>1370</td><td>3100</td></tr>
<tr><td>25</td><td>1470</td><td>3200</td></tr>
<tr><td>40</td><td>1320</td><td>1900</td></tr>
<tr><td>50</td><td>1650</td><td>2200</td></tr>
</table>

*1: Rated torque is based on L_{50} life of 20,000 hours at rated input speed.
*2: The limit for torque during start and stop cycles.
*3: The limit for torque during emergency stops or from external shock loads. Always operate below this value. Calculate the number of permissible events to ensure it meets required operating conditions.
*4: Maximum average input speed is limited by heat generation in the speed reducer assuming a continuous operating speed or the average input speed of a motion profile. The actual limit for average input speed depends on the operating environment.
*5: Maximum instantaneous input speed.
*6: The mass is for the gearhead only (without input shaft coupling & motor flange). Please contact us for the mass of your specific configuration.
*7: Flange output is standard for the size 65 gearhead. Shaft type (J2 & J6) is also available. Note: Never rely on these values as a margin in a system that must hold an external load. A brake must be used where back driving is not permissible.

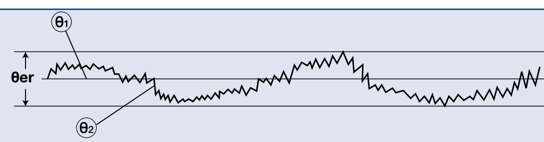
Performance Table

Table 032-1

Size	Ratio	Accuracy *1		Repeatability *2	Starting torque *3		Backdriving torque *4		No-load running torque *5	
		arc min	×10⁻⁴rad	arc sec	Ncm	kgfcm	Nm	kgfm	Ncm	kgfcm
11	5	5	14.5	±30	4.0	0.41	0.20	0.020	5.0	0.51
	9				3.7	0.37	0.33	0.034	2.5	0.26
	21				2.9	0.29	0.60	0.061	1.3	0.13
	37				1.6	0.17		0.062	0.90	0.092
	45				1.4	0.15	0.64	0.066	0.80	0.082
14	3	4	11.6	±20	14	1.5	0.43	0.044	21	2.1
	5				8.6	0.88			9.8	1.0
	11				8.0	0.82	0.90	0.092	4.9	0.50
	15				7.4	0.75	1.1	0.11	2.9	0.30
	21				5.2	0.53		0.12		
	33				3.3	0.34			2.0	0.20
	45				2.4	0.25				
20	3	4	11.6	±15	31	3.2	0.93	0.095	50	5.1
	5				19	1.9			28	2.9
	11				15	1.6	1.7	0.17	15	1.5
	15				12	1.2	1.8	0.18	11	1.1
	21				9.3	0.95	2.0	0.20	8.8	0.90
	33				6.4	0.65	2.1	0.22	5.9	0.60
	45				4.7	0.48			4.9	0.50
32	3	4	11.6	±15	56	5.7	1.7	0.17	135	14
	5				33	3.4			73	7.4
	11				27	2.7	2.9	0.30	38	3.9
	15				25	2.5	3.7	0.38	29	3.0
	21				22	2.3	4.7	0.48	24	2.4
	33				15	1.5	4.8	0.49	14	1.4
	45				11	1.2	5.1	0.52	13	1.3
50	3	3	8.7	±15	134	14	4.0	0.41	250	26
	5				80	8.2			130	13
	11				45	4.6	5.0	0.51	60	6.1
	15				40	4.1	6.0	0.61	47	4.8
	21				36	3.7	7.6	0.78	40	4.1
	33				24	2.4	7.8	0.80	24	2.5
	45				20	2.0	8.9	0.91	20	2.0
65	4	3	8.7	±15	288	29	12	1.2	420	43
	5				240	24			360	37
	12				125	13	15	1.5	190	19
	15				110	11	17	1.7	160	16
	20				95	10	19	1.9	130	13
	25				84	8.6	21	2.1	110	11
	40				75	7.7	30	3.1	76	7.7
	50				70	7.1	35	3.6	64	6.6

*1: Accuracy values represent the difference between the theoretical angle and the actual angle of output for any given input. The values in the table are maximum values.

Figure 032-1

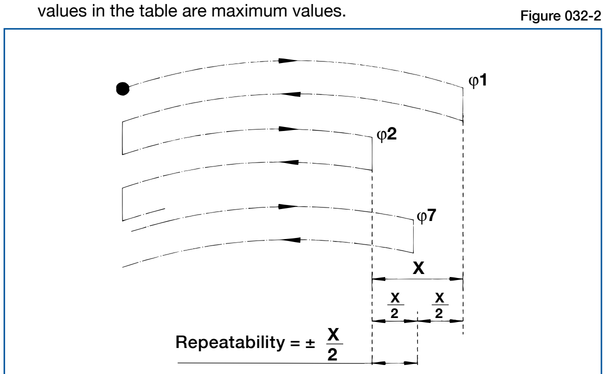


θer : Accuracy
θ_1 : Input angle
θ_2 : Actual output angle
R : Gear reduction ratio

$$\theta er = \theta_2 - \frac{\theta_1}{R}$$

*2: The repeatability is measured by moving to a given theoretical position seven times, each time approaching from the same direction. The actual position of the output shaft is measured each time and repeatability is calculated as the 1/2 of the maximum difference of the seven data points. Measured values are indicated in angles (arc-sec) prefixed with "±". The values in the table are maximum values.

Figure 032-2



*3: Starting torque is the torque value applied to the input side at which the output first starts to rotate. The values in the table are maximum values.

Table 032-2

Load	No load
HPG speed reducer surface temperature	25°C

*4: Backdriving torque is the torque value applied to the output side at which the input first starts to rotate. The values in the table are maximum values.

Note: Never rely on these values as a margin in a system that must hold an external load. A brake must be used where back driving is not permissible.

Table 032-3

Load	No load
HPG speed reducer surface temperature	25°C

*5: No-load running torque is the torque required at the input to operate the gearhead at a given speed under a no-load condition. The values in the table are average values.

Table 032-4

Input speed	3000 rpm
Load	No load
HPG speed reducer surface temperature	25°C

Backlash and Torsional Stiffness

■ Gearhead - Standard backlash (BL3) (≤ 3 arc-min)

Table 033-1

Size	Ratio	Backlash arc min	Backlash $\times10^{-4}$rad	Torsion angle on one side at TR X 0.15 D arc min	Torsion angle on one side at TR X 0.15 D $\times10^{-4}$rad	Torsional stiffness A/B kgfm/arc min	Torsional stiffness A/B x100Nm/rad
11	5, 9	3.0	8.7	2.5	7.3	0.065	22
11	21, 37, 45	3.0	8.7	3.0	8.7	0.065	22
14	3, 5	3.0	8.7	2.2	6.4	0.14	47
14	11, 15, 21, 33, 45	3.0	8.7	2.7	7.9	0.14	47
20	3, 5	3.0	8.7	1.5	4.4	0.55	180
20	11, 15, 21, 33, 45	3.0	8.7	2.0	5.8	0.55	180
32	3, 5	3.0	8.7	1.3	3.8	2.2	740
32	11, 15, 21, 33, 45	3.0	8.7	1.7	4.9	2.2	740
50	3, 5	3.0	8.7	1.3	3.8	14	4700
50	11, 15, 21, 33, 45	3.0	8.7	1.7	4.9	14	4700
65	4, 5	3.0	8.7	1.3	3.8	38	13000
65	12, 15, 20, 25, 40, 50	3.0	8.7	1.7	4.9	38	13000

■ Gearhead - Reduced backlash (BL1) (≤ 1 arc-min)

Table 033-2

Size	Ratio	Backlash arc min	Backlash $\times10^{-4}$rad	Torsion angle on one side at TR X 0.15 D arc min	Torsion angle on one side at TR X 0.15 D $\times10^{-4}$rad	Torsional stiffness A/B kgfm/arc min	Torsional stiffness A/B x100Nm/rad
11	not available						
14	3, 5	1.0	2.9	1.1	3.2	0.14	47
14	11, 15, 21, 33, 45	1.0	2.9	1.7	4.9	0.14	47
20	3, 5	1.0	2.9	0.6	1.7	0.55	180
20	11, 15, 21, 33, 45	1.0	2.9	1.1	3.2	0.55	180
32	3, 5	1.0	2.9	0.5	1.5	2.2	740
32	11, 15, 21, 33, 45	1.0	2.9	1.0	2.9	2.2	740
50	3, 5	1.0	2.9	0.5	1.5	14	4700
50	11, 15, 21, 33, 45	1.0	2.9	1.0	2.9	14	4700
65	4, 5	1.0	2.9	0.5	1.5	38	13000
65	12, 15, 20, 25, 40, 50	1.0	2.9	1.0	2.9	38	13000

Torsional stiffness curve

With the input of the gear locked in place, a torque applied to the output flange will torsionally deflect in proportion to the applied torque. We generate a torsional stiffness curve by slowly applying torque to the output in the following sequence:
(1) Clockwise torque to T_R, (2) Return to Zero, (3) Counter-Clockwise torque to $-T_R$, (4) Return to Zero and (5) again Clockwise torque to T_R.
A loop of (1) > (2) > (3) > (4) > (5) will be drawn as in Fig. 033-1.
The torsional stiffness in the region from "0.15 x T_R" to "T_R" is calculated using the average value of this slope. The torsional stiffness in the region from "zero torque" to "0.15 x T_R" is lower. This is caused by the small amount of backlash plus engagement of the mating parts and loading of the planet gears under the initial torque applied.

Calculation of total torsion angle

The method to calculate the total torsion angle (average value) on one side when the speed reducer applies a load in a no-load state.

Formula 033-1

● Calculation formula

$$\theta = D + \frac{T - T_L}{\frac{A}{B}}$$

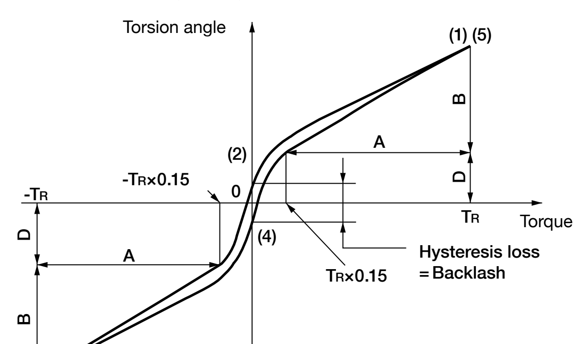
θ	Total torsion angle	——
D	Torsion angle on one side at output torque x 0.15 torque	See Fig. 033-1, Table 033-1, Table 033-2
T	Load torque	——
T_L	Output torque x 0.15 torque (=T_RX0.15)	See Fig. 033-1
A/B	Torsional stiffness	See Fig. 033-1, Table 033-1 to 2

Backlash (Hysteresis loss)

The vertical distance between points (2) & (4) in Fig. 033-1 is called a hysteresis loss. The hysteresis loss between "Clockwise load torque T_R" and "Counter Clockwise load torque $-T_R$" is defined as the backlash of the HPG series. Backlash of the HPG series is less than 3 arc-min (1 arc-min or less for a reduced backlash option).

Torque-torsion angle diagram

Figure 033-1



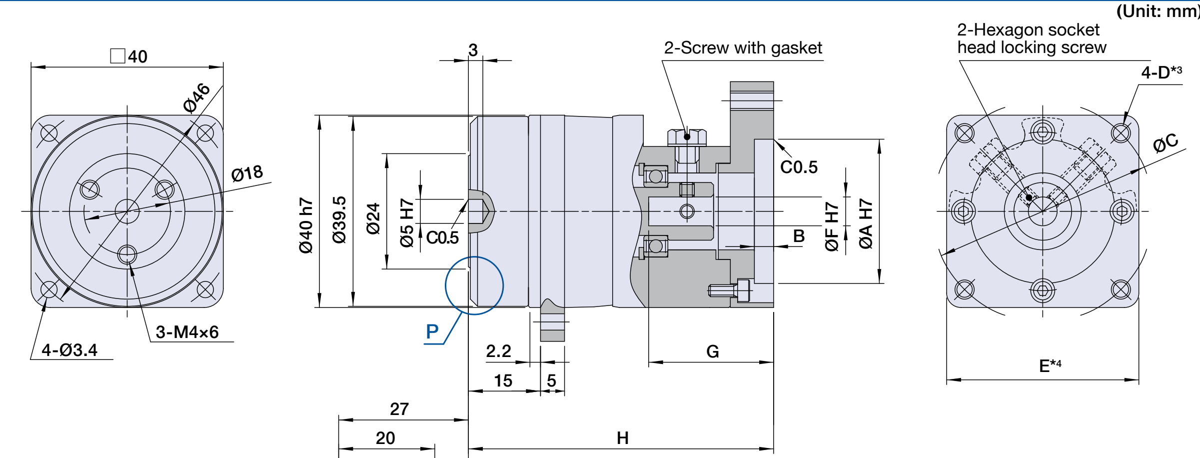
T_R: Rated output torque
A/B: Torsional stiffness
D: Torsion on one side at T_RX0.15

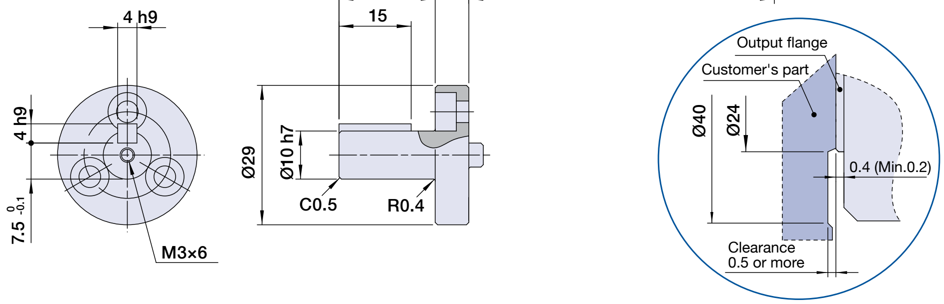
HPG-11 Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.

Figure 034-1

(Unit: mm)





Detail P

Recommended clearance dimension for customer's part mounted to the output flange

(Note)
When using a gearhead with an output flange, it is recommended for the customer to design clearance between the part mounted on the output flange and the housing face as shown in the figure on the left. The clearance is needed because the distance between the output flange and the oil seal (non-rotating) is small (min. 0.2mm).

(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

Dimension Table

(Unit: mm) Table 034-1

	Flange	Coupling	A (H7)		B	C		F (H7)		G		H *1	K	Mass (kg) *2	
			Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical		Shaft	Flange
Single Stage	Type I	1	20	50	4	28	70	5	8	17.5	26	54.5	21	0.34	0.30
Two Stage	Type I	1	20	50	4	28	70	5	8	17.5	26	63.5	30	0.34	0.30

Refer to the confirmation drawing for detailed dimensions. Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.
*1 May vary depending on motor interface dimensions.
*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.
*3 Tapped hole for motor mounting screw.
*4 E dimension is dependent on motor selection.

Moment of Inertia

(10^{-4} kgm^2) Table 034-2

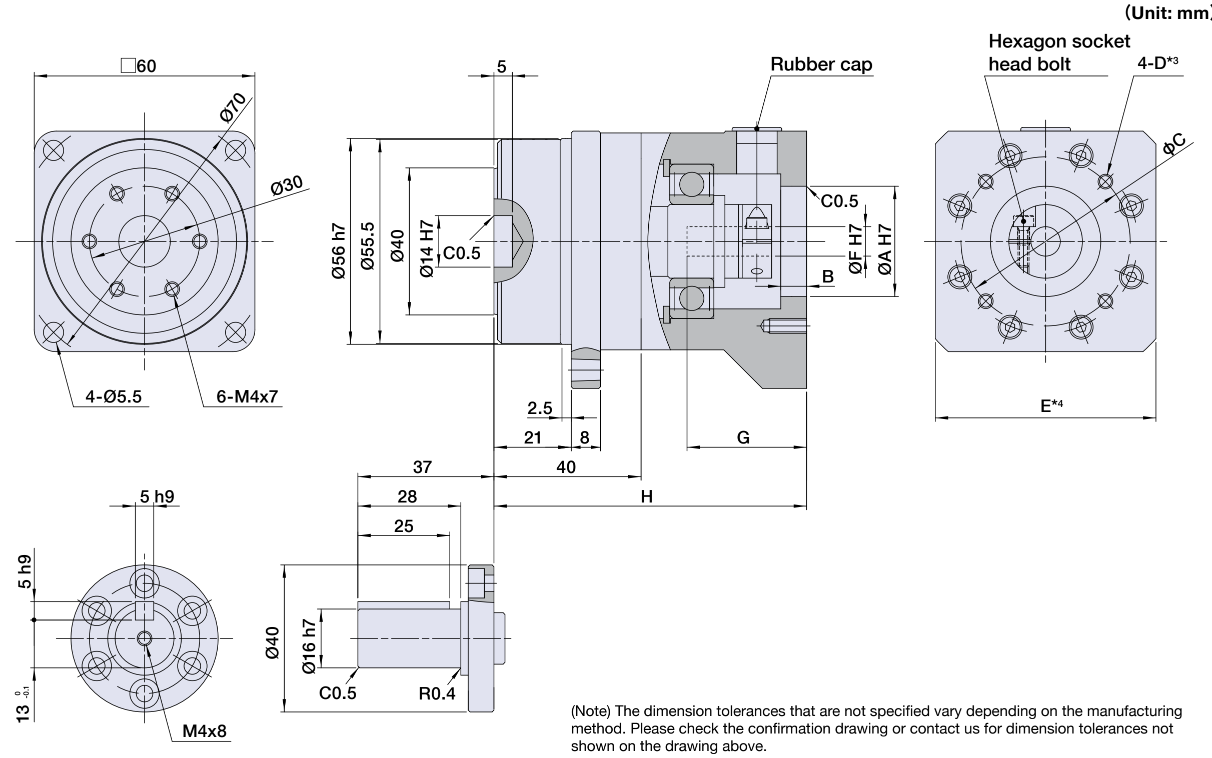
	Coupling \ Ratio	5	9	21	37	45
HPG 11	1	0.005	0.003	0.004	0.0027	0.0025

HPG-14 Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.

Figure 035-1

(Unit: mm)



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

Dimension Table

(Unit: mm) Table 035-1

Flange	Coupling	A (H7)		B	C		F (H7)		G		H *1	Mass (kg) *2	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	Shaft	Flange
Type I	1	30	58	7	35	74	6.0	7.8	21.5	32.5	85	1.07	0.95
Type II	2	40	70	7	45	84	9.0	14.2	25.8	33.8	85	1.12	1.00

Refer to the confirmation drawing for detailed dimensions. Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.

*1 May vary depending on motor interface dimensions.
*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.
*3 Tapped hole for motor mounting screw.
*4 E dimension is dependent on motor selection.

Moment of Inertia

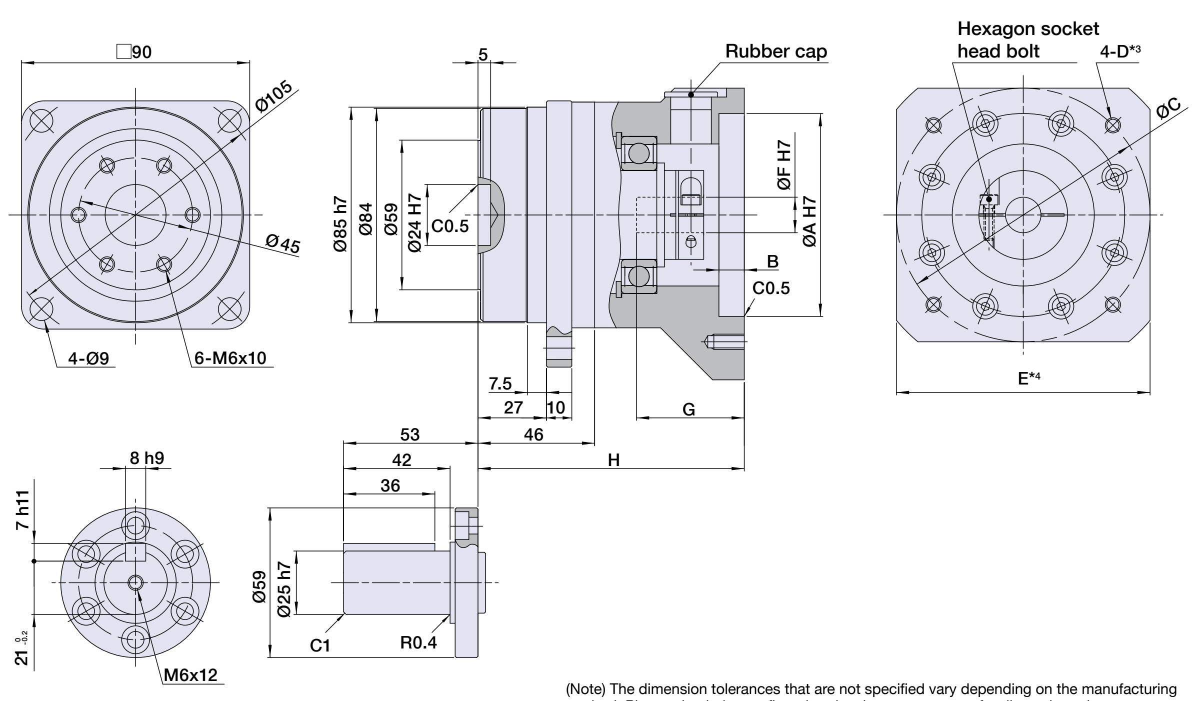
(10^{-4} kgm^2) Table 035-2

	Ratio / Coupling	3	5	11	15	21	33	45
HPG 14	1	-	-	0.06	0.058	0.05	0.044	0.044
	2	0.26	0.207	0.197	0.180	0.171	0.167	0.165

HPG-20 Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.

Figure 036-1



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

Dimension Table

(Unit: mm) Table 036-1

Flange	Coupling	A (H7)		B	C		F (H7)		G		H *1	Mass (kg) *2	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	Shaft	Flange
Type I	1	50	72	8	55	80	7.0	19.6	23.0	36.5	98.0	3.1	2.7
Type II	1	80	98	10	90	120	7.0	19.6	30.0	42.5	105.0	3.3	2.9
Type III	3	30	45	10	35	50	7.0	7.8	21.0	31.0	93.5	2.6	2.2
Type IV	1	46	70	10	55	96	7.0	19.6	30.0	42.5	105.0	3.3	2.9

Refer to the confirmation drawing for detailed dimensions. Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.
*1 May vary depending on motor interface dimensions.
*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.
*3 Tapped hole for motor mounting screw.
*4 E dimension for Flange Type IV is dependent on motor selection.

Moment of Inertia

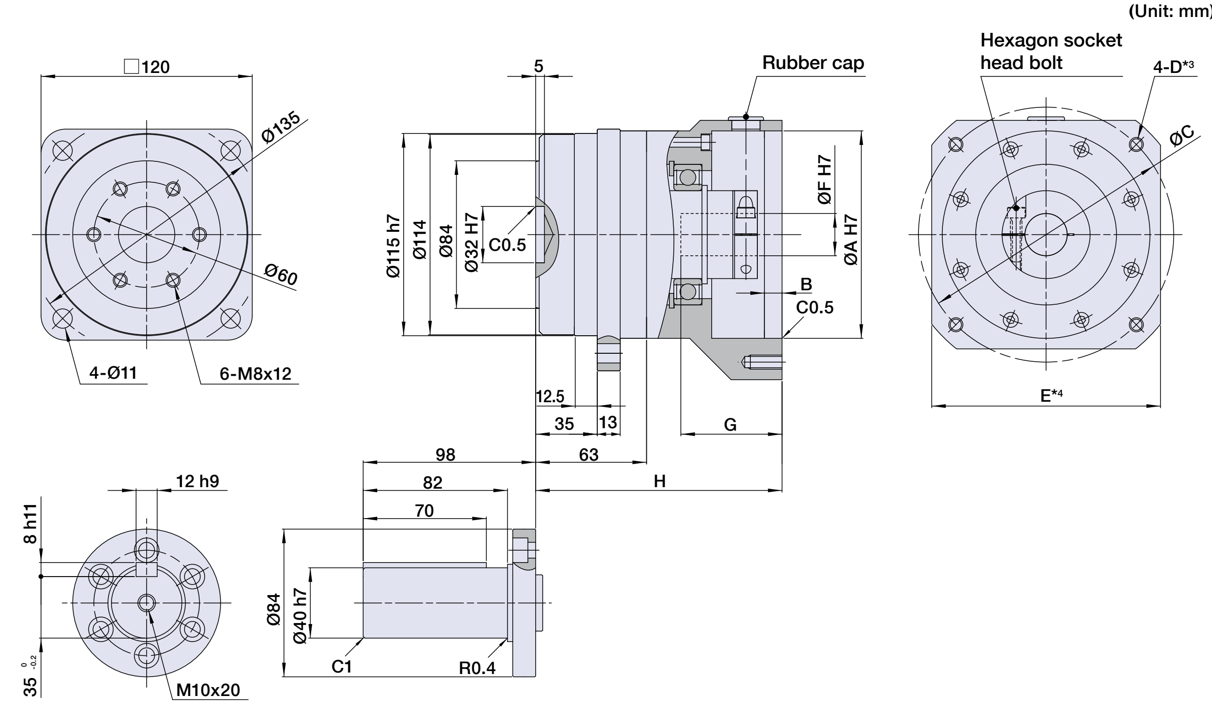
(10^{-4} kgm^2) Table 036-2

	Ratio / Coupling	3	5	11	15	21	33	45
HPG 20	1	1.1	0.7	0.6	0.56	0.49	0.45	0.45
	3	-	-	-	-	0.11	0.065	0.063

HPG-32 Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.

Figure 037-1



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

Dimension Table

(Unit: mm) Table 037-1

Flange	Coupling	A (H7)		B	C		F (H7)		G		H *1	Mass (kg) *2	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	Shaft	Flange
Type I	1	110	120	10	120	155	10.0	28.6	31.0	57.5	140	7.8	6.4
Type II	1	70	100	7	80	112	10.0	28.6	30.0	56.5	139	7.8	6.4
Type III	3	50	100	10	80	112	14.0	19.6	25.8	38.8	139	7.5	6.1
Type IV	1	70	95	10	80	115	10.0	28.6	41.0	67.5	150	7.9	6.5
Type V	1	70	110	10	80	155	10.0	28.6	45.0	71.5	154	9.5	8.1

Refer to the confirmation drawing for detailed dimensions. Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.
*1 May vary depending on motor interface dimensions.
*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.
*3 Tapped hole for motor mounting screw.
*4 E dimension is dependent on motor selection.

Moment of Inertia

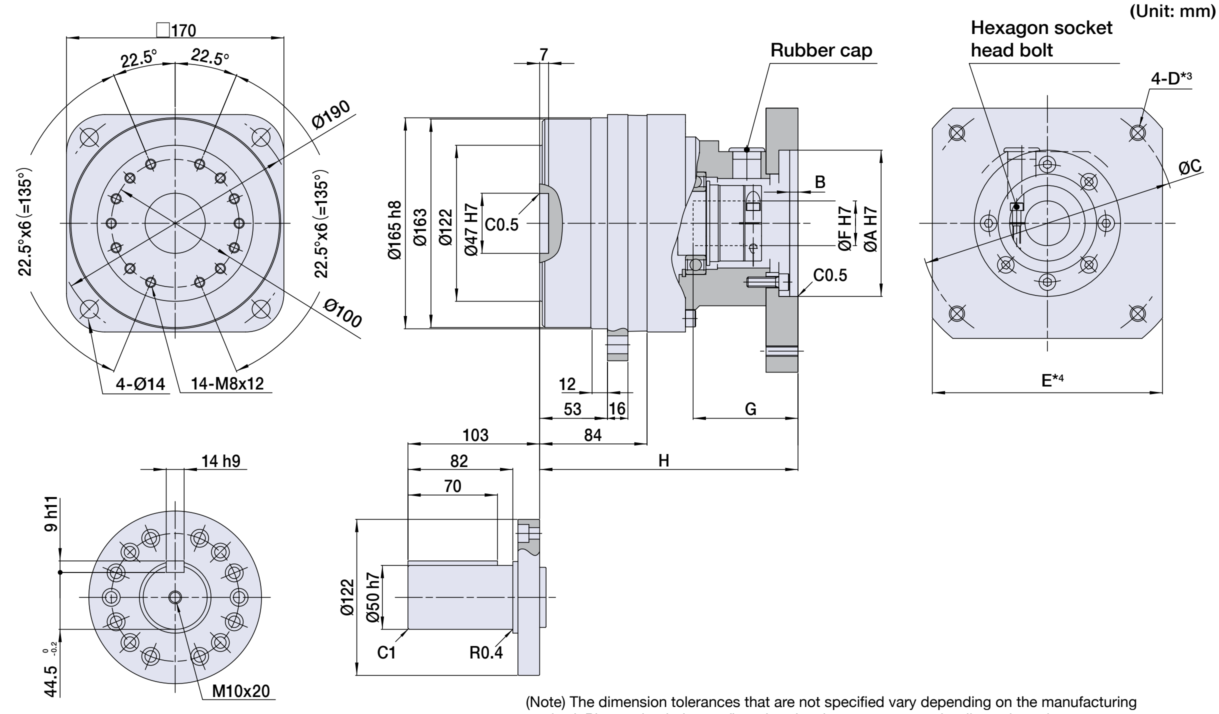
(10^{-4} kgm^2) Table 037-2

	Ratio / Coupling	3	5	11	15	21	33	45
HPG 32	1	5.6	3.9	3.4	3.2	3	2.8	2.8
	2	-	-	-	-	0.84	0.52	0.61

HPG-50 Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.

Figure 038-1



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

Dimension Table

(Unit: mm) Table 038-1

Flange	Coupling	A (H7)		B	C		F (H7)		G		H *1	Mass (kg) *2	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	Shaft	Flange
Type I	1	70	200	15	90	235	19.0	41.0	45.0	81.0	202	20.2	17.2
Type II	1	70	200	15	90	235	19.0	41.0	45.0	81.0	243.5	20.4	17.4
Type III	2	80	115	10	100	150	19.0	41.0	31.5	55.0	176	19.0	16.0
Type IV	1	70	200	15	90	235	19.0	41.0	45.0	81.0	202	27.5	24.5

Refer to the confirmation drawing for detailed dimensions. Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.
*1 May vary depending on motor interface dimensions.
*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling. Use type IV flange for motors weighing over 65 kg.
*3 Tapped hole for motor mounting screw.
*4 E dimension for Flange Type I, II and IV is dependent on motor selection.

Moment of Inertia

(10^{-4} kgm^2) Table 038-2

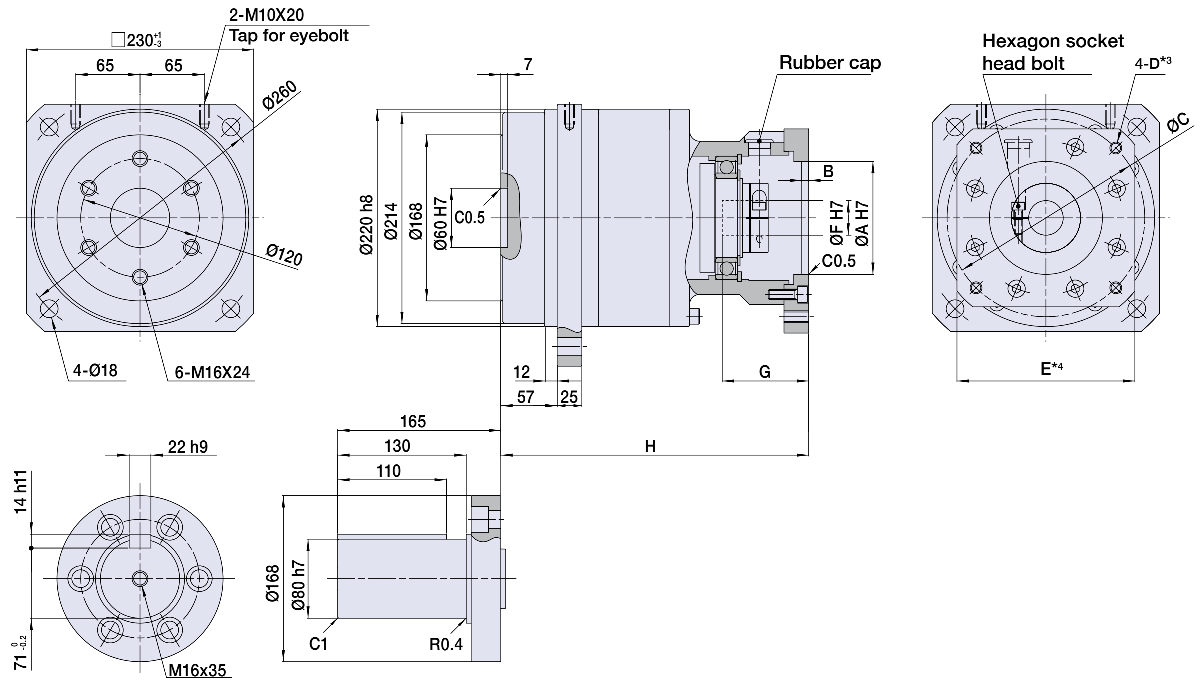
	Coupling \ Ratio	4	5	11	15	21	33	45
HPG 50	1	23	12	8.8	8.8	7	6	5.9
	2	-	-	-	7.7	5.8	4.8	4.7

HPG-65 Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.

Figure 039-1

(Unit: mm)



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above. The flange output is standard, the shaft output is optional.

Dimension Table

(Unit: mm) Table 039-1

	Flange	Coupling	A (H7)		B	C		F (H7)		G		H *1	Mass (kg) *2	
			Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	Shaft	Flange
Single Stage	Type I	1	125	230	15	150	265	35.0	43.9	63.0	87.5	241.5	48.0	38.0
Two Stage	Type I	1	125	230	15	150	265	35.0	43.9	63.0	87.5	311.5	52.0	42.0

Refer to the confirmation drawing for detailed dimensions. Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.

*1 May vary depending on motor interface dimensions.
*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.
*3 Tapped hole for motor mounting screw.
*4 E dimension is dependent on motor selection.

Moment of Inertia

(10^{-4} kgm^2) Table 039-2

	Coupling \ Ratio	4	5	12	15	20	25	40	50
HPG 65	1	-	-	25	24	15	14	9	9
	2	89	74	67	65	53	53	-	-

Product Sizing & Selection

To fully utilize the excellent performance of the HPG HarmonicPlanetary® gearheads, check your operating conditions and, using the flowchart, select the appropriate size gear for your application.

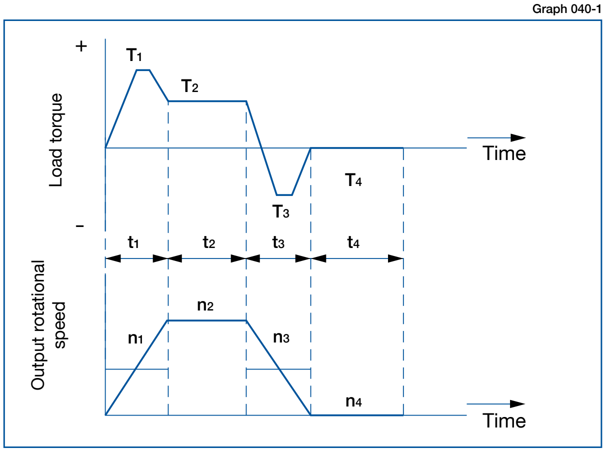
In general, a servo system rarely operates at a continuous load and speed. The input speed, load torque change and a comparatively large torque is applied during start and stop. Unexpected impact torques may also be applied.

Check your operating conditions against the following load torque pattern and select a suitable size based on the flowchart shown on the right. Also check the life and static safety coefficient of the cross roller bearing and input side main bearing (input shaft type only).

Checking the load torque pattern

Review the load torque pattern. Check the specifications shown in the figure below.

Graph 040-1



Obtain the value of each load torque pattern.

Load torque	T_1 to T_n (Nm)
Time	t_1 to t_n (sec)
Output rotational speed	n_1 to n_n (rpm)

<Normal operation pattern>

Starting	T_1, t_1, n_1
Steady operation	T_2, t_2, n_2
Stopping (slowing)	T_3, t_3, n_3
Idle	T_4, t_4, n_4

<Maximum rotational speed>

Max. output rotational speed	$n_{o\,max} \geqq n_1$ to n_n
Max. input rotational speed	$n_{i\,max}$ $n_1 \times R$ to $n_n \times R$
(Restricted by motors)	R: Reduction ratio

<Impact torque>

When impact torque is applied T_s

<Required life>

$L_{50} = L$ (hours)

Flowchart for selecting a size

Please use the flowchart shown below for selecting a size. Operating conditions must not exceed the performance ratings.

Calculate the average load torque applied on the output side from the load torque pattern: T_{av} (Nm).

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

Calculate the average output speed based on the load torque pattern: no av (rpm)

$$n_{o\,av} = \frac{|n_1|\cdot t_1+|n_2|\cdot t_2+\cdots+|n_n|\cdot t_n}{t_1+t_2+\cdots+t_n}$$

↓

Make a preliminary model selection with the following condition: $T_{av} \leqq$ Average load torque (Refer to rating table). — NG

OK ↓

Determine the reduction ratio (R) based on the maximum output rotational speed (no *max*) and maximum input rotational speed (ni *max*).

$$\frac{n_{i\,max}}{n_{o\,max}} \geqq R$$

(A limit is placed on ni *max* by motors.)
Calculate the maximum input speed (ni *max*) from the maximum output speed (no *max*) and the reduction ratio (R).

$$n_{i\,max} = n_{o\,max} \cdot R$$

↓

Calculate the average input speed (ni *av*) from the average output speed (no *av*) and the reduction ratio (R): $n_{i\,av} = n_{o\,av}\cdot R \leqq$ Max. average input speed (nr). — NG

Refer to the Caution note below.

OK ↓

Check whether the maximum input speed is equal to or less than the values in the rating table.
$n_{i\,max} \leqq$ maximum input speed (rpm) — NG

OK ↓

Check whether T1 and T3 are within peak torques (Nm) on start and stop in the rating table. — NG

OK ↓

Check whether T_s is equal to or less than the momentary max. torque (Nm) value from the ratings. — NG

OK ↓

Calculate the lifetime and check whether it meets the specification requirement.
Tr: Output torque
n_r: Max. average input speed

$$L_{50} = 20{,}000 \cdot \left(\frac{T_r}{T_{av}}\right)^{10/3} \cdot \left(\frac{n_r}{n_{i\,av}}\right) \text{(Hour)}$$

— NG

OK ↓

The model number is confirmed.

Review the operation conditions, size and reduction ratio.

Caution

If the expected operation will result in conditions where;
i) Actual average load torque (Tav) > Permissible maximum value of average load torque or
ii) Actual average input rotational speed (ni av) > Permissible average input rotational speed (nr),
then please check its effect on the speed reducer temperature rise or other factors. Consider selecting the next larger speed reducer, reduce the operating loads or take other means to ensure safe use of the gear. Exercise caution especially when the duty cycle is close to continuous operation.

Example of model number Selection

Value of each load torque pattern.

Load torque	T_n (Nm)		
Time	t_n (sec)		
Output rotational speed	n_n (rpm)		

<Normal operation pattern>

Starting	T_1 = 70 Nm,	t_1 = 0.3 sec,	n_1 = 60 rpm
Steady operation	T_2 = 18 Nm,	t_2 = 3 sec,	n_2 = 120 rpm
Stopping (slowing)	T_3 = 35 Nm,	t_3 = 0.4 sec,	n_3 = 60 rpm
Idle	T_4 = 0 Nm,	t_4 = 5 sec,	n_4 = 0 rpm

<Maximum rotational speed>

Max. output rotational speed	no *max* = 120 rpm
Max. input rotational speed	ni *max* = 5,000 rpm (Restricted by motors)

<Impact torque>
When impact torque is applied T_S = 180 Nm

<Required life>
L_{50} = 30,000 (hours)

Calculate the average load torque applied to the output side based on the load torque pattern: T*av* (Nm).

$$T_{av} = \sqrt[10/3]{\frac{|60\text{rpm}|\cdot 0.3\text{sec}\cdot|70\text{Nm}|^{10/3} + |120\text{rpm}|\cdot 3\text{sec}\cdot|18\text{Nm}|^{10/3} + |60\text{rpm}|\cdot 0.4\text{sec}\cdot|35\text{Nm}|^{10/3}}{|60\text{rpm}|\cdot 0.3\text{sec} + 120\text{rpm}|\cdot 3\text{sec} + |60\text{rpm}|\cdot 0.4\text{sec}|}}$$

Calculate the average output speed based on the load torque pattern: no *av* (rpm)

$$n_{o\,av} = \frac{|60\text{rpm}|\cdot 0.3\text{sec} + |120\text{rpm}|\cdot 3\text{sec} + |60\text{rpm}|\cdot 0.4\text{sec} + |0\text{rpm}|\cdot 5\text{sec}}{0.3\text{sec} + 3\text{sec} + 0.4\text{sec} + 5\text{sec}}$$

Make a preliminary model selection with the following conditions. T*av* = 30.2 Nm ≦ 70 Nm. (**HPG-20A-33** is tentatively selected based on the average load torque (see the rating table) of size 20 and reduction ratio of 33.)

OK / NG

Determine a reduction ratio (R) from the maximum output speed (no *max*) and maximum input speed (ni *max*).

$$\frac{5{,}000\text{ rpm}}{120\text{ rpm}} = 41.7 \geqq 33$$

Calculate the maximum input speed (ni *max*) from the maximum output speed (no *max*) and reduction ratio (R): ni *max* = 120 rpm・33 = 3,960 rpm

Calculate the average input speed (ni *av*) from the average output speed (no *av*) and reduction ratio (R):
ni *av* = 46.2 rpm・33= 1,525 rpm ≦ Max average input speed of size 20 3,000 rpm

OK / NG

Check whether the maximum input speed is equal to or less than the values specified in the rating table.
ni *max* = 3,960 rpm ≦ 5,000 rpm (maximum input speed of size 20)

OK / NG

Check whether T_1 and T_3 are within peak torques (Nm) on start and stop in the rating table.
T_1 = 70 Nm ≦ 117 Nm (Limit for repeated peak torque, size 20)
T_3 = 35 Nm ≦ 117 Nm (Limit for repeated peak torque, size 20)

OK / NG

Check whether Ts is equal to or less than limit for momentary torque (Nm) in the rating table.
T_S = 180 Nm ≦ 217 Nm (momentary max. torque of size 20)

OK / NG

Calculate life and check whether the calculated life meets the requirement.

$$L_{50} = 20{,}000 \cdot \left(\frac{70\text{ Nm}}{30.2\text{ Nm}}\right)^{10/3} \cdot \left(\frac{3{,}000\text{ rpm}}{1{,}525\text{ rpm}}\right) = 648{,}413\text{ (hours)} \geqq 30{,}000\text{ (hours)}$$

OK / NG

The selection of model number HPG-20A-33 is confirmed from the above calculations.

NG: Refer to the Caution note at the bottom of page 40.

NG: Review the operation conditions, size and reduction ratio.

HarmonicPlanetary®

HPG Right Angle Series

Size

3 Sizes

32, 50, 65

Peak torque

150Nm – 2200Nm

Reduction ratio

Single Stage: 5:1, Two Stage: 11:1 to 50:1

Low backlash

Standard: <3 arc-min Low Backlash for Life

Innovative ring gear automatically adjusts for backlash, ensuring consistent, low backlash for the life of the gearhead. The ring gear design automatically provides the optimum backlash in the planetary gear train and maintains the same low backlash for the life of the gearhead.

High efficiency

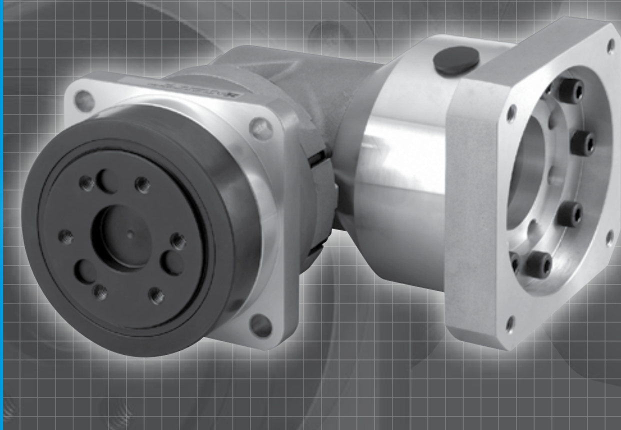
Up to 92%

High Load Capacity Output Bearing

A Cross Roller bearing is integrated with the output flange to provide high moment stiffness, high load capacity and precise positioning accuracy.

Easy mounting to a wide variety of servomotors

Quick Connect™ coupling



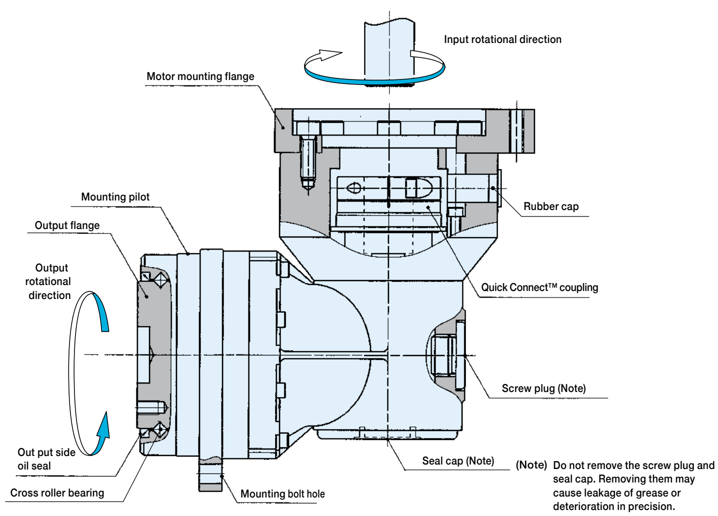
CONTENTS

HPG - 32 A - 05 - J2 - RA3 - Motor Code

Model Name	Size	Design Revision	Reduction Ratio	Output Configuration	Right Angle Type	Input Configuration
HarmonicPlanetary® HPG Right Angle	32	A	5, 11, 15, 21, 33, 45	F0: Flange output J2: Shaft output without key J6: Shaft output with key and center tapped hole (J2, J6 for Size 65 is also available)	Right angle specification, RA3 or RA5.	This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.
	50					
	65		5, 12, 15, 20, 25, 40, 50			

Gearhead Construction

Figure 042-1



Rating Table

Table 043-1

Size	Model	Ratio	Rated Torque *1	Limit for Repeated Peak Torque *2	Limit for Momentary Torque *3	Max. Average Input Speed *4	Max. Input Speed *5	Mass *6	
								Shaft	Flange
			Nm	Nm	Nm	rpm	rpm	kg	kg
32	RA3	5	120	150	200	1500	6000	7.4	6.0
		11	160	330	440			7.9	6.5
		15	170	300	600				
		21	190		650				
		33	200	330					
		45	240	300					
50	RA3	5	150	150	200	1500	4500	20	17
		11	330	330	440			21	18
		15	400	450	600				
		21	450	630	840				
		33	470	990	1320				
		45	560	1140	1800				
	RA5	5	290	400	500	1300	4500	21	18
		11	340	880	1100			22	19
		15	400	1200	1500				
		21	450	1150	2100				
		33	470	1140	2180				
		45	560						
65	RA5	5	400	400	500	1300	3000	45*7	35
		12	960	960	1200			60*7	50
		15	1200	1200	1500				
		20	1370	1600	2000				
		25	1470	2000	2500				
		40	1320	1900	4000				
		50	1650	2200	4500				

*1: Rated torque is based on L_{50} life of 20,000 hours at rated input speed.
*2: The limit for torque during start and stop cycles.
*3: The limit for torque during emergency stops or from external shock loads. Always operate below this value. Calculate the number of permissible events to ensure it meets required operating conditions.
*4: Maximum average input speed is limited by heat generation in the speed reducer assuming a continuous operating speed or the average input speed of a motion profile. The actual limit for average input speed depends on the operating environment.
*5: Maximum instantaneous input speed.
*6: The mass is for the gearhead only (without input shaft coupling & motor flange). Please contact us for the mass of your specific configuration.
*7: Flange output is standard for the size 65 gearhead. Shaft type (J2 & J6) is also available.

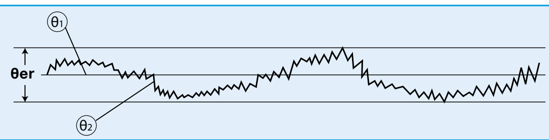
Performance Table

Table 044-1

Size	Model	Ratio	Accuracy *1		Repeatability *2	Starting torque *3		Backdriving torque *4		No-load running torque *5	
			arc min	×10⁻⁴rad	arc sec	Ncm	kgfcm	Nm	kgfm	Ncm	kgfcm
32	RA3	5	4.0	11.6	±15	64	6.5	3.3	0.34	179	18
		11				58	5.9	6.8	0.69	162	17
		15				56	5.7	8.9	0.91	155	16
		21				53	5.4	12	1.2		
		33				48	4.9	17	1.7	150	15
		45				47	4.8	23	2.3		
50	RA3	5	4.0	11.6	±15	111	11	5.8	0.59	241	25
		11				76	7.8	8.9	0.91	198	20
		15				71	7.2	11	1.2	173	18
		21				69	7.0	15	1.6		
		33				61	6.2	21	2.2	161	16
		45				59	6.0	28	2.9		
	RA5	5	3.0	8.7	±15	132	14	6.9	0.70	496	51
		11				97	9.9	11	1.2	459	47
		15				92	9.4	15	1.5	437	45
		21				90	9.2	20	2.1		
		33				82	8.4	29	2.9	427	44
		45				80	8.2	38	3.9		
65	RA5	5	3.0	8.7	±15	292	30	15	1.6	647	66
		12				177	18	23	2.3	532	54
		15				162	17	26	2.6	513	52
		20				147	15	31	3.2	494	50
		25				136	14	36	3.7	481	49
		40				127	13	51	5.2	460	47
		50				122	12	61	6.2	453	46

*1: Accuracy values represent the difference between the theoretical angle and the actual angle of output for any given input. The values in the table are maximum values.

Figure 044-1

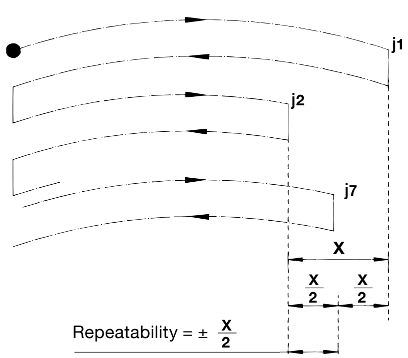


θer : Accuracy
θ_1 : Input angle
θ_2 : Actual output angle
R : Gear reduction ratio

$$\theta er = \theta_2 - \frac{\theta_1}{R}$$

*2: The repeatability is measured by moving to a given theoretical position seven times, each time approaching from the same direction. The actual position of the output shaft is measured each time and repeatability is calculated as the 1/2 of the maximum difference of the seven data points. Measured values are indicated in angles (arc-sec) prefixed with "±". The values in the table are maximum values.

Figure 044-2



*3: Starting torque is the torque value applied to the input side at which the output first starts to rotate. The values in the table are maximum values.

Table 044-2

Load	No load
HPG speed reducer surface temperature	25°C

*4: Backdriving torque is the torque value applied to the output side at which the input first starts to rotate. The values in the table are maximum values.

Note: Never rely on these values as a margin in a system that must hold an external load. A brake must be used where back driving is not permissible.

Table 044-3

Load	No load
HPG speed reducer surface temperature	25°C

*5: No-load running torque is the torque required at the input to operate the gearhead at a given speed under a no-load condition. The values in the table are average values.

Table 044-4

Input speed	Right Angle model RA3	1500 rpm
	Right Angle RA5	3000 rpm
Load		No load
HPG speed reducer surface temperature		25°C

Backlash and Torsional Stiffness

Table 045-1

■ **Right Angle**

Size	Model	Ratio	Backlash arc min	Backlash ×10⁻⁴rad	Torsion angle on one side at TR X 0.15 D arc min	D ×10⁻⁴rad	Torsional stiffness A/B kgfm/arc min	A/B ×100Nm/rad
32	RA3	5	<3.0	8.7	1.9	5.5	2.2	740
		11					2.4	820
		15					2.5	850
		21					2.6	880
		33					2.7	900
		45						910
50	RA3	5	<3.0	8.7	2.7	7.9	3.9	1300
		11			2.1	6.1	9.3	3100
		15					11	3800
		21					13	4300
		33					14	4700
		45						4800
	RA5	5	<3.0	8.7	1.7	4.9	7.5	2500
		11			1.8	5.2	12	4100
		15					13	4500
		21					14	4700
		33					15	4900
		45						5000
65	RA5	5	<3.0	8.7	2.3	6.7	10	3400
		12			2.0	5.8	26	8600
		15					29	9800
		20					32	11000
		25					34	
		40					36	12000
		50					37	

Torsional stiffness curve

With the input of the gear locked in place, a torque applied to the output flange will torsionally deflect in proportion to the applied torque. We generate a torsional stiffness curve by slowly applying torque to the output in the following sequence:
(1) Clockwise torque to TR, (2) Return to Zero, (3) Counter-Clockwise torque to -TR, (4) Return to Zero and (5) again Clockwise torque to TR.
A loop of (1) > (2) > (3) > 4) > (5) will be drawn as in Fig. 045-1.
The torsional stiffness in the region from "0.15 x TR," to "TR," is calculated using the average value of this slope. The torsional stiffness in the region from "zero torque" to "0.15 x TR," is lower. This is caused by the small amount of backlash plus engagement of the mating parts and loading of the planet gears under the initial torque applied.

