HarmonicGearhead®

HARMONIC DRIVE®

High-Performance Gearheads for Servo and Stepper Motors

HarmonicPlanetary®

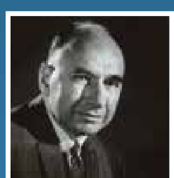
HPGP / HPG / HPN / HPF / NEW HPG Helical

HarmonicDrive®

CSG-GH / CSF-GH

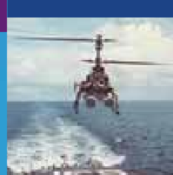
Revolutionary Technology for Evolving Industries

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

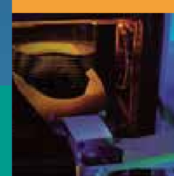
Photo credit: NASA

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

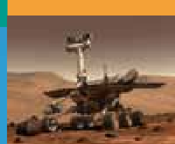
Market introduction of high-precision HPG Harmonic Planetary® gearheads with low backlash for life

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

2015

2015 DARPA Robotics Challenge

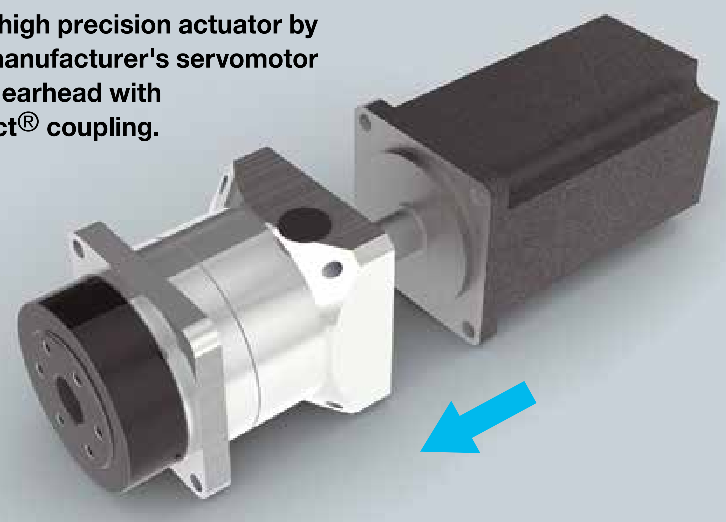
Innovative High Performance Gearheads for Servomotors

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.



CONTENTS

Product Line

Quick Connect Gearheads

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

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 Helical Series
(Peak torque 5Nm to 400Nm)

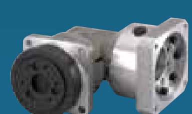
New Two-Stage Ratios Coming Soon!

NEW

Size	Outline Dimension (mm)	Reduction ratio*1	Backlash*2		Motor power
			Standard	Reduced	
11	□40	4, 5, 6, 7, 8, 9, 10	≤ 3 arc-min	n/a	10W ~ 100W
14	□ 60	3, 4, 5, 6, 7, 8, 9,10	≤ 3 arc-min	≤ 1 arc-min	30W ~ 3.5kW
20	□ 90	3, 4, 5, 6, 7, 8, 9,10	≤ 3 arc-min	≤ 1 arc-min	500W ~ 10kW
32	□120	3, 4, 5, 6, 7, 8, 9,10	≤ 3 arc-min	≤ 1 arc-min	1.3kW ~ 15kW

*1 New ratios coming soon: 15, 20, 25, 30, 40, 45, 50. *2 For details of repeatability and transmission accuracy, refer to HPG performance table on page 44.

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 55.

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

New Two-Stage Ratios Coming Soon!

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. New ratios coming soon: 15, 20, 25, 30, 40, 45, 50.

HarmonicDrive®
CSG-GH High Torque Series
(Peak torque 23Nm to 3419Nm)
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~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 78.

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 88.

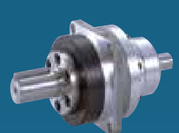
HarmonicPlanetary® Gear Units

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

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

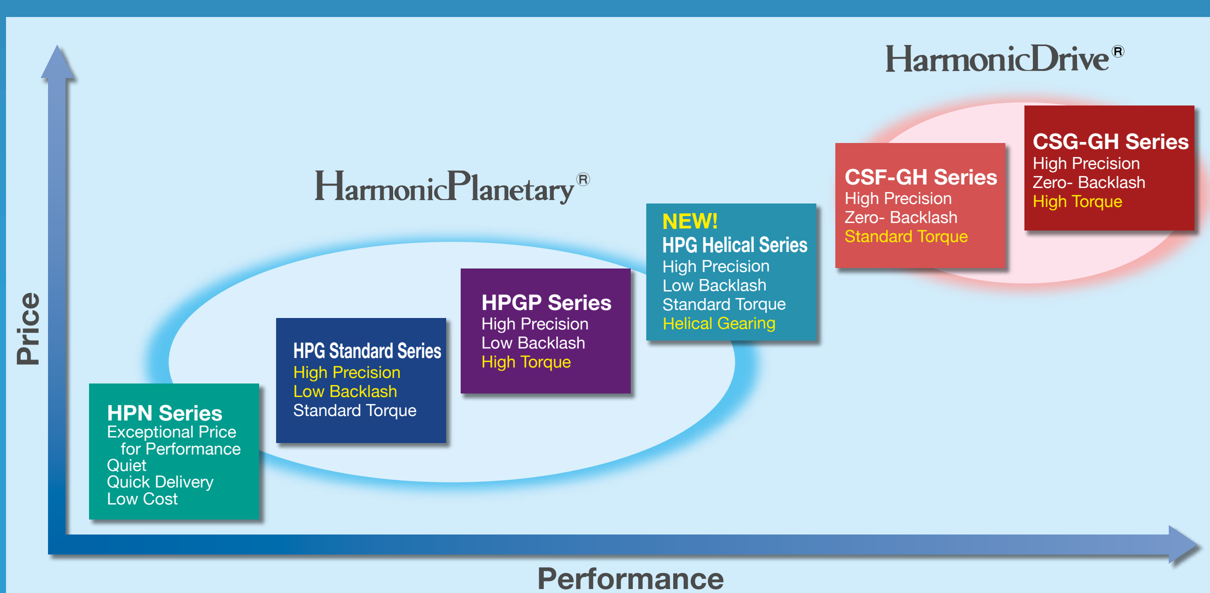
*1 For details of repeatability and transmission accuracy, refer to HPF Hollw shaft performance table on page 105.

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



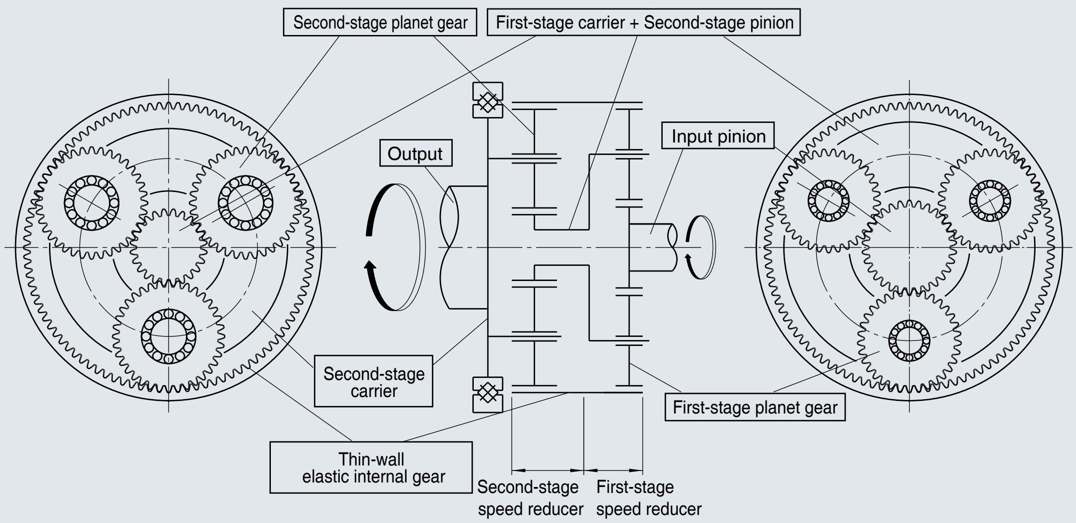
Size	Outline Dimension (mm)	Reduction ratio	Backlash*1 Standard	Backlash*1 Reduced
11	□40	5, 9, 21, 37, 45	≤ 3 arc-min	n/a
14, 20, 32	□60, □90, □120	3, 5, 11, 15, 21, 33, 45	≤ 3 arc-min	≤ 1 arc-min
50	□170		≤ 3 arc-min	≤ 1 arc-min
65	□230	4, 5, 12, 15, 20, 25, 40, 50	≤ 3 arc-min	≤ 1 arc-min

*1 For details of repeatability and transmission accuracy, refer to HPG Input shaft performance table on page 112.



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.

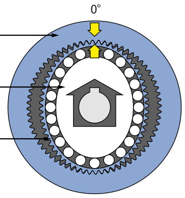
Operating Principle HarmonicDrive® Gearheads

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.

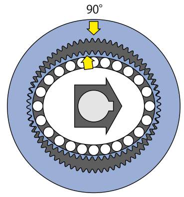
Wave Generator
The Wave Generator is a thin raced ball bearing fitted onto an elliptical hub. This serves as a high efficiency torque converter and is generally mounted onto the input or motor shaft.

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.

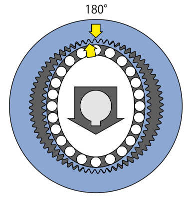
Circular Spline
The Circular Spline is a rigid ring with internal teeth. It engages the teeth of the Flexspline across the major axis of the Wave Generator ellipse. The Circular Spline has two more teeth than the Flexspline and is generally mounted onto a housing.



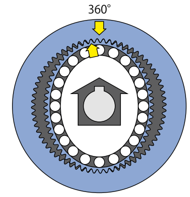
The Flexspline is slightly smaller in diameter than the Circular Spline and usually has two fewer teeth than the Circular Spline. The elliptical shape of the Wave Generator causes the teeth of the Flexspline to engage the Circular Spline at two opposite regions across the major axis of the ellipse.



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.

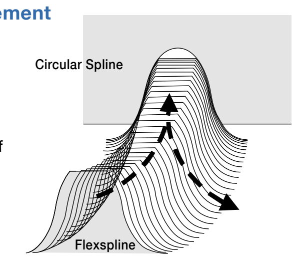
Direction of Rotation

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.



■Harmonic Planetary® Gearheads

HPGP - 11 A - 05 - BL3 - Z - 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)	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	BL3: Backlash less than 3 arc-min	D: Input side bearing with double contact seals. (Recommended for output flange up orientation.)	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 - Z - 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)	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	BL3: Backlash less than 3 arc-min	D: Input side bearing with double contact seals. (Recommended for output flange up orientation.)	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 - 20 R - 05 - BL3 - Z - F0 - Motor Code

Model Name	Size	Design Revision	Reduction Ratio	Backlash	Input Side Bearing	Output Configuration	Input Configuration & Options
HarmonicPlanetary® HPG Helical	11	R	4, 5, 6, 7, 8, 9, 10	BL1: Backlash less than 1 arc-min (Sizes 14 to 65)	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		3, 4, 5, 6, 7, 8, 9, 10	BL3: Backlash less than 3 arc-min	D: Input side bearing with double contact seals. (Recommended for output flange up orientation.)	F0: Flange output J2: Shaft output without key J6: Shaft output with key and center tapped hole	
	20						
	32						

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

Model Name	Size	Design Revision	Reduction Ratio	Output Configuration	Right Angle Specification	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	RA3	This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.
	50				RA3, RA5	
	65		5, 12, 15, 20, 25, 40, 50		RA5	

■Harmonic Planetary® Gearheads

HPN - 14 A - 05 - Z - J6 - Motor Code

Model Name	Size	Design Revision	Reduction Ratio	Input Side Bearing	Output Configuration	Input Configuration
HarmonicPlanetary® HPN High Torque	11	A	4, 5, 7, 10, 16, 20, 30	Z: Input side bearing with double non-contact shields D: Input side bearing with double contact seals. (Recommended for output flange up orientation.)	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, 10, 13, 21, 31			
	20					
	32					
	40					

■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					

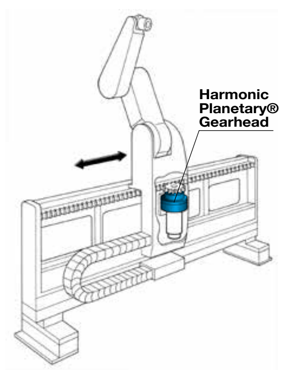
HPG - 20 A - 05 - BL3 - J2 U1 - SP1

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				

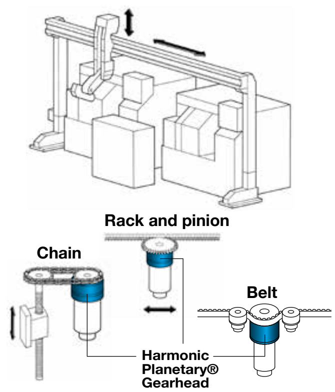
Application Examples for Harmonic Planetary® Gearheads

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.

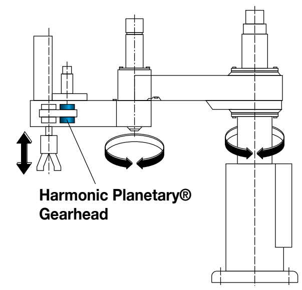
Linear axis for robots (Racks and pinion)



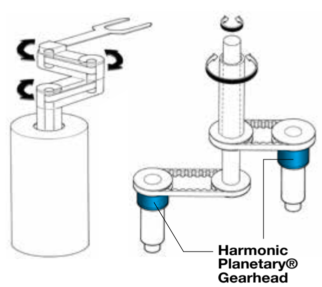
Gantry robots



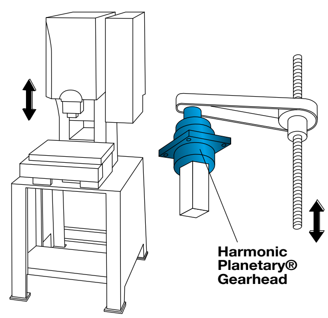
Primary axes of SCARA robots



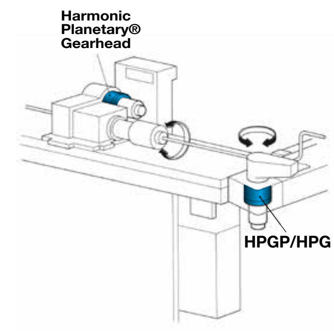
Wafer transfer robots



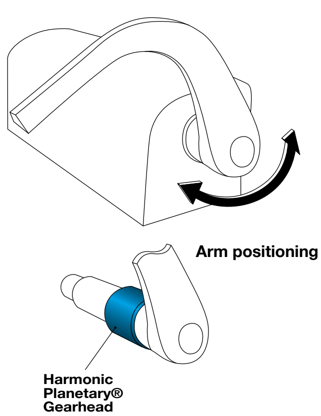
Electric presses



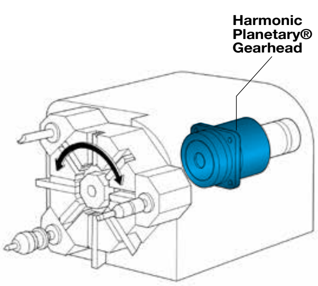
Pipe benders



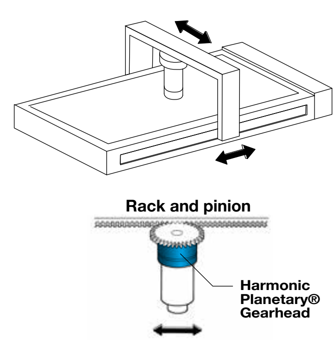
Injection molding unloading robots



Machine tool turrets



X-Y axes of machine tools



Application Examples for Harmonic Planetary® Gearheads

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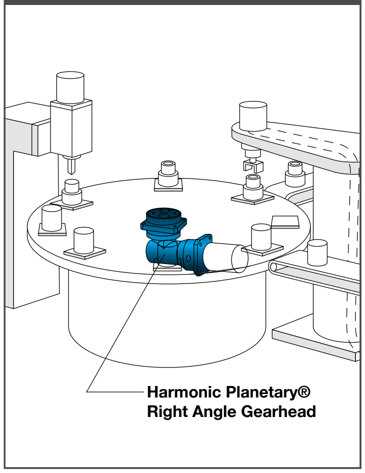
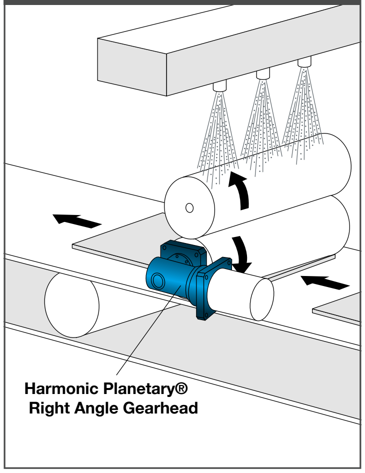
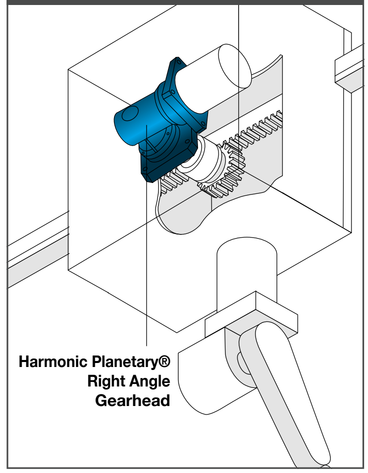


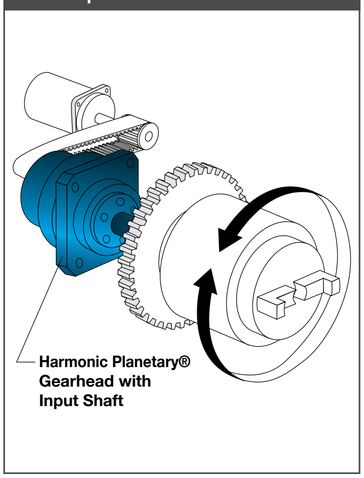
Roller drive



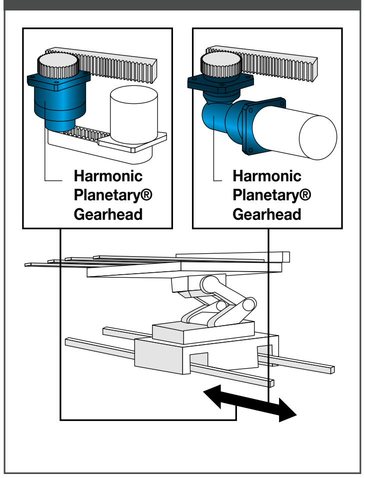
Linear axis drive



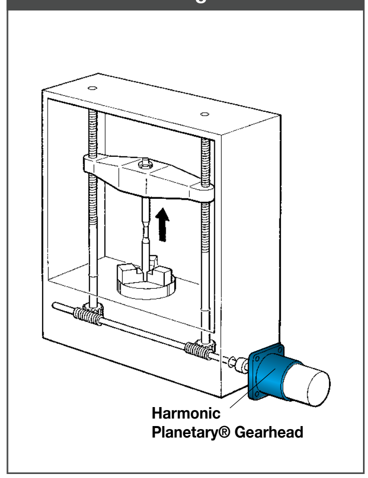
Input shaft with belt drive



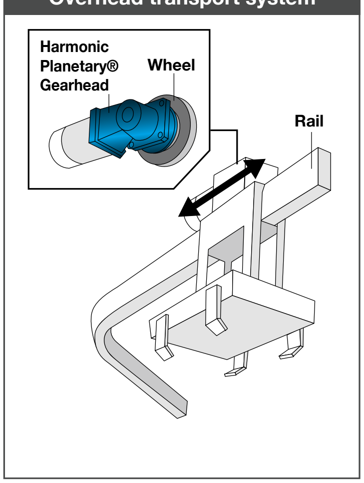
LCD transfer robots



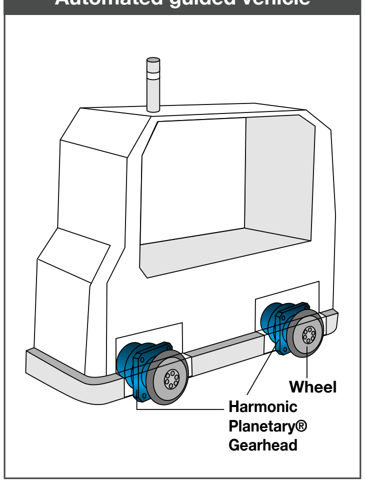
Tensile strength testers



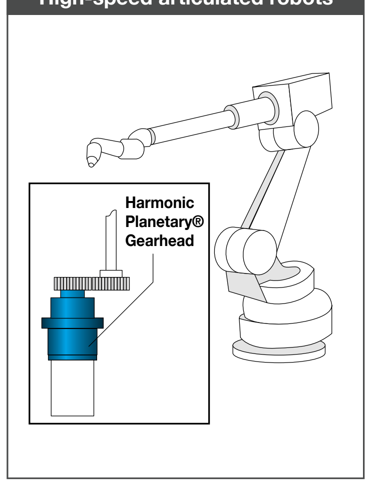
Overhead transport system



Automated guided vehicle



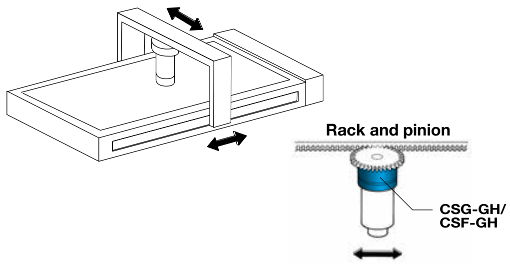
High-speed articulated robots



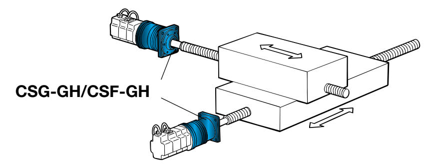
Application Examples for Harmonic Drive® Gearheads

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.

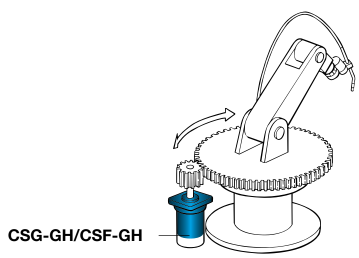
X-Y axes of machine tools



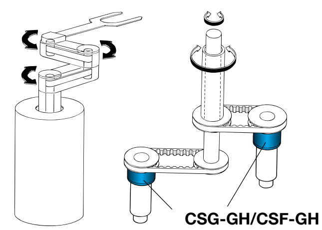
Linear Drive (XY table)



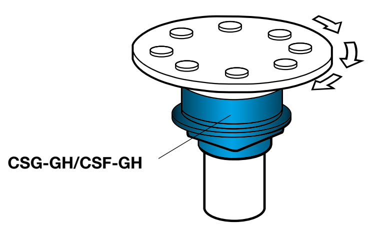
Rotation



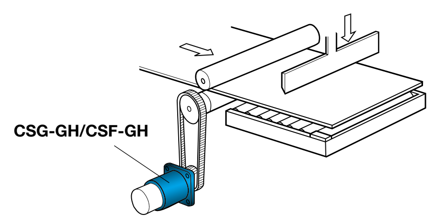
Transfer robot



Index table positioning



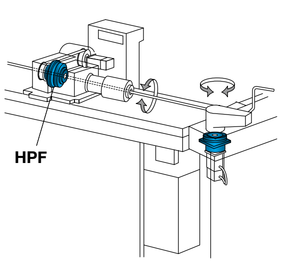
Roller drive



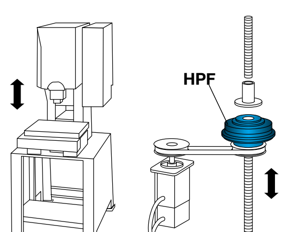
Application Examples for HPF Series Gearheads

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.

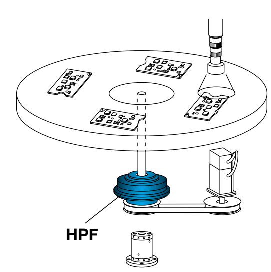
Pipe benders



Electric presses



Printed circuit board inspection



HarmonicPlanetary®

Gearheads for Servomotors

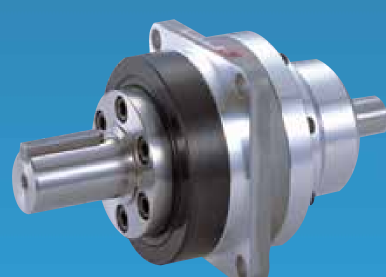
- HPGP High Torque Series
- HPG Standard Series
- HPG Helical Series
- HPG Right Angle Series
- HPN Value Series

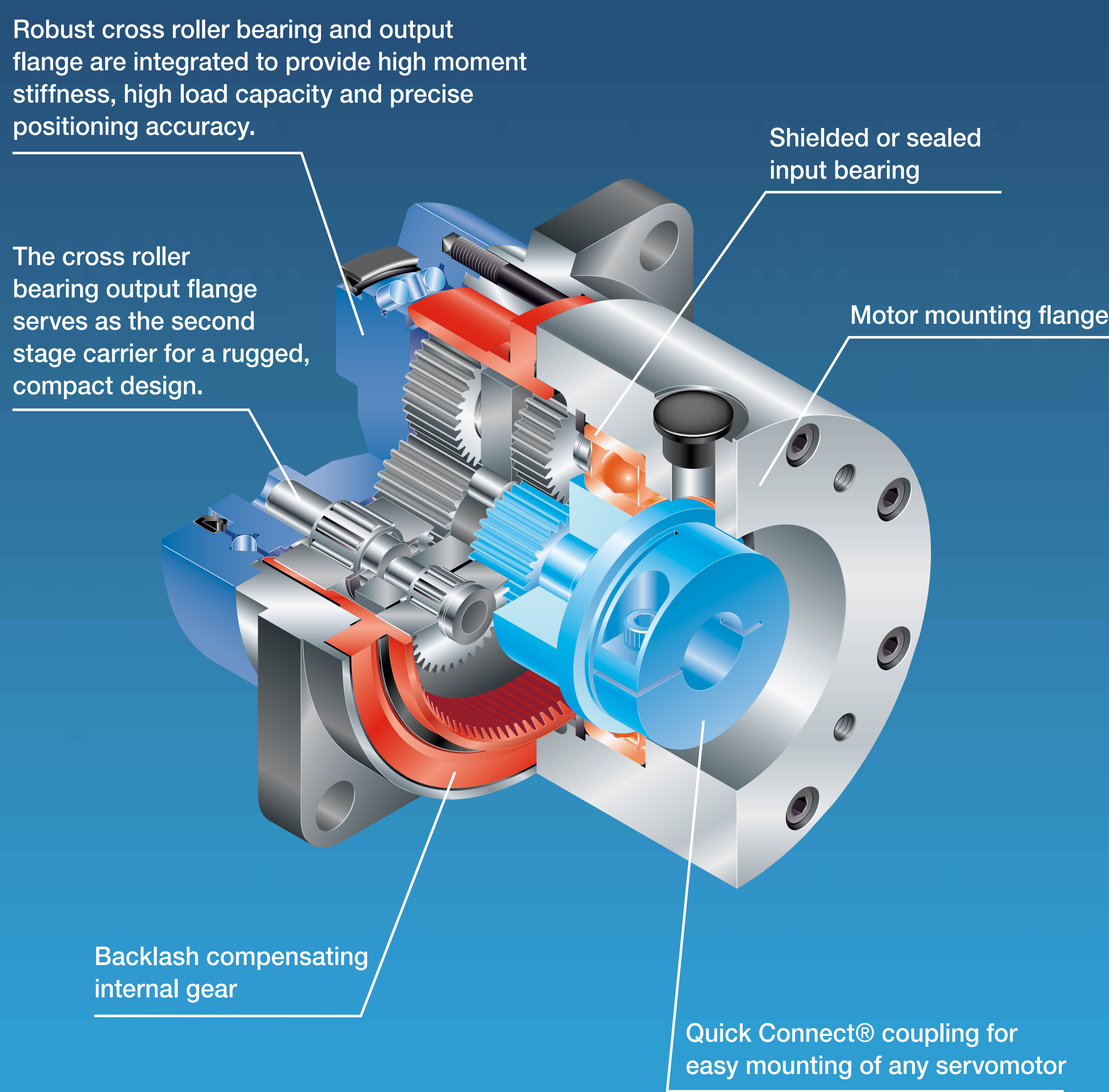
HarmonicPlanetary® HPGP ⁄ HPG Series

Harmonic Drive's expertise in the field of elasto-mechanics of metals is applied to the internal gear of the HPG, HPGP and HPF Series to provide the gearhead with continuous backlash compensation. Planetary gears have simultaneous meshing between the sun gear, planet gears, and the internal ring gear. Most 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, vibration, higher noise and premature wear (increase in backlash).

Harmonic Planetary® gears use a precision engineered elastic ring gear which compensates for interference between meshing parts. This proprietary Harmonic Planetary® gear design provides smooth and quiet motion and maintains ultra-low backlash for the life of the 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

HPGP Series HarmonicPlanetary® High-Performance Gearhead for Servomotors

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

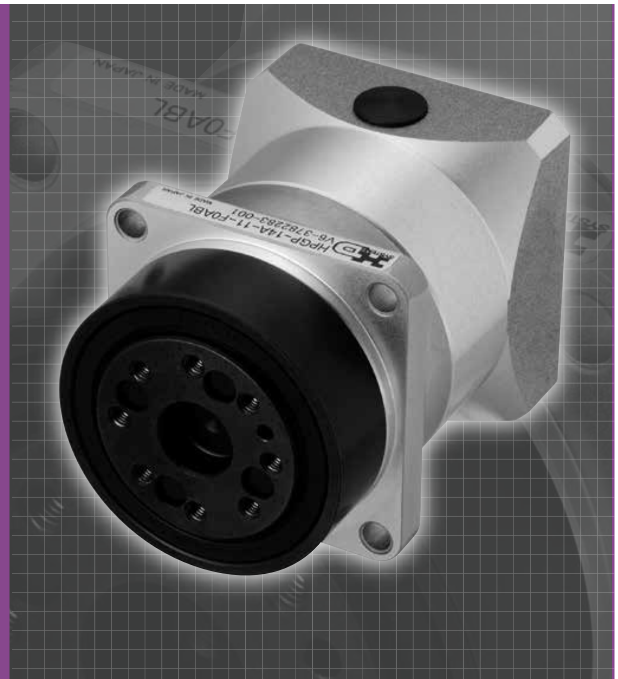
Low Backlash for Life

Innovative ring gear inherently compensates for interference between meshing parts, ensuring consistent, 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



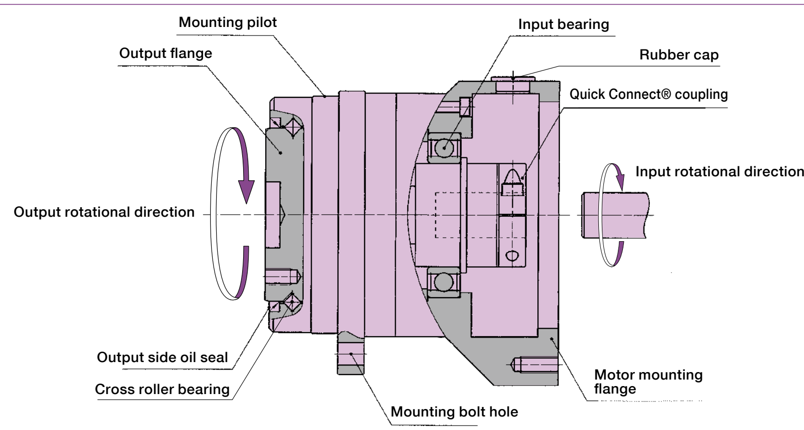
CONTENTS

HPGP - 11 A - 05 - BL3 - Z - 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	Z: Input side bearing with double non-contact shields D: Input side bearing with double contact seals. (Recommended for output flange up orientation.)	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, 20, 32, 50		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)	
	65		4, 5, 12, 15, 20, 25				

Gearhead Construction

Figure 018-1



Rating Table

Table 019-1

<table>
<tr><th rowspan="2">Size</th><th rowspan="2">Ratio</th><th>Rated Torque L10*1</th><th>Rated Torque L50*1</th><th>Limit for Average Load Torque *2</th><th>Limit for Repeated Peak Torque *3</th><th>Limit for Momentary Torque *4</th><th>Max. Average Input Speed *5</th><th>Max. Input Speed *6</th></tr>
<tr><th>Nm</th><th>Nm</th><th>Nm</th><th>Nm</th><th>Nm</th><th>rpm</th><th>rpm</th></tr>
<tr><td rowspan="4">11</td><td>5</td><td>3.4</td><td>6.6</td><td>6.7</td><td>12</td><td rowspan="4">20</td><td rowspan="4">3000</td><td rowspan="4">10000</td></tr>
<tr><td>21</td><td>4.6</td><td>8</td><td rowspan="3">8</td><td rowspan="3">13</td></tr>
<tr><td>37</td><td>4.6</td><td>8</td></tr>
<tr><td>45</td><td>4.6</td><td>8</td></tr>
<tr><td rowspan="6">14</td><td>5</td><td>7.8</td><td>15</td><td>17</td><td>39</td><td>56</td><td rowspan="6">3000</td><td rowspan="6">6000</td></tr>
<tr><td>11</td><td>10</td><td>20</td><td rowspan="5">20</td><td>38</td><td rowspan="5">63</td></tr>
<tr><td>15</td><td>12</td><td>20</td><td rowspan="4">39</td></tr>
<tr><td>21</td><td>12</td><td>20</td></tr>
<tr><td>33</td><td>13</td><td>20</td></tr>
<tr><td>45</td><td>13</td><td>20</td></tr>
<tr><td rowspan="6">20</td><td>5</td><td>21</td><td>47</td><td>47</td><td>133</td><td rowspan="6">217</td><td rowspan="6">3000</td><td rowspan="6">6000</td></tr>
<tr><td>11</td><td>26</td><td>59</td><td>60</td><td>156</td></tr>
<tr><td>15</td><td>32</td><td>70</td><td>70</td><td rowspan="2">142</td></tr>
<tr><td>21</td><td>33</td><td>73</td><td>73</td></tr>
<tr><td>33</td><td>39</td><td>72</td><td>80</td><td>156</td></tr>
<tr><td>45</td><td>39</td><td>80</td><td>80</td><td>142</td></tr>
<tr><td rowspan="6">32</td><td>5</td><td>87</td><td>150</td><td>200</td><td>400</td><td rowspan="6">650</td><td rowspan="6">3000</td><td rowspan="6">6000</td></tr>
<tr><td>11</td><td>104</td><td>160</td><td>226</td><td>440</td></tr>
<tr><td>15</td><td>122</td><td>220</td><td rowspan="2">226</td><td rowspan="2">400</td></tr>
<tr><td>21</td><td>130</td><td>226</td></tr>
<tr><td>33</td><td>143</td><td>200</td><td>266</td><td>440</td></tr>
<tr><td>45</td><td>143</td><td>266</td><td>266</td><td>400</td></tr>
<tr><td rowspan="6">50</td><td>5</td><td>226</td><td>380</td><td rowspan="2">452</td><td rowspan="2">1460</td><td>1850</td><td rowspan="6">2000</td><td rowspan="6">4500</td></tr>
<tr><td>11</td><td>266</td><td>450</td><td rowspan="5">2180</td></tr>
<tr><td>15</td><td>306</td><td>460</td><td>532</td><td>1500</td></tr>
<tr><td>21</td><td>346</td><td>490</td><td rowspan="2">600</td><td rowspan="2">1460</td></tr>
<tr><td>33</td><td>359</td><td>600</td></tr>
<tr><td>45</td><td>359</td><td>640</td><td>665</td><td>1360</td></tr>
<tr><td rowspan="6">65</td><td>4</td><td>665</td><td>1150</td><td>1200</td><td>3520</td><td rowspan="6">4500</td><td rowspan="6">2000</td><td>2500</td></tr>
<tr><td>5</td><td>705</td><td>1190</td><td rowspan="2">1330</td><td rowspan="2">3790</td><td rowspan="5">3000</td></tr>
<tr><td>12</td><td>798</td><td>1330</td></tr>
<tr><td>15</td><td>971</td><td>1460</td><td>1460</td><td>3940</td></tr>
<tr><td>20</td><td>1060</td><td>1520</td><td>1730</td><td>3790</td></tr>
<tr><td>25</td><td>1130</td><td>1900</td><td>2000</td><td>3840</td></tr>
</table>

*1: Rated torque is based on life of 20,000 hours at max average input speed.
*2: Average load torque calculated based on the application motion profile must not exceed values shown in the table. See p. 29
*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.
*5: Max value of average input rotational speed during operation.
*6: Maximum instantaneous input speed.

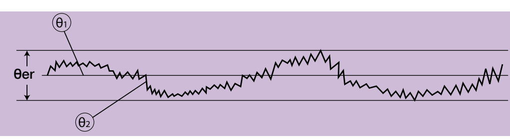
Performance Table

Table 020-1

Size	Ratio	Transmission Accuracy *1 arc min	Repeatability *2 arc sec	Starting torque *3 Ncm	Backdriving torque *4 Nm	No-load running torque *5 Ncm
11	5	5	±30	4.0	0.20	5.0
	21			2.9	0.60	1.3
	37			1.6	0.60	0.90
	45			1.4	0.64	0.80
14	5	4	±20	8.6	0.43	9.8
	11			8.0	0.90	4.9
	15			7.4	1.1	2.9
	21			5.2	1.1	2.9
	33			3.3	1.1	2.0
	45			2.4	1.1	2.0
20	5	4	±15	19	0.93	28
	11			15	1.7	15
	15			12	1.8	11
	21			9.3	2.0	8.8
	33			6.4	2.1	5.9
	45			4.7	2.1	4.9
32	5	4	±15	33	1.7	73
	11			27	2.9	38
	15			25	3.7	29
	21			22	4.7	24
	33			15	4.8	14
	45			11	5.1	13
50	5	3	±15	80	4.0	130
	11			45	5.0	60
	15			40	6.0	47
	21			36	7.6	40
	33			24	7.8	24
	45			20	8.9	20
65	4	3	±15	288	12	420
	5			240	12	360
	12			125	15	190
	15			110	17	160
	20			95	19	130
	25			84	21	110

*1: Transmission 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

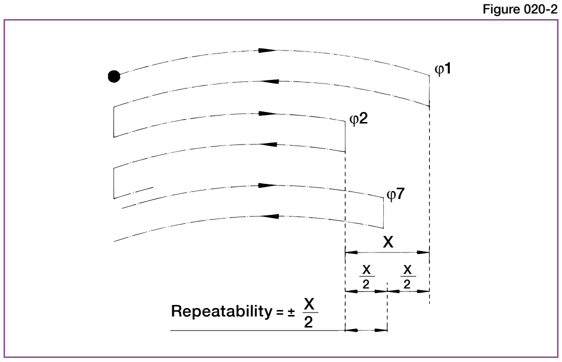


θ_{er} : Transmission accuracy
θ_1 : Input angle
θ_2 : Actual output angle
R : Gear reduction ratio

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

*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 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, and are based on Z option shielded input bearing unloaded.

*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, and are based on Z option shielded input bearing unloaded.

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.

*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, and are based on Z option shielded input bearing unloaded at 25° C at 3,000 rpm.

Backlash and Torsional Stiffness

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

Table 021-1

Size	Ratio	Backlash arc min	Torsion angle in one direction at TR X 0.15 D arc min	Torsional stiffness A/B Nm/arc min
11	5	3	2.5	.64
	21		3.0	
	37			
	45			
14	5	3	2.2	1.37
	11		2.7	
	15			
	21			
	33			
	45			
20	5	3	1.5	5.39
	11		2.0	
	15			
	21			
	33			
	45			
32	5	3	1.3	21.56
	11		1.7	
	15			
	21			
	33			
	45			
50	5	3	1.3	137.2
	11		1.7	
	15			
	21			
	33			
	45			
65	4	3	1.3	372.4
	5			
	12		1.7	
	15			
	20			
	25			

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

Table 021-2

Size	Ratio	Backlash arc min	Torsion angle in one direction at TR X 0.15 D arc min	Torsional stiffness A/B Nm/arc min
11	not available			
14	5	1	1.1	1.372
	11		1.7	
	15			
	21			
	33			
	45			
20	5	1	0.6	5.39
	11		1.1	
	15			
	21			
	33			
	45			
32	5	1	0.5	21.56
	11		1.0	
	15			
	21			
	33			
	45			
50	5	1	0.5	137.2
	11		1.0	
	15			
	21			
	33			
	45			
65	4	1	0.5	372.4
	5			
	12		1.0	
	15			
	20			
	25			

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) in one direction when a load is applied from a no-load state.

Formula 021-1

● Calculation formula

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

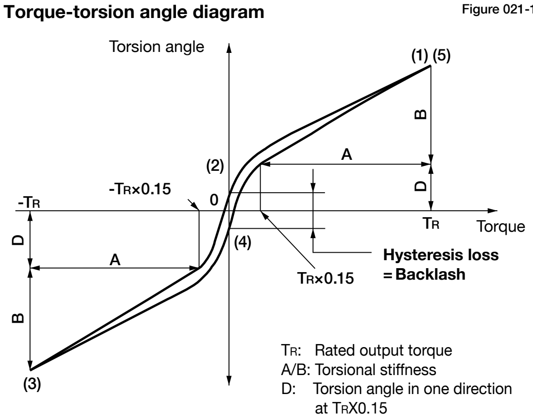
θ	Total torsion angle	——
D	Torsion angle in one direction at output torque x 0.15 torque	See Fig. 021-1, Table 021-1, Table 021-2
T	Load torque	——
T_L	Output torque x 0.15 torque ($=T_R$X0.15)	See Fig. 021-1 See Fig. 021-1, Table 021-1 to 2
A/B	Torsional stiffness	

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

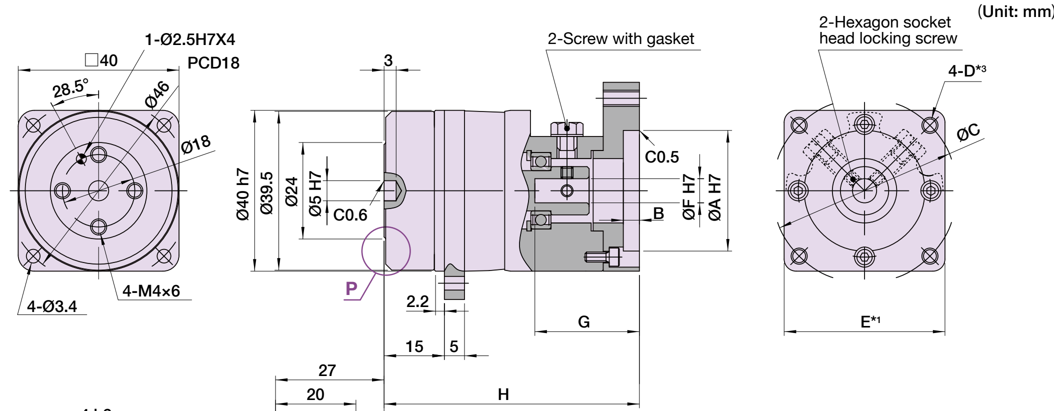


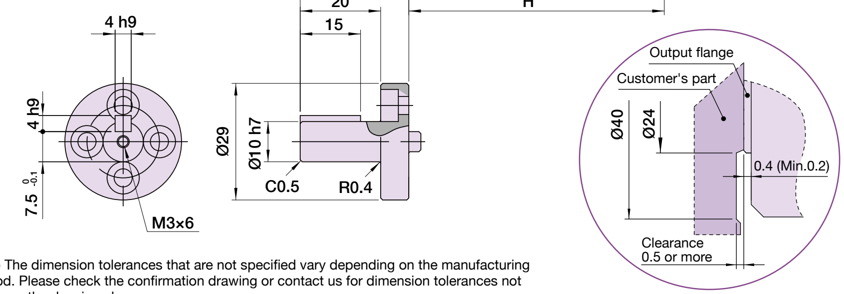
HPGP-11 Outline Dimensions

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 Type	Coupling Type	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	1	1	20	55	4	25	75	5	8	18.5	29	54.5	0.34	0.30
Two Stage	1	1	20	55	4	25	75	5	8	18.5	29	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.

Moment of Inertia

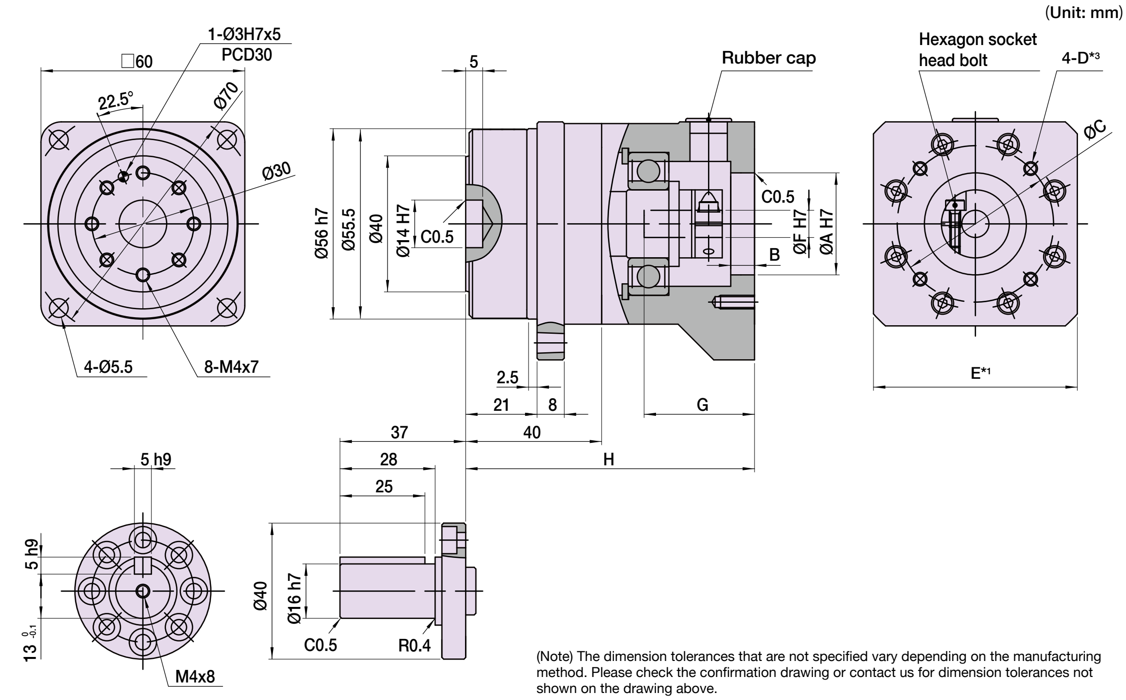
(10^{-4} kgm^2) Table 022-2

	Ratio / Coupling	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 Type	Coupling Type	A (H7)		B	C		F (H7)		G		H *1	Mass (kg) *2	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	Shaft	Flange
1	1	30	55	7	35	75	6.0	8	20.5 *1	32.5	85	1.07	0.95
2	2	35	75 *1	7	40	100 *1	9.0	14.2	17.5	33.5 *1	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.