Calculation of total torsion angle

The method to calculate the total torsion angle (average value) on one side when the speed reducer applies a load in a no-load state.

Formula 045-1

● Calculation formula

$$\theta = D + \frac{T - T_L}{\frac{A}{B}}$$

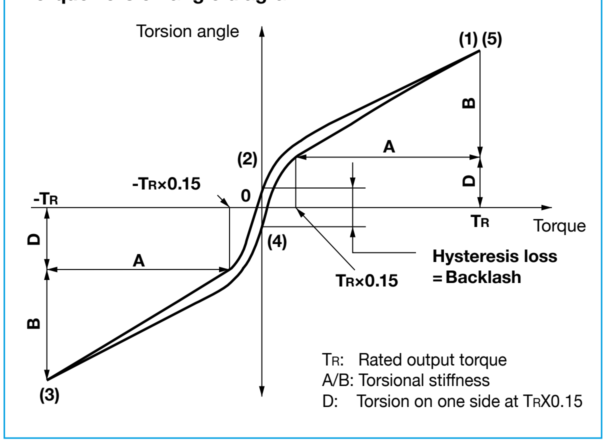
θ	Total torsion angle	——
D	Torsion angle on one side at output torque x 0.15 torque	See Fig. 045-1, Table 045-1
T	Load torque	——
T_L	Output torque x 0.15 torque (=TRX0.15)	See Fig. 045-1
A / B	Torsional stiffness	See Fig. 045-1, Table 045-1

Backlash (Hysteresis loss)

The vertical distance between points (2) & (4) in Fig. 045-1 is called a hysteresis loss. The hysteresis loss between "Clockwise load torque TR," and "Counter Clockwise load torque -TR," is defined as the backlash of the HPG series. Backlash of the HPG series is less than 3 arc-min (1 arc-min or less is also available).

Figure 045-1

Torque-torsion angle diagram

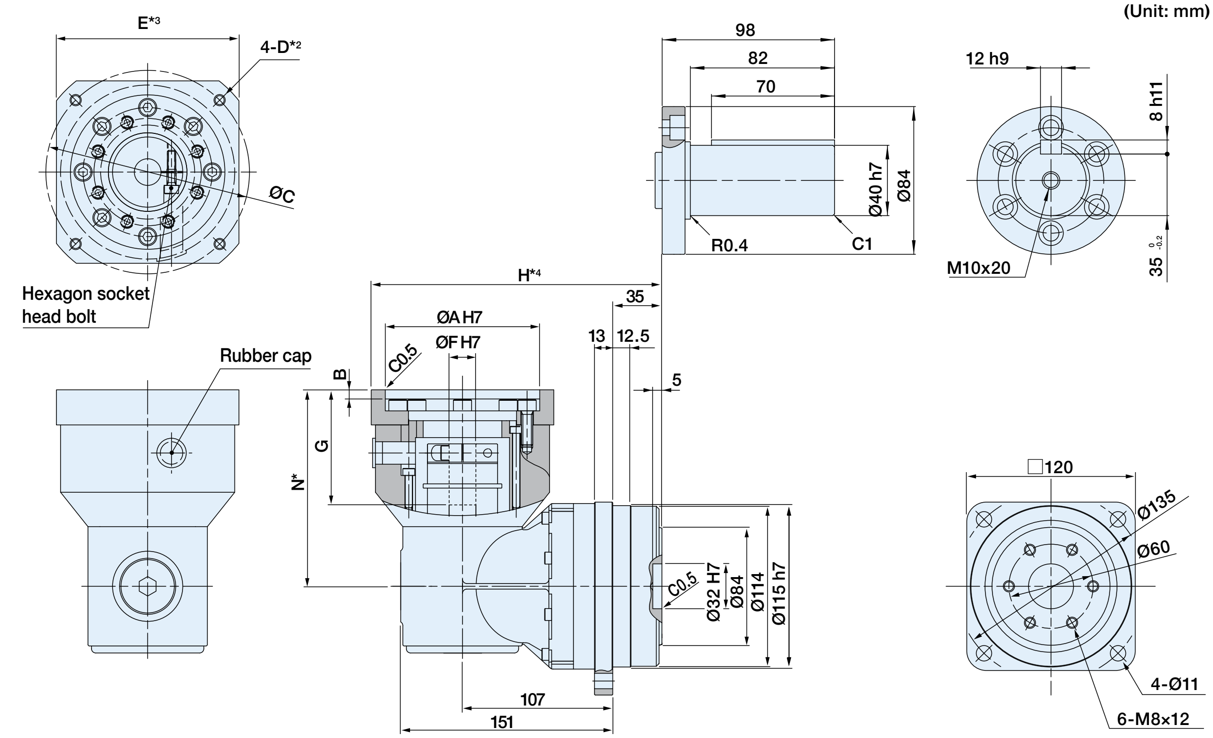


HPG-32 Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.

Figure 046-1

(Unit: mm)



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

Dimension Table

(Unit: mm) Table 046-1

Flange	Coupling	A (H7)		B	C		F (H7)		G		N	Mass (kg) *1	
		Min.	Max.*4	Max.	Min.	Max.*4	Min.	Max.	Min.	Max.		Shaft	Flange
1	1	70	200	10	115	235	10	24	29	56	115	10.1	8.7
2	2	110	200	6.5	125	235	10	35	54	81	140	10.3	8.9

Refer to the confirmation drawing for detailed dimensions. Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.

*1 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.

*2 Tapped hole for motor mounting screw.

*3 E dimension is dependent on motor selection.

*4 May vary depending on motor interface dimensions.

Moment of Inertia

(10^{-4} kgm^2) Table 046-2

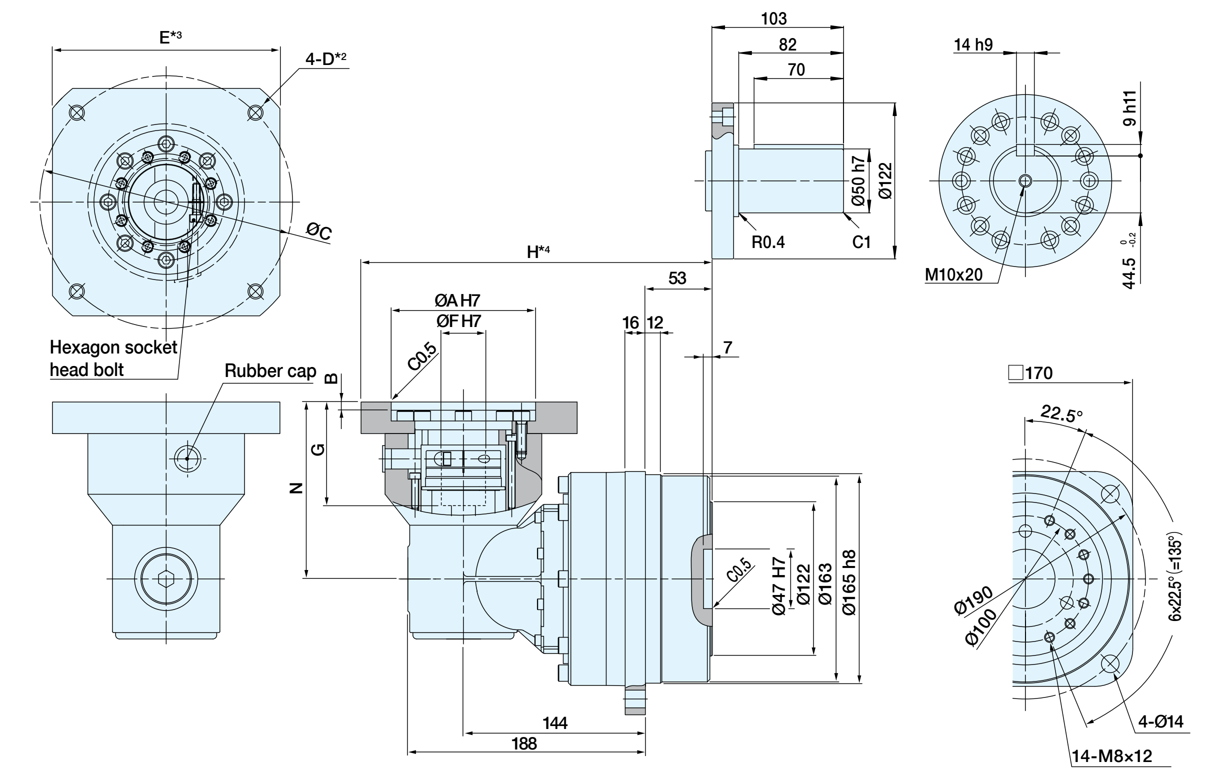
	Ratio / Coupling	5	11	15	21	33	45
HPG 32RA	1	6.7	6.3	6.1	5.8	-	-
	2	8.09	7.62	-	-	-	-

HPG-50RA3 Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.

Figure 047-1

(Unit: mm)



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

Dimension Table

(Unit: mm) Table 047-1

Flange	Coupling	A (H7)		B	C		F (H7)		G		N	Mass (kg) *1	
		Min.	Max.*4	Max.	Min.	Max.*4	Min.	Max.	Min.	Max.		Shaft	Flange
1	1	70	200	10	115	235	10	24	29	56	115	24	21
2	2	110	200	6.5	125	235	10	35	54	81	140	25	22

Refer to the confirmation drawing for detailed dimensions. Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.

*1 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.
*2 Tapped hole for motor mounting screw.
*3 E dimension is dependent on motor selection.
*4 May vary depending on motor interface dimensions.

Moment of Inertia

(10^{-4} kgm^2) Table 047-2

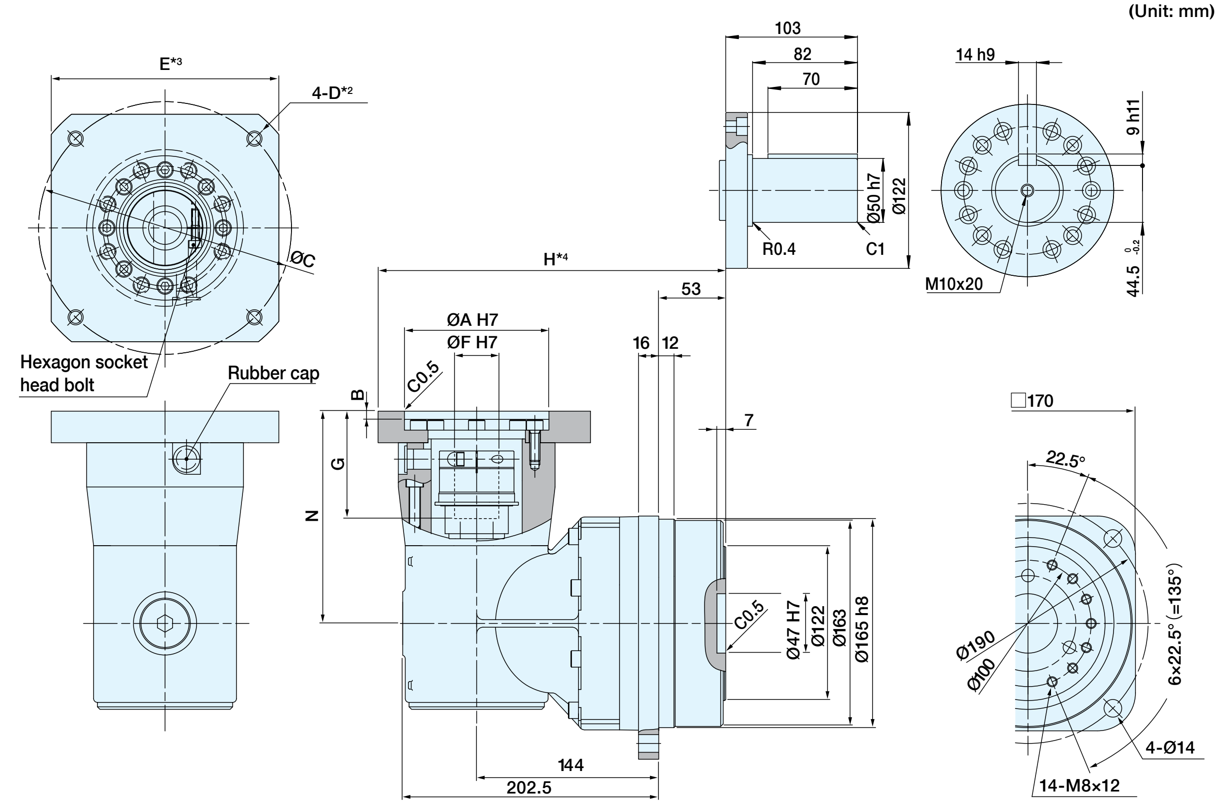
	Coupling \ Ratio	5	11	15	21	33	45
HPG 50RA3	1	-	9.4	8.8	7.5	6.4	6.4
	2	-	10.8	10.2	8.9	7.8	7.73

HPG-50RA5 Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.

Figure 048-1

(Unit: mm)



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

Dimension Table

(Unit: mm) Table 048-1

Flange	Coupling	A (H7)		B	C		F (H7)		G		N	Mass (kg) *1	
		Min.	Max.*4	Max.	Min.	Max.*4	Min.	Max.	Min.	Max.		Shaft	Flange
1	1	70	200	6.5	115	235	19	42	45	84	168	26.5	23.5
2	2	110	200	6.5	125	235	19	42	45	116	200	27.5	24.5

Refer to the confirmation drawing for detailed dimensions. Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.
*1 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.
*2 Tapped hole for motor mounting screw.
*3 E dimension is dependent on motor selection.
*4 May vary depending on motor interface dimensions.

Moment of Inertia

(10^{-4} kgm^2) Table 048-2

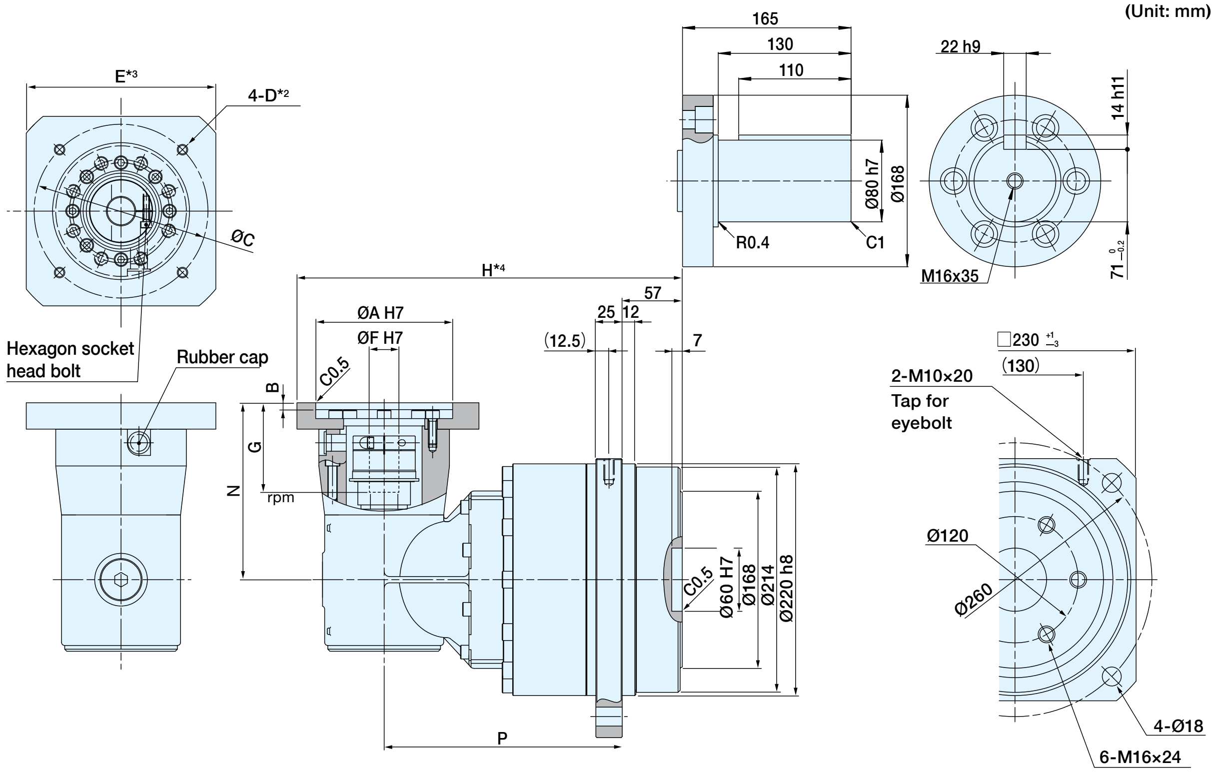
	Ratio / Coupling	5	11	15	21	33	45
HPG 50RA5	1	37.4	33.9	33.3	32	-	-

HPG-65 Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.

Figure 049-1

(Unit: mm)



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

Dimension Table

(Unit: mm) Table 049-1

	Flange	Coupling	A (H7)		B	C		F (H7)		G		N	P	Mass (kg) *1	
			Min.	Max.*4	Max.	Min.	Max.*4	Min.	Max.	Min.	Max.			Shaft	Flange
Single Stage	1	1	70	200	6.5	115	235	19	42	45	84	168	172	49.5	39.5
	2	2	110	200	6.5	125	235	19	42	45	116	200	172	50.5	40.5
Two Stage	1	1	70	200	6.5	115	235	19	42	45	84	168	226	58.8	48.8
	2	2	110	200	6.5	125	235	19	42	45	116	200	226	59.8	49.8

Refer to the confirmation drawing for detailed dimensions. Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.

*1 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.
*2 Tapped hole for motor mounting screw.
*3 E dimension is dependent on motor selection.
*4 May vary depending on motor interface dimensions.

Moment of Inertia

(10^{-4} kgm^2) Table 049-2

	Ratio / Coupling	5	12	15	20	25	40	50
HPG 65RA	1	-	48.8	47.8	37.9	37.3	32.3	32.1
	2	60.6	49.2	48.2	38.3	37.7	-	-

Product Sizing & Selection

To fully utilize the excellent performance of the HPG-RA HarmonicPlanetary® gearheads, check your operating conditions and, using the flowchart, select the appropriate size gear for your application.

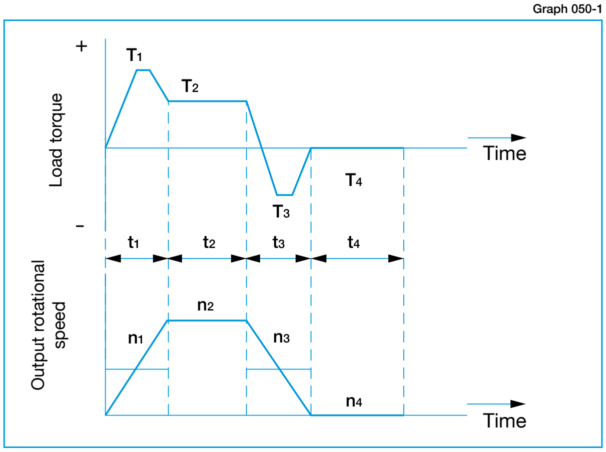
In general, a servo system rarely operates at a continuous load and speed. The input speed, load torque change and a comparatively large torque is applied during start and stop. Unexpected impact torques may also be applied.

Check your operating conditions against the following load torque pattern and select a suitable size based on the flowchart shown on the right. Also check the life and static safety coefficient of the cross roller bearing and input side main bearing (input shaft type only).

Checking the load torque pattern

Review the load torque pattern. Check the specifications shown in the figure below.

Graph 050-1



Obtain the value of each load torque pattern.

Load torque	T_1 to T_n (Nm)
Time	t_1 to t_n (sec)
Output rotational speed	n_1 to n_n (rpm)

<Normal operation pattern>

Starting	T_1, t_1, n_1
Steady operation	T_2, t_2, n_2
Stopping (slowing)	T_3, t_3, n_3
Idle	T_4, t_4, n_4

<Maximum rotational speed>

Max. output rotational speed	$n_{o\,max} \geqq n_1$ to n_n
Max. input rotational speed	$n_{i\,max}$ $n_1 \times R$ to $n_n \times R$
(Restricted by motors)	R: Reduction ratio

<Impact torque>

When impact torque is applied T_s

<Required life>

L_{50} = L (hours)

Flowchart for selecting a size

Please use the flowchart shown below for selecting a size. Operating conditions must not exceed the performance ratings.

Calculate the average load torque applied on the output side from the load torque pattern: T_{av} (Nm).

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

Calculate the average output speed based on the load torque pattern: no av (rpm)

$$n_{o\,av} = \frac{|n_1|\cdot t_1 + |n_2|\cdot t_2 + \cdots + |n_n|\cdot t_n}{t_1 + t_2 + \cdots + t_n}$$

Make a preliminary model selection with the following condition: $T_{av} \leqq$ Average load torque (Refer to rating table). — NG

OK

Determine the reduction ratio (R) based on the maximum output rotational speed (no *max*) and maximum input rotational speed (ni *max*).

$$\frac{n_{i\,max}}{n_{o\,max}} \geqq R$$

(A limit is placed on ni *max* by motors.)
Calculate the maximum input speed (ni *max*) from the maximum output speed (no *max*) and the reduction ratio (R).

$$n_{i\,max} = n_{o\,max} \cdot R$$

Calculate the average input speed (ni *av*) from the average output speed (no *av*) and the reduction ratio (R): $n_{i\,av} = n_{o\,av} \cdot R \leqq$ Max. average input speed (nr). — NG

OK

Check whether the maximum input speed is equal to or less than the values in the rating table.
$n_{i\,max} \leqq$ maximum input speed (rpm) — NG

OK

Check whether T1 and T3 are within peak torques (Nm) on start and stop in the rating table. — NG

OK

Check whether T_s is equal to or less than the momentary max. torque (Nm) value from the ratings. — NG

OK

Calculate the lifetime and check whether it meets the specification requirement.
Tr: Output torque
n_r: Max. average input speed

$$L_{50} = 20{,}000 \cdot \left(\frac{T_r}{T_{av}}\right)^{10/3} \cdot \left(\frac{n_r}{n_{i\,av}}\right) \text{(Hour)}$$

— NG

OK

The model number is confirmed.

Refer to the Caution note below.

Review the operation conditions, size and reduction ratio.

Caution

If the expected operation will result in conditions where;
i) Actual average load torque (Tav) > Permissible maximum value of average load torque or
ii) Actual average input rotational speed (ni av) > Permissible average input rotational speed (nr),
then please check its effect on the speed reducer temperature rise or other factors. Consider selecting the next larger speed reducer, reduce the operating loads or take other means to ensure safe use of the gear. Exercise caution especially when the duty cycle is close to continuous operation.

Example of model number Selection

Value of each load torque pattern.

Load torque T_n (Nm)
Time t_n (sec)
Output rotational speed n_n (rpm)

<Normal operation pattern>

Starting	T_1 = 70 Nm,	t_1 = 0.3 sec,	n_1 = 60 rpm
Steady operation	T_2 = 18 Nm,	t_2 = 3 sec,	n_2 = 120 rpm
Stopping (slowing)	T_3 = 35 Nm,	t_3 = 0.4 sec,	n_3 = 60 rpm
Idle	T_4 = 0 Nm,	t_4 = 5 sec,	n_4 = 0 rpm

<Maximum rotational speed>
Max. output rotational speed no *max* = 120 rpm
Max. input rotational speed ni *max* = 5,000 rpm (Restricted by motors)

<Impact torque>
When impact torque is applied T_s = 180 Nm

<Required life>
L_{50} = 30,000 (hours)

Calculate the average load torque applied to the output side based on the load torque pattern: T*av* (Nm).

$$T_{av} = \sqrt[10/3]{\frac{|60rpm|\cdot 0.3sec\cdot |70Nm|^{10/3} + |120rpm|\cdot 3sec\cdot |18Nm|^{10/3} + |60rpm|\cdot 0.4sec\cdot |35Nm|^{10/3}}{|60rpm|\cdot 0.3sec + 120rpm|\cdot 3sec + |60rpm|\cdot 0.4sec|}}$$

Calculate the average output speed based on the load torque pattern: no *av* (rpm)

$$no\ av = \frac{|60rpm|\cdot 0.3sec + |120rpm|\cdot 3sec + |60rpm|\cdot 0.4sec + |0rpm|\cdot 5sec}{0.3sec + 3sec + 0.4sec + 5sec}$$

Make a preliminary model selection with the following conditions. T*av* = 30.2 Nm ≦ 120 Nm. (**HPG-32A-5-RA3** is tentatively selected based on the average load torque (see the rating table) of size 32 and reduction ratio of 5.) — NG

OK

Determine a reduction ratio (R) from the maximum output speed (no *max*) and maximum input speed (ni *max*).

$$\frac{5{,}000\ rpm}{120\ rpm} = 41.7 \geqq 5$$

Calculate the maximum input speed (ni *max*) from the maximum output speed (no *max*) and reduction ratio (R): ni *max* = 120 rpm・5 = 600 rpm

Calculate the average input speed (ni *av*) from the average output speed (no *av*) and reduction ratio (R):
ni *av* = 46.2 rpm・5= 1,525 rpm ≦ Max average input speed of size 32 1,500 rpm — NG

OK

Check whether the maximum input speed is equal to or less than the values specified in the rating table.
ni *max* = 3,960 rpm ≦ 600 rpm (maximum input speed of size 32) — NG

OK

Check whether T_1 and T_3 are within peak torques (Nm) on start and stop in the rating table.
T_1 = 70 Nm ≦ 120 Nm (Limit for repeated peak torque, size 32)
T_3 = 35 Nm ≦ 120 Nm (Limit for repeated peak torque, size 32) — NG

OK

Check whether Ts is equal to or less than limit for momentary torque (Nm) in the rating table.
T_s = 180 Nm ≦ 200 Nm (momentary max. torque of size 32) — NG

OK

Calculate life and check whether the calculated life meets the requirement.

$$L_{50} = 20{,}000 \cdot \left(\frac{120\ Nm}{30.2\ Nm}\right)^{10/3} \cdot \left(\frac{3{,}000\ rpm}{231\ rpm}\right) = 25{,}932{,}572\ \text{(hours)} \geqq 30{,}000\ \text{(hours)}$$

— NG

OK

The selection of model number HPG-32A-5-RA is confirmed from the above calculations.

Refer to the Caution note at the bottom of page 50.

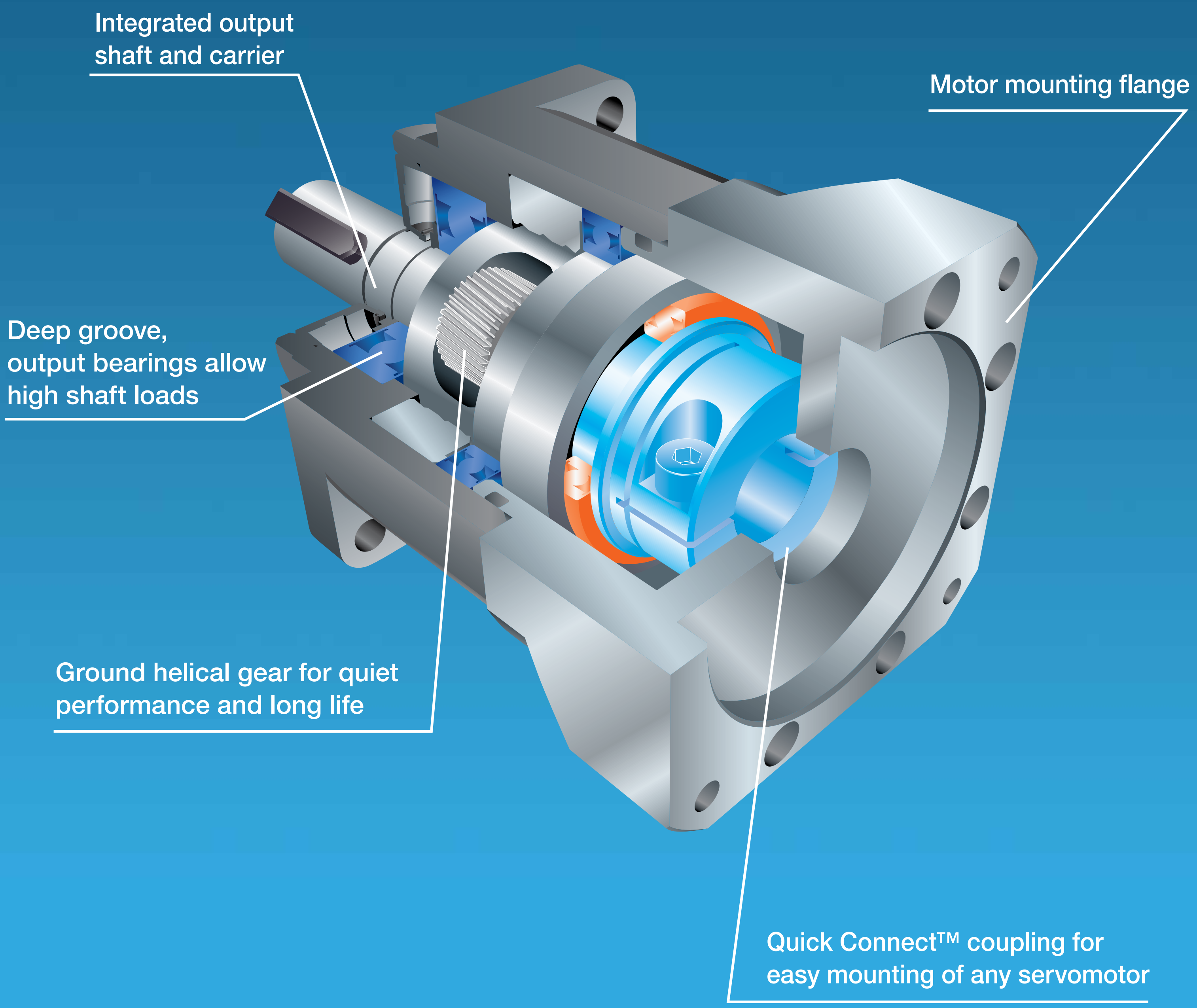
Review the operation conditions, size and reduction ratio.

HarmonicPlanetary® HPN Value Series

HPN Precision Planetary Gearheads are Quiet, Lightweight and Compact with Low Cost and Quick Delivery.

HPN Planetary gearheads feature a robust design utilizing helical gears for quiet performance and long life. These gearheads are available with short lead times and are designed to couple to any servomotor with our Quick Connect™ coupling. HPN gearheads are suitable for use in a wide range of applications for precision motion control and positioning. HPN Harmonic Planetary® gears are available in 5 sizes: 11, 14, 20, 32, and 40, with reduction ratios ranging from 3:1 to 31:1.

- **Backlash: One Stage <5 arc-min**
  Two Stage <7 arc-min
- **Low gear ratios, 3:1 to 31:1**
- **High efficiency**
- **Helical gearing**
- **Quiet design: Noise <58dB (Size 14)**


Integrated output shaft and carrier
Motor mounting flange
Deep groove, output bearings allow high shaft loads
Ground helical gear for quiet performance and long life
Quick Connect™ coupling for easy mounting of any servomotor

HarmonicPlanetary®
HPN Value Series

Size — 5 Sizes
11, 14, 20, 32, 40

Peak Torque
9Nm ～ 752Nm

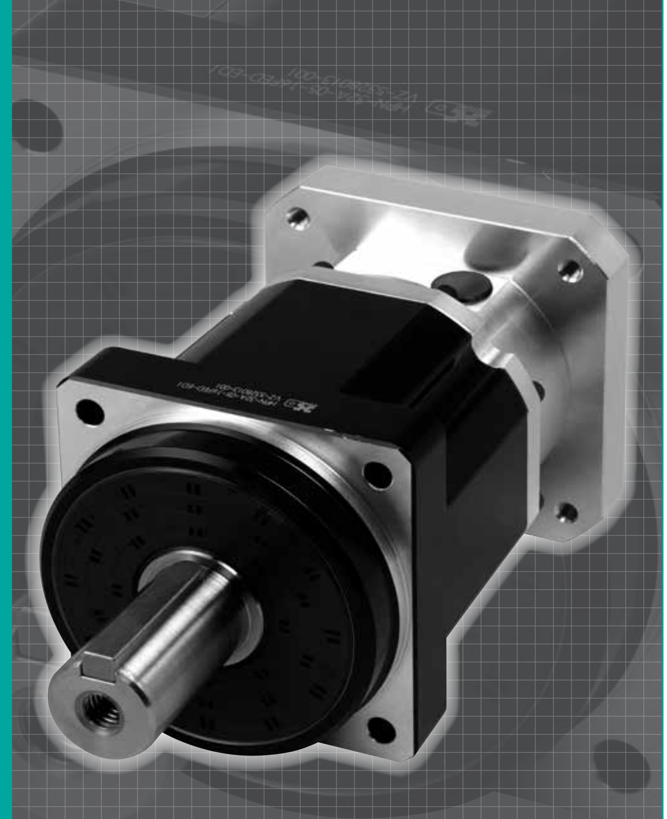
Reduction Ratio
Single stage: 3:1 to 10:1, Two stage: 13:1 to 31:1

Backlash
Single stage: < 5 arc-min, Two stage: < 7 arc-min

High Efficiency
Up to 97%

Output Bearing
A radial ball bearing is integrated with the output flange to provide high moment stiffness, high load capacity and precise positioning accuracy.

Easy mounting to a wide variety of servomotors
Quick Connect™ coupling



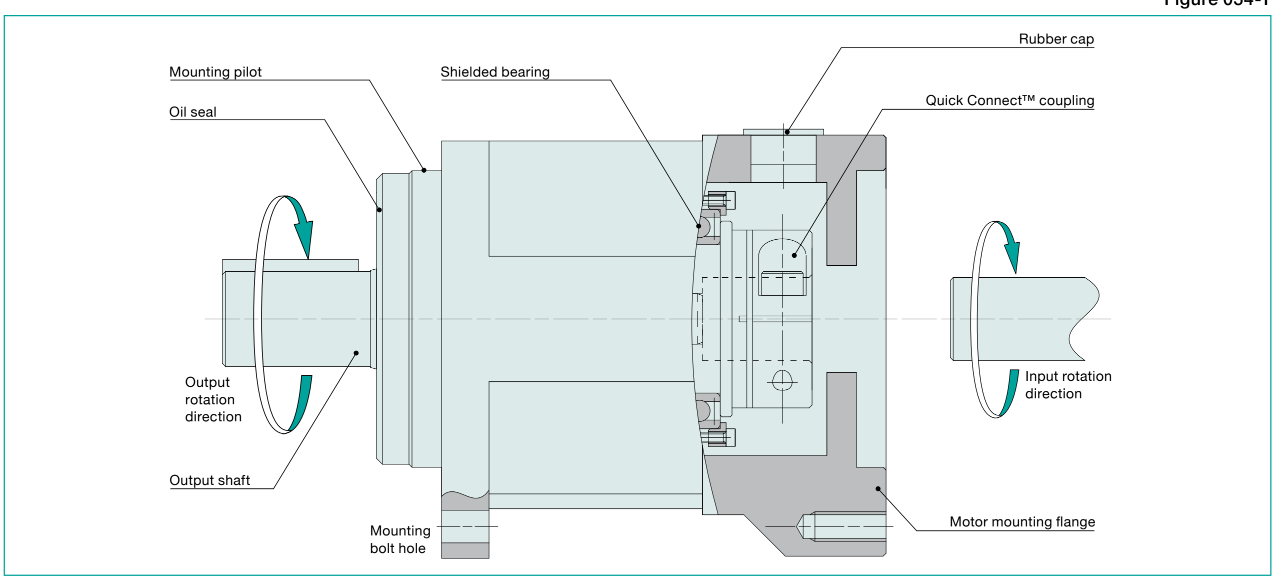
CONTENTS

HPN - 14 A - 05 - J6 - Motor Code

Model Name	Size	Design Revision	Reduction Ratio	Output Configuration	Input Configuration
HarmonicPlanetary® HPN High Torque	11	A	4, 5, 7, 10, 16, 20, 30	J6: Shaft output with key and center tapped hole J8: Shaft output with center tapped hole	This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.
	14		3, 4, 5, 7,1 0, 13, 21, 31		
	20				
	32				
	40				

Gearhead Construction

Figure 054-1



Rating Table

Please contact our sales office if you have any questions about our specifications or comparison with another company's products.

Table 055-1

Size	Number of Stages	Ratio	Rated Torque *1	Limit for Repeated Peak Torque *2	Limit for Momentary Peak Torque *3	Max. Average Rated Input Speed *4	Max. Input Speed (grease) *5	Allowable Radial Load *6	Allowable Axial Load *7
			Nm	Nm	Nm	rpm	rpm	N	N
11	1	4	14	14	40	3,000	10,000	240	280
		5	14	16	40			260	320
		7	11	11	40			280	360
		10	9	9	40			320	420
	2	16	18	24	40			360	460
		20	22	24	40			400	560
		30	25	26	40			480	640
14	1	3	22	25	89	3,000	6,000	380	340
		4	28	50	110			420	380
		5	29	50	107			450	410
		7	30	37	100			510	480
		10	18	18	79			570	580
	2	13	30	43	106			630	630
		21	30	50	99			740	780
		31	30	38	101			840	900
20	1	3	51	74	226	3,000	6,000	830	900
		4	80	130	256			920	1,100
		5	80	149	256			1,000	1,200
		7	80	113	256			1,100	1,400
		10	54	54	216			1,230	1,600
	2	13	80	130	256			1,350	1,850
		21	80	147	256			1,600	2,100
		31	80	113	256			1,800	2,200
32	1	3	153	254	625	3,000	6,000	1,800	2,000
		4	198	376	625			1,900	2,300
		5	200	376	625			2,000	2,500
		7	200	376	625			2,300	2,900
		10	185	185	625			2,600	3,200
	2	13	200	376	625			2,900	3,600
		21	200	376	625			3,400	3,800
		31	200	376	625			3,900	3,800
40	1	3	440	752	1,137	3,000	6,000	2,800	2,700
		4	460	752	1,265			3,100	3,000
		5	480	752	1,265			3,400	3,300
		7	510	752	829			3,800	3,800
		10	480	509	829			4,200	4,200
	2	13	530	752	823			4,500	4,500
		21	620	752	1,029			5,000	5,000
		31	700	752	1,097			5,500	5,400

*1: Rated torque is based on L_{50} life of 20,000 hours at rated input speed.
*2: The limit for torque during start and stop cycles.
*3: The limit for torque during emergency stops or from external shock loads. Always operate below this value. Calculate the number of permissible events to ensure it meets required operating conditions.
*4: Maximum average input speed is limited by heat generation in the speed reducer assuming a continuous operating speed or the average input speed of a motion profile. The actual limit for average input speed depends on the operating environment.
*5: Maximum instantaneous input speed.
*6: The load at which the output bearing will have 20,000 hour life at the rated input speed. (Axial load = 0 and radial load point is in the center of the output shaft.)
*7: The load at which the output bearing life will be 20,000 hours at the rated input speed. (Radial load = 0 and axial load point is in the center of the output shaft.)

Performance

Table 055-2

Size	Number of Stages	Reduction Ratio	Backlash	Noise*1	Torsional Stiffness	
			arc min	dB	kgfm/arc-min	X100N•m/rad
11	1	4	< 5	< 56*2	0.060	20
		5				
		7				
		10				
	2	16	< 7			
		20				
		30				
14	1	3*2	< 5	< 58*2	0.27	93
		4				
		5				
		7				
		10				
	2	13	< 7			
		21				
		31				
20	1	3*2	< 5	< 60*2	0.77	260
		4				
		5				
		7				
		10				
	2	13	< 7			
		21				
		31				

Table 055-3

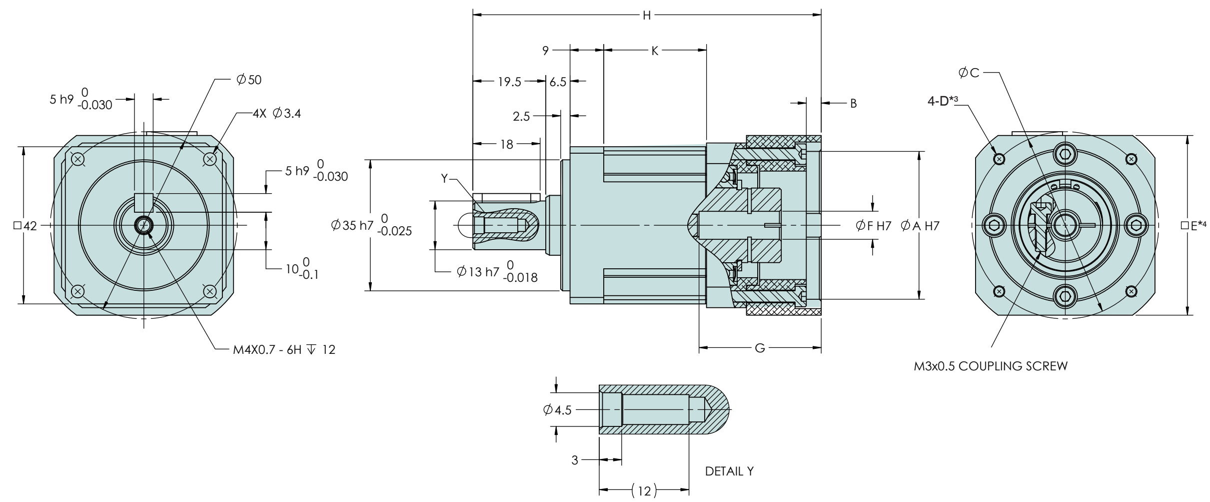
Size	Number of Stages	Reduction Ratio	Backlash	Noise*1	Torsional Stiffness	
			arc min	dB	kgfm/arc-min	X100N•m/rad
32	1	3*2	< 5	< 63*2	2.8	940
		4				
		5				
		7				
		10				
	2	13	< 7			
		21				
		31				
40	1	3*2	< 5	< 65*2	4.2	1430
		4				
		5				
		7				
		10				
	2	13	< 7			
		21				
		31				

*1: The above noise values are reference values.
*2: Contact us for noise values for sizes with a reduction ratio of 3.

HPN-11A Outline Dimensions

Figure 056-1

(Unit: mm)



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above. Output shaft configuration shown is J6 (with a key and center tapped hole). J8 configuration has no key.

Dimension Table

(Unit: mm) Table 056-1

	A (H7)		B	C		F (H7)		G		H*1	K	Mass(kg)*2
	Min.	Max.*4	Max.	Min.	Max.*4	Min.	Max.	Min.	Max.			
Single Stage	30	42	3	35	49	4.8	9	15	26	86.5	27.5	0.44
Two Stage										106	47	0.57

Refer to the confirmation drawing for detailed dimensions. Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.
*1 May vary depending on motor interface dimensions.
*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.
*3 Tapped hole for motor mounting screw.
*4 E dimension is dependent on motor selection.

Moment of Inertia

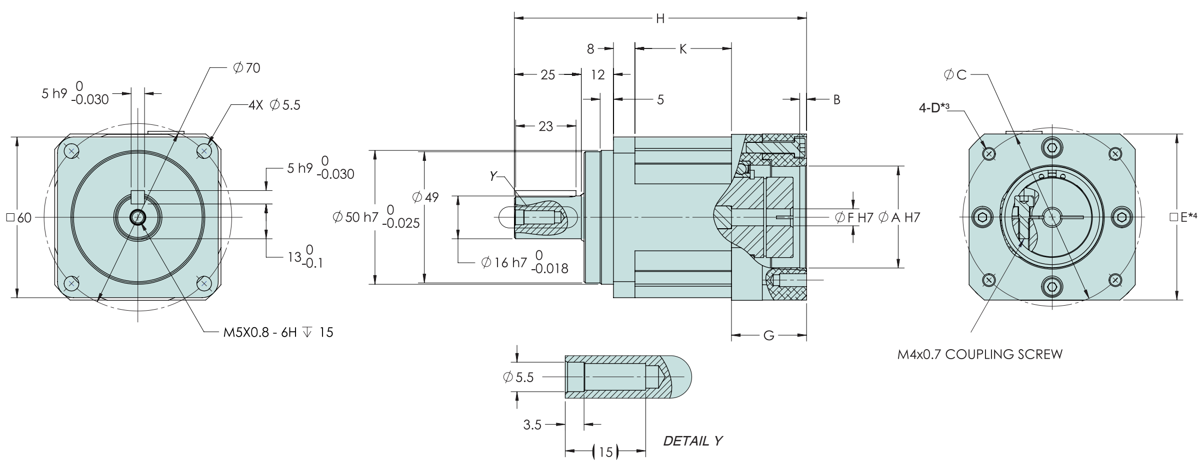
(10^{-4} kgm^2) Table 056-2

	Ratio / Coupling	4	5	7	10	16	20	30
HPN 11A	1	0.042	0.04	0.038	0.037	0.04	0.04	0.038

HPN-14A Outline Dimensions

Figure 057-1

(Unit: mm)



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above. Output shaft configuration shown is J6 (with a key and center tapped hole). J8 configuration has no key.

Dimension Table

(Unit: mm) Table 057-1

	Flange	Coupling	A (H7)		B	C		F (H7)		G		H*1	K	Mass(kg)*2
			Min.	Max.*1	Max.	Min.	Max.*1	Min.	Max.	Min.	Max.			
Single Stage	Type I	1	30	39	5	35	49	4.8	8	17	25	107	36	0.95
Two Stage												132	61	1.3
Single Stage	Type II	2	50	59	5	56	74	4.8	14	24	31	112	36	1.2
Two Stage												137	61	1.6

Refer to the confirmation drawing for detailed dimensions. Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.

*1 May vary depending on motor interface dimensions.
*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.
*3 Tapped hole for motor mounting screw.
*4 E dimension is dependent on motor selection.

Moment of Inertia

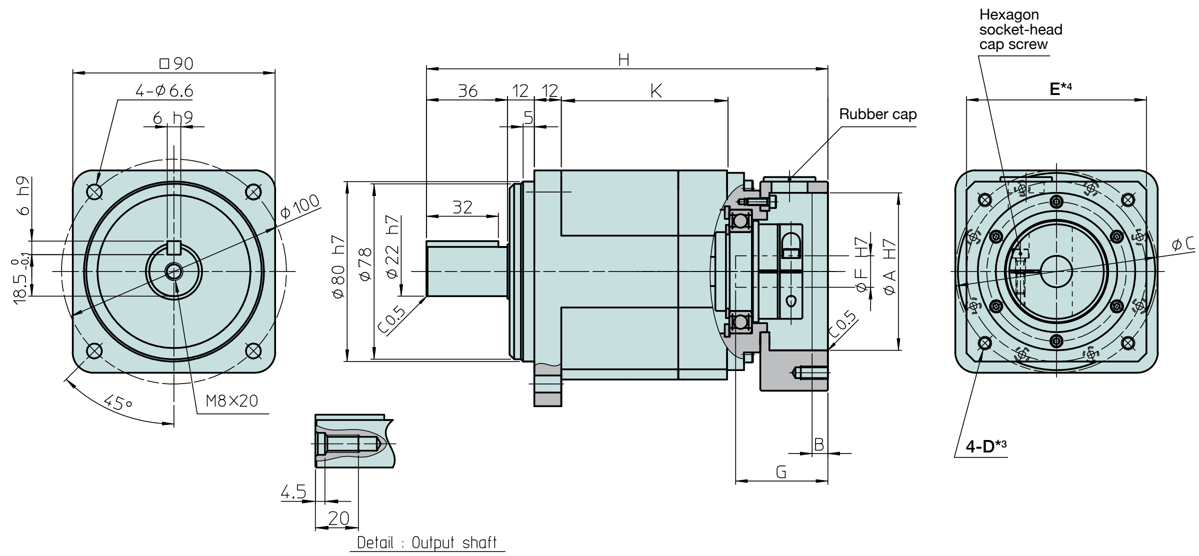
(10^{-4} kgm^2) Table 057-2

	Ratio / Coupling	3	4	5	7	10	13	21	31
HPN 14A	1	0.24	0.21	0.2	0.19	0.19	0.2	0.2	-
	2	0.124	0.096	0.083	0.072	0.066	0.049	0.043	0.041

HPN-20A Outline Dimensions

Figure 058-1

(Unit: mm)



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above. Output shaft configuration shown is J6 (with a key and center tapped hole). J8 configuration has no key.

Dimension Table

(Unit: mm) Table 058-1

	Flange	Coupling	A (H7)		B	C		F (H7)		G*1		H*1	K	Mass(kg)*2
			Min.	Max.*1	Max.	Min.	Max.*1	Min.	Max.	Min.	Max.			
Single Stage	Type I	1	38	85	7	58	110	8	25	21	42	151.8	52	3
Two Stage										19.5	36	173.5	73.7	3.7
Single Stage	Type II	2	50	125	7	58	155	4.8	25	45	66	169.8	52	5
Two Stage										43.5	60	191.5	73.7	6

Refer to the confirmation drawing for detailed dimensions. Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.

*1 May vary depending on motor interface dimensions.

*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.

*3 Tapped hole for motor mounting screw.

*4 E dimension is dependent on motor selection.

Moment of Inertia

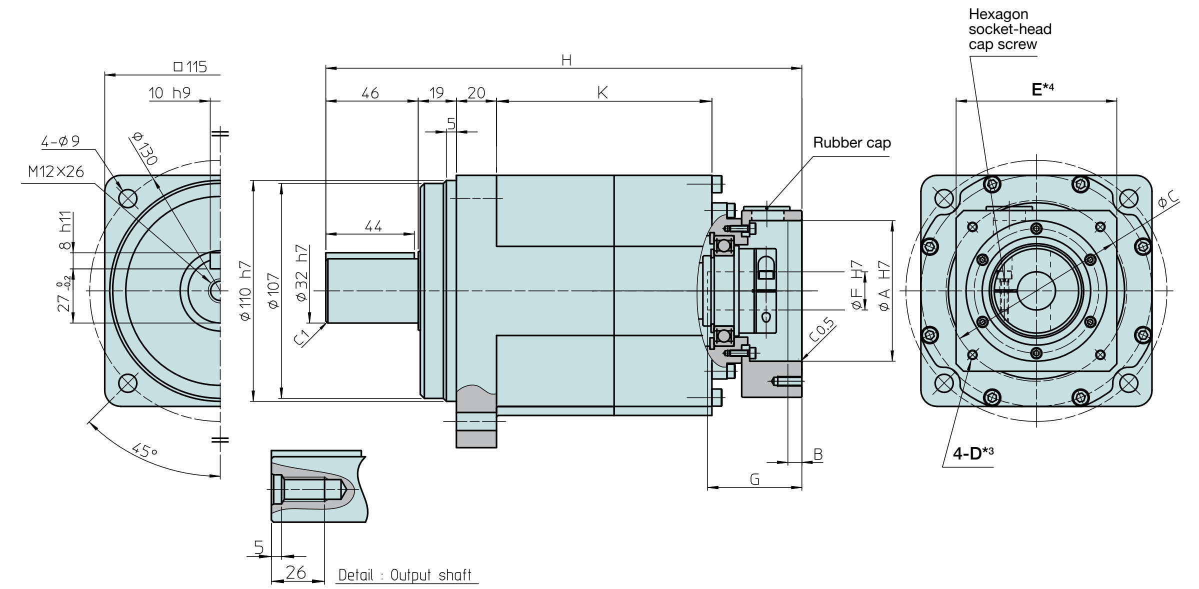
(10^{-4} kgm^2) Table 058-2

HPN 20A	Ratio / Coupling	3	4	5	7	10	13	21	31
	1	1.2	1	1	0.9	0.87	0.9	0.88	0.87

HPN-32A Outline Dimensions

Figure 059-1

(Unit: mm)



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above. Output shaft configuration shown is J6 (with a key and center tapped hole). J8 configuration has no key.

Dimension Table

(Unit: mm) Table 059-1

	Flange	Coupling	A (H7)		B	C		F (H7)		G*1		H*1	K	Mass(kg)*2
			Min.	Max.*1	Max.	Min.	Max.*1	Min.	Max.	Min.	Max.			
Single Stage	Type I	1	50	85	7	77	110	15.5	25	20	46	195	58.5	6.6
	Type II	2	70	125	7	77	155	15.5	28	47	69	212.5	58.5	7.7
	Type II	3	70	215	6.5	77	260	21.5	41	47	85	233.5	58.5	9.3
Two Stage	Type IV	4	50	85	7	58	110	8	25	21	42	232	107.2	7.9
	Type V	4	50	125	7	58	155	8	25	44	65	255	107.2	9.1

Refer to the confirmation drawing for detailed dimensions. Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.

*1 May vary depending on motor interface dimensions.
*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.
*3 Tapped hole for motor mounting screw.
*4 E dimension is dependent on motor selection.

Moment of Inertia

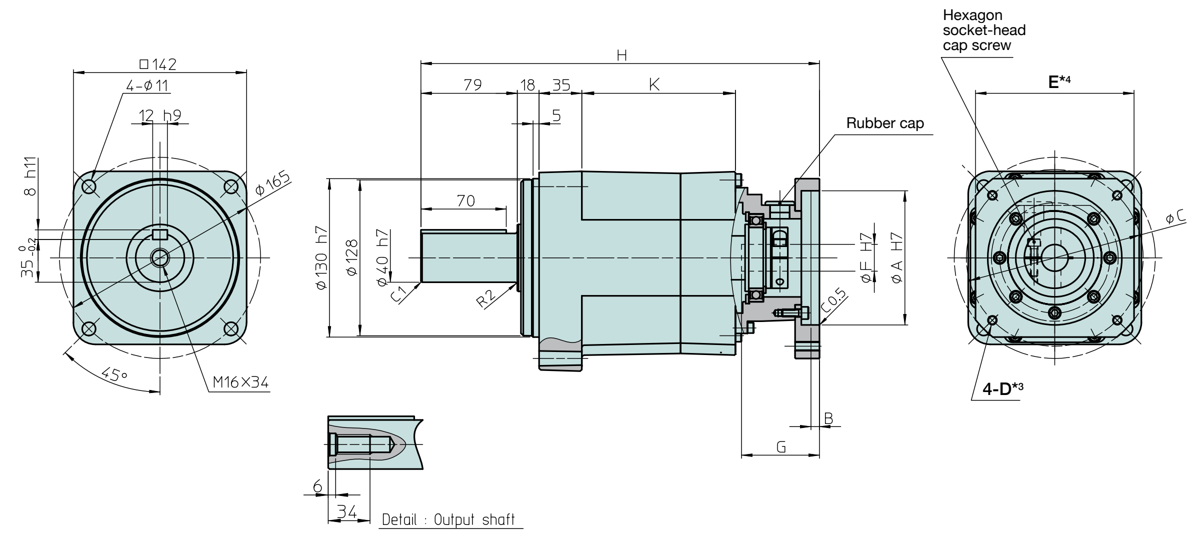
(10^{-4} kgm^2) Table 059-2

	Ratio / Coupling	3	4	5	7	10	13	21	31
HPN 32A	1	2.3	1.7	1.5	1.3	1.2	-	-	-
	2	5	3.8	3.3	2.9	2.7	-	-	-
	3	7.5	6.2	5.7	5.3	5.3	-	-	-
	4	-	-	-	-	-	1.3	1.1	1

HPN-40A Outline Dimensions

Figure 060-1

(Unit: mm)



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above. Output shaft configuration shown is J6 (with a key and center tapped hole). J8 configuration has no key.

Dimension Table

(Unit: mm) Table 060-1

	Flange	Coupling	A (H7)		B	C		F (H7)		G*1		H*1	K	Mass(kg)*2
			Min.	Max.*1	Max.	Min.	Max.*1	Min.	Max.	Min.	Max.			
Single Stage	Type I	1	70	215	6.5	78	260	15.5	41	34.5	72	295.5	81	17
	Type II	2	70	175	6.5	78	225	15.5	42	39	105	328.5	81	16
	Type III	3	70	125	7	78	155	15.5	24	47	77	282.5	81	13
Two Stage	Type IV	4	70	125	7	78	155	15.5	28	47	69	309.5	126	17
	Type V	5	70	215	6.5	77	260	21.5	41	47	85	348	126	18

Refer to the confirmation drawing for detailed dimensions. Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.

*1 May vary depending on motor interface dimensions.
*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.
*3 Tapped hole for motor mounting screw.
*4 E dimension is dependent on motor selection.

Moment of Inertia

(10^{-4} kgm^2) Table 060-2

	Coupling \ Ratio	3	4	5	7	10	13	21	31
HPN 40A	1	14	9.1	7.3	6.2	5.4	-	-	-
	2	15	11	8.8	7.3	6.5	-	-	-
	3	10.2	6.9	5.4	4.1	3.4	-	-	-
	4	-	-	-	-	-	4.5	3.5	3.4
	5	-	-	-	-	-	7	6	5.8

Product Sizing & Selection

To fully utilize the excellent performance of the HPN HarmonicPlanetary® gearheads, check your operating conditions and, using the flowchart, select the appropriate size gear for your application.

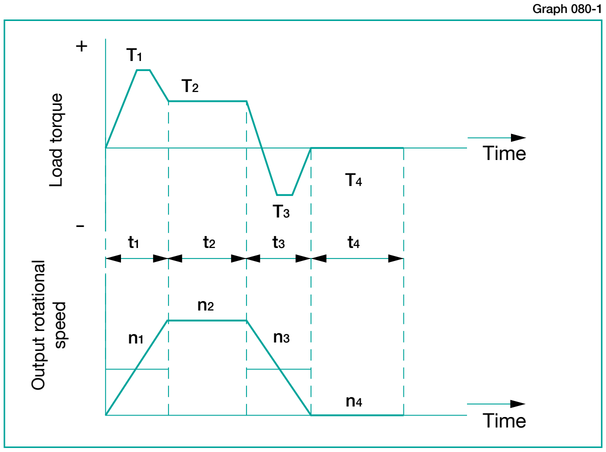
In general, a servo system rarely operates at a continuous load and speed. The input speed, load torque change and a comparatively large torque is applied during start and stop. Unexpected impact torques may also be applied.

Check your operating conditions against the following load torque pattern and select a suitable size based on the flowchart shown on the right. Also check the life and static safety coefficient of the cross roller bearing and input side main bearing (input shaft type only).

Checking the load torque pattern

Review the load torque pattern. Check the specifications shown in the figure below.

Graph 080-1



Obtain the value of each load torque pattern.

Load torque	T_1 to T_n (Nm)
Time	t_1 to t_n (sec)
Output rotational speed	n_1 to n_n (rpm)

<Normal operation pattern>

Starting	T_1, t_1, n_1
Steady operation	T_2, t_2, n_2
Stopping (slowing)	T_3, t_3, n_3
Idle	T_4, t_4, n_4

<Maximum rotational speed>

Max. output rotational speed	$n_{o\,max} \geqq n_1$ to n_n
Max. input rotational speed	$n_{i\,max}$ $n_1 \times R$ to $n_n \times R$
(Restricted by motors)	R: Reduction ratio

<Impact torque>
When impact torque is applied T_s

<Required life>
L_{50} = L (hours)

Flowchart for selecting a size

Please use the flowchart shown below for selecting a size. Operating conditions must not exceed the performance ratings.

Refer to the Caution note below.

Calculate the average load torque applied on the output side from the load torque pattern: T_{av} (Nm).

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

Calculate the average output speed based on the load torque pattern: no av (rpm)

$$n_{o\,av}=\frac{|n_1|\cdot t_1+|n_2|\cdot t_2+\cdots+|n_n|\cdot t_n}{t_1+t_2+\cdots+t_n}$$

▼

Make a preliminary model selection with the following condition: $T_{av} \leqq$ Average load torque (Refer to rating table). — NG

OK

Determine the reduction ratio (R) based on the maximum output rotational speed (no *max*) and maximum input rotational speed (ni *max*).

$$\frac{n_{i\,max}}{n_{o\,max}} \geqq R$$

(A limit is placed on ni *max* by motors.)
Calculate the maximum input speed (ni *max*) from the maximum output speed (no *max*) and the reduction ratio (R).

$$n_{i\,max}=n_{o\,max} \cdot R$$

▼

Calculate the average input speed (ni *av*) from the average output speed (no *av*) and the reduction ratio (R): $n_{i\,av} = n_{o\,av}\cdot R \leqq$ Max. average input speed (nr). — NG

OK

Review the operation conditions, size and reduction ratio.

Check whether the maximum input speed is equal to or less than the values in the rating table.
$n_{i\,max} \leqq$ maximum input speed (rpm) — NG

OK

Check whether T1 and T3 are within peak torques (Nm) on start and stop in the rating table. — NG

OK

Check whether T_s is equal to or less than the momentary max. torque (Nm) value from the ratings. — NG

OK

Calculate the lifetime and check whether it meets the specification requirement.
Tr: Output torque
n_r: Max. average input speed

$$L_{10}=20{,}000 \cdot \left(\frac{T_r}{T_{av}}\right)^{10/3} \cdot \left(\frac{n_r}{n_{i\,av}}\right) \text{ (Hour)}$$

— NG

OK

The model number is confirmed.

Caution

If the expected operation will result in conditions where;
i) Actual average load torque (Tav) > Permissible maximum value of average load torque or
ii) Actual average input rotational speed (ni av) > Permissible average input rotational speed (nr),
then please check its effect on the speed reducer temperature rise or other factors. Consider selecting the next larger speed reducer, reduce the operating loads or take other means to ensure safe use of the gear. Exercise caution especially when the duty cycle is close to continuous operation.

Example of model number Selection

Value of each load torque pattern.

Load torque	T_n (Nm)	
Time	t_n (sec)	
Output rotational speed	n_n (rpm)	

<Normal operation pattern>

Starting	T_1 = 70 Nm,	t_1 = 0.3 sec,	n_1 = 60 rpm
Steady operation	T_2 = 18 Nm,	t_2 = 3 sec,	n_2 = 120 rpm
Stopping (slowing)	T_3 = 35 Nm,	t_3 = 0.4 sec,	n_3 = 60 rpm
Idle	T_4 = 0 Nm,	t_4 = 5 sec,	n_4 = 0 rpm

<Maximum rotational speed>

Max. output rotational speed	no *max* = 120 rpm
Max. input rotational speed	ni *max* = 5,000 rpm (Restricted by motors)

<Impact torque>

When impact torque is applied T_s = 180 Nm

<Required life>

L_{50} = 30,000 (hours)

Calculate the average load torque applied to the output side based on the load torque pattern: T*av* (Nm).

$$T_{av}=\sqrt[10/3]{\frac{|60rpm|\cdot 0.3sec\cdot|70Nm|^{10/3}+|120rpm|\cdot 3sec\cdot|18Nm|^{10/3}+|60rpm|\cdot 0.4sec\cdot|35Nm|^{10/3}}{|60rpm|\cdot 0.3sec+120rpm|\cdot 3sec+|60rpm|\cdot 0.4sec|}}$$

Calculate the average output speed based on the load torque pattern: no *av* (rpm)

$$n_{o\,av}=\frac{|60rpm|\cdot 0.3sec+|120rpm|\cdot 3sec+|60rpm|\cdot 0.4sec+|0rpm|\cdot 5sec}{0.3sec+3sec+0.4sec+5sec}$$

▼

Make a preliminary model selection with the following conditions. T*av* = 30.2 Nm ≦ 80 Nm. (**HPN-20A-31** is tentatively selected based on the average load torque (see the rating table) of size 20 and reduction ratio of 31.) ● NG

OK

Determine a reduction ratio (R) from the maximum output speed (no *max*) and maximum input speed (ni *max*).

$$\frac{5{,}000\ rpm}{120\ rpm}=41.7\geqq 31$$

Calculate the maximum input speed (ni *max*) from the maximum output speed (no *max*) and reduction ratio (R): ni *max* = 120 rpm・31 = 3,720 rpm

▼

Calculate the average input speed (ni *av*) from the average output speed (no *av*) and reduction ratio (R):
ni *av* = 46.2 rpm・31= 1,432 rpm ≦ Max average input speed of size 20 3,000 rpm ● NG

OK

Check whether the maximum input speed is equal to or less than the values specified in the rating table.
ni *max* = 3,720 rpm ≦ 600 rpm (maximum input speed of size 20) ● NG

OK

Check whether T_1 and T_3 are within peak torques (Nm) on start and stop in the rating table.
T_1 = 70 Nm ≦ 113 Nm (Limit for repeated peak torque, size 20)
T_3 = 35 Nm ≦ 113 Nm (Limit for repeated peak torque, size 20) ● NG

OK

Check whether Ts is equal to or less than limit for momentary torque (Nm) in the rating table.
T_s = 180 Nm ≦ 256 Nm (momentary max. torque of size 20) ● NG

OK

Calculate life and check whether the calculated life meets the requirement.

$$L_{50}=20{,}000\cdot\left(\frac{80Nm}{30.2\ Nm}\right)^{10/3}\cdot\left(\frac{3{,}000\ rpm}{1{,}432\ rpm}\right)=25{,}809{,}937\ (hours)\geqq 30{,}000\ (hours)$$ ● NG

OK

The selection of model number HPN-20A-31 is confirmed from the above calculations.

Refer to the Caution note at the bottom of page 61.

Review the operation conditions, size and reduction ratio.

HarmonicDrive®

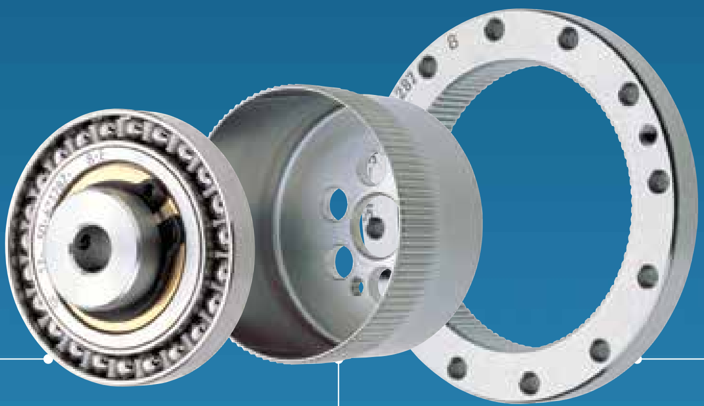
Gearheads for Servomotors

CSG-GH High Torque Series

CSF-GH Standard Series

HarmonicDrive® CSG/CSF-GH Series

HarmonicDrive® gearing has a unique operating principle which utilizes the elastic mechanics of metals. This precision gear reducer consists of only 3 basic parts and provides high accuracy and repeatability.



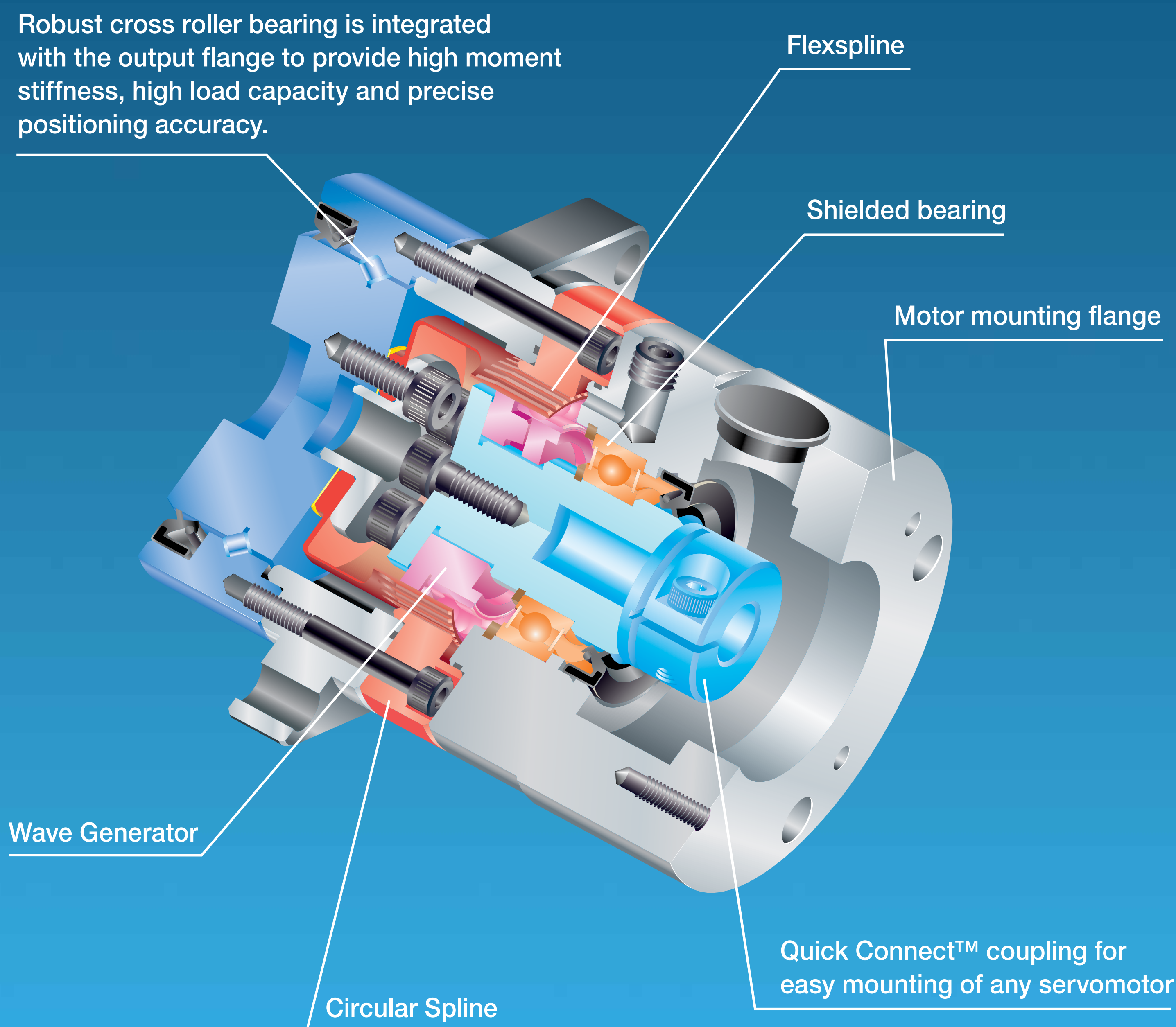
Wave Generator
The Wave Generator is a thin raced ball bearing fitted onto an elliptical shaped hub. The inner race of the bearing is fixed to the cam and the outer race is elastically deformed into an ellipse via the balls. The Wave Generator is usually mounted onto the input shaft.

Flexspline
The Flexspline is a non-rigid, thin cylindrical cup with external teeth. The Flexspline fits over the Wave Generator and takes on its elliptical shape. The Flexspline is generally used as the output of the gear.

Circular Spline
The Circular Spline is a rigid ring with internal teeth, engaging the teeth of the Flexspline across the major axis of the Wave Generator. The Circular Spline has two more teeth than the Flexspline and is generally mounted to the housing.

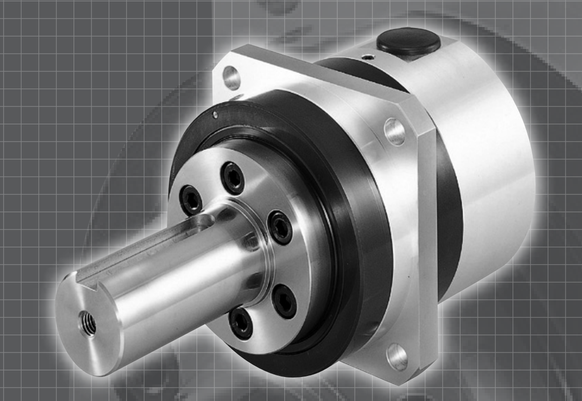
The greatest benefit of HarmonicDrive® gearing is the weight and space savings compared to other gearheads because it consists of only three basic parts. Since many teeth are engaged simultaneously, it can transmit higher torque and provides high accuracy. A unique S tooth profile significantly improves torque capacity, life and torsional stiffness of the gear.

- **Zero-backlash**
- **High Reduction ratios, 50:1 to 160:1 in a single stage**
- **High precision positioning (repeatability ±4 to ±10 arc-sec)**
- **High capacity cross roller output bearing**
- **High torque capacity**


Robust cross roller bearing is integrated with the output flange to provide high moment stiffness, high load capacity and precise positioning accuracy.
Flexspline
Shielded bearing
Motor mounting flange
Wave Generator
Circular Spline
Quick Connect™ coupling for easy mounting of any servomotor

HarmonicDrive®

CSG-GH High Torque Series



Size
14, 20, 32, 45, 65
5 Sizes

Peak torque
23Nm to 3419Nm

Reduction ratio
50:1 to 160:1

Zero backlash

High Accuracy
Repeatability ±4 to ±10 arc-sec

High Load Capacity Output Bearing
A Cross Roller bearing is integrated with the output flange to provide high moment stiffness, high load capacity and precise positioning accuracy.

Easy mounting to a wide variety of servomotors
Quick Connect™ coupling

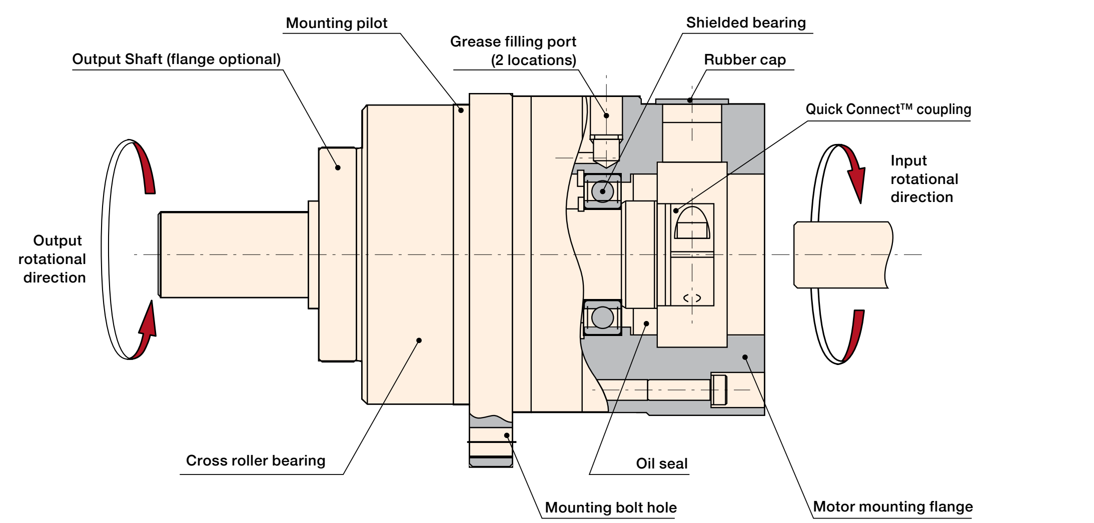
CONTENTS

CSG - 20 - 100 - GH - F0 - Motor Code

Model Name	Size	Reduction Ratio	Model	Output Configuration	Input Configuration
HarmonicDrive® CSG High Torque	14	50, 80, 100	GH: Gearhead	F0: Flange output J2: Shaft output without key J6: Shaft output with key and center tapped hole	This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.
	20	50, 80, 100, 120, 160			
	32				
	45				
	65	80, 100, 120, 160			

Gearhead Construction

Figure 066-1



(The figure indicates output shaft type.)

Rating Table CSG-GH

Table 067-1

Size	Ratio	Rated Torque at 2000 rpm *1	Rated Torque at 3000 rpm *2	Limit for Average Torque *3	Limit for Repeated Peak Torque *4	Limit for Momentary Torque *5	Max. Average Input Speed *6	Max. Input Speed *7	Mass *8 Shaft	Mass *8 Flange
		Nm	Nm	Nm	Nm	Nm	rpm	rpm	kg	kg
14	50	7.0	6.1	9.0	23	46	3500	8500	0.62	0.50
	80	10	8.7	14	30	61				
	100	10	8.7	14	36	70				
20	50	33	29	44	73	127	3500	6500	1.8	1.4
	80	44	38	61	96	165				
	100	52	45	64	107	191				
	120	52	45	64	113	191				
	160	52	45	64	120	191				
32	50	99	86	140	281	497	3500	4800	4.6	3.2
	80	153	134	217	395	738				
	100	178	155	281	433	812				
	120	178	155	281	459	812				
	160	178	155	281	484	812				
45	50	229	200	345	650	1235	3000	3800	13	10
	80	407	356	507	918	1651				
	100	459	401	650	982	2033				
	120	523	457	806	1070	2033				
	160	523	457	819	1147	2033				
65	80	969	846	1352	2743	4836	1900	2800	32	24
	100	1236	1080	1976	2990	5174				
	120	1236	1080	2041	3263	5174				
	160	1236	1080	2041	3419	5174				

*1: Rated torque is based on L10 life of 10,000 hours when input speed is 2000 rpm
*2: Rated torque is based on L10 life of 10,000 hours when input speed is 3000 rpm, input rotational speed for size 65 is 2800 rpm.
*3: Maximum value of average load torque is based on the load torque pattern. Note that exceeding this value may deteriorate the life or durability of the product.
*4: The limit for torque during start and stop cycles.
*5: The limit for torque during emergency stops or from external shock loads. Always operate below this value. Calculate the number of permissible events to ensure it meets required operating conditions.
*6: Maximum average input speed is limited by heat generation in the speed reducer assuming a continuous operating speed or the average input speed of a motion profile. The actual limit for average input speed depends on the operating environment.
*7: Maximum instantaneous input speed.
*8: The mass is for the gearhead only (without input shaft coupling & motor flange). Please contact us for the mass of your specific configuration.
*9: See page 86 for more information about Torque ratings.

Ratcheting Torque CSG-GH

(Unit: Nm) Table 067-2

Reduction ratio \ Size	14	20	32	45	65
50	110	280	1200	3500	–
80	140	450	1800	5000	14000
100	100	330	1300	4000	12000
120	–	310	1200	3600	10000
160	–	280	1200	3300	10000

Buckling Torque CSG-GH

(Unit: Nm) Table 067-3

Size	14	20	32	45	65
All Ratios	260	800	3500	8900	26600

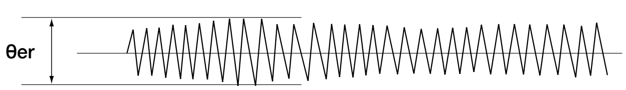
Performance Table CSG-GH

Table 068-1

Size	Flange Type	Ratio	Accuracy *1		Repeatability *2	Starting torque *3		Backdriving torque *4		No-load running torque *5	
			arc min	$x10^{-4}$rad	arc sec	Ncm	kgfcm	Nm	kgfm	Ncm	kgfcm
14	All	50	1.5	4.4	±10	8.5	0.9	3.0	0.3	5.6	0.6
		80				7.1	0.7	4.0	0.4	5.1	0.5
		100				6.8	0.7	4.9	0.5	4.6	0.5
20	Type I	50	1.0	2.9	±8	14	1.4	8	0.8	11	1.2
		80				10	1.1	10	1.0	10	1.0
		100				10	1.0	13	1.3	10	1.0
		120				9.4	1.0	14	1.4	9.8	1.0
		160				8.9	0.9	18	1.8	9.6	1.0
	Type II	50	1.0	2.9	±8	21	2.1	12	1.3	11	1.2
		80				17	1.8	16	1.7	10	1.0
		100				16	1.7	20	2.0	10	1.0
		120				16	1.7	24	2.4	9.8	1.0
		160				15	1.6	30	3.0	9.6	1.0
32	Type I &II	50	1.0	2.9	±6	61	6.2	37	3.8	47	4.8
		80				48	4.9	46	4.7	42	4.3
		100				47	4.8	56	5.7	41	4.2
		120				43	4.4	63	6.4	40	4.1
		160				42	4.3	81	8.3	40	4.1
	Type III	50	1.0	2.9	±6	53	5.4	32	3.3	47	4.8
		80				40	4.1	39	4.0	42	4.3
		100				39	4.0	47	4.8	41	4.2
		120				35	3.6	51	5.2	40	4.1
		160				34	3.5	66	6.7	40	4.1
45	All	50	1.0	2.9	±5	129	13	78	8.0	120	12
		80				99	10	96	9.8	109	11
		100				93	9.5	111	11	107	11
		120				88	9.0	128	13	105	11
		160				82	8.4	158	16	103	11
65	All	80	1.0	2.9	±4	197	20	191	19	297	30
		100				176	18	213	22	289	30
		120				165	17	240	24	285	29
		160				147	15	285	29	278	28

*1: Accuracy values represent the difference between the theoretical angle and the actual angle of output for any given input. The values in the table are maximum values.

Figure 068-1

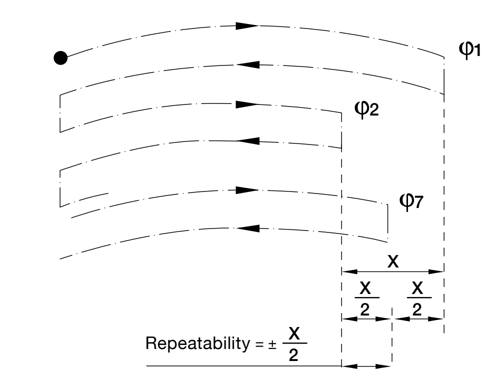


θer : Accuracy
θ_1 : Input angle
θ_2 : Actual output angle
R : Gear reduction ratio

$$\theta er = \theta_2 - \frac{\theta_1}{R}$$

*2: The repeatability is measured by moving to a given theoretical position seven times, each time approaching from the same direction. The actual position of the output shaft is measured each time and repeatability is calculated as the 1/2 of the maximum difference of the seven data points. Measured values are indicated in angles (arc-sec) prefixed with "±". The values in the table are maximum values.

Figure 068-2



*3: Starting torque is the torque value applied to the input side at which the output first starts to rotate. The values in the table are maximum values.

Table 068-2

Load	No load
Speed reducer surface temperature	25°C

*4: Backdriving torque is the torque value applied to the output side at which the input first starts to rotate. The values in the table are maximum values.

Note: Never rely on these values as a margin in a system that must hold an external load. A brake must be used where back driving is not permissible.

Table 068-3

Load	No load
Speed reducer surface temperature	25°C

*5: No-load running torque is the torque required at the input to operate the gearhead at a given speed under a no-load condition. The values in the table are average values.

Table 068-4

Input speed	2000 rpm
Load	No load
Speed reducer surface temperature	25°C

Torsional Stiffness CSG-GH and CSF-GH

Table 013-1

Symbol		Size	14	20	32	45	65
	T_1	Nm	2.0	7.0	29	76	235
		kgfm	0.2	0.7	3.0	7.8	24
	T_2	Nm	6.9	25	108	275	843
		kgfm	0.7	2.5	11	28	86
Reduction ratio 50	K_1	$\times10^4$Nm/rad	0.34	1.3	5.4	15	—
		kgfm/arc min	0.1	0.38	1.6	4.3	—
	K_2	$\times10^4$Nm/rad	0.47	1.8	7.8	20	—
		kgfm/arc min	0.14	0.52	2.3	6.0	—
	K_3	$\times10^4$Nm/rad	0.57	2.3	9.8	26	—
		kgfm/arc min	0.17	0.67	2.9	7.6	—
	θ_1	$\times10^{-4}$rad	5.8	5.2	5.5	5.2	—
		arc min	2.0	1.8	1.9	1.8	—
	θ_2	$\times10^{-4}$rad	16	15.4	15.7	15.1	—
		arc min	5.6	5.3	5.4	5.2	—
Reduction ratio 80 or more	K_1	$\times10^4$Nm/rad	0.47	1.6	6.7	18	54
		kgfm/arc min	0.14	0.47	2.0	5.4	16
	K_2	$\times10^4$Nm/rad	0.61	2.5	11	29	88
		kgfm/arc min	0.18	0.75	3.2	8.5	26
	K_3	$\times10^4$Nm/rad	0.71	2.9	12	33	98
		kgfm/arc min	0.21	0.85	3.7	9.7	29
	θ_1	$\times10^{-4}$rad	4.1	4.4	4.4	4.1	4.4
		arc min	1.4	1.5	1.5	1.4	1.5
	θ_2	$\times10^{-4}$rad	12	11.3	11.6	11.1	11.3
		arc min	4.2	3.9	4.0	3.8	3.9

* The values in this table are average values. See page 88 for more information about torsional stiffness.

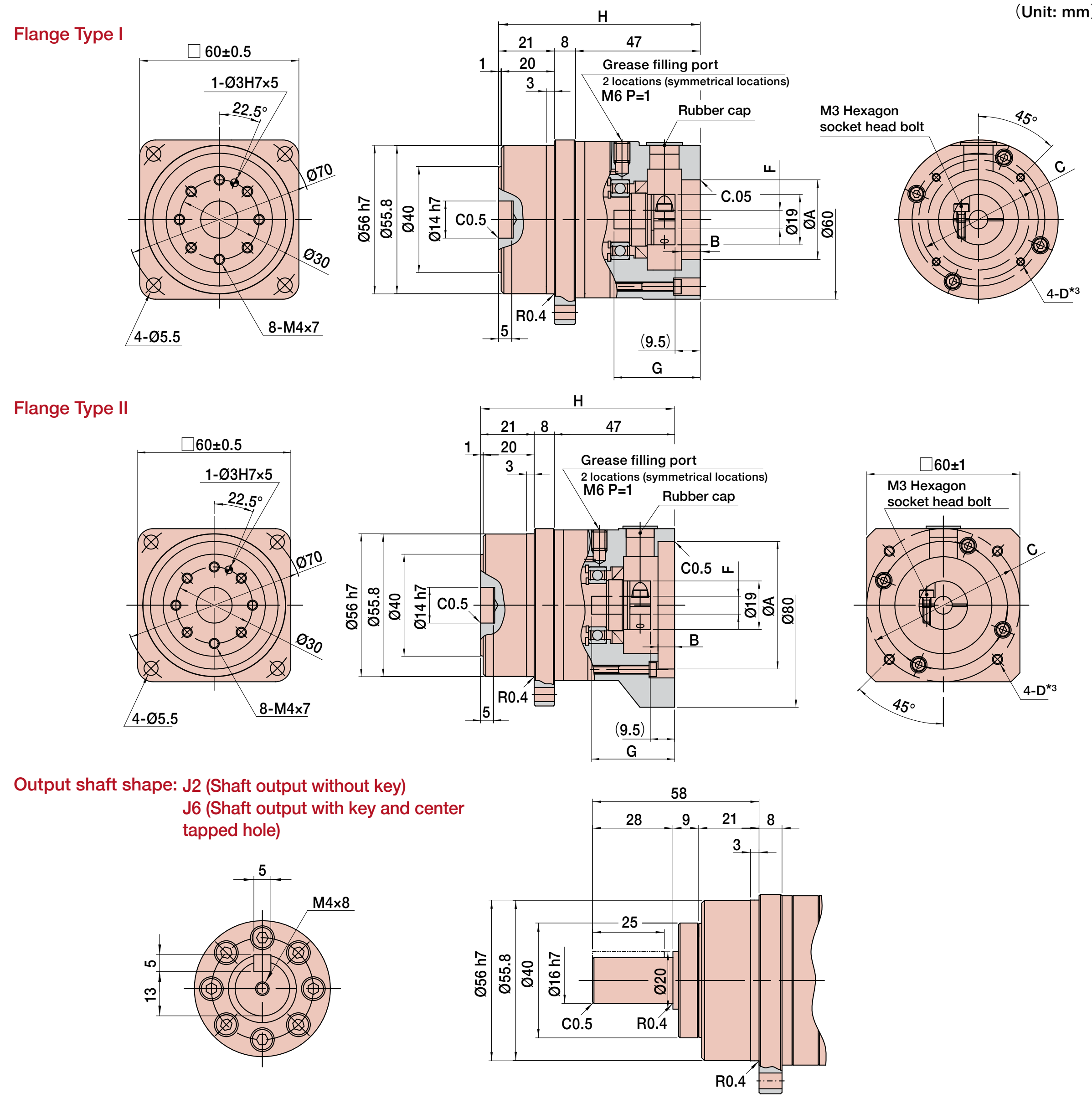
Hysteresis Loss CSG-GH

Reduction ratio 50: Approx. 5.8×10^{-4} rad (2arc min)
Reduction ratio 80 or more: Approx. 2.9×10^{-4} rad (1arc min)

CSG-GH-14 Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.

Figure 070-1



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

Dimension Table

(Unit: mm)

Table 070-1

Flange	Coupling	A (H7)		B	C		F (H7)		G		H *1	Moment of Inertia	Mass (kg) *2	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	(10^{-4}kgm^2)	Shaft	Flange
Type I	1	50	58	7	58	72	5.0	7.8	21.5	32.5	76	0.07	0.88	0.76
Type II	1	30	45	6.5	36	54	5.0	7.8	21.5	32.5	76	0.07	0.90	0.78

Refer to the confirmation drawing for detailed dimensions.
Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.

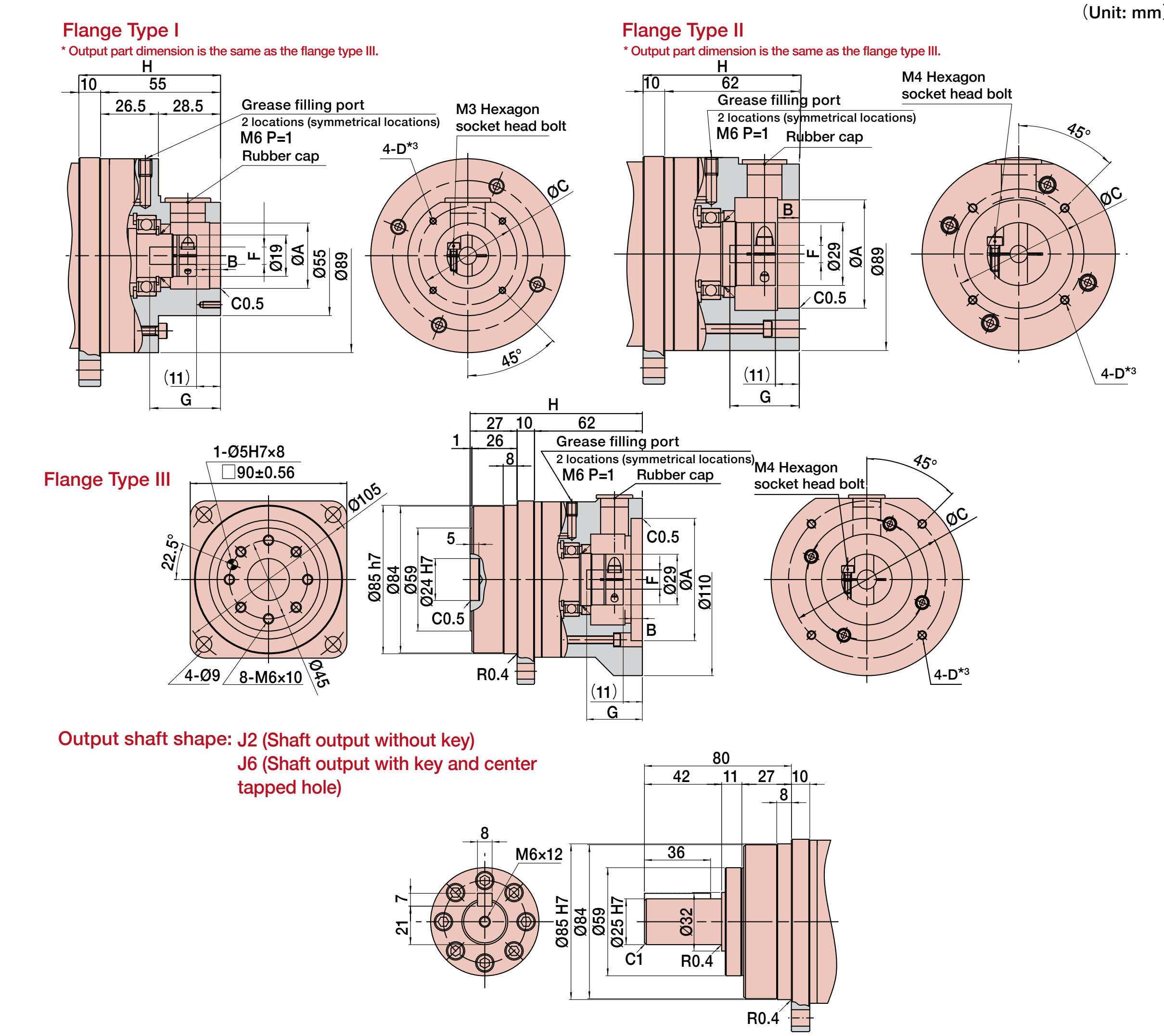
*1 May vary depending on motor interface dimensions.
*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.
*3 Tapped hole for motor mounting screw.

CSG-GH-20 Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.

Figure 071-1

(Unit: mm)



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

Dimension Table

(Unit: mm)

Table 071-1

Flange	Coupling	A (H7)		B	C		F (H7)		G		H *1	Moment of Inertia	Mass (kg) *2	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	(10^{-4}kgm^2)	Shaft	Flange
Type I	1	30	45	5	36	48	7.0	7.8	23.0	33.0	92.0	0.28	2.3	1.9
Type II	2	50	70	10	60	80	8.0	14.6	25.0	32.0	99.0	0.42	2.6	2.2
Type III	2	50	80	10	60	100	8.0	14.6	25.0	32.0	99.0	0.42	2.8	2.4

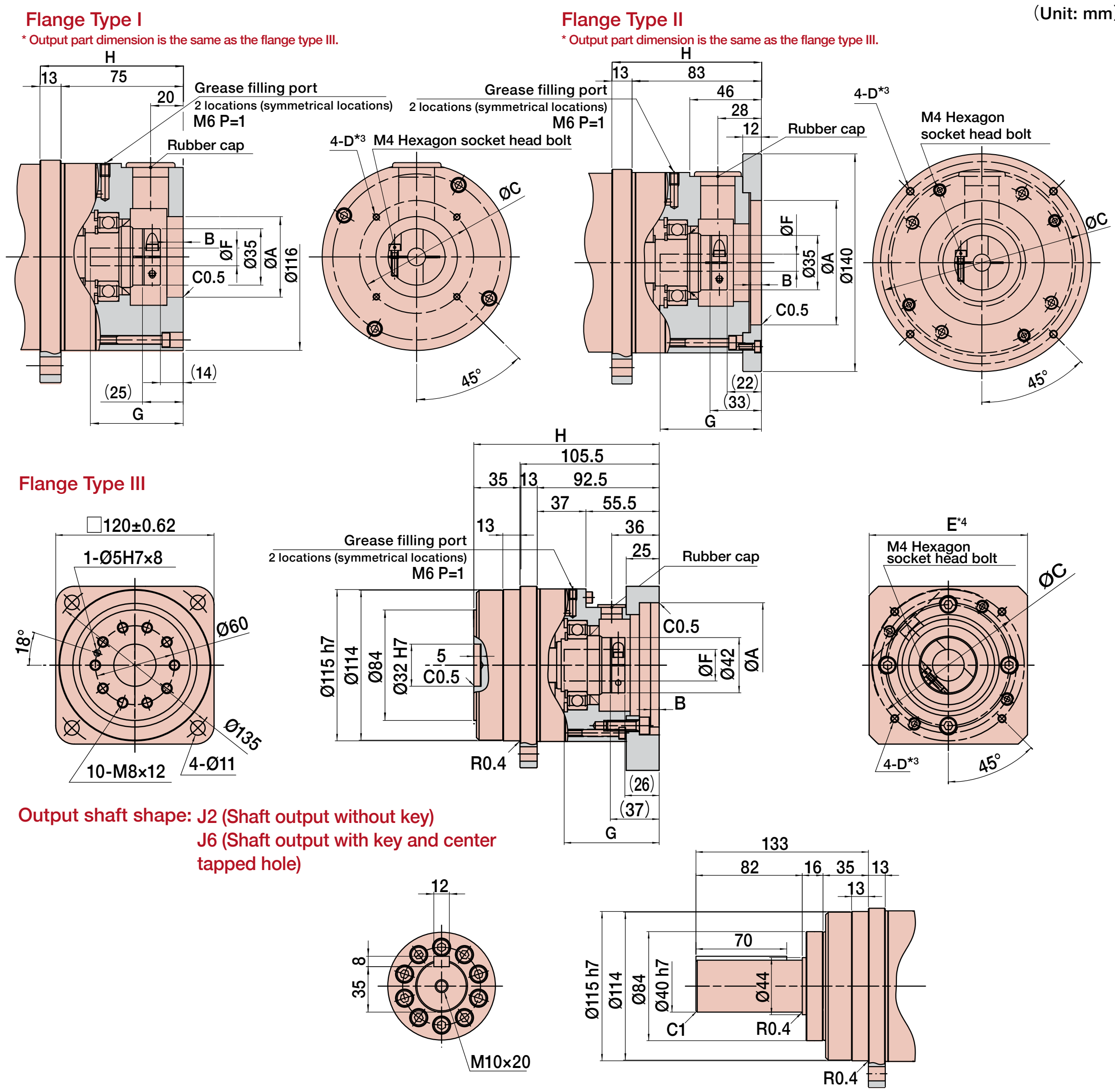
Refer to the confirmation drawing for detailed dimensions.
Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.
*1 May vary depending on motor interface dimensions.
*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.
*3 Tapped hole for motor mounting screw.

CSG-GH-32 Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.

Figure 072-1

(Unit: mm)



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

Dimension Table

(Unit: mm)

Table 072-1

Flange	Coupling	A (H7)		B	C		F (H7)		G		H*1	Moment of Inertia	Mass (kg) *2	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Max.	(10^{-4}kgm^2)	Shaft	Flange
Type I	3	50	85	10	58	105	9.0	19.6	28.0	57	133	2.7	6.4	5.0
Type II	2	70	95	5	85	115	16.0	25.8	35.0	67	145.5	2.7	6.6	5.2
Type III	1	95	130	7	115	165	11.0	19.6	36.0	65	141	2.0	7.9	6.5

Refer to the confirmation drawing for detailed dimensions.
Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.
*1 May vary depending on motor interface dimensions.
*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.
*3 Tapped hole for motor mounting screw.
*4 E dimension is dependent on motor selection.

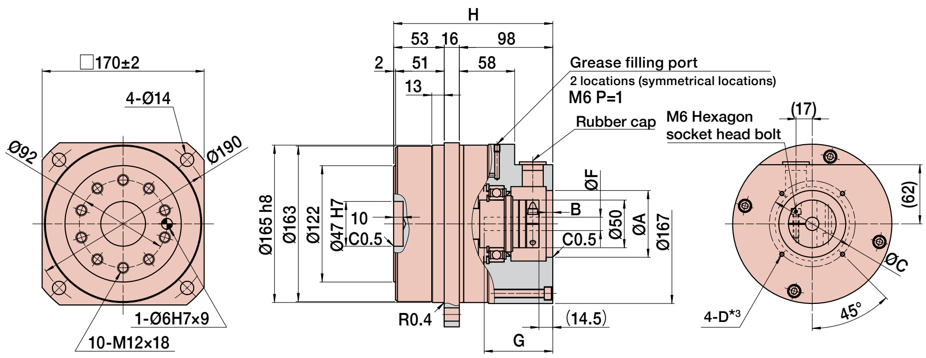
CSG-GH-45 Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.

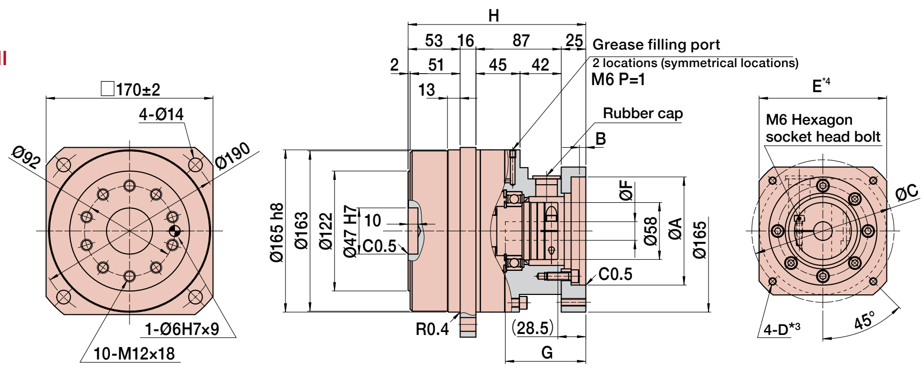
Figure 073-1

(Unit: mm)

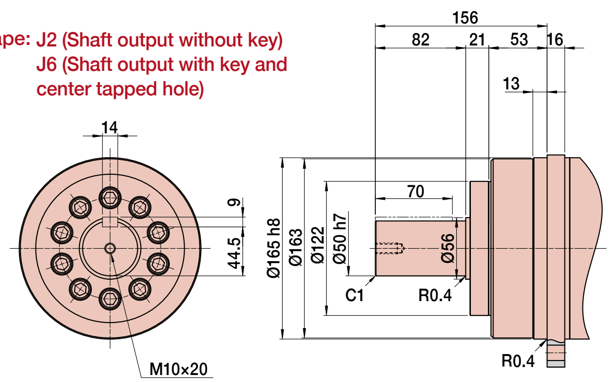
Flange Type I



Flange Type II



Output shaft shape: J2 (Shaft output without key)
J6 (Shaft output with key and center tapped hole)



(Note)
If using size 45 or 65 gearheads with a shaft output and require torques as high as the "Limit for Momentary Peak Torque" you must use a J2 shaft configuration (shaft output without key) with a friction / compression coupling to the output load. This is due to the limited strength of the connection using a keyed shaft.

(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

Dimension Table

(Unit: mm)

Table 073-1

Flange	Coupling	A (H7)		B	C		F (H7)		G		H *1	Moment of Inertia	Mass (kg) *2	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	(10^{-4}kgm^2)	Shaft	Flange
Type I	1	70	110	7	80	150	14.0	29.4	31.5	72	167	11	17.3	14.3
Type I	2	70	110	7	80	150	19.0	41	40.5	77	167	11	17.3	14.3
Type II	1	110	130	6.5	145	200	14.0	29.4	31.5	72	176	11	16.7	13.7
Type II	2	110	130	6.5	145	200	19.0	41	40.5	77	176	11	17.7	14.7

Refer to the confirmation drawing for detailed dimensions.
Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.
*1 May vary depending on motor interface dimensions.
*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.
*3 Tapped hole for motor mounting screw.
*4 E dimension is dependent on motor selection.

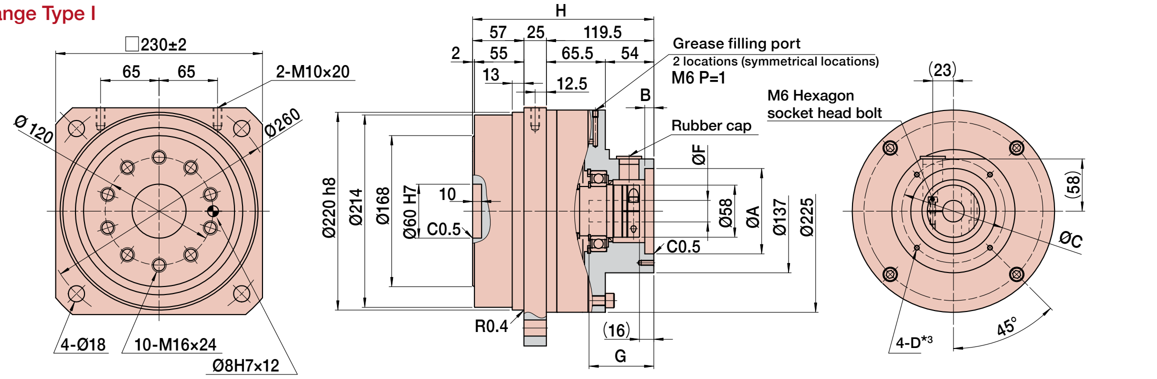
CSG-GH-65 Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.

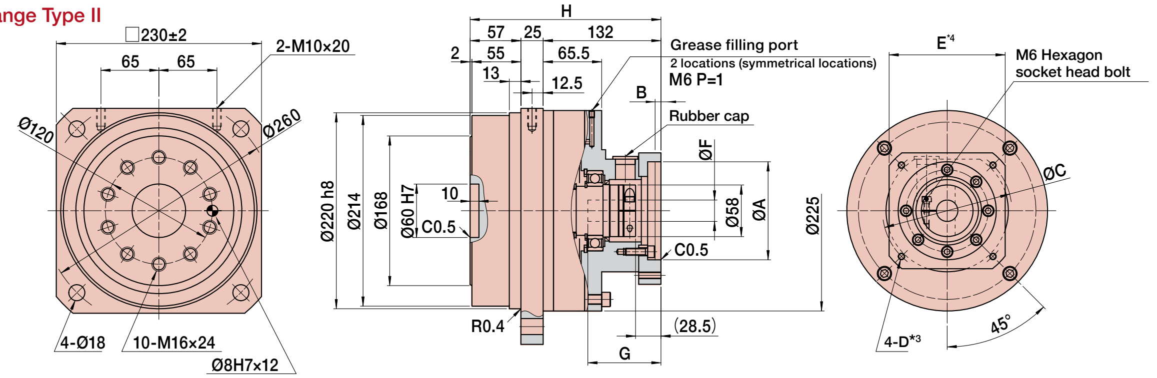
Figure 074-1

(Unit: mm)

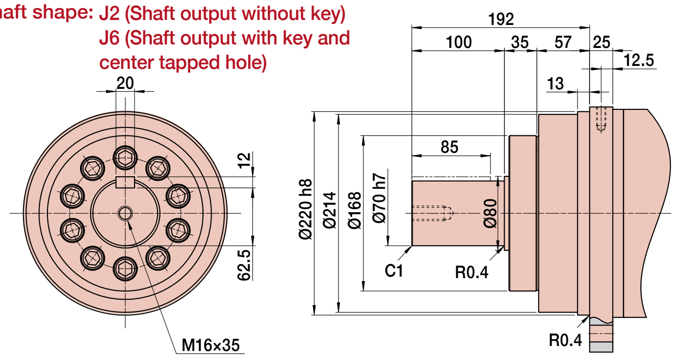
Flange Type I



Flange Type II



Output shaft shape: J2 (Shaft output without key)
J6 (Shaft output with key and center tapped hole)



(Note)
If using size 45 or 65 gearheads with a shaft output and required torques are as high as the "Limit for Momentary Peak Torque," you must use a J2 shaft configuration (shaft output without key) with a friction / compression coupling to the output load. This is due to the limited strength of the connection using a keyed shaft.

(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

Dimension Table

(Unit: mm)

Table 074-1

Flange	Coupling	A (H7)		B	C		F (H7)		G		H *1	Moment of Inertia	Mass (kg) *2	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Max.	(10^{-4}kgm^2)	Shaft	Flange
Type I	1	95	95	10	110	125	19.0	39.3	33.0	72	201.5	51	36.2	27.6
Type II	1	110	200	6.5	145	235	19.0	39.3	40.5	79.5	209	51	38.3	29.7

Refer to the confirmation drawing for detailed dimensions.
Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.