Moment of Inertia

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

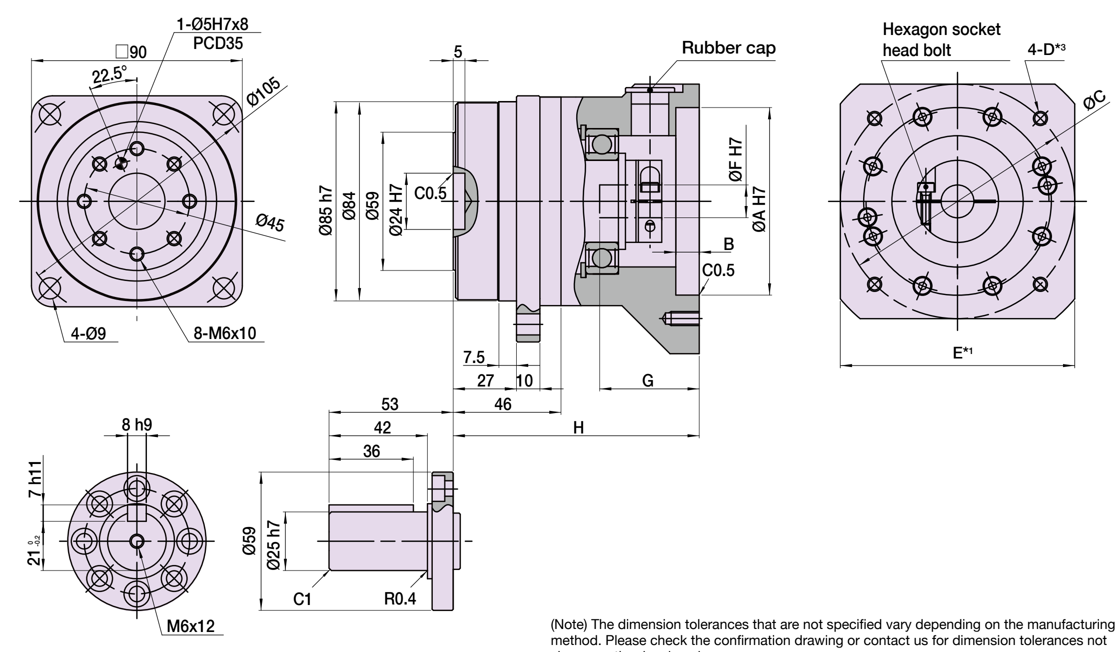
	Coupling \ Ratio	5	11	15	21	33	45
HPGP 14	1	-	0.06	0.058	0.05	0.044	0.044
	2	0.204	0.197	0.195	-	-	-

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 Type	Coupling Type	A (H7)		B	C		F (H7)		G		H *1		Mass (kg) *2	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	-33 Ratio	Shaft	Flange
1	1	50	68	8	55	84	7.0	19.6	22.0 *1	35.5	98.0	103.0	3.0	2.6
2	1	80	95	10	85	125	7.0	19.6	29.0 *1	42.5	105.0	110.0	3.2	2.8
3	1	30	45	10	35	50	6.0	7.8	20.0 *1	31.0	93.5	98.5	2.5	2.1
4	1	38	75 *1	10	45	100 *1	7.0	19.6	24.0	42.5	105.0	110.0	3.2	2.8

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 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.

Moment of Inertia

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

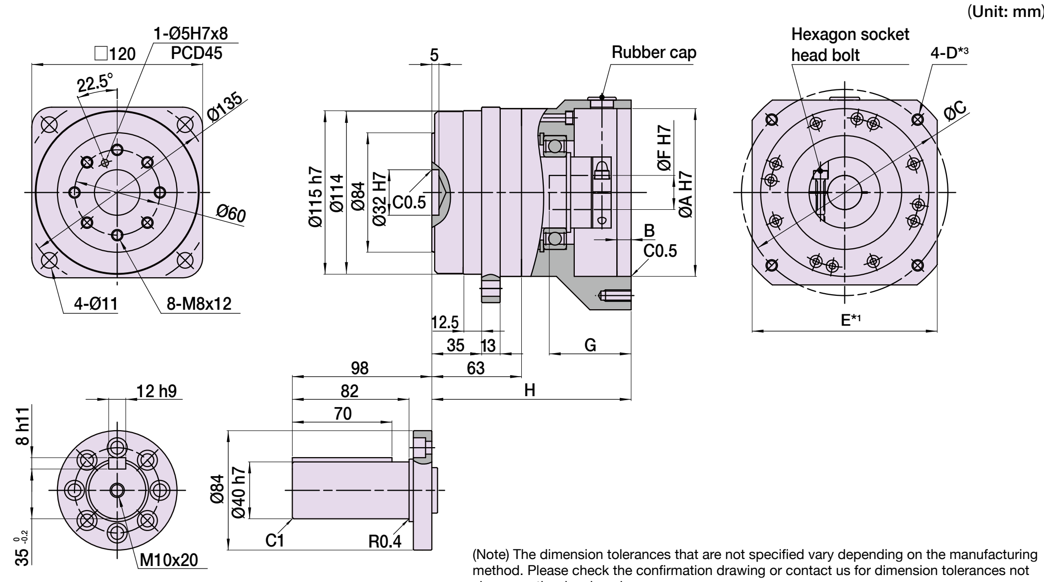
	Ratio / Coupling	5	11	15	21	33	45
HPGP 20	1	0.69	0.62	0.58	0.5	0.45	0.45

HPGP-32 Outline Dimensions

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

Figure 025-1

(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 025-1

Flange Type	Coupling Type	A (H7)		B	C		F (H7)		G		H *1		Mass (kg) *2	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	-33 Ratio	Shaft	Flange
2	1	70	100	7	80	112	10.0	28.6	29.0 *1	56.5	139	144	8.0	6.6
4	1	55	95 *1	10	60	135	10.0	28.6	40.0	67.5 *1	150	155	8.1	6.7
5	1	55	175 *1	10	65	225 *1	10.0	28.6	49.0	76.5 *1	159	164	9.7	8.3

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.

Moment of Inertia

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

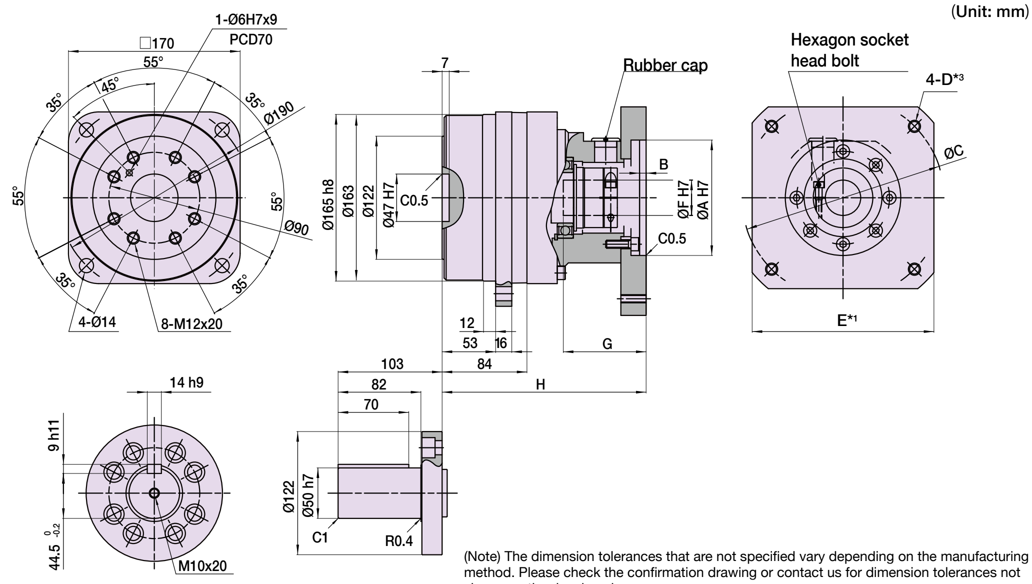
	Coupling \ Ratio	5	11	15	21	33	45
HPGP 32	1	3.9	3.7	3.5	3	2.8	2.8

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 Type	Coupling Type	A (H7)		B *1	C		F (H7)		G		H *1	Mass (kg) *2	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	Shaft	Flange
1	1	65	175 *1	15	75	235 *1	19.0	41.0	45.0	81 *1	202	20.2	17.2
2	2	80	130	10	90	160	19.0	41.0	30.5	55	176	19.0	16.0
3	1	65	175 *1	15	75	235 *1	19.0	41.0	45.0	81 *1	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.

Moment of Inertia

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

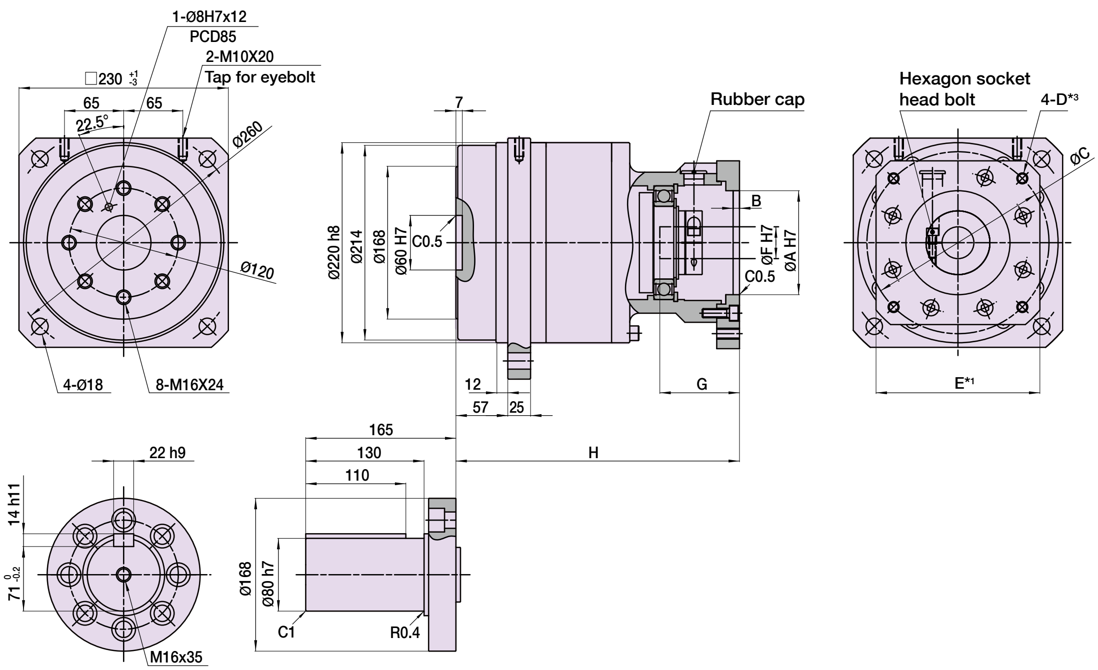
	Coupling \ Ratio	5	11	15	21	33	45
HPGP 50	1	12	9.4	9.1	7	6.1	5.9
	2	-	-	8.3	5.8	4.9	4.7

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 Type	Coupling Type	A (H7)		B	C		F (H7)		G *1		H *1	Mass (kg) *2	
			Min.	Max. *1	Max.	Min.	Max. *1	Min.	Max.	Min.	Max.	Typical	Shaft	Flange
Single Stage	2	2	130	245	15	140	290	35.0	44	65.0	126.5	246.5	48.0	38.0
Two Stage	1	1	65	175	15	75	225	24.0	36.5	52.0	85.0	288	52.0	42.0
	2	2	130	245	15	140	290	35.0	44	65.0	126.5	314.5	52.0	42.0
	3	1	65	175	15	75	225	24.0	36.5	52.0	85.0	288	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.

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	70	69	57	56

Sizing & Selection

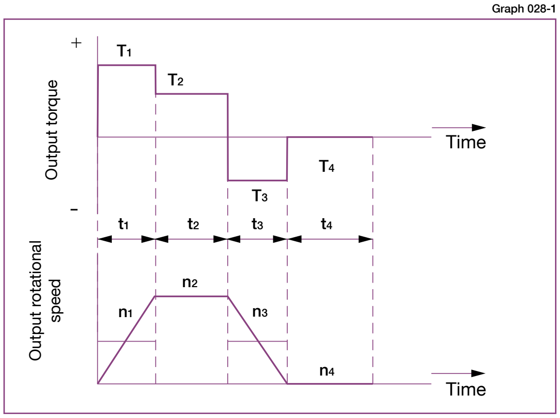
To fully utilize the excellent performance of the HPGP HarmonicPlanetary® gearheads, check your operating conditions and, using the flowchart, select the appropriate size gear for your application.

Check your operating conditions against the following application motion profile 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.

Application motion profile

Review the application motion profile. Check the specifications shown in the figure below.

Graph 028-1



Obtain the value of each application motion profile.

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 (acceleration)	T_1, t_1, n_1
Steady operation (constant velocity)	T_2, t_2, n_2
Stopping (deceleration)	T_3, t_3, n_3
Dwell	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 (Restricted by motors)	$n_{i\,max}$ $n_1 \times R$ to $n_n \times R$
	R: Reduction ratio

Emergency stop 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 application motion profile: 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 application motion profile: 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): ni *av* = no *av*·R $\leqq$ Max. average input speed (nr). → NG

(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. ni *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 less than the momentary max. torque (Nm) value from the ratings. → NG

OK ↓

Calculate the life and check whether it meets the specification requirement.
Tr: Rated Torque
nr: 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

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

OK ↓

The model number is confirmed.

Caution

If any of the following conditions exist, please consider selecting the next larger speed reducer, reduce the operating loads or reduce the operating speed. If this cannot be done, please contact Harmonic Drive LLC. Exercise caution especially when the duty cycle is close to continuous operation.
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).
iii) Gearhead housing temperature > 70°C.

Application sizing example

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

Normal operation pattern

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

Maximum rotational speed

Max. output rotational speed	$n_{o\,max}$ = 120 rpm
Max. input rotational speed	$n_{i\,max}$ = 5,000 rpm (Restricted by motors)

Emergency stop 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 application motion profile: 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 application motion profile: $n_{o\,av}$ (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 ≦ 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 ($n_{o\,max}$) and maximum input speed ($n_{i\,max}$).

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

Calculate the maximum input speed ($n_{i\,max}$) from the maximum output speed ($n_{o\,max}$) and reduction ratio (R): $n_{i\,max}$ = 120 rpm・33 = 3,960 rpm

Calculate the average input speed ($n_{i\,av}$) from the average output speed ($n_{o\,av}$) and reduction ratio (R):
$n_{i\,av}$ = 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.
$n_{i\,max}$ = 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 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 value 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 inherently compensates for interference between meshing parts, ensuring consistent, 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

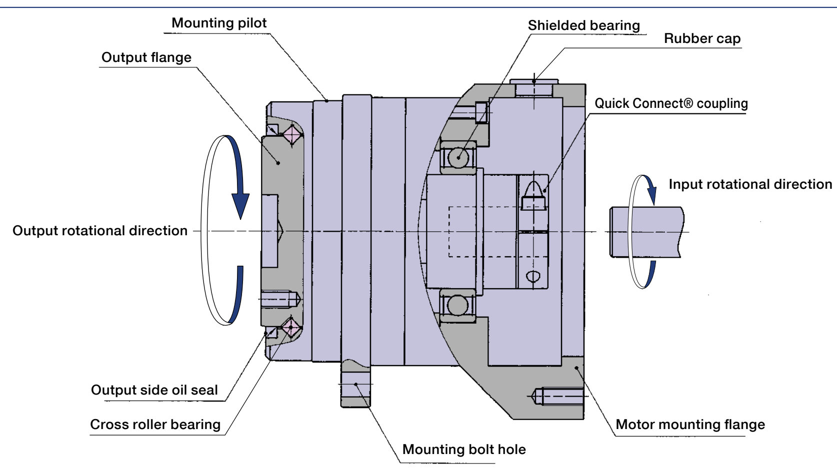
CONTENTS

HPG - 20 A - 05 - BL3 - Z - 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	Z: Input side bearing with double non-contact shields D: Input side bearing with double contact seals. (Recommended for output flange up orientation.)	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

Size	Ratio	Rated Torque L10 *1	Rated Torque L50 *1	Limit for Average Load Torque *2	Limit for Repeated Peak Torque *3	Limit for Momentary Torque *4	Max. Average Input Speed *5	Max. Input Speed *6
		Nm	Nm	Nm	Nm	Nm	rpm	rpm
11	5	2.5	5	5	10	20	3000	10000
	9	2.5	3.9	3.9	5			
	21	3.4	6	6	10			
	37	3.4	6	6				
	45	3.4	6	6				
14	3	2.9	6.4	6.4	15	37	3000	5000
	5	5.9	13	13	30	56		6000
	11	7.8	15	15		63		
	15	9	15	15				
	21	8.8	15	15				
	33	10	15	15				
	45	10	15	15				
20	3	8.8	17	19	64	124	3000	4000
	5	16	35	35	100	217		6000
	11	20	45	45	117			
	15	24	53	53	107			
	21	25	55	55				
	33	29	60	60	117			
	45	29	60	60	106			
32	3	31	60	71	225	507	3000	3600
	5	66	150	150	300	650		6000
	11	88	170	170	330			
	15	92	170	170	300			
	21	98	170	170				
	33	108	200	200	330			
	45	108	200	200	300			
50	3	97	160	195	850	1200	2000	3000
	5	170	290	340	1110	1850		4500
	11	200	340	400	1200	2180		
	15	230	400	450	1250			
	21	260	450	500	1140			
	33	270	470	500				
	45	270	500	500	1130			
65	4	500	870	900	2890	4500	2000	2500
	5	530	900	1000	3100			3000
	12	600	1020	1100				
	15	730	1260	1300	3200			
	20	800	1370	1500	3100			
	25	850	1470	1500	3200			
	40	640	1320	1300	1900			
	50	750	1650	1500	2200			

*1: Rated torque is based on life of 20,000 hours at max average input speed.
*2: Average load torque calculated based on the application motion profile must not exceed values shown in the table. See p. 40.
*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.
*5: Max value of average input rotational speed during operation.
*6: Maximum instantaneous input speed.

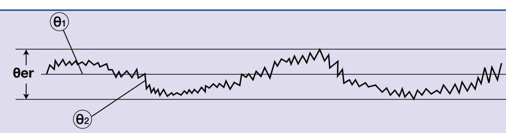
Performance Table

Table 032-1

Size	Ratio	Accuracy *1 arc min	Repeatability *2 arc sec	Starting torque *3 Ncm	Backdriving torque *4 Nm	No-load running torque *5 Ncm
11	5	5	±30	4.0	0.20	5.0
	9			3.7	0.33	2.5
	21			2.9	0.60	1.3
	37			1.6	0.60	0.90
	45			1.4	0.64	0.80
14	3	4	±20	14	0.43	21
	5			8.6	0.43	9.8
	11			8.0	0.90	4.9
	15			7.4	1.1	2.9
	21			5.2	1.1	2.9
	33			3.3	1.1	2.0
	45			2.4	1.1	2.0
20	3	4	±15	31	0.93	50
	5			19	0.93	28
	11			15	1.7	15
	15			12	1.8	11
	21			9.3	2.0	8.8
	33			6.4	2.1	5.9
	45			4.7	2.1	4.9
32	3	4	±15	56	1.7	135
	5			33	1.7	73
	11			27	2.9	38
	15			25	3.7	29
	21			22	4.7	24
	33			15	4.8	14
	45			11	5.1	13
50	3	3	±15	134	4.0	250
	5			80	4.0	130
	11			45	5.0	60
	15			40	6.0	47
	21			36	7.6	40
	33			24	7.8	24
	45			20	8.9	20
65	4	3	±15	288	12	420
	5			240	12	360
	12			125	15	190
	15			110	17	160
	20			95	19	130
	25			84	21	110
	40			75	30	76
	50			70	35	64

*1: Transmission 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

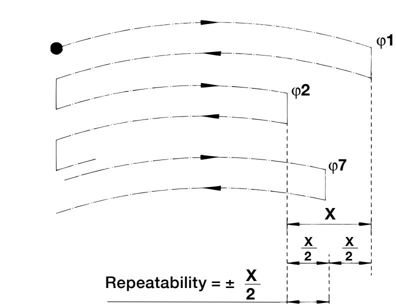


θer : Accuracy
θ_1 : Input angle
θ_2 : Actual output angle
R : Gear reduction ratio

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

*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, and are based on Z option shielded input bearing unloaded.

*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, and are based on Z option shielded input bearing unloaded.

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.

*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, and are based on Z option shielded input bearing unloaded at 25° C at 3,000 rpm.

Backlash and Torsional Stiffness

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

Table 033-1

Size	Ratio	Backlash arc min	Torsion angle in one direction at TR X 0.15 D arc min	Torsional stiffness A/B Nm/arc min
11	5, 9	3	2.5	.637
	21, 37, 45		3.0	
14	3, 5	3	2.2	1.37
	11, 15, 21, 33, 45		2.7	
20	3, 5	3	1.5	5.39
	11, 15, 21, 33, 45		2.0	
32	3, 5	3	1.3	21.56
	11, 15, 21, 33, 45		1.7	
50	3, 5	3	1.3	137.2
	11, 15, 21, 33, 45		1.7	
65	4, 5	3	1.3	372.4
	12, 15, 20, 25, 40, 50		1.7	

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

Table 033-2

Size	Ratio	Backlash arc min	Torsion angle in one direction at TR X 0.15 D arc min	Torsional stiffness A/B Nm/arc min
11	not available			
14	3, 5	1	1.1	1.37
	11, 15, 21, 33, 45		1.7	
20	3, 5	1	0.6	5.39
	11, 15, 21, 33, 45		1.1	
32	3, 5	1	0.5	21.56
	11, 15, 21, 33, 45		1.0	
50	3, 5	1	0.5	137.2
	11, 15, 21, 33, 45		1.0	
65	4, 5	1	0.5	372.4
	12, 15, 20, 25, 40, 50		1.0	

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) in one direction when a load is applied from a no-load state.

Formula 033-1

● Calculation formula

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

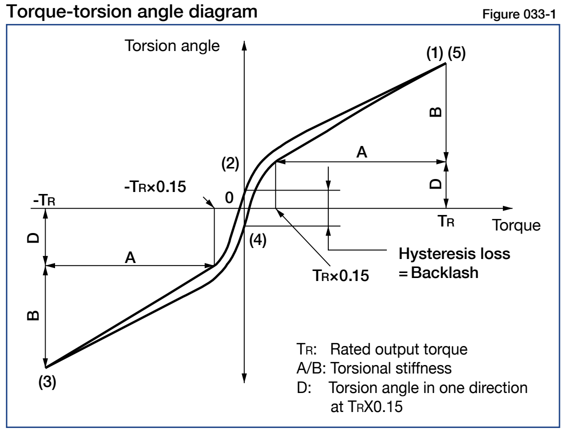
θ	Total torsion angle	——
D	Torsion angle in one direction at output torque x 0.15 torque	See Fig. 033-1, Table 033-1, Table 033-2
T	Load torque	——
T_L	Output torque x 0.15 torque (=T_RX0.15)	See Fig. 033-1
A/B	Torsional stiffness	See Fig. 033-1, Table 033-1 to 2

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, size 14-65).

Torque-torsion angle diagram

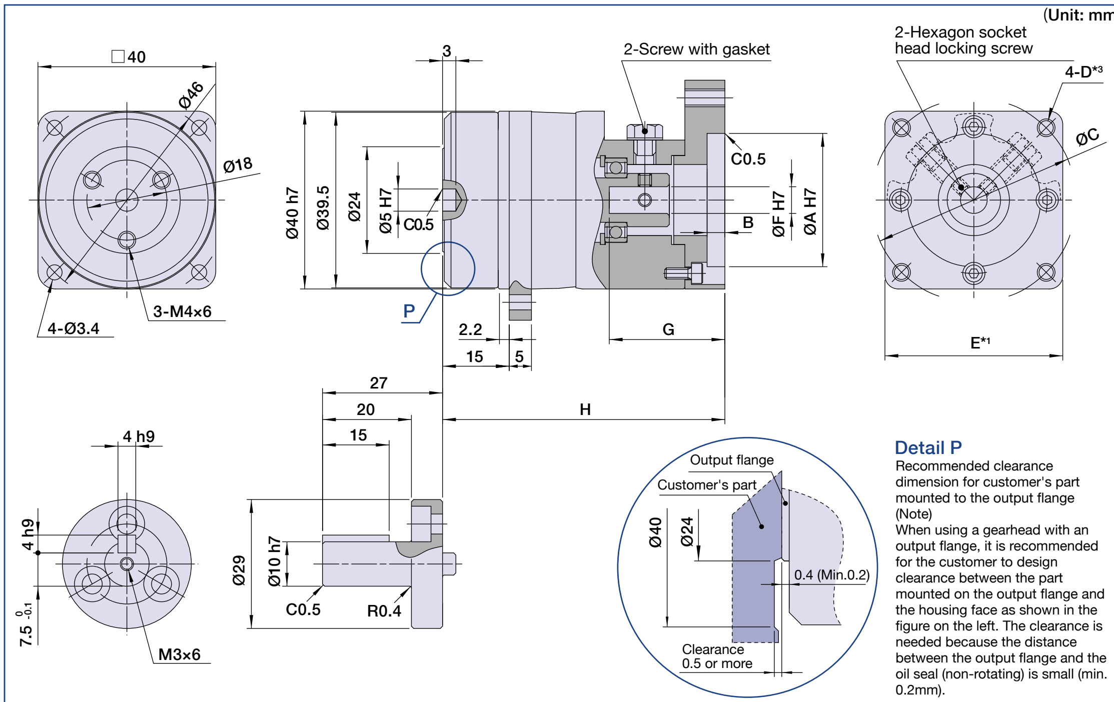
Figure 033-1



HPG-11 Outline Dimensions

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

Figure 034-1



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 *1	C		F (H7)		G *1		H *1	Mass (kg) *2	
			Min.	Max. *1	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	Shaft	Flange
Single Stage	1	1	20	55	4	25	75	5	8	18.5	29	54.5	0.34	0.30
Two Stage	1	1	20	55	4	25	75	5	8	18.5	29	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.

Moment of Inertia

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

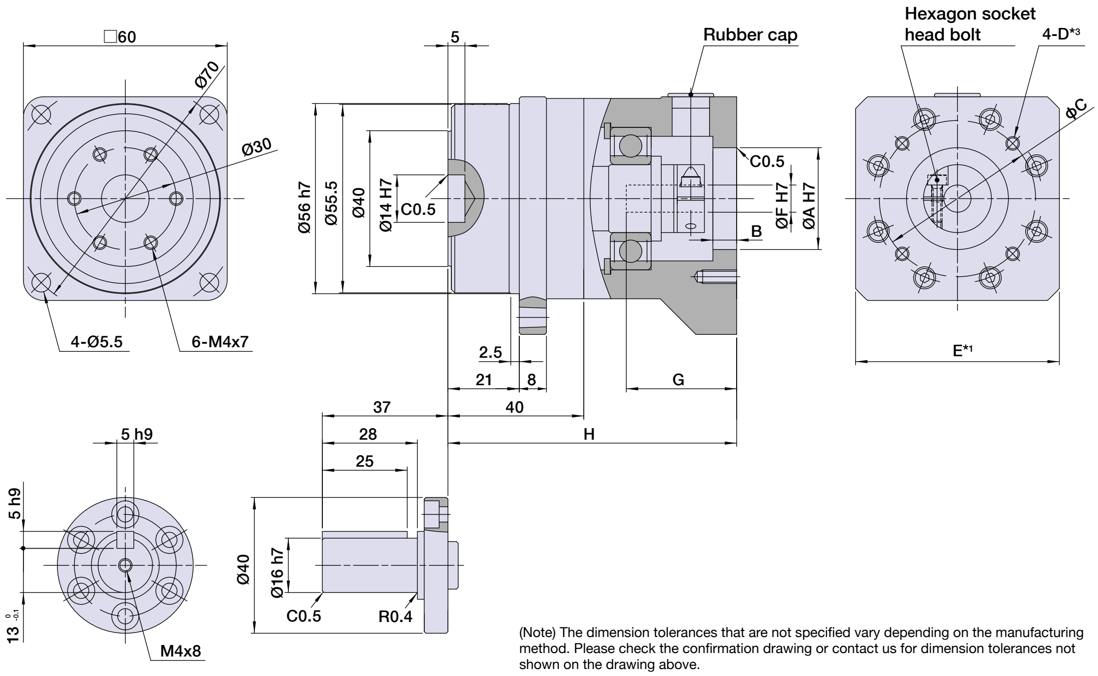
	Coupling \ Ratio	5	9	21	37	45
HPG 11	1	0.005	0.003	0.004	0.0027	0.0025

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 *1	C		F (H7)		G *1		H *1	Mass (kg) *2	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	Shaft	Flange
1	1	30	55	7	35	75	6.0	7.8	20.5	32.5	85	1.04	0.92
2	2	35	75 *1	7	40	100 *1	9.0	14.2	24	33.5	85	1.09	.097

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.

Moment of Inertia

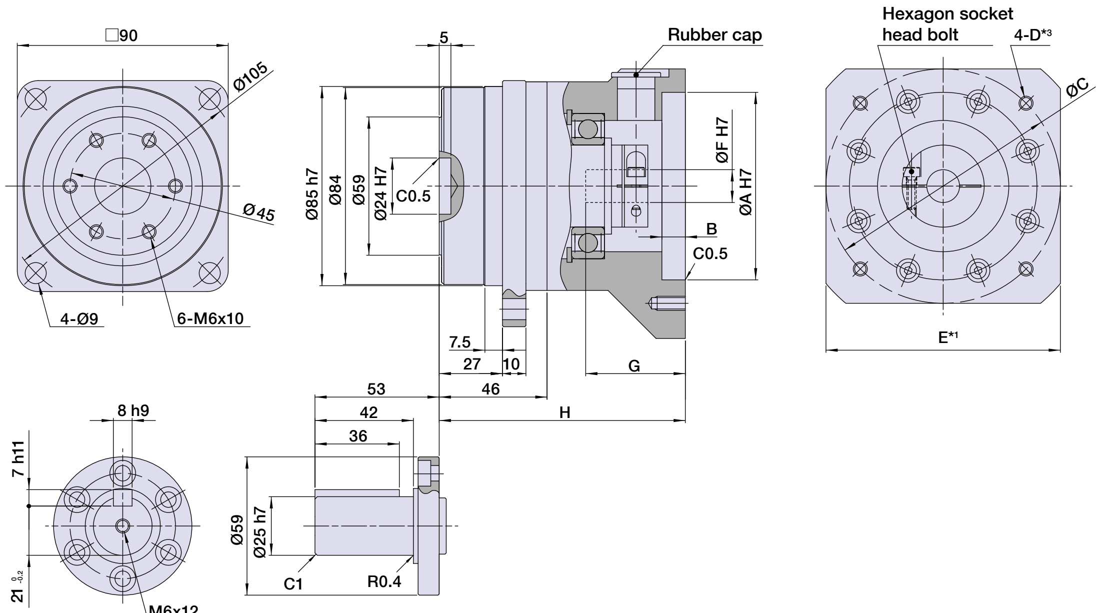
(10^{-4} kgm^2) Table 035-2

	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 *1	C		F (H7)		G *1		H *1	Mass (kg) *2	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	Shaft	Flange
1	1	50	68	8	55	84	7.0	19.6	22.0	35.5	98.0	3.1	2.7
2	1	80	95	10	85	125	7.0	19.6	29.0	42.5	105.0	3.3	2.9
3	3	30	45	10	35	50	6.0	7.8	20.0	31.0	93.5	2.6	2.2
4	1	40	75 *1	10	45	100 *1	7.0	19.6	29.0	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.

Moment of Inertia

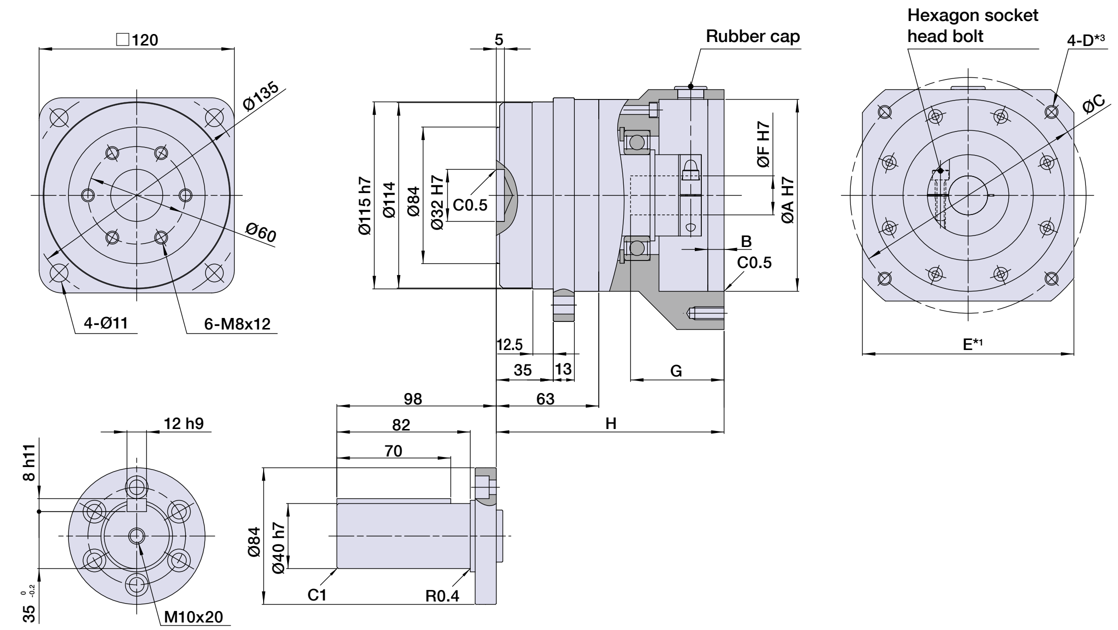
(10^{-4} kgm^2) Table 036-2

	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 *1	C		F (H7)		G *1		H *1	Mass (kg) *2	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	Shaft	Flange
1	1	110	124	10	120	155	10.0	28.6	30.0	57.5	140	7.8	6.4
2	1	70	100	7	80	112	10.0	28.6	29.0	56.5	139	7.8	6.4
4	1	55	95 *1	10	60	135	10.0	28.6	40.0	67.5	150	7.9	6.5
5	1	55	175 *1	10	65	225 *1	10.0	28.6	49.0	76.5	159	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.

Moment of Inertia

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

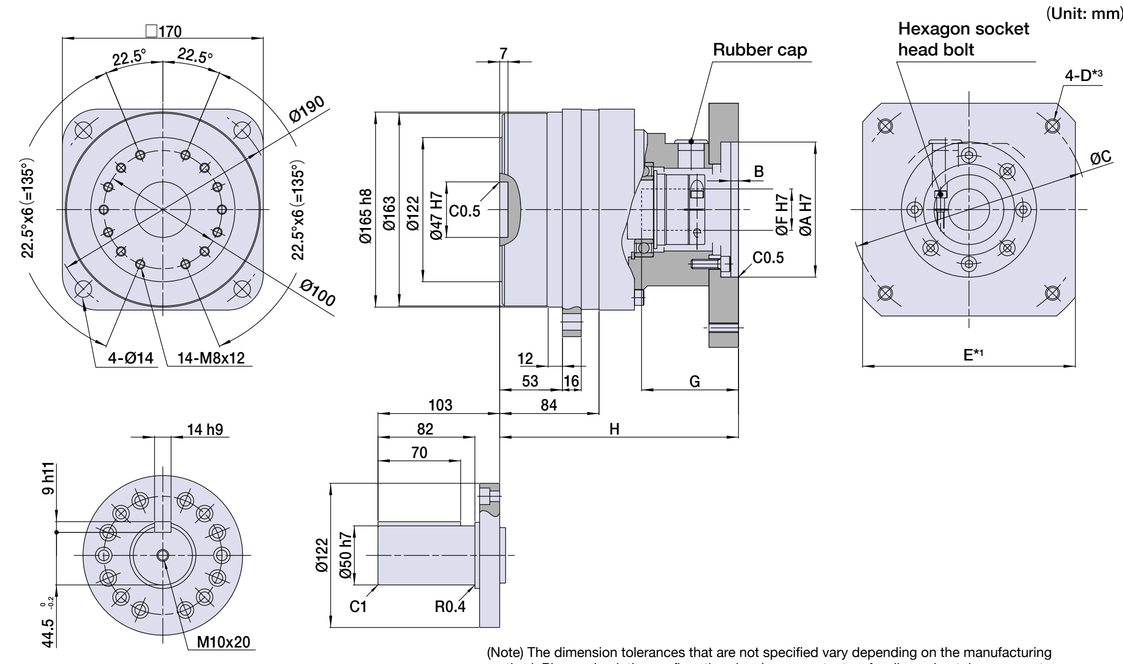
	Ratio / Coupling	3	5	11	15	21	33	45
HPG 32	1	5.6	3.9	3.4	3.2	3	2.8	2.8

HPG-50 Outline Dimensions

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

Figure 038-1

(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 038-1

Flange	Coupling	A (H7)		B *1	C		F (H7)		G *1		H *1	Mass (kg) *2	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	Shaft	Flange
1	1	65	175 *1	15	75	235 *1	19.0	41.0	45.0	81.0	202	20.2	17.2
2	2	80	130	10	90	160	19.0	41.0	30.5	55.0	176	19.0	16.0
3	1	65	175 *1	15	75	235 *1	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 flange type 3 for motors weighing over 65 kg.

*3 Tapped hole for motor mounting screw.

Moment of Inertia

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

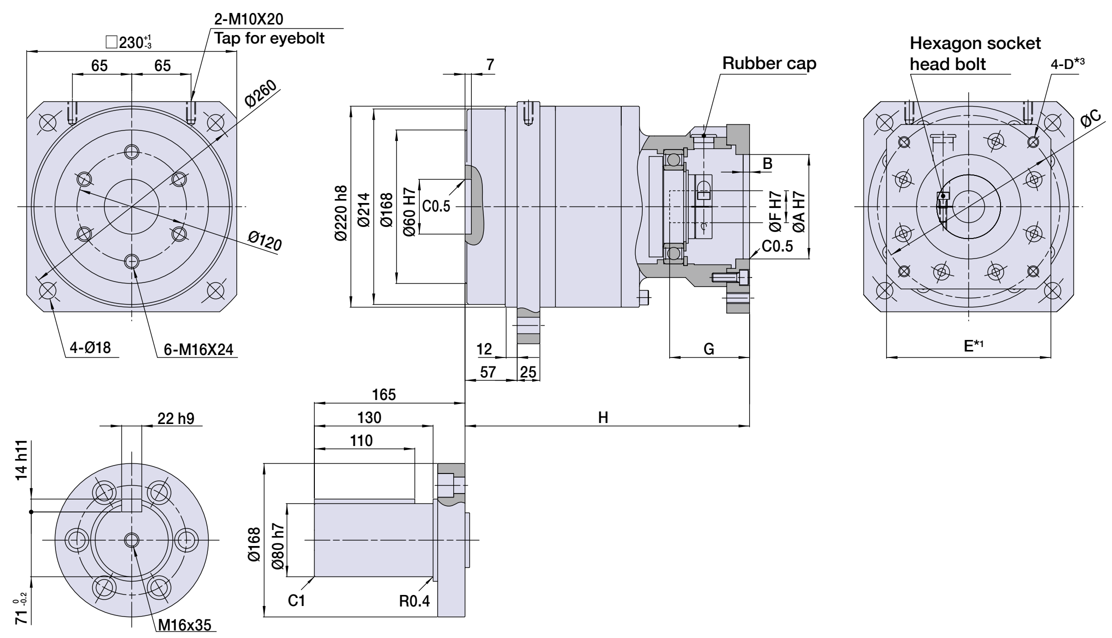
	Coupling \ Ratio	4	5	11	15	21	33	45
HPG 50	1	23	12	8.8	8.8	7	6	5.9
	2	-	-	-	7.7	5.8	4.8	4.7

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 *1		H *1	Mass (kg) *1	
			Min.	Max. *1	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	Shaft	Flange
Single Stage	2	2	130	245	15	140	290	35.0	43.9	65.0	126.5	246.5	48.0	38.0
Two Stage	1	1	65	175	15	75	225	24.0	36.5	52.0	85.0	288	52.0	42.0
	2	2	130	245	15	140	290	35.0	43.9	65.0	126.5	314.5	52.0	42.0
	3	1	65	175	15	75	225	24.0	36.5	52.0	85.0	288	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.

Moment of Inertia

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

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

Sizing & Selection

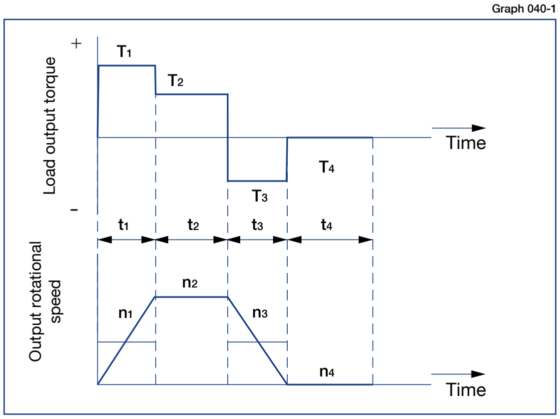
To fully utilize the excellent performance of the HPG HarmonicPlanetary® gearheads, check your operating conditions and, using the flowchart, select the appropriate size gear for your application.

Check your operating conditions against the following application motion profile 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).

Application motion profile

Review the application motion profile. Check the specifications shown in the figure below.

Graph 040-1



Obtain the value of each application motion profile

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 (acceleration)	T_1, t_1, n_1
Steady operation (constant velocity)	T_2, t_2, n_2
Stopping (deceleration)	T_3, t_3, n_3
Dwell	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

Emergency stop 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 application motion profile: 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 application motion profile: $n_{o\,av}$ (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 ($n_{o\,max}$) and maximum input rotational speed ($n_{i\,max}$).

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

(A limit is placed on $n_{i\,max}$ by motors.)
Calculate the maximum input speed ($n_{i\,max}$) from the maximum output speed ($n_{o\,max}$) and the reduction ratio (R).

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

↓

Calculate the average input speed ($n_{i\,av}$) from the average output speed ($n_{o\,av}$) 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 T1 and T3 are within peak torques (Nm) on start and stop in the rating table. → NG

OK ↓

Check whether T_s is than the momentary max. torque (Nm) value from the ratings. → NG

OK ↓

Calculate the life and check whether it meets the specification requirement.
T_r: Rated 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 any of the following conditions exist, please consider selecting the next larger speed reducer, reduce the operating loads or reduce the operating speed. If this cannot be done, please contact Harmonic Drive LLC. Exercise caution especially when the duty cycle is close to continuous operation.
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),
iii) Gearhead housing temperature > 70°C

Example of size selection

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

Normal operation pattern

Starting (acceleration)	T_1 = 70 Nm,	t_1 = 0.3 sec,	n_1 = 60 rpm
Steady operation (constant velocity)	T_2 = 18 Nm,	t_2 = 3 sec,	n_2 = 120 rpm
Stopping (deceleration)	T_3 = 35 Nm,	t_3 = 0.4 sec,	n_3 = 60 rpm
Dwell	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)

Emergency stop 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 application motion profile: 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 application motion profile: 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 ≦ 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.) — NG / OK

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

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

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 ≦ 117 Nm (Limit for repeated peak torque, size 20)
T_3 = 35 Nm ≦ 117 Nm (Limit for repeated peak torque, size 20) — NG / OK

Check whether Ts is 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.

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

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 40.

Review the operation conditions, size and reduction ratio.

HarmonicPlanetary®

HPG Helical Series

Size
4 Sizes

11, 14, 20, 32

Peak torque
5Nm – 400Nm

Reduction ratio
New Two-Stage Ratios Coming Soon!

3:1 to 10:1

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

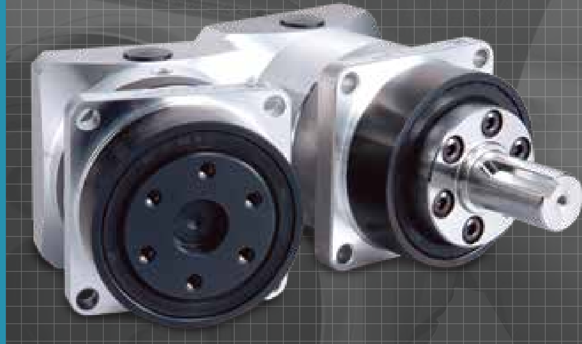
Low Backlash for Life

Innovative ring gear inherently compensates for interference between meshing parts, ensuring consistent, 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



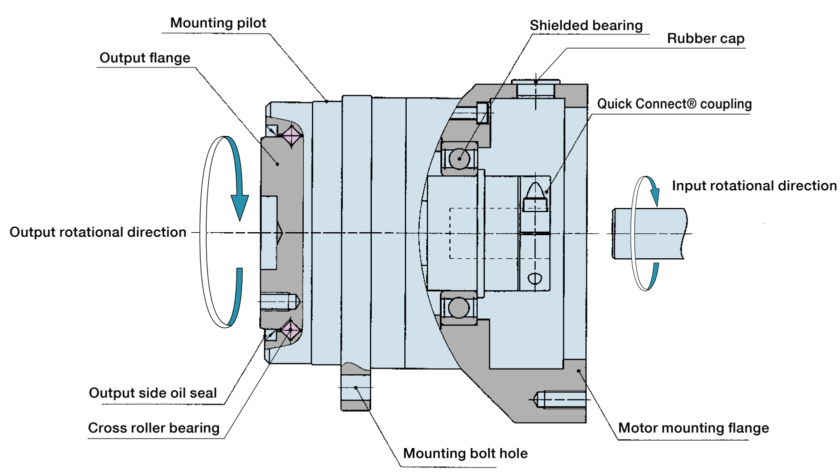
CONTENTS

HPG - 20 R - 05 - BL3 - Z - F0 - Motor Code

Model Name	Size	Design Revision	Reduction Ratio	Backlash	Input Side Bearing	Output Configuration	Input Configuration & Options
HarmonicPlanetary® HPG Helical	11	R	4, 5, 6, 7, 8, 9, 10	BL1: Backlash less than 1 arc-min (size 14 to 32 only) BL3: Backlash less than 3 arc-min	Z: Input side bearing with double non-contact shields D: Input side bearing with double contact seals. (Recommended for output flange up orientation.)	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		3, 4, 5, 6, 7, 8, 9, 10			F0: Flange output J2: Shaft output without key J6: Shaft output with key and center tapped hole	
	20						
	32						

Gearhead Construction

Figure 042-1



Rating Table

Table 043-1

Size	Ratio	Rated Torque L10 *1	Rated Torque L50 *1	Limit for Average Load Torque *2	Limit for Repeated Peak Torque *3	Limit for Momentary Torque *4	Max. Average Input Speed *5	Max. Input Speed *6
		Nm	Nm	Nm	Nm	Nm	rpm	rpm
11	4	2.8	4.0	6.3	10	20	3000	10000
	5	2.9	5.0	6.5	10			
	6	2.9	5.0	6.5	10			
	7	3.1	5.0	7.0	9.0			
	8	3.1	5.0	7.0	7.0			
	9	3.1	5.0	6.0	6.0			
	10	3.4	5.0	5.0	5.0			
14	3	4.0	7.0	9.0	20	37	3000	5000
	4	7.0	11	16	30	56		6000
	5	7.2	11	16	30			
	6	7.3	11	16	30			
	7	7.8	12	18	26			
	8	7.8	12	18	20			
	9	7.9	12	17	17			
	10	8.5	13	15	15			
20	3	11	17	25	90	124	3000	4000
	4	23	36	51	133	217		6000
	5	23	38	53	133			
	6	23	37	53	126			
	7	25	40	56	108			
	8	25	40	56	84			
	9	25	40	57	73			
	10	27	44	61	65			
32	3	50	60	110	290	507	3000	3600
	4	77	120	170	400	650		6000
	5	80	120	180	400			
	6	80	130	180	390			
	7	85	138	190	330			
	8	85	138	190	260			
	9	86	139	190	220			
	10	92	149	200	200			

*1: Rated torque is based on life of 20,000 hours at max average input speed.
*2: Average load torque calculated based on the application motion profile must not exceed values shown in the table. See p. 50.
*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.
*5: Max value of average input rotational speed during operation.
*6: Maximum instantaneous input speed.