*1 May vary depending on motor interface dimensions.
*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.
*3 Tapped hole for motor mounting screw.
*4 E dimension is dependent on motor selection.

NOTES

HarmonicDrive®
CSF-GH Standard Series

Size — 5 Sizes
14, 20, 32, 45, 65

Peak torque
18Nm to 2630Nm

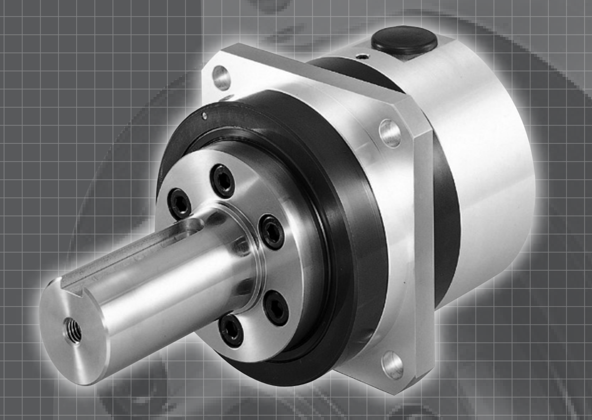
Reduction ratio
50:1 to 160:1

Zero backlash

High Accuracy
Repeatability ±4 to ±10 arc-sec

High Load Capacity Output Bearing
A Cross Roller bearing is integrated with the output flange to provide high moment stiffness, high load capacity and precise positioning accuracy.

Easy mounting to a wide variety of servomotors
Quick Connect™ coupling



CONTENTS

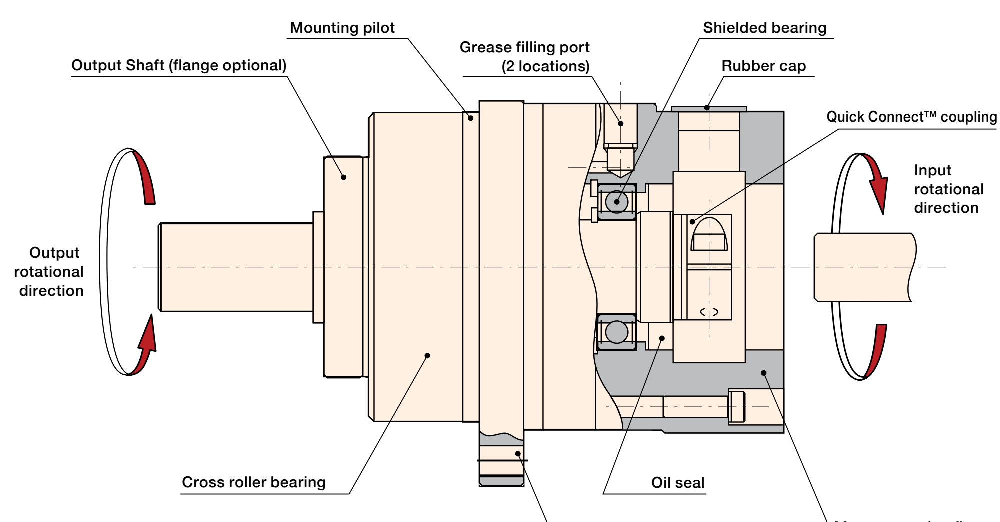
Model Ordering Code

CSF - 20 - 100 - GH - F0 - Motor Code

Model Name	Size	Reduction Ratio	Model	Output Configuration	Input Configuration
HarmonicDrive® CSF Standard	14	50, 80, 100	GH: Gearhead	F0: Flange output J2: Shaft output without key J6: Shaft output with key and center tapped hole	This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.
	20	50, 80, 100, 120, 160			
	32				
	45				
	65	80, 100, 120, 160			

Gearhead Construction

Figure 18-1



(The figure indicates output shaft type.)

Rating Table CSF-GH

Table 077-1

Size	Ratio	Rated ouput torque at 2000 rpm *1	Rated ouput torque at 3000 rpm *2	Limit for Average Torque *3	Limit for Repeated Peak Torque *4	Limit for Momentary Torque *5	Max. Input Speed *6	Mass *7	
								Shaft	Flange
		Nm	Nm	Nm	Nm	Nm	rpm	kg	kg
14	50	5.4	4.7	6.9	18	35	8500	0.62	0.50
	80	7.8	6.8	11	23	47			
	100	7.8	6.8	11	28	54			
20	50	25	22	34	56	98	6500	1.8	1.4
	80	34	30	47	74	127			
	100	40	35	49	82	147			
	120	40	35	49	87	147			
	160	40	35	49	92	147			
32	50	76	66	108	216	382	4800	4.6	3.2
	80	118	103	167	304	568			
	100	137	120	216	333	647			
	120	137	120	216	353	686			
	160	137	120	216	372	686			
45	50	176	154	265	500	950	3800	13	10
	80	313	273	390	706	1270			
	100	353	308	500	755	1570			
	120	402	351	620	823	1760			
	160	402	351	630	882	1910			
65	80	745	651	1040	2110	3720	2800	32	24
	100	951	831	1520	2300	4750			
	120	951	831	1570	2510	4750			
	160	951	831	1570	2630	4750			

*1: Rated torque is based on L10 life of 7,000 hours when input speed is 2000 rpm
*2: Rated torque is based on L10 life of 7,000 hours when input speed is 3000 rpm, input speed for size 65 is 2800 rpm.
*3: Maximum value of average load torque is based on the load torque pattern. Note that exceeding this value may deteriorate the life or durability of the product.
*4: The limit for torque during start and stop cycles.
*5: The limit for torque during emergency stops or from external shock loads. Always operate below this value. Calculate the number of permissible events to ensure it meets required operating conditions.
*6: Maximum instantaneous input speed.
*7: The mass is for the gearhead only (without input shaft coupling & motor flange). Please contact us for the mass of your specific configuration.
*8: See page 86 for more information on torque ratings.

Ratcheting Torque CSF-GH

(Unit: Nm) Table 077-2

Reduction ratio \ Size	14	20	32	45	65
50	88	220	980	2700	–
80	110	350	1400	3900	11000
100	84	260	1000	3100	9400
120	–	240	980	2800	8300
160	–	220	980	2600	8000

Buckling Torque CSF-GH

(Unit: Nm) Table 0773

Size	14	20	32	45	65
All Ratios	190	560	2200	5800	17000

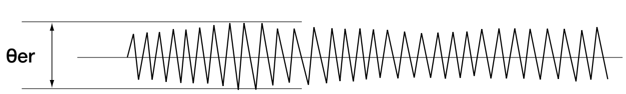
Performance Table CSF-GH

Table 078-1

Size	Flange Type	Ratio	Accuracy*1		Repeatability*2	Starting torque*3		Backdriving torque*4		No-load running torque*5	
			arc min	x10^{-4}rad	arc sec	Ncm	kgfcm	Nm	kgfm	Ncm	kgfcm
14	All	50	1.5	4.4	±10	8.2	0.8	2.9	0.3	5.6	0.6
		80				6.9	0.7	3.9	0.4	5.1	0.5
		100				6.6	0.7	4.7	0.5	4.6	0.5
20	Type I	50	1.0	2.9	±8	13	1.3	7.8	0.8	11	1.2
		80				10	1.0	9.6	1.0	10	1.0
		100				9.6	1.0	12	1.2	10	1.0
		120				9.1	0.9	13	1.3	9.8	1.0
		160				8.6	0.9	17	1.7	9.6	1.0
	Type II	50	1.0	2.9	±8	20	2.0	12	1.2	11	1.2
		80				17	1.7	16	1.6	10	1.0
		100				16	1.7	19	2.0	10	1.0
		120				16	1.6	23	2.3	9.8	1.0
		160				15	1.6	29	3.1	9.6	1.0
32	Type I &II	50	1.0	2.9	±6	58	5.9	35	3.6	47	4.8
		80				46	4.7	44	4.5	42	4.3
		100				45	4.6	54	5.5	41	4.2
		120				42	4.3	61	6.2	40	4.1
		160				41	4.2	79	8.1	40	4.1
	Type III	50	1.0	2.9	±6	50	5.1	30	3.1	47	4.8
		80				38	3.9	37	3.8	42	4.3
		100				37	3.8	45	4.6	41	4.2
		120				34	3.5	49	5.1	40	4.1
		160				33	3.4	64	6.6	40	4.1
45	All	50	1.0	2.9	±5	123	13	74	7.8	120	12
		80				95	9.7	92	9.3	109	11
		100				89	9.1	107	11	107	11
		120				85	8.7	123	13	105	11
		160				79	8.1	152	16	103	11
65	All	80	1.0	2.9	±4	186	19	179	18	297	30
		100				166	17	200	20	289	30
		120				156	16	226	23	285	29
		160				139	14	268	27	278	28

*1: Accuracy values represent the difference between the theoretical angle and the actual angle of output for any given input. The values shown in the table are maximum values.

Figure 078-1

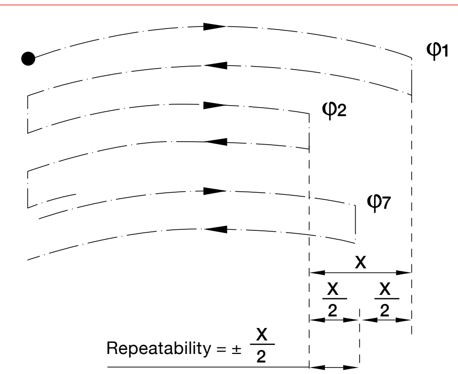


θer : Accuracy
θ_1 : Input angle
θ_2 : Actual output angle
R : Gear reduction ratio

$$\theta er = \theta_2 - \frac{\theta_1}{R}$$

*2: The repeatability is measured by moving to a given theoretical position seven times, each time approaching from the same direction. The actual position of the output shaft is measured each time and repeatability is calculated as the 1/2 of the maximum difference of the seven data points. Measured values are indicated in angles (arc-sec) prefixed with "±". The values in the table are maximum values.

Figure 078-2



*3: Starting torque is the torque value applied to the input side at which the output first starts to rotate. The values in the table are maximum values.

Table 078-2

Load	No load
Speed reducer surface temperature	25°C

*4: Backdriving torque is the torque value applied to the output side at which the input first starts to rotate. The values in the table are maximum values.

Note: Never rely on these values as a margin in a system that must hold an external load. A brake must be used where back driving is not permissible.

Table 078-3

Load	No load
Speed reducer surface temperature	25°C

*5: No-load running torque is the torque required at the input to operate the gearhead at a given speed under a no-load condition. The values in the table are average values.

Table 078-4

Input speed	2000 rpm
Load	No load
Speed reducer surface temperature	25°C

Torsional Stiffness CSF-GH

Table 079-1

Symbol		Size	14	20	32	45	65
T_1		Nm	2.0	7.0	29	76	235
		kgfm	0.2	0.7	3.0	7.8	24
T_2		Nm	6.9	25	108	275	843
		kgfm	0.7	2.5	11	28	86
Reduction ratio 50	K_1	$\times10^4$Nm/rad	0.34	1.3	5.4	15	—
		kgfm/arc min	0.1	0.38	1.6	4.3	—
	K_2	$\times10^4$Nm/rad	0.47	1.8	7.8	20	—
		kgfm/arc min	0.14	0.52	2.3	6.0	—
	K_3	$\times10^4$Nm/rad	0.57	2.3	9.8	26	—
		kgfm/arc min	0.17	0.67	2.9	7.6	—
	θ_1	$\times10^{-4}$rad	5.8	5.2	5.5	5.2	—
		arc min	2.0	1.8	1.9	1.8	—
	θ_2	$\times10^{-4}$rad	16	15.4	15.7	15.1	—
		arc min	5.6	5.3	5.4	5.2	—
Reduction ratio 80 or more	K_1	$\times10^4$Nm/rad	0.47	1.6	6.7	18	54
		kgfm/arc min	0.14	0.47	2.0	5.4	16
	K_2	$\times10^4$Nm/rad	0.61	2.5	11	29	88
		kgfm/arc min	0.18	0.75	3.2	8.5	26
	K_3	$\times10^4$Nm/rad	0.71	2.9	12	33	98
		kgfm/arc min	0.21	0.85	3.7	9.7	29
	θ_1	$\times10^{-4}$rad	4.1	4.4	4.4	4.1	4.4
		arc min	1.4	1.5	1.5	1.4	1.5
	θ_2	$\times10^{-4}$rad	12	11.3	11.6	11.1	11.3
		arc min	4.2	3.9	4.0	3.8	3.9

* The values in this table are average values. See page 88 for more information about torsional stiffness.

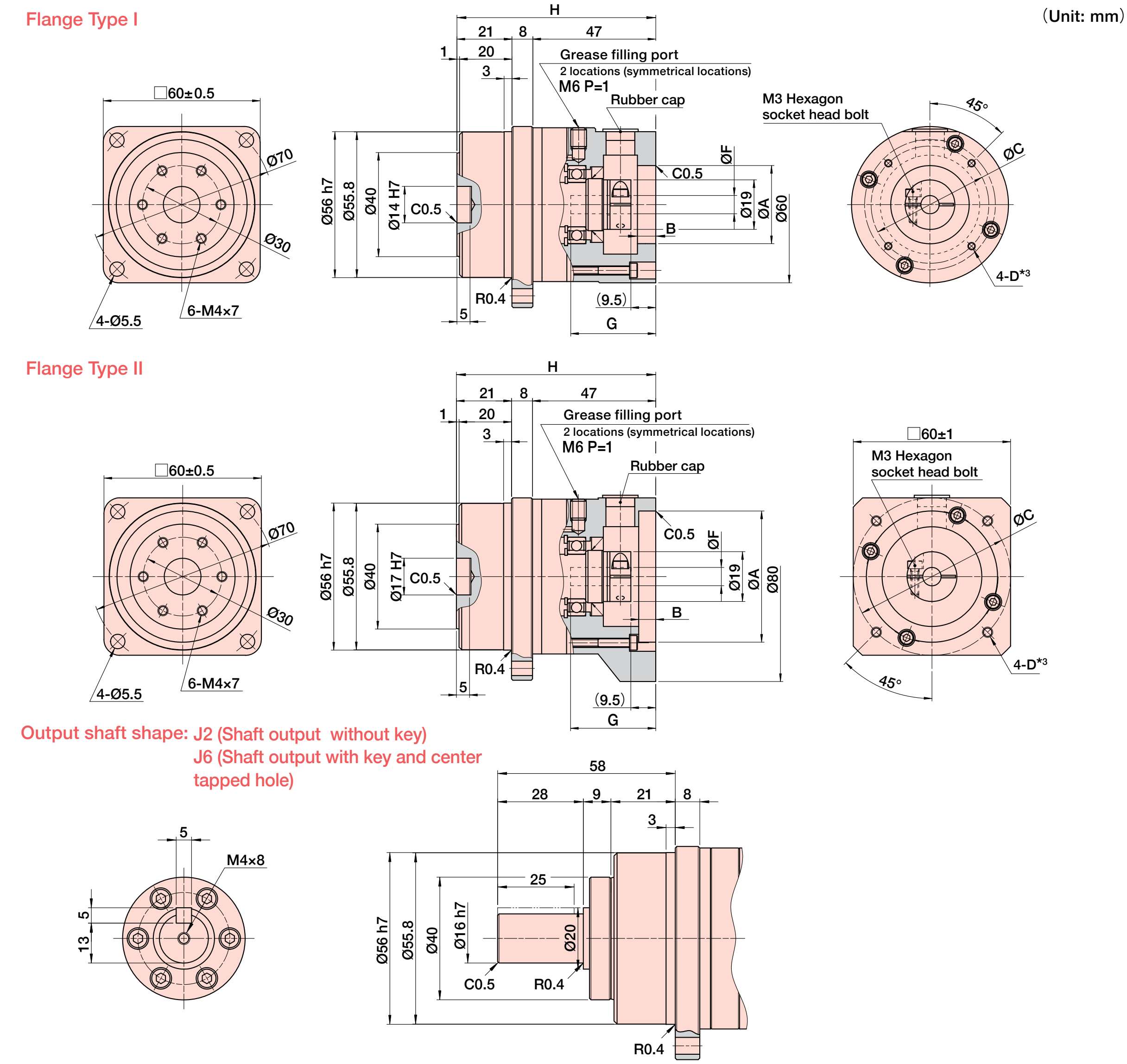
Hysteresis Loss CSF-GH

Reduction ratio 50: Approx. $5.8\mathrm{X}10^{-4}$ rad (2arc min)
Reduction ratio 80 or more: Approx. $2.9\mathrm{X}10^{-4}$ rad (1arc min)

CSF-GH-14 Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.

Figure 080-1



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method.
Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

Dimension Table

(Unit: mm)

Table 080-1

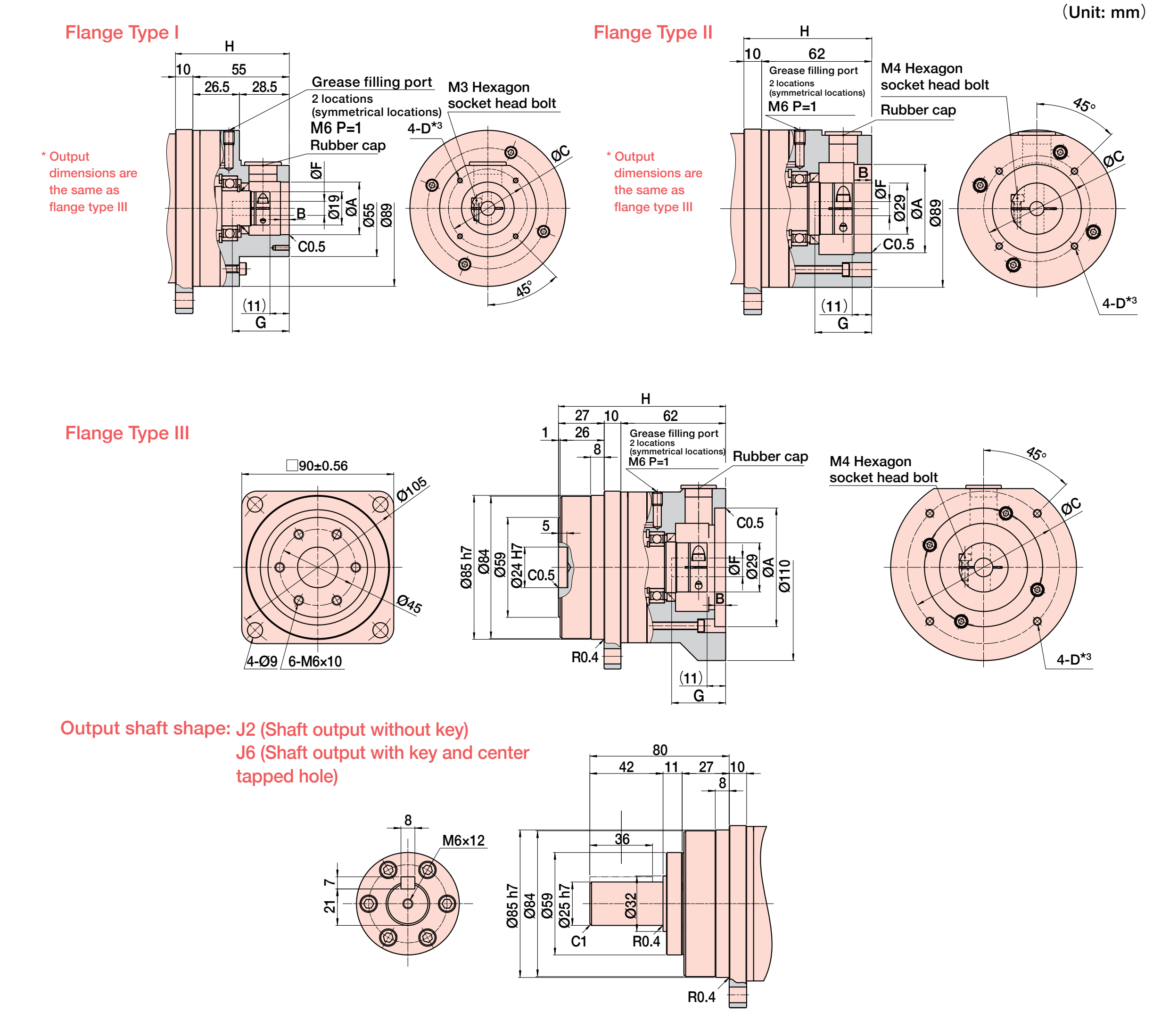
Flange	Coupling	A (H7)		B	C		F (H7)		G		H *1	Moment of Inertia	Mass (kg) *2	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	(10^{-4}kgm^2)	Shaft	Flange
Type I	1	50	58	7	58	72	6.0	7.8	21.5	32.5	76	0.07	0.88	0.76
Type II	1	30	45	6.5	36	54	6.0	7.8	21.5	32.5	76	0.07	0.90	0.78

Refer to the confirmation drawing for detailed dimensions.
Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.
*1 May vary depending on motor interface dimensions.
*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.
*3 Tapped hole for motor mounting screw.

CSF-GH-20 Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.

Figure 081-1



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method.
Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

Dimension Table

(Unit: mm)

Table 081-1

Flange	Coupling	A (H7)		B	C		F (H7)		G		H *1	Moment of Inertia	Mass (kg) *2	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	(10^{-4}kgm^2)	Shaft	Flange
Type I	1	30	45	5	36	48	7.0	7.8	23.0	33.0	82.0	0.28	2.3	1.9
Type II	2	50	70	10	60	80	8.0	14.6	25.0	32.0	99.0	0.42	2.6	2.2
Type III	2	50	80	10	60	100	8.0	14.6	25.0	32.0	99.0	0.42	2.8	2.4

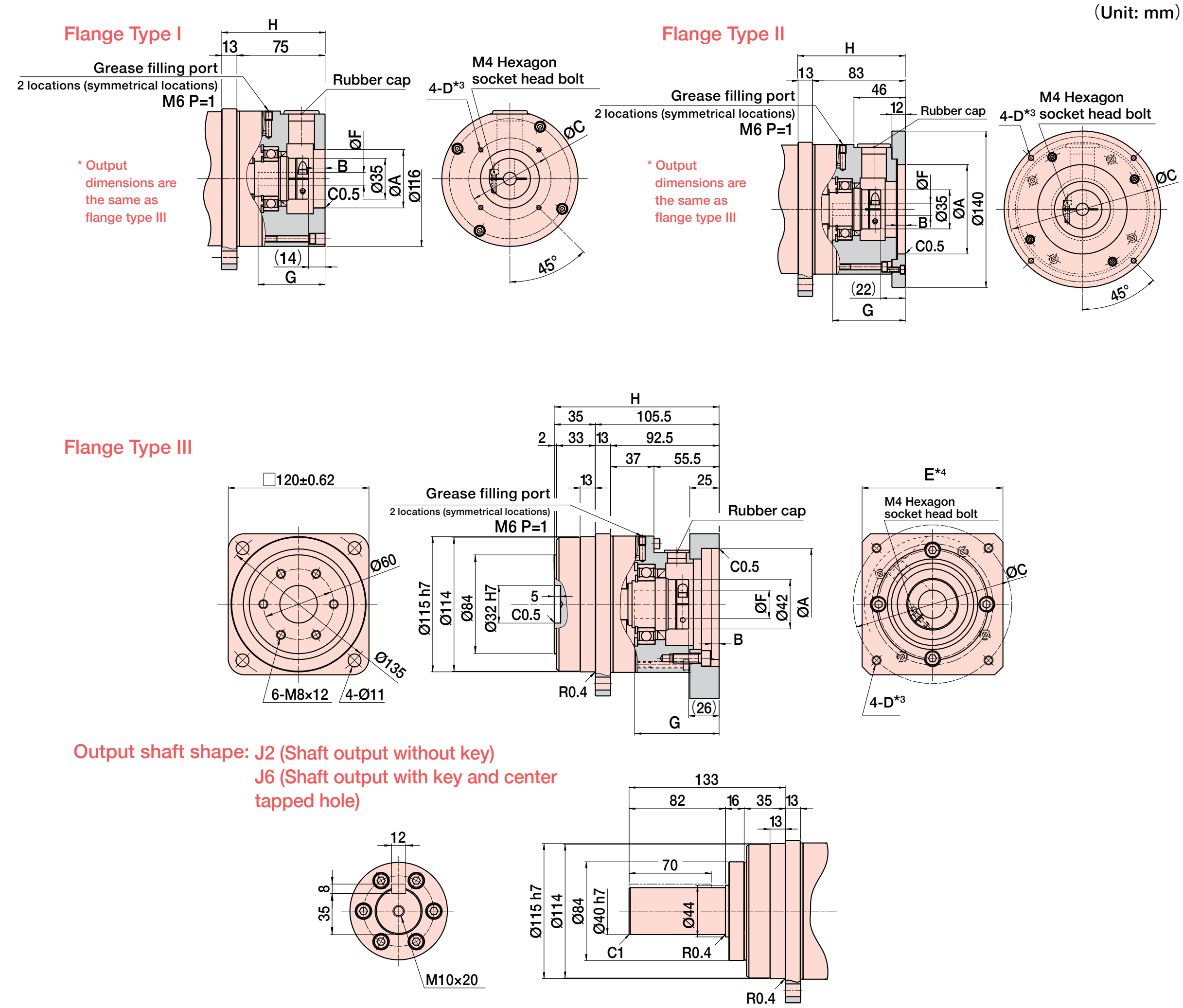
Refer to the confirmation drawing for detailed dimensions.
Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.
*1 May vary depending on motor interface dimensions.
*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.
*3 Tapped hole for motor mounting screw.

CSF-GH-32 Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.

Figure 082-1

(Unit: mm)



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method.
Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

Dimension Table

(Unit: mm)

Table 082-1

Flange	Coupling	A (H7)		B	C		F (H7)		G		H	Moment of Inertia	Mass (kg) *1	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Max.	($10^{-4}kgm^2$)	Shaft	Flange
Type I	3	50	85	10	58	105	11.0	19.6	28.0	57	133	2.7	6.4	5.0
Type II	2	70	95	5	85	115	16.0	25.8	35.0	67	145.5	2.7	6.6	5.2
Type III	1	95	130	7	115	165	11.0	19.6	36.0	65	141	2.0	7.9	6.5

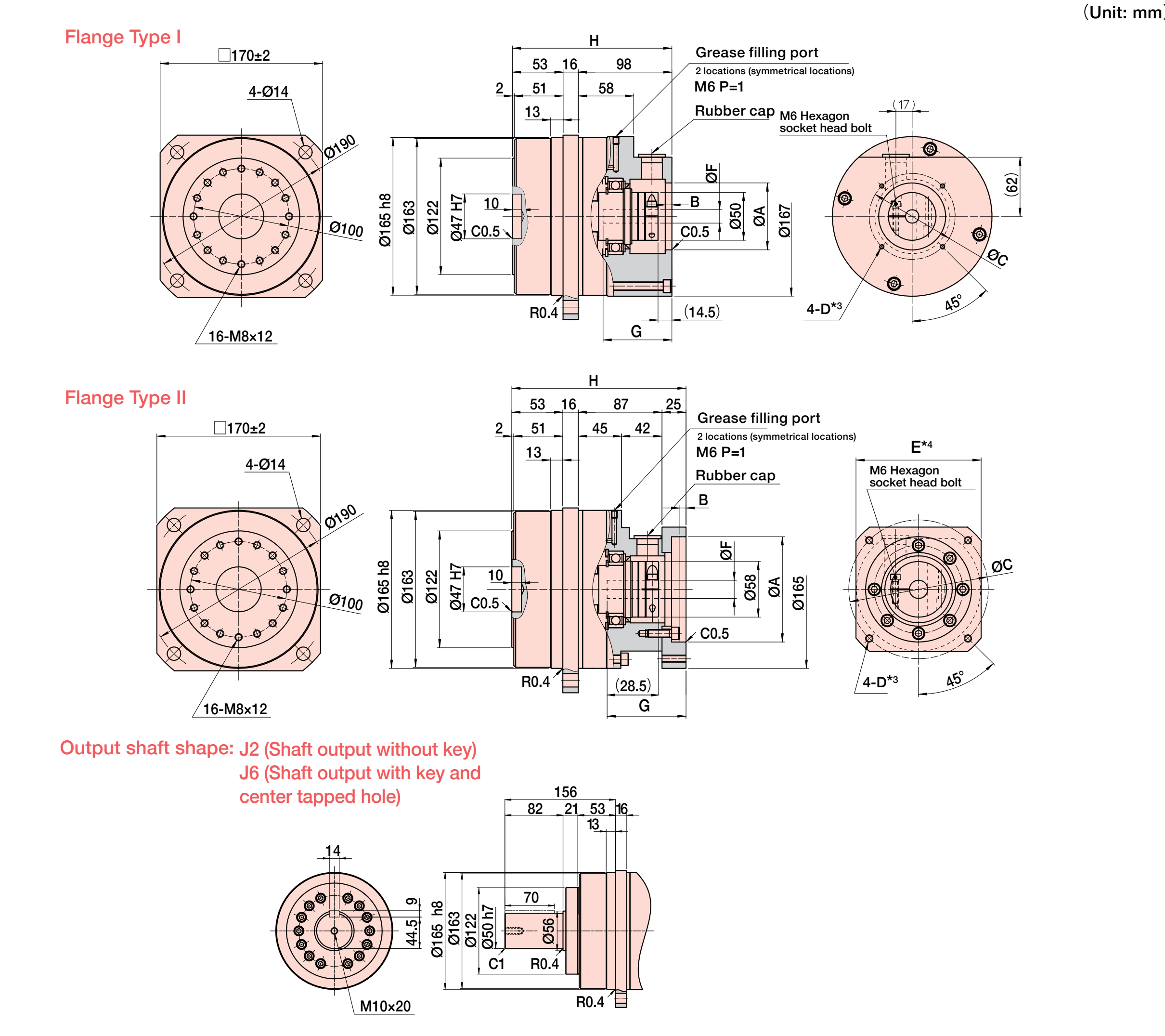
Refer to the confirmation drawing for detailed dimensions.
Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.
*1 May vary depending on motor interface dimensions.
*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.
*3 Tapped hole for motor mounting screw.
*4 E dimension is dependent on motor selection.

CSF-GH-45 Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.

Figure 083-1

(Unit: mm)



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method.
Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

Dimension Table

(Unit: mm)

Table 083-1

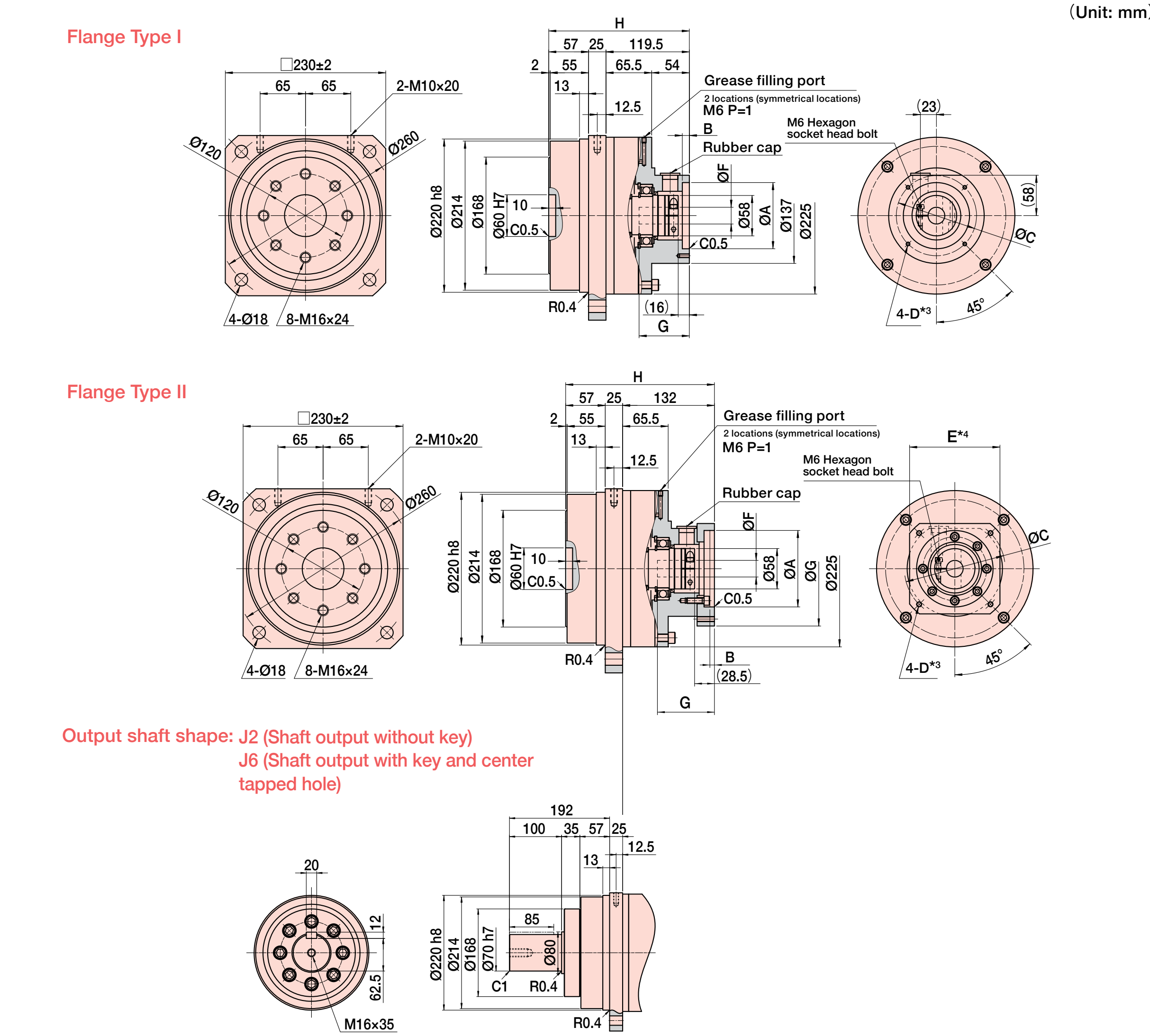
Flange	Coupling	A (H7)		B	C		F (H7)		G		H *1	Moment of Inertia	Mass (kg) *2	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	(10^{-4}kgm^2)	Shaft	Flange
Type I	1	70	110	7	80	150	14.0	29.4	31.5	72	167	11	17.3	14.3
Type I	2	70	110	7	80	150	19.0	41	40.5	77	167	11	17.3	14.3
Type II	1	110	130	6.5	145	200	14.0	29.4	31.5	72	176	11	16.7	13.7
Type II	2	110	130	6.5	145	200	19.0	41	40.5	77	176	11	17.7	14.7

Refer to the confirmation drawing for detailed dimensions.
Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.
*1 May vary depending on motor interface dimensions.
*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.
*3 Tapped hole for motor mounting screw.
*4 E dimension is dependent on motor selection.

CSF-GH-65 Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.

Figure 084-1



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method.
Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

Dimension Table

(Unit: mm) Table 084-1

Flange	Coupling	A (H7)		B	C		F (H7)		G		H *1	Moment of Inertia	Mass (kg) *2	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Max.	(10^{-4}kgm^2)	Shaft	Flange
Type I	1	95	95	10	110	125	19.0	39.3	33.0	72	201.5	51	36.2	27.6
Type II	1	110	200	6.5	145	235	19.0	39.3	40.5	79.5	209	51	38.3	29.7

Refer to the confirmation drawing for detailed dimensions.
Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.
*1 May vary depending on motor interface dimensions.
*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.
*3 Tapped hole for motor mounting screw.
*4 E dimension is dependent on motor selection.

NOTES

Rating Table Definitions

See the corresponding pages of each series for values from the ratings.

■ Rated torque

Rated torque indicates allowable continuous load torque at input speed.

■ Limit for Repeated Peak Torque (see Graph 086-1)

During acceleration and deceleration the Harmonic Drive® gear experiences a peak torque as a result of the moment of inertia of the output load. The table indicates the limit for repeated peak torque.

■ Limit for Average Torque

In cases where load torque and input speed vary, it is necessary to calculate an average value of load torque. The table indicates the limit for average torque. The average torque calculated must not exceed this limit. (calculation formula: Page 91)

■ Limit for Momentary Torque (see Graph 086-1)

The gear may be subjected to momentary peak torques in the event of a collision or emergency stop. The magnitude and frequency of occurrence of such peak torques must be kept to a minimum and they should, under no circumstance, occur during normal operating cycle. The allowable number of occurrences of the momentary peak torque may be calculated by using formula 073-1.

■ Maximum Average Input Speed Maximum Input Speed

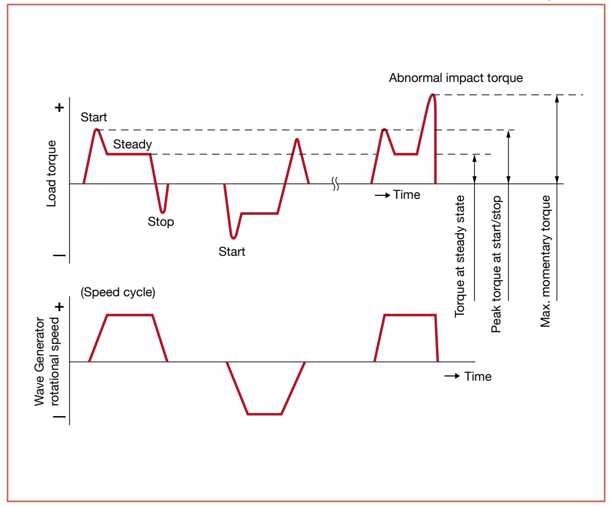
Do not exceed the allowable rating. (calculation formula of the average input speed: Page 91).

■ Inertia

The rating indicates the moment of inertia reflected to the gear input.

Example of load torque pattern

Graph 086-1



Life

■ Life of the wave generator

The life of a gear is determined by the life of the wave generator bearing. The life may be calculated by using the input speed and the output load torque.

Table 086-1

Series name	Life	
	CSF-GH	CSG-GH
L_{10}	7,000 hours	10,000 hours
L_{50} (average life)	35,000 hours	50,000 hours

* Life is based on the input speed and output load torque from the ratings.

Calculation formula for Rated Lifetime

Formula 086-1

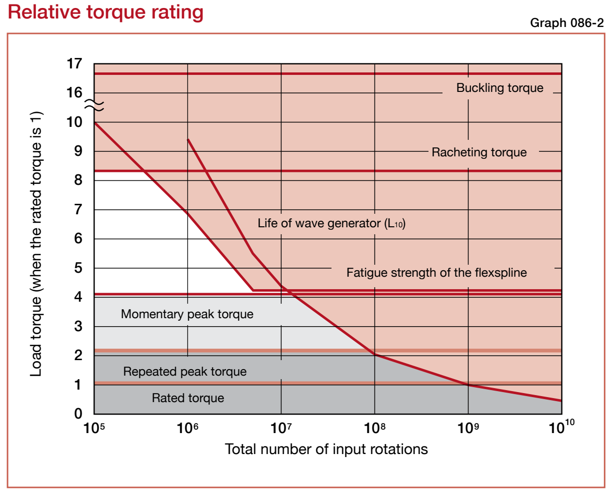
$$Lh = Ln \cdot \left(\frac{Tr}{Tav}\right)^3 \cdot \left(\frac{Nr}{Nav}\right)$$

Table 086-2

Ln	Life of L_{10} or L_{50}c
Tr	Rated torque
Nr	Rated input speed
Tav	Average load torque on the output side (calculation formula: Page 91)
Nav	Average input speed (calculation formula: Page 91)

Relative torque rating

Graph 086-2



* Lubricant life not taken into consideration in the graph described above.
* Use the graph above as reference values.

Torque Limits

■ Strength of flexspline

The Flexspline is subjected to repeated deflections, and its strength determines the torque capacity of the Harmonic Drive® gear. The values given for Rated Torque at Rated Speed and for the allowable Repeated Peak Torque are based on an infinite fatigue life for the Flexspline.
The torque that occurs during a collision must be below the momentary peak torque (impact torque). The maximum number of occurrences is given by the equation below.

Allowable limit of the bending cycles of the flexspline during rotation of the wave generator while the impact torque is applied: 1.0 x 10^4 (cycles)

The torque that occurs during a collision must be below the momentary peak torque (impact torque). The maximum number of occurrences is given by the equation below.

Calculation formula

Formula 087-1

$$N = \frac{1.0\times10^4}{2\times\frac{n}{60}\times t}$$

Permissible occurances	N occurances
Time that impact torque is applied	t sec
Rotational speed of the wave generator	n rpm
The flexspline bends two times per one revolution of the wave generator.	

Caution If the number of occurances is exceeded, the Flexspline may experience a fatigue failure.

■ Buckling torque

When a highly excessive torque (16 to 17 times rated torque) is applied to the output with the input stationary, the flexspline may experience plastic deformation. This is defined as buckling torque.

* See the corresponding pages of each series for buckling torque values.

Warning When the flexspline buckles, early failure of the HarmonicDrive® gear may occur.

■ Ratcheting torque

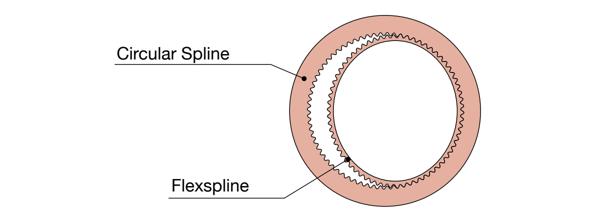
When excessive torque (8 to 9 times rated torque) is applied while the gear is in motion, the teeth between the Circular Spline and Flexspline may not engage properly.
This phenomenon is called ratcheting and the torque at which this occurs is called ratcheting torque. Ratcheting may cause the Flexspline to become non-concentric with the Circular Spline. Operating in this condition may result in shortened life and a Flexspline fatigue failure.

* See the corresponding pages of each series for ratcheting torque values.
* Ratcheting torque is affected by the stiffness of the housing to be used when installing the circular spline. Contact us for details of the ratcheting torque.

Caution When ratcheting occurs, the teeth may not be correctly engaged and become out of alignment as shown in Figure 087-1. Operating the drive in this condition will cause vibration and damage the flexspline.

Caution Once ratcheting occurs, the teeth wear excessively and the ratcheting torque may be lowered.

Figure 087-1



"Dedoidal" condition.

Torsional Stiffness

Stiffness and backlash of the drive system greatly affects the performance of the servo system. Please perform a detailed review of these items before designing your equipment and selecting a model number.

■ Stiffness

Fixing the input side (wave generator) and applying torque to the output side (flexspline) generates torsion almost proportional to the torque on the output side. Figure 088-1 shows the torsional angle at the output side when the torque applied on the output side starts from zero, increases up to $+T_0$ and decreases down to $-T_0$. This is called the “Torque – torsion angle diagram,” which normally draws a loop of 0 – A – B – A’ – B’ – A. The slope described in the “Torque – torsion angle diagram” is represented as the spring constant for the stiffness of the HarmonicDrive® gear (unit: Nm/rad).
As shown in Figure 074-2, this “Torque – torsional angle diagram” is divided into 3 regions, and the spring constants in the area are represented by K_1, K_2 and K_3.

K_1 ···· The spring constant when the torque changes from [zero] to [T_1]
K_2 ···· The spring constant when the torque changes from [T_1] to [T_2]
K_3 ···· The spring constant when the torque changes from [T_2] to [T_3]

■ See the corresponding pages of each series for values of the spring constants (K_1, K_2, K_3) and the torque-torsional angles (T_1, T_2, - θ_1, θ_2).

■ Example for calculating the torsion angle

The torsion angle (θ) is calculated here using CSG-32-100-GH as an example.

T1 = 29 Nm
T2 = 108 Nm
K1 = 6.7×10^4 Nm/rad
K2 = 6.7×10^4 Nm/rad
K3 = 6.7×10^4 Nm/rad
θ1 = 4.4×10^{-4} rad
θ2 = 11.6×10^{-4} rad

When the applied torque is T_1 or less, the torsion angle θ_{L1} is calculated as follows:
When the load torque T_{L1}=6.0 Nm

$$\theta_{L1} = T_{L1}/K_1 = 6.0/6.7\times10^4 = 9.0\times10^{-5}\text{ rad (0.31 arc min)}$$

When the applied torque is between T_1 and T_2, the torsion angle θ_{L2} is calculated as follows:
When the load torque is T_{L2}=50 Nm

$$\begin{aligned}\theta_{L2} &= \theta_1 + (T_{L2}-T_1)/K_2\\ &= 4.4\times10^{-4} + (50-6)/11.0\times10^4\\ &= 4.4\times10^{-4} + 40.0\times10^{-5}\\ &= 8.4\times10^{-4}\text{ rad (2.89 arc min)}\end{aligned}$$

When the applied torque is greater than T_2, the torsion angle θ_{L3} is calculated as follows:
When the load torque is T_{L3}=178 Nm

$$\begin{aligned}\theta_{L3} &= \theta_1 + \theta_2 + (T_{L3}-T_2)/K_3\\ &= 4.4\times10^{-4} + 11.6\times10^{-4} + (178-108)/12.0\times10^4\\ &= 4.4\times10^{-4} + 11.6\times10^{-4} + 5.8\times10^{-4}\\ &= 2.18\times10^{-3}\text{ rad (7.5 arc min)}\end{aligned}$$

When a bidirectional load is applied, the total torsion angle will be 2 x θ_{LX} plus hysteresis loss.

* The torsion angle calculation is for the gear component set only and does not include any torsional windup of the output shaft.

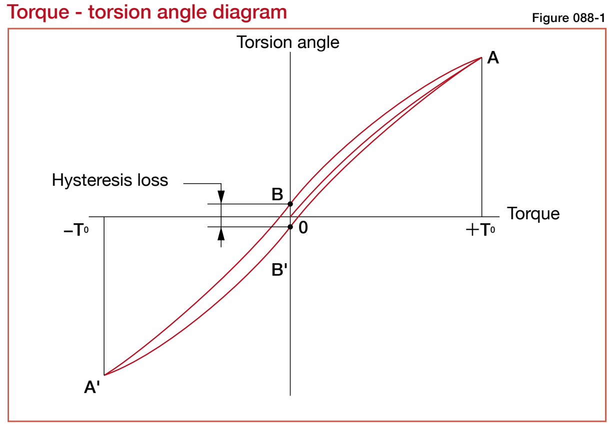
■ Hysteresis loss

As shown in Figure 088-1, when the applied torque is increased to the rated torque and is brought back to [zero], the torsional angle does not return exactly back to the zero point This small difference (B – B') is called hysteresis loss.

■ See the appropriate page for each model series for the hysteresis loss value.

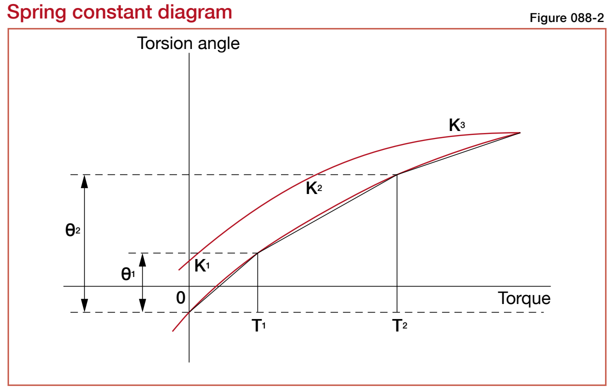
Torque - torsion angle diagram

Figure 088-1



Spring constant diagram

Figure 088-2



■ Backlash

Hysteresis loss is primarily caused by internal friction. It is a very small value and will vary roughly in proportion to the applied load. Because HarmonicDrive® gearheads have zero backlash, the only true backlash is due to the clearance in the Oldham coupling, a self-aligning mechanism used on the wave generator. Since the Oldham coupling is used on the input, the backlash measured at the output is extremely small (arc-seconds) since it is divided by the gear reduction ratio.

Vibration

The primary frequency of the transmission error of the HarmonicDrive® gear may rarely cause a vibration of the load inertia. This can occur when the driving frequency of the servo system including the HarmonicDrive® gear is at, or close to the resonant frequency of the system. Refer to the design guide of each series.

The primary component of the transmission error occurs twice per input revolution of the input. Therefore, the frequency generated by the transmission error is 2x the input frequency (rev / sec).

If the resonant frequency of the entire system, including the HarmonicDrive® gear, is F=15 Hz, then the input speed (N) which would generate that frequency could be calculated with the formula below.

Formula 089-1

$$N = \frac{15}{2} \cdot 60 = 450 \text{ rpm}$$

The resonant frequency is generated at an input speed of 450 rpm.

How to the calculate resonant frequency of the system

Formula 089-2

$$f = \frac{1}{2\pi} \sqrt{\frac{K}{J}}$$

Formula variables

Table 089-1

f	The resonant frequency of the system	Hz	
K	Spring constant of the HarmonicDrive® gear	Nm/rad	See pages of each series.
J	Load inertia	kgm^2	

Efficiency

The efficiency will vary depending on the following factors:

- Reduction ratio
- Input speed
- Load torque
- Temperature
- Lubrication condition (Type of lubricant and the quantity)

Product Sizing & Selection

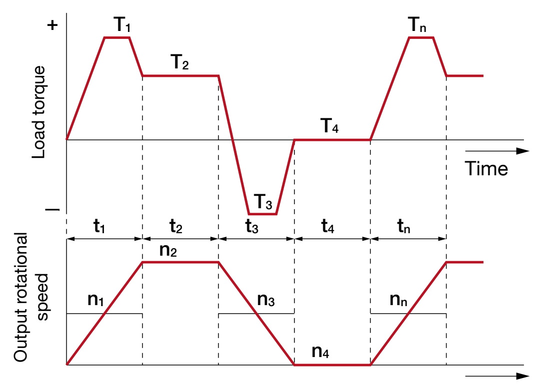
In general, a servo system rarely operates at a continuous load and speed. The input rotational speed, load torque change and comparatively large torque are applied at start and stop. Unexpected impact torque may be applied.
These fluctuating load torques should be converted to the average load torque when selecting a model number.
As an accurate cross roller bearing is built in the direct external load support (output flange), the maximum moment load, life of the cross roller bearing and the static safety coefficient should also be checked.

(Note) If HarmonicDrive® CSG-GH series is installed with the output shaft facing downward (motor faces upward) and continuously operated in one direction under the constant load state, lubrication failure may occur. In this case, please contact us for details.

■ Checking the load torque pattern

Review the load torque pattern. Check the specifications shown in the figure below.

Graph 090-1



* n_1, n_2 and n_n indicate the average values.

Obtain the value of each load torque pattern.

Load torque	T_n (Nm)
Time	t_n (sec)
Output rotational speed	n_n (rpm)

<Normal operation pattern>

Starting	T_1, t_1, n_1
Steady operation	T_2, t_2, n_2
Stopping (slowing)	T_3, t_3, n_3
Idle	T_4, t_4, n_4

<Maximum rotational speed>

Max. output speed	no ***max***
Max. input rotational speed (Restricted by motors)	ni ***max***

<Impact torque>

When impact torque is applied	T_s, t_s, n_s

<Required life>

L_{10} = L (hours)

■ Flowchart for selecting a size

Please use the flowchart shown below for selecting a size. Operating conditions must not exceed the performance ratings.

Calculate the average load torque applied on the output side from the load torque pattern: T***av*** (Nm).

$$Tav = \sqrt[3]{\frac{n_1 \cdot t_1 \cdot |T_1|^3 + n_2 \cdot t_2 \cdot |T_2|^3 + \cdots n_n \cdot t_n \cdot |T_n|^3}{n_1 \cdot t_1 + n_2 \cdot t_2 + \cdots n_n \cdot t_n}}$$

↓

Make a preliminary model selection with the following conditions.
T***av*** ≦ Limit for average torque torque
(See the ratings of each series).

↓

Calculate the average output speed: no ***av*** (rpm)

$$no\,av = \frac{n_1 \cdot t_1 + n_2 \cdot t_2 + \cdots n_n \cdot t_n}{t_1 + t_2 + \cdots t_n}$$

Obtain the reduction ratio (R). A limit is placed on "ni ***max***" by motors.

$$\frac{ni\,max}{no\,max} \geqq R$$

Calculate the average input rotational speed from the average output rotational speed (no ***av***) and the reduction ratio (R): ni ***av*** (rpm)

$$ni\,av = no\,av \cdot R$$

Calculate the maximum input rotational speed from the max. output rotational speed (no ***max***) and the reduction ratio (R): ni ***max*** (rpm)

$$ni\,max = no\,max \cdot R$$

↓

Check whether the preliminary model number satisfies the following condition from the ratings.

Ni ***av*** ≦ Limit for average speed (rpm)
Ni ***max*** ≦ Limit for maximum speed (rpm)

NG / OK

Check whether T_1 and T_3 are equal to or less than the repeated peak torque specification.

NG / OK

Check whether T_s is equal to or less than the the momentary peak torque specification.

NG / OK

Calculate (Ns) the allowable number of rotations during impact torque.

$$N_S = \frac{10^4}{2 \cdot \frac{n_S \cdot R}{60} \cdot t} \quad \cdots\cdots N_S \leqq 1.0 \times 10^4$$

NG / OK

Calculate the lifetime.

$$L_{10} = 7000 \cdot \left(\frac{Tr}{Tav}\right)^3 \cdot \left(\frac{nr}{ni\,av}\right) \text{(hours)}$$

Check whether the calculated lifetime is equal to or more than the life of the wave generator (see Page 086).