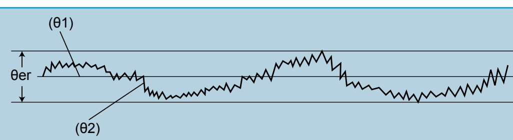
Performance Table

Table 044-1

Size	Ratio	Transmission Accuracy *1	Repeatability *2	Starting Torque *3	Backdriving Torque *4	No-Load Running Torque *5
		arc min	arc sec	Ncm	Nm	Ncm
11	4	5	±20	4.7	0.19	6.8
	5			4.1	0.21	5.4
	6			3.6	0.22	4.5
	7			3.3	0.23	3.9
	8			3.0	0.24	3.4
	9			2.8	0.25	3.0
	10			2.6	0.26	2.7
14		4	±15	13	0.38	22
	4			11	0.45	17
	5			10	0.51	13
	6			9.5	0.57	11
	7			9.0	0.63	9.4
	8			8.5	0.68	8.3
	9			8.1	0.73	7.3
	10			7.8	0.78	6.6
20	3	4	±10	31	0.93	50
	4			25	1.0	38
	5			22	1.1	30
	6			20	1.2	25
	7			18	1.3	21
	8			17	1.4	19
	9			17	1.5	17
	10			16	1.6	15
32	3	4	±10	56	1.7	135
	4			52	2.1	101
	5			49	2.5	81
	6			47	2.8	68
	7			45	3.2	58
	8			44	3.5	51
	9			43	3.9	45
	10			42	4.2	41

*1. Transmission accuracy values represent the difference between the theoretical angle and the actual angle of output for any given input. The values shown are maximum values.

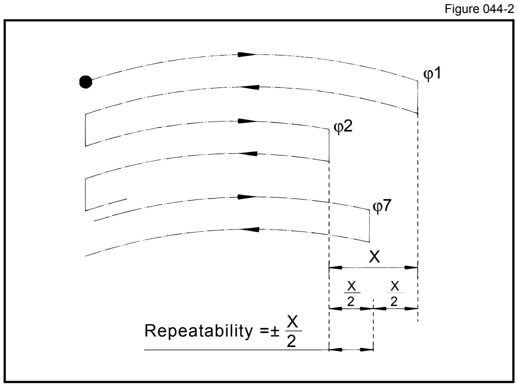
Figure 044-1



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

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

Figure 044-2



*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. See 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. and are based on Z option shielded input bearing unloaded.

*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, and are based on Z option shielded input bearing unloaded.

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.

*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. and are based on Z option shielded input bearing unloaded at 25° C at 3,000 rpm.

Backlash and Torsional Stiffness

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

Table 045-1

Size	Ratio	Backlash	Torsion angle in one direction at T_R x 0.15 D	Torsional stiffness A/B
		arc min	arc min	Nm/arc min
11	4	3	2.5	0.64
	5			
	6			
	7			
	8			
	9			
	10			
14	3	3	2.2	1.37
	4			
	5			
	6			
	7			
	8			
	9			
	10			
20	3	3	1.5	5.39
	4			
	5			
	6			
	7			
	8			
	9			
	10			
32	3	3	1.3	21.56
	4			
	5			
	6			
	7			
	8			
	9			
	10			

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

Table 045-2

Size	Ratio	Backlash	Torsion angle in one direction at T_R x 0.15 D	Torsional stiffness A/B
		arc min	arc min	Nm/arc min
11	4	N/A	N/A	N/A
	5			
	6			
	7			
	8			
	9			
	10			
14	3	1	1.1	1.37
	4			
	5			
	6			
	7			
	8			
	9			
	10			
20	3	1	0.6	5.39
	4			
	5			
	6			
	7			
	8			
	9			
	10			
32	3	1	0.5	21.56
	4			
	5			
	6			
	7			
	8			
	9			
	10			

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. 045-1.
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) in one direction when when a load is applied from a load in a no-load state.

Formula 045-1

● Calculation formula

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

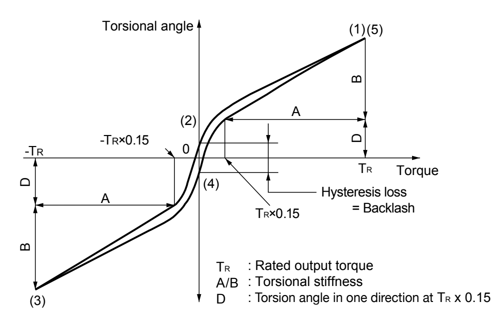
θ Total torsion angle		———
D	Torsion angle in one direction at output torque x 0.15 torque	Figure 045-1, Table 045-1 See Table 045-2.
T	Load torque	———
T_L	Output torque x 0.15 torque (= T_R x 0.15)	See Figure 045-1.
A/B	Torsional stiffness	See Figure 045-1 and Tables 045-1 and 045-2.

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 T_R" and "Counter Clockwise load torque - T_R" is defined as the backlash of the HPG-helical series. Backlash of the HPG-helical series is less than 3 arc-min (1 arc-min is also available for sizes 14-32).

Figure 045-1

Torque - Torsional Angle Diagram

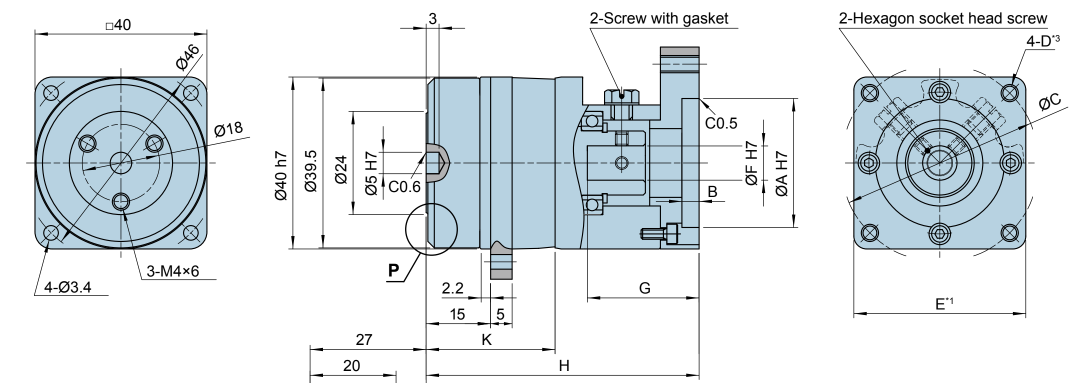


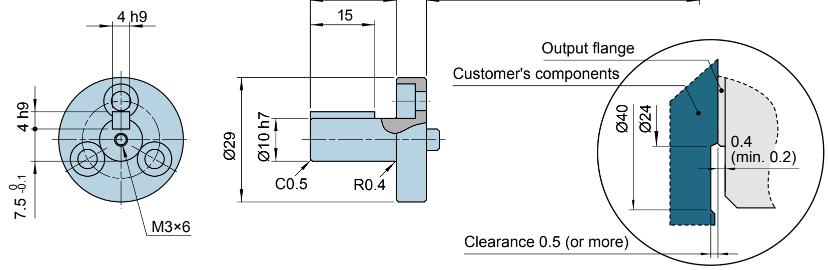
HPG-11R Outline Dimensions

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

Figure 046-1

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 046-1

Flange	Coupling	A (H7)		B*1	C		F (H7)		G*1		H*1	Mass (kg) *2	
		Min	Max	Max	Min	Max	Min	Max	Min	Max	Typical	Shaft	Flange
1	1	20	55	4	25	75	5	8	18.5	29	54.5	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.

Moment of Inertia

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

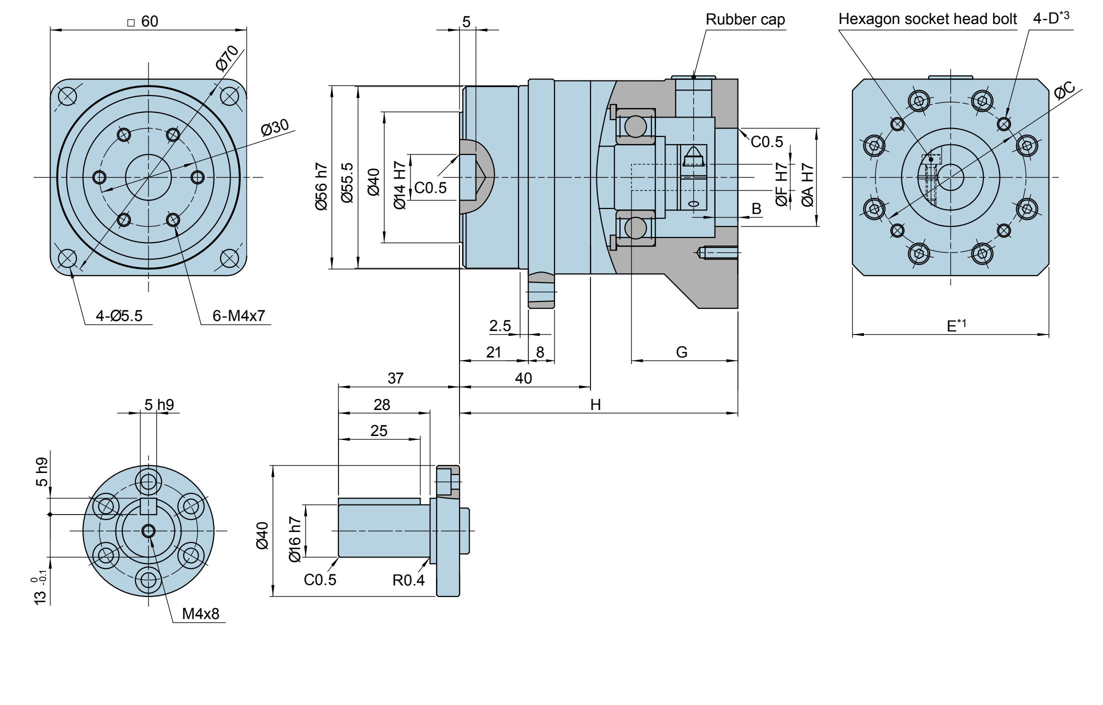
	Ratio / Coupling	4	5	6	7	8	9	10
HPG-11R	1	0.0156	0.0125	0.0108	0.0099	0.0092	0.0088	0.0085

HPG-14R 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		H*1	Mass (kg) *2	
		Min	Max	Max	Min	Max	Min	Max	Min	Max	Typical	Shaft	Flange
1	1	30	55	7	35	75	5.8	8	20.5*1	32.5	85	1.07	0.95

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.

Moment of Inertia

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

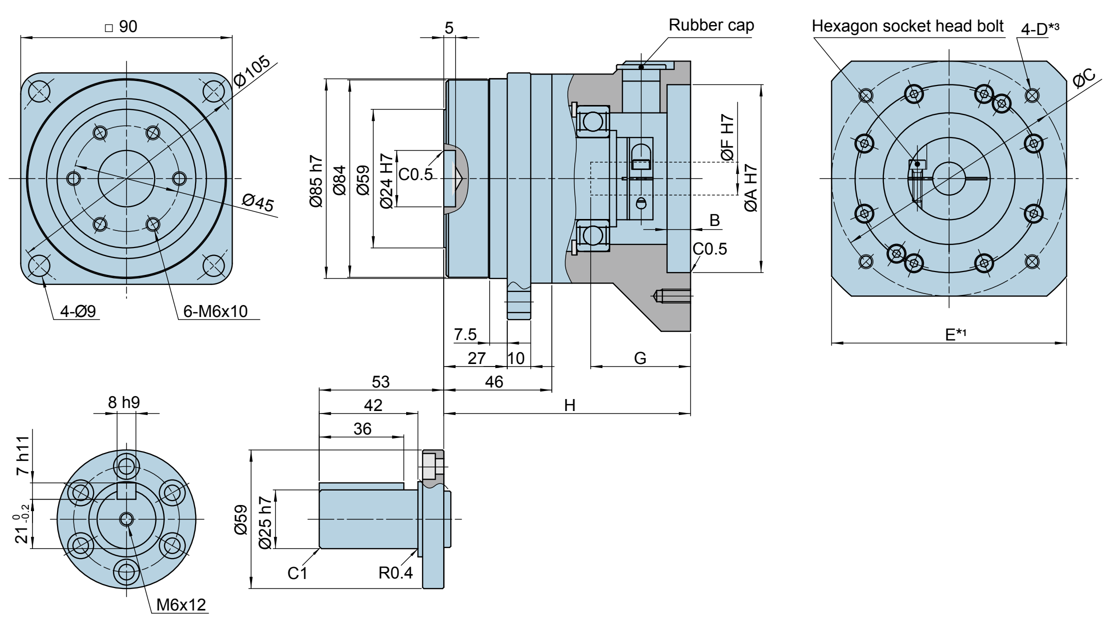
	Ratio / Coupling	3	4	5	6	7	8	9	10
HPG-14R	1	0.118	0.083	0.069	0.069	0.063	0.059	0.056	0.054

HPG-20R 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		H*1	Mass (kg) *2	
		Min	Max	Max	Min	Max	Min	Max	Min	Max	Typical	Shaft	Flange
1	1	50	68	8	55	84	8.8	19.6	22*1	39	98	3	2.6
2	1	80	95	10	85	125	8.8	19.6	29*1	46	105	3.2	2.8
4	2	38	75*1	10	45	100*1	8.8	19.6	24	46*1	105	3.2	2.8

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 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.

Moment of Inertia

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

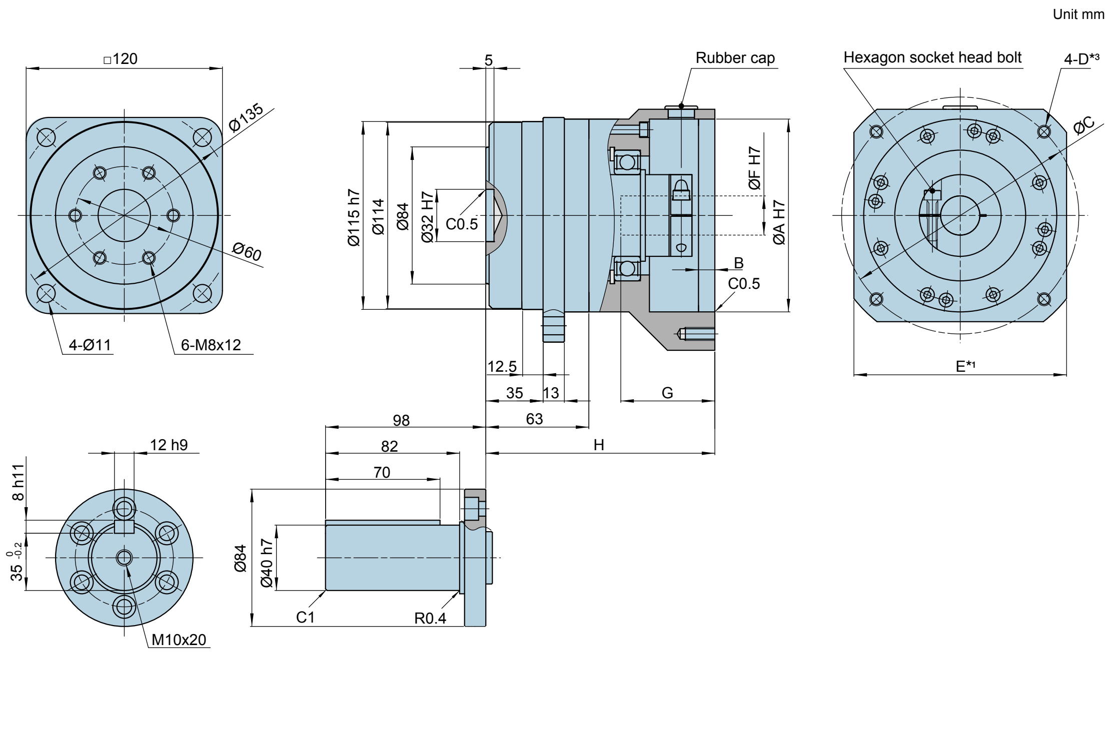
	Coupling \ Ratio	3	4	5	6	7	8	9	10
HPG-20R	1	1.005	0.775	0.665	0.609	0.572	0.549	0.534	0.525
	2	0.992	0.762	0.652	0.597	0.560	0.537	0.522	0.513

HPG-32R 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		H*1	Mass (kg) *2	
		Min	Max	Max	Min	Max	Min	Max	Min	Max	Typical	Shaft	Flange
1	1	70	81	7	80	112	15.8	26	29*1	56.5	139	8	6.6
4	1	55	95*1	10	60	135*1	15.8	26	40	67.5*1	150	8.1	6.7
5	1	55	175*1	10	65	225*1	15.8	26	49	76.5*1	159	9.7	8.3

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.

Moment of Inertia

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

	Ratio / Coupling	3	4	5	6	7	8	9	10
HPG-32R	1	5.45	3.95	3.44	3.23	3.09	3.01	2.94	2.90

Sizing & Selection

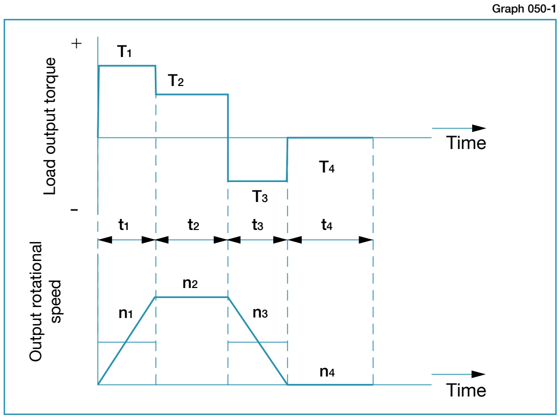
To fully utilize the excellent performance of the HPG HarmonicPlanetary® gearheads, check your operating conditions and, using the flowchart, select the appropriate size gear for your application.

Check your operating conditions against the following application motion profile 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.

Application motion profile

Review the application motion profile. Check the specifications shown in the figure below.

Graph 050-1



Obtain the value of each application motion profile

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 (acceleration)	T_1, t_1, n_1
Steady operation (constant velocity) T_2, t_2, n_2	
Stopping (deceleration)	T_3, t_3, n_3
Dwell	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

Emergency stop 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 application motion profile: 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 application motion profile: 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 less than the momentary max. torque (Nm) value from the ratings. — NG

↓ OK

Calculate the life and check whether it meets the specification requirement.
Tr: Rated 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 any of the following conditions exist, please consider selecting the next larger speed reducer, reduce the operating loads or reduce the operating speed. If this cannot be done, please contact Harmonic Drive LLC. Exercise caution especially when the duty cycle is close to continuous operation.
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),
iii) Gearhead housing temperature > 70°C

Example of size selection

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

Normal operation pattern

Starting (acceleration)	T_1 = 70 Nm,	t_1 = 0.3 sec,	n_1 = 60 rpm
Steady operation (constant velocity)	T_2 = 18 Nm,	t_2 = 3 sec,	n_2 = 120 rpm
Stopping (deceleration)	T_3 = 35 Nm,	t_3 = 0.4 sec,	n_3 = 60 rpm
Dwell	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)

Emergency stop 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 application motion profile: 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 application motion profile: 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 ≦ 70 Nm. (**HPG-20R-7** is tentatively selected based on the average load torque (see the rating table) of size 20 and reduction ratio of 7.) — NG

OK

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

$$\frac{5{,}000\ rpm}{120\ rpm}=41.7\geqq 7$$

Calculate the maximum input speed (ni *max*) from the maximum output speed (no *max*) and reduction ratio (R): ni *max* = 120 rpm • 7 = 840 rpm

Calculate the average input speed (ni *av*) from the average output speed (no *av*) and reduction ratio (R):
ni *av* = 46.2 rpm•7= 323 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* = 840 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 ≦ 108 Nm (Limit for repeated peak torque, size 20)
T_3 = 35 Nm ≦ 108 Nm (Limit for repeated peak torque, size 20) — NG

OK

Check whether Ts is 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.

$$L_{50}=20{,}000\cdot\left(\frac{40\ Nm}{30.2\ Nm}\right)^{10/3}\cdot\left(\frac{3{,}000\ rpm}{1{,}525\ rpm}\right)=100{,}398\ (hours)\geqq 30{,}000\ (hours)$$

— NG

OK

The selection of model number HPG-20R-7 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®

HPG Right Angle Series

Size
3 Sizes

32, 50, 65

Peak torque
150Nm – 2200Nm

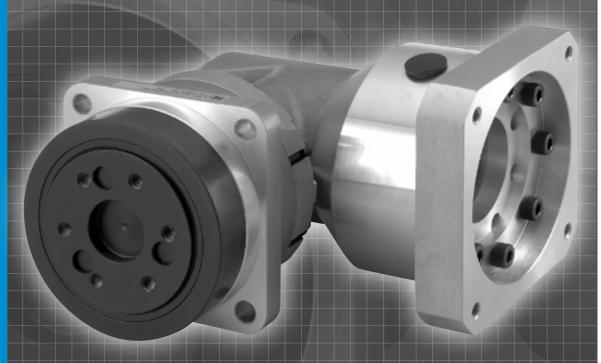
Reduction ratio
Single Stage: 5:1, Two Stage: 11:1 to 50:1

Low backlash
<3 arc-min Low Backlash for Life
Innovative ring gear inherently compensates for interference between meshing parts, ensuring consistent, 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



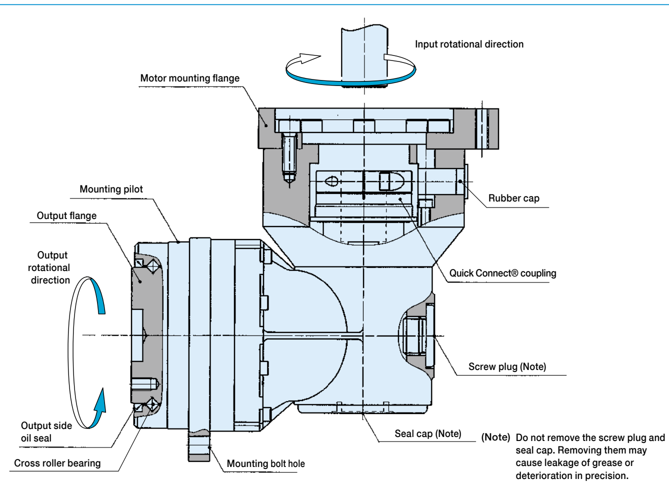
CONTENTS

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

Model Name	Size	Design Revision	Reduction Ratio	Output Configuration	Right Angle Specification	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	RA3	This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.
	50				RA3, RA5	
	65		5, 12, 15, 20, 25, 40, 50		RA5	

Gearhead Construction

Figure 052-1



(Note) Do not remove the screw plug and seal cap. Removing them may cause leakage of grease or deterioration in precision.

Rating Table

Table 053-1

Size	Model	Ratio	Rated Torque L10 *1	Rated Torque L50 *1	Limit for Average Load Torque *2	Limit for Repeated Peak Torque *3	Limit for Momentary Torque *4	Max. Average Input Speed *5	Max. Input Speed *6
			Nm	Nm	Nm	Nm	Nm	rpm	rpm
32	RA3	5	66	120	150	150	200	1500	6000
		11	88	170	170	330	440		
		15	92	170	170	300	600		
		21	98	170	170		650		
		33	108	200	200	330			
		45	108	200	200	300			
50	RA3	5	150	150	150	150	200	1500	4500
		11	170	330	330	330	440		
		15	200	400	450	450	600		
		21	200	450	500	630	840		
		33	230	470	500	990	1320		
		45	230	500	500	1140	1800		
	RA5	5	260	290	340	400	500	1300	4500
		11	260	340	400	880	1100		
		15	270	400	450	1200	1500		
		21	270	450	500	1150	2100		
		33	270	470	500	1140	2180		
		45	270	500	500				
65	RA5	5	400	400	400	400	500	1300	3000
		12	600	960	960	960	1200		
		15	730	1200	1200	1200	1500		
		20	800	1370	1500	1600	2000		
		25	850	1470	1500	2000	2500		
		40	640	1300	1300	1900	4000		
		50	750	1500	1500	2200	4500		

*1: Rated torque is based on life of 20,000 hours at max average input speed.
*2: Average load torque calculated based on the application motion profile must not exceed values shown in the table. See p. 60.
*3: The limit for torque during start and stop cycles. Always operate below this value.
*4: The limit for torque during emergency stops or from external shock loads.
*5: Max value of average input rotational speed during operation.
*6: Maximum instantaneous input speed.

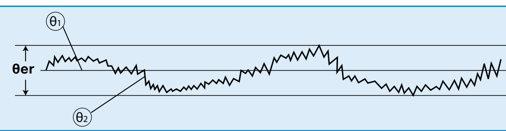
Performance Table

Table 054-1

Size	Model	Ratio	Accuracy *1 arc min	Repeatability *2 arc sec	Starting torque *3 Ncm	Backdriving torque *4 Nm	No-load running torque *5 Ncm
32	RA3	5	4	±15	64	3.3	179
		11			58	6.8	162
		15			56	8.9	155
		21			53	12	
		33			48	17	150
		45			47	23	
50	RA3	5	4	±15	111	5.8	241
		11			76	8.9	198
		15			71	11	173
		21			69	15	
		33			61	21	161
		45			59	28	
	RA5	5	3	±15	132	6.9	496
		11			97	11	459
		15			92	15	437
		21			90	20	
		33			82	29	427
		45			80	38	
65	RA5	5	3	±15	292	15	647
		12			177	23	532
		15			162	26	513
		20			147	31	494
		25			136	36	481
		40			127	51	460
		50			122	61	453

*1: Transmission 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 054-1

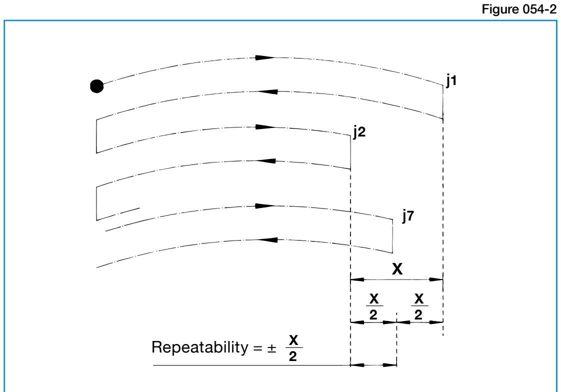


θer : Accuracy
θ1 : Input angle
θ2 : Actual output angle
R : Gear reduction ratio

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

*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 054-2



*3: Starting torque is the torque applied to the input side at which the output first starts to rotate. The values in the table are maximum values, and are based on 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, and are based on 25° C.

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.

*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, and are based on 25° C at 1,300 rpm for RA5 and 1500 rpm for RA3.

Backlash and Torsional Stiffness

Table 055-1

■ Right Angle

Size	Model	Ratio	Backlash	Torsion angle in one direction at TR X 0.15 D	Torsional stiffness A/B
			arc min	arc min	Nm/arc min
32	RA3	5	3	1.9	21.56
		11			23.52
		15			24.5
		21			25.48
		33			26.46
		45			
50	RA3	5	3	2.7	38.22
		11		2.1	91.14
		15			107.8
		21			127.4
		33			137.2
		45			
	RA5	5	3	1.7	73.5
		11		1.8	117.6
		15			127.4
		21			137.2
		33			147
		45			
65	RA5	5	3	2.3	98
		12		2.0	254.8
		15			284.2
		20			313.6
		25			333.2
		40			352.8
		50			362.6

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. 055-1.
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) in one direction when a load is applied from no-load state.

Formula 055-1

● Calculation formula

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

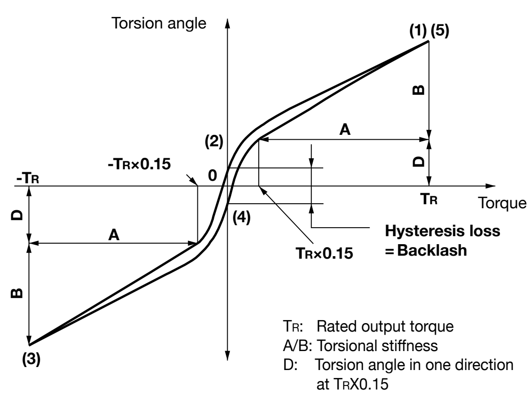
θ	Total torsion angle	—
D	Torsion angle in one direction at output torque x 0.15 torque	See Fig. 055-1, Table 055-1
T	Load torque	—
T_L	Output torque x 0.15 torque (=T_RX0.15)	See Fig. 055-1
A / B	Torsional stiffness	See Fig. 055-1, Table 055-1

Backlash (Hysteresis loss)

The vertical distance between points (2) & (4) in Fig. 055-1 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 Right Angle series is less than 3 arc-min.

Figure 055-1

Torque-torsion angle diagram

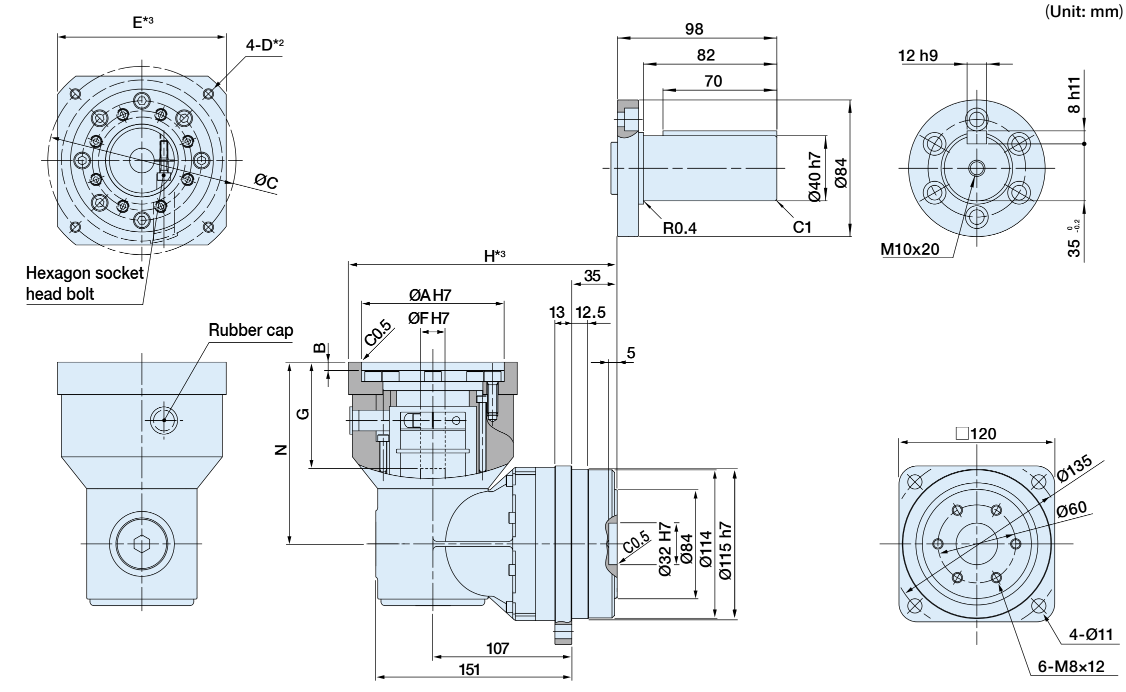


HPG-32RA Outline Dimensions

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

Dimension Table

(Unit: mm) Table 056-1

Flange	Coupling	A (H7)		B	C		F (H7)		G		N	Mass (kg) *1	
		Min.	Max.*2	Max.	Min.	Max.*2	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 mounting screw.
*3 May vary depending on motor interface dimensions.

Moment of Inertia, Input Side

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

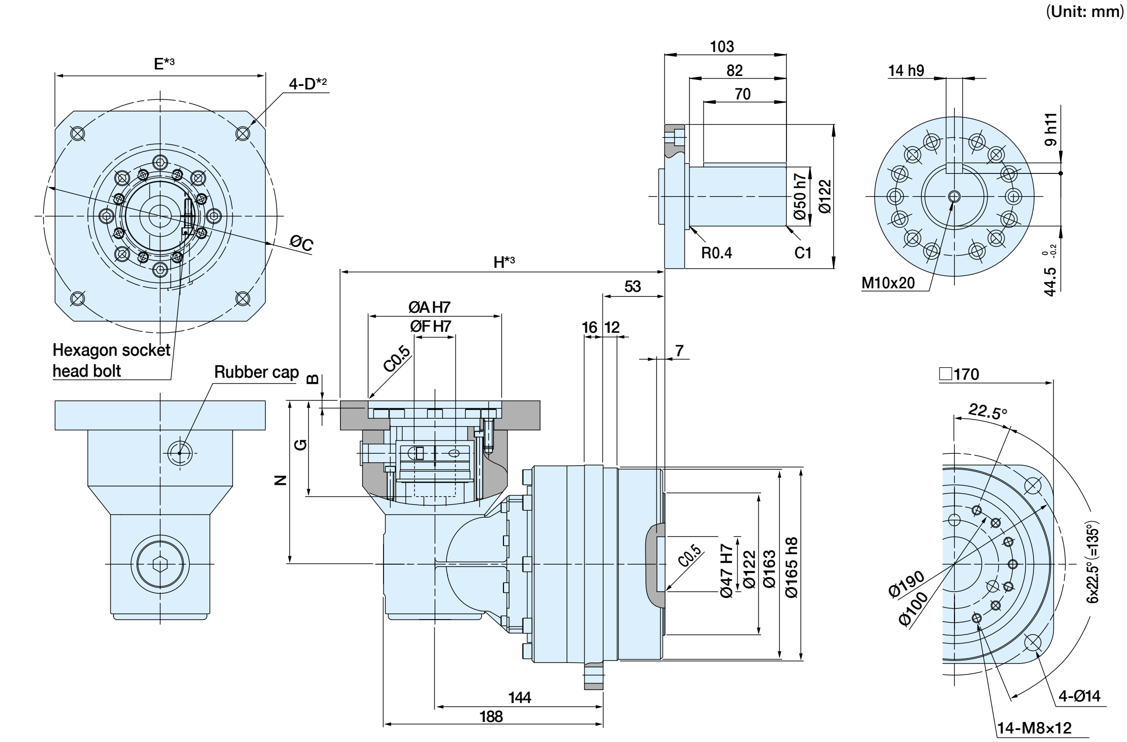
	Coupling \ Ratio	5	11	15	21	33	45
HPG 32RA	1	6.7	6.3	6.1	5.8	-	-
	2	8.09	7.62	-	-	-	-

HPG-50RA3 Outline Dimensions

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

Figure 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.

Dimension Table

(Unit: mm) Table 057-1

Flange	Coupling	A (H7)		B	C		F (H7)		G		N	Mass (kg) *1	
		Min.	Max.*3	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 May vary depending on motor interface dimensions.

Moment of Inertia, Input Side

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

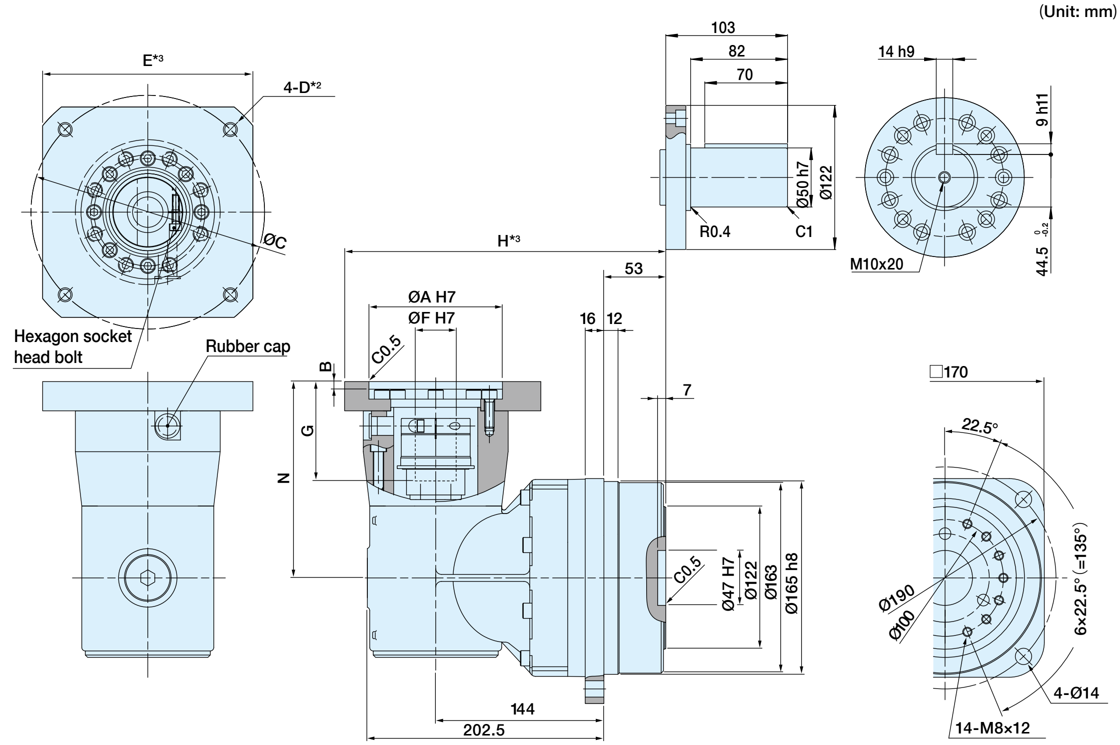
	Ratio / Coupling	5	11	15	21	33	45
HPG 50RA3	1	-	9.4	8.8	7.5	6.4	6.4
	2	-	10.8	10.2	8.9	7.8	7.73

HPG-50RA5 Outline Dimensions

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

Figure 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.

Dimension Table

(Unit: mm) Table 058-1

Flange	Coupling	A (H7)		B	C		F (H7)		G		N	Mass (kg) *1	
		Min.	Max.*3	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 May vary depending on motor interface dimensions.

Moment of Inertia, Input Side

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

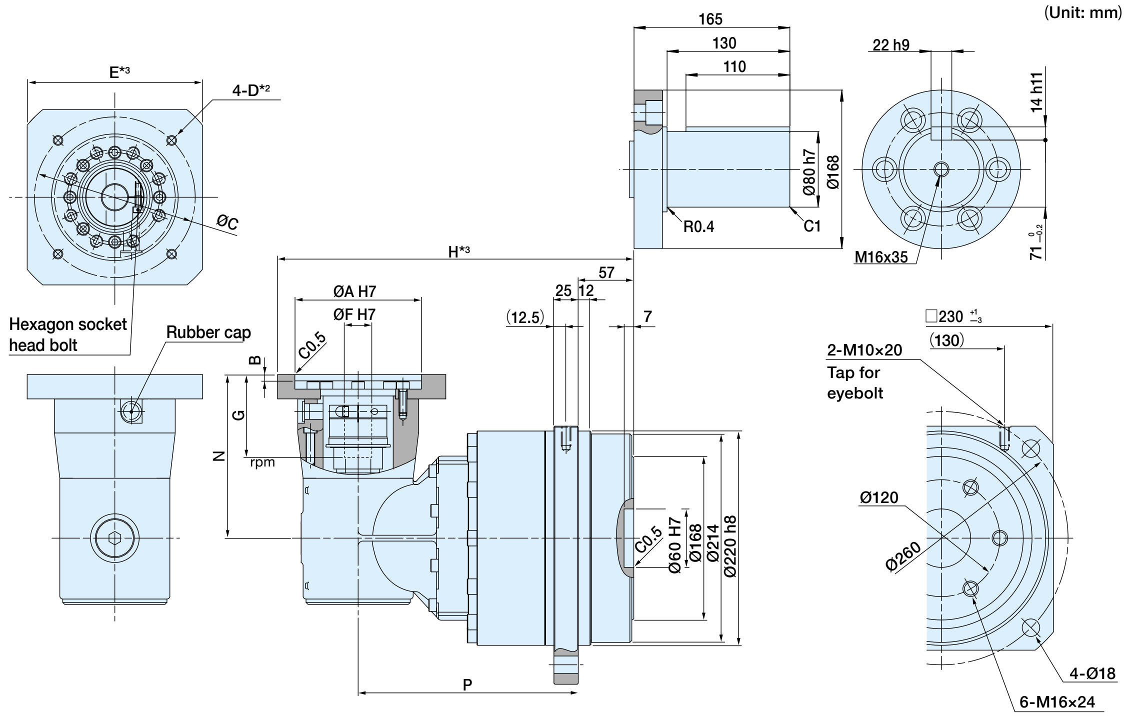
	Coupling \ Ratio	5	11	15	21	33	45
HPG 50RA5	1	37.4	33.9	33.3	32	-	-

HPG-65RA Outline Dimensions

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

Dimension Table

(Unit: mm) Table 059-1

	Flange	Coupling	A (H7)		B	C		F (H7)		G		N	P	Mass (kg) *1	
			Min.	Max.*3	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 May vary depending on motor interface dimensions.

Moment of Inertia, Input Side

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

	Coupling \ Ratio	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	-	-

Sizing & Selection

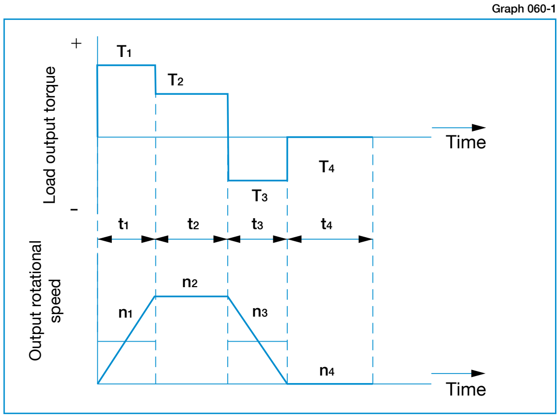
To fully utilize the excellent performance of the HPG-RA HarmonicPlanetary® gearheads, check your operating conditions and, using the flowchart, select the appropriate size gear for your application.

Check your operating conditions against the following application motion profile 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.

Application motion profile

Review the application motion profile. Check the specifications shown in the figure below.

Graph 060-1



Obtain the value of each application motion profile

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 (acceleration)	T_1, t_1, n_1
Steady operation (constant velocity)	T_2, t_2, n_2
Stopping (deceleration)	T_3, t_3, n_3
Dwell	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 (Restricted by motors)	$n_{i\,max}$ $n_1 \times R$ to $n_n \times R$
	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 application motion profile: Tav (Nm).

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

Calculate the average output speed based on the application motion profile: 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: $Tav \leqq$ 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

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 less than the momentary max. torque (Nm) value from the ratings. → NG

↓ OK

Calculate the life and check whether it meets the specification requirement.
Tr: Rated torque
nr: Max. average input speed

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

→ NG

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

↓ OK

The model number is confirmed.

Caution

If any of the following conditions exist, please consider selecting the next larger speed reducer, reduce the operating loads or reduce the operating speed. If this cannot be done, please contact Harmonic Drive LLC. Exercise caution especially when the duty cycle is close to continuous operation.
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),
iii) Gearhead housing temperature > 70°C

Example of model number Selection

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

Normal operation pattern

Starting (acceleration)	T_1 = 70 Nm,	t_1 = 0.3 sec,	n_1 = 60 rpm
Steady operation (constant velocity)	T_2 = 18 Nm,	t_2 = 3 sec,	n_2 = 120 rpm
Stopping (deceleration)	T_3 = 35 Nm,	t_3 = 0.4 sec,	n_3 = 60 rpm
Dwell	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)

Emergency stop 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 application motion profile: 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 application motion profile: 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 ≦ 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*).

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

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 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.

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

NG

OK

The selection of model number HPG-32A-5-RA3 is confirmed from the above calculations.

Refer to the Caution note at the bottom of page 60.

Review the operation conditions, size and reduction ratio.

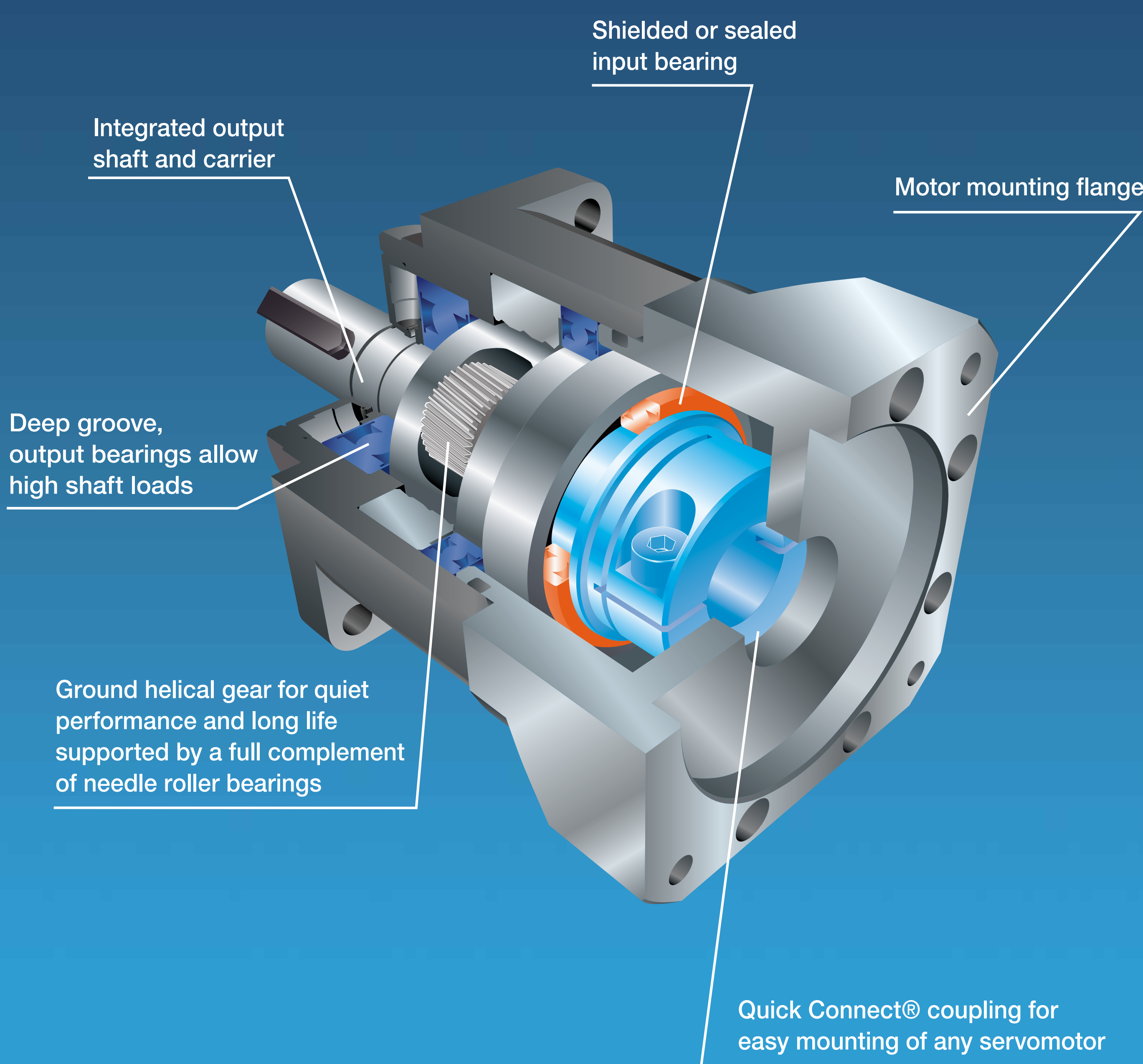
HarmonicPlanetary® HPN Value Series

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)**

New two-stage ratios coming soon!


Shielded or sealed
input bearing
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
supported by a full complement
of needle roller bearings
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
New Two-Stage Ratios Coming Soon!

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

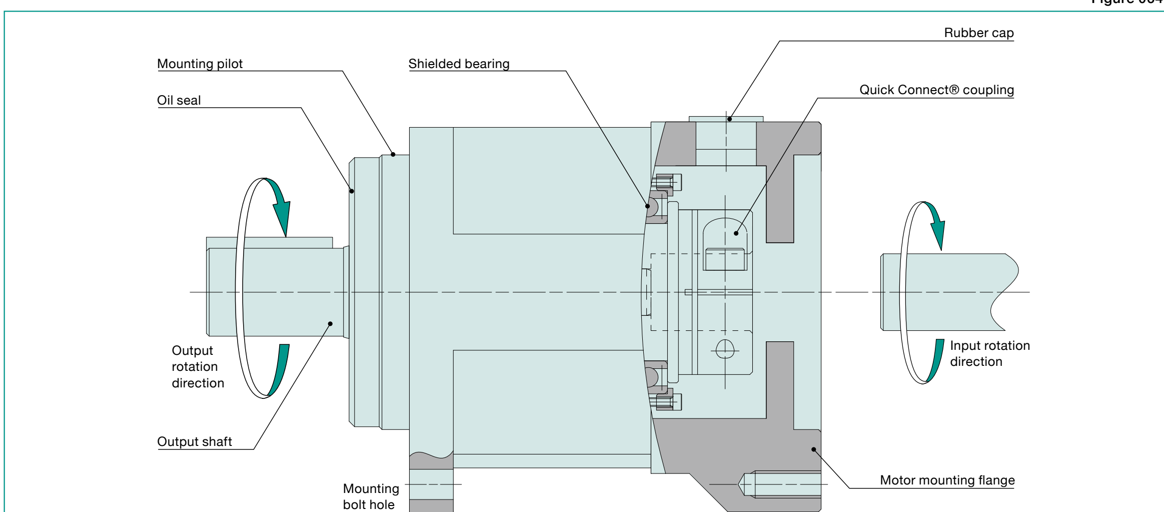
CONTENTS

HPN - 14 A - 05 - Z - J6 - Motor Code

Model Name	Size	Design Revision	Reduction Ratio	Input Side Bearing	Output Configuration	Input Configuration
HarmonicPlanetary® HPN High Torque	11	A	4, 5, 7, 10, 16, 20, 30	Z: Input side bearing with double non- contact shields	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.
	14					
	20		3, 4, 5, 7, 10, 13, 21, 31	D: Input side bearing with double contact seals. (Recommended for output shaft up orientation.)	J8: Shaft output with center tapped hole	
	32					
	40					

Gearhead Construction

Figure 064-1



Rating Table

Table 065-1

Size	Number of Stages	Ratio	Rated Torque L10 *1	Rated Torque L50 *1	Limit for Average Load Torque *2	Limit for Repeated Peak Torque *3	Limit for Momentary Torque *4	Max. Average Input Speed *5	Max. Input Speed (grease) *6	Allowable Radial Load *7	Allowable Axial Load *8
			Nm	Nm	Nm	Nm	Nm	rpm	rpm	N	N
11	1	4	9	14	14	14	40	3,000	10,000	240	280
		5	9	14	14	16	40			260	320
		7	8	11	11	11	40			280	360
		10	7	9	9	9	40			320	420
	2	16	11	18	18	24	40			360	460
		20	13	22	22	24	40			400	560
		30	15	25	25	26	40			480	640
14	1	3	14	22	22	25	89	3,000	6,000	380	340
		4	18	28	28	50	110			420	380
		5	18	29	29	50	107			450	410
		7	20	30	30	37	100			510	480
		10	14	18	18	18	79			570	580
	2	13	20	30	30	43	106			630	630
		21	24	30	30	50	99			740	780
		31	27	30	30	38	101			840	900
20	1	3	31	51	51	74	226	3,000	6,000	830	900
		4	50	80	80	130	256			920	1,100
		5	52	80	80	149	256			1,000	1,200
		7	55	80	80	113	256			1,100	1,400
		10	41	54	54	54	216			1,230	1,600
	2	13	57	80	80	130	256			1,350	1,850
		21	67	80	80	147	256			1,600	2,100
		31	76	80	80	113	256			1,800	2,200
32	1	3	94	153	153	254	625	3,000	6,000	1,800	2,000
		4	122	198	198	376	625			1,900	2,300
		5	127	200	200	376	625			2,000	2,500
		7	135	200	200	376	625			2,300	2,900
		10	128	185	185	185	625			2,600	3,200
	2	13	141	200	200	376	625			2,900	3,600
		21	166	200	200	376	625			3,400	3,800
		31	186	200	200	376	625			3,900	3,800
40	1	3	272	440	440	752	1,137	3,000	6,000	2,800	2,700
		4	287	460	460	752	1,265			3,100	3,000
		5	298	480	480	752	1,265			3,400	3,300
		7	317	510	510	752	829			3,800	3,800
		10	302	480	480	509	829			4,200	4,200
	2	13	331	530	530	752	823			4,500	4,500
		21	384	620	620	752	1,029			5,000	5,000
		31	437	700	700	752	1,097			5,500	5,400

*1: Rated torque is based on life of 20,000 hours at max average input speed.
*2: Average load torque calculated based on the application motion profile must not exceed values shown in the table. See p. 71.
*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.
*5: Max value of average input rotational speed during operation.
*6: Maximum instantaneous input speed.
*7: 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.)
*8: 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 065-2

Size	Number of Stages	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 065-3

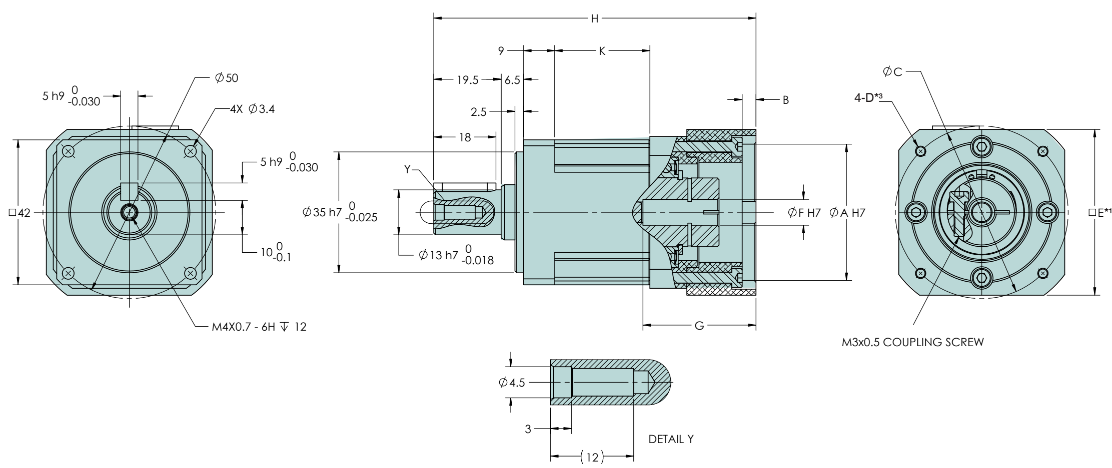
Size	Number of Stages	Ratio	Backlash	Noise*1	Torsional Stiffness	
			arc min	dB	kgfm/arc-min	X100N•m/rad
32	1	3*2	< 5	< 63*2	2.8	940
		4				
		5				
		7				
		10				
	2	13	< 7			
		21				
		31				
40	1	3*2	< 5	< 65*2	4.2	1430
		4				
		5				
		7				
		10				
	2	13	< 7			
		21				
		31				

*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 066-1

(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 066-1

<table>
<tr><th rowspan="2"></th><th colspan="2">A (H7)</th><th>B</th><th colspan="2">C</th><th colspan="2">F (H7)</th><th colspan="2">G *1</th><th rowspan="2">H *1</th><th rowspan="2">K</th><th rowspan="2">Mass(kg) *1</th></tr>
<tr><th>Min.</th><th>Max.*4</th><th>Max.</th><th>Min.</th><th>Max.*4</th><th>Min.</th><th>Max.</th><th>Min.</th><th>Max.</th></tr>
<tr><td>Single Stage</td><td rowspan="2">20</td><td rowspan="2">55</td><td rowspan="2">3</td><td rowspan="2">30</td><td rowspan="2">75</td><td rowspan="2">5</td><td rowspan="2">9</td><td rowspan="2">18</td><td rowspan="2">29</td><td>93.5</td><td>27.5</td><td>0.44</td></tr>
<tr><td>Two Stage</td><td>113</td><td>47</td><td>0.57</td></tr>
</table>

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.

Moment of Inertia

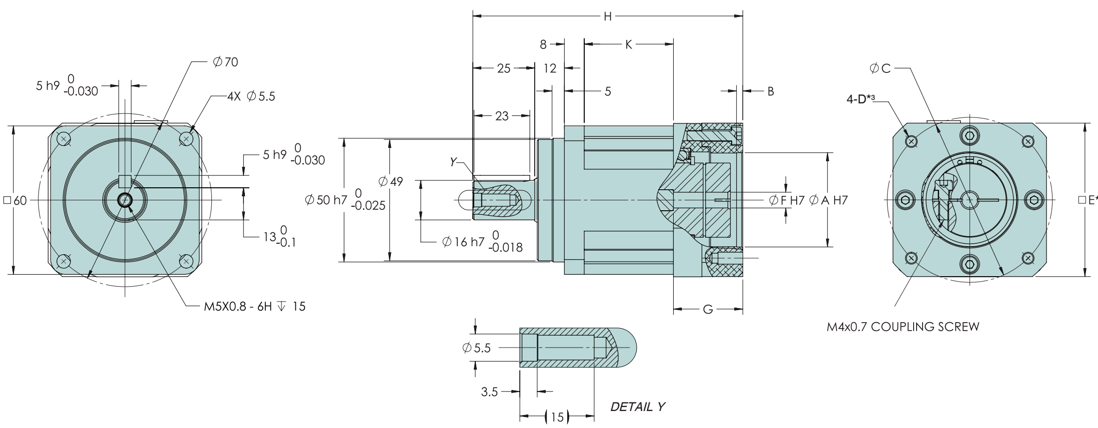
(10^{-4} kgm^2) Table 066-2

	Coupling \ Ratio	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 067-1

(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 067-1

	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	3	3	35	75	5	40	100	6	14	18	28	117	36	0.95
Two Stage												142	61	1.3

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.

Moment of Inertia

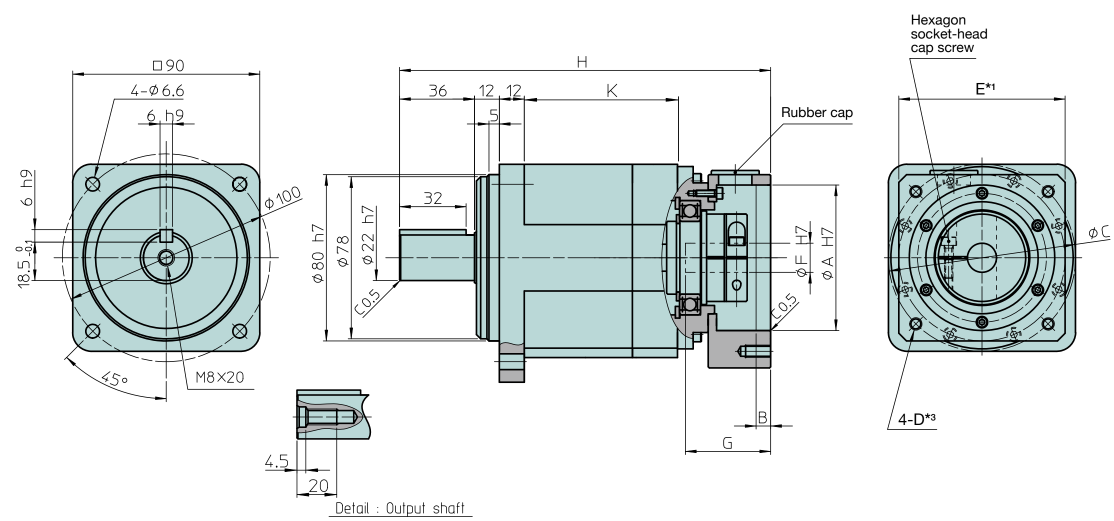
(10^{-4} kgm^2) Table 067-2

	Ratio / Coupling	3	4	5	7	10	13	21	31
HPN 14A	3	0.24	0.21	0.2	0.19	0.19	0.2	0.2	0.2

HPN-20A Outline Dimensions

Figure 068-1

(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 068-1

	Flange	Coupling	A (H7)		B	C		F (H7)		G*1		H*1	K	Mass(kg)*1
			Min.	Max.*1	Max.	Min.	Max.*1	Min.	Max.	Min.	Max.			
Single Stage	1	1	50	85	7	55	115	13.5	25.4	26	47	166.5	52	3
Two Stage										24.5	41	188.2	73.7	3.7
Single Stage	2	1	50	125	7	60	155	13.5	25.4	44	65	184.5	52	3.7
Two Stage										42.5	59	206.2	73.7	4.7
Single Stage	3	2	35	75	7	40	100	9.5	14.2	25.5	40.5	160	52	2.6
Two Stage	4	3	35	75	5	40	100	6	14.2	18	28	175	73.7	3.2

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.

Moment of Inertia

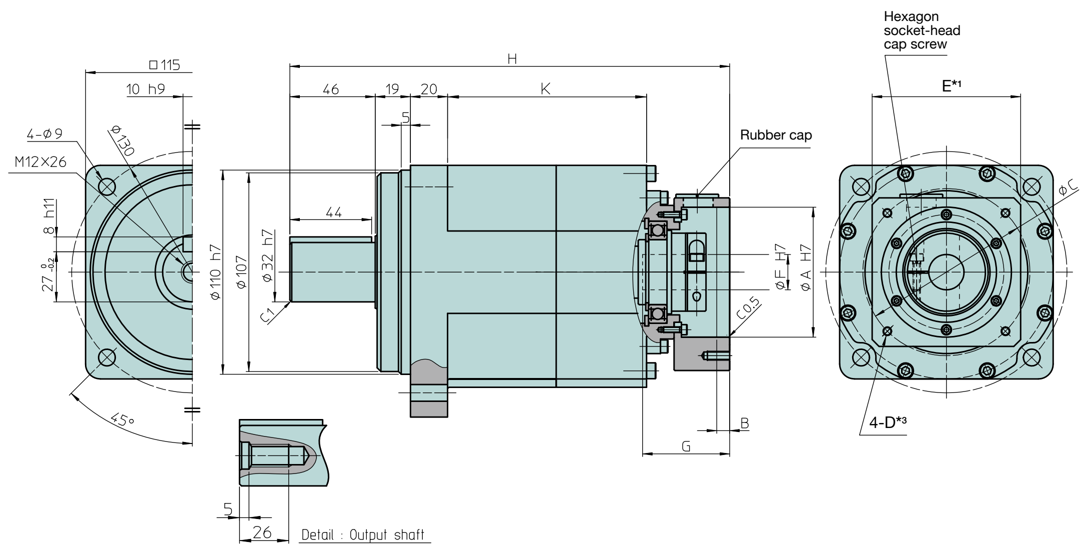
(10^{-4} kgm^2) Table 068-2

	Coupling \ Ratio	3	4	5	7	10	13	21	31
HPN 20A	1	1.2	1	1	0.9	0.87	0.9	0.88	0.87
	2	0.55	0.35	0.3	0.24	0.21	-	-	-
	3	-	-	-	-	-	0.25	0.22	0.22

HPN-32A Outline Dimensions

Figure 069-1

(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 069-1

	Flange	Coupling	A (H7)		B	C		F (H7)		G*1		H*1	K	Mass(kg)*1
			Min.	Max.*1	Max.	Min.	Max.*1	Min.	Max.	Min.	Max.			
Single Stage	1	1	50	85	7	55	115	13.5	25.4	25	51	200	58.5	6.6
	2	2	55	125	7	65	155	15.5	28	42	64	217.5	58.5	7.7
	3	3	65	215	6.5	75	260	21.5	41	47	85	238.5	58.5	9.3
Two Stage	4	4	50	85	7	55	115	13.5	25.4	26	46.5	246.5	107.2	7.9
	5	4	50	125	7	60	155	13.5	25.4	44	65	264.5	107.2	9.1
	6	5	35	75	7	40	100	9.5	14.2	25.5	40.5	240.5	107.2	7.2

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.

Moment of Inertia

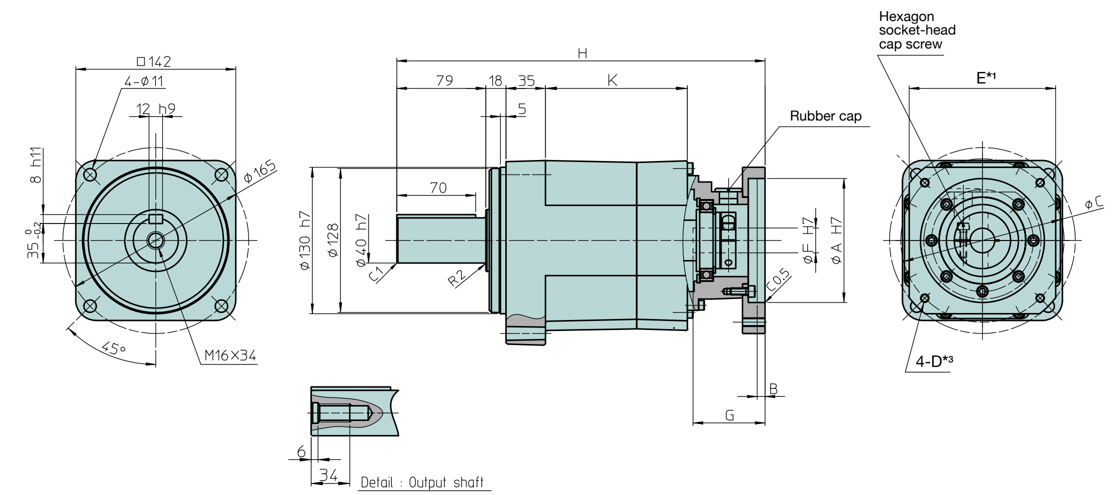
(10^{-4} kgm^2) Table 069-2

	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
	5	-	-	-	-	-	0.55	0.35	0.3

HPN-40A Outline Dimensions

Figure 070-1

(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 070-1

	Flange	Coupling	A (H7)		B	C		F (H7)		G*1		H*1	K	Mass(kg)*1
			Min.	Max.*1	Max.	Min.	Max.*1	Min.	Max.	Min.	Max.			
Single Stage	1	1	70	215	6.5	80	260	27.5	41	34.5	71.5	295.5	81	17
	2	2	70	175	6.5	80	225	42	42	39	104.5	328.5	81	16
	3	3	70	125	7	80	155	15.5	18.5	42	71.5	295.5	81	13
Two Stage	4	4	55	125	7	65	155	15.5	28.5	42	63.5	332	126	17
	5	5	65	215	6.5	75	260	21.5	41	47	84.5	353	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.

Moment of Inertia

(10^{-4} kgm^2) Table 070-2

	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

Sizing & Selection

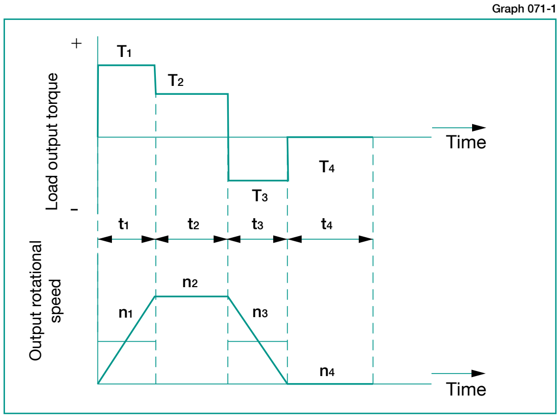
To fully utilize the excellent performance of the HPN HarmonicPlanetary® gearheads, check your operating conditions and, using the flowchart, select the appropriate size gear for your application.

Check your operating conditions against the following application motion profile and select a suitable size based on the flowchart shown on the right. Also, compare any application radial and axial loads supported by the gearhead output shaft to the allowable values in the ratings table to ensure an adequate output bearing service life.

Application motion profile

Review the application motion profile. Check the specifications shown in the figure below.

Graph 071-1



Obtain the value of each application motion profile

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 (Acceleration)	T_1, t_1, n_1
Steady operation (constant velocity)	T_2, t_2, n_2
Stopping (deceleration)	T_3, t_3, n_3
Dwell	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 (Restricted by motors)	$n_{i\,max}$ $n_1 \times R$ to $n_n \times R$
	R: Reduction ratio
Emergency stop 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 application motion profile: 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 application motion profile: 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 less than the momentary max. torque (Nm) value from the ratings. → NG

OK ↓

Calculate the life and check whether it meets the specification requirement.
Tr: Rated 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 any of the following conditions exist, please consider selecting the next larger speed reducer, reduce the operating loads or reduce the operating speed. If this cannot be done, please contact Harmonic Drive LLC. Exercise caution especially when the duty cycle is close to continuous operation.
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),
iii) Gearhead housing temperature > 70°C.

Example of size selection

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

Normal operation pattern

Starting (acceleration)	T_1 = 70 Nm,	t_1 = 0.3 sec,	n_1 = 60 rpm
Steady operation (constant velocity)	T_2 = 18 Nm,	t_2 = 3 sec,	n_2 = 120 rpm
Stopping (deceleration)	T_3 = 35 Nm,	t_3 = 0.4 sec,	n_3 = 60 rpm
Dwell	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)

Emergency stop 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 ≦ 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*).

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

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 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 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.

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

— 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 71.

Review the operation conditions, size and reduction ratio.

HarmonicDrive®

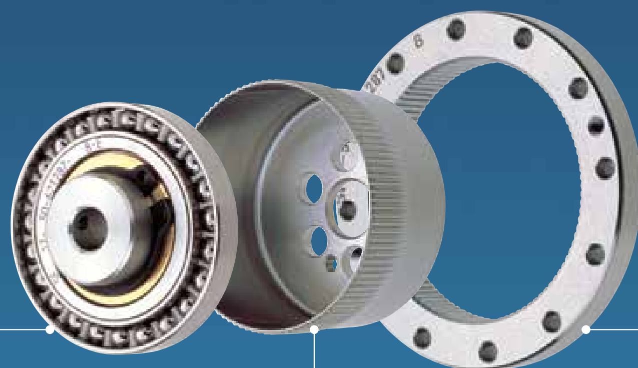
Gearheads for Servomotors

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.



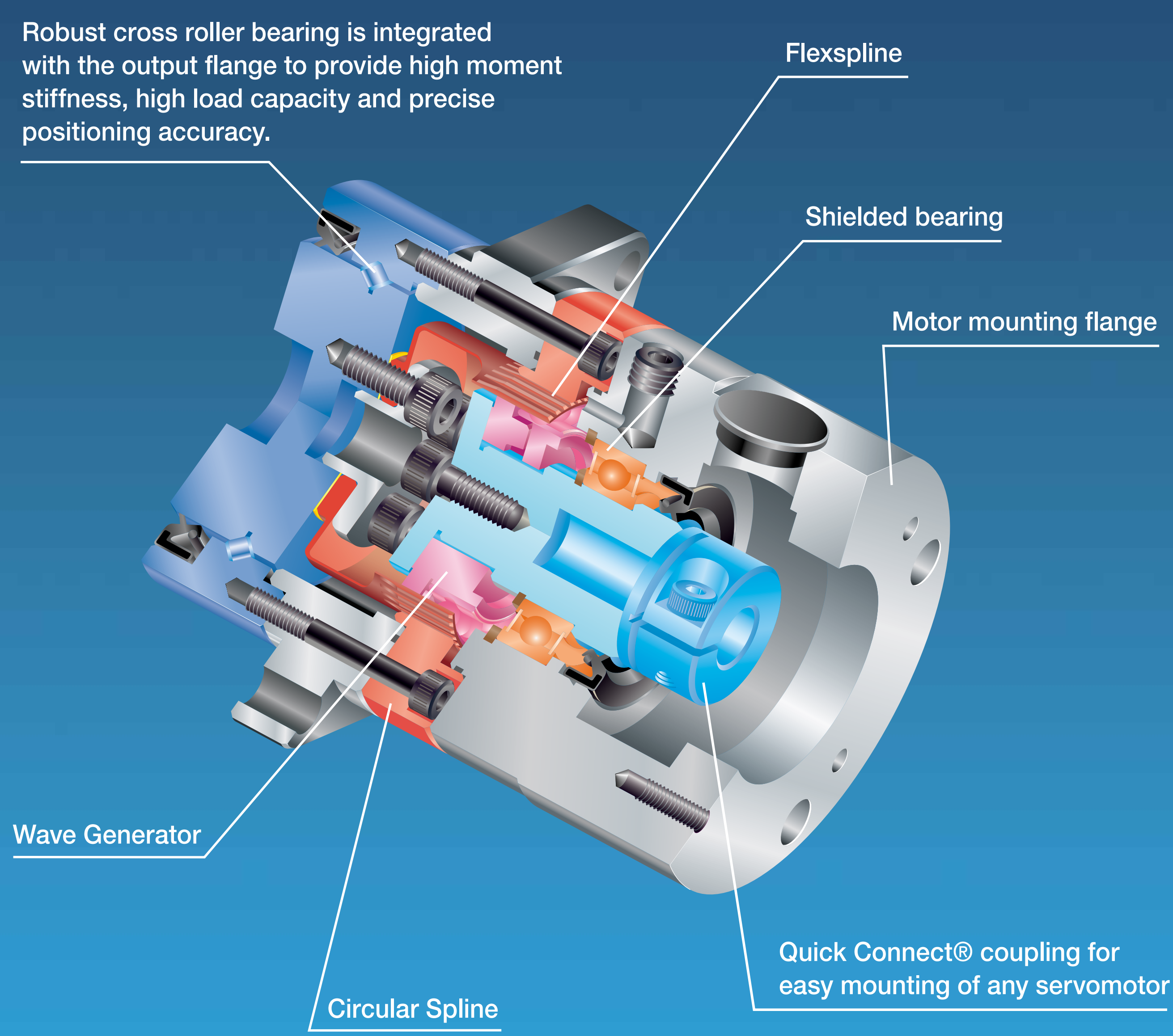
Wave Generator
The Wave Generator is a thin raced ball bearing fitted onto an elliptical shaped hub. The inner race of the bearing is fixed to the cam and the outer race is elastically deformed into an ellipse via the balls. The Wave Generator is usually mounted onto the input shaft.

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 — 5 Sizes
14, 20, 32, 45, 65

Peak torque
23Nm to 3419Nm

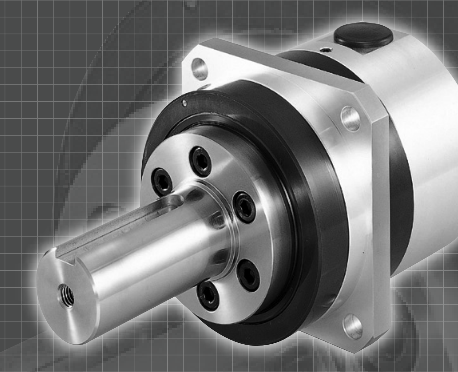
Reduction ratio
50:1 to 160:1

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



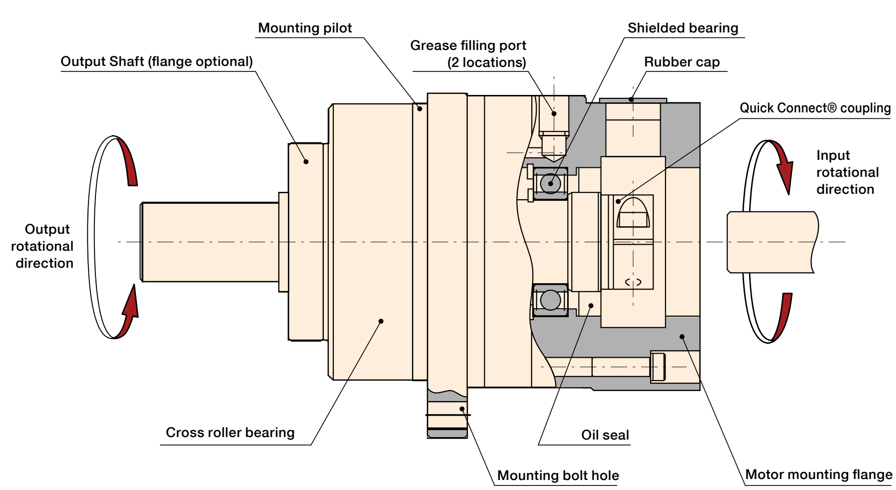
CONTENTS

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 076-1



(The figure indicates output shaft type.)

Rating Table CSG-GH

Table 077-1

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: Average load torque calculated based on the application motion profile must not exceed values shown in the table. See p. 101.
*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.
*6: Max value of average input rotational speed during operation.
*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.

Ratcheting Torque CSG-GH

(Unit: Nm) Table 077-2

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 077-3

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

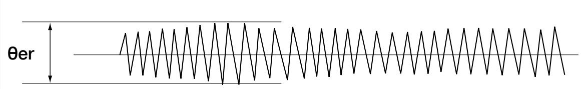
Performance Table CSG-GH

Table 078-1

Size	Flange Type	Ratio	Accuracy *1	Repeatability *2	Starting torque *3	Backdriving torque *4	No-load running torque *5
			arc min	arc sec	Ncm	Nm	Ncm
14	All	50	1.5	±10	8.5	3.0	5.6
		80			7.1	4.0	5.1
		100			6.8	4.9	4.6
20	Type I	50	1.0	±8	14	8	11
		80			10	10	10
		100			10	13	10
		120			9.4	14	9.8
		160			8.9	18	9.6
	Type II & III	50	1.0	±8	21	12	11
		80			17	16	10
		100			16	20	10
		120			16	24	9.8
		160			15	30	9.6
32	Type II	50	1.0	±6	61	37	47
		80			48	46	42
		100			47	56	41
		120			43	63	40
		160			42	81	40
	Type I & III	50	1.0	±6	53	32	47
		80			40	39	42
		100			39	47	41
		120			35	51	40
		160			34	66	40
45	All	50	1.0	±5	129	78	120
		80			99	96	109
		100			93	111	107
		120			88	128	105
		160			82	158	103
65	All	80	1.0	±4	197	191	297
		100			176	213	289
		120			165	240	285
		160			147	285	278

*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 078-1

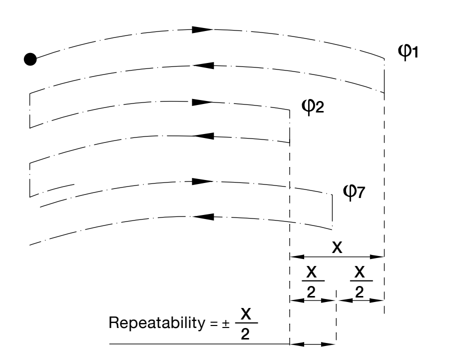


θer : Accuracy
θ1 : Input angle
θ2 : Actual output angle
R : Gear reduction ratio

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

*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 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 CSG-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	$\times 10^4$Nm/rad	0.34	1.3	5.4	15	—
		kgfm/arc min	0.1	0.38	1.6	4.3	—
	K_2	$\times 10^4$Nm/rad	0.47	1.8	7.8	20	—
		kgfm/arc min	0.14	0.52	2.3	6.0	—
	K_3	$\times 10^4$Nm/rad	0.57	2.3	9.8	26	—
		kgfm/arc min	0.17	0.67	2.9	7.6	—
	θ_1	$\times 10^{-4}$rad	5.8	5.2	5.5	5.2	—
		arc min	2.0	1.8	1.9	1.8	—
	θ_2	$\times 10^{-4}$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	$\times 10^4$Nm/rad	0.47	1.6	6.7	18	54
		kgfm/arc min	0.14	0.47	2.0	5.4	16
	K_2	$\times 10^4$Nm/rad	0.61	2.5	11	29	88
		kgfm/arc min	0.18	0.75	3.2	8.5	26
	K_3	$\times 10^4$Nm/rad	0.71	2.9	12	33	98
		kgfm/arc min	0.21	0.85	3.7	9.7	29
	θ_1	$\times 10^{-4}$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	$\times 10^{-4}$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 98 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)

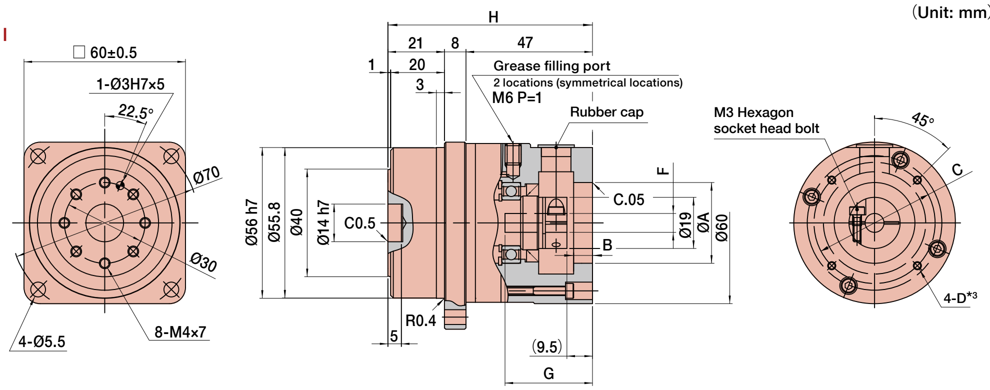
CSG-GH-14 Outline Dimensions

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

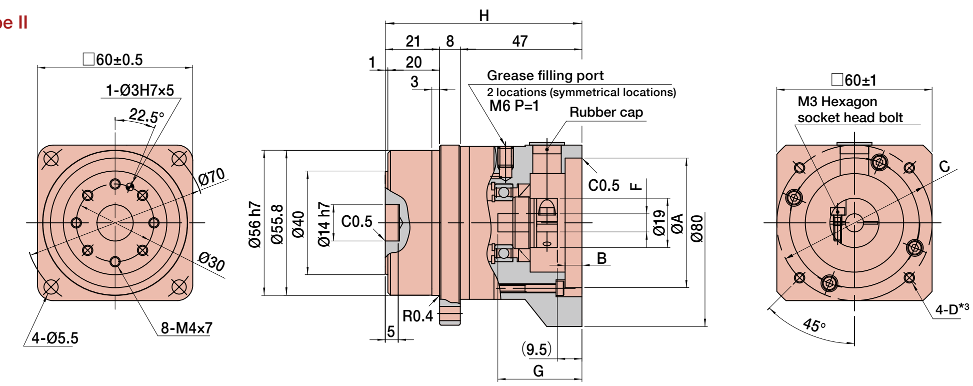
Figure 080-1

(Unit: mm)

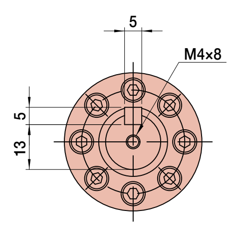
Flange Type I

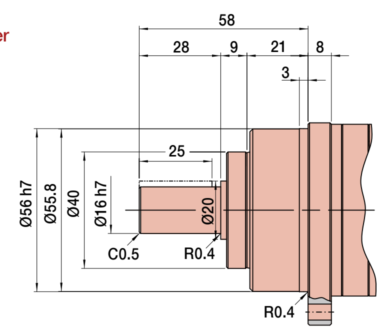


Flange Type II



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





(Note) 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

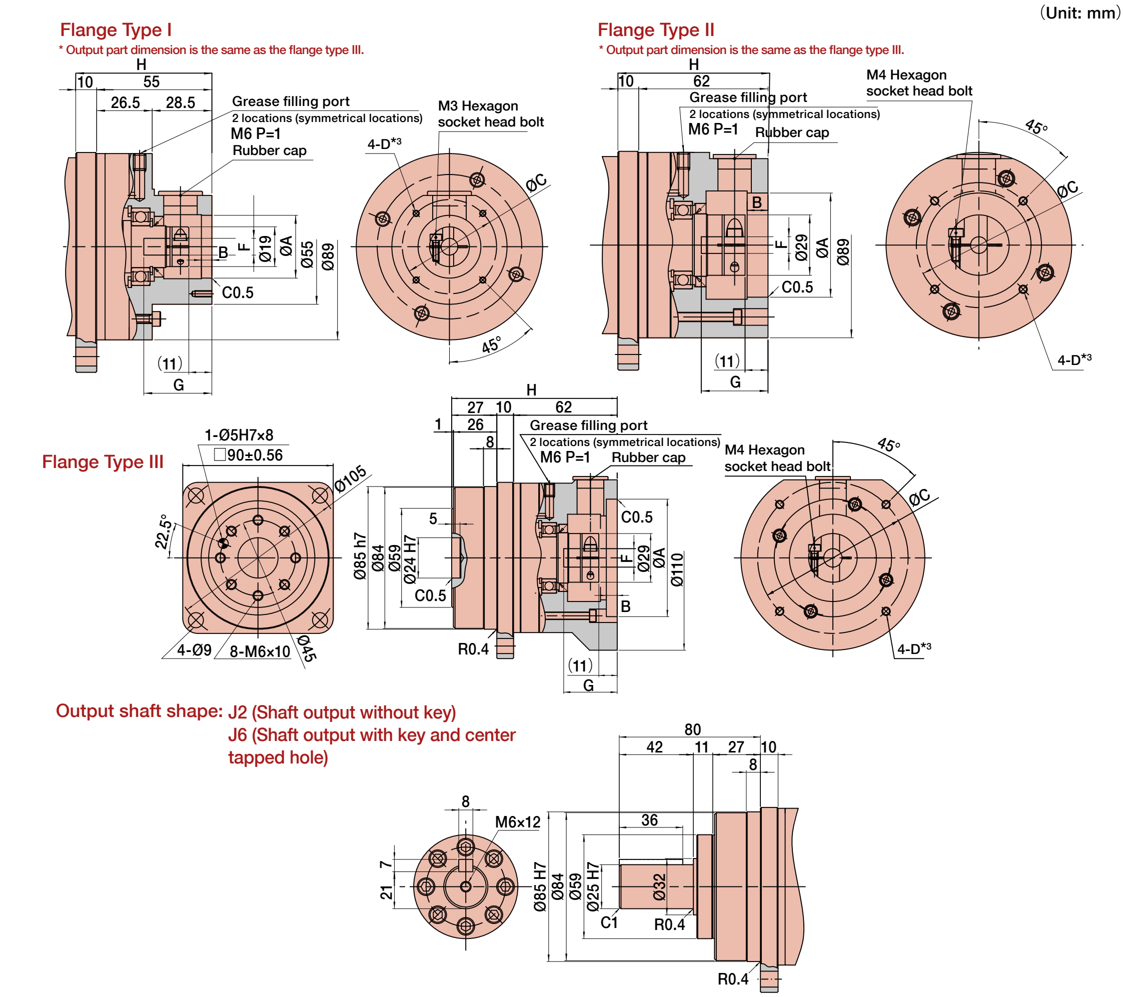
Flange	Coupling	A (H7)		B *1	C		F (H7)		G *1		H	Moment of Inertia	Mass (kg) *2	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	($10^{-4}kgm^2$)	Shaft	Flange
Type I	1	30	50	6.5	35	55	6.0	8	20.5	32.5	76	0.07	0.88	0.76
Type II	1	50	55	7	55	75	6.0	8	20.5	32.5	76	0.07	0.90	0.78

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 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

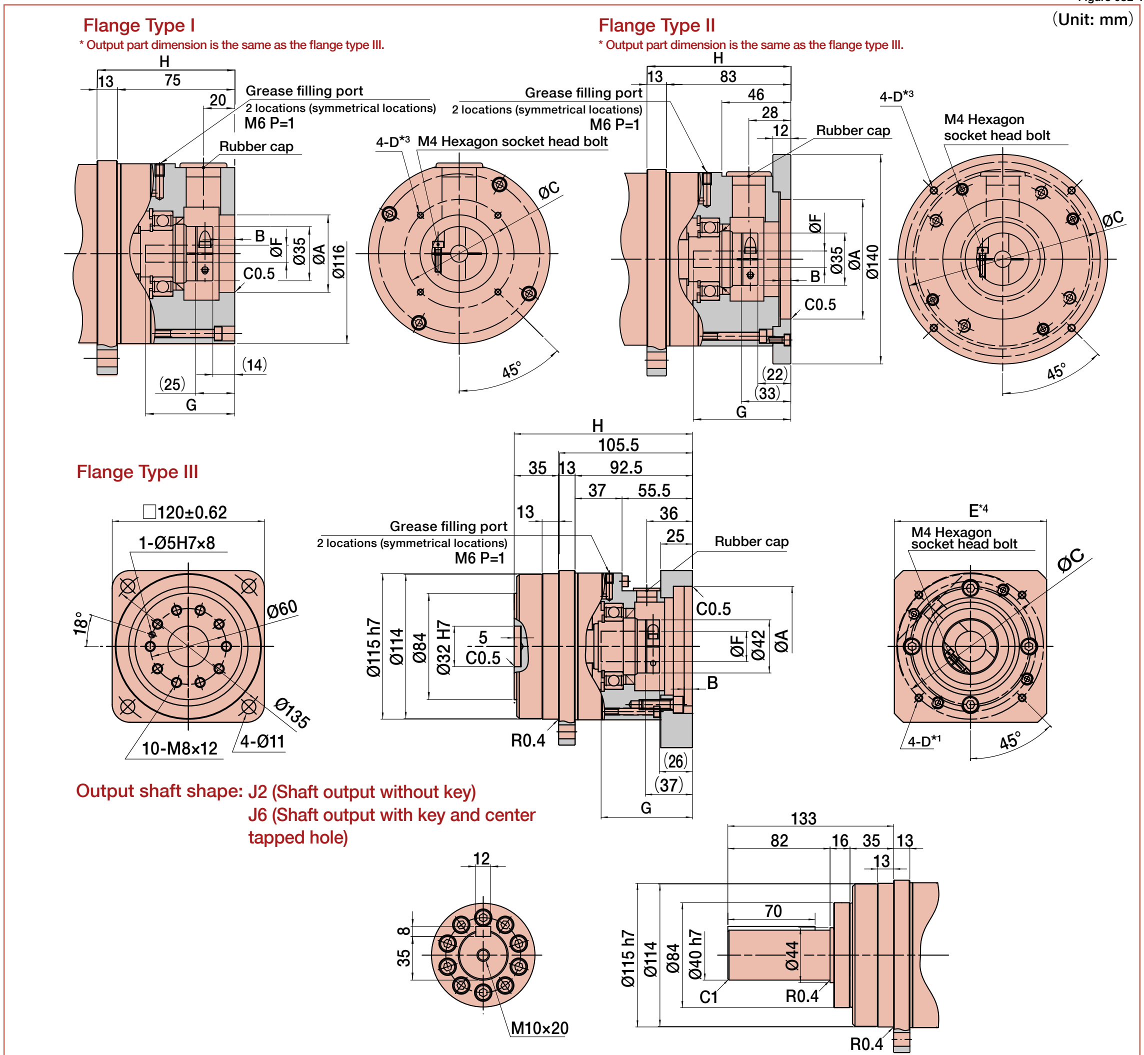
Flange	Coupling	A (H7)		B	C		F (H7)		G		H	Moment of Inertia	Mass (kg) *1	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	(10⁻⁴kgm²)	Shaft	Flange
Type I	1	30	45	5	35	50	7.0	7.8	22.0	33.0	92.0	0.28	2.3	1.9
Type II	2	50	79	10	55	84	8.0	14.6	24.0	32.0	99.0	0.42	2.6	2.2
Type III	2	50	100	10	55	105	8.0	14.6	24.0	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 082-1



(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 082-1

Flange	Coupling	A (H7)		B *1	C		F (H7)		G *1		H *1	Moment of Inertia	Mass (kg) *1	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Max.	(10^{-4}kgm^2)	Shaft	Flange
Type I	1	50	105	10	55	110	10.8	19.6	27.0	57	123	2.7	6.4	5.0
	3						8.8	19.6	27.0	57			6.4	5.0
Type II	2	60	175 *1	5	70	225 *1	16.0	25.8	39.0	72	140.5	2.7	7.9	6.5
Type III	1	35	130 *1	7	40	135 *1	10.8	19.6	35.0	65	131	2.0	6.6	5.2
	3						8.8	19.6	35.0	65			6.6	5.2

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.

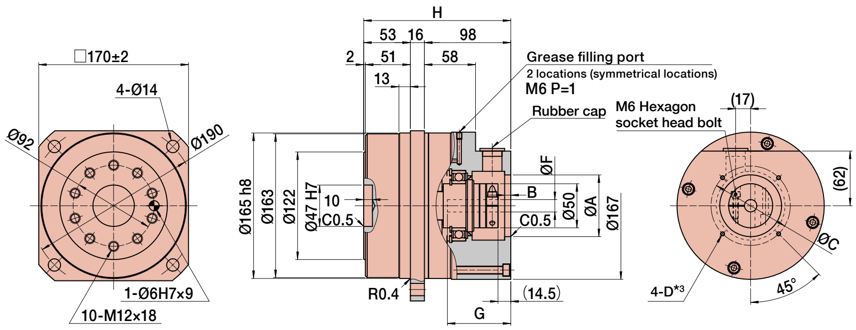
CSG-GH-45 Outline Dimensions

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

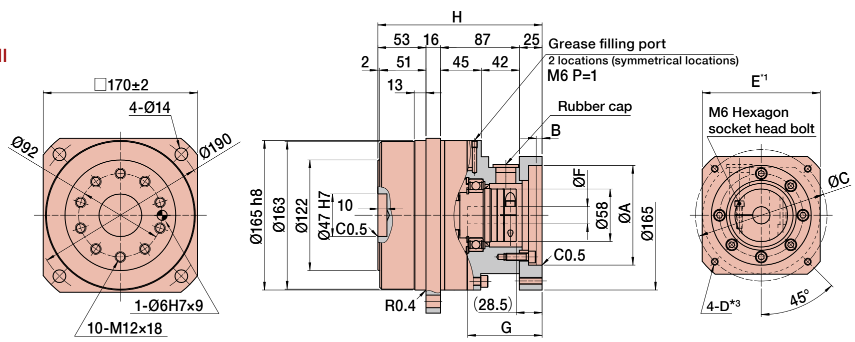
Figure 083-1

(Unit: mm)

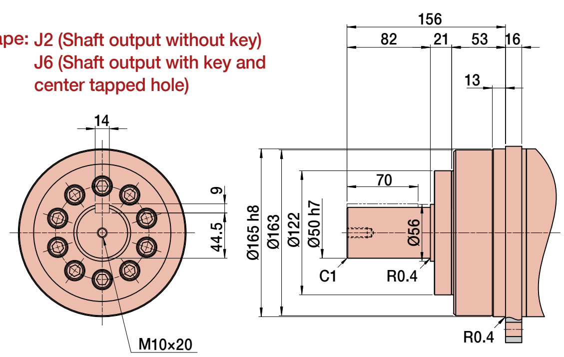
Flange Type I



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 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 083-1

Flange	Coupling	A (H7)		B	C		F (H7)		G *1		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	119	7	80	157	14.0	29.4	30.5	72	167	11	17.3	14.3
	2	70	119	7	80	157	19.0	41	30.5	68	167	11	17.3	14.3
Type II	1	70	175 *1	6.5	80	225 *1	14.0	29.4	44.5	86	181	11	17.7	14.7
	2	70	175 *1	6.5	80	225 *1	19.0	41	44.5	82	181	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.