NG / OK

The model number is confirmed.

NG → Review the operation conditions and model number

Example of model number selection

Value of each load torque pattern.

Load torque	T_n (Nm)
Time	t_n (sec)
Output speed	n_n (rpm)

<Normal operation pattern>

Starting	T_1 = 400 Nm, t_1 = 0.3 sec, n_1 = 7 rpm
Steady operation	T_2 = 320 Nm, t_2 = 3 sec, n_2 = 14 rpm
Stopping (slowing)	T_3 = 200 Nm, t_3 = 0.4 sec, n_3 = 7 rpm
Idle	T_4 = 0 Nm, t_4 = 0.2 sec, n_4 = 0 rpm

<Maximum rotational speed>

Max. output speed	no ***max*** = 14 rpm
Max. input speed	ni ***max*** = 1800 rpm
(Restricted by motors)	

<Impact torque>

When impact torque is applied T_s = 500 Nm, t_s = 0.15 sec, n_s = 14 rpm

<Required life>

L_{10} = 7000 (hours)

Calculate the average load torque applied on the output side of the Harmonic Drive® gear from the load torque pattern: T***av*** (Nm).

$$T_{av} = \sqrt[3]{\frac{7\text{ rpm}\cdot 0.3\text{ sec}\cdot|400\text{Nm}|^3+14\text{ rpm}\cdot 3\text{ sec}\cdot|320\text{Nm}|^3+7\text{ rpm}\cdot 0.4\text{ sec}\cdot|200\text{Nm}|^3}{7\text{ rpm}\cdot 0.3\text{ sec}+14\text{ rpm}\cdot 3\text{ sec}+7\text{ rpm}\cdot 0.4\text{ sec}}}$$

Make a preliminary model selection with the following conditions. T***av*** = 319 Nm ≦ 620 Nm
(Limit for average torque for model number CSF-45-120-GH: See the ratings on Page 77.)
Thus, **CSF-45-120-GH** is tentatively selected.

Calculate the average output rotational speed: no ***av*** (rpm)

$$no_{av} = \frac{7\text{ rpm}\cdot 0.3\text{ sec}+14\text{ rpm}\cdot 3\text{ sec}+7\text{ rpm}\cdot 0.4\text{ sec}}{0.3\text{ sec} + 3\text{ sec} + 0.4\text{ sec} + 0.2\text{ sec}} = 12\text{ rpm}$$

Obtain the reduction ratio (R).

$$\frac{1800\text{ rpm}}{14\text{ rpm}} = 128.6 \geqq 120$$

Calculate the average input rotational speed from the average output rotational speed (no ***av***) and the reduction ratio (R): ni ***av*** (rpm)

ni ***av*** = 12 rpm·120 = 1440 rpm

Calculate the maximum input rotational speed from the maximum output rotational speed (no ***max***) and the reduction ratio (R): ni ***max*** (rpm)

ni ***max*** = 14 rpm·120 = 1680 rpm

Check whether the preliminary selected model number satisfies the following condition from the ratings.

Ni ***av*** = 1440 rpm ≦ 3000 rpm (Max average input speed of size 45)
Ni ***max*** = 1680 rpm ≦ 3800 rpm (Max input speed of size 45)

NG

OK

Check whether T_1 and T_3 are equal to or less than the repeated peak torque specification.

T_1 = 400 Nm ≦ 823 Nm (Limit of repeated peak torque of size 45)
T_3 = 200 Nm ≦ 823 Nm (Limit of repeated peak torque of size 45)

NG

OK

Check whether Ts is equal to or less than the momentary peak torque specification.

T_s = 500 Nm ≦ 1760 Nm (Limit for momentary torque of size 45)

NG

OK

Calculate the allowable number (Ns) rotation during impact torque and confirm ≦ 1.0×10⁴

$$N_S = \frac{10^4}{2\cdot\frac{14\text{ rpm}\cdot 120}{60}\cdot 0.15\text{ sec}} = 1190 \leqq 1.0\times10^4$$

NG

OK

Calculate the lifetime.

$$L_{10} = 7000\cdot\left(\frac{402\text{ Nm}}{319\text{ Nm}}\right)^3\cdot\left(\frac{2000\text{ rpm}}{1440\text{ rpm}}\right)\text{(hours)}$$

Check whether the calculated life is equal to or more than the life of the wave generator (see Page 86).
L_{10} =19,457 hours ≧ 7000 (life of the wave generator: L_{10})

NG

OK

The selection of model number **CSF-45-120-GH** is confirmed from the above calculations.

Review the operation conditions and model number

CSG-GH Series HarmonicDrive® High-Performance Gearhead for Servomotors

CSF-GH Series HarmonicDrive® High-Performance Gearhead for Servomotors

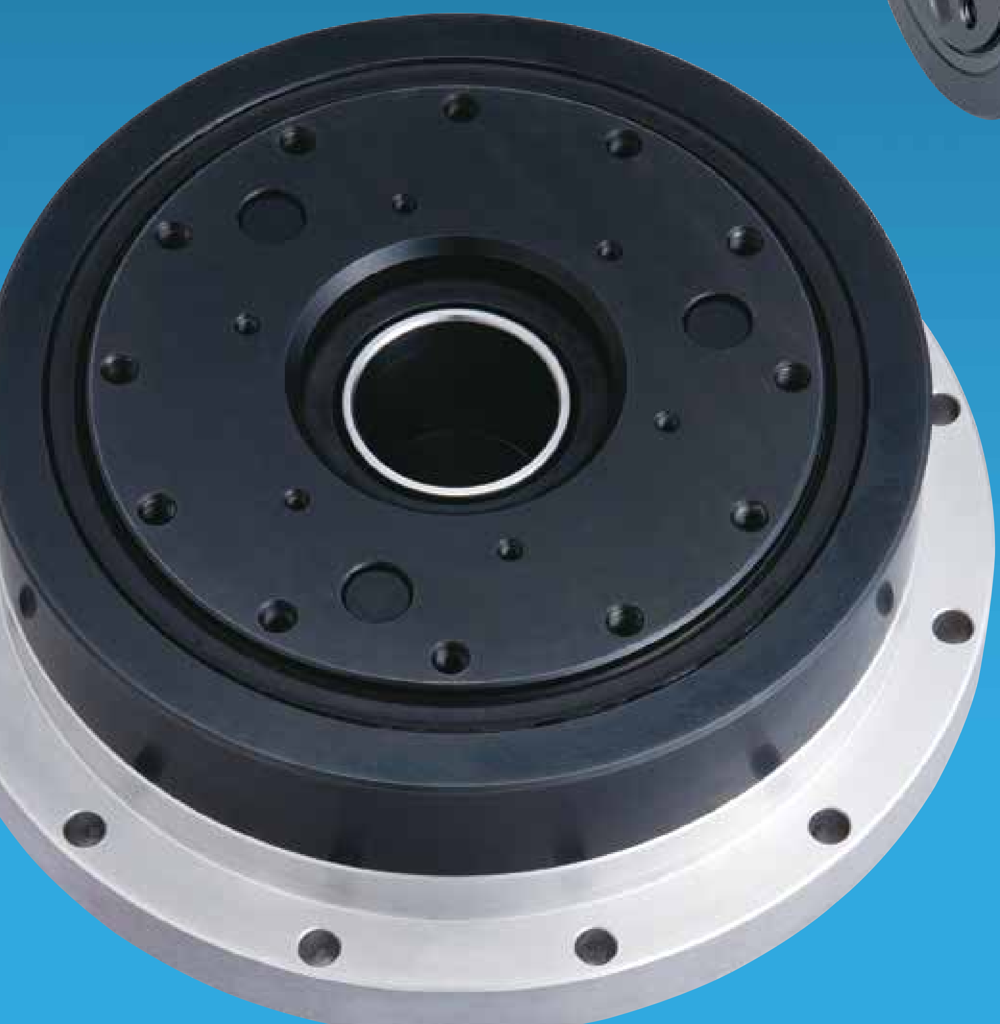
NOTES

HarmonicPlanetary®

Planetary Gear Units

HPF Series - Hollow Shaft

HPG Series - Input Shaft



HarmonicPlanetary®

HPF Hollow Shaft Gear Unit

Size

2 Sizes

25, 32

Peak torque

Size 25: 100Nm, Size 32: 220Nm

Reduction ratio

11:1

Low backlash

Standard: <3 arc-min Low Backlash for Life

Innovative ring gear automatically adjusts for backlash, ensuring consistent, low backlash for the life of the gearhead. The ring gear design automatically provides the optimum backlash in the planetary gear train and maintains the same low backlash for the life of the gearhead.

Inside diameter of the hollow shaft

Size 25: Ø25mm Size 32: Ø30mm

High Load Capacity Output Bearing

A Cross Roller bearing is integrated with the output flange to provide high moment stiffness, high load capacity and precise positioning accuracy.

Based on Harmonic Planetary® gearhead design concept, the hollow shaft planetary features the same superior performance and specifications as the HPG line. The large hollow shaft allows cables, pipes, or shafts to pass directly through the axis of rotation, simplifying the design and improving reliability.

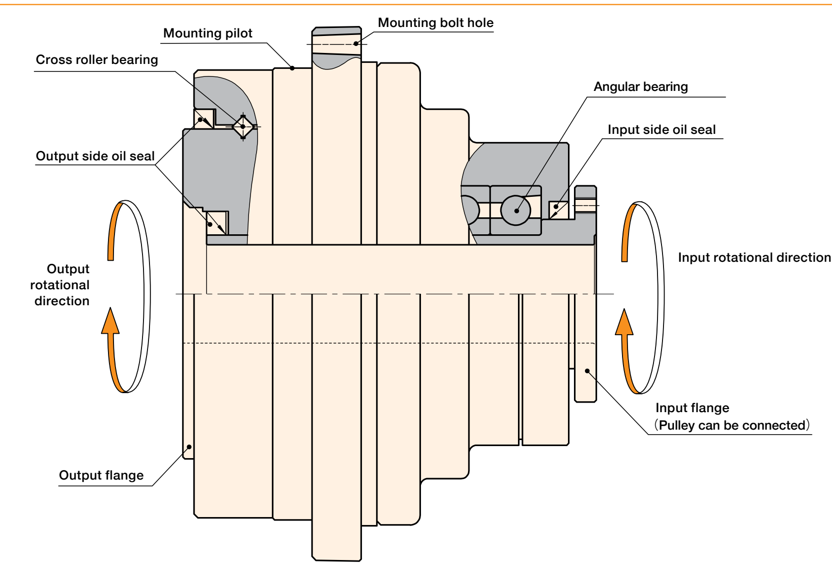
CONTENTS

HPF - 25 A - 11 - F0 U1 - SP1

Model Name	Size	Design Revision	Reduction Ratio	Output Configuration	Input Configuration	Options
HarmonicPlanetary® HPF Hollow Shaft	25	A	11	F0: Flange output	U1: Hollow shaft	None: Standard item SP: Special specification
	32					

Gearhead Construction

Figure 094-1



Rating Table

The HPF hollow shaft planetary gear features a large hollow shaft that allows cables, shafts, ball screws or lasers to pass directly through the axis of rotation.

Table 095-1

Size	Ratio	Rated Torque at 2000 rpm *1	Rated Torque at 3000 rpm *2	Limit for Repeated Peak Torque *3	Limit for Momentary Torque *4	Max. Average Input Speed *5	Max. Input Speed *6	Input Moment of Inertia	Mass
		Nm	Nm	Nm	Nm	rpm	rpm	$\times10^{-4}$kgm^2	kg
25	11	48	21	100	170	3000	5600	1.63	3.8
32	11	100	44	220	450	3000	4800	3.84	7.2

*1: Rated torque is based on L10 life of 20,000 hours when input speed is 2000 rpm
*2: Rated torque is based on L10 life of 20,000 hours when input speed is 3000 rpm
*3: The limit for torque during start and stop cycles.
*4: The limit for torque during emergency stops or from external shock loads. Always operate below this value. Calculate the number of permissible events to ensure it meets required operating conditions.
*5: Maximum average input speed is limited by heat generation in the speed reducer assuming a continuous operating speed or the average input speed of a motion profile. The actual limit for average input speed depends on the operating environment.
*6: Maximum instantaneous input speed.

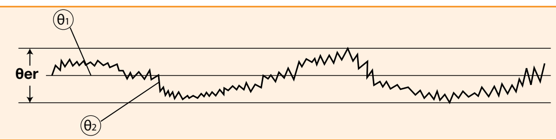
Performance Table

Table 095-2

Size	Reduction ratio	Accuracy *1		Repeatability *2	Starting torque *3		Backdriving torque *4		No-load running torque *5	
		arc min	$\times10^{-4}$rad	arc sec	Ncm	kgfcm	Nm	kgfm	Ncm	kgfcm
25	11	4	11.6	±15	59	6.0	6.5	0.66	78	8.0
32	11	4	11.6	±15	75	7.7	8.3	0.85	105	10.7

*1: Accuracy values represent the difference between the theoretical angle and the actual angle of output for any given input. The values in the table are maximum values.

Figure 095-1

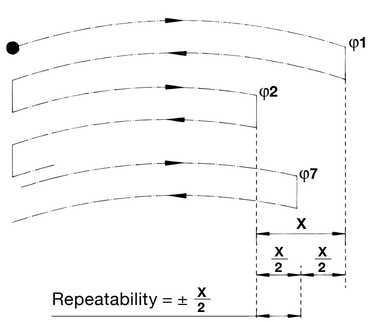


θer : Accuracy
θ_1 : Input angle
θ_2 : Actual output angle
R : Gear reduction ratio

$$\theta er = \theta_2 - \frac{\theta_1}{R}$$

*2: The repeatability is measured by moving to a given theoretical position seven times, each time approaching from the same direction. The actual position of the output shaft is measured each time and repeatability is calculated as the 1/2 of the maximum difference of the seven data points. Measured values are indicated in angles (arc-sec) prefixed with "±". The values in the table are maximum values.

Figure 095-2



*3: Starting torque is the torque value applied to the input side at which the output first starts to rotate. The values in the table are maximum values.

Table 095-3

Load	No load
HPF speed reducer surface temperature	25°C

*4: Backdriving torque is the torque value applied to the output side at which the input first starts to rotate.The values in the table are maximum values.

Note: Never rely on these values as a margin in a system that must hold an external load. A brake must be used where back driving is not permissible.

Table 095-4

Load	No load
HPF speed reducer surface temperature	25°C

*5: No-load running torque is the torque required at the input to operate the gearhead at a given speed under a no-load condition. The values in the table are average values.

Table 095-5

Input speed	3000 rpm
Load	No load
HPF speed reducer surface temperature	25°C

Backlash and Torsional Stiffness

Table 096-1

■ HPF Hollow Shaft Unit

Size	Reduction Ratio	Backlash		Torsion angle at TR X 0.15 D		Torsional stiffness A/B	
		arc min	×10⁻⁴rad	arc min	×10⁻⁴rad	kgfm/arc min	×100Nm/rad
25	11	3.0	8.7	2.0	5.8	1.7	570
32	11	3.0	8.7	1.7	4.9	3.5	1173

Torsional stiffness curve

With the input of the gear locked in place, a torque applied to the output flange will torsionally deflect in proportion to the applied torque. We generate a torsional stiffness curve by slowly applying torque to the output in the following sequence:

(1) Clockwise torque to T_R, (2) Return to Zero, (3) Counter-Clockwise torque to $-T_R$, (4) Return to Zero and (5) again Clockwise torque to T_R.

A loop of (1) > (2) > (3) > (4) > (5) will be drawn as in Fig. 096-1.

The torsional stiffness in the region from "0.15 x T_R" to "T_R" is calculated using the average value of this slope. The torsional stiffness in the region from "zero torque" to "0.15 x T_R" is lower. This is caused by the small amount of backlash plus engagement of the mating parts and loading of the planet gears under the initial torque applied.

Calculation of total torsion angle

The method to calculate the total torsion angle (average value) on one side when the speed reducer applies a load in a no-load state.

Formula 096-1

● Calculation formula

$$\theta = D + \frac{T - T_L}{\frac{A}{B}}$$

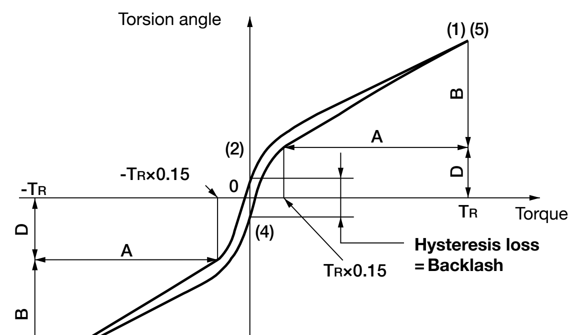
θ	Total torsion angle	——
D	Torsion angle on one side at output torque x 0.15 torque	See Fig. 096-1, Table 096-1
T	Load torque	——
T_L	Output torque x 0.15 torque (=T_RX0.15)	See Fig. 096-1
A/B	Torsional stiffness	See Fig. 096-1, Table 096-1

Backlash (Hysteresis Loss)

The vertical distance between points (2) & (4) in Fig. 096-1 is called a hysteresis loss. The hysteresis loss between "Clockwise load torque T_R" and "Counter Clockwise load torque $-T_R$" is defined as the backlash of the HPF series. The backlash of the HPF series is less than 3 arc-min (1 arc-min or less is also available.).

Figure 096-1

Torque-torsion angle diagram



T_R: Rated output torque
A/B: Torsional stiffness
D: Torsion on one side at T_RX0.15

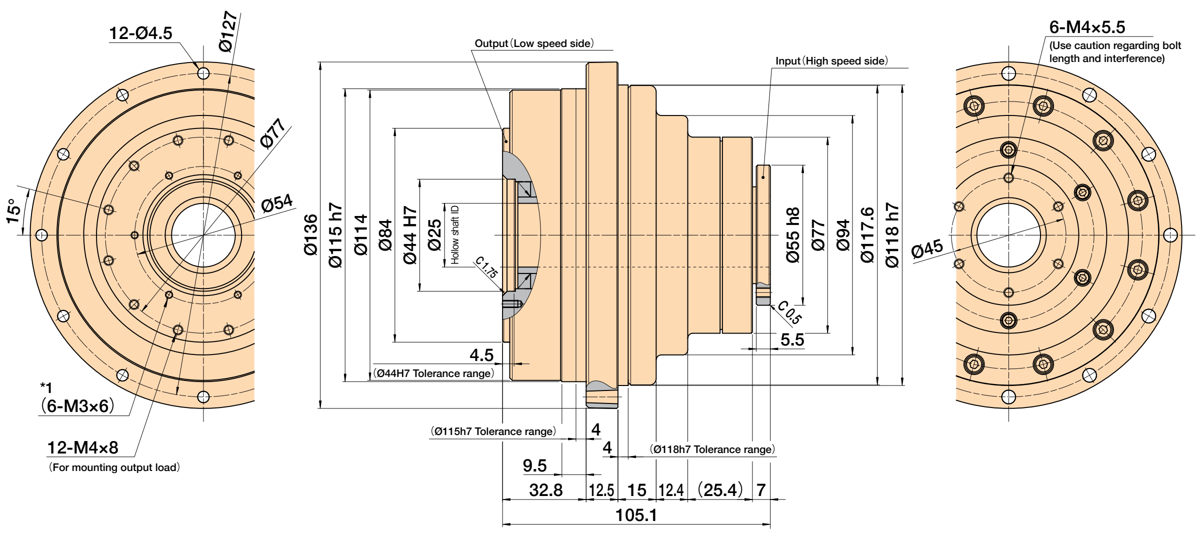
Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.
For the specifications of the input side bearing of the hollow shaft gear unit, refer to page 133.

HPF-25 Outline Dimensions

Figure 097-1

(Unit: mm)

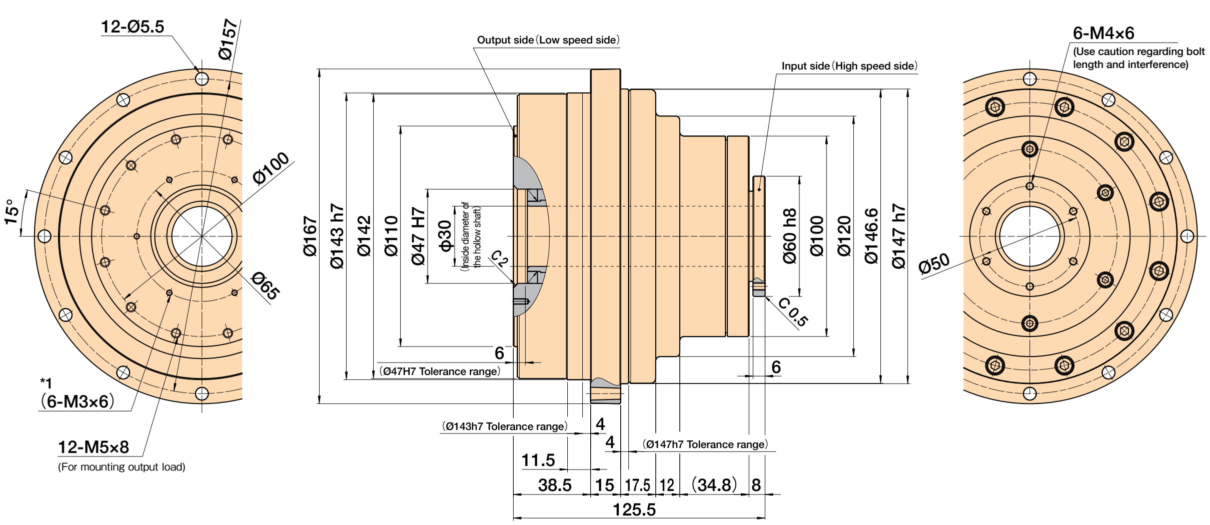


(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.
*1: The inside diameter of the hollow shaft rotates with the input shaft (high speed). Use these holes for installing a sleeve which rotates with the output side.
(These holes are not for mounting the load).

HPF-32 Outline Dimensions

Figure 097-2

(Unit: mm)



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.
*1: The inside diameter of the hollow shaft rotates with the input shaft (high speed). Use these holes for installing a sleeve which rotates with the output side.
(These holes are not for mounting the load).

Product Sizing & Selection

To fully utilize the excellent performance of the HPF HarmonicPlanetary® gearheads, check your operating conditions and, using the flowchart, select the appropriate size gear for your application.

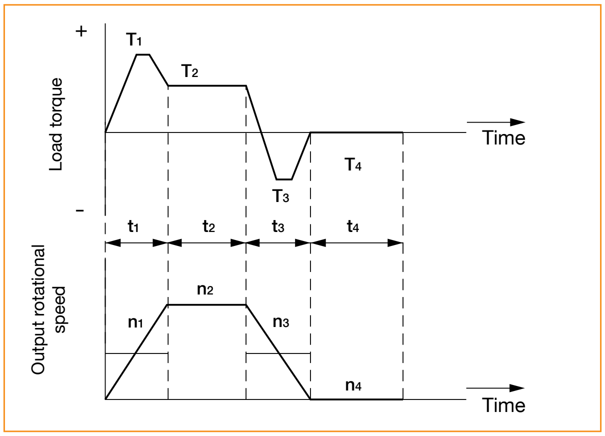
In general, a servo system rarely operates at a continuous load and speed. The input speed, load torque change and a comparatively large torque is applied during start and stop. Unexpected impact torques may also be applied.

Check your operating conditions against the following load torque pattern and select a suitable size based on the flowchart shown on the right. Also check the life and static safety coefficient of the cross roller bearing and input side main bearing (input shaft type only).

Checking the load torque pattern

Review the load torque pattern. Check the specifications shown in the figure below.

Graph 098-1



Obtain the value of each load torque pattern.

Load torque	T_1 to T_n (Nm)
Time	t_1 to t_n (sec)
Output rotational speed	n_1 to n_n (rpm)

<Normal operation pattern>

Starting	T_1, t_1, n_1
Steady operation	T_2, t_2, n_2
Stopping (slowing)	T_3, t_3, n_3
Idle	T_4, t_4, n_4

<Maximum rotational speed>

Max. output rotational speed	$n_{o\,max} \geqq n_1$ to n_n
Max. input rotational speed	$n_{i\,max}$ $n_1 \times R$ to $n_n \times R$
(Restricted by motors)	R: Reduction ratio

<Impact torque>

When impact torque is applied	T_s

<Required life>

L_{10} = L (hours)

Flowchart for selecting a size

Please use the flowchart shown below for selecting a size. Operating conditions must not exceed the performance ratings.

Calculate the average load torque applied on the output side from the load torque pattern: T_{av} (Nm).

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

Calculate the average output speed based on the load torque pattern: no av (rpm)

$$n_{o\,av} = \frac{|n_1| \cdot t_1 + |n_2 \cdot t_2 + \cdots + |n_n| \cdot t_n}{t_1 + t_2 + \cdots + t_n}$$

▼

Make a preliminary model selection with the following condition: $T_{av} \leqq$ Average load torque (Refer to rating table). — NG

OK ▼

Determine the reduction ratio (R) based on the maximum output rotational speed (no *max*) and maximum input rotational speed (ni *max*).

$$\frac{n_{i\,max}}{n_{o\,max}} \geqq R$$

(A limit is placed on ni *max* by motors.)
Calculate the maximum input speed (ni *max*) from the maximum output speed (no *max*) and the reduction ratio (R).

$$n_{i\,max} = n_{o\,max} \cdot R$$

▼

Calculate the average input speed (ni *av*) from the average output speed (no *av*) and the reduction ratio (R): $n_{i\,av} = n_{o\,av} \cdot R \leqq$ Max. average input speed (nr). — NG

OK ▼

Check whether the maximum input speed is equal to or less than the values in the rating table.
$n_{i\,max} \leqq$ maximum input speed (rpm) — NG

OK ▼

Check whether T1 and T3 are within peak torques (Nm) on start and stop in the rating table. — NG

OK ▼

Check whether T_s is equal to or less than the momentary max. torque (Nm) value from the ratings. — NG

OK ▼

Calculate the lifetime and check whether it meets the specification requirement.
Tr: Output torque
n_r: Max. average input speed

$$L_{10} = 20{,}000 \cdot \left(\frac{T_r}{T_{av}}\right)^{10/3} \cdot \left(\frac{n_r}{n_{i\,av}}\right) \text{ (Hour)}$$

— NG

OK ▼

The model number is confirmed.

Refer to the Caution note below.

Review the operation conditions, size and reduction ratio.

Caution

If the expected operation will result in conditions where;
i) Actual average load torque (Tav) > Permissible maximum value of average load torque or
ii) Actual average input rotational speed (ni av) > Permissible average input rotational speed (nr),
then please check its effect on the speed reducer temperature rise or other factors. Consider selecting the next larger speed reducer, reduce the operating loads or take other means to ensure safe use of the gear. Exercise caution especially when the duty cycle is close to continuous operation.

HPF Series HarmonicPlanetary® Hollow Shaft Gear Unit

Example of model number Selection

Value of each load torque pattern.

Load torque	T_n (Nm)
Time	t_n (sec)
Output rotational speed	n_n (rpm)

<Normal operation pattern>

Starting	T_1 = 70 Nm,	t_1 = 0.3 sec,	n_1 = 60 rpm
Steady operation	T_2 = 18 Nm,	t_2 = 3 sec,	n_2 = 120 rpm
Stopping (slowing)	T_3 = 35 Nm,	t_3 = 0.4 sec,	n_3 = 60 rpm
Idle	T_4 = 0 Nm,	t_4 = 5 sec,	n_4 = 0 rpm

<Maximum rotational speed>

Max. output rotational speed	no *max* = 120 rpm
Max. input rotational speed	ni *max* = 5,000 rpm (Restricted by motors)

<Impact torque>

When impact torque is applied T_s = 120 Nm

<Required life>

L_{10} = 30,000 (hours)

Calculate the average load torque applied to the output side based on the load torque pattern: T*av* (Nm).

$$T_{av} = \sqrt[10/3]{\frac{|60rpm|\cdot 0.3sec \cdot |70Nm|^{10/3} + |120rpm|\cdot 3sec \cdot |18Nm|^{10/3} + |60rpm|\cdot 0.4sec \cdot |35Nm|^{10/3}}{|60rpm|\cdot 0.3sec + |120rpm|\cdot 3sec + |60rpm|\cdot 0.4sec}}$$

Calculate the average output speed based on the load torque pattern: no *av* (rpm)

$$n_{o\,av} = \frac{|60rpm|\cdot 0.3sec + |120rpm|\cdot 3sec + |60rpm|\cdot 0.4sec + |0rpm|\cdot 5sec}{0.3sec + 3sec + 0.4sec + 5sec}$$

▼

Make a preliminary model selection with the following conditions. T *av* = 30.2 Nm ≦ 48 Nm. (**HPF-25A-11** is tentatively selected based on the average load torque (see the rating table on page 95) of size 25 and reduction ratio of 11.) — NG

OK ▼

Determine a reduction ratio (R) from the maximum output speed (no *max*) and maximum input speed (ni *max*).

$$\frac{5{,}000\ rpm}{120\ rpm} = 41.7 \geqq 11$$

Calculate the maximum input speed (ni *max*) from the maximum output speed (no *max*) and reduction ratio (R): ni *max* = 120 rpm・11 = 1,320 rpm

▼

Calculate the average input speed (ni *av*) from the average output speed (no *av*) and reduction ratio (R):
ni *av* = 46.2 rpm・11= 508 rpm ≦ Max average input speed of size 25 3,000 rpm — NG

OK ▼

Check whether the maximum input speed is equal to or less than the values specified in the rating table.
ni *max* = 1,320 rpm ≦ 5,600 rpm (maximum input speed of size 25) — NG

OK ▼

Check whether T_1 and T_3 are within peak torques (Nm) on start and stop in the rating table.
T_1 = 70 Nm ≦ 100 Nm (Limit for repeated peak torque, size 25)
T_3 = 35 Nm ≦ 100 Nm (Limit for repeated peak torque, size 25) — NG

OK ▼

Check whether Ts is equal to or less than limit for momentary torque (Nm) in the rating table.
T_s = 120 Nm ≦ 170 Nm (momentary max. torque of size 25) — NG

OK ▼

Calculate life and check whether the calculated life meets the requirement.

$$L_{10} = 20{,}000 \cdot \left(\frac{21\ Nm}{30.2\ Nm}\right)^{10/3} \cdot \left(\frac{3{,}000\ rpm}{508\ rpm}\right) = 35{,}182\ (hours) \geqq 30{,}000\ (hours)$$

— NG

OK ▼

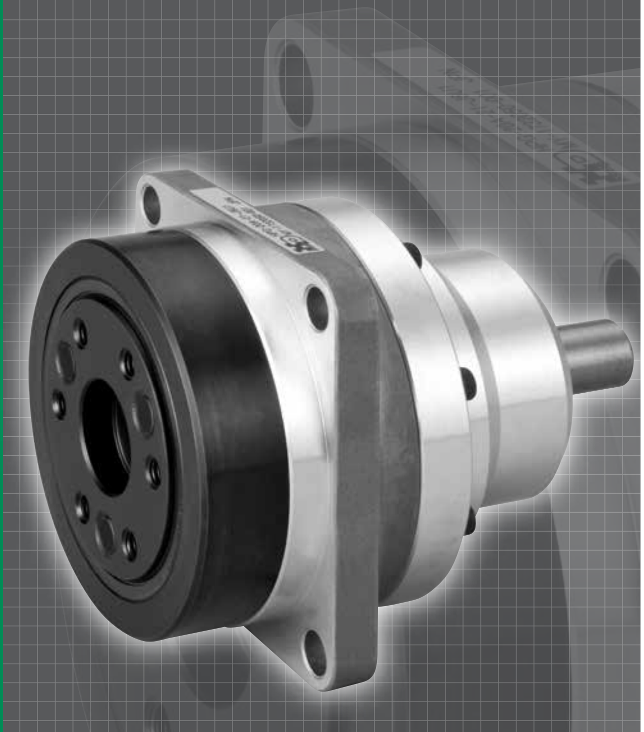
The selection of model number HPF-25A-11 is confirmed from the above calculations.

Refer to the Caution note at the bottom of page 98.

Review the operation conditions, size and reduction ratio.

HarmonicPlanetary®

HPG Input Shaft



Size

6 Sizes

11, 14, 20, 32, 50, 65

Peak torque

3.9Nm – 2200Nm

Reduction ratio

Single Stage: 3:1 to 9:1, Two Stage: 11:1 to 50:1

High efficiency

Up to 97%

Low backlash

Standard: <3 arc-min Optional: <1 arc-min

Low Backlash for Life

Innovative ring gear automatically adjusts for backlash, ensuring consistent, low backlash for the life of the gearhead. The ring gear design automatically provides the optimum backlash in the planetary gear train and maintains the same low backlash for the life of the gearhead.

High Load Capacity Output Bearing

A Cross Roller bearing is integrated with the output flange to provide high moment stiffness, high load capacity and precise positioning accuracy.

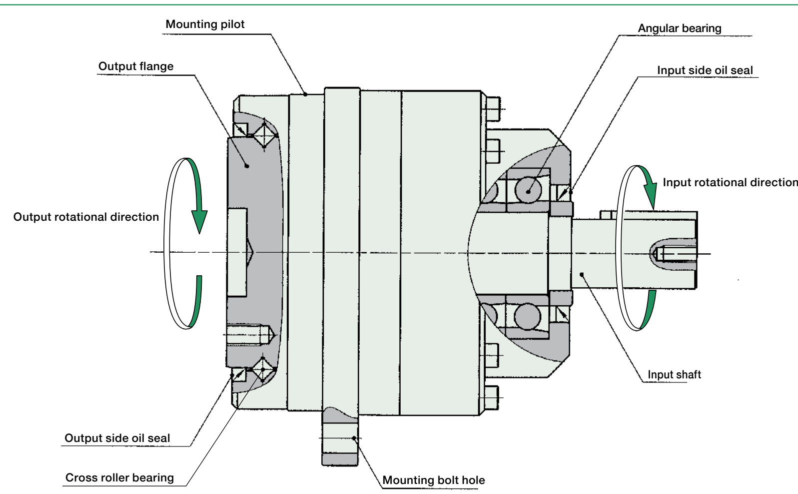
CONTENTS

HPG - 20 A - 05 - BL3 - J2 U1 - SP1

Model Name	Size	Design Revision	Reduction Ratio	Backlash	Output Configuration	Input Configuration	Options
HarmonicPlanetary® HPG Input Shaft	11	B	5, 9, 21, 37, 45	BL1: Backlash less than 1 arc-min (Sizes 14 to 65) BL3: Backlash less than 3 arc-min	F0: Flange output J20: Shaft output without key J60: Shaft output with key and center tapped hole	U1: Input shaft (with key; no center tapped hole)	None: Standard item SP: Special specification
	14	A	3, 5, 11, 15, 21, 33, 45		F0: Flange output J2: Shaft output without key J6: Shaft output with key and center tapped hole (J2, J6 for Size 65 is also available)	U1: Input shaft (with key and center tapped hole)	
	20						
	32						
	50						
	65		4, 5, 12, 15, 20, 25, 40, 50				

Gearhead Construction

Figure 100-1



HPG Series HarmonicPlanetary® Input Shaft Gear Unit

Rating Table

Table 101-1

Size	Ratio	Rated Torque*1	Limit for Average Torque*2	Limit for Repeated Peak Torque*3	Limit for Momentary Torque*4	Max. Average Input Speed*5	Max. Input Speed*6	Input Moment of Inertia*7		Mass*8	
								Shaft	Flange	Shaft	Flange
		Nm	Nm	Nm	Nm	rpm	rpm	$\times10^{-4}$kgm^2	$\times10^{-4}$kgm^2	kg	kg
11	5	2.5	5.0	7.8	20	3000	10000	0.0087	0.0072	0.24	0.20
	9	2.5	3.9	3.9				0.0063	0.0058		
	21	3.4	6.0	9.8				0.0064	0.0063	0.30	0.26
	37	3.4						0.0052	0.0052		
	45	3.4						0.0050	0.0050		
14	3	2.9	6.4	15	37	3000	5000	0.12	0.11	0.80	0.70
	5	5.9	13	23	56		6000	0.073	0.067		
	11	7.8	15					0.059	0.058	0.90	0.80
	15	9.0						0.057	0.056		
	21	8.8						0.049	0.049		
	33	10						0.043	0.043		
	45	10									
20	3	8.8	19	64	124	3000	4000	0.80	0.69	2.4	2.0
	5	16	35	100	217		6000	0.44	0.40		
	11	20	45					0.32	0.31	2.7	2.1
	15	24	53					0.30	0.30		
	21	25	55					0.23	0.23		
	33	29	60					0.19	0.19		
	45	29						0.18	0.18		
32	3	31	71	225	507	3000	3600	4.2	3.4	6.3	4.9
	5	66	150	300	650		6000	2.4	2.2		
	11	88	170					2.0	1.9	6.9	5.3
	15	92						1.8	1.8		
	21	98						1.5	1.5		
	33	108	200					1.3	1.3		
	45	108									
50	3	97	195	657	1200	2000	3000	21	18	17	14
	5	170	340	850	1850		4500	11	9.2		
	11	200	400					7.4	7.1	19	16
	15	230	450					6.8	6.7		
	21	260	500					5.5	5.4		
	33	270						4.4	4.3		
	45	270						4.3	4.3		
65*9	4	500	900	2200	4500	2000	2500	58	44	43	33
	5	530	1000				3000	43	34		
	12	600	1100					33	32	58	48
	15	730	1300					32	31		
	20	800	1500					22	21		
	25	850						21	21		
	40	640	1300	1900				16	16		
	50	750	1500	2200				16	16		

*1: Rated torque is based on L_{10} life of 20,000 hours at rated input speed.
*2: Maximum value of average load torque is based on the load torque pattern. Note that exceeding this value may deteriorate the life or durability of the product.
*3 The limit for torque during start and stop cycles.
*4: The limit for torque during emergency stops or from external shock loads. Always operate below this value. Calculate the number of permissible events to ensure it meets required operating conditions.
*5: Maximum average input speed is limited by heat generation in the speed reducer assuming a continuous operating speed or the average input speed of a motion profile. The actual limit for average input speed depends on the operating environment.
*6: Maximum instantaneous input speed.
*7: Inertia value is for the gearhead only (without input shaft coupling). Please contact us for the inertia of your specific configuration.
*8: The mass is for the gearhead only (without input shaft coupling & motor flange). Please contact us for the mass of your specific configuration.
*9: Flange output is standard for the size 65 gearhead. Shaft type (J2 & J6) is also available.

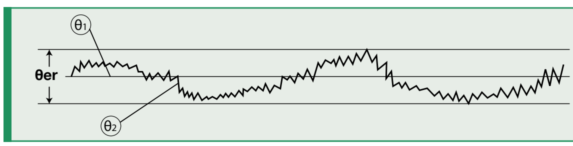
Performance Table

Table 102-1

Model	Reduction Ratio	Accuracy *1		Repeatability *2	Starting torque *3		Backdriving torque *4		No-load running torque *5	
		arc min	×10⁻⁴rad	arc sec	Ncm	kgfcm	Nm	kgfm	Ncm	kgfcm
11	5	5	14.5	±30	7.9	0.81	0.40	0.040	8.9	0.91
	9				7.6	0.77	0.68	0.069	6.3	0.65
	21				6.8	0.69	1.4	0.14	5.2	0.53
	37				5.5	0.57	2.0	0.21	4.8	0.49
	45				5.3	0.55	2.4	0.25	4.7	0.48
14	3	4	11.6	±20	22	2.2	0.66	0.067	26	2.7
	5				17	1.7	0.83	0.085	15	1.5
	11				16	1.6	1.8	0.18	10	1.0
	15				15		2.3	0.23	8.2	0.84
	21				13	1.4	2.9	0.30		
	33				11	1.2	3.8	0.39	7.3	0.74
	45					1.1	4.8	0.49		
20	3	4	11.6	±15	46	4.7	1.4	0.14	61	6.2
	5				34	3.4	1.7	0.17	39	4.0
	11				30	3.1	3.3	0.34	26	2.6
	15				27	2.8	4.0	0.41	22	2.2
	21				24	2.5	5.1	0.52	20	2.0
	33				21	2.2	7.1	0.72	17	1.7
	45				20	2.0	8.9	0.91	16	1.6
32	3	4	11.6	±15	92	9.4	2.8	0.28	146	15
	5				69	7.1	3.5	0.35	100	10
	11				63	6.4	6.9	0.70	66	6.8
	15				61	6.2	9.1	0.93	57	5.9
	21				58	6.0	12	1.3	52	5.3
	33				52	5.3	17	1.7	42	4.3
	45				46	4.8	21	2.1	41	4.2
50	3	3	8.7	±15	197	20	5.9	0.60	300	31
	5				140	14	7.0	0.71	180	18
	11				110	11	12	1.2	110	11
	15				100	10	15	1.5	97	9.9
	21				98		21	2.1	90	9.2
	33				88	8.9	29	3.0	74	7.6
	45				83	8.4	37	3.8	70	7.1
65	4	3	8.7	±15	406	41	16	1.7	576	59
	5				358	36	18	1.8	517	53
	12				243	25	29	3.0	341	35
	15				228	23	34	3.5	311	32
	20				213	22	43	4.3	282	29
	25				202	21	51	5.2	262	27
	40				193	20	77	7.9	230	24
	50				188	19	94	9.6	219	22

*1: Accuracy values represent the difference between the theoretical angle and the actual angle of output for any given input. The values in the table are maximum values.

Figure 102-1

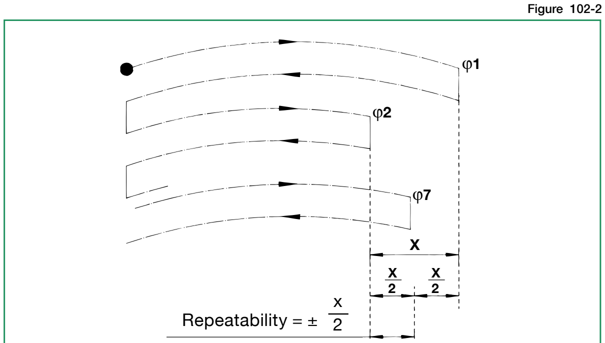


θer : Accuracy
θ1 : Input angle
θ2 : Actual output angle
R : Reduction ratio

$$\theta er = \theta_2 - \frac{\theta_1}{R}$$

*2: The repeatability is measured by moving to a given theoretical position seven times, each time approaching from the same direction. The actual position of the output shaft is measured each time and repeatability is calculated as the 1/2 of the maximum difference of the seven data points. Measured values are indicated in angles (arc-sec) prefixed with "±". The values in the table are maximum values.

Figure 102-2



*3: Starting torque is the torque value applied to the input side at which the output first starts to rotate. The values in the table are maximum values.

Table 102-2

Load	No load
HPG speed reducer surface temperature	25°C

*4: Backdriving torque is the torque value applied to the output side at which the input first starts to rotate. The values in the table are maximum values.

Note: Never rely on these values as a margin in a system that must hold an external load. A brake must be used where back driving is not permissible.

Table 102-3

Load	No load
HPG speed reducer surface temperature	25°C

*5: No-load running torque is the torque required at the input to operate the gearhead at a given speed under a no-load condition. The values in the table are average values.

Table 102-4

Input speed	3000 rpm
Load	No load
HPG speed reducer surface temperature	25°C

Backlash and Torsional Stiffness

Table 103-1

■ Input Shaft Gear Unit - Standard backlash (BL3) (≤ 3 arc-min)

Size	Ratio	Backlash		Torsion angle on one side at TR X 0.15 (D)		Torsional stiffness (A/B)	
		arc min	×10⁻⁴rad	arc min	×10⁻⁴rad	kgfm/arc min	×100Nm/rad
11	5, 9	3.0	8.7	2.5	7.3	0.060	20
	21, 37, 45			3.0	8.7	0.065	22
14	3, 5	3.0	8.7	2.2	6.4	0.13	44
	11, 15, 21, 33, 45			2.7	7.9	0.14	47
20	3, 5	3.0	8.7	1.5	4.4	0.50	170
	11, 15, 21, 33, 45			2.0	5.8	0.55	180
32	3	3.0	8.7	1.3	3.8	1.7	570
	5					2.0	670
	11, 15, 21, 33, 45			1.7	4.9	2.2	740
50	3	3.0	8.7	1.3	3.8	8.4	2800
	5					11	3700
	11, 15, 21, 33, 45			1.7	4.9	14	4700
65	4, 5	3.0	8.7	1.3	3.8	30	10000
	12, 15, 20, 25, 40, 50			1.7	4.9	37	12500

Table 103-2

■ Input Shaft Gear Unit - Reduced backlash (BL1) (≤ 1 arc-min)

Size	Ratio	Backlash		Torsion angle on one side at TR X 0.15 (D)		Torsional stiffness (A/B)	
		arc min	×10⁻⁴rad	arc min	×10⁻⁴rad	kgfm/arc min	×100Nm/rad
11	not available						
14	3, 5	1.0	2.9	1.1	3.2	0.13	44
	9, 21, 33, 45			1.7	4.9	0.14	47
20	3, 5	1.0	2.9	0.6	1.7	0.50	170
	11, 15, 21, 33, 45			1.1	3.2	0.55	180
32	3	1.0	2.9	0.5	1.5	1.7	570
	5					2.0	670
	11, 15, 21, 33, 45			1.0	2.9	2.2	740
50	3	1.0	2.9	0.5	1.5	8.4	2800
	5					11	3700
	11, 15, 21, 33, 45			1.0	2.9	14	4700
65	4, 5	1.0	2.9	0.5	1.5	30	10000
	12, 15, 20, 25, 40, 50			1.0	2.9	37	12500

Torsional stiffness curve

With the input of the gear locked in place, a torque applied to the output flange will torsionally deflect in proportion to the applied torque. We generate a torsional stiffness curve by slowly applying torque to the output in the following sequence:
(1) Clockwise torque to T_R, (2) Return to Zero, (3) Counter-Clockwise torque to $-T_R$, (4) Return to Zero and (5) again Clockwise torque to T_R.
A loop of (1) > (2) > (3) > (4) > (5) will be drawn as in Fig. 103-1.
The torsional stiffness in the region from "0.15 x T_R" to "T_R" is calculated using the average value of this slope. The torsional stiffness in the region from "zero torque" to "0.15 x T_R" is lower. This is caused by the small amount of backlash plus engagement of the mating parts and loading of the planet gears under the initial torque applied.

Calculation of total torsion angle

The method to calculate the total torsion angle (average value) on one side when the speed reducer applies a load in a no-load state.

Formula 103-1

● Calculation formula

$$\theta = D + \frac{T - T_L}{\frac{A}{B}}$$

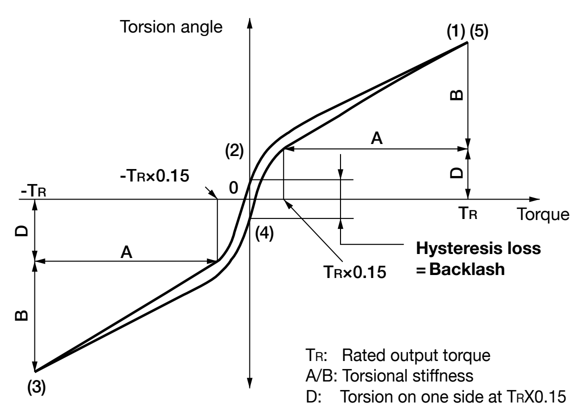
θ	Total torsion angle	–
D	Torsion angle on one side at output torque x 0.15 torque	See Fig. 103-1, Table 103-1 to 2
T	Load torque	–
T_L	Output torque x 0.15 torque (=TRX0.15)	See Fig. 103-1
A/B	Torsional stiffness	See Fig. 103-1, Table 103-1 to 2

Backlash (Hysteresis loss)

The vertical distance between points (2) & (4) in Fig. 103-1 is called a hysteresis loss. The hysteresis loss between "Clockwise load torque T_R" and "Counter Clockwise load torque $-T_R$" is defined as the backlash of the HPG series. The backlash of the HPG series is less than 3 arc-min (1 arc-min or less for a custom product).

Figure 103-1

Torque-torsion angle diagram



Outline Dimensions

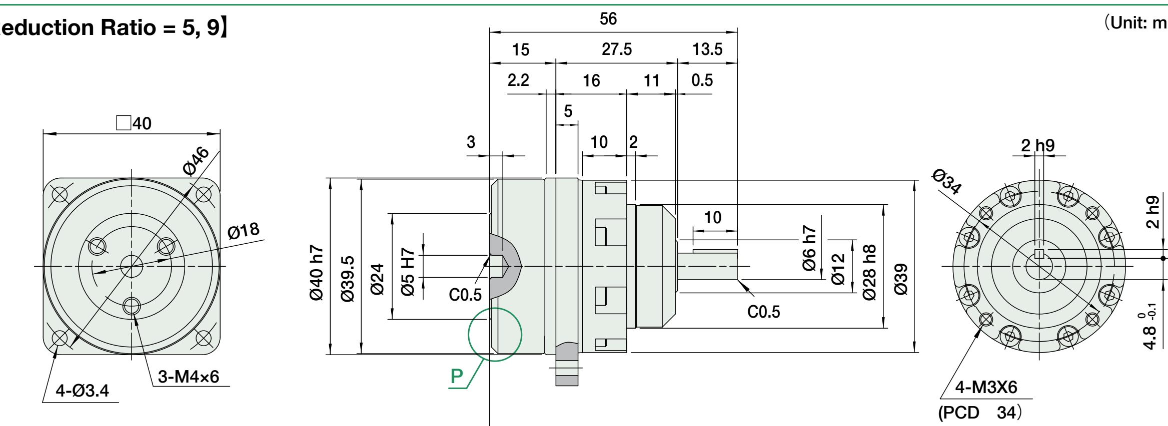
Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.
For the specifications of the input side bearing refer to page 133.

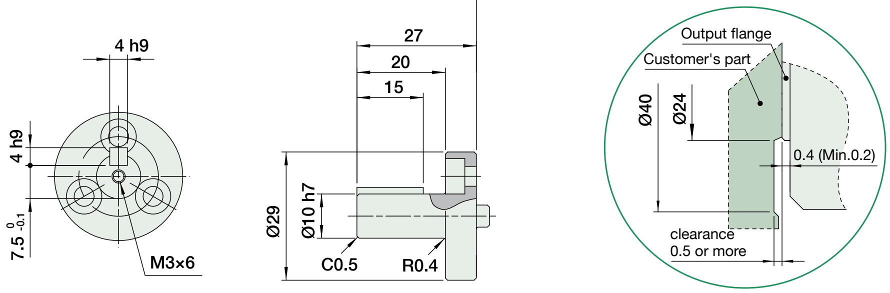
HPG-11 Outline Dimensions

Figure 104-1

【Reduction Ratio = 5, 9】

(Unit: mm)





Detail P

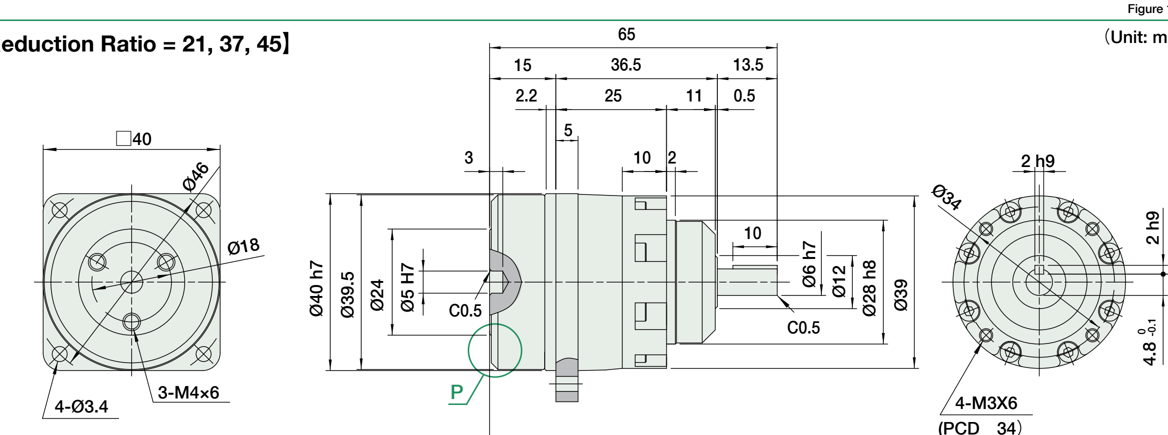
Recommended clearance dimension for customer's part mounted to the output flange
(Note)
When using a gearhead with an output flange, it is recommended for the customer to design clearance between the part mounted on the output flange and the housing face as shown in the figure on the left.
The clearance is needed because the distance between the output flange and the oil seal (non-rotating) is small (min. 0.2mm).

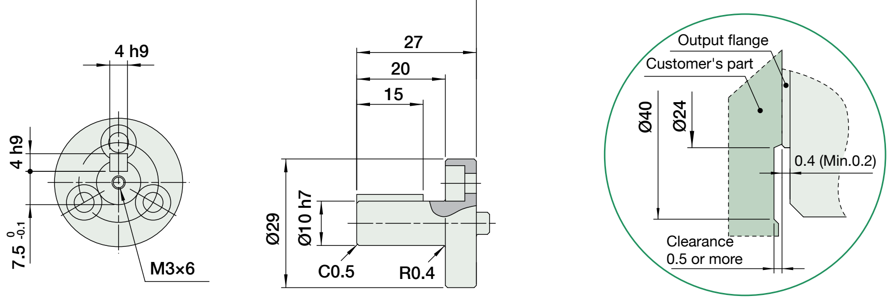
(Note) The dimension tolerances that are not specified vary depending on the manufacturing method.
Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

Figure 104-2

【Reduction Ratio = 21, 37, 45】

(Unit: mm)





Detail P

Recommended clearance dimension for customer's part mounted to the output flange
(Note)
When using a gearhead with an output flange, it is recommended for the customer to design clearance between the part mounted on the output flange and the housing face as shown in the figure on the left.
The clearance is needed because the distance between the output flange and the oil seal (non-rotating) is small (min. 0.2mm).