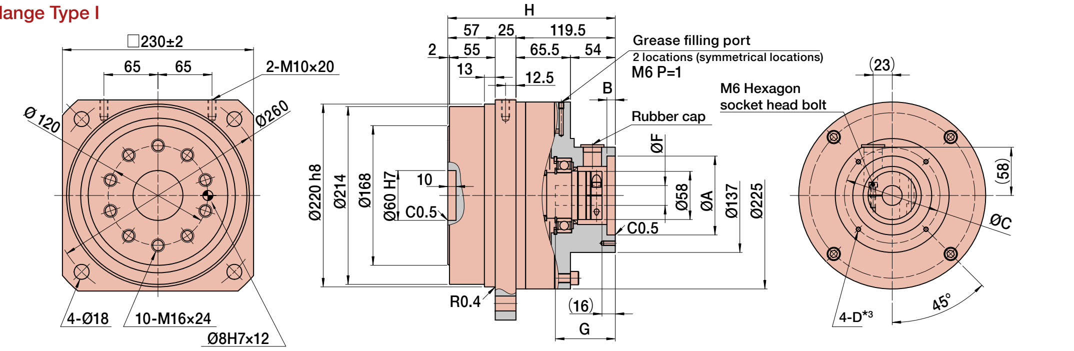
CSG-GH-65 Outline Dimensions

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

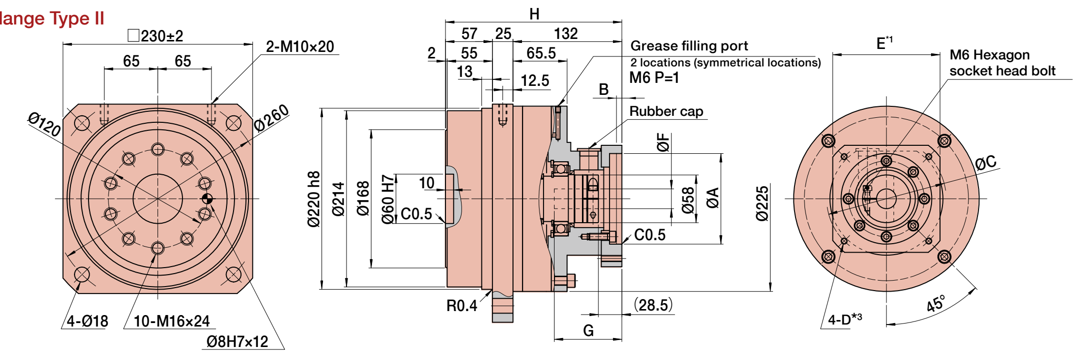
Figure 084-1

(Unit: mm)

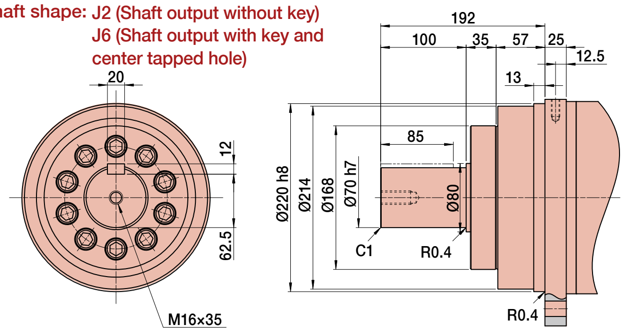
Flange Type I



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 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 084-1

Flange	Coupling	A (H7)		B	C		F (H7)		G *1		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	110	10	105	125	19.0	39.3	32.0	72	201.5	51	36.2	27.6
Type II	1	70	215 *1	6.5	80	260 *1	19.0	39.3	44.5	84.5	214	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.

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

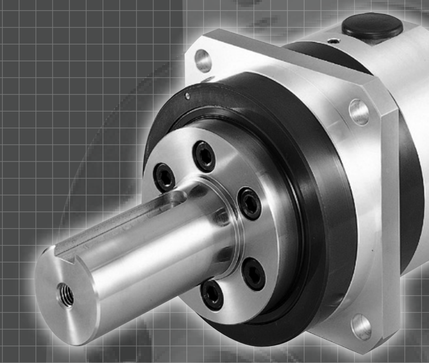
Repeatability ±4 to ±10 arc-sec

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



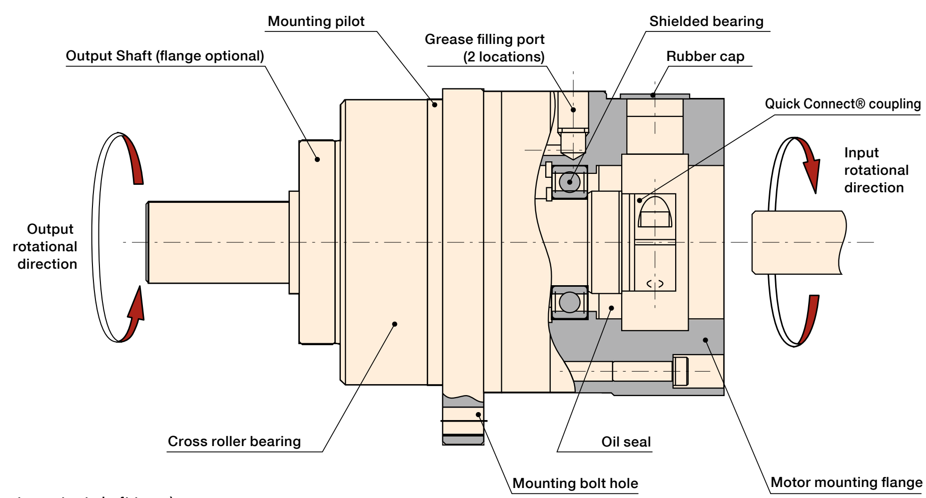
CONTENTS

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 086-1



(The figure indicates output shaft type.)

Rating Table CSF-GH

Table 087-1

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	Flange
		Nm	Nm	Nm	Nm	Nm	rpm	rpm	kg	kg
14	50	5.4	4.7	6.9	18	35	3500	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	3500	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	3500	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	3000	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	1900	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: Average load torque calculated based on the application motion profile must not exceed values shown in the table. See p. 101.
*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.
*6: Max value of average input rotational speed during operation.
*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.

Ratcheting Torque CSF-GH

(Unit: Nm) Table 087-2

Size / Ratio	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 087-3

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

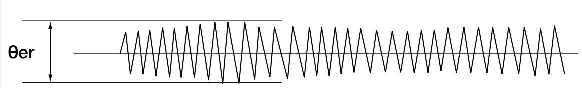
Performance Table CSF-GH

Table 088-1

Size	Flange Type	Ratio	Accuracy*1	Repeatability*2	Starting torque*3	Backdriving torque*4	No-load running torque*5
			arc min	arc sec	Ncm	Nm	Ncm
14	All	50	1.5	±10	8.2	2.9	5.6
		80			6.9	3.9	5.1
		100			6.6	4.7	4.6
20	Type I	50	1.0	±8	13	7.8	11
		80			10	9.6	10
		100			9.6	12	10
		120			9.1	13	9.8
		160			8.6	17	9.6
	Type II & III	50	1.0	±8	20	12	11
		80			17	16	10
		100			16	19	10
		120			16	23	9.8
		160			15	29	9.6
32	Type II	50	1.0	±6	58	35	47
		80			46	44	42
		100			45	54	41
		120			42	61	40
		160			41	79	40
	Type I & III	50	1.0	±6	50	30	47
		80			38	37	42
		100			37	45	41
		120			34	49	40
		160			33	64	40
45	All	50	1.0	±5	123	74	120
		80			95	92	109
		100			89	107	107
		120			85	123	105
		160			79	152	103
65	All	80	1.0	±4	186	179	297
		100			166	200	289
		120			156	226	285
		160			139	268	278

*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 088-1

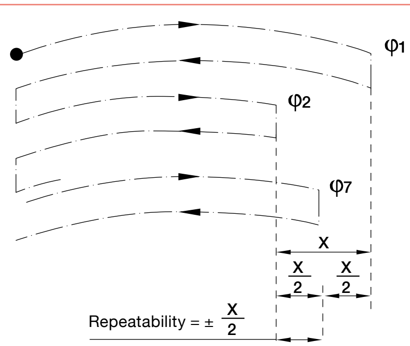


θer : Accuracy
θ1 : Input angle
θ2 : Actual output angle
R : Gear reduction ratio

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

*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 088-2



$$\text{Repeatability} = \pm \frac{x}{2}$$

*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 088-2

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 088-3

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 088-4

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

Torsional Stiffness　CSF-GH

Table 089-1

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	$\times 10^4$Nm/rad	0.34	1.3	5.4	15	—
		kgfm/arc min	0.1	0.38	1.6	4.3	—
	K_2	$\times 10^4$Nm/rad	0.47	1.8	7.8	20	—
		kgfm/arc min	0.14	0.52	2.3	6.0	—
	K_3	$\times 10^4$Nm/rad	0.57	2.3	9.8	26	—
		kgfm/arc min	0.17	0.67	2.9	7.6	—
	θ_1	$\times 10^{-4}$rad	5.8	5.2	5.5	5.2	—
		arc min	2.0	1.8	1.9	1.8	—
	θ_2	$\times 10^{-4}$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	$\times 10^4$Nm/rad	0.47	1.6	6.7	18	54
		kgfm/arc min	0.14	0.47	2.0	5.4	16
	K_2	$\times 10^4$Nm/rad	0.61	2.5	11	29	88
		kgfm/arc min	0.18	0.75	3.2	8.5	26
	K_3	$\times 10^4$Nm/rad	0.71	2.9	12	33	98
		kgfm/arc min	0.21	0.85	3.7	9.7	29
	θ_1	$\times 10^{-4}$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	$\times 10^{-4}$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 98 for more information about torsional stiffness.

Hysteresis Loss　CSF-GH

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

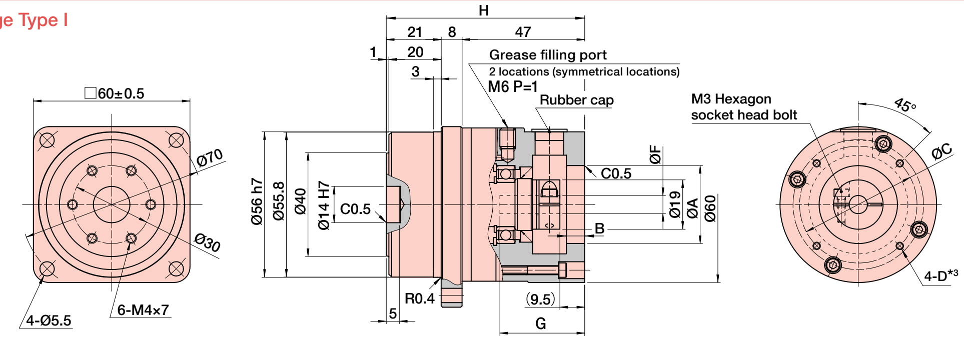
CSF-GH-14 Outline Dimensions

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

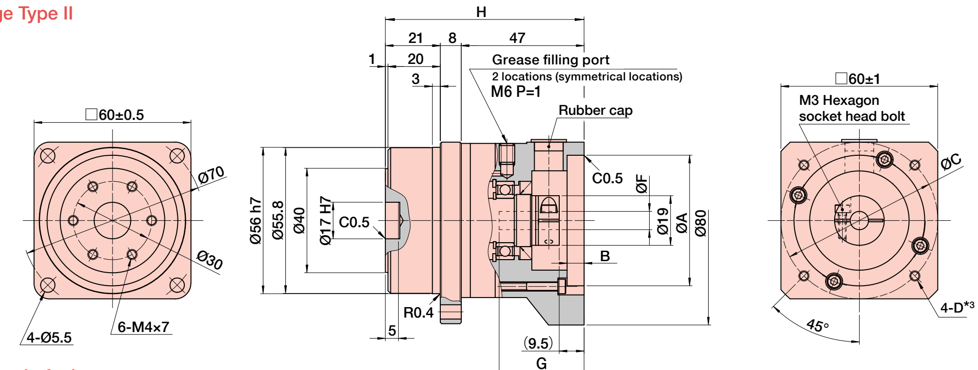
Figure 090-1

(Unit: mm)

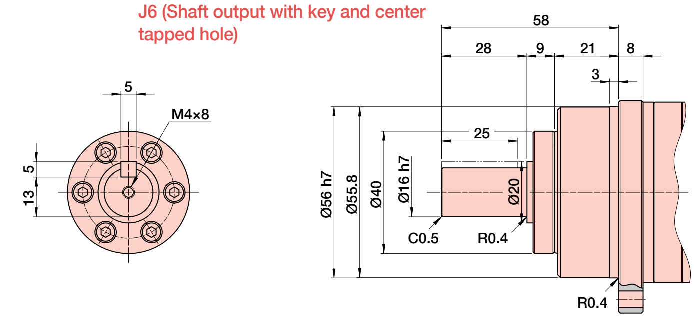
Flange Type I



Flange Type II



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



(Note) 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 090-1

Flange	Coupling	A (H7)		B *1	C		F (H7)		G		H *1	Moment of Inertia	Mass (kg) *2	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	(10^{-4}kgm²)	Shaft	Flange
Type I	1	30	50	6.5	35	55	6.0	8	20.5	32.5	76	0.07	0.88	0.76
Type II	1	30	55	7	55	75	6.0	8	20.5	32.5	76	0.07	0.90	0.78

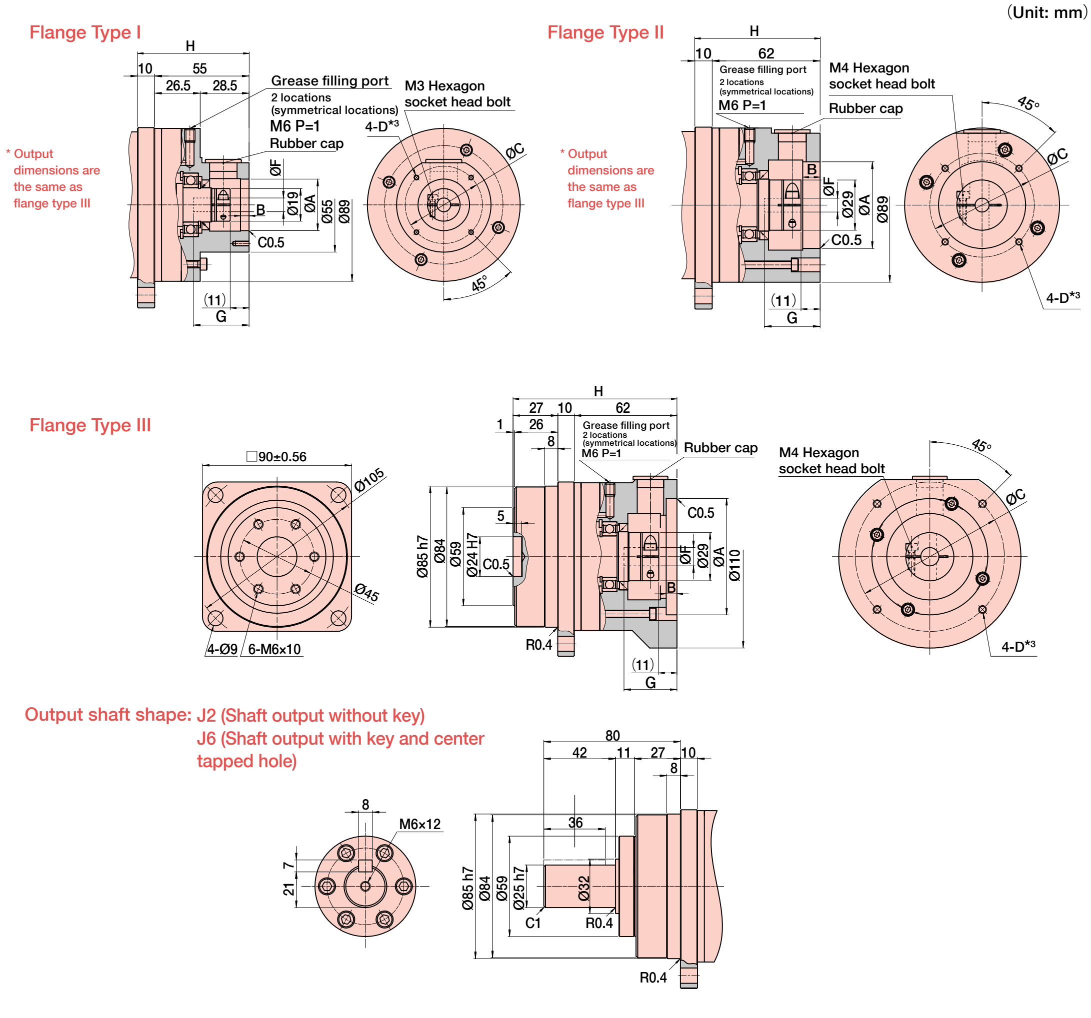
Refer to the confirmation drawing for detailed dimensions.
Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.
*1 May vary depending on motor interface dimensions.
*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.
*3 Tapped hole for 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 091-1

(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 091-1

Flange	Coupling	A (H7)		B *1	C		F (H7)		G *1		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	35	50	7.0	7.8	22	33	92	0.28	2.3	1.9
Type II	2	50	79	10	55	84	8.0	14.6	24	32	99	0.42	2.6	2.2
Type III	2	50	100	10	55	105	8.0	14.6	24	32	99	0.42	2.8	2.4

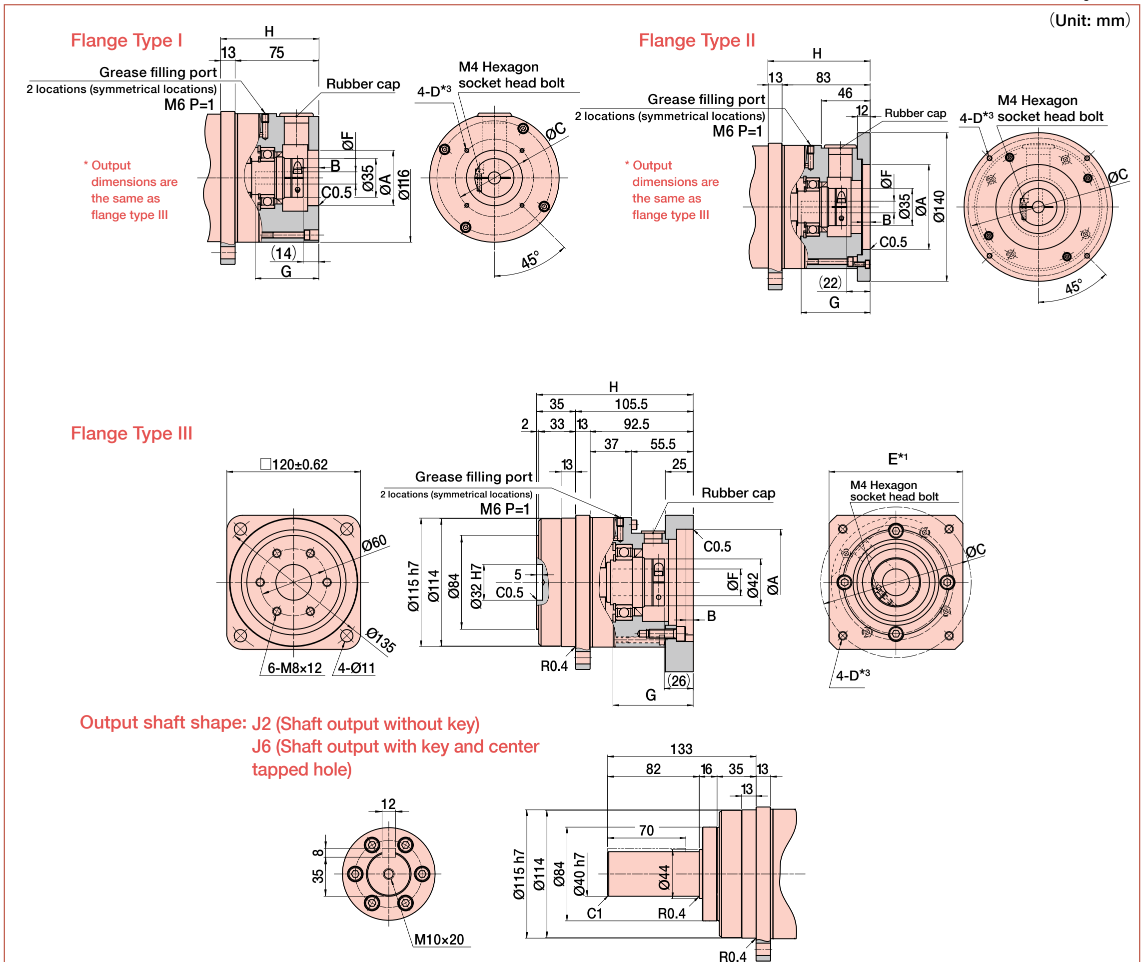
Refer to the confirmation drawing for detailed dimensions.
Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.
*1 May vary depending on motor interface dimensions.
*2 The mass will vary slightly 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 092-1

(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 092-1

Flange	Coupling	A (H7)		B *1	C		F (H7)		G *1		H *1	Moment of Inertia	Mass (kg) *1	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Max.	(10^{-4}kgm^2)	Shaft	Flange
Type I	1	50	105	10	55	100	10.8	19.6	27	57	123	2.7	6.4	5.0
	3						8.8	19.6	27	46			6.4	5.0
Type II	2	60	175 *1	5	70	225 *1	16	25.8	39	72	140.5	2.7	7.9	6.5
Type III	1	35	130 *1	7	40	135 *1	10.8	19.6	35	65	131	2.0	6.6	5.2
	3						8.8	19.6	35	54			6.6	5.2

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.

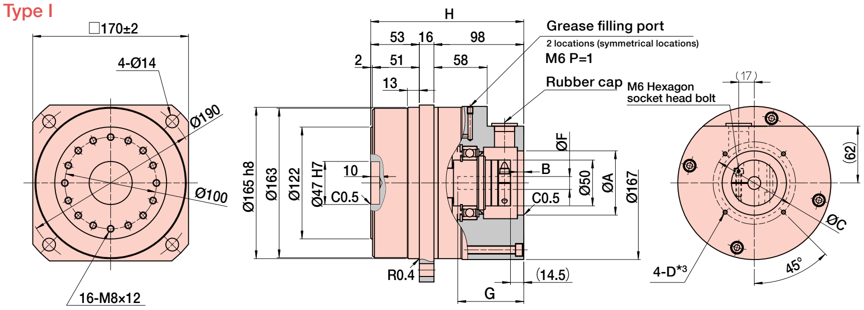
CSF-GH-45 Outline Dimensions

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

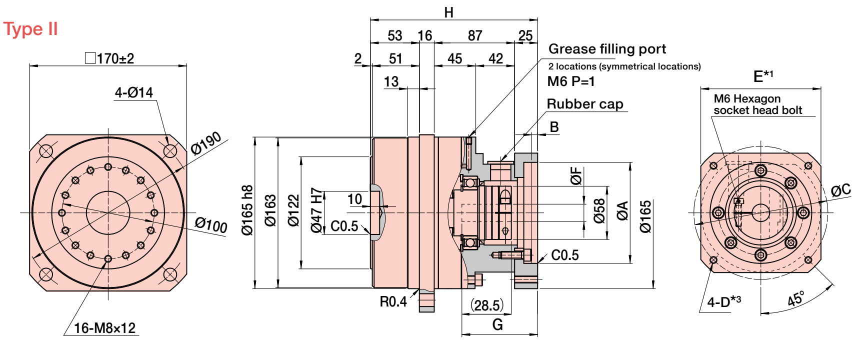
Figure 093-1

(Unit: mm)

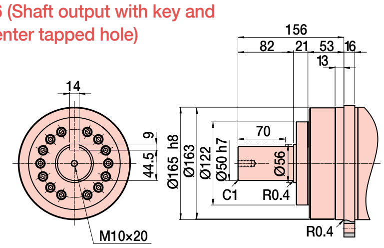
Flange Type I



Flange Type II



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



(Note) 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 093-1

Flange	Coupling	A (H7)		B	C		F (H7)		G *1		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	119	7	80	157	14.0	29.4	30.5	72	167	11	17.3	14.3
Type I	2	70	119	7	80	157	19.0	41	30.5	68	167	11	17.3	14.3
Type II	1	70	175 *1	6.5	80	225 *1	14.0	29.4	44.5	86	181	11	17.7	14.7
Type II	2	70	175 *1	6.5	80	225 *1	19.0	41	44.5	82	181	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.

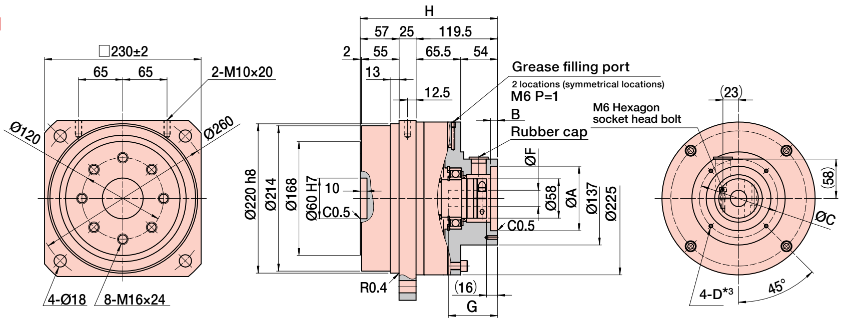
CSF-GH-65 Outline Dimensions

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

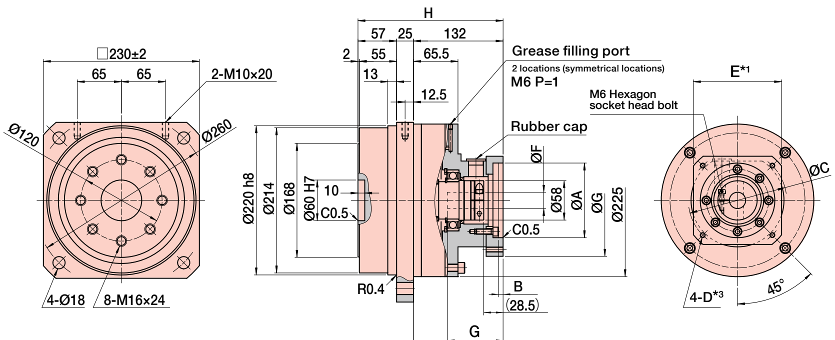
Figure 094-1

(Unit: mm)

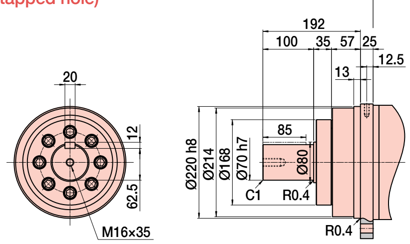
Flange Type I



Flange Type II



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



(Note) 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 094-1

Flange	Coupling	A (H7)		B	C		F (H7)		G *1		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	110	10	105	125	19.0	39.3	32.0	72	201.5	51	36.2	27.6
Type II	1	70	215 *1	6.5	80	260 *1	19.0	39.3	44.5	84.5	214	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.

■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 096-1)

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 100)

■ Limit for Momentary Torque (see Graph 096-1)

The gear may be subjected to momentary 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 torque may be calculated by using the formula on page 100.

■ Maximum Average Input Speed Maximum Input Speed

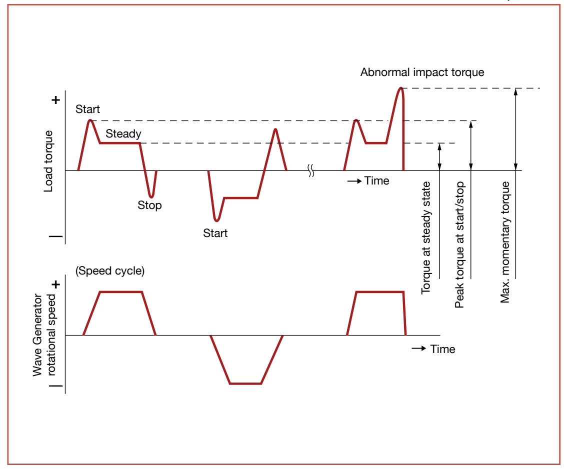
Do not exceed the allowable rating. (calculation formula of the average input speed: Page 100).

■ Inertia

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

Example of load torque pattern

Graph 096-1



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 096-1

Series name	Life: CSF-GH	Life: 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 096-1

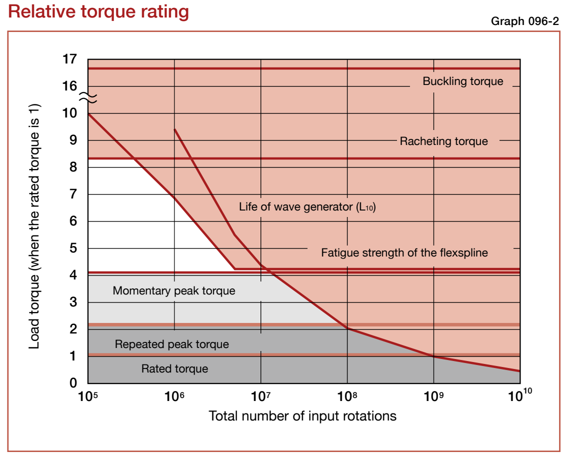
$$Lh = Ln \cdot \left(\frac{Tr}{Tav}\right)^3 \cdot \left(\frac{Nr}{Nav}\right)$$

Table 096-2

Ln	Life of L_{10} or L_{50}
Tr	Rated torque
Nr	Rated input speed
Tav	Average load torque on the output side (calculation formula: Page 100)
Nav	Average input speed (calculation formula: Page 100)

Relative torque rating

Graph 096-2



* 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 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 torque (impact torque). The maximum number of occurrences is given by the equation below.

Calculation formula

Formula 097-1

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

Permissible occurrences	N occurrences
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 occurrences 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 elastic 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

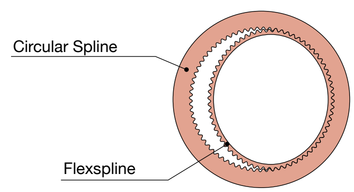
When excessive torque (8 to 9 times rated torque) is applied while the gear is in motion, the teeth between the Circular Spline and Flexspline may not engage properly.
This phenomenon is called ratcheting and the torque at which this occurs is called ratcheting torque. Ratcheting may cause the Flexspline 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 097-1. 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 097-1



"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 098-1 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 098-2, 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 = 11 x 10^4 Nm/rad
K2 = 12 x 10^4 Nm/rad
K3 = 6.7 x 10^4 Nm/rad
$\theta_1 = 4.4 \times 10^{-4}$ rad
$\theta_2 = 11.6 \times 10^{-4}$ 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

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

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

$$\theta_{L2} = \theta_1 + (T_{L2}-T_1)/K_2 = 4.4\times10^{-4} + (50-29)/11.0\times10^4 = 4.4\times10^{-4} + 1.9\times10^{-4} = 6.3\times10^{-4}\ \text{rad}\ (2.17\ \text{arc min})$$

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

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

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.

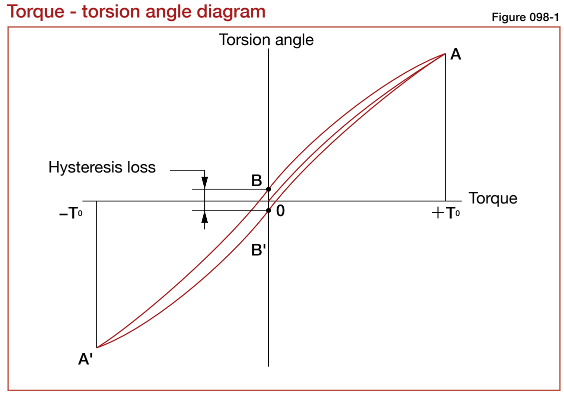
■ Hysteresis loss

As shown in Figure 098-1, 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.

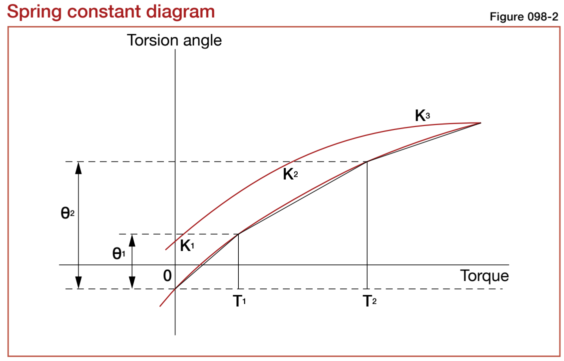
Torque - torsion angle diagram

Figure 098-1



Spring constant diagram

Figure 098-2



■ 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 099-1

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

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

How to the calculate resonant frequency of the system

Formula 099-2

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

Formula variables

Table 099-1

f	The resonant frequency of the system	Hz	
K	Spring constant	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

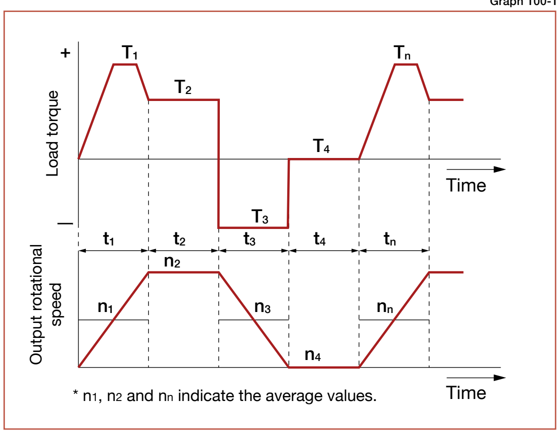
In general, a servo system rarely operates at a continuous load and speed. The input rotational speed, load torque change and comparatively large torque are applied at start and stop. Unexpected impact torque may be applied.
These fluctuating load torques should be converted to the average load torque 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 or CSG-GH series is installed vertically with the output shaft facing downward (motor mounted above it) and continuously operated in one direction under the constant load state, lubrication failure may occur. In this case, please contact us for details.

■ Application Motion Profile

Review the application motion profile. Check the specifications shown in the figure below.

Graph 100-1



Obtain the value of each application motion profile.

Load torque	T_n (Nm)
Time	t_n (sec)
Output rotational speed	n_n (rpm)
Normal operation pattern	
Starting (acceleration)	T_1, t_1, n_1
Steady operation (constant velocity)	T_2, t_2, n_2
Stopping (deceleration)	T_3, t_3, n_3
Idle	T_4, t_4, n_4
Maximum rotational speed	
Max. output speed	$n_{o\,max}$
Max. input rotational speed (Restricted by motors)	$n_{i\,max}$
Emergency stop 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).

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

↓

Make a preliminary model selection with the following conditions.
$T_{av} \leqq$ Limit for average torque torque
(See the ratings of each series).

↓

Calculate the average output speed: $n_{o\,av}$ (rpm)
$$n_{o\,av} = \frac{n_1 \cdot t_1 + n_2 \cdot t_2 + \cdots n_n \cdot t_n}{t_1 + t_2 + \cdots t_n}$$

Obtain the reduction ratio (R). A limit is placed on "$n_{i\,max}$" by motors.
$$\frac{n_{i\,max}}{n_{o\,max}} \geqq R$$

Calculate the average input rotational speed from the average output rotational speed ($n_{o\,av}$) and the reduction ratio (R): $n_{i\,av}$ (rpm)
$$n_{i\,av} = n_{o\,av} \cdot R$$

Calculate the maximum input rotational speed from the max. output rotational speed ($n_{o\,max}$) and the reduction ratio (R): $n_{i\,max}$ (rpm)
$$n_{i\,max} = n_{o\,max} \cdot R$$

↓

Check whether the preliminary model number satisfies the following condition from the ratings.
$N_{i\,av} \leqq$ Limit for average speed (rpm)
$N_{i\,max} \leqq$ 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 torque specification. → NG

OK ↓

Calculate (N_s) 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.
$$L_{10} = 7{,}000 \cdot \left(\frac{T_r}{T_{av}}\right)^3 \cdot \left(\frac{n_r}{n_{i\,av}}\right) \text{(hours)}$$

↓

Check whether the calculated lifetime is equal to or more than the life of the wave generator (see Page 96). → NG

OK ↓

The model number is confirmed.

NG → Review the operation conditions and model number

Example of model number selection

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

Normal operation pattern

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

Maximum rotational speed

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

Emergency stop 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 87.)
Thus, **CSF-45-120-GH** is tentatively selected.

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

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

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 T_s is equal to or less than the momentary 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 96).
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

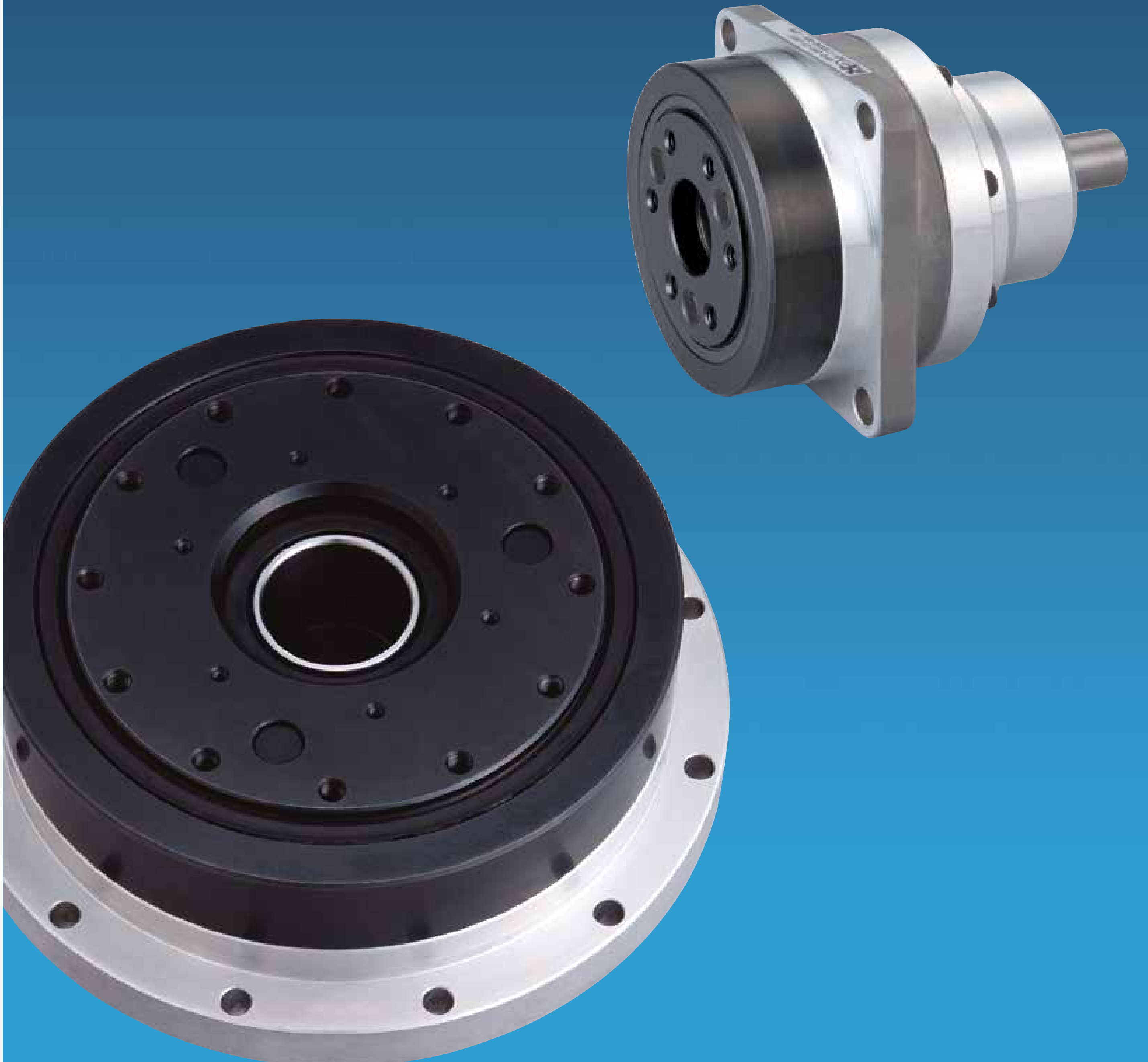
■NOTES

HarmonicPlanetary®

Planetary Gear Units

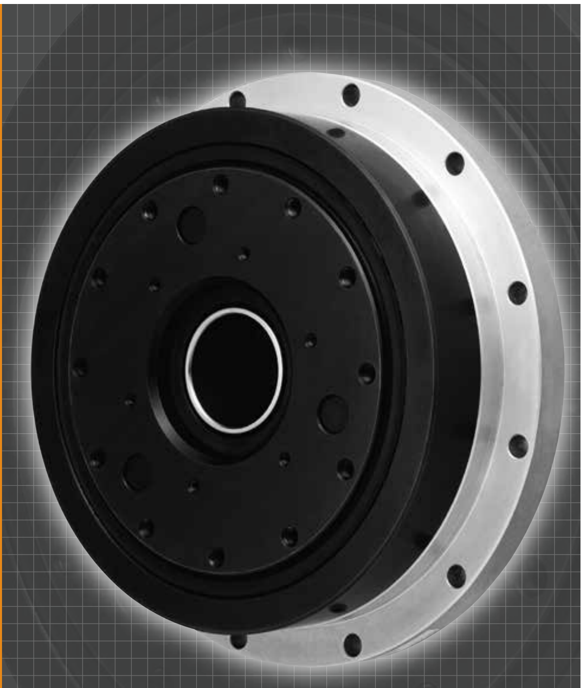
HPF Series - Hollow Shaft

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 inherently compensates for interference between meshing parts, ensuring consistent, 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.

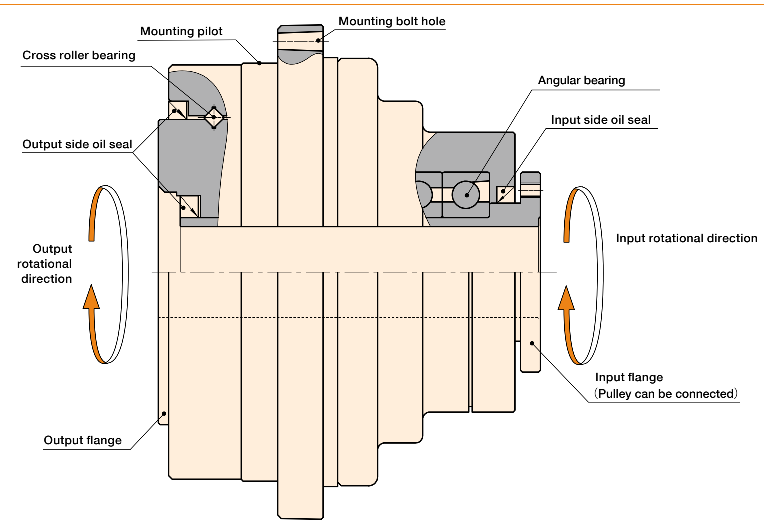
CONTENTS

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 104-1



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 105-1

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: Max value of average input rotational speed during operation.
*6: Maximum instantaneous input speed.

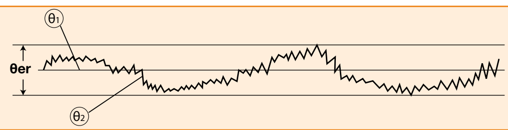
Performance Table

Table 105-2

Size	Ratio	Transmission accuracy *1	Repeatability *2	Starting torque *3	Backdriving torque *4	No-load running torque *5
		arc min	arc sec	Ncm	Nm	Ncm
25	11	4	±15	59	6.5	78
32	11	4	±15	75	8.3	105

*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 105-1

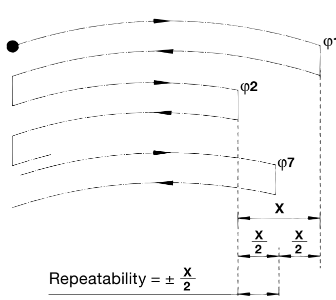


θer : Transmission accuracy
θ1 : Input angle
θ2 : Actual output angle
R : Gear reduction ratio

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

*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 095-2



Repeatability = $\pm \frac{X}{2}$

*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 105-3

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 105-4

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 105-5

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

Backlash and Torsional Stiffness

Table 106-1

■ **HPF Hollow Shaft Unit**

Size	Ratio	Backlash	Torsion angle in one direction at TR X 0.15	Torsional stiffness
			D	A/B
		arc min	arc min	Nm/arc min
25	11	3.0	2.0	16.66
32	11	3.0	1.7	34.3

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. 106-1.
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) in one direction when a load is applied from a no-load state.

Formula 106-1

● Calculation formula

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

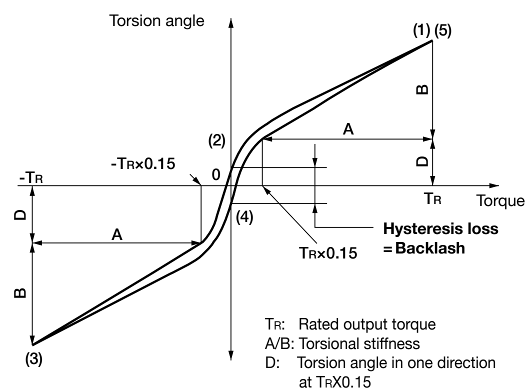
θ	Total torsion angle	——
D	Torsion angle in one direction at output torque x 0.15 torque	See Fig. 106-1, Table 106-1
T	Load torque	——
T_L	Output torque x 0.15 torque (=T_RX0.15)	See Fig. 106-1
A/B	Torsional stiffness	See Fig. 106-1, Table 106-1

Backlash (Hysteresis Loss)

The vertical distance between points (2) & (4) in Fig. 106-1 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.

Figure 106-1

Torque-torsion angle diagram



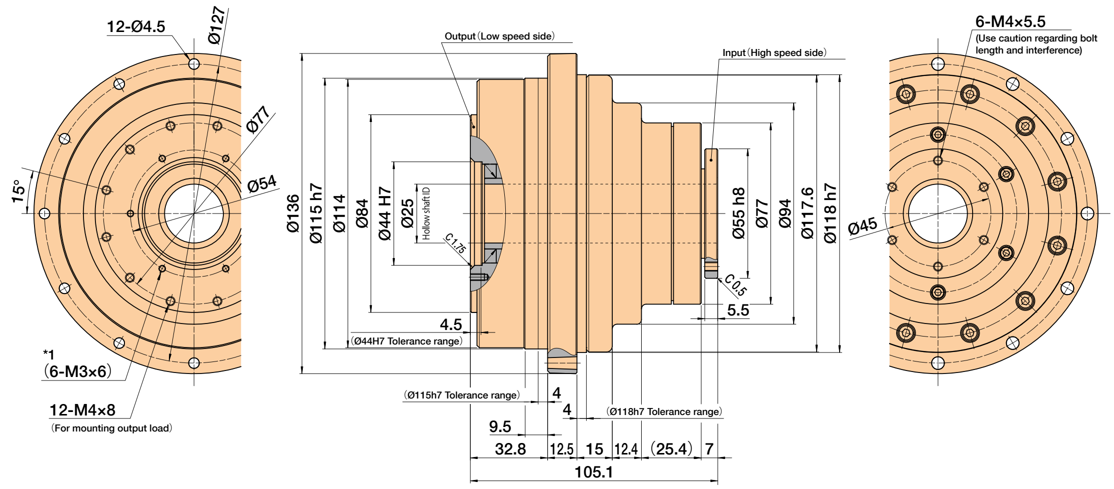
Outline Dimensions

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 of the hollow shaft gear unit, refer to page 145.

HPF-25 Outline Dimensions

Figure 107-1

(Unit: mm)

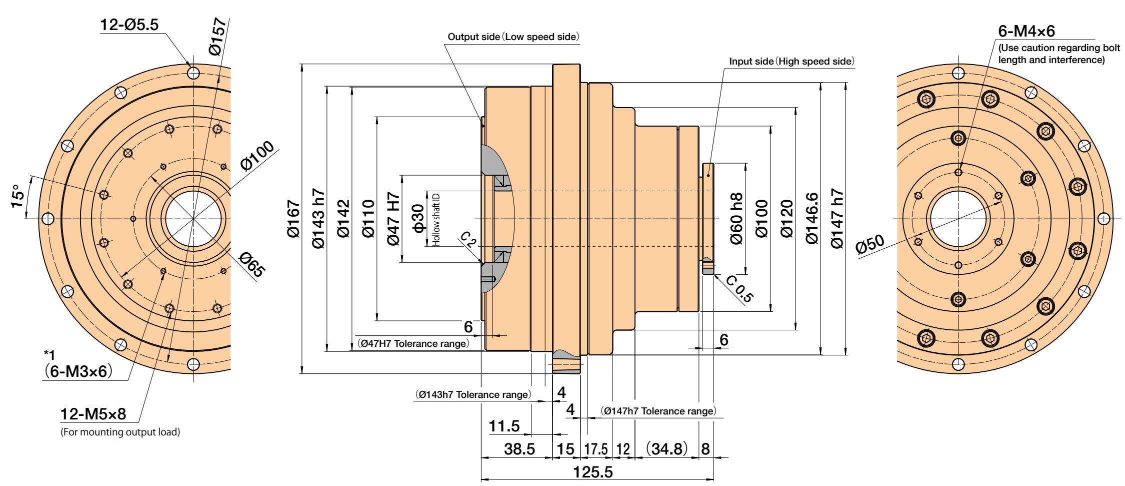


(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.
*1: The inside diameter of the hollow shaft rotates with the input shaft (high speed). Use these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

HPF-32 Outline Dimensions

Figure 107-2

(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).