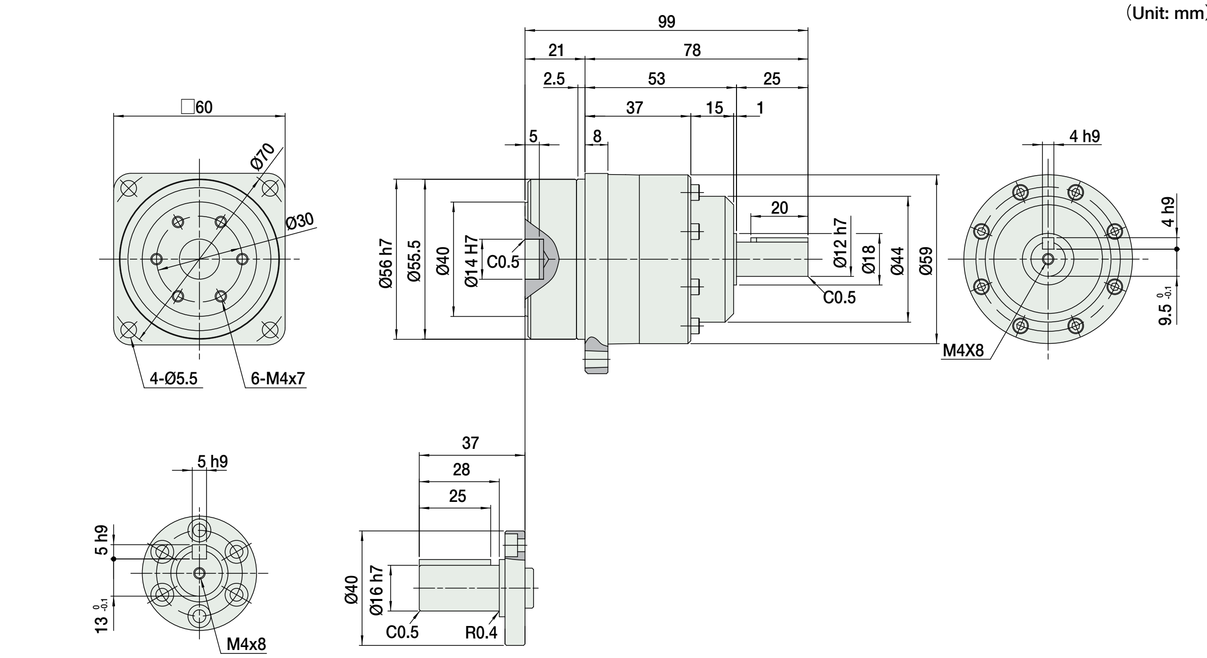
(Note) The dimension tolerances that are not specified vary depending on the manufacturing method.
Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.
For the specifications of the input side bearing, refer to page 133.

HPG-14 Outline Dimensions

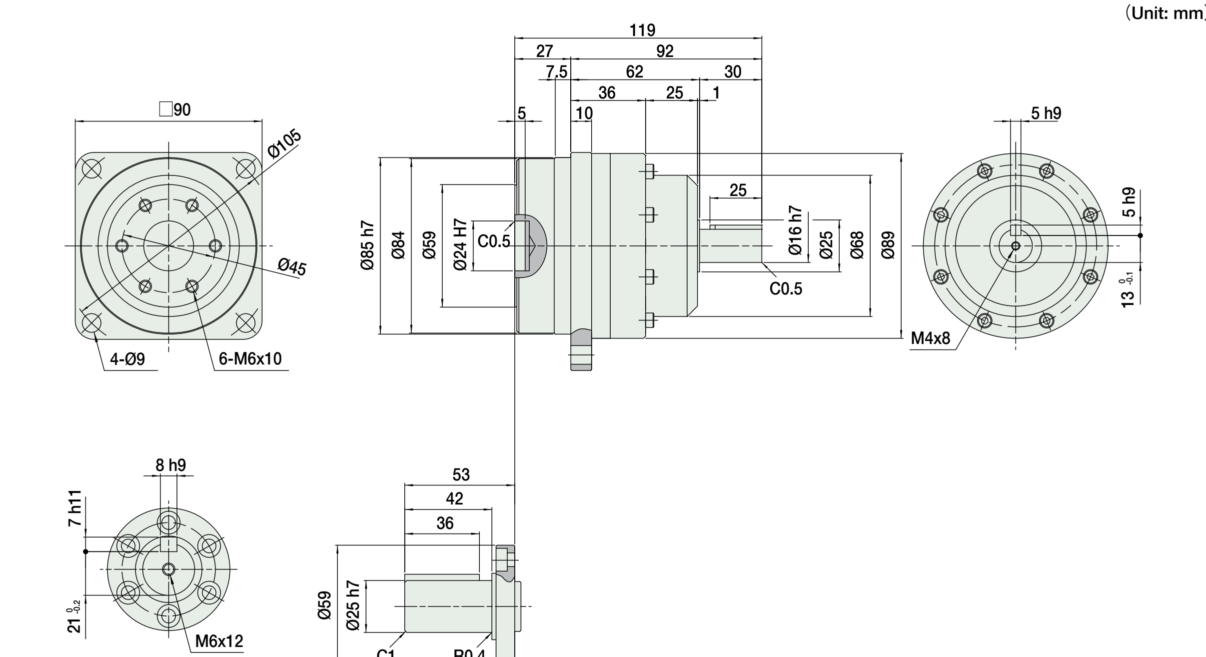
Figure 105-1



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method.
Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

HPG-20 Outline Dimensions

Figure 105-2



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

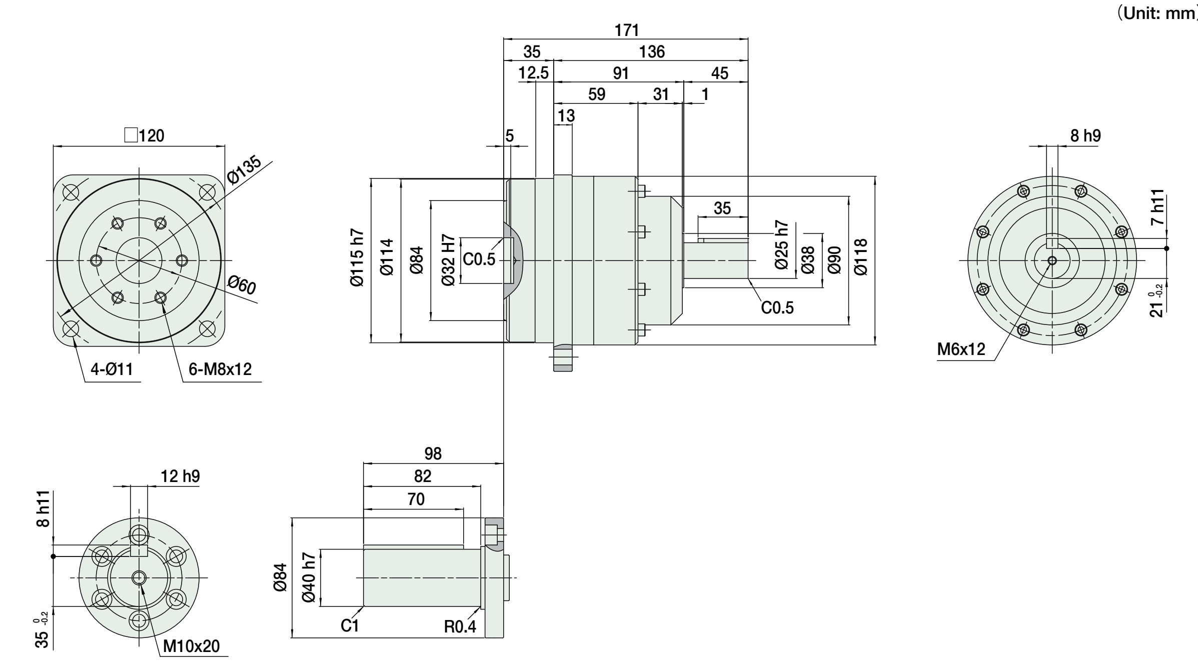
Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.
For the specifications of the input side bearing, refer to page 133.

HPG-32 Outline Dimensions

Figure 106-1

(Unit: mm)

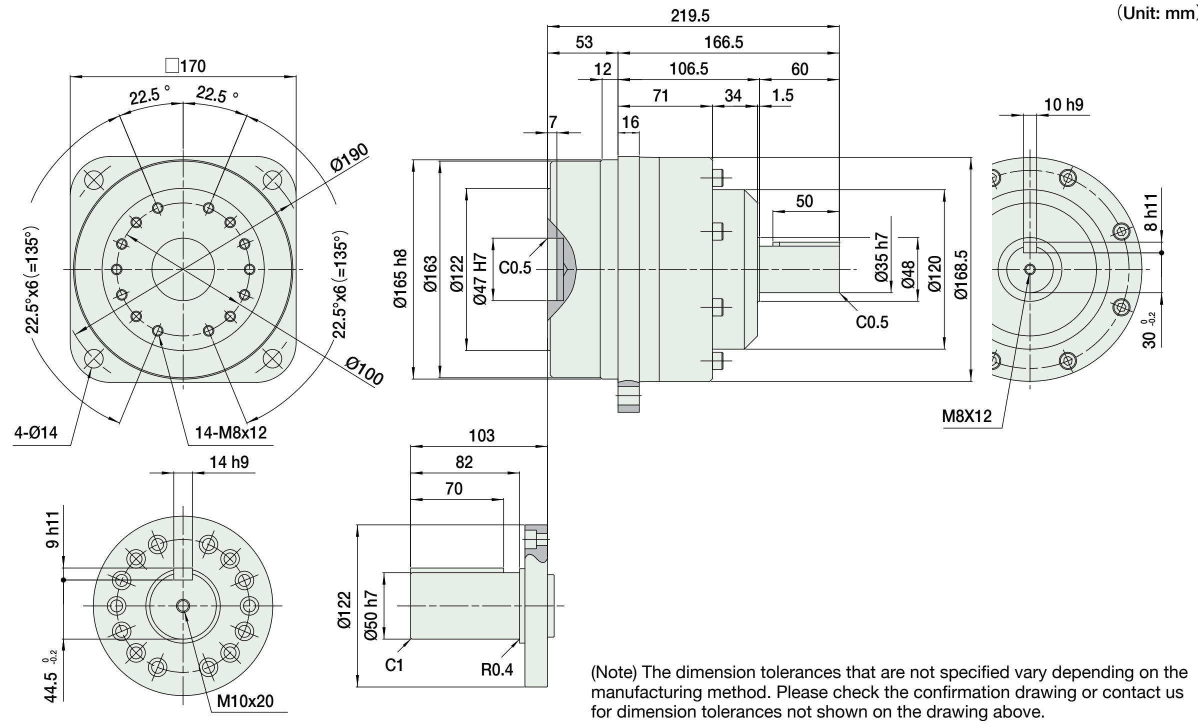


(Note) The dimension tolerances that are not specified vary depending on the manufacturing method.
Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

HPG-50 Outline Dimensions

Figure 106-2

(Unit: mm)



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

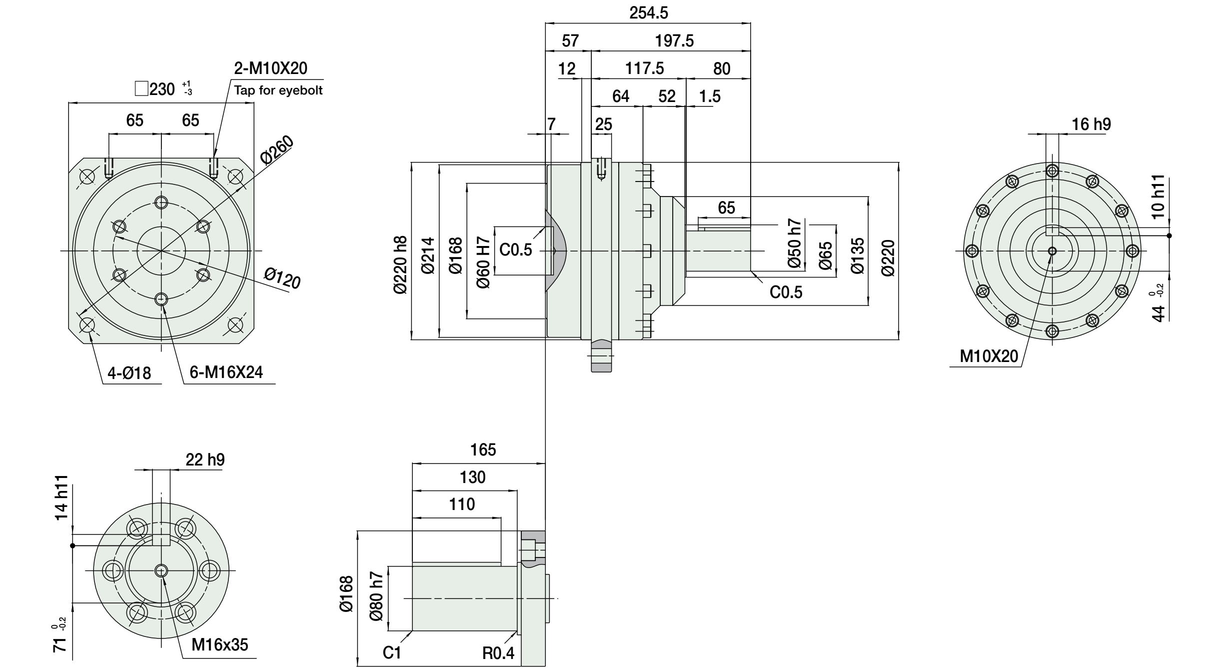
Outline Dimensions

Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.
For the specifications of the input side bearing, refer to page 133.

HPG-65 Outline Dimensions

Figure 107-1

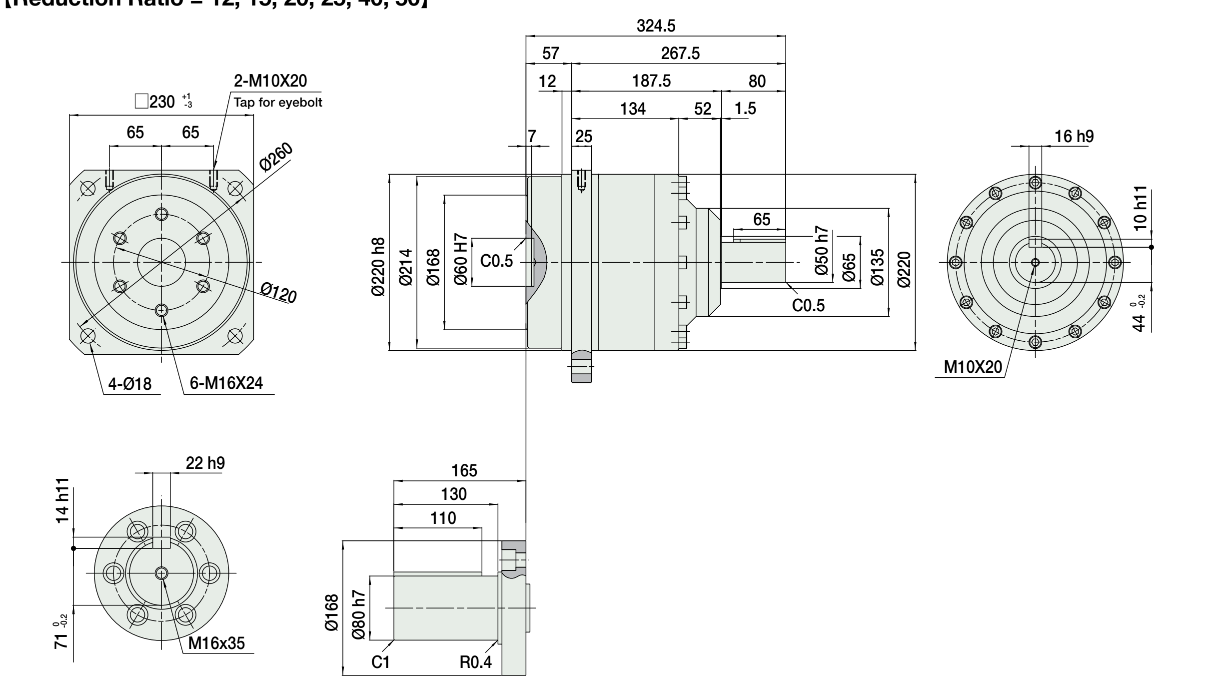
【Reduction Ratio = 4, 5】 (Unit: mm)



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method.
Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

Figure 107-2

【Reduction Ratio = 12, 15, 20, 25, 40, 50】 (Unit: mm)



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method.
Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

Product Sizing & Selection

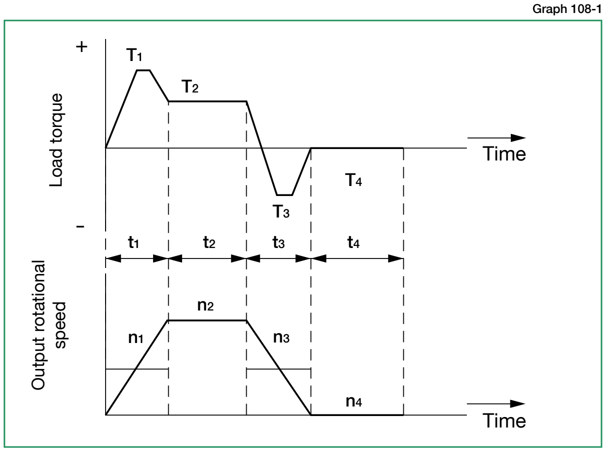
To fully utilize the excellent performance of the HPG HarmonicPlanetary® gearheads, check your operating conditions and, using the flowchart, select the appropriate size gear for your application.

In general, a servo system rarely operates at a continuous load and speed. The input speed, load torque change and a comparatively large torque is applied during start and stop. Unexpected impact torques may also be applied.
Check your operating conditions against the following load torque pattern and select a suitable size based on the flowchart shown on the right. Also check the life and static safety coefficient of the cross roller bearing and input side main bearing (input shaft type only).

Checking the load torque pattern

Review the load torque pattern. Check the specifications shown in the figure below.

Graph 108-1



Obtain the value of each load torque pattern.

Load torque	T_1 to T_n (Nm)
Time	t_1 to t_n (sec)
Output rotational speed	n_1 to n_n (rpm)

<Normal operation pattern>

Starting	T_1, t_1, n_1
Steady operation	T_2, t_2, n_2
Stopping (slowing)	T_3, t_3, n_3
Idle	T_4, t_4, n_4

<Maximum rotational speed>

Max. output rotational speed	$n_{o\,max} \geqq n_1$ to n_n
Max. input rotational speed	$n_{i\,max}$ $n_1 \times R$ to $n_n \times R$
(Restricted by motors)	R: Reduction ratio

<Impact torque>

When impact torque is applied T_s

<Required life>

L_{10} = L (hours)

Flowchart for selecting a size

Please use the flowchart shown below for selecting a size. Operating conditions must not exceed the performance ratings.

Calculate the average load torque applied on the output side from the load torque pattern: T_{av} (Nm).

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

Calculate the average output speed based on the load torque pattern: no av (rpm)

$$n_{o\,av} = \frac{|n_1| \cdot t_1 + |n_2| \cdot t_2 + \cdots + |n_n| \cdot t_n}{t_1 + t_2 + \cdots + t_n}$$

Select a preliminary model number with the following condition: $T_{av} \leqq$ Average load torque (See the rating table on page 101) — NG

OK

Determine the reduction ratio (R) based on the maximum output speed (no *max*) and maximum input speed (ni *max*).

$$\frac{n_{i\,max}}{n_{o\,max}} \geqq R$$

(A limit is placed on ni *max* by motors.)
Calculate the maximum input speed (ni *max*) from the maximum output speed (no *max*) and the reduction ratio (R).

$$n_{i\,max} = n_{o\,max} \cdot R$$

Calculate the average input speed (ni *av*) from the average output speed (no *av*) and the reduction ratio (R): $n_{i\,av} = n_{o\,av} \cdot R \leqq$ Max. average input speed (n_r). — NG

Refer to the Caution note below.

OK

Check whether the maximum input speed is equal to or less than the values in the rating table.
$n_{i\,max} \leqq$ maximum input speed (rpm) — NG

OK

Check whether T_1 and T_3 are equal to or less than the limit for repeated peak torque (Nm) in the rating table. — NG

OK

Check whether T_s is equal to or less than the limit for momentary torque (Nm) in the rating table. — NG

OK

Calculate the lifetime and check whether it meets the specification requirement.
Tr: Output torque
n_r: Max. average input speed

$$L_{10} = 20{,}000 \cdot \left(\frac{T_r}{T_{av}}\right)^{10/3} \cdot \left(\frac{n_r}{n_{i\,av}}\right) \text{ (Hour)}$$

— NG

OK

The model number is confirmed.

Review the operation conditions, size and reduction ratio.

Caution

If the expected operation will result in conditions where;
i) Actual average load torque (Tav) > Limit for average torque or
ii) Actual average input rotational speed (ni av) > Maximum average input speed (nr),
then please check its effect on the speed reducer temperature rise or other factors. Consider selecting the next larger speed reducer, reduce the operating loads or take other means to ensure safe use of the gear. Exercise caution especially when the duty cycle is close to continuous operation.

Example of Model Number Selection

Value of each load torque pattern.

Load torque	T_n (Nm)
Time	t_n (sec)
Output rotational speed	n_n (rpm)

<Normal operation pattern>

Starting	T_1 = 70 Nm,	t_1 = 0.3 sec,	n_1 = 60 rpm
Steady operation	T_2 = 18 Nm,	t_2 = 3 sec,	n_2 = 120 rpm
Stopping (slowing)	T_3 = 35 Nm,	t_3 = 0.4 sec,	n_3 = 60 rpm
Idle	T_4 = 0 Nm,	t_4 = 5 sec,	n_4 = 0 rpm

<Maximum rotational speed>

Max. output rotational speed	no *max* = 120 rpm
Max. input rotational speed	ni *max* = 5,000 rpm (Restricted by motors)

<Impact torque>

When impact torque is applied T_s = 180 Nm

<Required lifespan>

L_{10} = 30,000 (hours)

Calculate the average load torque applied on the output side based on the load torque pattern: T*av* (Nm).

$$T_{av}=\sqrt[10/3]{\frac{|60\text{rpm}|\cdot 0.3\text{sec}\cdot|70\text{Nm}|^{10/3}+|120\text{rpm}|\cdot 3\text{sec}\cdot|18\text{Nm}|^{10/3}+|60\text{rpm}|\cdot 0.4\text{sec}\cdot|35\text{Nm}|^{10/3}}{|60\text{rpm}|\cdot 0.3\text{sec}+|120\text{rpm}|\cdot 3\text{sec}+|60\text{rpm}|\cdot 0.4\text{sec}}}$$

Calculate the average output speed based on the load torque pattern: no *av* (rpm)

$$n_{o\,av}=\frac{|60\text{rpm}|\cdot 0.3\text{sec}+|120\text{rpm}|\cdot 3\text{sec}+|60\text{rpm}|\cdot 0.4\text{sec}+|0\text{rpm}|\cdot 5\text{sec}}{0.3\text{sec}+3\text{sec}+0.4\text{sec}+5\text{sec}}$$

▼

Make a preliminary model selection with the following conditions. T*av* = 30.2Nm ≦ 60Nm. (**HPG-20A-33** is tentatively selected based on the average load torque (see the rating table on page 101) of model No. 20 and reduction ratio of 33.) — NG

OK

Determine a reduction ratio (R) from the maximum output speed (no *max*) and maximum input speed (ni *max*).

$$\frac{5{,}000\text{ rpm}}{120\text{ rpm}} = 41.7 \geqq 33$$

Calculate the maximum input speed (ni *max*) from the maximum output speed (no *max*) and reduction ratio (R): ni *max* = 120 rpm・33 = 3,960 rpm

▼

Calculate the average input rotational speed (ni *av*) from the average output speed (no *av*) and reduction ratio (R):
ni *av* = 46.2 rpm・33= 1,525 rpm ≦ Max. average input speed of size 20 3,000 (rpm) — NG

OK

Check whether the maximum input speed is equal to or less than the values specified in the rating table.
ni *max* = 3,960 rpm ≦ 6,000 rpm (maximum input rotational speed of size 20) — NG

OK

Check whether T_1 and T_3 are equal to or less than the peak torques (Nm) on start and stop in the rating table.
T_1 = 70 Nm ≦ 100 Nm (Limit for repeated torque, size 20)
T_3 = 35 Nm ≦ 100 Nm (Limit for repeated torque, size 20) — NG

OK

Check whether Ts is equal to or less than the values of the momentary max. torque (Nm) in the rating table.
T_s = 180 Nm ≦ 217 Nm (momentary max. torque of size 20) — NG

OK

Calculate life and check whether the calculated life meets the requirement.

$$L_{10} = 20{,}000\cdot\left(\frac{29\text{ Nm}}{30.2\text{ Nm}}\right)^{10/3}\cdot\left(\frac{3{,}000\text{ rpm}}{1{,}525\text{ rpm}}\right) = 34{,}543\text{ (hours)} \geqq 30{,}000\text{ (hours)}$$

— NG

OK

The selection of model number HPG-20A-33 is confirmed from the above calculations.

Refer to the Caution note at the bottom of page 108.

Review the operation conditions, size and reduction ratio.

NOTES

HarmonicPlanetary®

HarmonicDrive®

Technical Information

Product Handling

The rated value and performance vary depending on the product series. Be sure to check the usage conditions and refer to the items conforming to the related product.

Efficiency

In general, the efficiency of a speed reducer depends on the reduction ratio, input rotational speed, load torque, temperature and lubrication condition. The efficiency of each series under the following measurement conditions is plotted in the graphs on the next page. The values in the graph are average values.

Measurement condition

Table 112-1

Input rotational speed	HPGP / HPG / HPF / HPN：3000rpm CSG-GH / CSF-GH：Indicated on each efficiency graph.
Ambient temperature	25°C
Lubricant	Use standard lubricant for each model. (See pages 139-140 for details.)

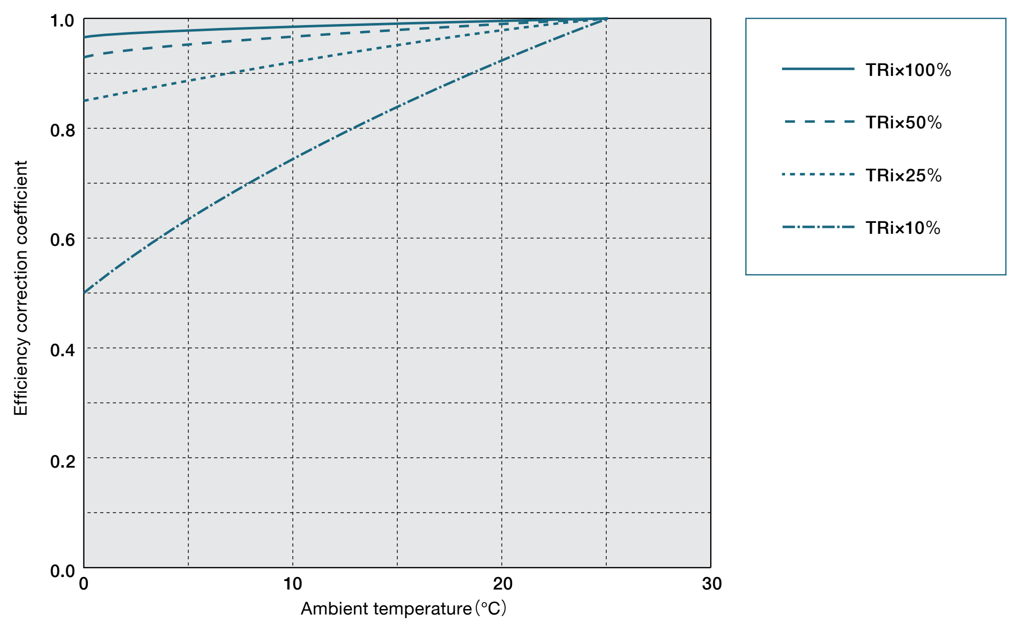
Efficiency compensated for low temperature

Calculate the efficiency at an ambient temperature of 25°C or less by multiplying the efficiency at 25°C by the low-temperature efficiency correction value. Obtain values corresponding to an ambient temperature and to an input torque (TRi*) from the following graphs when calculating the low-temperature efficiency correction value.

HPGP HPG HPF HPN

* TRi is an input torque corresponding to output torque at 25°C.

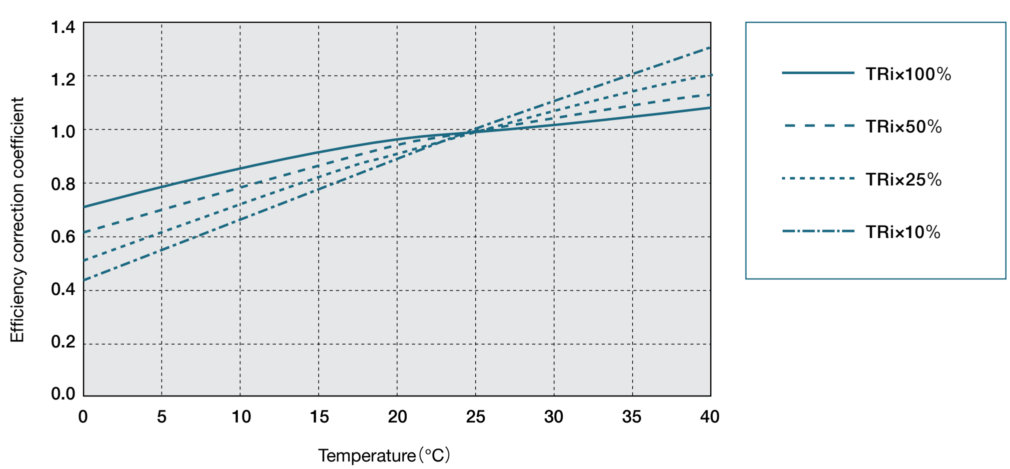
Graph 112-1



CSG-GH CSF-GH

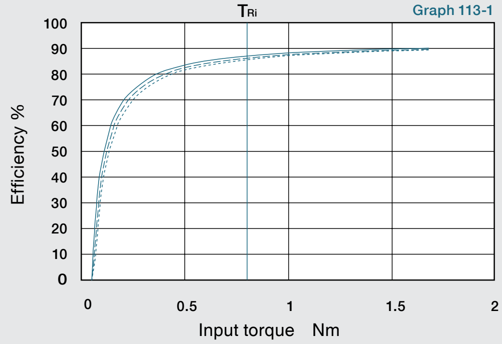
* TRi is an input torque corresponding to output torque at 25°C.

Graph 112-2

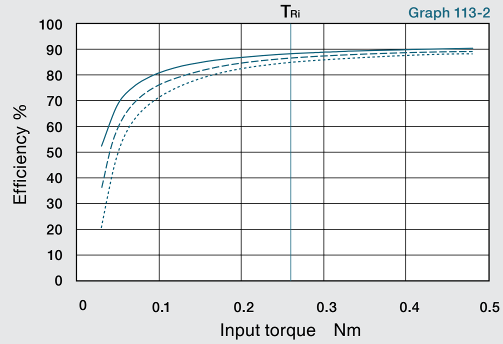


Size 11 : Gearhead **HPGP**

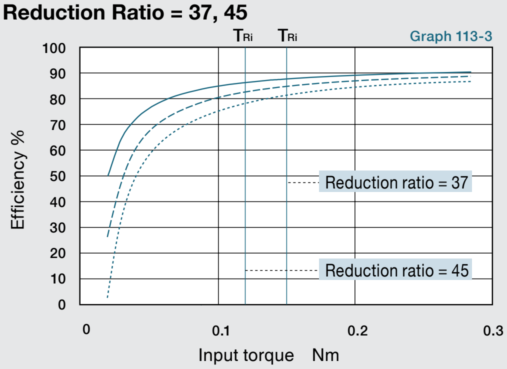
Reduction Ratio = 5



Reduction Ratio = 21



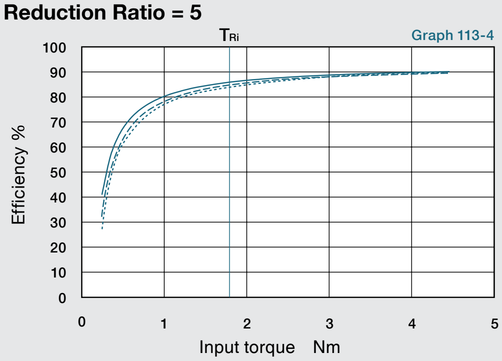
Reduction Ratio = 37, 45



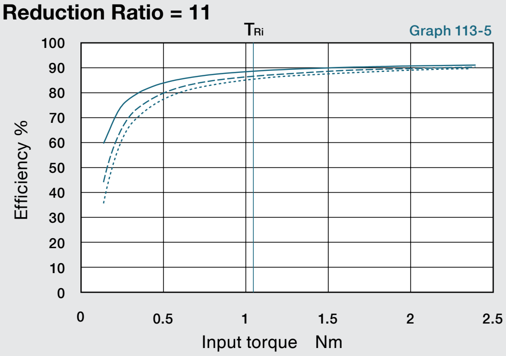
—— Speed reducer only
– – – Gearhead (standard item)
········ DDU bearing (bearing with double side rubber contact seal) assembled on input side of the gearhead **(optional)**
TRi Input torque corresponding to output torque

Size 14 : Gearhead **HPGP**

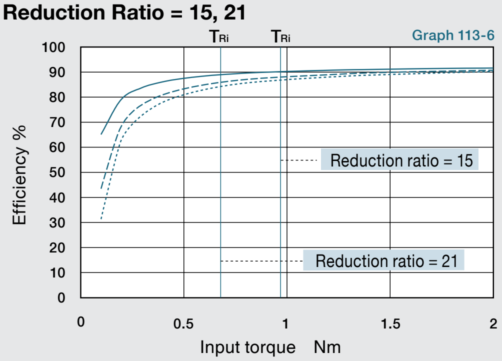
Reduction Ratio = 5



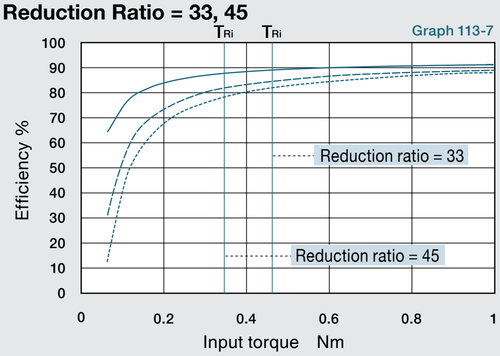
Reduction Ratio = 11



Reduction Ratio = 15, 21



Reduction Ratio = 33, 45

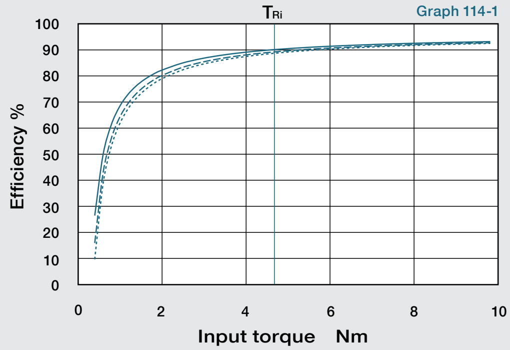


—— Speed reducer only
– – – Gearhead (standard item)
········ DDU bearing (bearing with double side rubber contact seal) assembled on input side of the gearhead **(optional)**
TRi Input torque corresponding to output torque

Size 20 : Gearhead HPGP

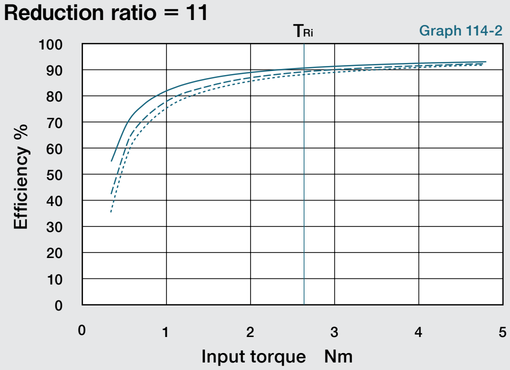
Reduction ratio = 5

Graph 114-1



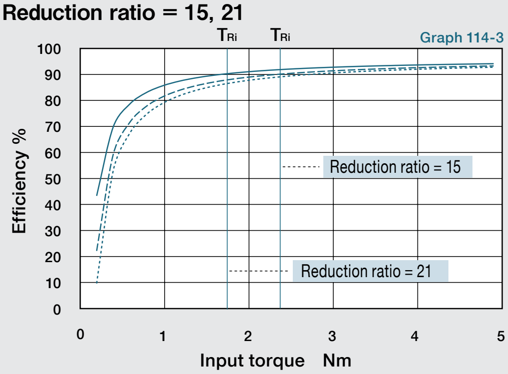
Reduction ratio = 11

Graph 114-2



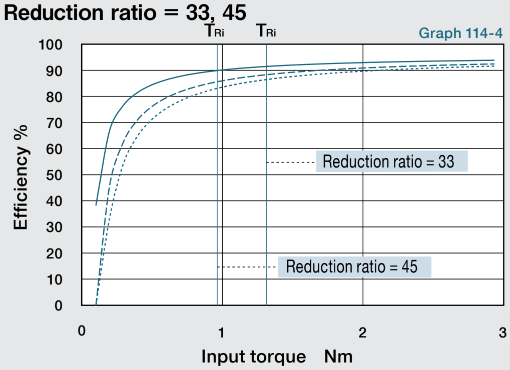
Reduction ratio = 15, 21

Graph 114-3



Reduction ratio = 33, 45

Graph 114-4

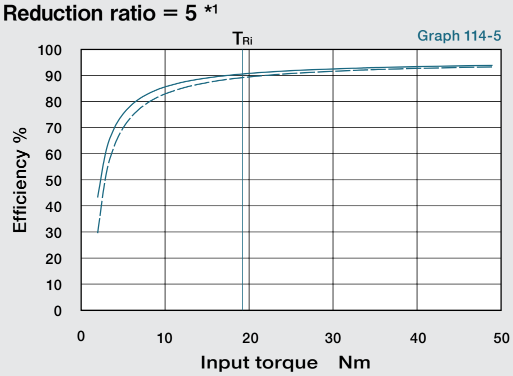


Speed reducer only — Gearhead (standard item) — DDU bearing (bearing with double side rubber contact seal) assembled on input side of the gearhead (optional) — T_{Ri} Input torque corresponding to output torque

Size 32 : Gearhead HPGP

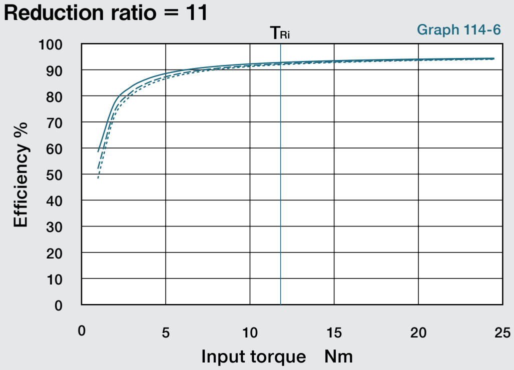
Reduction ratio = 5 *1

Graph 114-5



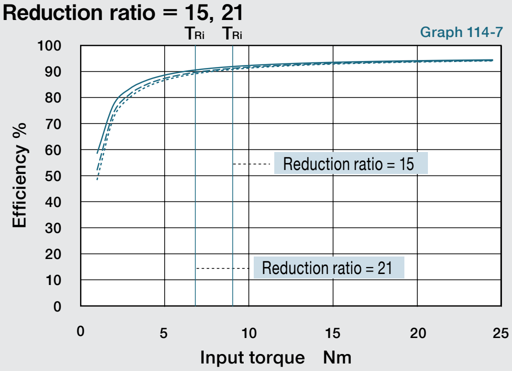
Reduction ratio = 11

Graph 114-6



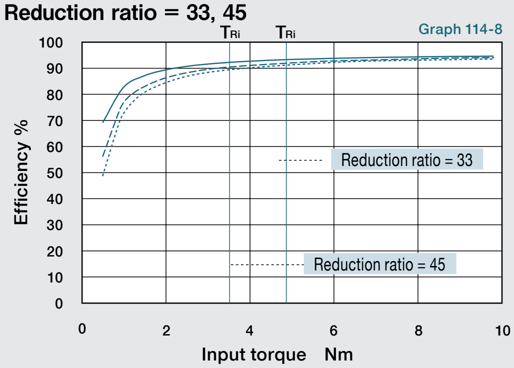
Reduction ratio = 15, 21

Graph 114-7



Reduction ratio = 33, 45

Graph 114-8

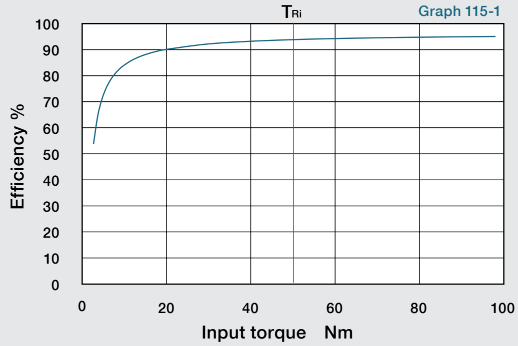


Speed reducer only — Gearhead (standard item) — DDU bearing (bearing with double side rubber contact seal) assembled on input side of the gearhead (optional) — T_{Ri} Input torque corresponding to output torque

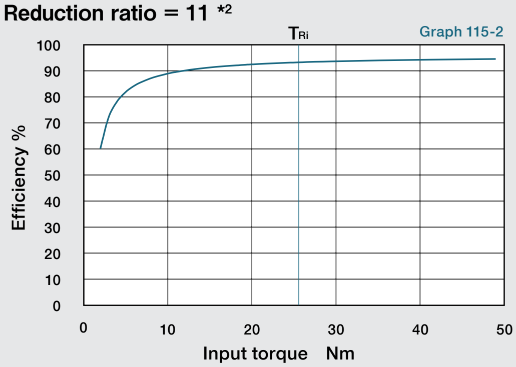
*1 Only one line is shown because the difference between the gearhead and a bearing assembled on the input side is small.

Size 50 : Gearhead HPGP

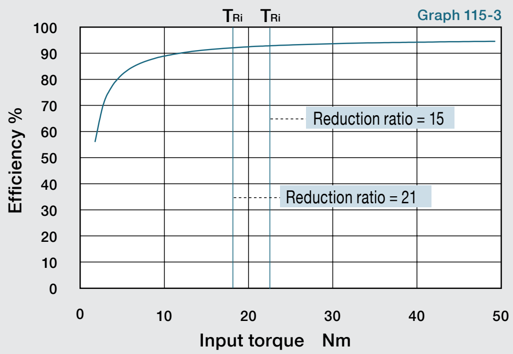
Reduction ratio = 5 *2



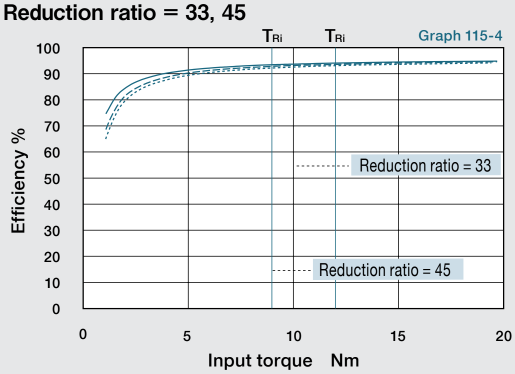
Reduction ratio = 11 *2



Reduction ratio = 15, 21 *2



Reduction ratio = 33, 45

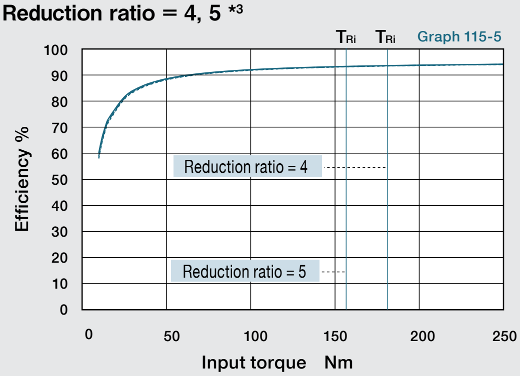


Speed reducer only
Gearhead (standard item)
DDU bearing (bearing with double side rubber contact seal) assembled on input side of the gearhead (optional)
TRi Input torque corresponding to output torque

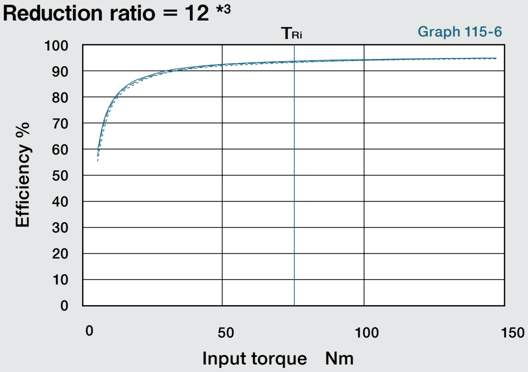
*2 Only one line is shown because the difference between the gearhead and a bearing assembled on the input side is small.

Size 65 : Gearhead HPGP

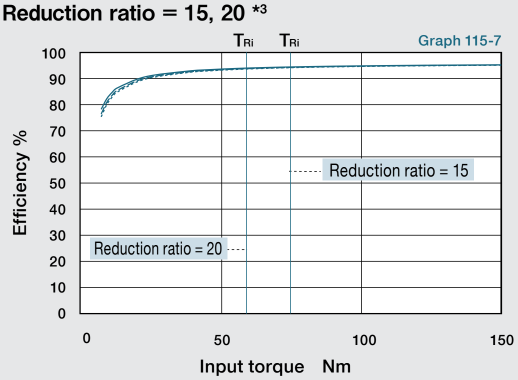
Reduction ratio = 4, 5 *3



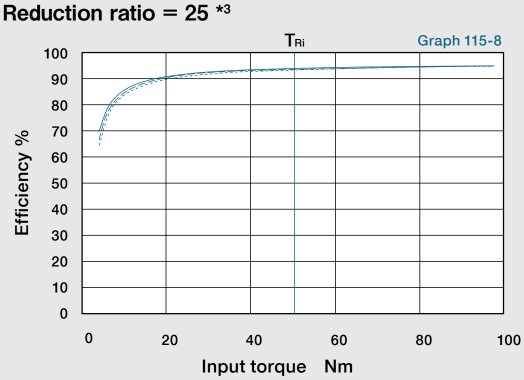
Reduction ratio = 12 *3



Reduction ratio = 15, 20 *3



Reduction ratio = 25 *3



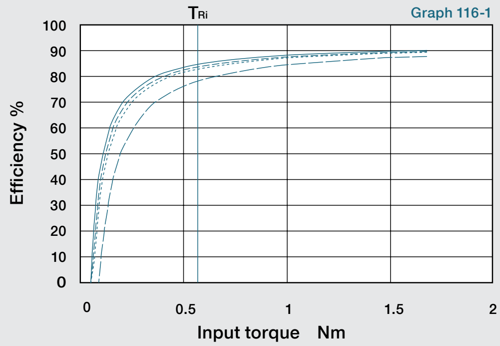
Speed reducer only
Gearhead (standard item)
DDU bearing (bearing with double side rubber contact seal) assembled on input side of the gearhead (optional)
TRi Input torque corresponding to output torque

*3 Only one line is shown because the difference between the gearhead and a bearing assembled on the input side is small.

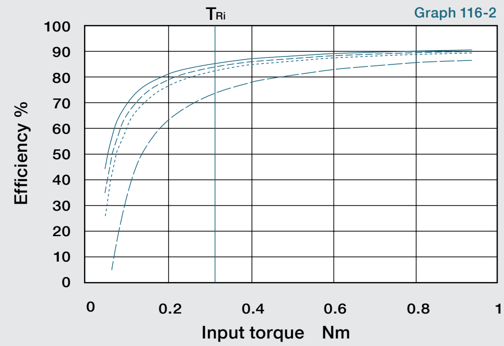
Technical Information / Handling Explanation

Size 11 : Gearhead ／ Input Shaft Unit HPG

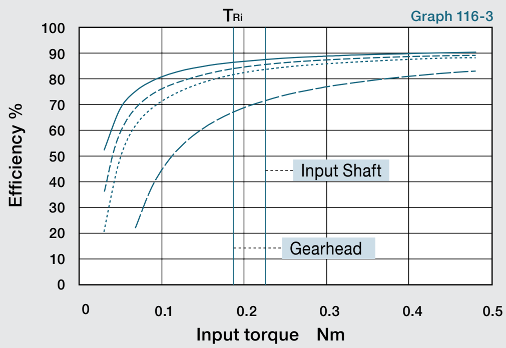
Reduction ratio = 5



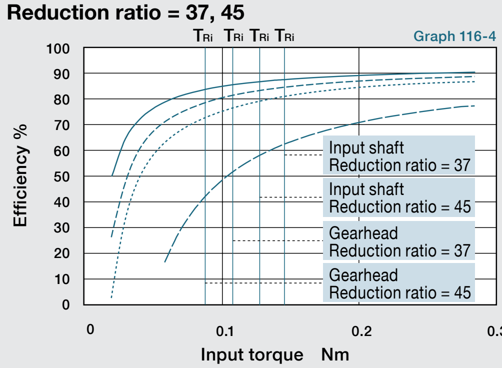
Reduction ratio = 9



Reduction ratio = 21



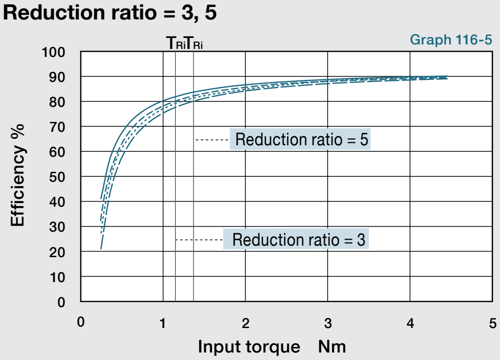
Reduction ratio = 37, 45



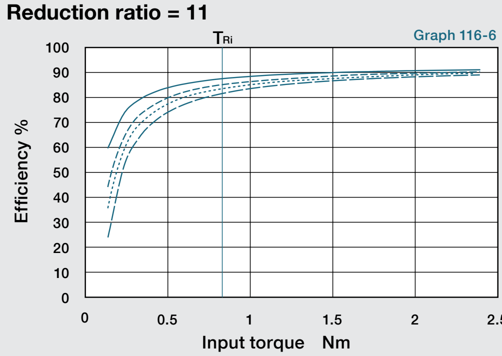
Speed reducer only — Gearhead (standard item) — DDU bearing (bearing with double side rubber contact seal) assembled on input side of the gearhead (optional) — Input Shaft — TRi Input torque corresponding to output torque

Size 14 : Gearhead ／ Input Shaft Unit HPG

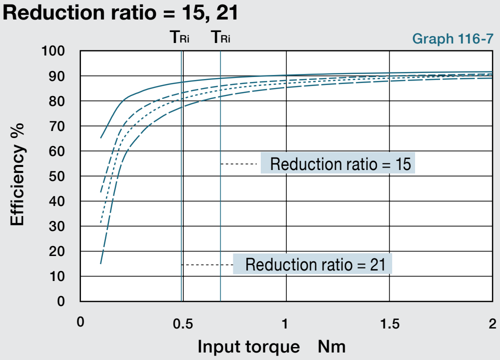
Reduction ratio = 3, 5



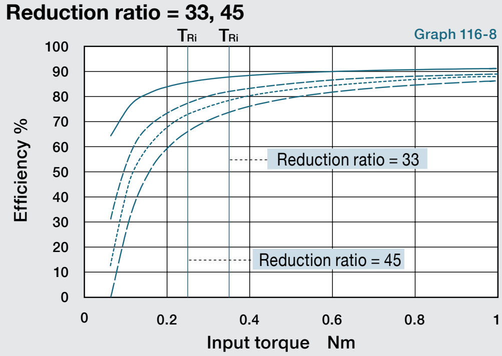
Reduction ratio = 11



Reduction ratio = 15, 21



Reduction ratio = 33, 45

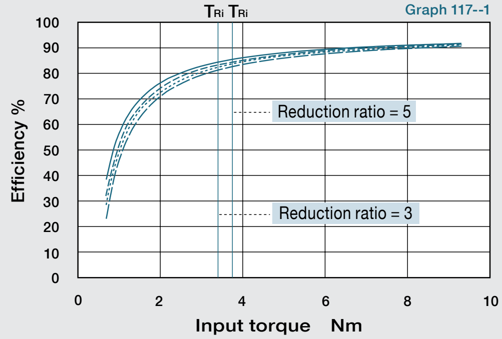


Speed reducer only — Gearhead (standard item) — DDU bearing (bearing with double side rubber contact seal) assembled on input side of the gearhead (optional) — Input Shaft — TRi Input torque corresponding to output torque

Size 20 : Gearhead ／ Input Shaft Unit HPG

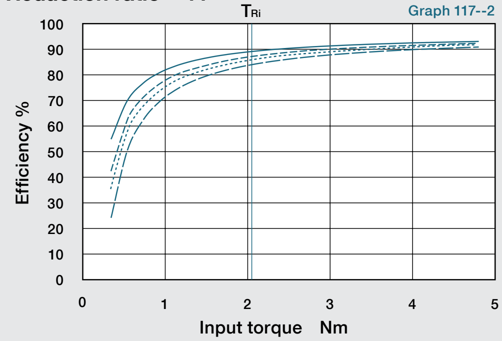
Reduction ratio = 3, 5

Graph 117--1



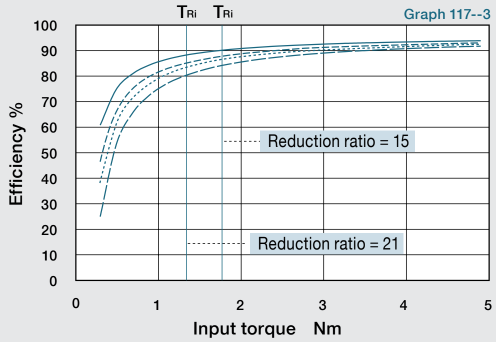
Reduction ratio = 11

Graph 117--2



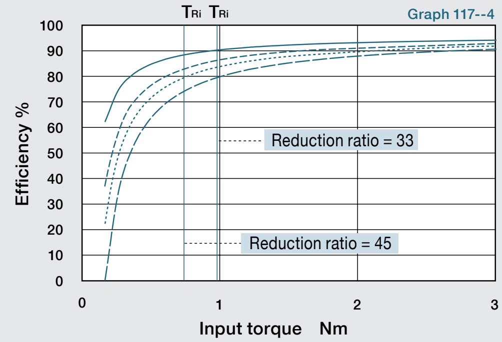
Reduction ratio = 15, 21

Graph 117--3



Reduction ratio = 33, 45

Graph 117--4

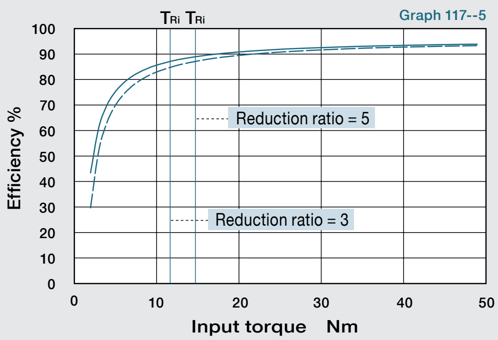


—— Speed reducer only　－－－ Gearhead (standard item)　······ DDU bearing (bearing with double side rubber contact seal) assembled on input side of the gearhead (optional)　— — Input Shaft　TRi Input torque corresponding to output torque

Size 32 : Gearhead ／ Input Shaft Unit HPG

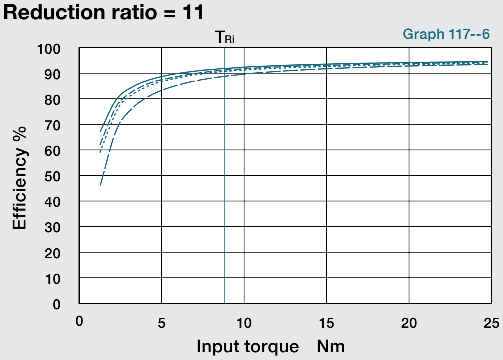
Reduction ratio = 3, 5*1

Graph 117--5



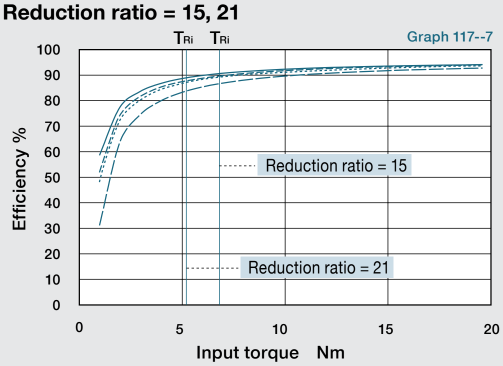
Reduction ratio = 11

Graph 117--6



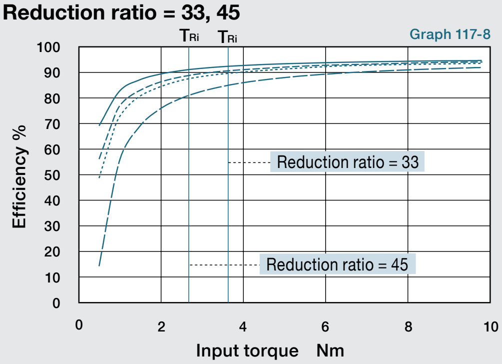
Reduction ratio = 15, 21

Graph 117--7



Reduction ratio = 33, 45

Graph 117-8

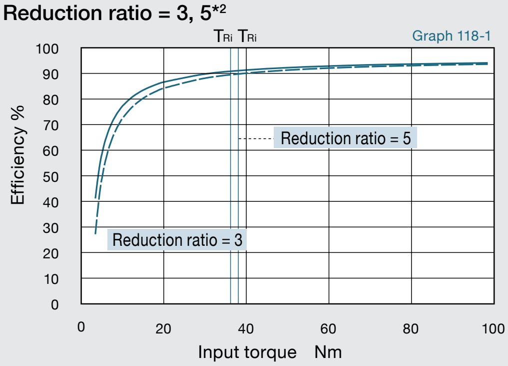


—— Speed reducer only　－－－ Gearhead (standard item)　······ DDU bearing (bearing with double side rubber contact seal) assembled on input side of the gearhead (optional)　— — Input Shaft　TRi Input torque corresponding to output torque

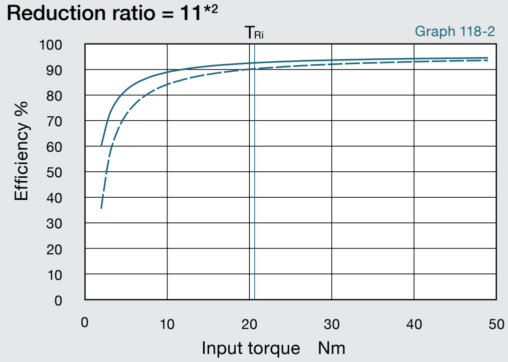
*1 Only one line is shown because the difference between the gearhead and a bearing assembled on the input side is small.

Size 50 : Gearhead ／ Input Shaft Unit HPG

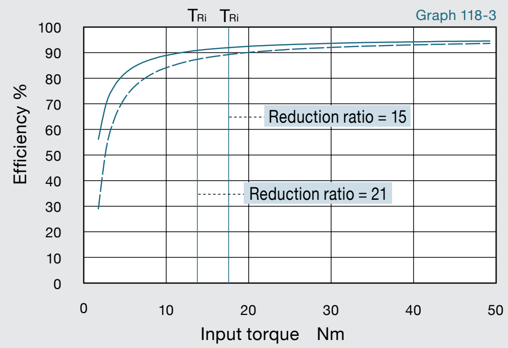
Reduction ratio = 3, 5*2



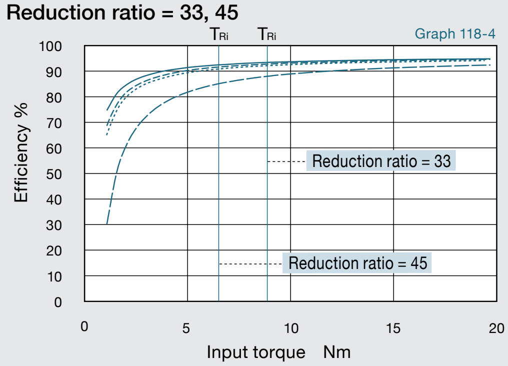
Reduction ratio = 11*2



Reduction ratio = 15, 21*2



Reduction ratio = 33, 45

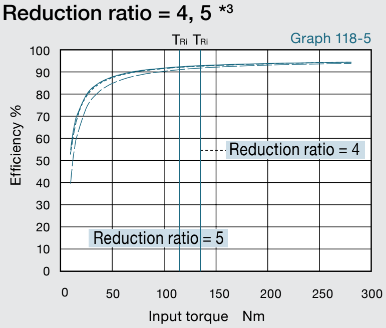


—— Speed reducer only　– – – Gearhead (standard item)　······ DDU bearing (bearing with double side rubber contact seal) assembled on input side of the gearhead (optional)　— — Input Shaft　TRi Input torque corresponding to output torque

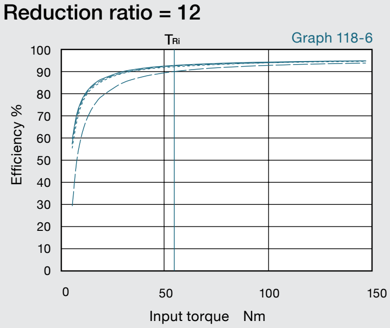
*2 Only one line is shown because the difference between the gearhead and a bearing assembled on the input side is small.

Size 65 : Gearhead ／ Input Shaft Unit HPG

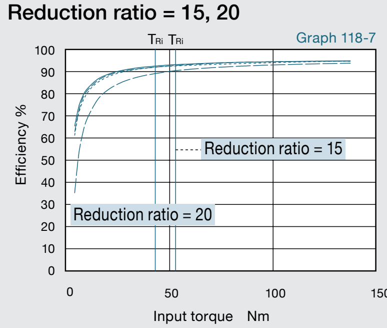
Reduction ratio = 4, 5 *3



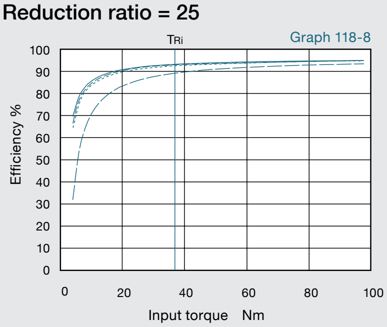
Reduction ratio = 12



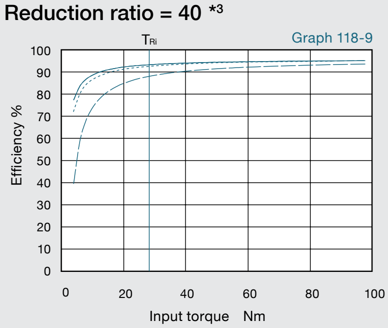
Reduction ratio = 15, 20



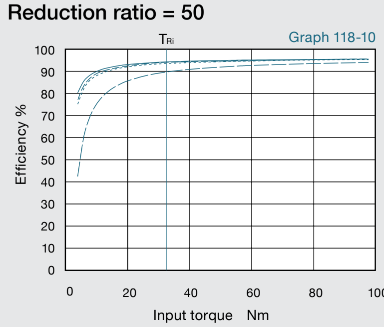
Reduction ratio = 25



Reduction ratio = 40 *3



Reduction ratio = 50



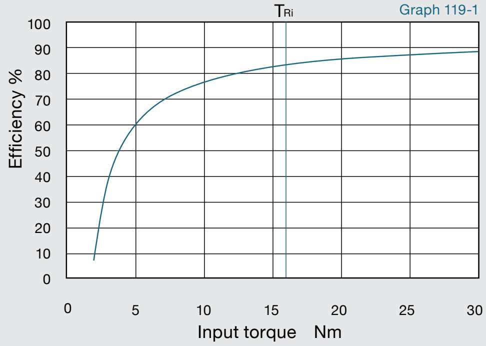
—— Speed reducer only　– – – Gearhead (standard item)　······ DDU bearing (bearing with double side rubber contact seal) assembled on input side of the gearhead (optional)　— — Input Shaft　TRi Input torque corresponding to output torque

*3 Only one line is shown because the difference between the gearhead and a bearing assembled on the input side is small.

Size 32 RA3 : Right Angle Gearhead HPG

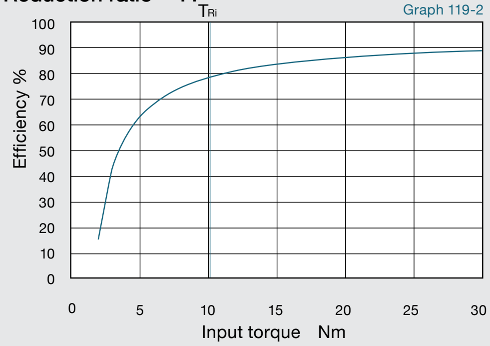
Reduction ratio = 5

Graph 119-1



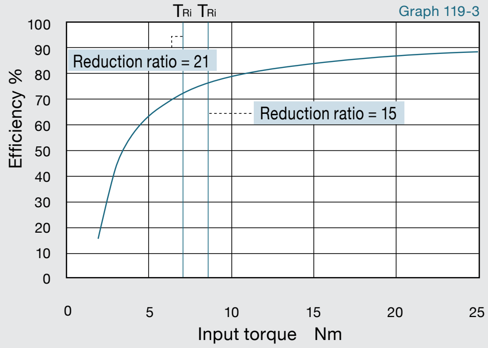
Reduction ratio = 11

Graph 119-2



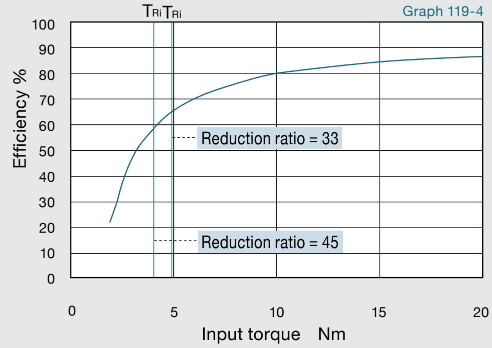
Reduction ratio = 15, 21

Graph 119-3



Reduction ratio = 33, 45

Graph 119-4

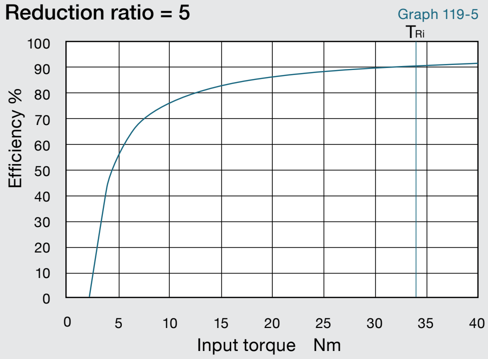


TRi Input torque corresponding to output torque

Size 50 RA3 : Right Angle Gearhead HPG

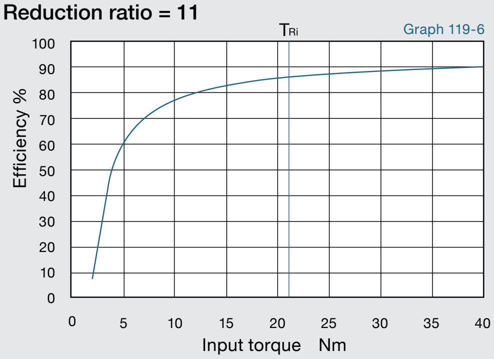
Reduction ratio = 5

Graph 119-5



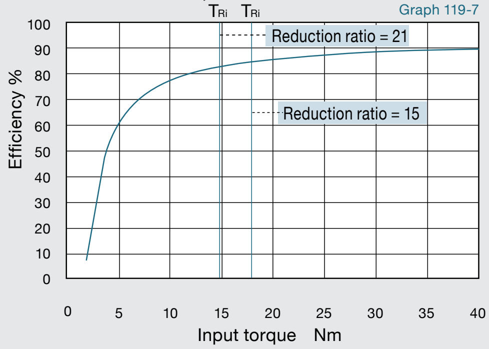
Reduction ratio = 11

Graph 119-6



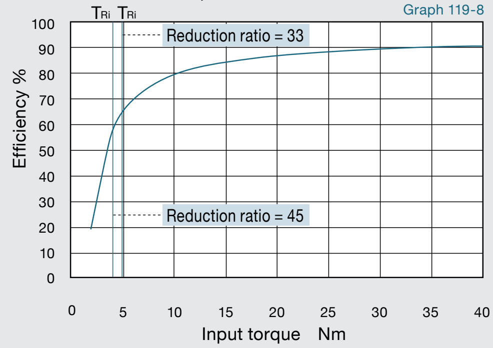
Reduction ratio = 15, 21

Graph 119-7



Reduction ratio = 33, 45

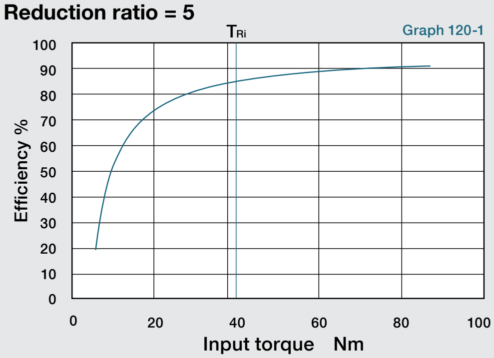
Graph 119-8



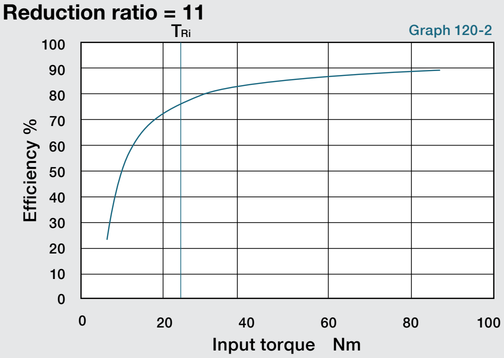
TRi Input torque corresponding to output torque

Size 50 RA5 : Right Angle Gearhead HPG

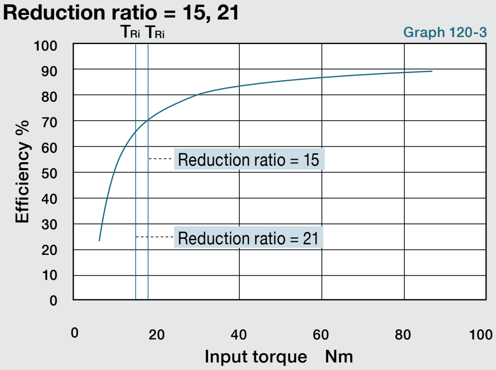
Reduction ratio = 5



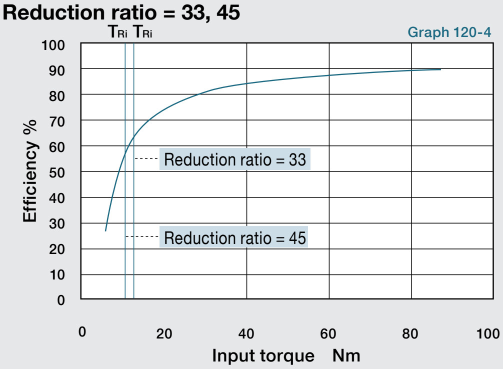
Reduction ratio = 11



Reduction ratio = 15, 21



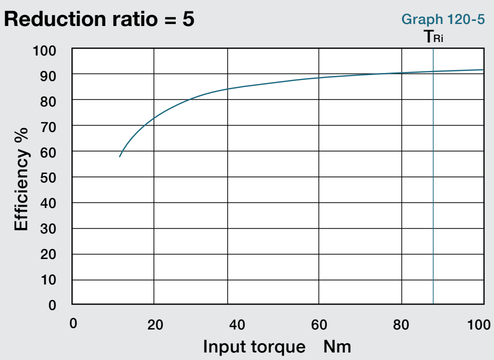
Reduction ratio = 33, 45



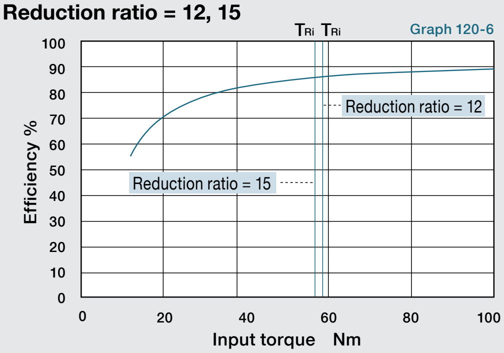
T_{Ri} Input torque corresponding to output torque

Size 65 RA5 : Right Angle Gearhead HPG

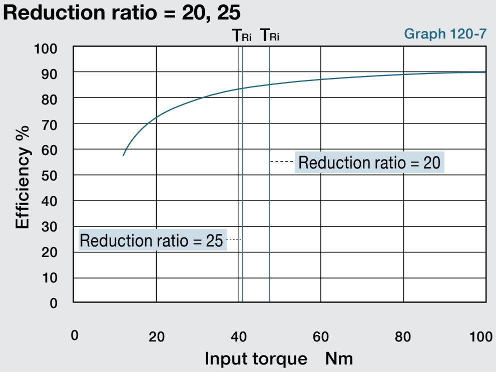
Reduction ratio = 5



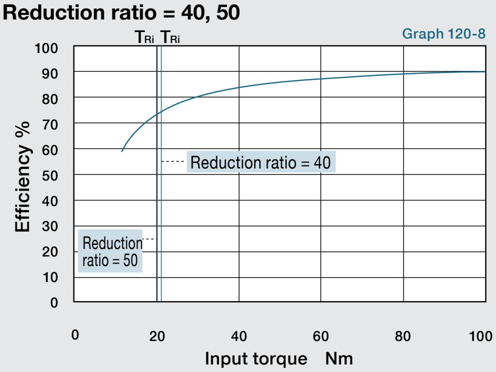
Reduction ratio = 12, 15



Reduction ratio = 20, 25



Reduction ratio = 40, 50

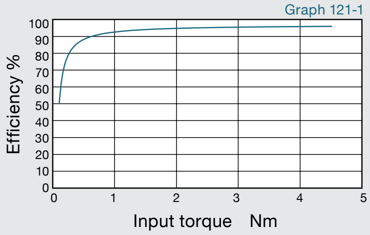


T_{Ri} Input torque corresponding to output torque

Size 11A : Gearhead HPN

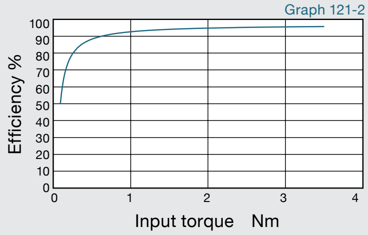
Reduction ratio = 4

Graph 121-1



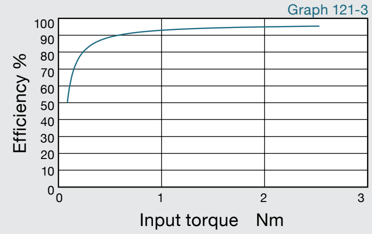
Reduction ratio = 5

Graph 121-2



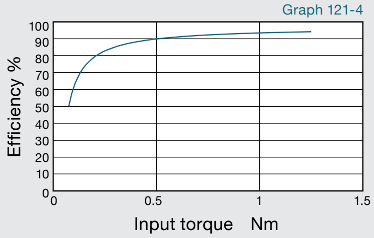
Reduction ratio = 7

Graph 121-3



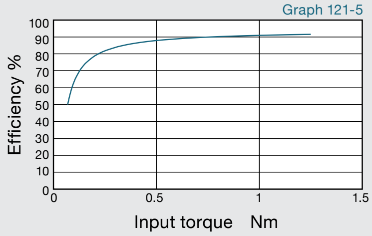
Reduction ratio = 10

Graph 121-4



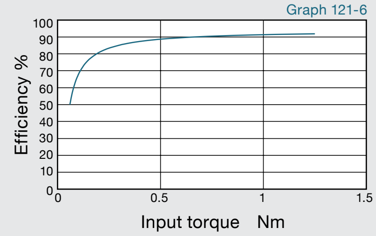
Reduction ratio = 16

Graph 121-5



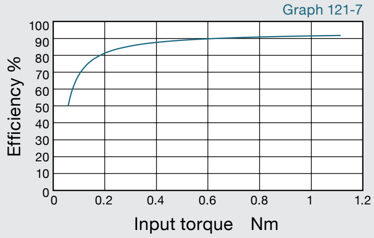
Reduction ratio = 20

Graph 121-6



Reduction ratio = 30

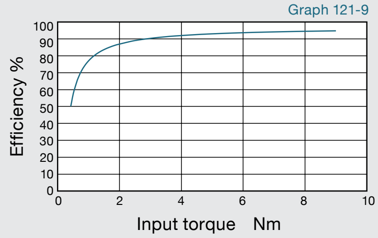
Graph 121-7



Size 14A : Gearhead HPN

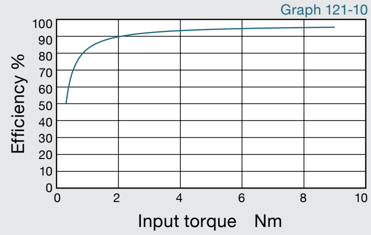
Reduction ratio = 3

Graph 121-9



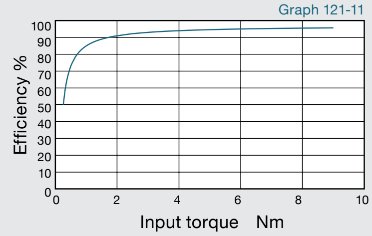
Reduction ratio = 4

Graph 121-10



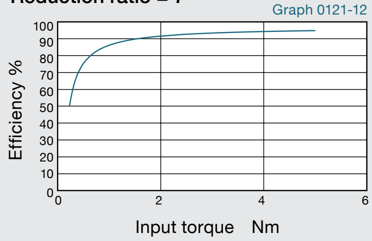
Reduction ratio = 5

Graph 121-11



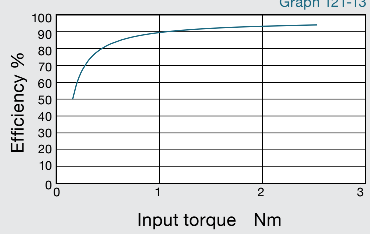
Reduction ratio = 7

Graph 0121-12



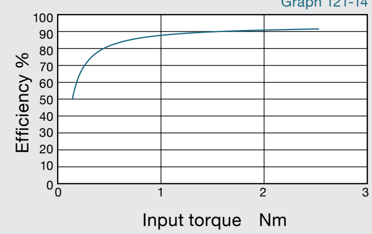
Reduction ratio = 10

Graph 121-13



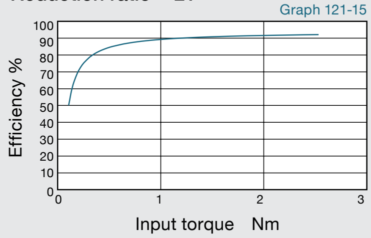
Reduction ratio = 13

Graph 121-14



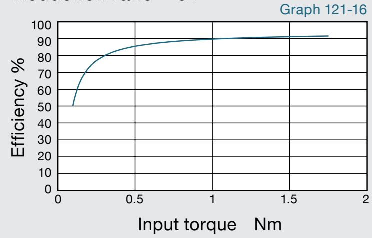
Reduction ratio = 21

Graph 121-15



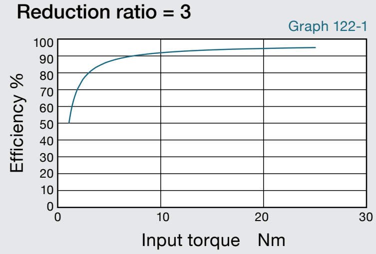
Reduction ratio = 31

Graph 121-16

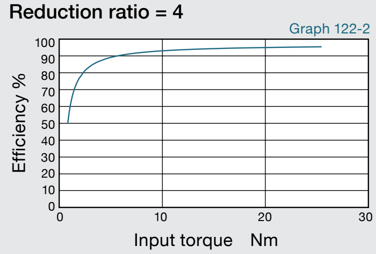


Size 20A : Gearhead HPN

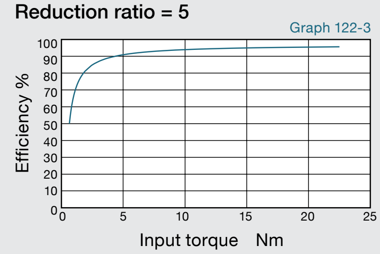
Reduction ratio = 3



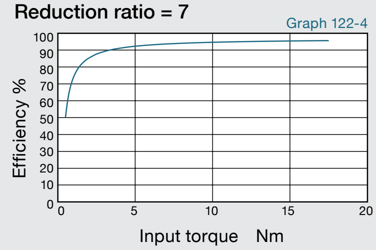
Reduction ratio = 4



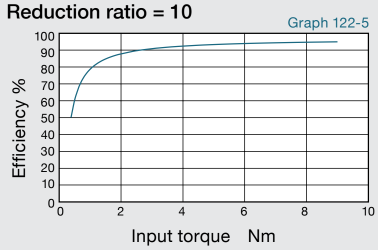
Reduction ratio = 5



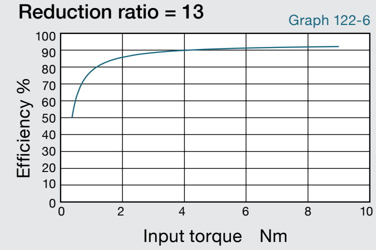
Reduction ratio = 7



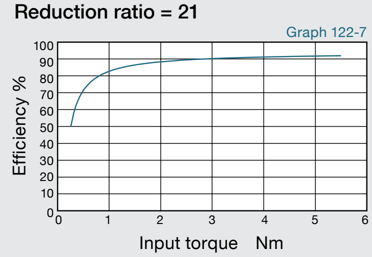
Reduction ratio = 10



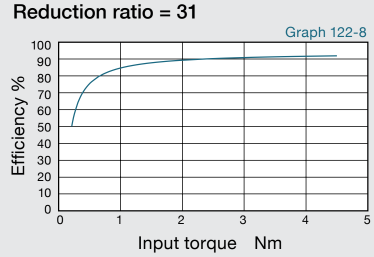
Reduction ratio = 13



Reduction ratio = 21

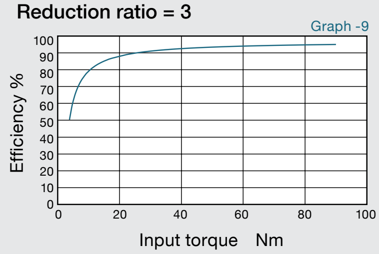


Reduction ratio = 31

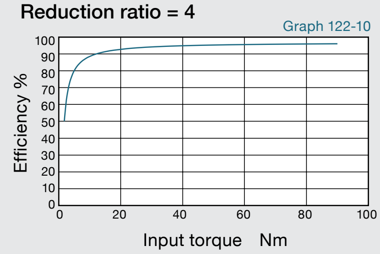


Size 32A : Gearhead HPN

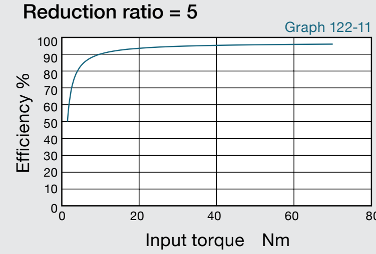
Reduction ratio = 3



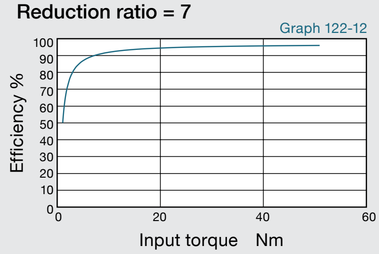
Reduction ratio = 4



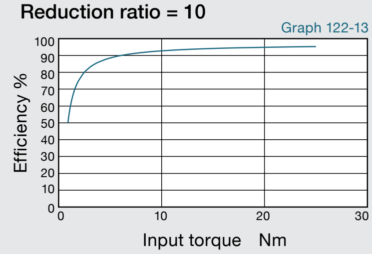
Reduction ratio = 5



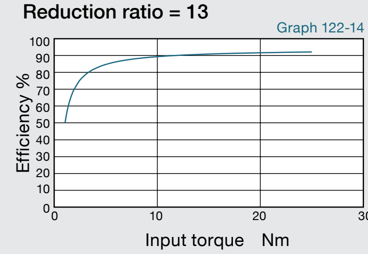
Reduction ratio = 7



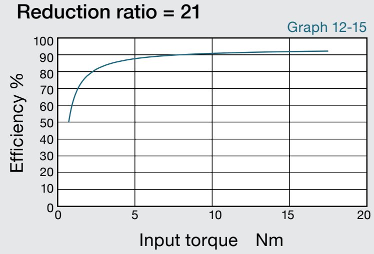
Reduction ratio = 10



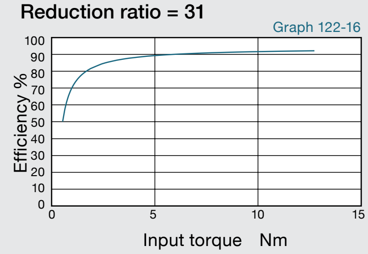
Reduction ratio = 13



Reduction ratio = 21



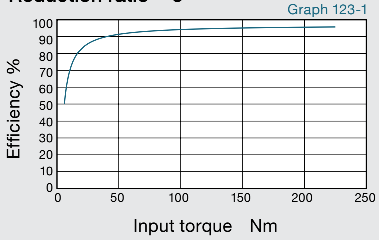
Reduction ratio = 31



Size 40A : Gearhead HPN

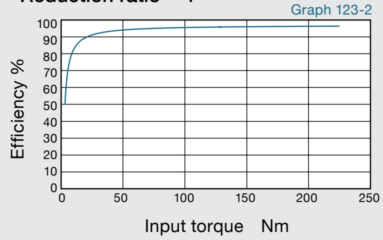
Reduction ratio = 3

Graph 123-1



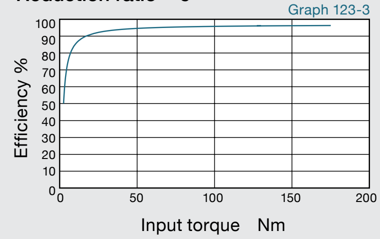
Reduction ratio = 4

Graph 123-2



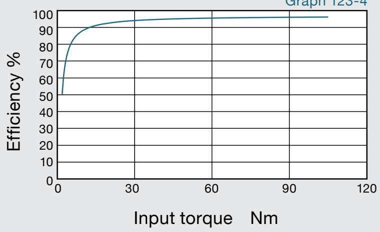
Reduction ratio = 5

Graph 123-3



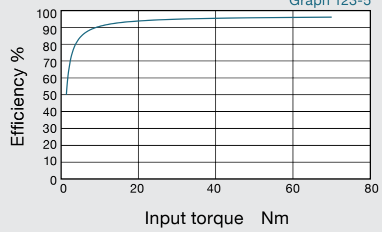
Reduction ratio = 7

Graph 123-4



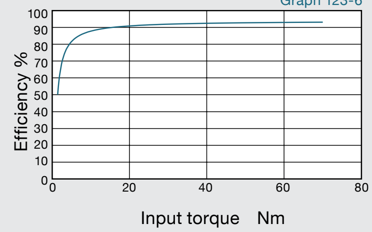
Reduction ratio = 10

Graph 123-5



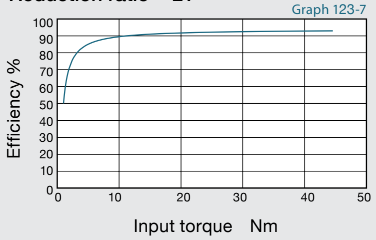
Reduction ratio = 13

Graph 123-6



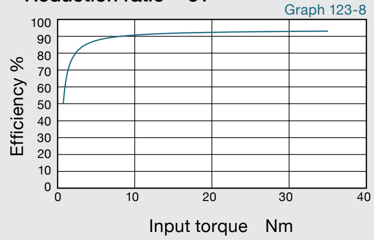
Reduction ratio = 21

Graph 123-7

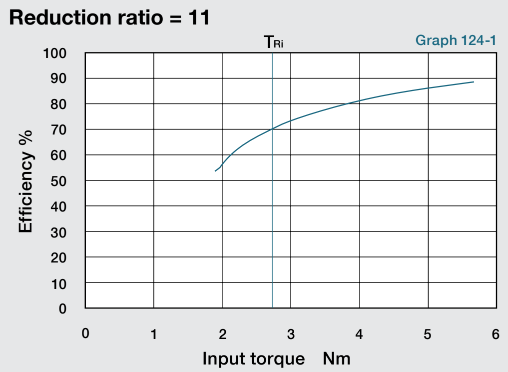


Reduction ratio = 31

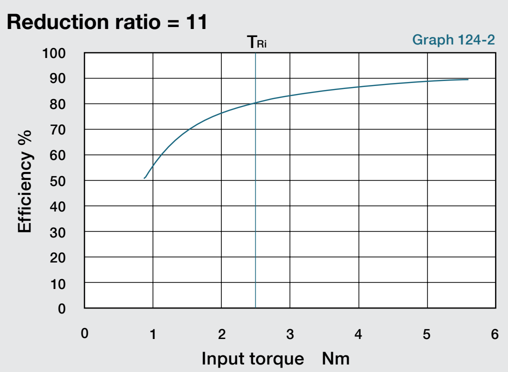
Graph 123-8



Size 25 : Hollow Shaft Unit **HPF**



Size 32 : Hollow Shaft Unit **HPF**

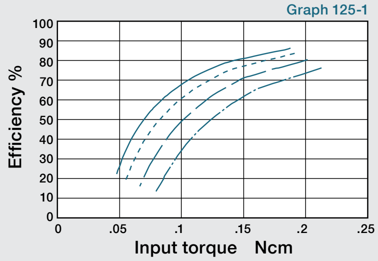


Size 14 : Gearhead

CSG-GH **CSF-GH**

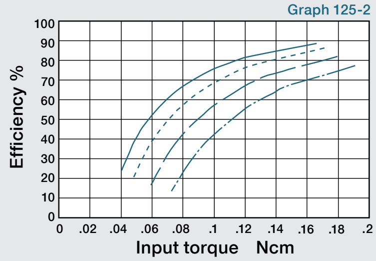
Reduction ratio = 50

Graph 125-1



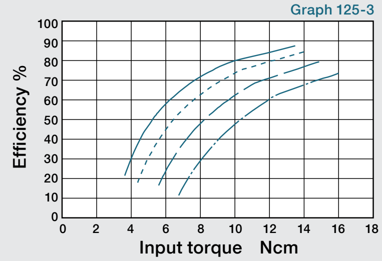
Reduction ratio = 80

Graph 125-2



Reduction ratio = 100

Graph 125-3



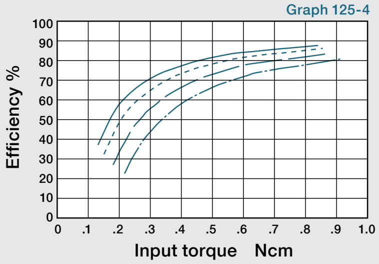
Input rotational speed ——— 500 rpm - - - - - - 1000 rpm —— —— 2000 rpm ——·—— 3500 rpm

Size 20 : Gearhead

CSG-GH **CSF-GH**

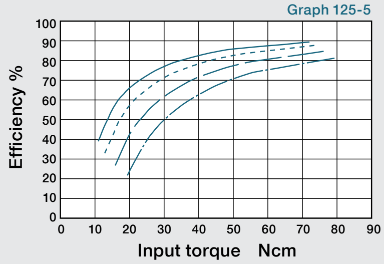
Reduction ratio = 50

Graph 125-4



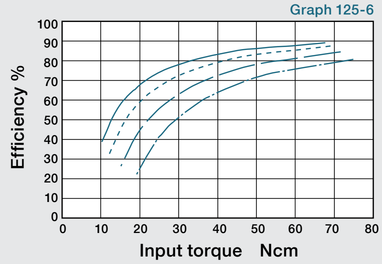
Reduction ratio = 80

Graph 125-5



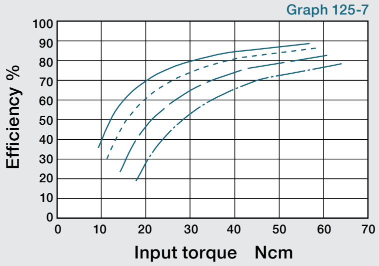
Reduction ratio = 100

Graph 125-6



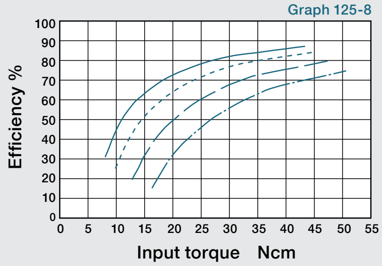
Reduction ratio = 120

Graph 125-7



Reduction ratio = 160

Graph 125-8



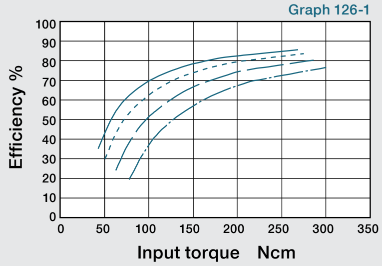
Input rotational speed ——— 500 rpm - - - - - - 1000 rpm —— —— 2000 rpm ——·—— 3500 rpm

Size 32 : Gearhead

CSG-GH **CSF-GH**

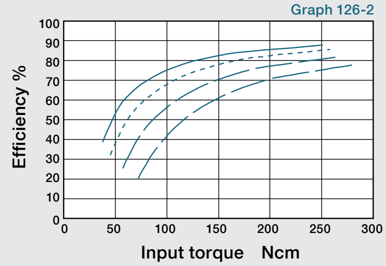
Reduction ratio = 50

Graph 126-1



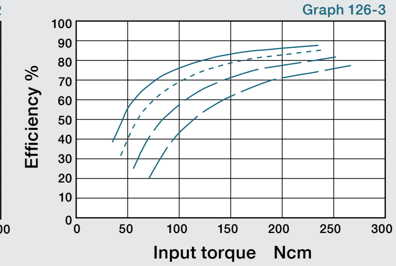
Reduction ratio = 80

Graph 126-2



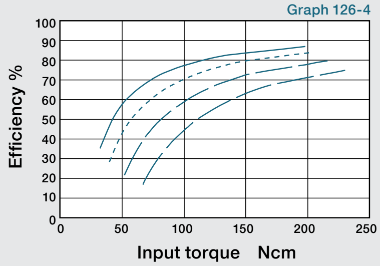
Reduction ratio = 100

Graph 126-3



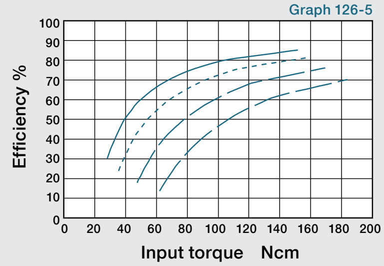
Reduction ratio = 120

Graph 126-4



Reduction ratio = 160

Graph 126-5



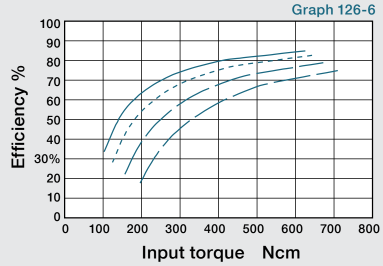
Input rotational speed —— 500 rpm - - - - - - 1000 rpm —— —— 2000 rpm ——·—— 3500 rpm

Size 45 : Gearhead

CSG-GH **CSF-GH**

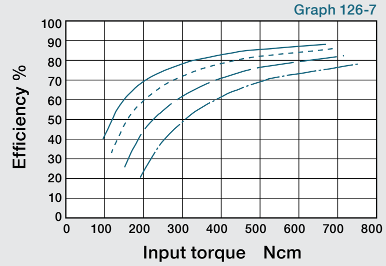
Reduction ratio = 50

Graph 126-6



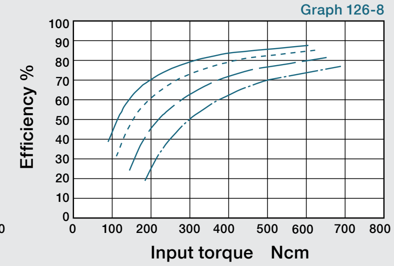
Reduction ratio = 80

Graph 126-7



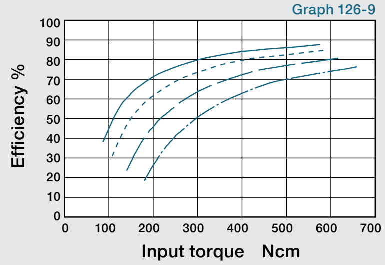
Reduction ratio = 100

Graph 126-8



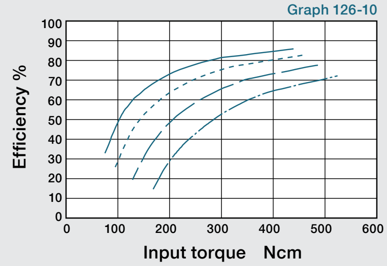
Reduction ratio = 120

Graph 126-9



Reduction ratio = 160

Graph 126-10

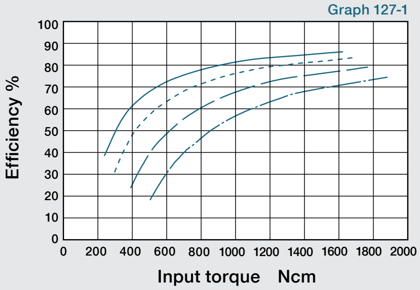


Input rotational speed —— 500 rpm - - - - - - 1000 rpm —— —— 2000 rpm ——·—— 3500 rpm

Size 65 : Gearhead CSG-GH CSF-GH

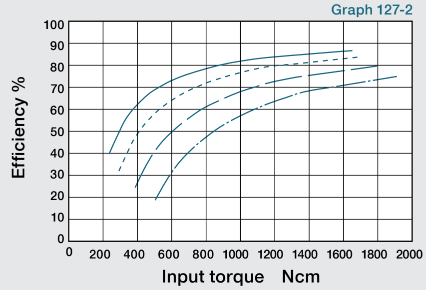
Reduction ratio = 80

Graph 127-1



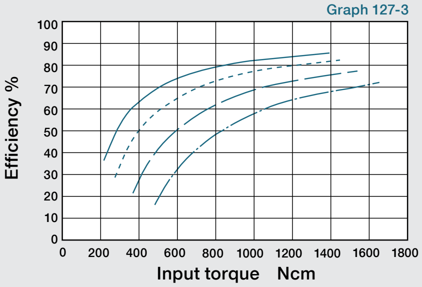
Reduction ratio = 100

Graph 127-2



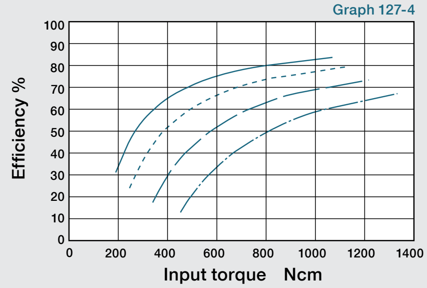
Reduction ratio = 120

Graph 127-3



Reduction ratio = 160

Graph 127-4



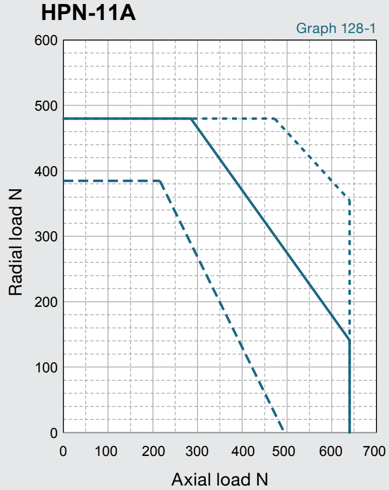
Input rotational speed: 500 rpm, 1000 rpm, 2000 rpm, 3500 rpm

Output Shaft Bearing Load Limits

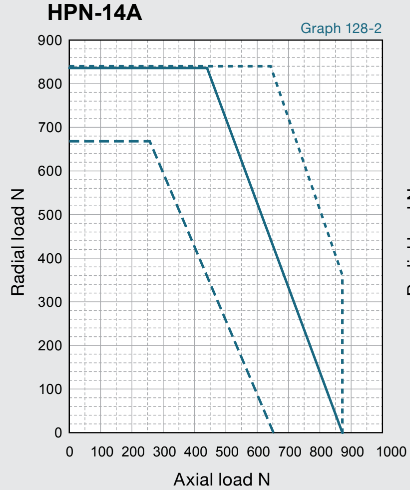
HPN Series Output Shaft Load Limits are plotted below.

HPN uses radial ball bearings to support the output shaft. Please use the curve on the graph for the appropriate load coefficient (fw) that represents the expected operating condition.

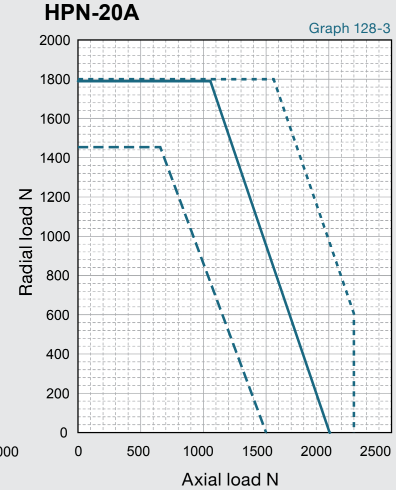
HPN-11A



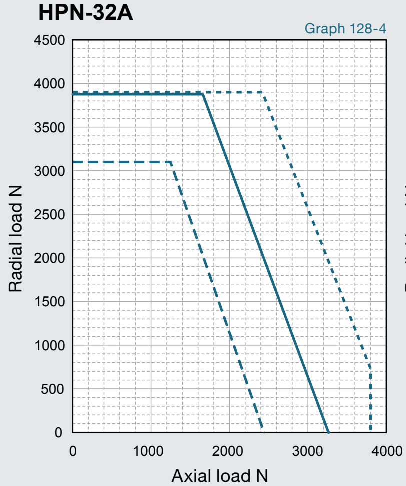
HPN-14A



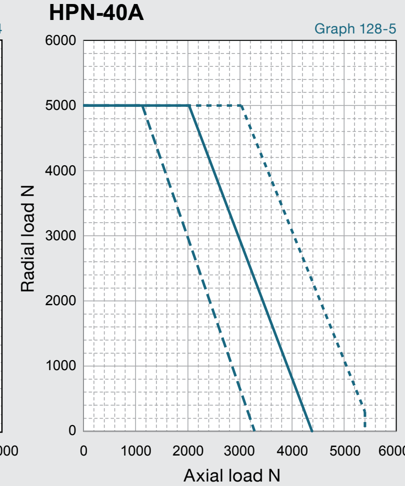
HPN-20A

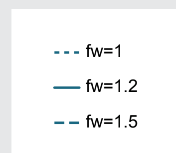


HPN-32A



HPN-40A





Load coefficient
fw=1~1.2 Smooth operation without impact
fw=1.2~1.5 Standard operation

Output shaft speed - 100 rpm, shaft life is based on 20,000 hours. The load-point is based on shaft center of radial load and axial load.

Technical Information / Handling Explanation

HarmonicPlanetary® & HarmonicDrive®

Output Bearing Specifications and Checking Procedure

A precision cross roller bearing supports the external load (output flange).
Check the maximum load, moment load, life of the bearing and static safety coefficient to maximize performance.

Checking procedure

(1) Checking the maximum load moment load (M*max*)

Obtain the maximum load moment load (M*max*). ➔ Maximum load moment load (M*max*) ≦ Permissible moment (Mc)

(2) Checking the life

Obtain the average radial load (Fr*av*) and the average axial load (Fa*av*). ➔ Obtain the radial load coefficient (X) and the axial load coefficient (Y). ➔ Calculate the life and check it.

(3) Checking the static safety coefficient

Obtain the static equivalent radial load coefficient (Po). ➔ Check the static safety coefficient. (fs)

Specification of output bearing

HPGP/HPG Series Table 129-1, -2 and -3 indicate the specifications for gearhead, right angle and input shaft unit, and cross roller bearing.

Table 129-1

Size	Pitch circle	Offset amount	Basic rated load				Allowable moment load Mc*3		Moment stiffness Km*4	
	dp	R	Basic dynamic load rating C*1		Basic static load rating Co*2		Nm	Kgfm	x10⁴ Nm/rad	Kgfm/ arc min
	m	m	N	kgf	N	kgf				
11	0.0275	0.006	3116	318	4087	417	9.50	0.97	0.88	0.26
14	0.0405	0.011	5110	521	7060	720	32.3	3.30	3.0	0.90
20	0.064	0.0115	10600	1082	17300	1765	183	18.7	16.8	5.0
32	0.085	0.014	20500	2092	32800	3347	452	46.1	42.1	12.5
50	0.123	0.019	41600	4245	76000	7755	1076	110	100	29.7
65	0.170	0.023	90600	9245	148000	15102	3900	398	364	108

Table 129-2

Size	Reduction ratio	Allowable radial load*5	Allowable axial load*5
		N	N
11	5	280	430
	(9)	340	510
	21	440	660
	37	520	780
	45	550	830
14	(3)	400	600
	5	470	700
	11	600	890
	15	650	980
	21	720	1080
	33	830	1240
	45	910	1360
20	(3)	840	1250
	5	980	1460
	11	1240	1850
	15	1360	2030
	21	1510	2250
	33	1729	2580
	45	1890	2830

* The ratio specified in parentheses is for the HPG Series.