Sizing & Selection

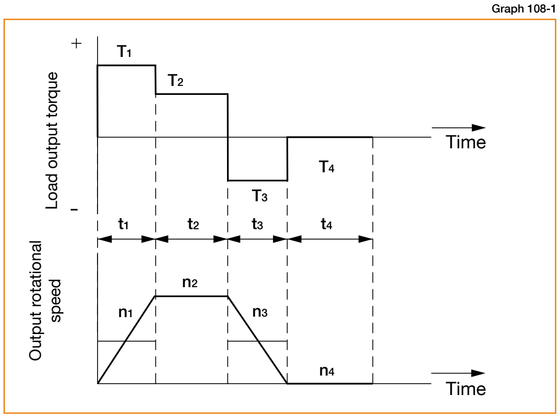
To fully utilize the excellent performance of the HPF HarmonicPlanetary® gearheads, check your operating conditions and, using the flowchart, select the appropriate size gear for your application.

Check your operating conditions against the following application motion profile 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.

Application motion profile

Review the application motion profile. Check the specifications shown in the figure below.

Graph 108-1



Obtain the value of each application motion profile

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 (acceleration)	T_1, t_1, n_1
Steady operation (constant velocity)	T_2, t_2, n_2
Stopping (deceleration)	T_3, t_3, n_3
Dwell	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 (Restricted by motors)	$n_{i\,max}$ $n_1 \times R$ to $n_n \times R$
	R: Reduction ratio

Emergency stop 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 application motion profile: 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 application motion profile: 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 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: Rated 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 any of the following conditions exist, please consider selecting the next larger speed reducer, reduce the operating loads or reduce the operating speed. If this cannot be done, please contact Harmonic Drive LLC. Exercise caution especially when the duty cycle is close to continuous operation.
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),
iii) Gearhead housing temperature > 70°C.

Example of size selection

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

Normal operation pattern

Starting (acceleration)	T_1 = 70 Nm,	t_1 = 0.3 sec,	n_1 = 60 rpm
Steady operation (constant velocity)	T_2 = 18 Nm,	t_2 = 3 sec,	n_2 = 120 rpm
Stopping (deceleration)	T_3 = 35 Nm,	t_3 = 0.4 sec,	n_3 = 60 rpm
Dwell	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)

Emergency stop 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 application motion profile.

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

Calculate the average output speed based on the application motion profile.

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

Make a preliminary model selection with the following conditions. T_{av} = 30.2 Nm ≦ 48 Nm. (**HPF-25A-11** is tentatively selected based on the average load torque (see the rating table on page 105) of size 25 and reduction ratio of 11.)

OK / NG

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

OK / NG

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

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 ≦ 100 Nm (Limit for repeated peak torque, size 25)
T_3 = 35 Nm ≦ 100 Nm (Limit for repeated peak torque, size 25)

OK / NG

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)

OK / NG

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

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

OK / NG

The selection of model number HPF-25A-11 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.

HarmonicPlanetary®

HPG Input Shaft

Size — 6 Sizes
11, 14, 20, 32, 50, 65

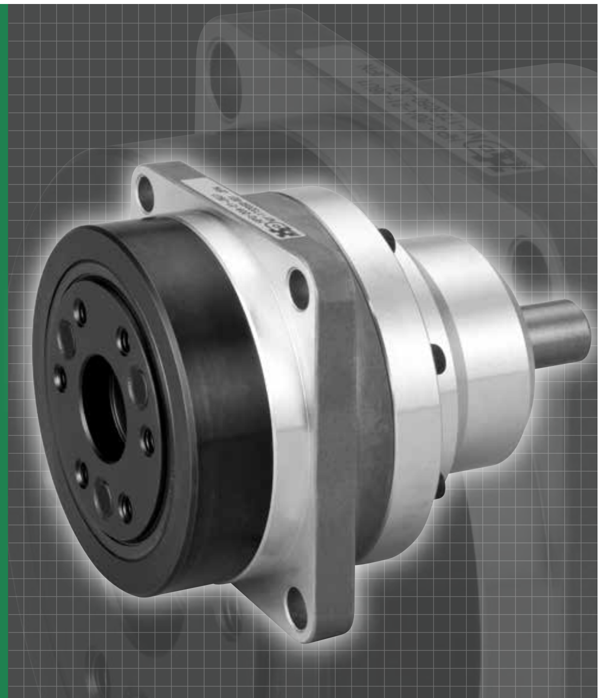
Peak torque
3.9Nm – 2200Nm

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 inherently compensates for interference between meshing parts, ensuring consistent, 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.



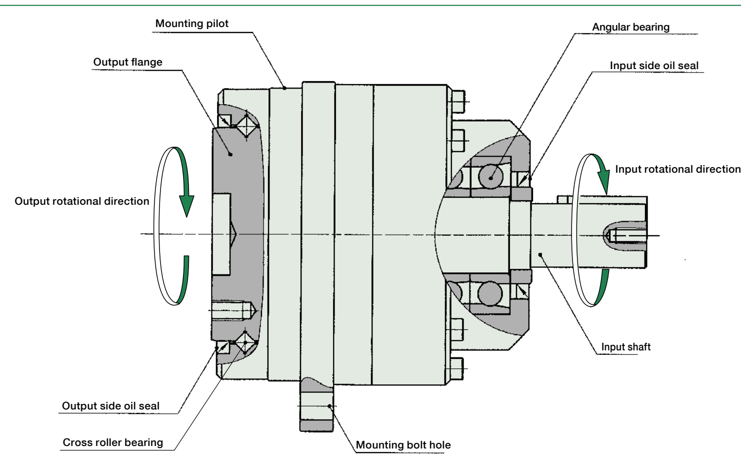
CONTENTS

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 110-1



Rating Table

Table 111-1

<table>
<tr><th rowspan="2">Size</th><th rowspan="2">Ratio</th><th>Rated Torque L10*1</th><th>Rated Torque L50*1</th><th>Limit for Average Torque*2</th><th>Limit for Repeated Peak Torque*3</th><th>Limit for Momentary Torque*4</th><th>Max. Average Input Speed*5</th><th>Max. Input Speed *6</th></tr>
<tr><th>Nm</th><th>Nm</th><th>Nm</th><th>Nm</th><th>Nm</th><th>rpm</th><th>rpm</th></tr>
<tr><td rowspan="5">11</td><td>5</td><td>2.5</td><td>5</td><td>5.0</td><td>7.8</td><td rowspan="5">20</td><td rowspan="5">3000</td><td rowspan="5">10000</td></tr>
<tr><td>9</td><td>2.5</td><td>3.9</td><td>3.9</td><td>3.9</td></tr>
<tr><td>21</td><td>3.4</td><td>6</td><td rowspan="3">6.0</td><td rowspan="3">9.8</td></tr>
<tr><td>37</td><td>3.4</td><td>6</td></tr>
<tr><td>45</td><td>3.4</td><td>6</td></tr>
<tr><td rowspan="7">14</td><td>3</td><td>2.9</td><td>6.4</td><td>6.4</td><td>15</td><td>37</td><td rowspan="7">3000</td><td>5000</td></tr>
<tr><td>5</td><td>5.9</td><td>13</td><td>13</td><td rowspan="6">23</td><td rowspan="6">56</td><td rowspan="6">6000</td></tr>
<tr><td>11</td><td>7.8</td><td>15</td><td rowspan="5">15</td></tr>
<tr><td>15</td><td>9.0</td><td>15</td></tr>
<tr><td>21</td><td>8.8</td><td>15</td></tr>
<tr><td>33</td><td>10</td><td>15</td></tr>
<tr><td>45</td><td>10</td><td>15</td></tr>
<tr><td rowspan="7">20</td><td>3</td><td>8.8</td><td>17</td><td>19</td><td>64</td><td>124</td><td rowspan="7">3000</td><td>4000</td></tr>
<tr><td>5</td><td>16</td><td>35</td><td>35</td><td rowspan="6">100</td><td rowspan="6">217</td><td rowspan="6">6000</td></tr>
<tr><td>11</td><td>20</td><td>45</td><td>45</td></tr>
<tr><td>15</td><td>24</td><td>53</td><td>53</td></tr>
<tr><td>21</td><td>25</td><td>55</td><td>55</td></tr>
<tr><td>33</td><td>29</td><td>60</td><td rowspan="2">60</td></tr>
<tr><td>45</td><td>29</td><td>60</td></tr>
<tr><td rowspan="7">32</td><td>3</td><td>31</td><td>60</td><td>71</td><td>225</td><td>507</td><td rowspan="7">3000</td><td>3600</td></tr>
<tr><td>5</td><td>66</td><td>150</td><td>150</td><td rowspan="6">300</td><td rowspan="6">650</td><td rowspan="6">6000</td></tr>
<tr><td>11</td><td>88</td><td>170</td><td rowspan="3">170</td></tr>
<tr><td>15</td><td>92</td><td>170</td></tr>
<tr><td>21</td><td>98</td><td>170</td></tr>
<tr><td>33</td><td>108</td><td>200</td><td rowspan="2">200</td></tr>
<tr><td>45</td><td>108</td><td>200</td></tr>
<tr><td rowspan="7">50</td><td>3</td><td>97</td><td>160</td><td>195</td><td>657</td><td>1200</td><td rowspan="7">2000</td><td>3000</td></tr>
<tr><td>5</td><td>170</td><td>290</td><td>340</td><td rowspan="6">850</td><td rowspan="6">1850</td><td rowspan="6">4500</td></tr>
<tr><td>11</td><td>200</td><td>340</td><td>400</td></tr>
<tr><td>15</td><td>230</td><td>400</td><td>450</td></tr>
<tr><td>21</td><td>260</td><td>450</td><td rowspan="3">500</td></tr>
<tr><td>33</td><td>270</td><td>470</td></tr>
<tr><td>45</td><td>270</td><td>500</td></tr>
<tr><td rowspan="8">65*7</td><td>4</td><td>500</td><td>870</td><td>900</td><td rowspan="6">2200</td><td rowspan="8">4500</td><td rowspan="8">2000</td><td>2500</td></tr>
<tr><td>5</td><td>530</td><td>900</td><td>1000</td><td rowspan="7">3000</td></tr>
<tr><td>12</td><td>600</td><td>1020</td><td>1100</td></tr>
<tr><td>15</td><td>730</td><td>1260</td><td>1300</td></tr>
<tr><td>20</td><td>800</td><td>1370</td><td rowspan="2">1500</td></tr>
<tr><td>25</td><td>850</td><td>1470</td></tr>
<tr><td>40</td><td>640</td><td>1320</td><td>1300</td><td>1900</td></tr>
<tr><td>50</td><td>750</td><td>1650</td><td>1500</td><td>2200</td></tr>
</table>

*1: Rated torque is based on life of 20,000 hours at max average input speed.
*2: Average load torque calculated based on the application motion profile must not exceed values shown in the table. See p. 118.
*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.
*5: Max value of average input rotational speed during operation.
*6: Maximum instantaneous input speed.
*7: Size 65 is built-to-order.

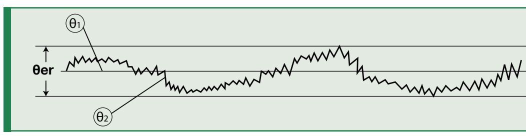
Performance Table

Table 112-1

Model	Ratio	Accuracy *1 arc min	Repeatability *2 arc sec	Starting torque *3 Ncm	Backdriving torque *4 Nm	No-load running torque *5 Ncm
11	5	5	±30	7.9	0.40	8.9
	9			7.6	0.68	6.3
	21			6.8	1.4	5.2
	37			5.5	2.0	4.8
	45			5.3	2.4	4.7
14	3	4	±20	22	0.66	26
	5			17	0.83	15
	11			16	1.8	10
	15			15	2.3	8.2
	21			13	2.9	
	33			11	3.8	7.3
	45				4.8	
20	3	4	±15	46	1.4	61
	5			34	1.7	39
	11			30	3.3	26
	15			27	4.0	22
	21			24	5.1	20
	33			21	7.1	17
	45			20	8.9	16
32	3	4	±15	92	2.8	146
	5			69	3.5	100
	11			63	6.9	66
	15			61	9.1	57
	21			58	12	52
	33			52	17	42
	45			46	21	41
50	3	3	±15	197	5.9	300
	5			140	7.0	180
	11			110	12	110
	15			100	15	97
	21			98	21	90
	33			88	29	74
	45			83	37	70
65	4	3	±15	406	16	576
	5			358	18	517
	12			243	29	341
	15			228	34	311
	20			213	43	282
	25			202	51	262
	40			193	77	230
	50			188	94	219

*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 112-1

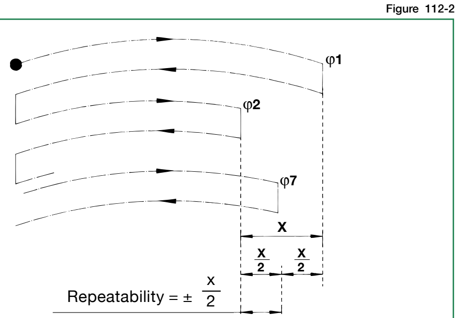


θer : Accuracy
θ1 : Input angle
θ2 : Actual output angle
R : Reduction ratio

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

*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 112-2



*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 112-2

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 112-3

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 112-4

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

Backlash and Torsional Stiffness

Table 113-1

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

Size	Ratio	Backlash	Torsion angle in one direction at T_R X 0.15 D	Torsional stiffness A/B
		arc min	arc min	Nm/arc min
11	5, 9	3	2.5	0.59
	21, 37, 45		3.0	0.64
14	3, 5	3	2.2	1.27
	11, 15, 21, 33, 45		2.7	1.37
20	3, 5	3	1.5	4.9
	11, 15, 21, 33, 45		2.0	5.39
32	3	3	1.3	16.66
	5			19.6
	11, 15, 21, 33, 45		1.7	21.56
50	3	3	1.3	82.71
	5			107.8
	11, 15, 21, 33, 45		1.7	137.2
65	4, 5	3	1.3	270
	12, 15, 20, 25, 40, 50		1.7	362.6

Table 113-2

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

Size	Ratio	Backlash	Torsion angle in one direction at T_R X 0.15 D	Torsional stiffness A/B
		arc min	arc min	Nm/arc min
11	not available			
14	3, 5	1	1.1	1.27
	9, 21, 33, 45		1.7	1.37
20	3, 5	1	0.6	4.9
	11, 15, 21, 33, 45		1.1	5.39
32	3	1	0.5	16.66
	5			19.6
	11, 15, 21, 33, 45		1.0	21.56
50	3	1	0.5	82.71
	5			107.8
	11, 15, 21, 33, 45		1.0	137.2
65	4, 5	1	0.5	270
	12, 15, 20, 25, 40, 50		1.0	362.6

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. 113-1.

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) in one direction when a load is applied from a no-load state.

Formula 113-1

● Calculation formula

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

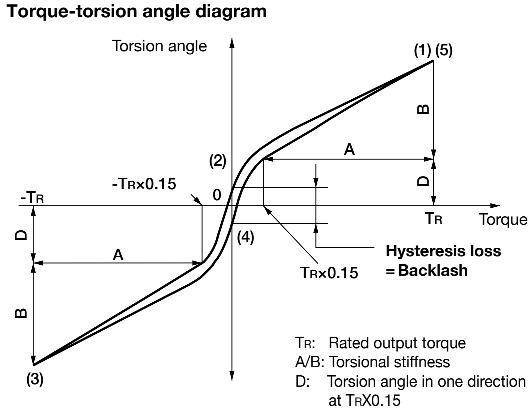
θ	Total torsion angle	–
D	Torsion angle in one direction at output torque x 0.15 torque	See Fig. 113-1, Table 113-1 to 2
T	Load torque	–
T_L	Output torque x 0.15 torque (=TRX0.15)	See Fig. 113-1
A/B	Torsional stiffness	See Fig. 113-1, Table 113-1 to 2

Backlash (Hysteresis loss)

The vertical distance between points (2) & (4) in Fig. 113-1 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 available for sizes 14-65).

Figure 113-1

Torque-torsion angle diagram



Outline Dimensions

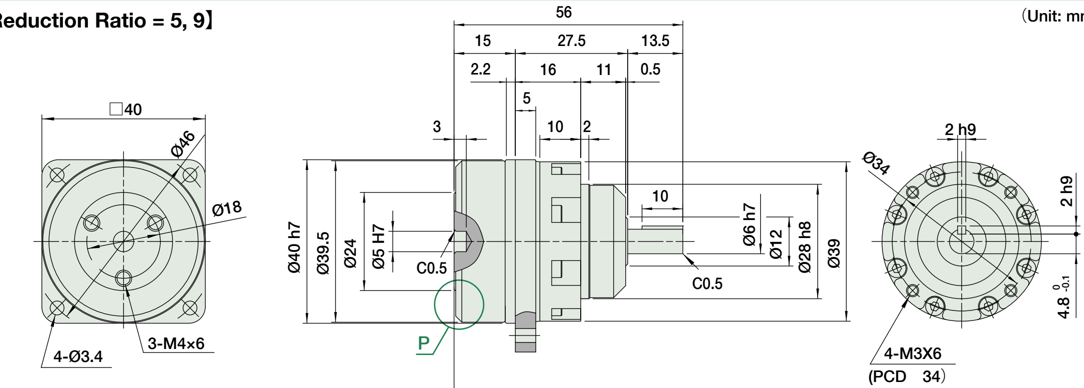
Only primary dimensions are shown in the drawings below. Refer to the confirmation drawing for detailed dimensions.
For the specifications of the input side bearing refer to page 145.

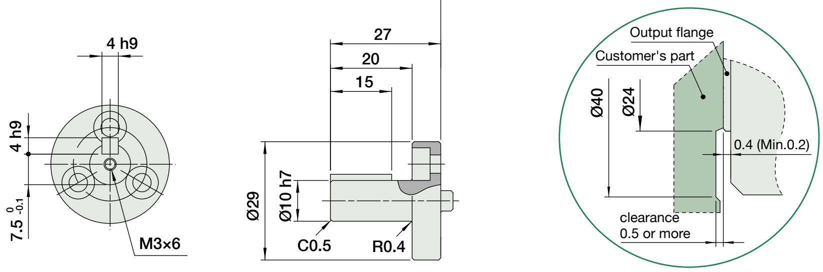
HPG-11 Outline Dimensions

Figure 114-1

【Reduction Ratio = 5, 9】

(Unit: mm)





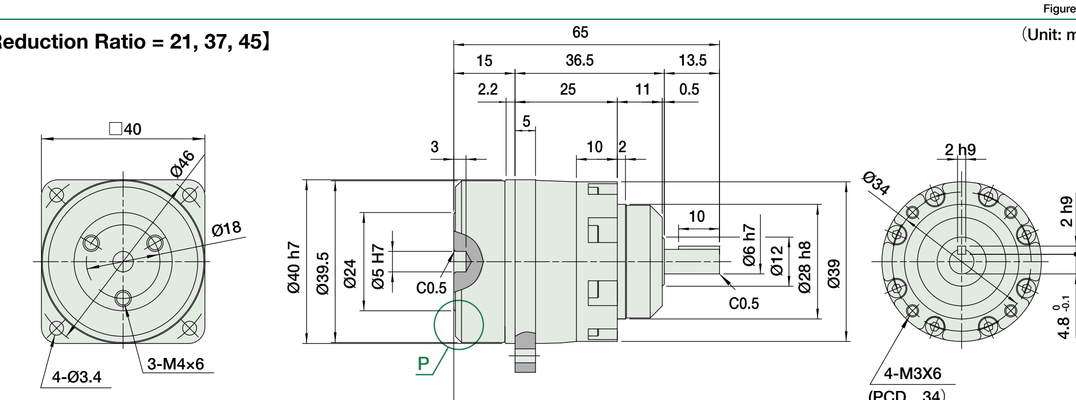
Detail P
Recommended clearance dimension for customer's part mounted to the output flange
(Note)
When using a gearhead with an output flange, it is recommended for the customer to design clearance between the part mounted on the output flange and the housing face as shown in the figure on the left. The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

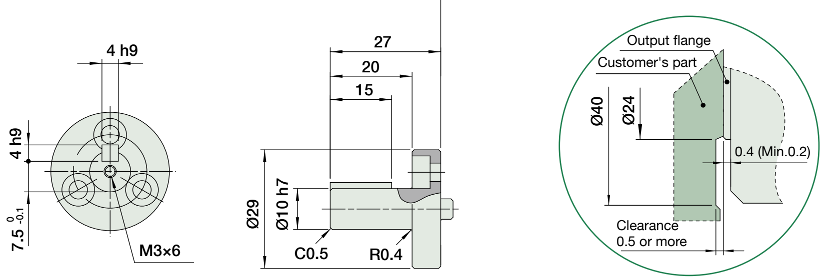
(Note) The dimension tolerances that are not specified vary depending on the manufacturing method.
Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

Figure 114-2

【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).

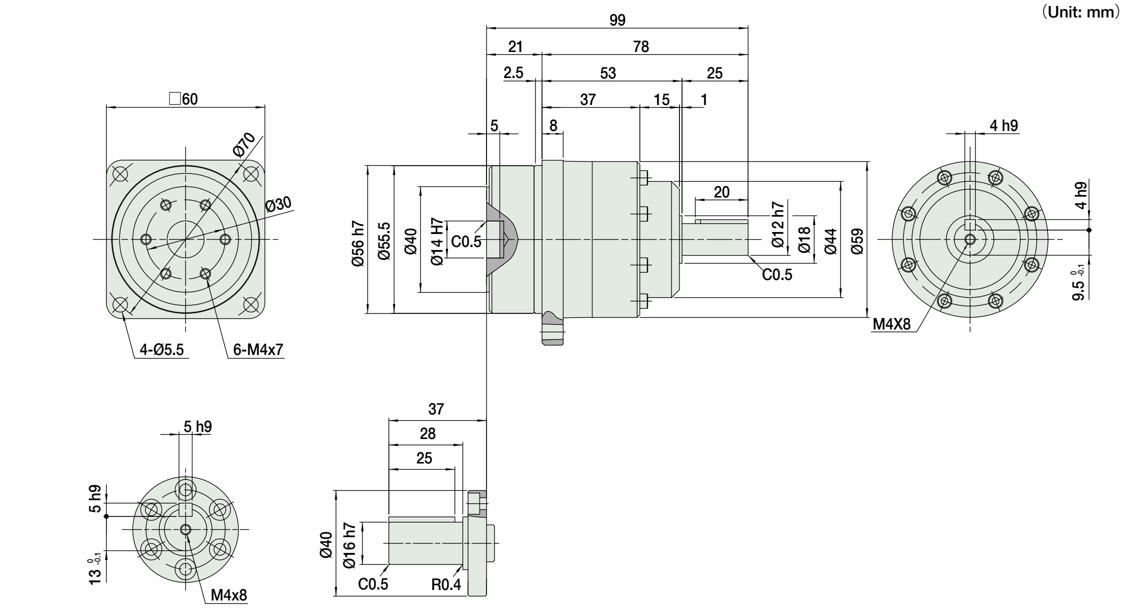
(Note) The dimension tolerances that are not specified vary depending on the manufacturing method.
Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

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 145.

HPG-14 Outline Dimensions

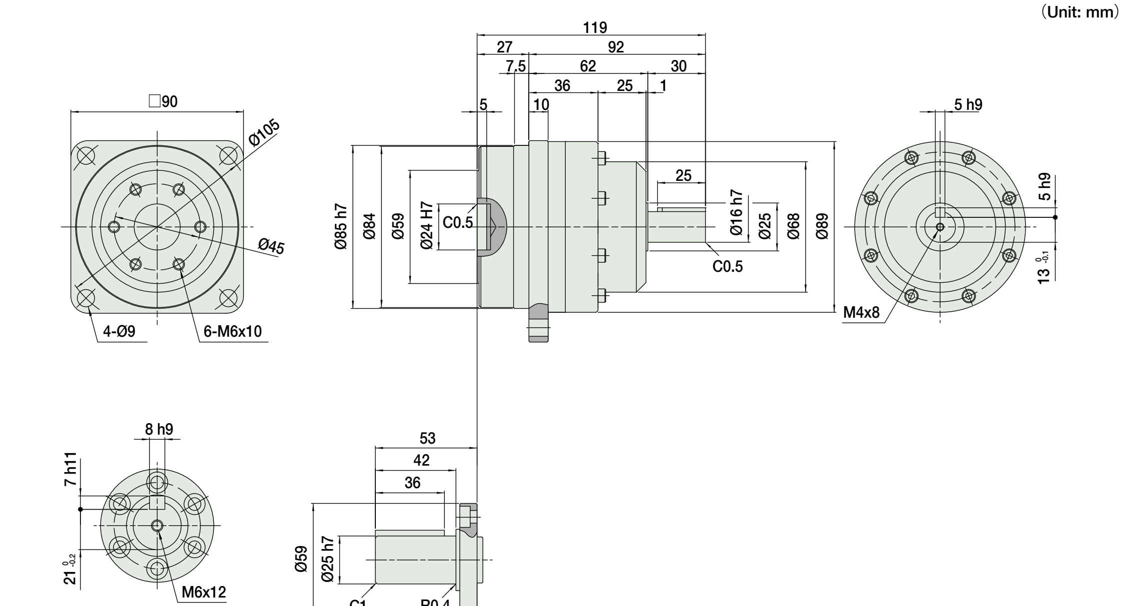
Figure 115-1



(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 115-2



(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.

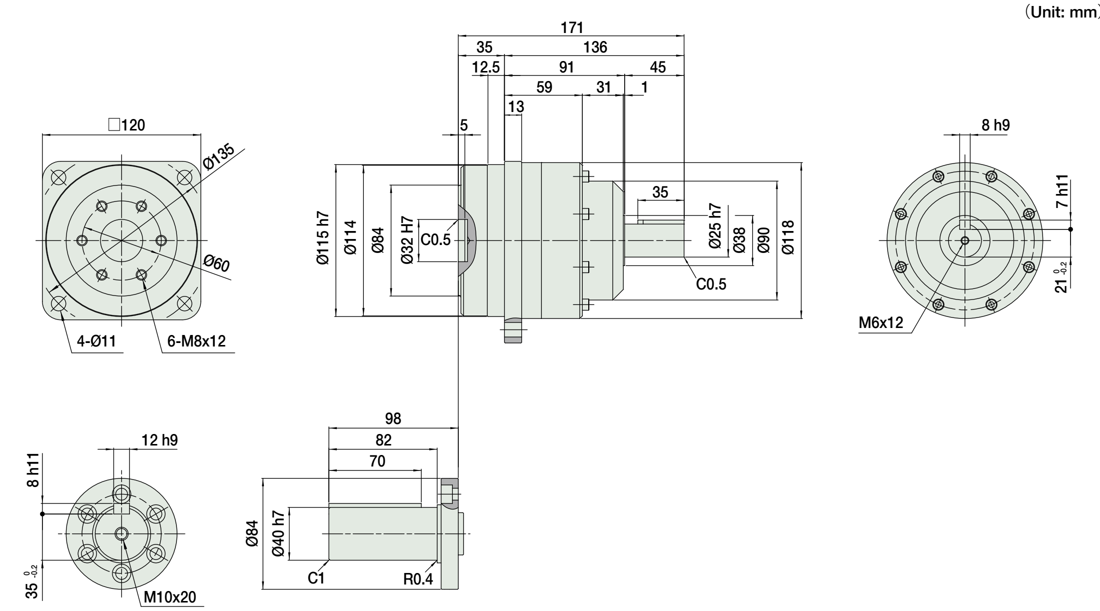
Outline Dimensions

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 145.

HPG-32 Outline Dimensions

Figure 116-1

(Unit: mm)

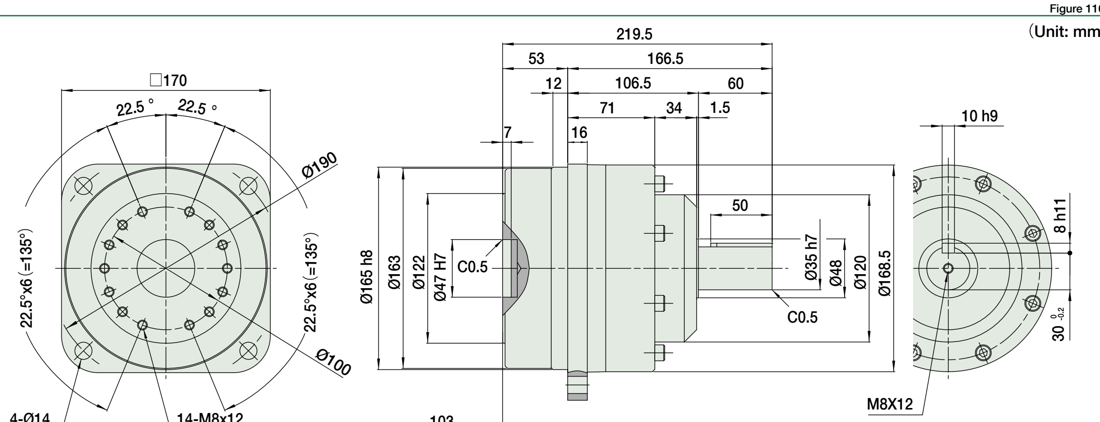


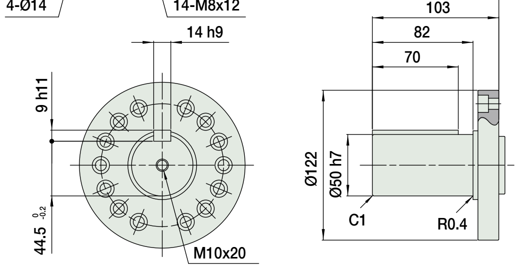
(Note) The dimension tolerances that are not specified vary depending on the manufacturing method.
Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

HPG-50 Outline Dimensions

Figure 116-2

(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.

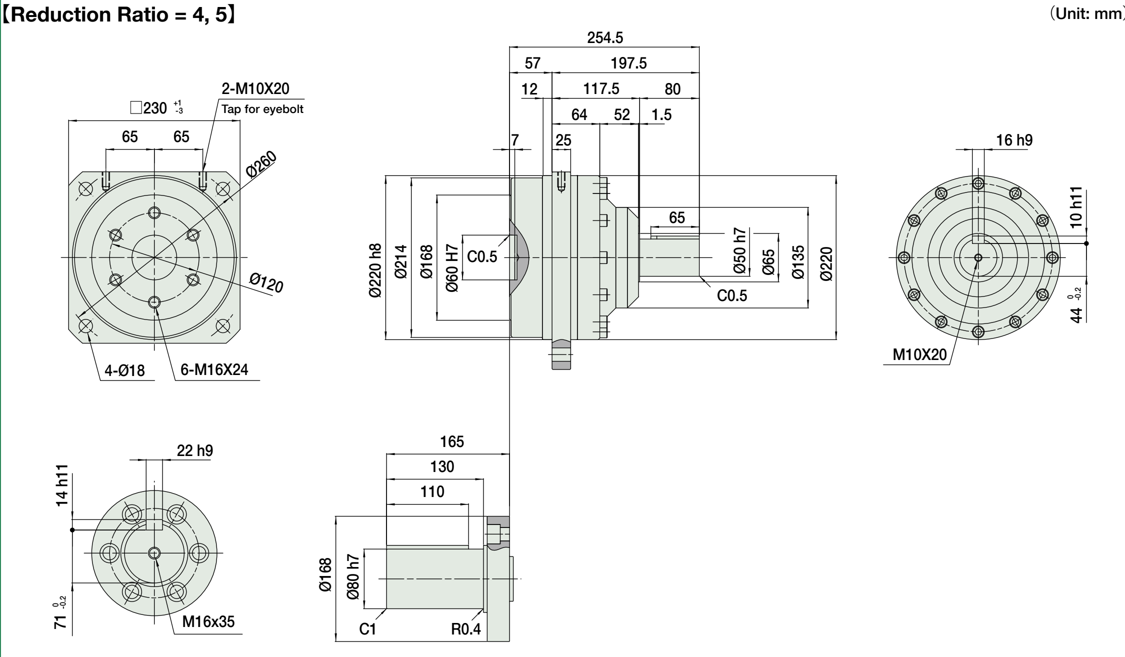
Outline Dimensions

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 145.

HPG-65 Outline Dimensions

Figure 117-1

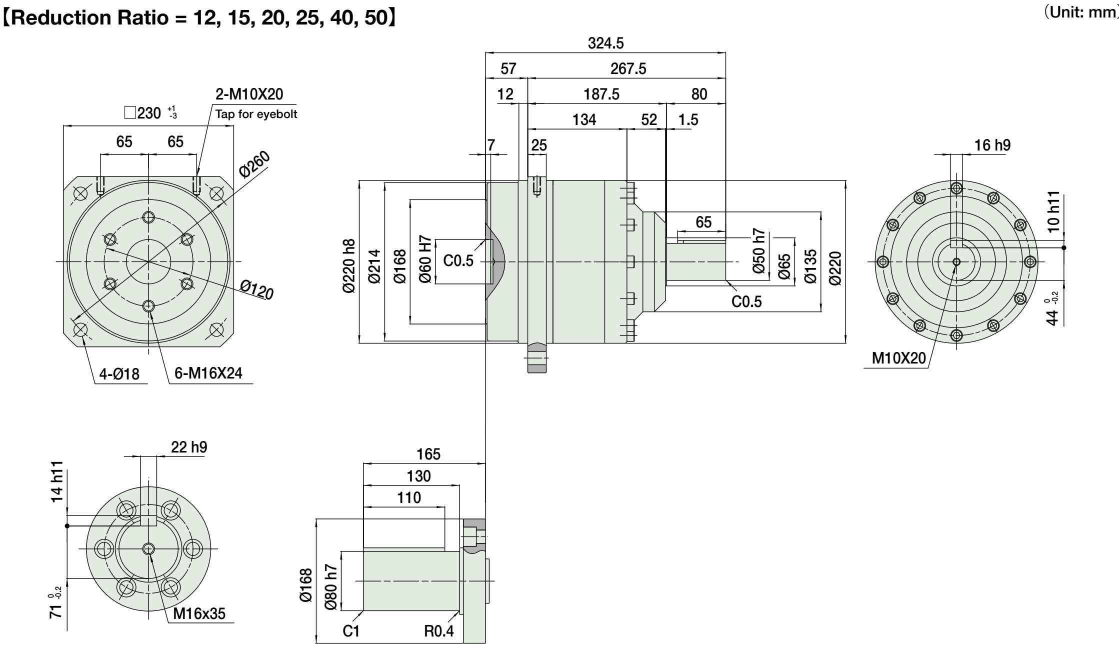
【Reduction Ratio = 4, 5】 (Unit: mm)



(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 117-2

【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.

Sizing & Selection

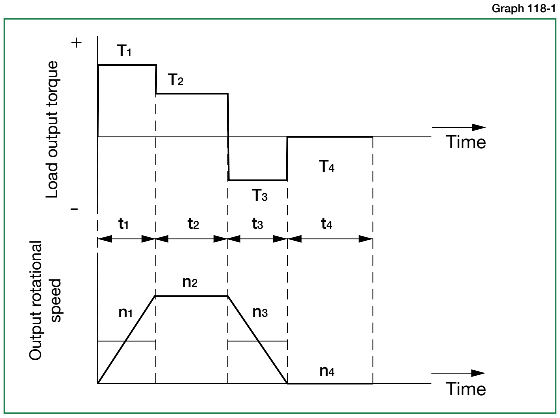
To fully utilize the excellent performance of the HPG HarmonicPlanetary® gearheads, check your operating conditions and, using the flowchart, select the appropriate size gear for your application.

Check your operating conditions against the following application motion profile 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).

Application motion profile

Review the application motion profile. Check the specifications shown in the figure below.

Graph 118-1



Obtain the value of each application motion profile

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 (acceleration)	T_1, t_1, n_1
Steady operation (constant velocity)	T_2, t_2, n_2
Stopping (deceleration)	T_3, t_3, n_3
Dwell	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 (Restricted by motors)	$n_{i\,max}$ $n_1 \times R$ to $n_n \times R$
	R: Reduction ratio

Emergency stop 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 application motion profile: 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 application motion profile: 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 111) — 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 less than the limit for momentary torque (Nm) in the rating table. — NG

OK

Calculate the life and check whether it meets the specification requirement.
T_r: Rated 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 any of the following conditions exist, please consider selecting the next larger speed reducer, reduce the operating loads or reduce the operating speed. If this cannot be done, please contact Harmonic Drive LLC. Exercise caution especially when the duty cycle is close to
i) Actual average load torque (Tav) > Limit for average torque or
ii) Actual average input rotational speed (ni av) > Maximum average input speed (nr),
iii) Gearhead housing temperature > 70°C.

Example of size selection

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

Normal operation pattern

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

Maximum rotational speed

Max. output rotational speed — $n_{o\,max}$ = 120 rpm

Max. input rotational speed — $n_{i\,max}$ = 5,000 rpm (Restricted by motors)

Emergency stop 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 application motion profile: 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 application motion profile: $n_{o\,av}$ (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 111) of size 20 and reduction ratio of 33.) — NG

OK

Determine a reduction ratio (R) from the maximum output speed ($n_{o\,max}$) and maximum input speed ($n_{i\,max}$).

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

Calculate the maximum input speed ($n_{i\,max}$) from the maximum output speed ($n_{o\,max}$) and reduction ratio (R): $n_{i\,max}$ = 120 rpm · 33 = 3,960 rpm

▼

Calculate the average input rotational speed ($n_{i\,av}$) from the average output speed ($n_{o\,av}$) and reduction ratio (R):
$n_{i\,av}$ = 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.
$n_{i\,max}$ = 3,960 rpm ≦ 6,000 rpm (maximum input rotational speed of size 20) — NG

OK

Check whether T_1 and T_3 are 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 118.

Review the operation conditions, size and reduction ratio.

Technical Information / Handling Explanation
HarmonicPlanetary® & HarmonicDrive®

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 122-1

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 151- 152 for details.)

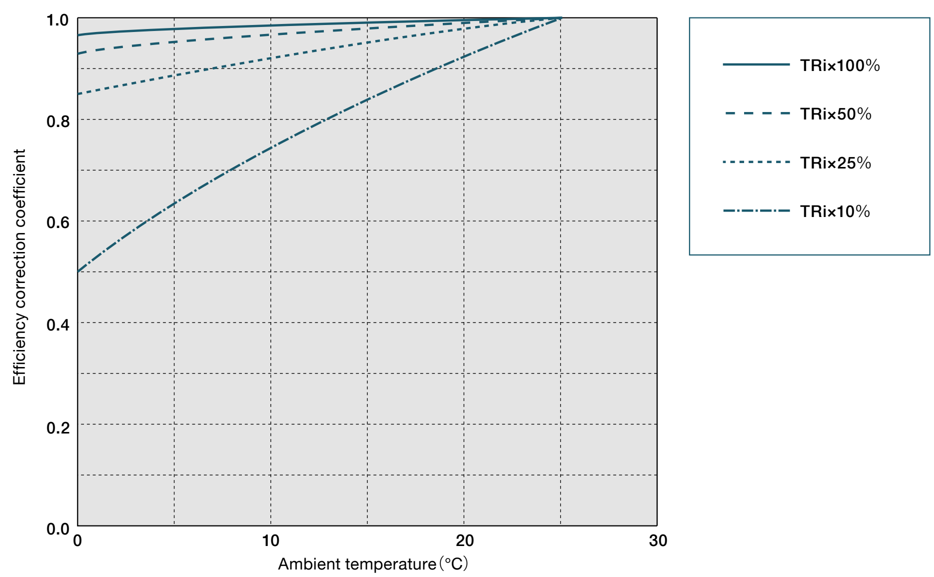
Efficiency compensated for low temperature

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.

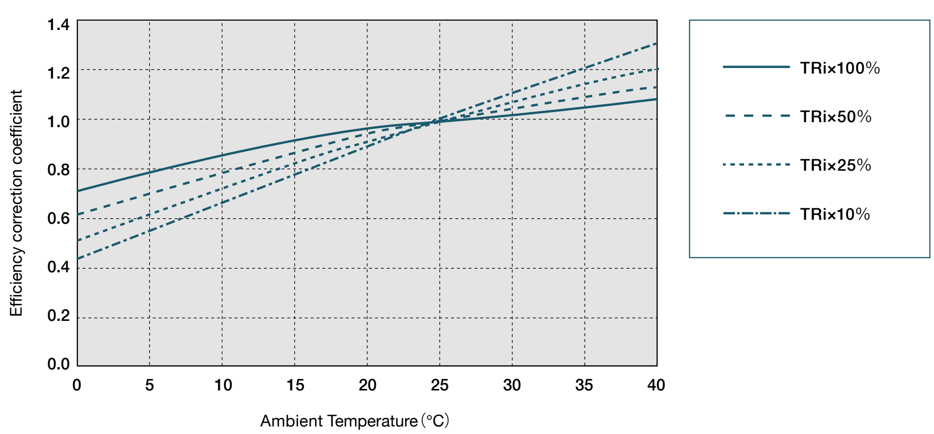
Graph 122-1



CSG-GH CSF-GH

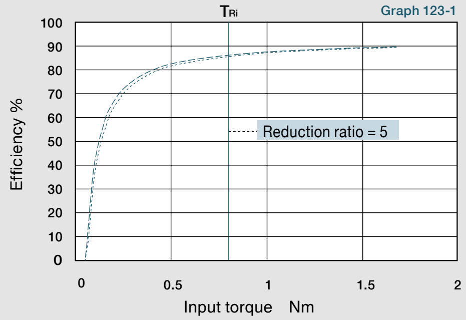
* TRi is an input torque corresponding to output torque at 25°C.

Graph 122-2

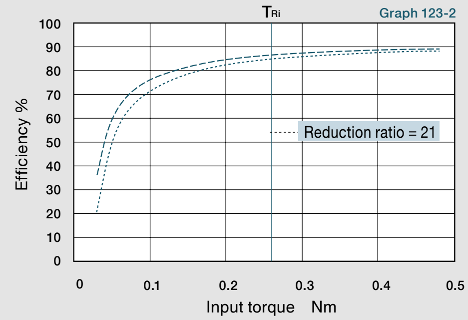


Size 11 : Gearhead HPGP

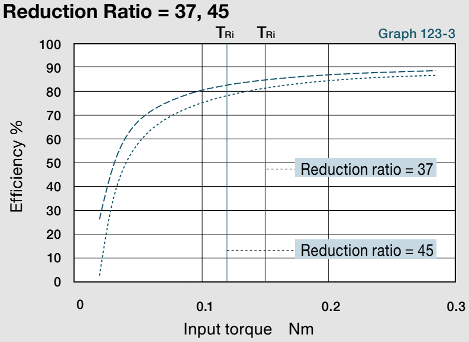
Reduction Ratio = 5



Reduction Ratio = 21



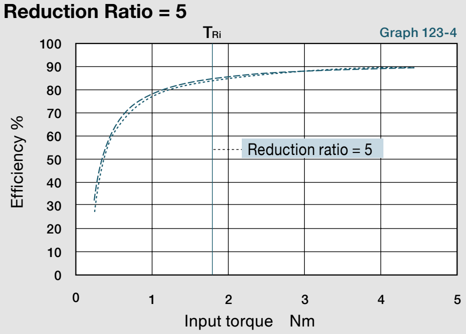
Reduction Ratio = 37, 45



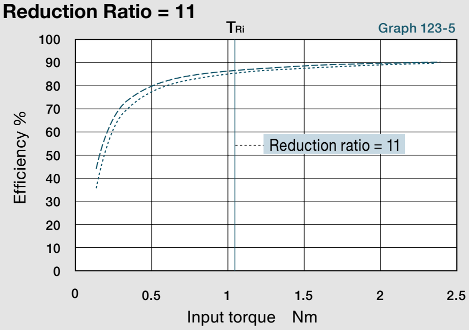
--- Gearhead (standard item) ...... Gearhead with D bearing (double sealed) T_{Ri} Input torque corresponding to output torque

Size 14 : Gearhead HPGP

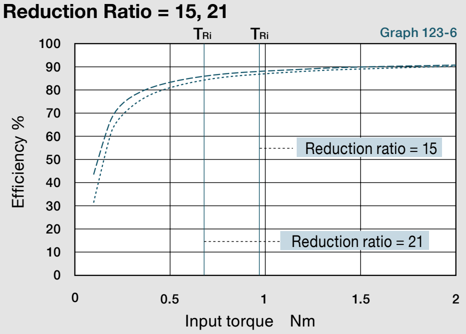
Reduction Ratio = 5



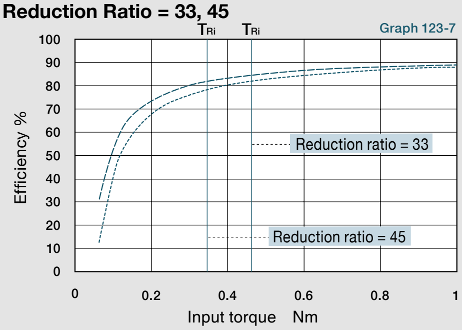
Reduction Ratio = 11



Reduction Ratio = 15, 21



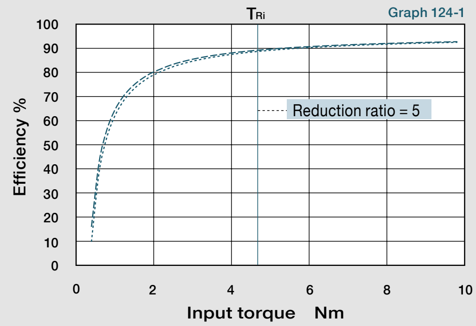
Reduction Ratio = 33, 45



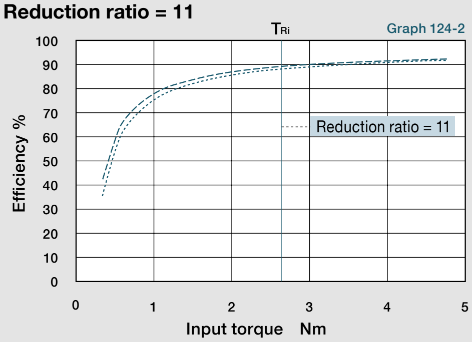
--- Gearhead (standard item) ...... Gearhead with D bearing (double sealed) T_{Ri} Input torque corresponding to output torque

Size 20 : Gearhead HPGP

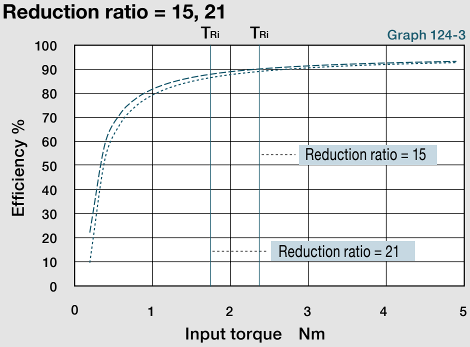
Reduction ratio = 5



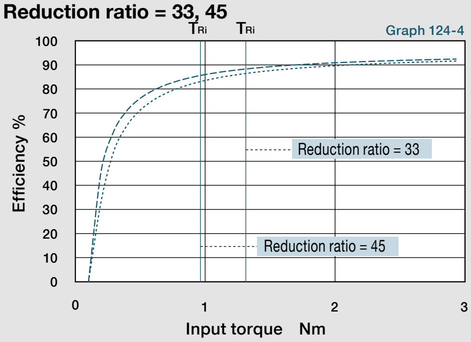
Reduction ratio = 11



Reduction ratio = 15, 21



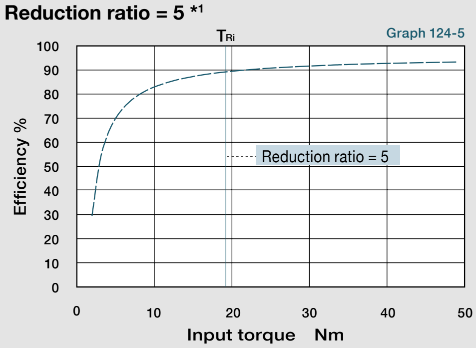
Reduction ratio = 33, 45



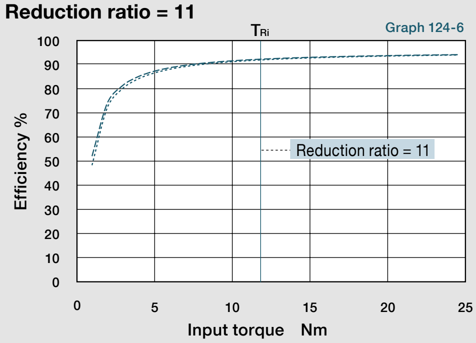
--- Gearhead (standard item) ······ Gearhead with D bearing (double sealed) TRi Input torque corresponding to output torque

Size 32 : Gearhead HPGP

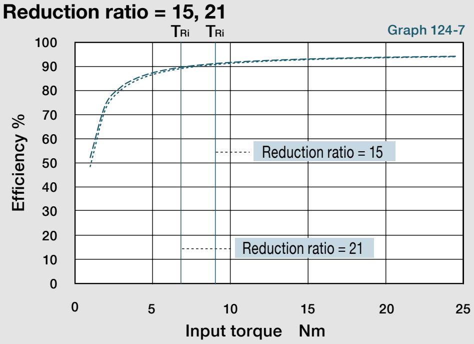
Reduction ratio = 5 *1



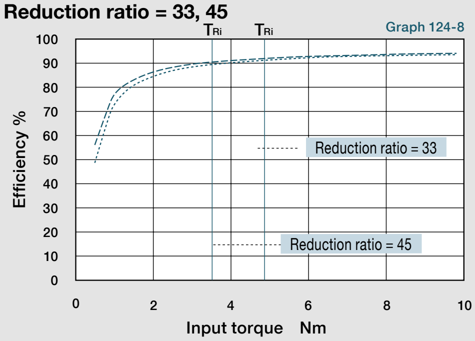
Reduction ratio = 11



Reduction ratio = 15, 21



Reduction ratio = 33, 45

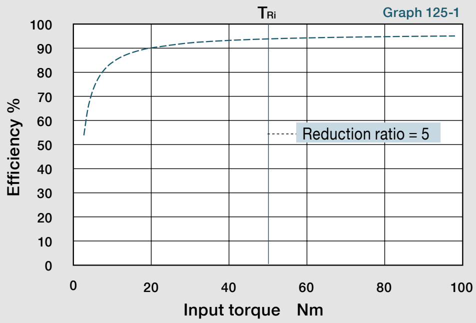


--- Gearhead (standard item) ······ Gearhead with D bearing (double sealed) TRi Input torque corresponding to output torque

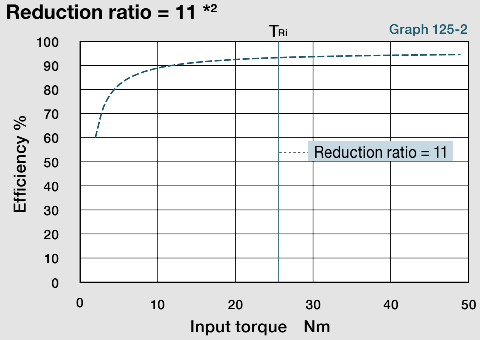
*1 Only one line is shown because the difference between the gearhead and a bearing assembled on the input side is small.

Size 50 : Gearhead HPGP

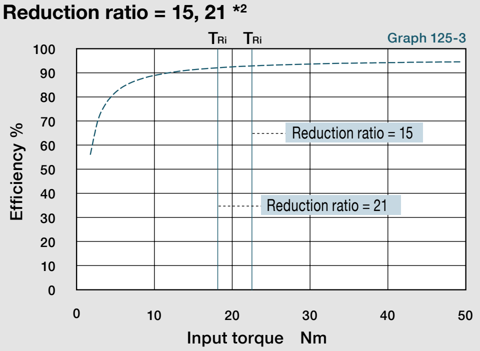
Reduction ratio = 5 *2



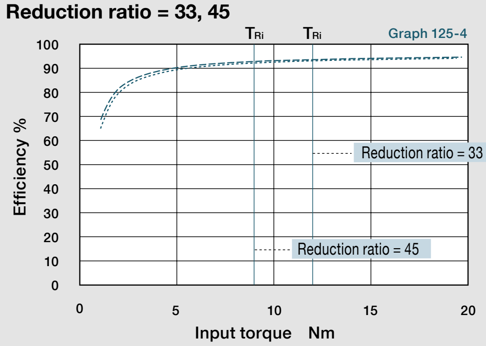
Reduction ratio = 11 *2



Reduction ratio = 15, 21 *2



Reduction ratio = 33, 45

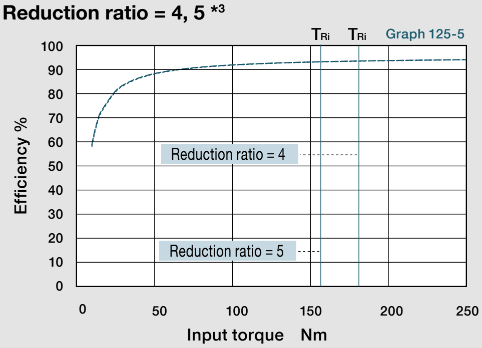


Gearhead (standard item) Gearhead with D bearing (double sealed) T_{Ri} Input torque corresponding to output torque

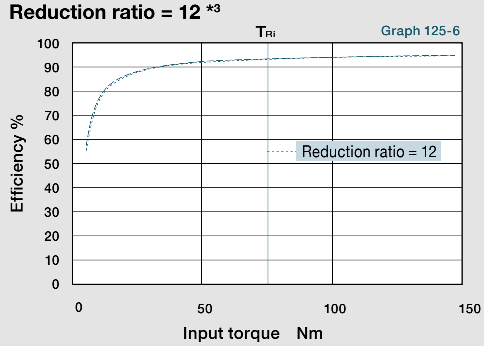
*2 Only one line is shown because the difference between the gearhead and a bearing assembled on the input side is small.

Size 65 : Gearhead HPGP

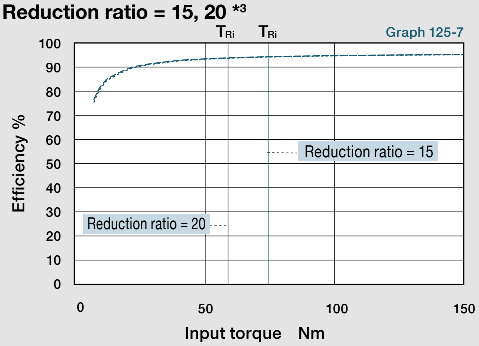
Reduction ratio = 4, 5 *3



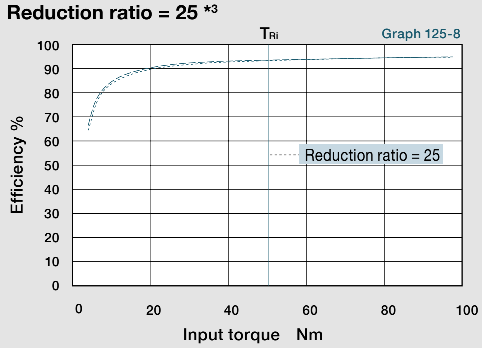
Reduction ratio = 12 *3



Reduction ratio = 15, 20 *3



Reduction ratio = 25 *3

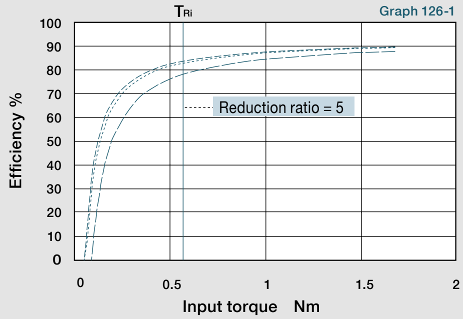


Gearhead (standard item) Gearhead with D bearing (double sealed) T_{Ri} Input torque corresponding to output torque

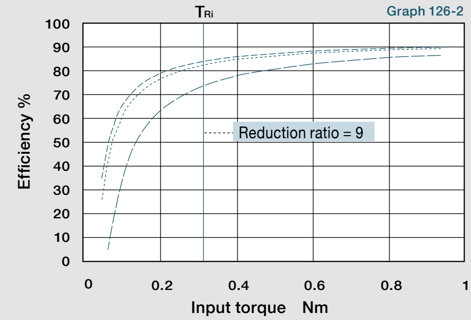
*3 Only one line is shown because the difference between the gearhead and a bearing assembled on the input side is small.

Size 11 : Gearhead & Input Shaft Unit HPG

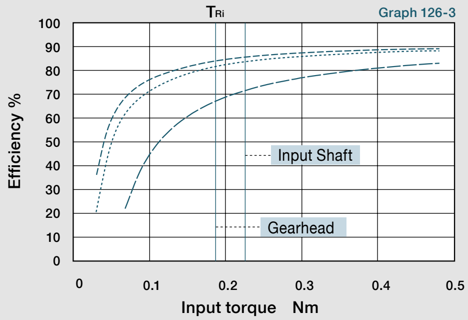
Reduction ratio = 5



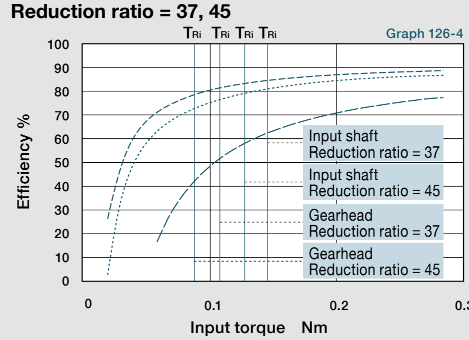
Reduction ratio = 9



Reduction ratio = 21



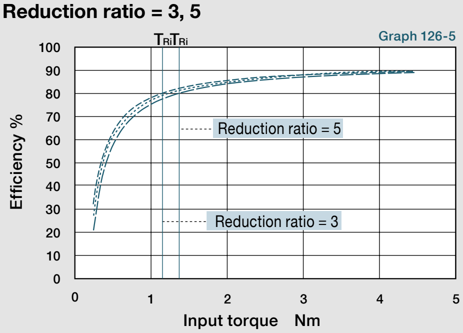
Reduction ratio = 37, 45



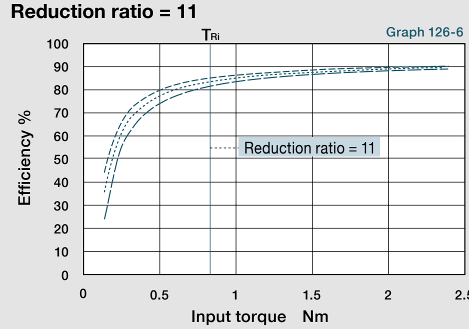
--- Gearhead (standard item) ...... Gearhead with D bearing (double sealed) TRi Input torque corresponding to output torque

Size 14 : Gearhead & Input Shaft Unit HPG

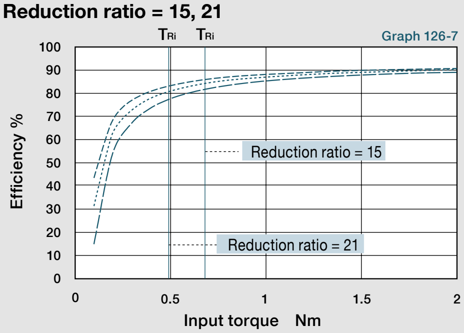
Reduction ratio = 3, 5



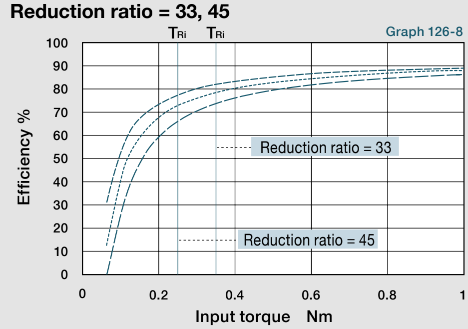
Reduction ratio = 11



Reduction ratio = 15, 21



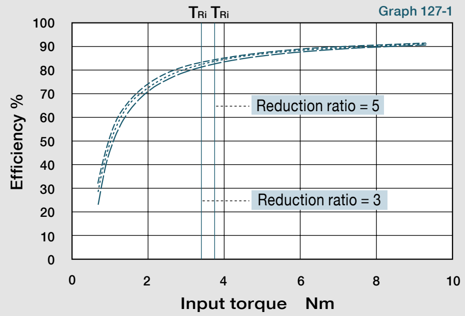
Reduction ratio = 33, 45



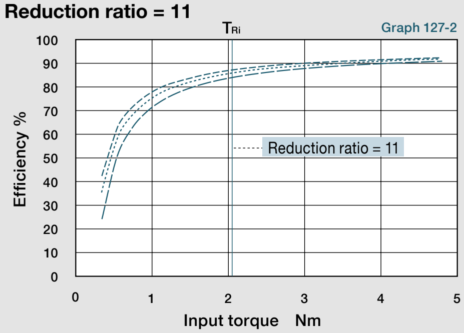
--- Gearhead (standard item) ...... Gearhead with D bearing (double sealed) TRi Input torque corresponding to output torque

Size 20 :Gearhead & Input Shaft Unit HPG

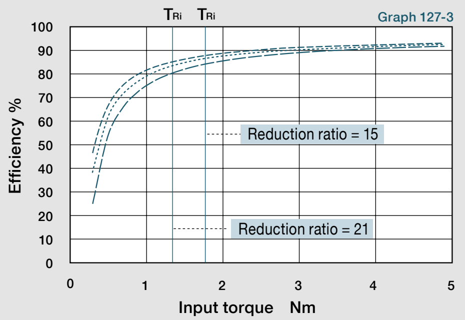
Reduction ratio = 3, 5



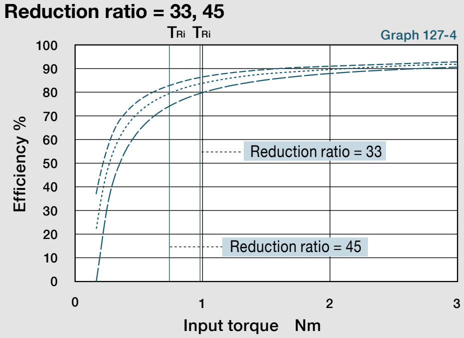
Reduction ratio = 11



Reduction ratio = 15, 21



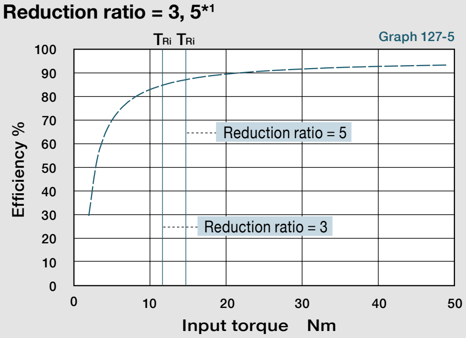
Reduction ratio = 33, 45



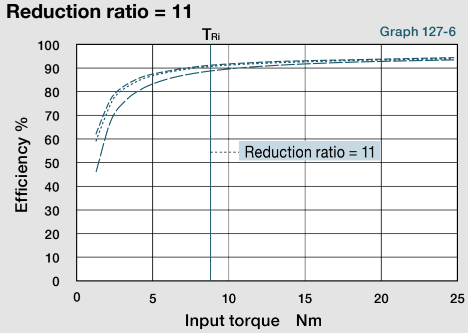
– – – Gearhead (standard item) ······ Gearhead with D bearing (double sealed) —— Input Shaft TRi Input torque corresponding to output torque

Size 32 :Gearhead & Input Shaft Unit HPG

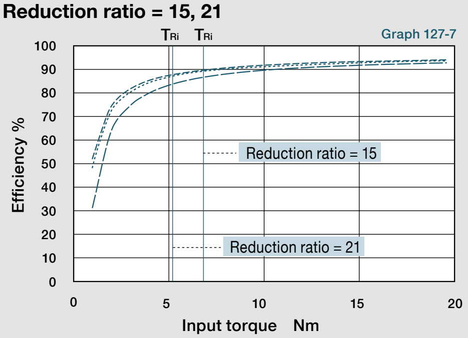
Reduction ratio = 3, 5*1



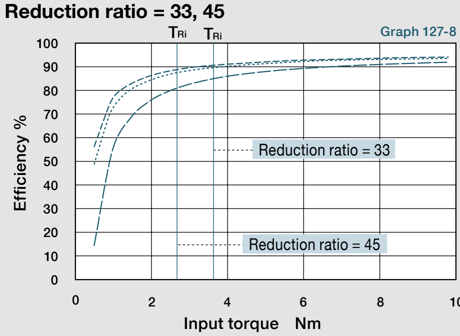
Reduction ratio = 11



Reduction ratio = 15, 21



Reduction ratio = 33, 45

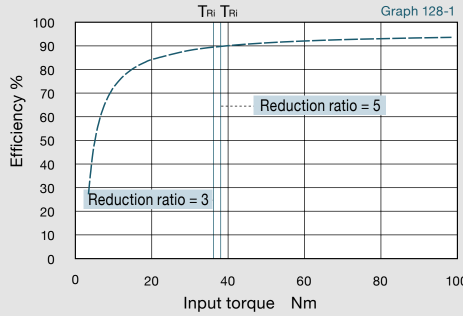


– – – Gearhead (standard item) ······ Gearhead with D bearing (double sealed) —— Input Shaft TRi Input torque corresponding to output torque

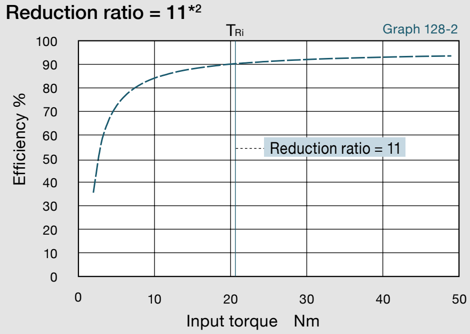
*1 Only one line is shown because the difference between the gearhead and a bearing assembled on the input side is small.

Size 50 :Gearhead & Input Shaft Unit HPG

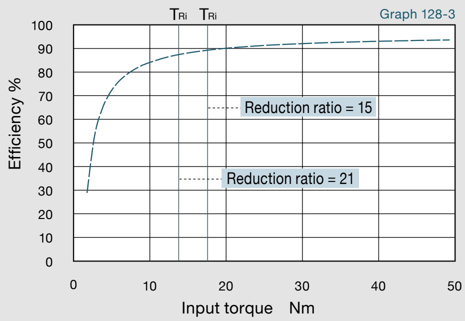
Reduction ratio = 3, 5*2



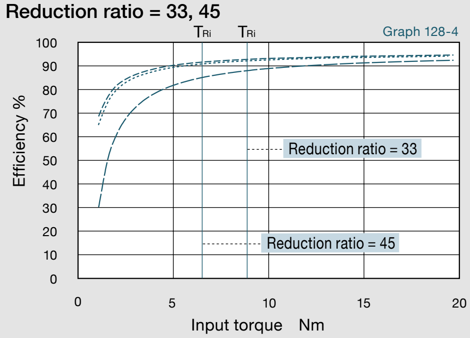
Reduction ratio = 11*2



Reduction ratio = 15, 21*2



Reduction ratio = 33, 45

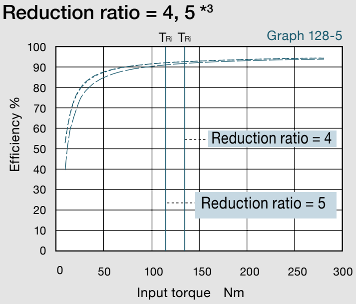


- - - Gearhead (standard item) ······ Gearhead with D bearing (double sealed) —— Input Shaft TRi Input torque corresponding to output torque

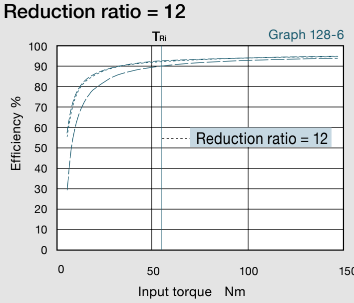
*2 Only one line is shown because the difference between the gearhead and a bearing assembled on the input side is small.

Size 65 :Gearhead & Input Shaft Unit HPG

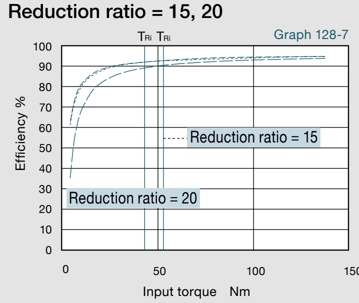
Reduction ratio = 4, 5 *3



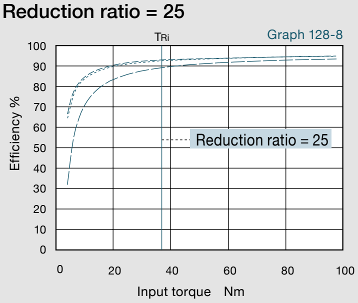
Reduction ratio = 12



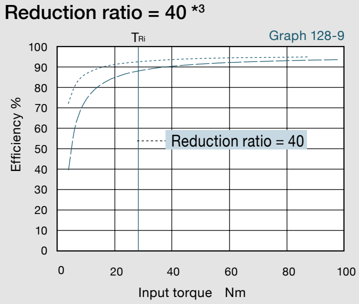
Reduction ratio = 15, 20



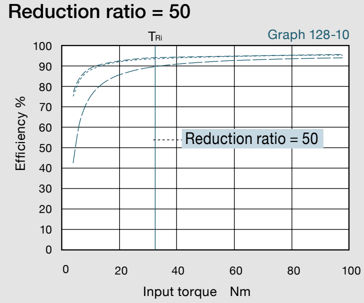
Reduction ratio = 25



Reduction ratio = 40 *3



Reduction ratio = 50

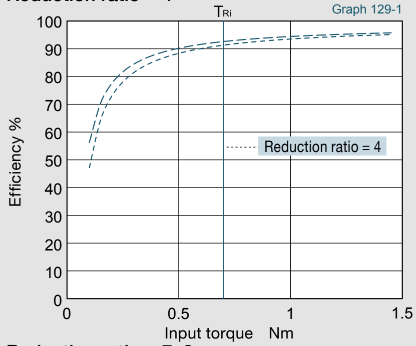


- - - Gearhead (standard item) ······ Gearhead with D bearing (double sealed) —— Input Shaft TRi Input torque corresponding to output torque

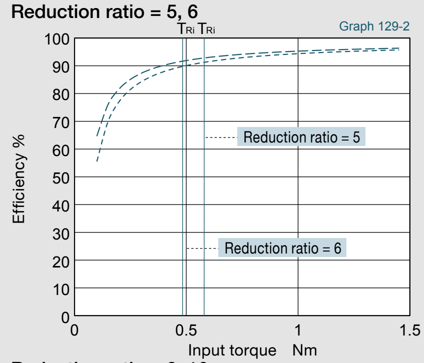
*3 Only one line is shown because the difference between the gearhead and a bearing assembled on the input side is small.

Size 11 : Gearhead **HPG-Helical**

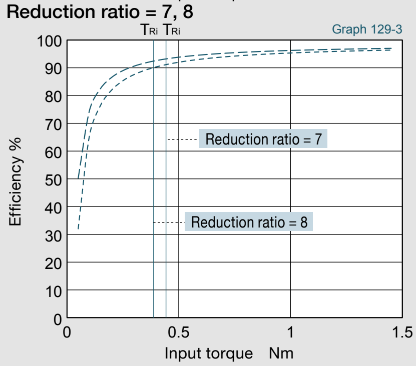
Reduction ratio = 4



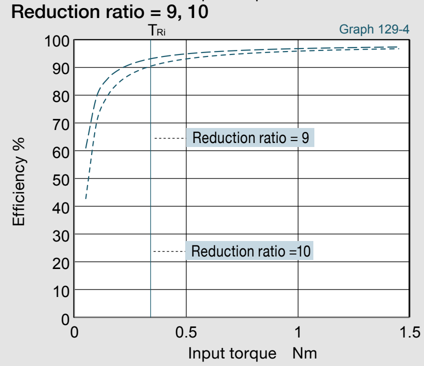
Reduction ratio = 5, 6



Reduction ratio = 7, 8



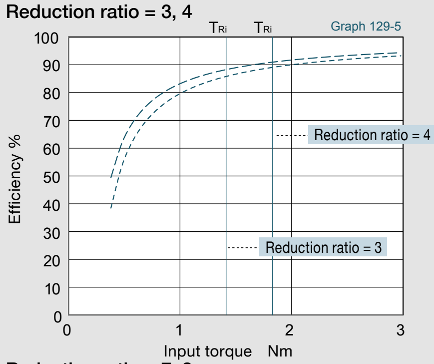
Reduction ratio = 9, 10



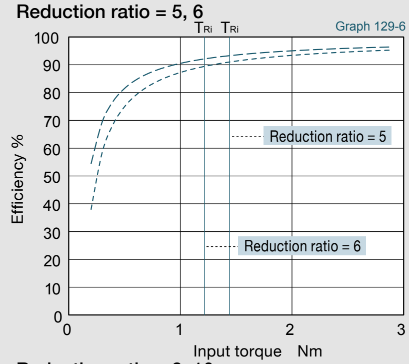
--- Gearhead with Z bearing (Double sheilded) ...... Gearhead with D bearing (double sealed) TRi Input torque corresponding to output torque

Size 14 : Gearhead **HPG-Helical**

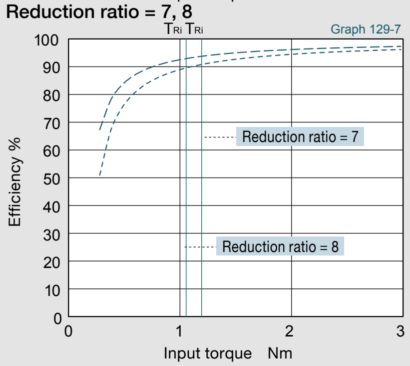
Reduction ratio = 3, 4



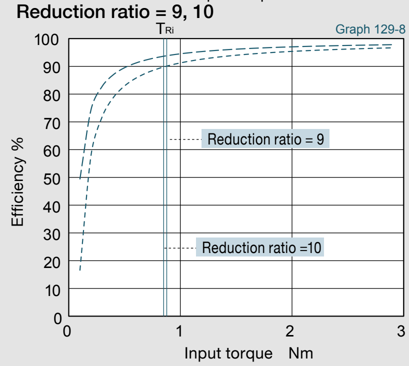
Reduction ratio = 5, 6



Reduction ratio = 7, 8



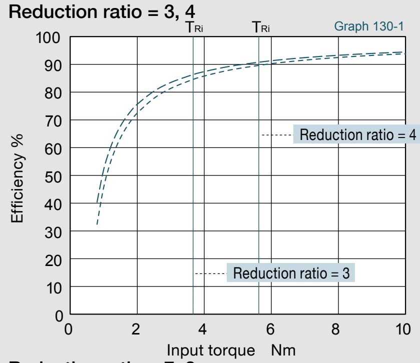
Reduction ratio = 9, 10



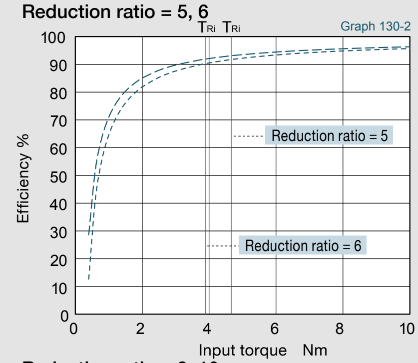
--- Gearhead with Z bearing (Double sheilded) ...... Gearhead with D bearing (double sealed) TRi Input torque corresponding to output torque

Size 20 : Gearhead HPG-Helical

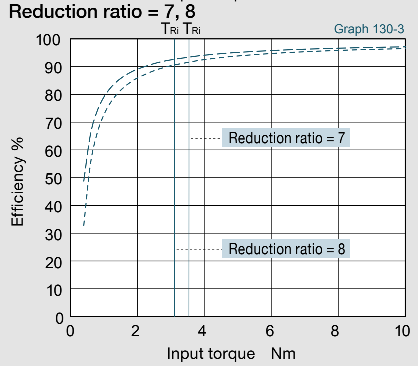
Reduction ratio = 3, 4



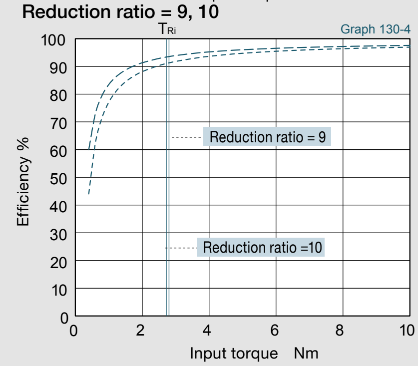
Reduction ratio = 5, 6



Reduction ratio = 7, 8



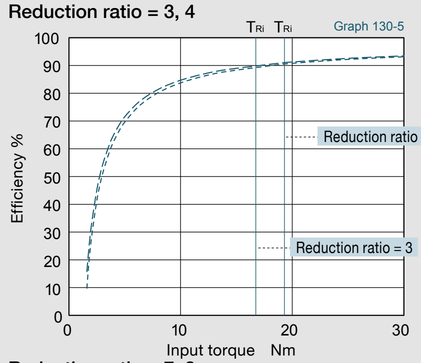
Reduction ratio = 9, 10



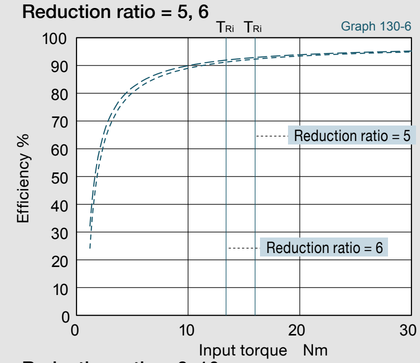
--- Gearhead with Z bearing (Double sheilded) ...... Gearhead with D bearing (double sealed) TRi Input torque corresponding to output torque

Size 32 : Gearhead HPG-Helical

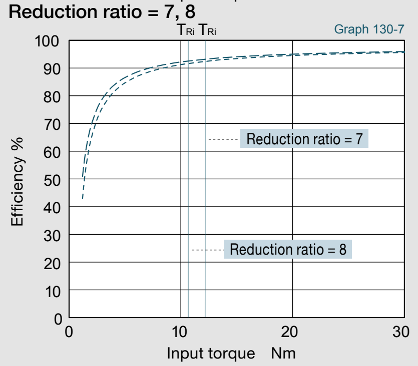
Reduction ratio = 3, 4



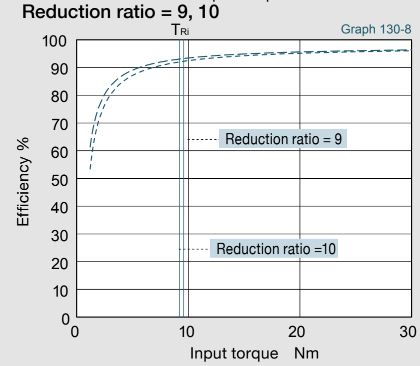
Reduction ratio = 5, 6



Reduction ratio = 7, 8



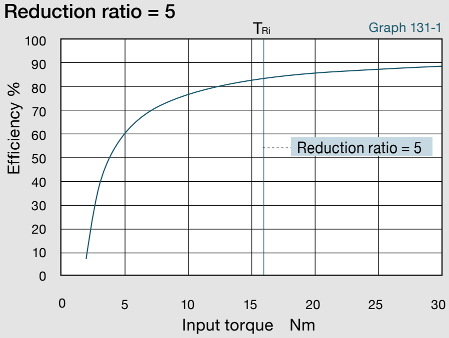
Reduction ratio = 9, 10



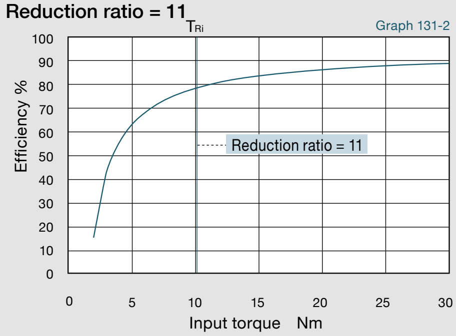
--- Gearhead with Z bearing (Double sheilded) ...... Gearhead with D bearing (double sealed) TRi Input torque corresponding to output torque

Size 32 RA3 : Right Angle Gearhead HPG

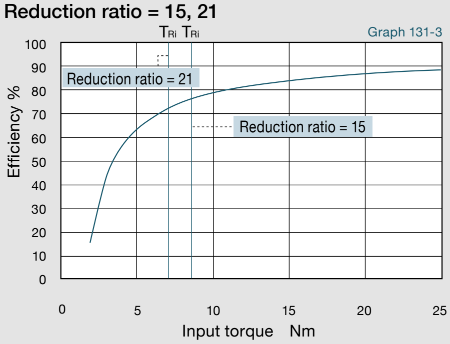
Reduction ratio = 5



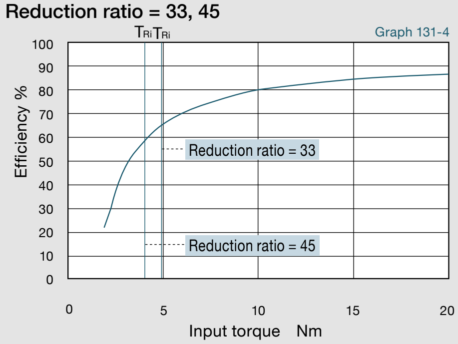
Reduction ratio = 11



Reduction ratio = 15, 21



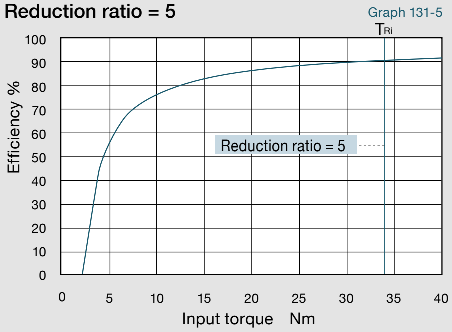
Reduction ratio = 33, 45



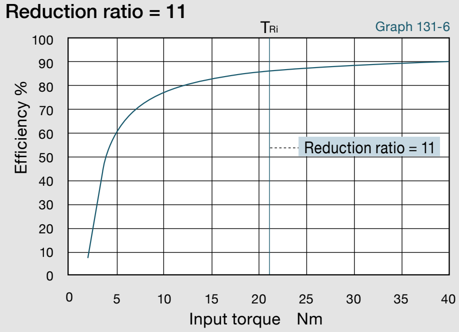
TRi Input torque corresponding to output torque

Size 50 RA3 : Right Angle Gearhead HPG

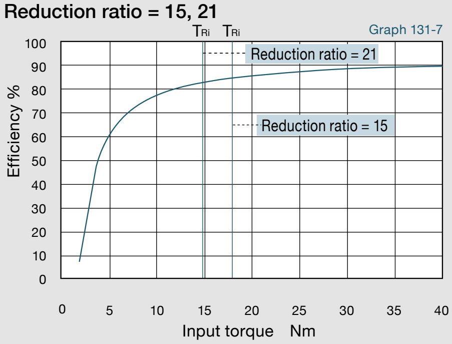
Reduction ratio = 5



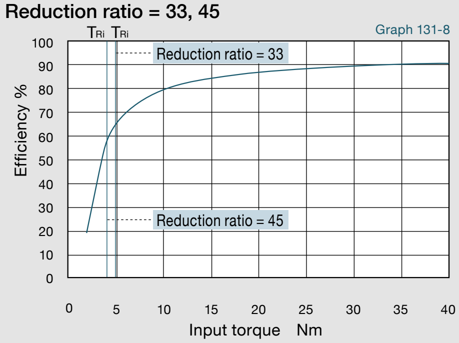
Reduction ratio = 11



Reduction ratio = 15, 21



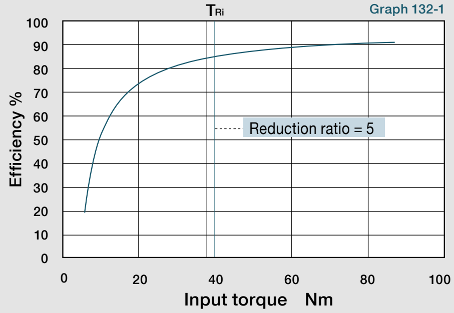
Reduction ratio = 33, 45



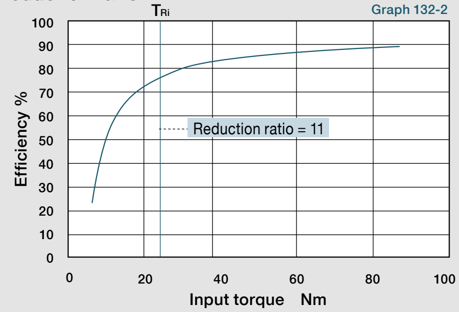
TRi Input torque corresponding to output torque

Size 50 RA5 : Right Angle Gearhead HPG

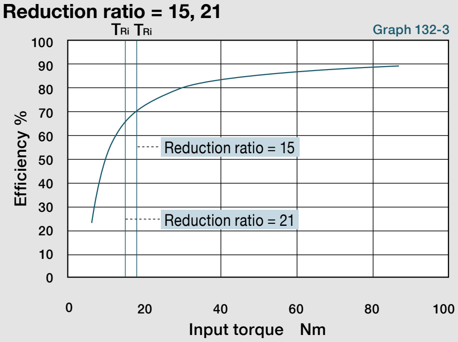
Reduction ratio = 5



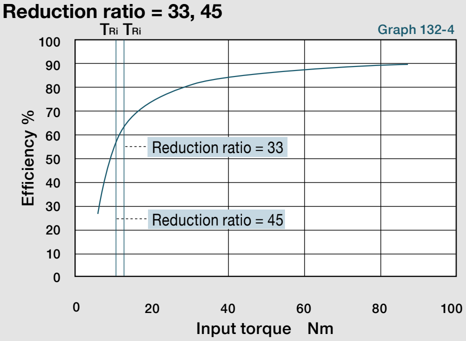
Reduction ratio = 11



Reduction ratio = 15, 21



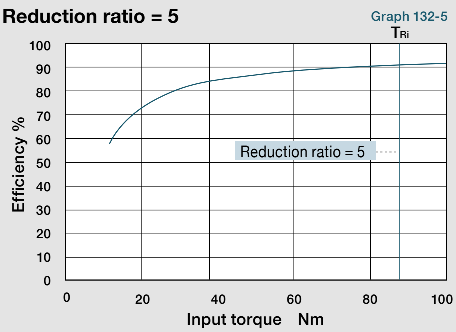
Reduction ratio = 33, 45



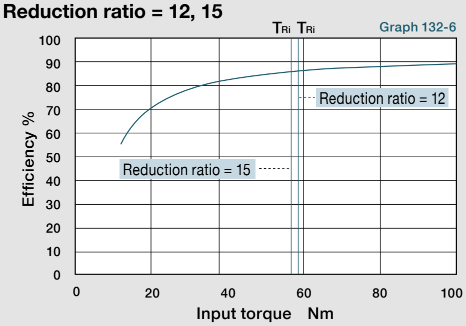
T_{Ri} Input torque corresponding to output torque