Table 129-3

Size	Reduction ratio	Allowable radial load*5	Allowable axial load*5
		N	N
32	(3)	1630	2430
	5	1900	2830
	11	2410	3590
	15	2640	3940
	21	2920	4360
	33	3340	4990
	45	3670	5480
50	(3)	3700	5570
	5	4350	6490
	11	5500	8220
	15	6050	9030
	21	6690	9980
	33	7660	11400
	45	8400	12500
65	4	8860	13200
	5	9470	14100
	12	12300	18300
	15	13100	19600
	20	14300	21400
	25	15300	22900
	(40)	17600	26300
	(50)	18900	28200

* The ratio specified in parentheses is for the HPG Series.

CSG-GH/CSF-GH Series

Table 130-1 indicates the specifications for cross roller bearing.

Table 130-1

Size	Pitch circle	Offset amount	Basic load rating				Allowable moment load Mc[*3]		Moment stiffness Km[*4]		Allowable radial load[*5]	Allowable axial load[*5]
	dp	R	Basic dynamic load rating C[*1]		Basic static load rating Co[*2]				$\times 10^4$ Nm/rad	kgfm/arc min		
	m	m	N	kgf	N	kgf	Nm	kgfm			N	N
14	0.0405	0.011	5110	521	7060	720	27	2.76	3.0	0.89	732	1093
20	0.064	0.0115	10600	1082	17300	1765	145	14.8	17	5.0	1519	2267
32	0.085	0.014	20500	2092	32800	3347	258	26.3	42	12	2938	4385
45	0.123	0.019	41600	4245	76000	7755	797	81.3	100	30	5962	8899
65	0.170	0.0225	81600	8327	149000	15204	2156	220	323	96	11693	17454

HPF Series

Table 130-2 indicates the specifications for cross roller bearing.

Table 130-2

Size	Pitch circle	Offset amount	Basic load rating				Allowable moment load Mc[*3]		Moment stiffness Km[*4]		Allowable radial load[*5]	Allowable axial load[*5]
	dp	R	Basic dynamic load rating C[*1]		Basic static load rating Co[*2]				$\times 10^4$ Nm/rad	kgfm/arc min		
	m	m	N	kgf	N	kgf	Nm	kgfm			N	N
25	0.085	0.0153	11400	1163	20300	2071	410	41.8	37.9	11.3	1330	1990
32	0.1115	0.015	22500	2296	39900	4071	932	95	86.1	25.7	2640	3940

〔Note：Table 129-1, -2 and -3　Table 130-1 and -2〕

*1 The basic dynamic load rating means a certain static radial load so that the basic dynamic rated life of the roller bearing is a million rotations.
*2 The basic static load rating means a static load that gives a certain level of contact stress (4kN/mm^2) in the center of the contact area between rolling element receiving the maximum load and orbit.
*3 The allowable moment load is a maximum moment load applied to the bearing. Within the allowable range, basic performance is maintained and the bearing is operable. Check the bearing life based on the calculations shown on the next page.
*4 The value of the moment stiffness is the average value.
*5 The allowable radial load and allowable axial load are the values that satisfy the life of a speed reducer when a pure radial load or an axial load applies to the main bearing. (Lr + R = 0 mm for radial load and La = 0 mm for axial load) If a compound load applies, refer to the calculations shown on the next page.

How to calculate the maximum load moment load

HPGP | HPG | CSG-GH | CSF-GH | HPF

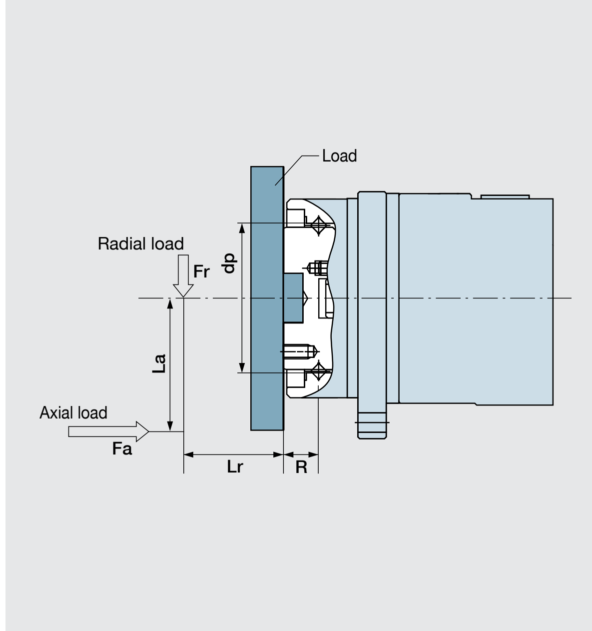
Maximum load moment load (M_{max}) is obtained as follows.
Make sure that $M_{max} \leqq Mc$.

Formula 131-1

$$M_{max} = Fr_{max}(Lr+R) + Fa_{max}\,La$$

Fr_{max}	Max. radial load	N (kgf)	See Fig. 131-1.
Fa_{max}	Max. axial load	N (kgf)	See Fig. 131-1.
Lr, La	—	m	See Fig. 131-1.
R	Offset amount	m	See Fig. 131-1. See “Specification of main bearing” of each series

Figure 131-1



How to calculate the radial load coefficient and the axial load coefficient

HPGP | HPG | CSG-GH | CSF-GH | HPF

The radial load coefficient (X) and the axial load coefficient (Y)

Formula 131-2

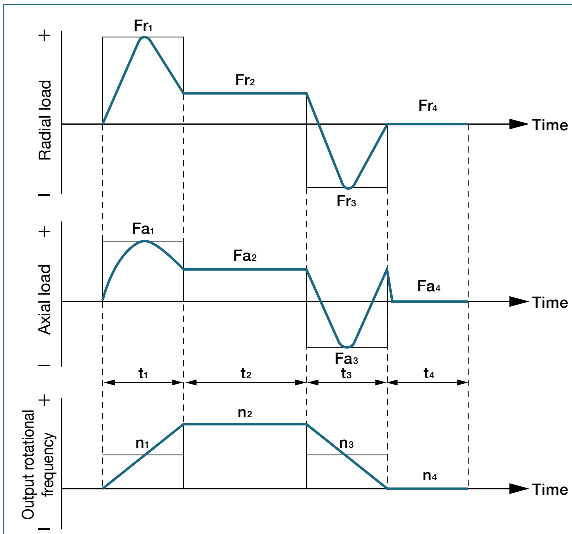
Formula	X	Y
$\frac{Fa_{av}}{Fr_{av}+2(Fr_{av}(Lr+R)+Fa_{av}\cdot La)/dp} \leqq 1.5$	1	0.45
$\frac{Fa_{av}}{Fr_{av}+2(Fr_{av}(Lr+R)+Fa_{av}\cdot La)/dp} > 1.5$	0.67	0.67

Fr_{av}	Average radial load	N (kgf)	See “How to obtain the average load.”
Fa_{av}	Average axial load	N (kgf)	See “How to obtain the average load.”
Lr, La	—	m	See Fig. 131-1.
R	Offset amount	m	See Fig. 131-1. See “Output Shaft Bearing Specifications” of each series.
dp	Circlar pitch of roller	m	See Fig. 131-1. See “Output Shaft Bearing Specifications” of each series.

How to calculate the average load (Average radial load, average axial load, average output rotational frequency)

HPGP | HPG | CSG-GH | CSF-GH | HPF

If the radial load and the axial load fluctuate, they should be converted into the average load to check the life of the cross roller bearing.



How to obtain the average radial load (Fr_{av})

Formula 131-3

$$Fr_{av} = \sqrt[10/3]{\frac{n_1t_1(|Fr_1|)^{10/3} + n_2t_2(|Fr_2|)^{10/3}\cdots n_nt_n(|Fr_n|)^{10/3}}{n_1t_1+n_2t_2+\cdots+n_nt_n}}$$

Note that the maximum radial load within the t_1 section is Fr_1 and the maximum axial load within the t_3 section is Fr_3.

How to obtain the average axial load (Fa_{av})

Formula 131-4

$$Fa_{av} = \sqrt[10/3]{\frac{n_1t_1(|Fa_1|)^{10/3} + n_2t_2(|Fa_2|)^{10/3}\cdots n_nt_n(|Fa_n|)^{10/3}}{n_1t_1+n_2t_2+\cdots+n_nt_n}}$$

Note that the maximum axial load within the t_1 section is Fr_1 and the maximum axial load within the t_3 section is Fr_3.

How to obtain the average output rotational frequency (N_{av})

Formula 131-5

$$N_{av} = \frac{n_1t_1+n_2t_2+\cdots+n_nt_n}{t_1+t_2+\cdots+t_n}$$

How to calculate the life HPGP HPG CSG-GH CSF-GH HPF

Calculate the life of the cross roller bearing using Formula 132-1. You can obtain the dynamic equivalent radial load (Pc) using Formula 132-2.

Formula 132-1

$$L_{10}=\frac{10^6}{60\times N_{av}}\times\left(\frac{C}{fw\cdot Pc}\right)^{10/3}$$

L_{10}	Life	hour	—
N_{av}	Ave. output speed	rpm	See "How to calculate the ave. load."
C	Basic dynamic rated load	N (kgf)	See "Output Bearing Specs."
Pc	Dynamic equi. radial load	N (kgf)	See Formula 132-2.
fw	Load coefficient	—	See Table 132-1.

Formula 132-2

$$Pc=X\cdot\left(Fr_{av}+\frac{2(Fr_{av}(Lr+R)+Fa_{av}\cdot La)}{dp}\right)+Y\cdot Fa_{av}$$

Fr_{av}	Average radial load	N (kgf)	See "How to calculate the ave. load."
Fa_{av}	Average axial load	N (kgf)	
dp	Circlar pitch of roller	m	See "Output Bearing Specs."
X	Radial load coefficient	-	See "How to calculate the radial load coefficient and the axial load coefficient."
Y	Axial load coefficient	-	
Lr, La	—	m	See Figure 131-1. See "External load influence diagram."
R	Offset amount	m	See Figure 131-1. See "External load influence diagram" and "Output Bearing Specs" of each series.

Load coefficient

Table 132-1

Load status	fw
During smooth operation without impact or vibration	1 to 1.2
During normal operation	1.2 to 1.5
During operation with impact or vibration	1.5 to 3

How to calculate the life during oscillating movement HPGP HPG CSG-GH CSF-GH HPF

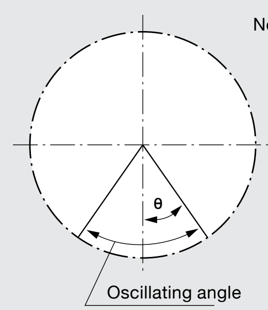
Calculate the life of the cross roller bearing during oscillating movement by Formula 132-3.

Formula 132-3

$$Loc=\frac{10^6}{60\times n1}\times\frac{90}{\theta}\times\left(\frac{C}{fw\cdot Pc}\right)^{10/3}$$

Loc	Rated life under oscillating movement	hour	-
n1	No. of reciprocating oscillation per min.	cpm	-
C	Basic dynamic rated load	N (kgf)	See "Output Bearing Specs."
Pc	Dynamic equivalent radial load	N (kgf)	See Formula 132-2.
fw	Load coefficient	—	See Table 132-1.
θ	Oscillating angle /2	Deg.	See Figure 132-1.

Figure 132-1



Note: When the oscillating angle is small (5° or less), it is difficult to generate an oil film on the contact surface of the orbit ring, and the rolling element and fretting may be generated. Contact us if this happens.

Note When it is used for a long time while the rotation speed of the output shaft is in the ultra-low operation range (0.02rpm or less), the lubrication of the bearing becomes insufficient, resulting in deterioration of the bearing or increased load in the driving side. When using it in the ultra-low operation range, contact us.

How to calculate the static safety coefficient HPGP HPG CSG-GH CSF-GH HPF

In general, the basic static rated load (Co) is considered to be the permissible limit of the static equivalent load. However, obtain the limit based on the operating and required conditions. Calculate the static safety coefficient (fs) of the cross roller bearing using Formula 132-4.
General values under the operating condition are shown in Table 132-2. You can calculate the static equivalent radial load (Po) using Formula 132-5.

Formula 132-4

$$fs=\frac{Co}{Po}$$

Co	Basic static rated load	N (kgf)	See "Output Bearing Specs."
Po	Static equivalent radial load	N (kgf)	See Formula 132-5.

Formula 132-5

$$Po=Fr_{max}+\frac{2M_{max}}{dp}+0.44Fa_{max}$$

Fr_{max}	Max. radial load	N (kgf)	See "How to calculate the max. load moment load."
Fa_{max}	Max. axial load	N (kgf)	
M_{max}	Max. load moment load	Nm (kgfm)	
dp	Circlar pitch of roller	m	See "Output Bearing Specs" of each series.

Static safety coefficient

Table 132-2

Load status	fs
When high rotation precision is required	≧3
When impact or vibration is expected	≧2
Under normal operating condition	≧1.5

Input Bearing Specifications and Checking Procedure

Check the maximum load and life of the bearing on the input side if the reducer is an HPG input shaft unit or an HPF hollow shaft unit.

Checking procedure HPG HPF

(1) Checking maximum load

Calculate:
Maximum load moment load (Mi *max*)
Maximum load axial load (Fai *max*)
Maximum load radial load (Fri *max*)

Maximum load moment load (Mi *max*) ≦ Permissible moment load (Mc)
Maximum load axial load (Fai *max*) ≦ Permissible axial load (Fac)
Maximum load radial load (Fri *max*) ≦ Permissible radial load (Frc)

(2) Checking the life

Calculate:
Average moment load (Mi *av*)
Average axial load (Fai *av*)
Average input speed (Ni *av*)

Calculate the life and check it.

Specification of input shaft bearing

The specification of the input side main bearing of the input shaft unit is shown below.

Specification of input shaft bearing HPG

Table 133-1

Size	Basic rated load			
	Basic dynamic rated load Cr		Basic static rated load Cor	
	N	kgf	N	kgf
11	2700	275	1270	129
14	5800	590	3150	320
20	9700	990	5600	570
32	22500	2300	14800	1510
50	35500	3600	25100	2560
65	51000	5200	39500	4050

Table 133-2

Size	Allowable moment load Mc		Allowable axial load Fac *1		Allowable radial load Frc *2	
	Nm	kgfm	N	kgf	N	kgf
11	0.16	0.016	245	25	20.6	2.1
14	6.3	0.64	657	67	500	51
20	13.5	1.38	1206	123	902	92
32	44.4	4.53	3285	335	1970	201
50	96.9	9.88	5540	565	3226	329
65	210	21.4	8600	878	5267	537

Specification of input shaft bearing HPF

Table 133-3

Size	Basic rated load			
	Basic dynamic rated load Cr		Basic static rated load Cor	
	N	kgf	N	kgf
25	14500	1480	10100	1030
32	29700	3030	20100	2050

Table 133-4

Size	Allowable moment load Mc		Allowable axial load Fac *1		Allowable radial load Frc *3	
	Nm	kgfm	N	kgf	N	kgf
25	10	1.02	1538	157	522	53.2
32	19	1.93	3263	333	966	98.5

(Note: Table 133-2 and 133-4)
*1 The allowable axial load is the tolerance of an axial load applied to the shaft center.
*2 The allowable radial load of HPG series is the tolerance of a radial load applied to the shaft length center.
*3 The allowable radial load of HPG series is the tolerance of a radial load applied to the point of 20 mm from the shaft edge (input flange edge).

Calculating maximum load moment load to input shaft

HPG HPF

The maximum load moment load (Mi_{max}) is calculated as follows.
Check that the following formulas are established in all circumstances:

Formula 134-1

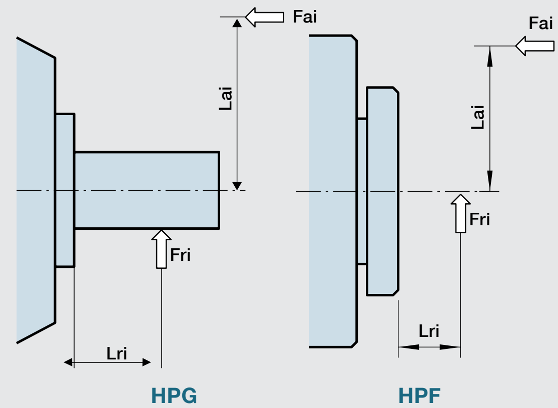
$$Mi_{max} = Fri_{max} \cdot Lri + Fai_{max} \cdot Lai$$

Fri_{max}	Max. radial load	N (kgf)	See Fig. 134-1.
Fai_{max}	Max. axial load	N (kgf)	See Fig. 134-1.
Lri,Lai	————	m	See Fig. 134-1.

$Mi_{max} \leqq Mc$ (Permissible moment load)
$Fai_{max} \leqq Fac$ (Permissible axial load)

Figure 134-1

External load influence diagram

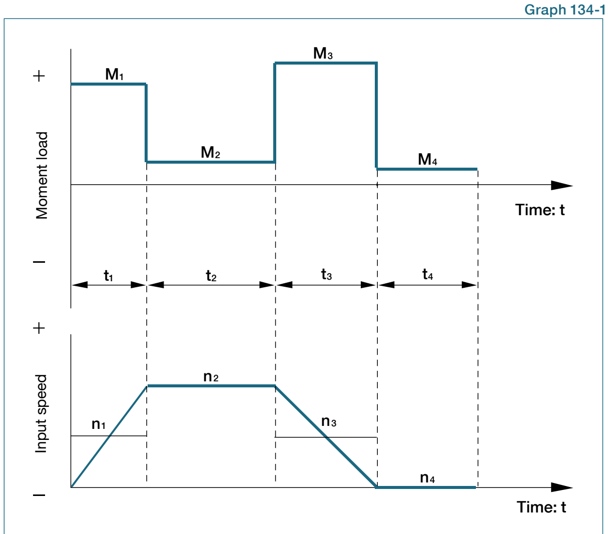


How to calculate average load
(Average moment load, average axial load, average input rotational frequency)

HPG HPF

If moment load and axial load fluctuate, they should be converted into the average load to check the life of the bearing.

Graph 134-1



How to calculate the average moment load (Mi_{av})

Formula 134-2

$$Mi_{av} = \sqrt[3]{\frac{n_1 t_1 (|Mi_1|)^3 + n_2 t_2 (|Mi_2|)^3 \cdots n_n t_n (|Mi_n|)^3}{n_1 t_1 + n_2 t_2 + \cdots + n_n t_n}}$$

How to calculate the average axial load (Fai_{av})

Formula 134-3

$$Fai_{av} = \sqrt[3]{\frac{n_1 t_1 (|Fai_1|)^3 + n_2 t_2 (|Fai_2|)^3 \cdots n_n t_n (|Fai_n|)^3}{n_1 t_1 + n_2 t_2 + \cdots + n_n t_n}}$$

How to calculate the average output rotational frequency (Ni_{av})

Formula 134-4

$$Ni_{av} = \frac{n_1 t_1 + n_2 t_2 + \cdots + n_n t_n}{t_1 + t_2 + \cdots + t_n}$$

Calculating life of input side bearing

Calculate the bearing life according to Calculation Formula 132-5 and check the life.

Formula 134-5

$$L_{10} = \frac{10^6}{60 \times Ni_{av}} \times \left(\frac{Cr}{Pci}\right)^3$$

L_{10}	Life	Hour	—
Ni_{av}	Average input rotational speed	rpm	See Formula 134-4
Cr	Basic dynamic rated load	N (kgf)	See Table 133-1 and -3
Pci	Dynamic equivalent radial load	N	See Table 134-1 and -2

Dynamic equivalent radial load HPG

Table 134-1

Size	Pci
11	$0.444 \times Mi_{av} + 1.426 \times Fai_{av}$
14	$0.137 \times Mi_{av} + 1.232 \times Fai_{av}$
20	$0.109 \times Mi_{av} + 1.232 \times Fai_{av}$
32	$0.071 \times Mi_{av} + 1.232 \times Fai_{av}$
50	$0.053 \times Mi_{av} + 1.232 \times Fai_{av}$
65	$0.041 \times Mi_{av} + 1.232 \times Fai_{av}$

Dynamic equivalent radial load HPF

Table 134-2

Size	Pci
25	$121 \times Mi_{av} + 2.7 \times Fai_{av}$
32	$106 \times Mi_{av} + 2.7 \times Fai_{av}$

Mi_{av} Average moment load Nm (kgfm) See Formula 134-2
Fai_{av} Average axial load N (kgf) See Formula 134-3

Assembly

Assemble and mount your gearhead in accordance with these instructions to achieve the best performance.
Be sure to use the recommended bolts and use a torque wrench to achieve the proper tightening torques as recommended in tables below.

Motor assembly procedure

HPGP HPG CSG-GH CSF-GH HPN

To properly mount the motor to the gearhead, follow the procedure outlined below, refer to figure 135-1

(1) Turn the input shaft coupling and align the bolt head with the rubber cap hole.

(2) For HPG/HPGP/HPN series, apply a sealant to the surface of the motor flange that will contact the gearhead mounting flange. (Recommended sealant: LOCTITE 515)

(3) With the speed reducer in an upright position as illustrated in the figure below, slowly insert the motor shaft into the coupling of speed reducer. Slide the motor shaft into the input shaft coupling by guiding the motor shaft into it without letting it drop down. If the speed reducer cannot be positioned upright, slowly insert the motor shaft into the coupling of speed reducer, then tighten the motor bolts evenly (little by little) until the motor flange and gearhead flange are in full contact. Exercise care to avoid tilting the motor when inserting it into the gear head.

(4) Tighten the input shaft coupling bolt to the recommended torque specified in the table below. The bolt(s) or screw(s) is (are) already inserted into the input shaft coupling when delivered. Check the bolt size on the confirmation drawing provided.

Bolt tightening torque

Table 135-1

Bolt size		M3	M4	M5	M6	M8	M10	M12
Tightening torque	Nm	2.0	4.5	9.0	15.3	37.2	73.5	128
	kgfm	0.20	0.46	0.92	1.56	3.8	7.5	13.1

Caution: Always tighten the bolts to the tightening torque specified in the table above. If the bolt is not tightened to the torque value recommended slippage of the motor shaft in the shaft coupling may result. The bolt size will vary depending on the size of the gear and the shaft diameter of the mounted motor. Check the bolt size on the confirmation drawing provided.

Two setscrews need to be tightened on size 11. See the outline dimensions on page 22 (HPGP) and page 34 (HPG) for size 11. Tighten the screws to the tightening torque specified below.

Table 135-2

Bolt size		M3
Tightening torque	Nm	0.69
	kgfm	0.07

(5) Fasten the motor to the gearhead flange with bolts.

Bolt* tightening torque

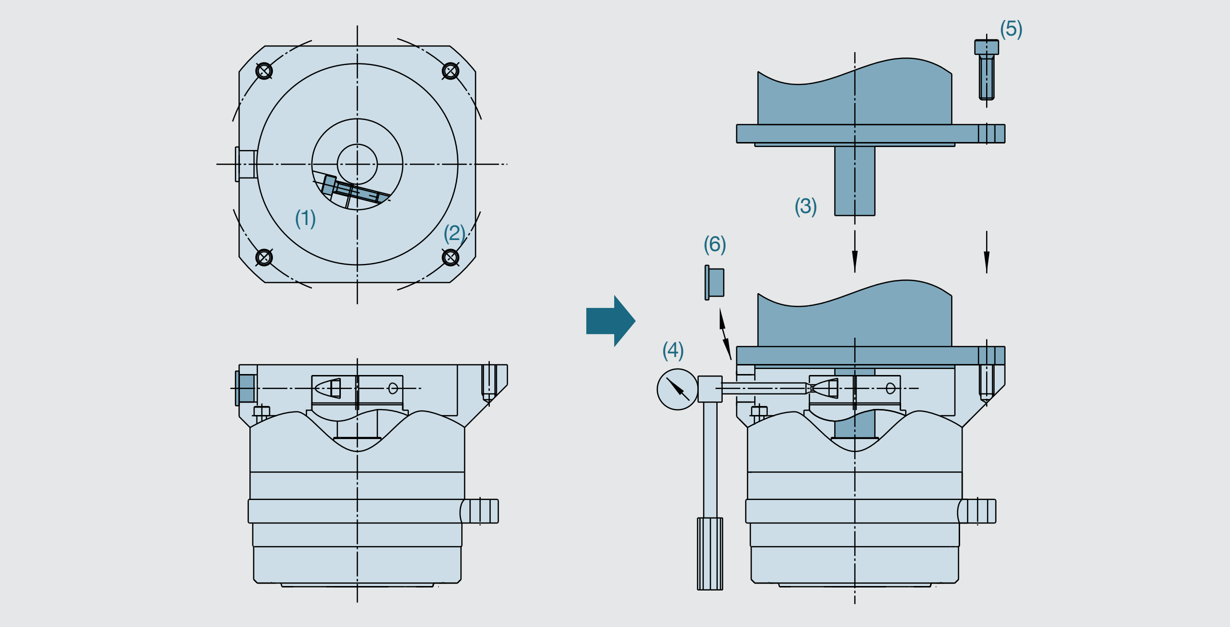
Table 135-3

Bolt size		M2.5	M3	M4	M5	M6	M8	M10	M12
Tightening torque	Nm	0.59	1.4	3.2	6.3	10.7	26.1	51.5	89.9
	kgfm	0.06	0.14	0.32	0.64	1.09	2.66	5.25	9.17

∗Recommended bolt: JIS B 1176 Hexagon socket head bolt, Strength: JIS B 1051 12.9 or higher
Caution: Be sure to tighten the bolts to the tightening torques specified in the table.

(6) Insert the rubber cap provided. This completes the assembly. (Size 11: Fasten screws with a gasket in two places)

Figure 135-1



Technical Information / Handling Explanation

Speed reducer assembly

HPGP HPG CSG-GH CSF-GH HPF HPN

Some right angle gearhead models weigh as much as 60 kg. No thread for an eyebolt is provided because the mounting orientation varies depending on the customer's need. When mounting the reducer, hoist it using a sling paying extreme attention to safety.
When assembling gearheads into your equipment, check the flatness of your mounting surface and look for any burrs on tapped holes. Then fasten the flange (Part A in the diagram below) using appropriate bolts.

Bolt* tightening torque for flange (Part A in the diagram below)

Table 136-1

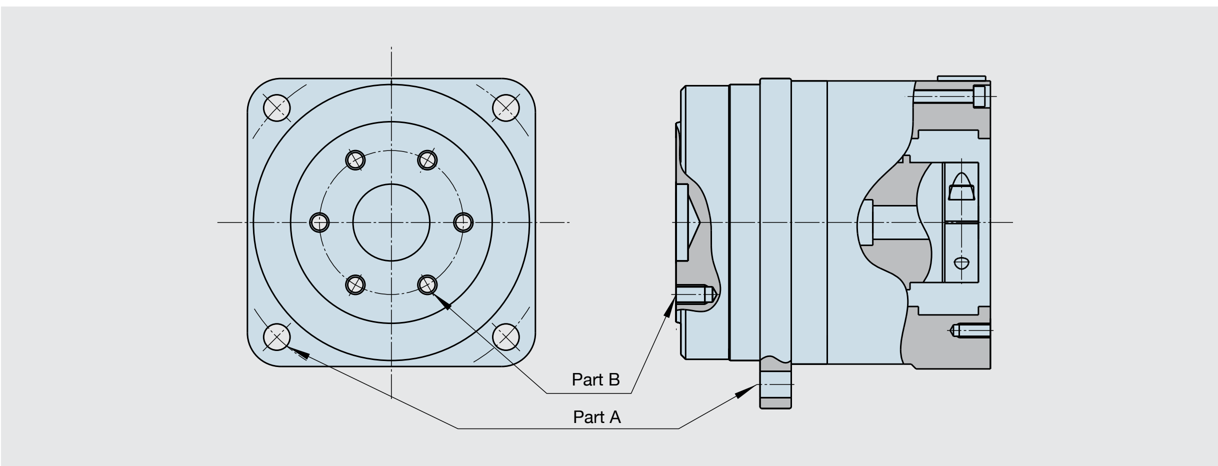
Size		HPN					HPGP / HPG / CSG-GH / CSF-GH						HPF	
		11	14	20	32	40	11	14	20	32	45/50	65	25	32
Number of bolts		4	4	4	4	4	4	4	4	4	4	4	12	12
Bolt size		M3	M5	M6	M8	M10	M3	M5	M8	M10	M12	M16	M4	M5
Mounting PCD	mm	50	70	100	130	165	46	70	105	135	190	260	127	157
Tightening torque	Nm	1.4	6.3	10.7	26.1	51.5	1.4	6.3	26.1	51.5	103	255	4.5	9.0
	kgfm	0.14	0.64	1.09	2.66	5.26	0.14	0.64	2.66	5.25	10.5	26.0	0.46	0.92
Transfer torque	Nm	27.9	110	223	528	1063	26.3	110	428	868	2030	5180	531	1060
	kgfm	2.85	11.3	22.8	53.9	108.5	2.69	11.3	43.6	88.6	207	528	54.2	108

* Recommended bolts: JIS B 1176 "Hexagon socket head bolts." Strength classification 12.9 or higher in JIS B 1051.

Mounting the load to the output flange

Follow the specifications in the table below when mounting the load onto the output flange.

Figure 136-1



Output flange mounting specifications

Bolt* tightening torque for output flange (Part B in the Figure 136-1) HPGP

Table 136-2

Size		11	14	20	32	50	65
Number of bolts		4	8	8	8	8	8
Bolt size		M4	M4	M6	M8	M12	M16
Mounting PCD	mm	18	30	45	60	90	120
Tightening torque	Nm	4.5	4.5	15.3	37.2	128.4	319
	kgfm	0.46	0.46	1.56	3.8	13.1	32.5
Transmission torque	Nm	25.3	84	286	697	2407	5972
	kgfm	2.58	8.6	29.2	71.2	245	609

* Recommended bolts: JIS B 1176 "Hexagon socket head bolts." Strength classification 12.9 or higher in JIS B 1051.

Bolt* tightening torque for output flange (Part B in the Figure 136-1) HPG

Table 136-3

Size		11	14	20	32	50	65
Number of bolts		3	6	6	6	14	6
Bolt size		M4	M4	M6	M8	M8	M16
Mounting PCD	mm	18	30	45	60	100	120
Tightening torque	Nm	4.5	4.5	15.3	37.2	37.2	319
	kgfm	0.46	0.46	1.56	3.8	3.80	32.5
Transmission torque	Nm	19.0	63	215	524	2036	4480
	kgfm	1.9	6.5	21.9	53.4	207.8	457

* Recommended bolts: JIS B 1176 "Hexagon socket head bolts." Strength classification 12.9 or higher in JIS B 1051.

Mounting the load to the output flange

Bolt* tightening torque for output flange (Part B in Figure 136-1) CSG-GH

Table 137-1

Size		14	20	32	45	65
Number of bolts		8	8	10	10	10
Bolt size		M4	M6	M8	M12	M16
Mounting PCD	mm	30	45	60	94	120
Tightening torque	Nm	4.5	15.3	37	128	319
	kgfm	0.46	1.56	3.8	3.1	32.5
Transmission torque	Nm	84	287	867	3067	7477
	kgfm	8.6	29.3	88.5	313	763

Bolt* tightening torque for output flange (Part B in Figure 136-1) CSF-GH

Table 137-2

Size		14	20	32	45	65
Number of bolts		6	6	6	16	8
Bolt size		M4	M6	M8	M8	M16
Mounting PCD	mm	30	45	60	100	120
Tightening torque	Nm	4.5	15.3	37.2	37.2	319
	kgfm	0.46	1.56	3.80	3.80	32.5
Transmission torque	Nm	63	215	524	2326	5981
	kgfm	6.5	21.9	53.4	237	610

Bolt* tightening torque for output flange (Part B in Figure 136-1) HPF

Table 137-3

Size		25	32
Number of bolts		12	12
Bolt size		M4	M5
Mounting PCD	mm	77	100
Tightening torque	Nm	4.5	9.0
	kgfm	0.46	0.92
Transmission torque	Nm	322	675
	kgfm	32.9	68.9

* Recommended bolts: JIS B 1176 "Hexagon socket head bolts." Strength classification 12.9 or higher in JIS B 1051.

Gearheads with an output shaft

HPN HPG HPGP CSG-GH CSF-GH HPF

**Do not subject the output shaft to any impact when mounting a pulley, pinion or other parts.
An impact to the the output bearing will deteriorate the speed reducer precision and may cause reduced life or failure.**

Mechanical Tolerances

Superior mechanical precision is achieved by integrating the output flange with a high-precision cross roller bearing as a single component. The mechanical tolerances of the output shaft and mounting flange are specified below.

Figure 138-1

Output Flange: F0 (flange)

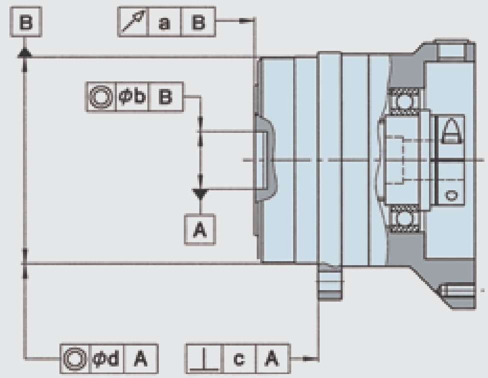
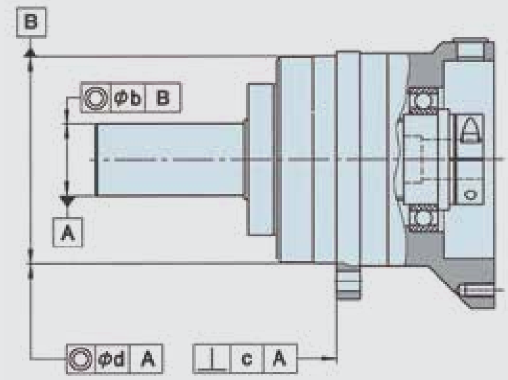


Figure 138-2

Output shaft: J2 [J20], J6 [J60] (shaft output)



HPGP HPG CSG-GH CSF-GH

Table 138-1

Size	Axial runout of output flange a	Radial runout of output flange pilot or output shaft b	Perpendicularity of mounting flange c	Concentricity of mounting flange d
11	0.020	0.030	0.050	0.040
14	0.020	0.040	0.060	0.050
20	0.020	0.040	0.060	0.050
32	0.020	0.040	0.060	0.050

HPGP HPG

Table 138-2

50	0.020	0.040	0.060	0.050
65	0.040	0.060	0.090	0.080

CSG-GH CSF-GH

Table 138-3

45	0.020	0.040	0.060	0.050
65	0.020	0.040	0.060	0.050

HPF

Table 138-4

25	0.020	0.040	0.060	0.050
32	0.020	0.040	0.060	0.050

* T.I.R.: Total indicator reading

(T.I.R.* Unit: mm)

Lubrication

Prevention of grease and oil leakage

(Common to all models)

- Only use the recommended greases.
- Provisions for proper sealing to prevent grease leakage are incorporated into the gearheads. However, please note that some leakage may occur depending on the application or operating condition. Discuss other sealing options with our applications engineers.
- When mounting the gearhead horizontally position the gearhead so the rubber cap in the adapter flange is facing upwards.

(CSG/CSF-GH Series)

- Contact us when using HarmonicDrive® CSG/CSF-GH series with the output shaft facing downward (motor on top) at a constant load or rotating continuously in one direction.

Sealing

(Common to all models)

- Provisions for proper sealing to prevent grease leakage from the input shaft are incorporated into the gearhead.
- A double lip Teflon oil seal is used for the output shaft (HPGP/HPG uses a single lip seal), gaskets or o-rings are used on all mating surfaces, and non contact shielded bearing are used for the motor shaft coupling (Double sealed bearings (DDU type) are available as an option*) . On the CSG/CSF-GH series, non contact shielded bearing and a Teflon oil seal with a spring is used.

* DDU type: Bearing with a rubber contact seal on both sides

(HPG/HPGP/HPF/HPN Series)

- Using the doubled sealed bearing (DDU type) for the HPGP/HPG series gearhead will result in a slightly lower efficiency compared to the standard product.
- An oil seal without a spring is used in the input shaft side of HPG series with an input shaft (HPG-1U) and HPF series hollow shaft reducer. An option for an oil seal with a spring is available for improved seal reliability, however, the efficiency will be slightly lower (available for HPF and HPG series for sizes 14 and larger).
- Do not remove the screw plug and seal cap of the HPG series right angle gearhead. Removing them may cause leakage of grease or affect the precision of the gear.

Lubricant

HPG/HPGP/HPF/HPN Series

The standard lubrication for the HPG/HPGP/HPF/HPN series gearheads is grease.
All gearheads are lubricated at the factory prior to shipment and additional application of grease during assembly is not required.
The gearheads are lubricated for the life of the gear and do not require re-lubrication.
High efficiency is achieved through the unique planetary gear design and grease selection .

Lubricants

Harmonic Grease SK-2 (HPGP/HPG-14, 20, 32)
Manufacturer: Harmonic Drive Systems Inc.

Base oil: Refined mineral oil	Consistency: 265 to 295 at 25°C
Soap radical: Lithium soap	Dropping point: 198°C
Additive: Extreme pressure agent and other	Product appearance: Green
Standard: NLGI No. 2	

EPNOC Grease AP (N) 2 (HPGP/HPG-11, 50, 65／HPF-25, 32)
Manufacturer: Nippon Oil Co.

Base oil: Refined mineral oil	Consistency: 282 at 25°C
Soap radical: Lithium soap	Dropping point: 200°C
Additive: Extreme pressure agent and other	Product appearance: Light brown
Standard: NLGI No. 2	

PYRONOC UNIVERSAL 00 (HPG right angle gearhead/HPN)
Manufacturer: Nippon Oil Co.

Base oil: Refined mineral oil	Consistency: 420 at 25°C
Soap radical: Urea	Dropping point: 250°C or higher
Standard: NLGI No. 00	Product appearance: Light yellow

Ambient operating temperature range: –10°C to +40°C

The lubricant may deteriorate if the ambient operating temperature is too high or too low. Please contact our sales office or distributor for operation outside of the ambient operating temperature range.
The temperature rise of the gear depends upon the operating cycle, ambient temperature and heat conduction and radiation as affected by the customers installation of the gear. A housing surface temperature of 70°C is the maximum allowable limit.

CSG-GH/CSF-GH Series

The standard lubrication for the CGS-GH / CSF-GH series gearheads is grease.
All gearheads are lubricated at the factory prior to shipment and additional application of grease during assembly is not necessary.

Lubricants

Harmonic Grease SK-1A (Size 20, 32, 45, 65)
Manufacturer: Harmonic Drive Systems Inc.
This has been developed exclusively for HarmonicDrive® gears and is excellent in durability and efficiency compared to commercial general-purpose grease.

Base oil: Refined mineral oil
Soap radical: Lithium soap
Additive: Extreme pressure agent and other
Standard: NLGI No. 2
Consistency: 265 to 295 at 25°C
Dropping point: 197°C
Product appearance: Yellow

Harmonic Grease SK-2 (Size 14)
Manufacturer: Harmonic Drive Systems Inc.
This has been developed exclusively for smaller sized HarmonicDrive® gears and allows smooth wave generator rotation.

Base oil: Refined mineral oil
Soap radical: Lithium soap
Additive: Extreme pressure agent and other
Standard: NLGI No. 2
Consistency: 265 to 295 at 25°C
Dropping point: 198°C
Product appearance: Green

Ambient operating temperature range: –10°C to +40°C

The lubricant may deteriorate if the ambient operating temperature is too high or too low. Please contact our sales office or distributor for operation outside of the ambient operating temperature range.
The temperature rise of the gear depends upon the operating cycle, ambient temperature and heat conduction and radiation as affected by the customers installation of the gear. A housing surface temperature of 70°C is the maximum allowable limit.

When to change the grease

The life of the Harmonic Drive® gear is affected by the grease performance. The grease performance varies with temperature and deteriorates with temperatures. Therefore, the grease will need to be changed sooner than usual when operating at higher temperatures. The graph on the right indicates when to change the grease based upon the temperature and the total number of input rotations when the average load torque is less than or equal to the rated output torque at 2000 rpm. Also, using the formula below, you can calculate when to change the grease when the average load torque exceeds the rated output torque at 2000 rpm.

Formula to calculate the grease change interval when the average load torque exceeds the rated torque

Formula 140-1

$$L_{GT} = L_{GTn} \times \left(\frac{Tr}{Tav} \right)^3$$

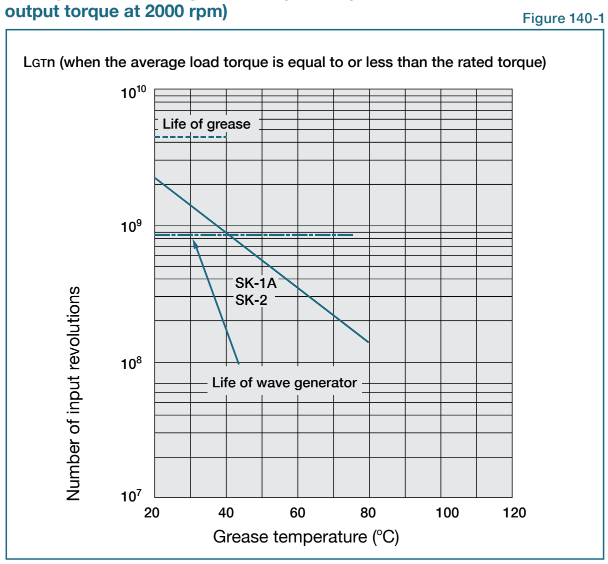
Formula symbols

Table 140-1

L_{GT}	Grease change interval when Tav > Tr	Input rotations	————
L_{GTn}	Grease change interval when Tav <= Tr	Input rotations	See Graph 140-1
Tr	Output torque at 2000 rpm	Nm, kgfm	See the "Rating table" on pages 067 & 077.
T_{av}	Average load torque	Nm, kgfm	Calculation formula: See page 090.

When to change the grease: LGTn (when the average load torque is equal to or less than the rated output torque at 2000 rpm)

Figure 140-1



* L10 Life of wave generator bearing

Grease quantity for Reference value of grease refill amount for replacement

Table 140-2

Size	14	20	32	45	65
Amount: g	0.8	3.2	6.6	11.6	78.6

Precautions when changing the grease

Strictly observe the following instructions when changing the grease to avoid problems such as grease leakage or increase in running torque.

- **Note that the amount of grease listed in Table 140-2 is the amount used to lubricate the gear at assembly. This should be used as a reference. Do not exceed this amount when re-greasing the gearhead.**
- **Remove grease from the gearhead and refill it with the same quantity. The adverse effects listed above normally do not occur until the gear has been re-greased 2 times. When re-greasing 3 times or more, it is essential to remove grease (using air pressure or other means) before re-lubricating with the same amount of grease that was removed.**

Warranty

Please contact us or visit our website at www.harmonicdrive.net for warranty details for your specific product.

All efforts have been made to ensure that the information in this catalog is complete and accurate. However, Harmonic Drive LLC is not liable for any errors, omissions or inaccuracies in the reported data. Harmonic Drive LLC reserves the right to change the product specifications, for any reason, without prior notice. For complete details please refer to our current Terms and Conditions posted on our website.

Disposal

When disposing of the product, disassemble it and sort the component parts by material type and dispose of the parts as industrial waste in accordance with the applicable laws and regulations. The component part materials can be classified into three categories.

(1) Rubber parts: Oil seals, seal packings, rubber caps, seals of shielded bearings on input side (DDU type only)
(2) Aluminum parts: Housings, motor flanges
(3) Steel parts: Other parts

Trademark

HarmonicDrive® is a registered trademark of Harmonic Drive LLC.
HarmonicPlanetary® is a registered trademark of Harmonic Drive LLC.

Safety

⚠ Warning : Means that improper use or handling could result in a risk of death or serious injury.

⚠ Caution : Means that improper use or handling could result in personal injury or damage to property.

Limited Applications

This product cannot be used for the following applications:

* Space flight hardware
* Vacuum environments
* Equipment for transport of humans
* Aircraft equipment
* Automotive equipment
* Nuclear power equipment
* Personal recreation equipment
* Equipment for use in a special environment
* Equipment and apparatus used in domestic homes
* Equipment that directly works on human bodies
* Medical equipment

Please consult Harmonic Drive LLC beforehand if intending to use one of our product for the aforementioned applications.
Fail-safe devices that prevent an accident must be designed into the equipment when the products are used in any equipment that could result in personal injury or damage to property in the event of product failure.

Design Precaution: Be certain to read the catalog when designing the equipment.

Caution

Use only in the proper environment.
- Please ensure to comply with the following environmental conditions:
  - Ambient temperature 0 to 40˚C
  - No splashing of water or oil
  - Do not expose to corrosive or explosive gas
  - No dust such as metal powder

Caution

Install the equipment properly.
- Carry out the assembly and installation precisely as specified in the catalog.
- Observe our recommended fastening methods (including bolts used and tightening torques).
- Operating the equipment without precise assembly can cause problems such as vibration, reduction in life, deterioration of precision and product failure.

Caution

Install the equipment with the required precision.
- Design and assemble parts to keep all catalog recommended tolerances for installation.
- Failure to hold the recommended tolerances can cause problems such as vibration, reduction in life, deterioration of precision and product failure.

Caution

Use the specified lubricant.
- Using other than our recommended lubricant can reduce the life of the product. Replace the lubricant as recommended.
- Gearheads are factory lubricated. Do not mix installed lubricant with other kinds of grease.

Operational Precaution: Be certain to read the catalog before operating the equipment.

Caution

Use caution when handling the product and parts.
- Do not hit the gear or any part with a hammer.
- If you use the equipment in a damaged condition, the gearhead may not perform to catalog specifications. It can also cause problems including product failure.

Caution

Operate within the allowable torque range.
- Do not apply torque exceeding the momentary peak torque. Applying excess torque can cause problems such as loosened bolts, generation of backlash and product failure.
- An arm attached directly to the output shaft that strikes a solid object can damage the arm or cause the output of the gearhead to fail.

Caution

Do not alter or disassemble the product or parts.
- Harmonic Planetary® and Harmonic Drive® products are manufactured as matched sets. Catalog rated performance may not be achieved if the component parts are interchanged.

Caution

Do not disassemble the products.
- Do not disassemble and reassemble the products. Original performance may not be achieved.

Warning

Do not use your finger to turn the gear.
- Do not insert your finger into the gear under any circumstances. The finger may get caught in the gear causing an injury.

Warning

Large model Nos. (45, 50 and 65) are heavy. Use caution when handling.
- They are heavy and may cause a lower-back injury or an injury if dropped on a hand or foot. Wear protective shoes and back support when handling the product.

Caution

Stop operating the system if any abnormality occurs.
- Shut down the system promptly if any abnormal sound or vibration is detected, the rotation has stopped, an abnormally high temperature is generated, an abnormal motor current value is observed or any other anomalies are detected. Continuing to operate the system without stopping may adversely affect the product or equipment.
- Please contact our sales office or distributor if any anomaly is detected.

Caution

- Rust-proofing was applied before shipping. However, please note that rusting may occur depending on the customers' storage environment.
- Although black oxide finish is applied to some of our products, it does not guarantee that rust will not form.

Handling Lubricant

Warning

Precautions on handling lubricants
- Lubricant in the eye can cause inflammation. Wear protective glasses to prevent it from getting in your eye.
- Lubricant coming in contact with the skin can cause inflammation. Wear protective gloves when you handle the lubricant to prevent it from contacting your skin.
- Do not eat it (to avoid diarrhea and vomiting).
- Use caution when opening the container. There may be sharp edges that can cut your hand. Wear protective gloves.
- Keep lubricant out of reach of children.

Warning

First-aid
- Inhalation: Remove exposed person to fresh air if adverse effects are observed.
- Ingestion: Seek immediate medical attention and do not induce vomiting unless directed by medical personnel.
- Eye: Flush immediately with water for at least 15 minutes. Get immediate medical attention.
- Skin: Wash with soap and water. Get medical attention if irritation develops.

Caution

Disposal of waste oil and containers
- Follow all applicable laws regarding waste disposal. Contact your distributor if you are unsure how to properly dispose of the material.
- Do not apply pressure tn an empty container. The container may blow up.
- Do not weld, heat, drill or cut the container. This may cause residual oil to ignite or cause an explosion.

Caution

Storage
- Tightly seal the container after use. Store in a cool, dry, dark place. Keep away from open flames and high temperatures.

Disposal

Caution

Please dispose as industrial waste.
- Please dispose of the products as industrial waste when their useful life is over.

NOTES

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Major Applications of Our Products

Metal Working Machines

Processing Machine Tools

Measurement, Analytical and Test Systems

Medical Equipment

Telescopes

Source: National observatory of Inter-University Research Institute Corporation

Energy

Courtesy of Haliiburton/Sperry Drilling Services

Crating and Packaging Machines

Communication Equipment

Space Flight Hardware

Rover image created by Dan Maas, copyrighted to Cornell and provided courtesy NASA/ JPL-Caltech.

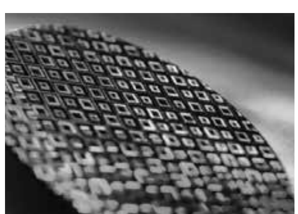
Glass and Ceramic Manufacturing Systems

Robots

Humanoid Robots

Source: Honda Motor Co., Ltd.

Printing, Bookbinding and Paper Machines



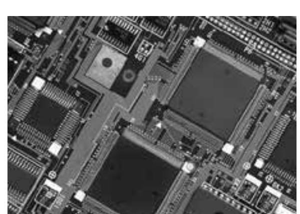
Semiconductor Manufacturing Equip.

Optical Equipment

Machine Tools

Paper-making Machines

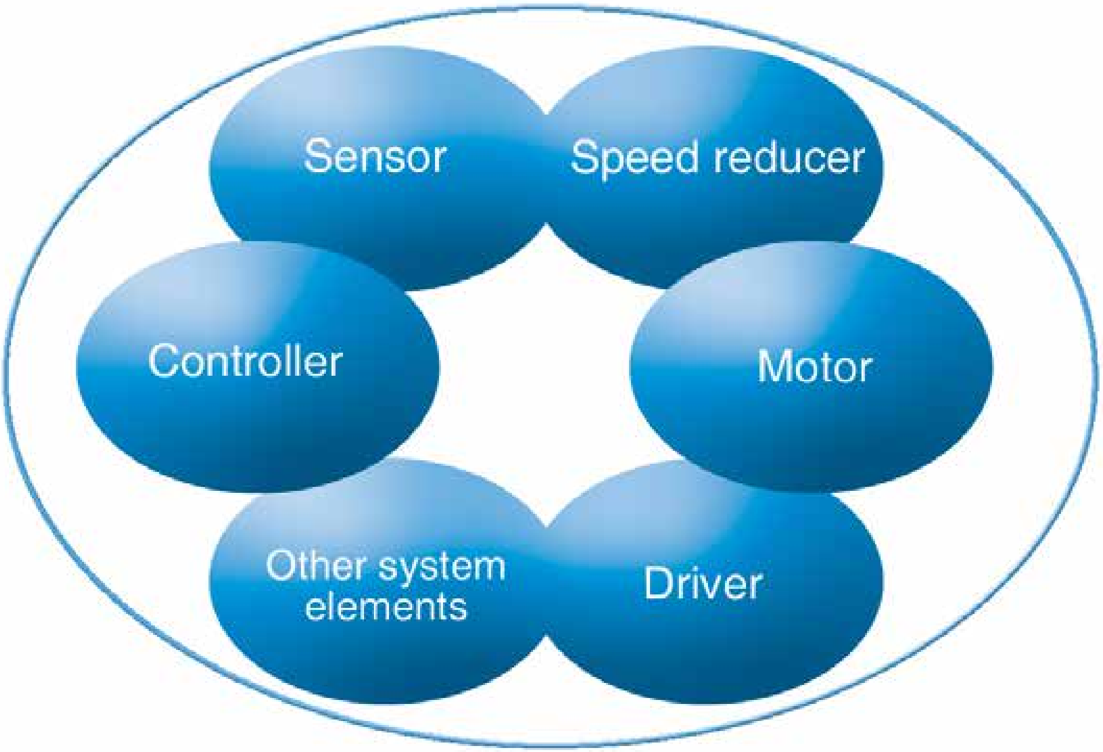
Flat Panel Display Manufacturing Equip.



Printed Circuit Board Manufacturing Machines

Aerospace

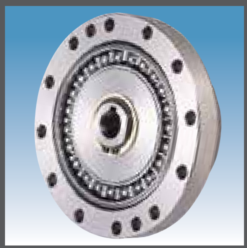
Experts in Precision Motion Control



Other Products

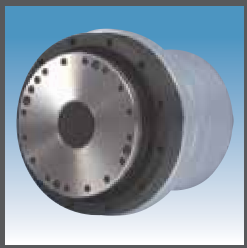
HarmonicDrive® Gearing

HarmonicDrive® speed reducer delivers precise motion control by utilizing the strain wave gearing principle.



Rotary Actuators

High-torque actuators combine performance matched servomotors with Harmonic Drive® gears to deliver excellent dynamic control characteristics.



Linear Actuators

Compact linear actuators combine a precision lead screw and HarmonicDrive® gear. Our versatile actuators deliver both ultra precise positioning and high torque.

CSF Mini Gearheads

CSF mini gearheads provide high positioning accuracy in a super-compact package.

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Rev 03-03-15