Size 65 RA5 : Right Angle Gearhead HPG

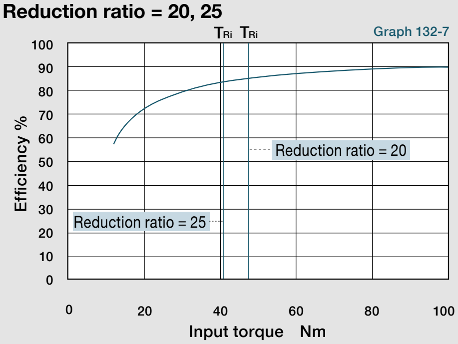
Reduction ratio = 5



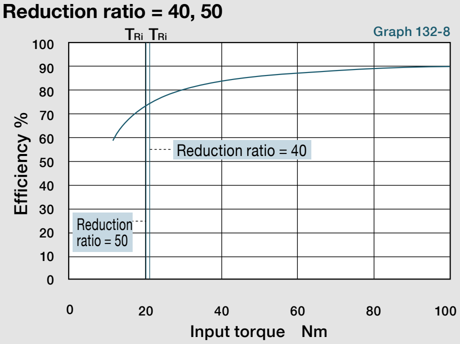
Reduction ratio = 12, 15



Reduction ratio = 20, 25



Reduction ratio = 40, 50

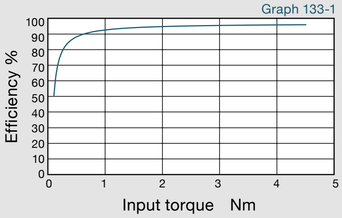


T_{Ri} Input torque corresponding to output torque

Size 11A :Gearhead HPN

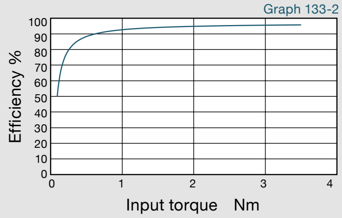
Reduction ratio = 4

Graph 133-1



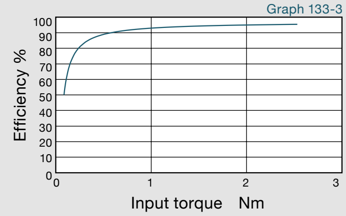
Reduction ratio = 5

Graph 133-2



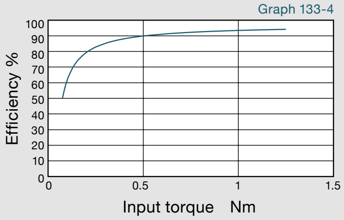
Reduction ratio = 7

Graph 133-3



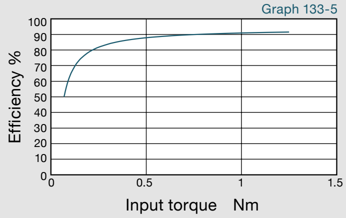
Reduction ratio = 10

Graph 133-4



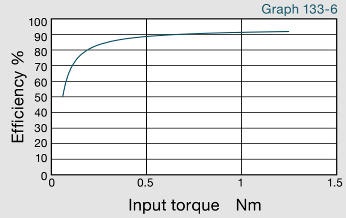
Reduction ratio = 16

Graph 133-5



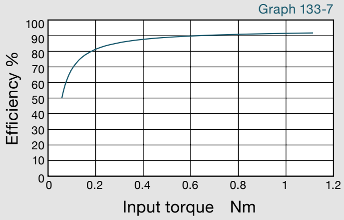
Reduction ratio = 20

Graph 133-6



Reduction ratio = 30

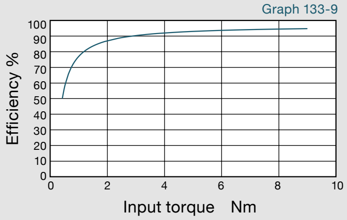
Graph 133-7



Size 14A :Gearhead HPN

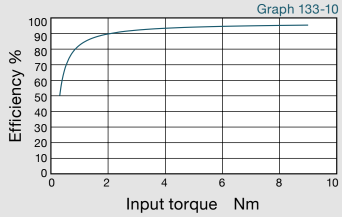
Reduction ratio = 3

Graph 133-9



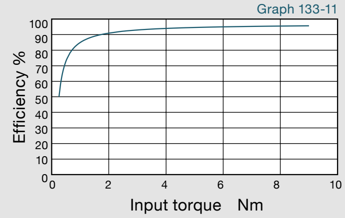
Reduction ratio = 4

Graph 133-10



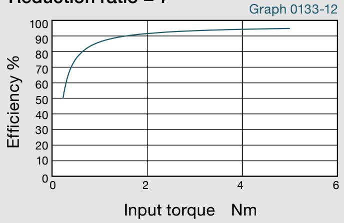
Reduction ratio = 5

Graph 133-11



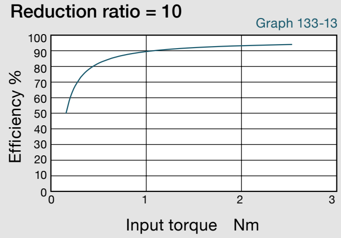
Reduction ratio = 7

Graph 0133-12



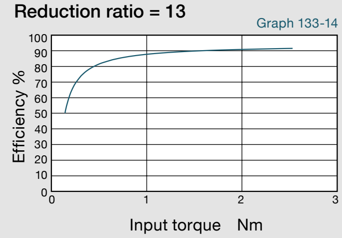
Reduction ratio = 10

Graph 133-13



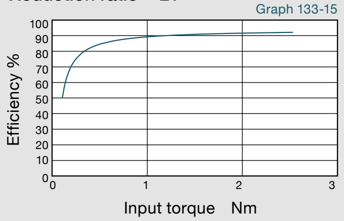
Reduction ratio = 13

Graph 133-14



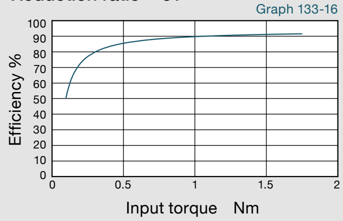
Reduction ratio = 21

Graph 133-15



Reduction ratio = 31

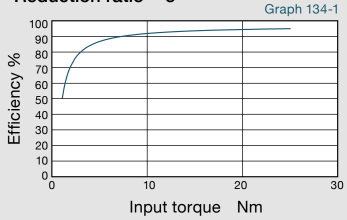
Graph 133-16



Size 20A : Gearhead HPN

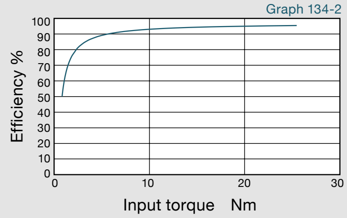
Reduction ratio = 3

Graph 134-1



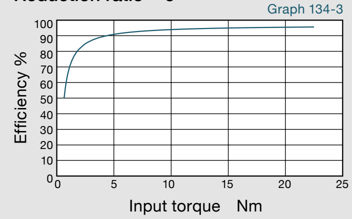
Reduction ratio = 4

Graph 134-2



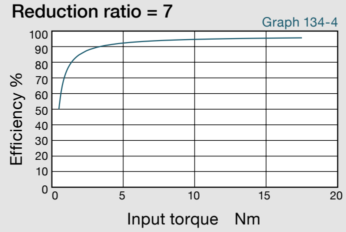
Reduction ratio = 5

Graph 134-3



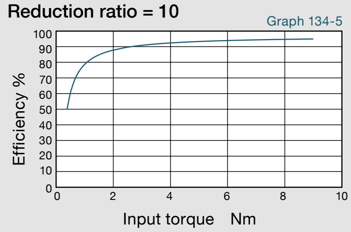
Reduction ratio = 7

Graph 134-4



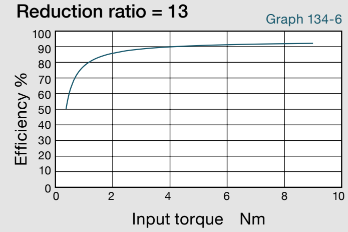
Reduction ratio = 10

Graph 134-5



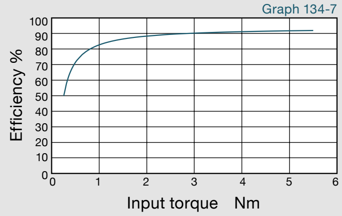
Reduction ratio = 13

Graph 134-6



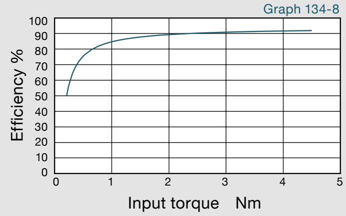
Reduction ratio = 21

Graph 134-7



Reduction ratio = 31

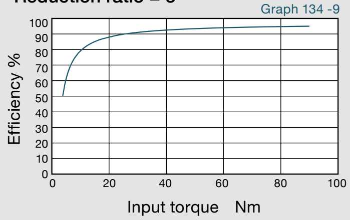
Graph 134-8



Size 32A : Gearhead HPN

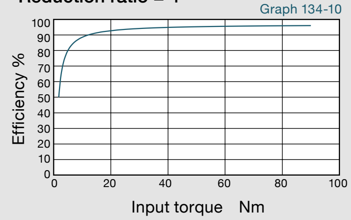
Reduction ratio = 3

Graph 134 -9



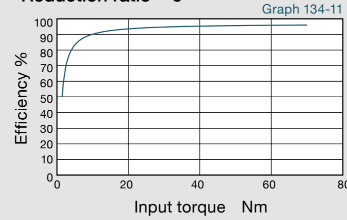
Reduction ratio = 4

Graph 134-10



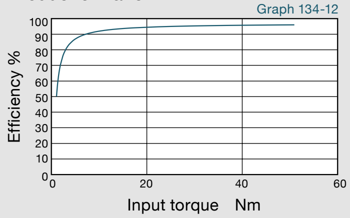
Reduction ratio = 5

Graph 134-11



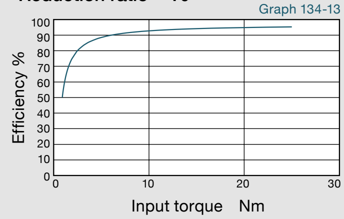
Reduction ratio = 7

Graph 134-12



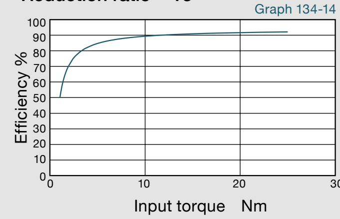
Reduction ratio = 10

Graph 134-13



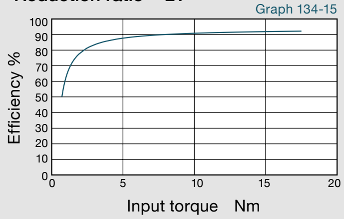
Reduction ratio = 13

Graph 134-14



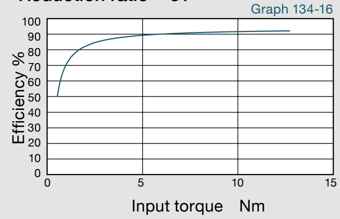
Reduction ratio = 21

Graph 134-15



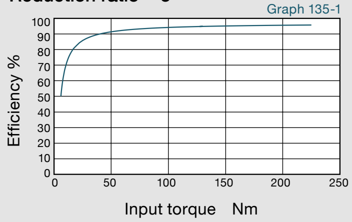
Reduction ratio = 31

Graph 134-16



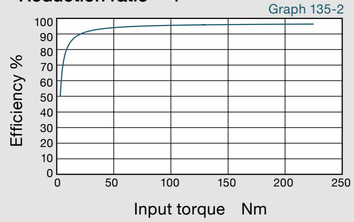
Size 40A : Gearhead **HPN**

Reduction ratio = 3



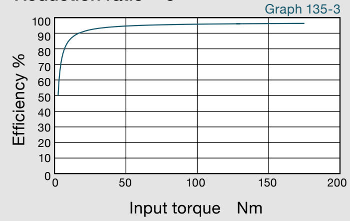
Graph 135-1

Reduction ratio = 4



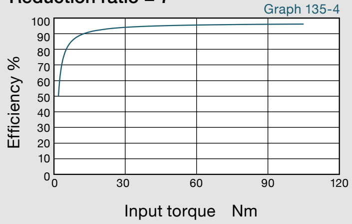
Graph 135-2

Reduction ratio = 5



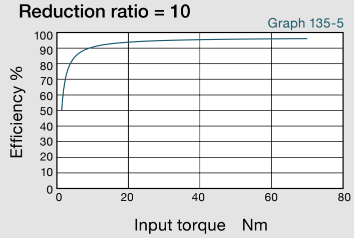
Graph 135-3

Reduction ratio = 7



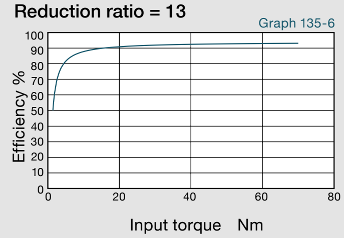
Graph 135-4

Reduction ratio = 10



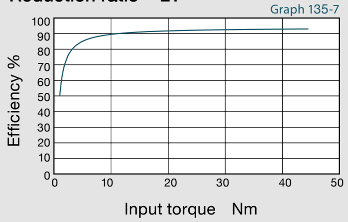
Graph 135-5

Reduction ratio = 13



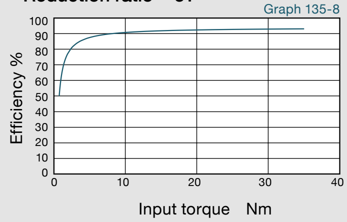
Graph 135-6

Reduction ratio = 21



Graph 135-7

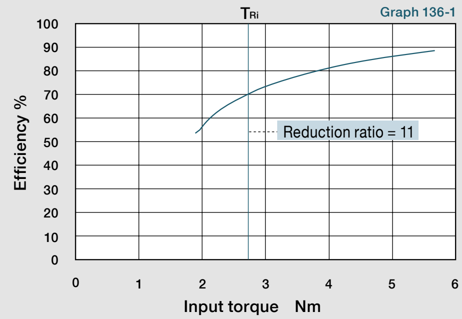
Reduction ratio = 31



Graph 135-8

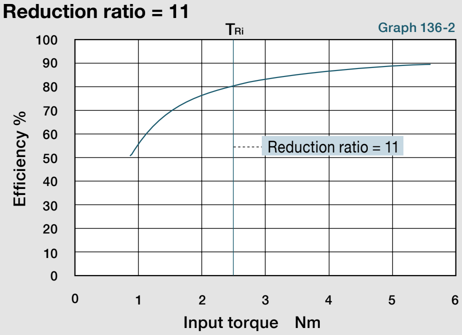
Size 25 : Hollow Shaft Unit HPF

Reduction ratio = 11



Size 32 : Hollow Shaft Unit HPF

Reduction ratio = 11

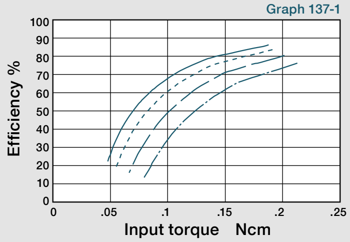


Size 14 : Gearhead

CSG-GH CSF-GH

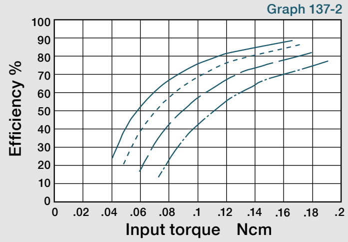
Reduction ratio = 50

Graph 137-1



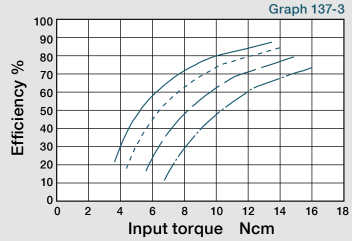
Reduction ratio = 80

Graph 137-2



Reduction ratio = 100

Graph 137-3



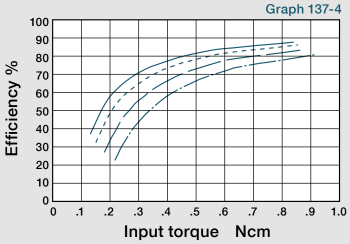
Input rotational speed —— 500 rpm - - - - - - 1000 rpm —— —— 2000 rpm —·— 3500 rpm

Size 20 : Gearhead

CSG-GH CSF-GH

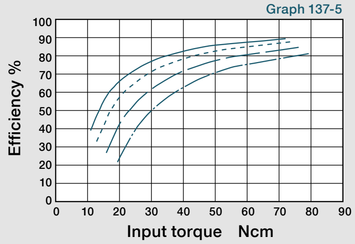
Reduction ratio = 50

Graph 137-4



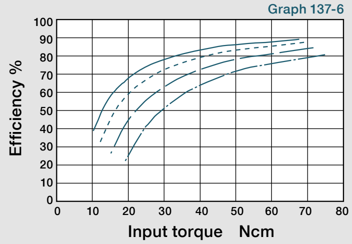
Reduction ratio = 80

Graph 137-5



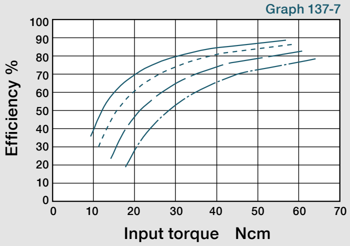
Reduction ratio = 100

Graph 137-6



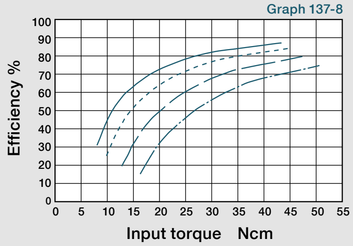
Reduction ratio = 120

Graph 137-7



Reduction ratio = 160

Graph 137-8



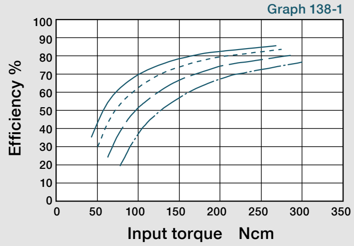
Input rotational speed —— 500 rpm - - - - - - 1000 rpm —— —— 2000 rpm —·— 3500 rpm

Size 32 : Gearhead

CSG-GH CSF-GH

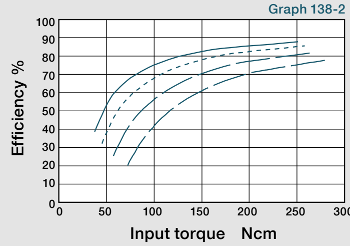
Reduction ratio = 50

Graph 138-1



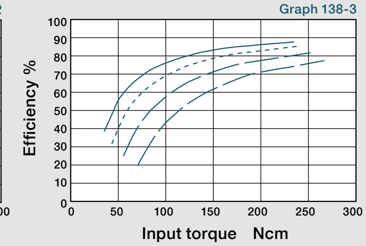
Reduction ratio = 80

Graph 138-2



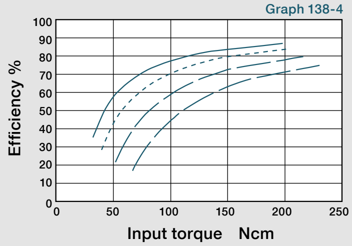
Reduction ratio = 100

Graph 138-3



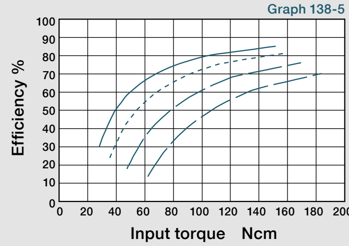
Reduction ratio = 120

Graph 138-4



Reduction ratio = 160

Graph 138-5



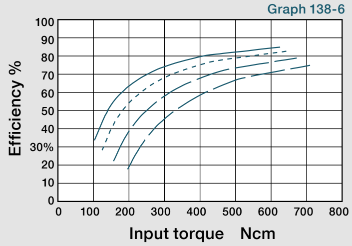
Input rotational speed —— 500 rpm - - - - - - 1000 rpm —— —— 2000 rpm ——·—— 3500 rpm

Size 45 : Gearhead

CSG-GH CSF-GH

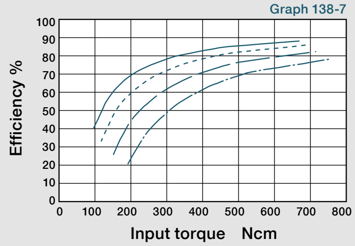
Reduction ratio = 50

Graph 138-6



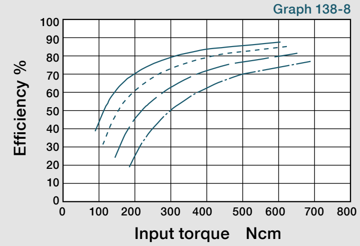
Reduction ratio = 80

Graph 138-7



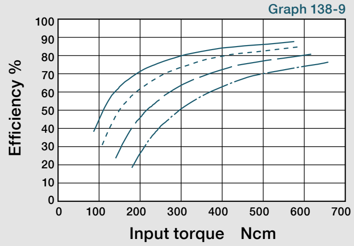
Reduction ratio = 100

Graph 138-8



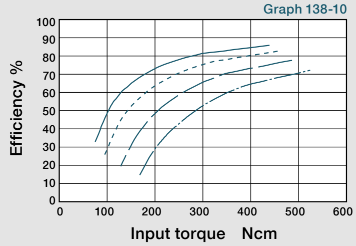
Reduction ratio = 120

Graph 138-9



Reduction ratio = 160

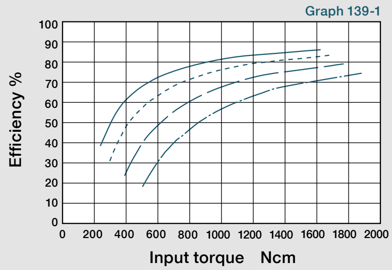
Graph 138-10



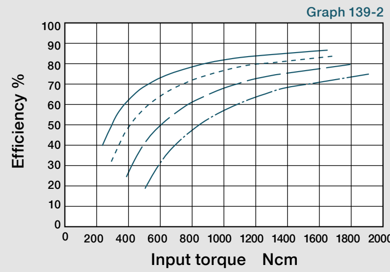
Input rotational speed —— 500 rpm - - - - - - 1000 rpm —— —— 2000 rpm ——·—— 3500 rpm

Size 65 : Gearhead CSG-GH CSF-GH

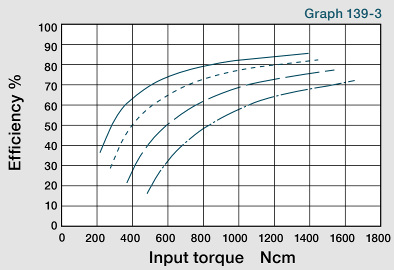
Reduction ratio = 80



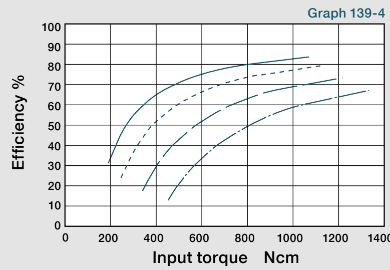
Reduction ratio = 100



Reduction ratio = 120



Reduction ratio = 160



Input rotational speed ——— 500 rpm - - - - - - 1000 rpm —— — 2000 rpm ——·—— 3500 rpm

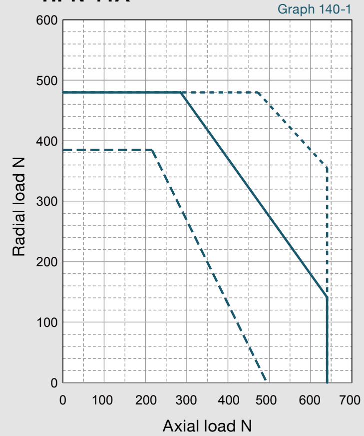
Output Shaft Bearing Load Limits

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.

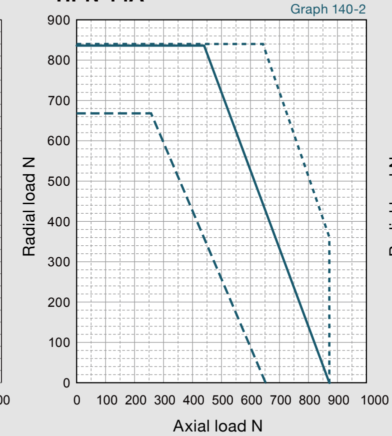
HPN-11A

Graph 140-1



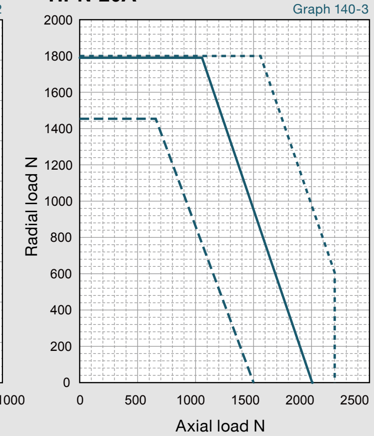
HPN-14A

Graph 140-2



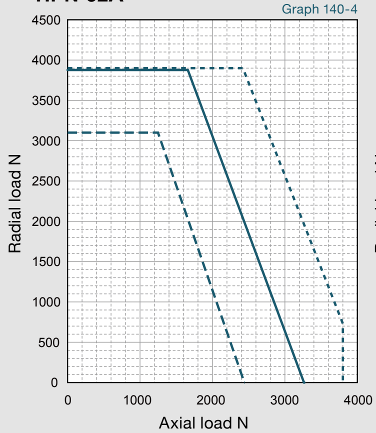
HPN-20A

Graph 140-3



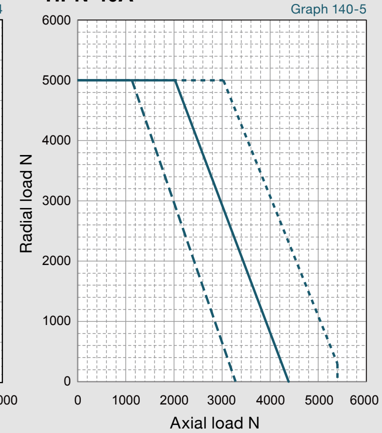
HPN-32A

Graph 140-4



HPN-40A

Graph 140-5



fw=1
fw=1.2
fw=1.5

Load coefficient
fw=1~1.2 Smooth operation without impact
fw=1.2~1.5 Standard operation

Output shaft speed - 100 rpm, bearing life is based on 20,000 hours. The load-point is based on shaft center of radial load and axial load.

Output Bearing Specifications and Checking Procedure

HPGP, HPG, HPG Helical, CSF-GH, CSG-GH, HPF, and HPG-U1 are equipped with cross roller bearings. 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 moment load (M *max*)

Calculate the maximum moment load (M*max*).

Maximum moment load (M*max*) ≦ Permissible moment (Mc)

(2) Checking the life

Calculate the average radial load (Fr*av*) and the average axial load (Fa*av*).

Calculate the radial load coefficient (X) and the axial load coefficient (Y).

Calculate the life and check it.

(3) Checking the static safety coefficient

Calculate the static equivalent radial load coefficient (Po).

Check the static safety coefficient. (fs)

Specification of output bearing

HPGP/HPG Series Tables 141-1, -2 and -3 indicate the cross roller bearing specifications for in-line, right angle and input shaft gears.

Table 141-1

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	$\times 10^4$ 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 141-2

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 141-3

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.

〔Note：Table 141-1, -2 and -3　Table 142-1 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/mm²) 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.

CSG-GH/CSF-GH Series Table 142-1 indicates the specifications for cross roller bearing.

Table 142-1

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				×10⁴ 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 142-2 indicates the specifications for cross roller bearing.

Table 142-2

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				×10⁴ 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 141-1, -2 and -3　Table 142-1 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/mm²) 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 moment load

HPGP | HPG | CSG-GH | CSF-GH | HPF

Maximum moment load (M_{max}) is obtained as follows.
Make sure that $M_{max} \leqq Mc$.

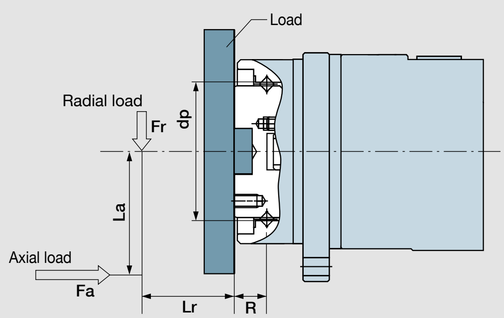
Formula 143-1

$$M_{max} = Fr_{max}(Lr+R) + Fa_{max} La$$

Fr_{max}	Max. radial load	N (kgf)	See Fig. 143-1.
Fa_{max}	Max. axial load	N (kgf)	See Fig. 143-1.
Lr, La	—	m	See Fig. 143-1.
R	Offset amount	m	See Fig. 143-1. See "Output Bearing Specifications" of each series, p.141 & 142

Figure 143-1

External load influence diagram



How to calculate the radial and the axial load coefficient

HPGP | HPG | CSG-GH | CSF-GH | HPF

The radial load coefficient (X) and the axial load coefficient (Y)

Formula 143-2

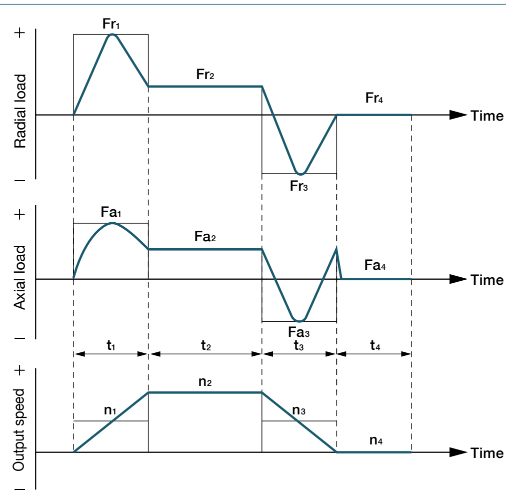
Formula	X	Y
$\frac{Fa_{av}}{Fr_{av}+2(Fr_{av}(Lr+R)+Fa_{av} \cdot La)/dp} \leqq 1.5$	1	0.45
$\frac{Fa_{av}}{Fr_{av}+2(Fr_{av}(Lr+R)+Fa_{av} \cdot La)/dp} > 1.5$	0.67	0.67

Fr_{av}	Average radial load	N (kgf)	See "How to calculate the average load below."
Fa_{av}	Average axial load	N (kgf)	See "How to calculate the average load below."
Lr, La	—	m	See Fig. 143-1.
R	Offset amount	m	See Fig. 143-1. See "OOutput Bearing Specifications" of each series, p. 141 & 142.
dp	Circlar pitch of roller	m	See Fig. 143-1. See "Output Bearing Specifications" of each series, p. 141 & 142.

How to calculate the average load (Average radial load, average axial load, average output speed)

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 143-3

$$Fr_{av} = \sqrt[10/3]{\frac{n_1t_1(|Fr_1|)^{10/3} + n_2t_2(|Fr_2|)^{10/3} \cdots n_nt_n(|Fr_n|)^{10/3}}{n_1t_1+n_2t_2+\cdots+n_nt_n}}$$

Note that the maximum radial load within the t_1 section is Fr_1 and the maximum radial load within the t_3 section is Fr_3.

How to obtain the average axial load (Fa_{av})

Formula 143-4

$$Fa_{av} = \sqrt[10/3]{\frac{n_1t_1(|Fa_1|)^{10/3} + n_2t_2(|Fa_2|)^{10/3} \cdots n_nt_n(|Fa_n|)^{10/3}}{n_1t_1+n_2t_2+\cdots+n_nt_n}}$$

Note that the maximum axial load within the t_1 section is Fa_1 and the maximum axial load within the t_3 section is Fa_3.

How to obtain the average output speed (N_{av})

Formula 143-5

$$N_{av} = \frac{n_1t_1+n_2t_2+\cdots+n_nt_n}{t_1+t_2+\cdots+t_n}$$

How to calculate the life
HPGP HPG CSG-GH CSF-GH HPF

Calculate the life of the cross roller bearing using Formula 144-1. You can obtain the dynamic equivalent load (Pc) using Formula 144-2.

Formula 144-1

$$L_{10}=\frac{10^6}{60\times N_{av}}\times\left(\frac{C}{fw\cdot Pc}\right)^{10/3}$$

L_{10}	Life	hour	—
N_{av}	Ave. output speed	rpm	See “How to calculate the ave. load.”
C	Basic dynamic load rating	N (kgf)	See “Output Bearing Specs.”
Pc	Dynamic equivalent load	N (kgf)	See Formula 144-2.
fw	Load coefficient	—	See Table 144-1.

Formula 144-2

$$Pc=X\cdot\left(Fr_{av}+\frac{2(Fr_{av}(Lr+R)+Fa_{av}\cdot La)}{dp}\right)+Y\cdot Fa_{av}$$

Fr_{av}	Average radial load	N (kgf)	See "How to calculate the ave. load."
Fa_{av}	Average axial load	N (kgf)	
dp	Pitch Circle 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 143-1. See “External load influence diagram.”
R	Offset amount	m	See Figure 143-1. See “External load influence diagram” and “Output Bearing Specs” of each series.

Load coefficient

Table 144-1

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 motion
HPGP HPG CSG-GH CSF-GH HPF

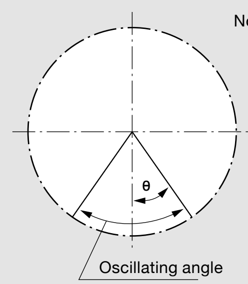
Calculate the life of the cross roller bearing during oscillating motion by Formula 144-3.

Formula 144-3

$$Loc=\frac{10^6}{60\times n1}\times\frac{90}{\theta}\times\left(\frac{C}{fw\cdot Pc}\right)^{10/3}$$

Loc	Rated life under oscillating motion	hour	–
n1	No. of reciprocating oscillation per min.	cpm	–
C	Basic dynamic load rating	N (kgf)	See “Output Bearing Specs.”
Pc	Dynamic equivalent load	N (kgf)	See Formula 144-2.
fw	Load coefficient	—	See Table 144-1.
θ	Oscillating angle /2	Deg.	See Figure 144-1.

Figure 144-1



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 corrosion may develop.

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 output 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 load rating (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 144-4.
General values under the operating condition are shown in Table 144-2. You can calculate the static equivalent load (Po) using Formula 144-5.

Formula 144-4

$$fs=\frac{Co}{Po}$$

Co	Basic static load	N (kgf)	See “Output Bearing Specs.”
Po	Static equivalent load	N (kgf)	See Formula 144-5.

Formula 144-5

$$Po=Fr_{max}+\frac{2M_{max}}{dp}+0.44Fa_{max}$$

Fr_{max}	Max. radial load	N (kgf)	See “How to calculate the max. moment load.”
Fa_{max}	Max. axial load	N (kgf)	
M_{max}	Max. moment load	Nm (kgfm)	
dp	Pitch Circle	m	See “Output Bearing Specs” of each series.

Static safety coefficient

Table 144-2

Load status	fs
When high 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 moment load (Mi *max*)
Maximum axial load (Fai *max*)
Maximum radial load (Fri *max*)

Maximum moment load (Mi *max*) ≦ Allowable moment load (Mc)
Maximum axial load (Fai *max*) ≦ Allowable axial load (Fac)
Maximum radial load (Fri *max*) ≦ Allowable 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 bearing

Specification of input bearing HPG

Table 145-1

Size	Basic load rating			
	Basic dynamic load rating Cr		Basic static load rating 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 145-2

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 145-3

Size	Basic load rating			
	Basic dynamic load rating Cr		Basic static load rating Cor	
	N	kgf	N	kgf
25	14500	1480	10100	1030
32	29700	3030	20100	2050

Table 145-4

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 145-2 and 145-4〕
*1 The allowable axial load is the value of an axial load applied along the axis of rotation.
*2 The allowable radial load of HPG series is the value of a radial load applied at the mid-point of the input shaft.
*3 The allowable radial load of HPG series is the value of a radial load applied to the point of 20 mm from the shaft edge (input flange edge).

Calculating maximum moment load ON input shaft

HPG HPF

The maximum moment load (Mi_{max}) is calculated as follows.
Check that the following formulas are established in all circumstances:

Formula 146-1

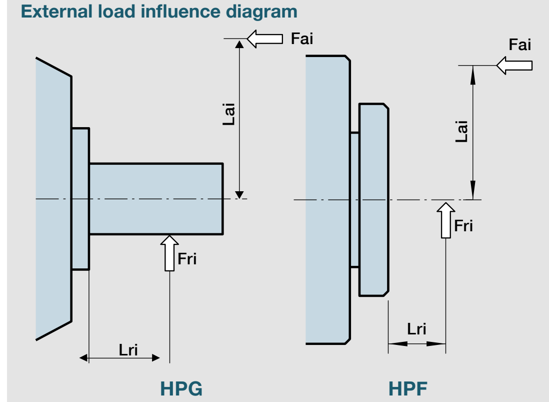
$$Mi_{max} = Fri_{max} \cdot Lri + Fai_{max} \cdot Lai$$

Fri_{max}	Max. radial load	N (kgf)	See Fig. 146-1.
Fai_{max}	Max. axial load	N (kgf)	See Fig. 146-1.
Lri,Lai	————	m	See Fig. 146-1.

$Mi_{max} \leqq Mc$ (Allowable moment load)
$Fai_{max} \leqq Fac$ (Allowable axial load)

Figure 146-1

External load influence diagram

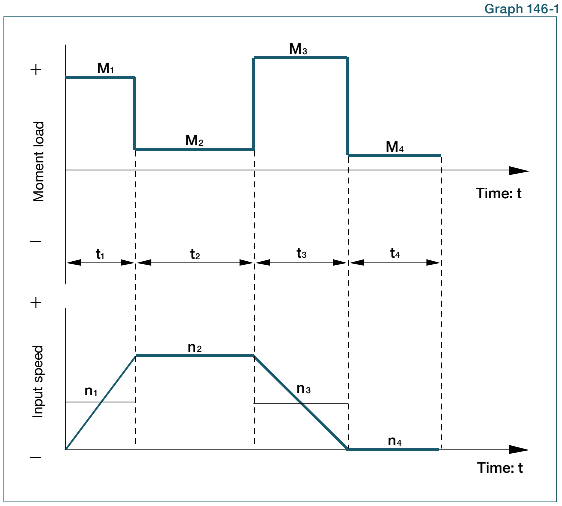


How to calculate average load (Average moment load, average axial load, average input speed)

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 146-1



How to calculate the average moment load (Mi_{av})

Formula 146-2

$$Mi_{av} = \sqrt[3]{\frac{n_1t_1(|Mi_1|)^3 + n_2t_2(|Mi_2|)^3 \cdots n_nt_n(|Mi_n|)^3}{n_1t_1+n_2t_2+\cdots+n_nt_n}}$$

How to calculate the average axial load (Fai_{av})

Formula 146-3

$$Fai_{av} = \sqrt[3]{\frac{n_1t_1(|Fai_1|)^3 + n_2t_2(|Fai_2|)^3 \cdots n_nt_n(|Fai_n|)^3}{n_1t_1+n_2t_2+\cdots+n_nt_n}}$$

How to calculate the average input speed (Ni_{av})

Formula 146-4

$$Ni_{av} = \frac{n_1t_1 + n_2t_2 + \cdots + n_nt_n}{t_1 + t_2 + \cdots + t_n}$$

Calculating life of input bearing

Calculate the bearing life according to Calculation Formula 132-5 and check the life.

Formula 146-5

$$L_{10} = \frac{10^6}{60 \times Ni_{av}} \times \left(\frac{Cr}{Pci}\right)^3$$

L_{10}	Life	Hour	—
Ni_{av}	Average input speed	rpm	See Formula 146-4
Cr	Basic dynamic load rating	N (kgf)	See Table 145-1 and -3
Pci	Dynamic equivalent load	N	See Table 146-1 and -2

Dynamic equivalent load HPG

Table 146-1

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 load HPF

Table 146-2

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 146-2
Fai_{av}	Average axial load N (kgf)	See Formula 146-3

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 147-1

(1) Turn the input shaft coupling and align the bolt head with the rubber cap hole.

(2) 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 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 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.

(3) 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 coupling when delivered. Check the bolt size on the confirmation drawing provided.

Bolt tightening torque

Table 147-1

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 occur. 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 standard) and page 46 (HPG helical). Tighten the screws to the tightening torque specified below.

Table 147-2

Bolt size		M3
Tightening torque	Nm	0.69
	kgfm	0.07

(4) Fasten the motor to the gearhead flange with bolts.

Bolt* tightening torque

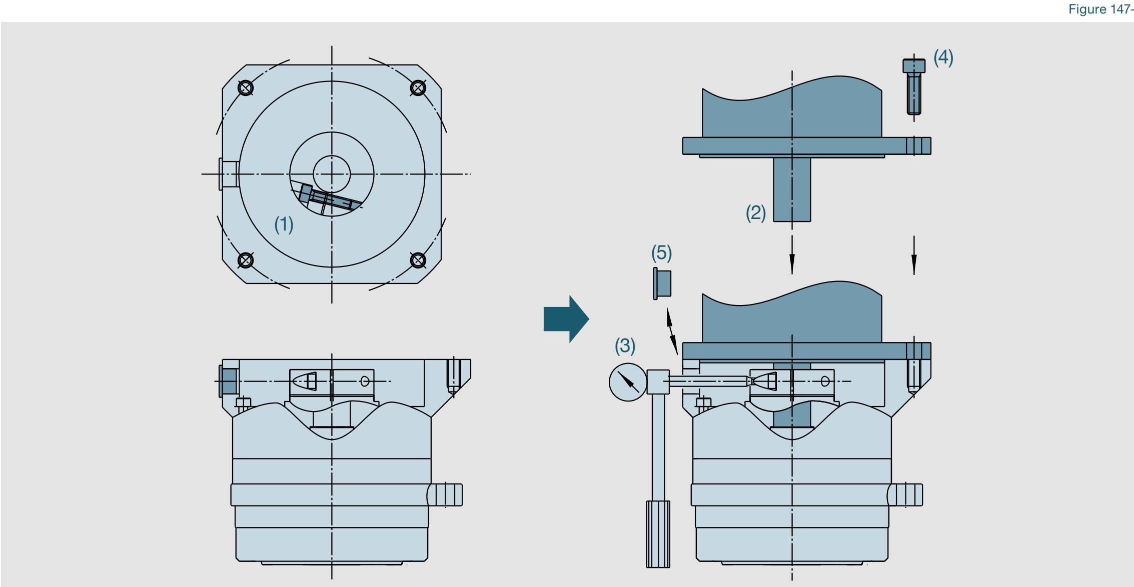
Table 147-3

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.

(5) Insert the rubber cap provided. This completes the assembly. (Size 11: Fasten screws with a gasket in two places)

Figure 147-1



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 needs. 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 148-1

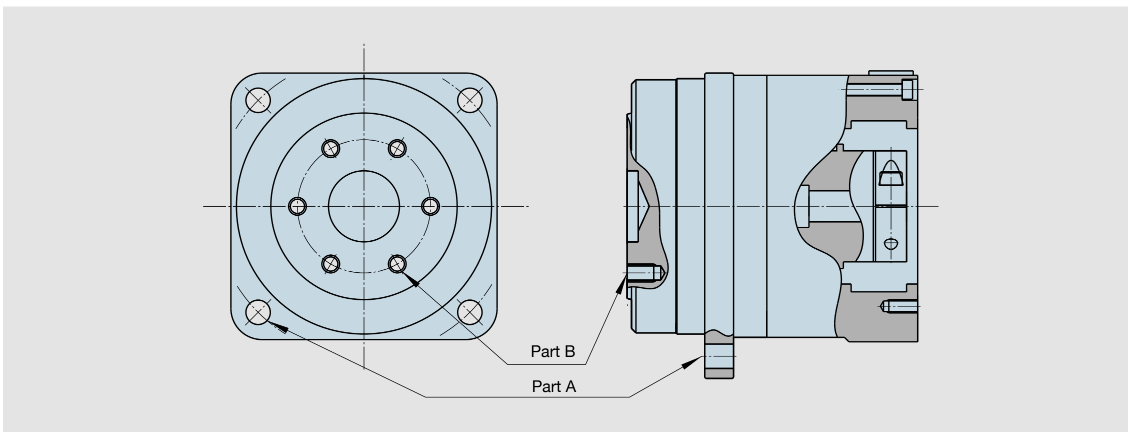
Size		HPN					HPGP / HPG / CSG-GH / CSF-GH						HPF	
		11	14	20	32	40	11	14	20	32	45/50	65	25	32
Number of bolts		4	4	4	4	4	4	4	4	4	4	4	12	12
Bolt size		M3	M5	M6	M8	M10	M3	M5	M8	M10	M12	M16	M4	M5
Mounting PCD	mm	50	70	100	130	165	46	70	105	135	190	260	127	157
Tightening torque	Nm	1.4	6.3	10.7	26.1	51.5	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
Transmission 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 148-1



Output flange mounting specifications

Bolt* tightening torque for output flange (Part B in the Figure 148-1) HPGP

Table 148-2

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 148-1) HPG

Table 148-3

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 148-1) **CSG-GH**

Table 149-1

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 148-1) **CSF-GH**

Table 149-2

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 148-1) **HPF**

Table 149-3

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 may affect 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 150-1

Output Flange: F0 (flange)

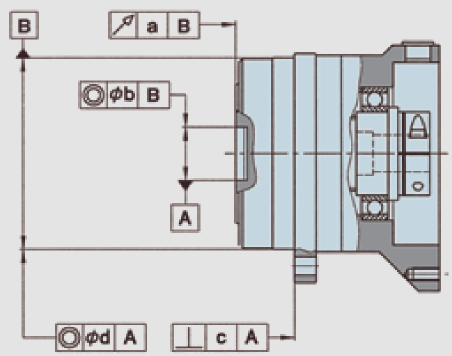
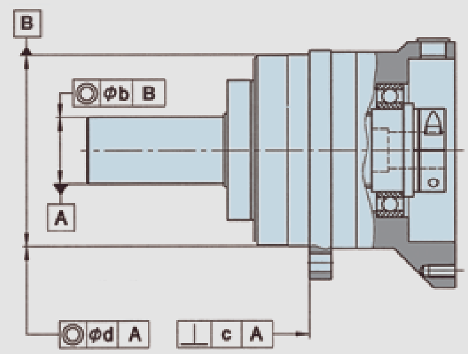


Figure 150-2

Output shaft: J2 [J20], J6 [J60] (shaft output)



HPGP HPG CSG-GH CSF-GH

Table 150-1

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 150-2

50	0.020	0.040	0.060	0.050
65	0.040	0.060	0.090	0.080

CSG-GH CSF-GH

Table 150-3

45	0.020	0.040	0.060	0.050
65	0.020	0.040	0.060	0.050

HPF

Table 150-4

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 that 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 bearings are used for the motor shaft coupling (Double sealed bearings (D 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.
- Material and surface: Gearbox: Aluminum, corrosion protected roller bearing steel, carbon steel (output shaft). Adapter flange: (if provided by Harmonic Drive) high-strength aluminum or carbon steel. Screws: black phosphate. The ambient environment should not subject any corrosive agents to the above mentioned material. The product provides protection class IP 65 under the provision that corrosion from the ambient atmosphere (condensation, liquids or gases) at the running surface of the output shaft seal is prevented. If necessary, the adapter flange can be sealed by means of a surface seal (e.g. Loctite 515).

* D type: Bearing with a rubber contact seal on both sides

(**HPG/HPGP/HPF/HPN Series**)

- Using the double sealed bearing (D 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 ON the input 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.

Standard Lubricants

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
Thickening agent: Lithium soap
Additive: Extreme pressure agent and other
Standard: NLGI No. 2
Consistency: 265 to 295 at 25°C
Dropping point: 198°C
Color: Green

EPNOC Grease AP (N) 2 (HPGP/HPG-11, 50, 65／HPF-25, 32)
Manufacturer: Nippon Oil Co.

Base oil: Refined mineral oil
Thickening agent: Lithium soap
Additive: Extreme pressure agent and other
Standard: NLGI No. 2
Consistency: 282 at 25°C
Dropping point: 200°C
Color: Light brown

PYRONOC UNIVERSAL 00 (HPG right angle gearhead/HPN)
Manufacturer: Nippon Oil Co.

Base oil: Refined mineral oil
Thickening agent: Urea
Standard: NLGI No. 00
Consistency: 420 at 25°C
Dropping point: 250°C or higher
Color: Light yellow

MULTEMP AC-P (HPG-X-R)
Manufacturer: KYODO YUSHI CO, LTD

Base oil: Composite hydrocarbon oil and diester
Thickening agent: Lithium soap
Additive: Extreme pressure and others
Standard: NLGI No. 2
Consistency: 280 at 25°C
Dropping point: 200°C
Color: Black viscose

Ambient operating temperature range: –10°C to +40°C

The lubricant may deteriorate if the ambient operating temperature is outside of recommended operating range. 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 based on the customers installation of the gear. A housing surface temperature of 70ºC 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 grease 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	Consistency: 265 to 295 at 25°C
Thickening Agent: Lithium soap	Dropping point: 197°C
Additive: Extreme pressure agent and other	Color: Yellow
Standard: NLGI No. 2	

Harmonic Grease SK-2 (Size 14)
Manufacturer: Harmonic Drive Systems Inc.
This grease has been developed exclusively for smaller sized HarmonicDrive® gears and allows smooth wave generator rotation.

Base oil: Refined mineral oil	Consistency: 265 to 295 at 25°C
Thickening Agent: Lithium soap	Dropping point: 198°C
Additive: Extreme pressure agent and other	Color: Green
Standard: NLGI No. 2	

Ambient operating temperature range: –10°C to +40°C

The lubricant may deteriorate if the ambient operating temperature is outside the recommended temperature range. 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 based on 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 at elevated 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 (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 152-1

$$L_{GT} = L_{GTn} \times \left(\frac{Tr}{Tav}\right)^3$$

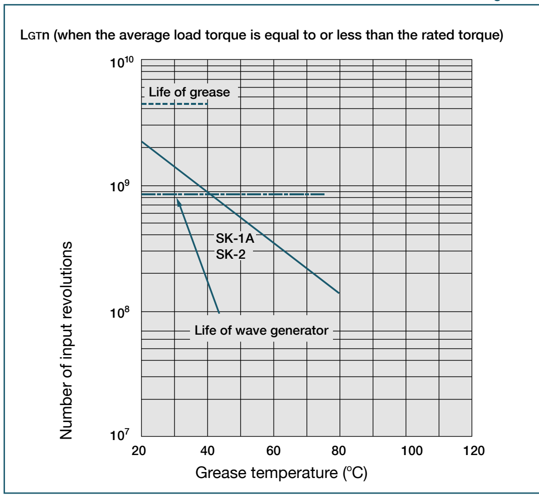
Formula symbols

Table 152-1

L_{GT}	Grease change interval when Tav > Tr	Input rotations	————————
L_{GTn}	Grease change interval when Tav <= Tr	Input rotations	See Graph 152-1
Tr	Output torque at 2000 rpm	Nm, kgfm	See the "Rating table" on pages 77 & 87.
T_{av}	Average load torque	Nm, kgfm	Calculation formula: See page 100.

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 152-1



* L10 Life of wave generator bearing

Reference values for grease refill amount

Table 152-2

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 152-2 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 (D 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.

Application Restrictions

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 residential dwellings
* 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℃
  - 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 ratings 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 sizes (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 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 ingest (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.
- Eyes: 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 to an empty container. The container may explode.
- 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 of 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

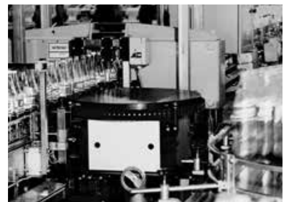

Medical Equipment


Telescopes

Source: National observatory of Inter-University Research Institute Corporation


Energy

Courtesy of Halliburton/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.

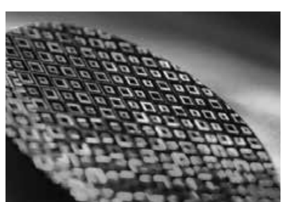

Glass and Ceramic Manufacturing Systems


Robots


Humanoid Robots

Source: Honda Motor Co., Ltd.


Printing, Bookbinding and Paper Machines

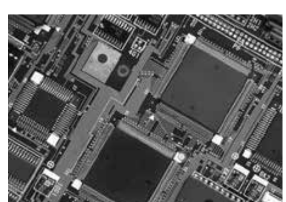

Semiconductor Manufacturing Equip.


Optical Equipment


Machine Tools

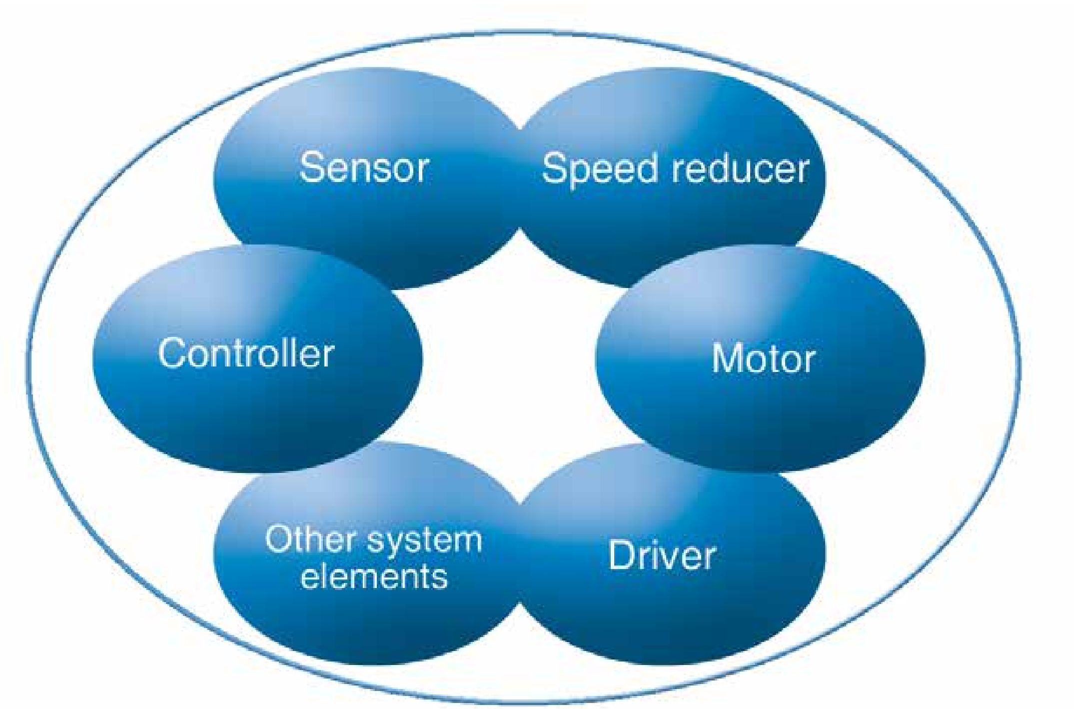

Paper-making Machines


Flat Panel Display Manufacturing Equip.


Printed Circuit Board Manufacturing Machines


Aerospace

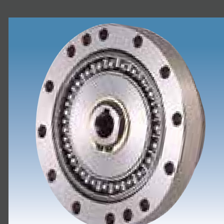
Experts in Precision Motion Control



Other Products

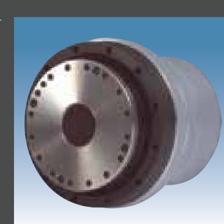
HarmonicDrive® Gearing

HarmonicDrive® speed reducer delivers precise motion control by utilizing the strain wave gearing principle.



Rotary Actuators

High-torque actuators combine performance matched servomotors with HarmonicDrive® 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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