High-Performance Gearheads for Servo and Stepper Motors

HarmonicPlanetary®
HPGP / HPG / HPN / HPF / 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.

- 1963: Harmonic Drive® components used in inertial damping system for an unmanned helicopter
- 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
- 1999: Ultra-flat Harmonic Drive® gearing developed
- 2004: Market introduction of high-precision HPG Harmonic Planetary® gearheads with low backlash for life
- 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
- 2011: Robonaut 2 launches on STS-133 and becomes the first permanent robotic crew member of the International Space Station
- 2011: Introduction of Hollow Shaft Harmonic Planetary® gear unit
- 2018: Market introduction of HPN-L face mount gearhead
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.
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.
You can create a high precision actuator by connecting any manufacturer’s servomotor to our precision gearhead with our Quick Connect® coupling.

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#### Quick Connect® Gearheads

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- HPG Standard Series: 30-41
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**HarmonicPlanetary®** (Ratios 3:1 to 50:1)

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- Hollow Shaft HPF Series: 116-121
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## Product Line

### Quick Connect Gearheads

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

<table>
<thead>
<tr>
<th>Size</th>
<th>Outline Dimension (mm)</th>
<th>Reduction ratio</th>
<th>Backlash*1</th>
<th>Motor power</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>40</td>
<td>5, 21, 37, 45</td>
<td>≤ 3 arc-min</td>
<td>10W~200W</td>
</tr>
<tr>
<td>14, 20, 32</td>
<td>60, 80, 120</td>
<td>5, 11, 15, 21, 33, 45</td>
<td>≤ 3 arc-min</td>
<td>30W~4kW</td>
</tr>
<tr>
<td>50</td>
<td>170</td>
<td>4, 5, 12, 15, 20, 25</td>
<td>≤ 3 arc-min</td>
<td>500W~10kW</td>
</tr>
</tbody>
</table>

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

#### HPG Standard Series
(Peak torque 5Nm to 200Nm)

<table>
<thead>
<tr>
<th>Size</th>
<th>Outline Dimension (mm)</th>
<th>Reduction ratio</th>
<th>Backlash*1</th>
<th>Motor power</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>40</td>
<td>5, 9, 21, 37, 45</td>
<td>≤ 3 arc-min</td>
<td>10W~100W</td>
</tr>
<tr>
<td>14, 20, 32</td>
<td>60, 80, 120</td>
<td>3, 5, 11, 15, 21, 33, 45</td>
<td>≤ 3 arc-min</td>
<td>30W~3.5kW</td>
</tr>
<tr>
<td>50</td>
<td>170</td>
<td>4, 5, 12, 15, 20, 25</td>
<td>≤ 3 arc-min</td>
<td>500W~10kW</td>
</tr>
</tbody>
</table>

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

#### HPG Helical Series
(Peak torque 5Nm to 400Nm)

<table>
<thead>
<tr>
<th>Size</th>
<th>Outline Dimension (mm)</th>
<th>Reduction ratio</th>
<th>Backlash*1</th>
<th>Motor power</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>40</td>
<td>4, 5, 6, 7, 8, 9, 10</td>
<td>≤ 3 arc-min</td>
<td>10W~100W</td>
</tr>
<tr>
<td>14</td>
<td>60</td>
<td>3, 4, 5, 6, 7, 8, 9,10</td>
<td>≤ 3 arc-min</td>
<td>30W~3.5kW</td>
</tr>
<tr>
<td>20</td>
<td>90</td>
<td>3, 4, 5, 6, 7, 8, 9,10</td>
<td>≤ 3 arc-min</td>
<td>500W~10kW</td>
</tr>
</tbody>
</table>

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

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

<table>
<thead>
<tr>
<th>Size</th>
<th>Outline Dimension (mm)</th>
<th>Reduction ratio</th>
<th>Backlash*1</th>
<th>Motor power</th>
</tr>
</thead>
<tbody>
<tr>
<td>32, 50</td>
<td>120, 170</td>
<td>5, 11, 15, 21, 33, 45</td>
<td>≤ 3 arc-min</td>
<td>500W~8kW</td>
</tr>
</tbody>
</table>

*1 For details of repeatability and transmission accuracy, refer to HPG Right Angle performance table on page 54.

#### HPN-L Standard Series
(Peak torque 18Nm to 300Nm)

<table>
<thead>
<tr>
<th>Size</th>
<th>Outline Dimension (mm)</th>
<th>Reduction ratio*1</th>
<th>Backlash</th>
<th>Motor power</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>Ø60</td>
<td>3, 4, 5, 7, 10, 15, 20, 25, 30, 35, 40, 45, 50</td>
<td>≤ 5 arc-min</td>
<td>100W~600W</td>
</tr>
<tr>
<td>20</td>
<td>Ø90</td>
<td>3, 4, 5, 7, 10, 15, 20, 25, 30, 35, 40, 45, 50</td>
<td>≤ 5 arc-min</td>
<td>200W~2kW</td>
</tr>
<tr>
<td>32</td>
<td>Ø115</td>
<td>3, 4, 5, 7, 10, 15, 20, 25, 30, 35, 40, 45, 50</td>
<td>≤ 5 arc-min</td>
<td>400W~7kW</td>
</tr>
</tbody>
</table>

*1 One stage reduction ratio - 3, 4, 5, 7, 10, two stage reduction ratio - 15, 20, 25, 30, 35, 45, 50.

#### HPN-A Standard Series
(Peak torque 9Nm to 752Nm)

<table>
<thead>
<tr>
<th>Size</th>
<th>Outline Dimension (mm)</th>
<th>Reduction ratio*1</th>
<th>Backlash</th>
<th>Motor power</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>42</td>
<td>4, 5, 7, 10, 15, 20, 25, 30, 35, 40, 45, 50</td>
<td>≤ 5 arc-min</td>
<td>30W~150W</td>
</tr>
</tbody>
</table>

*1 One stage reduction ratio - 3, 4, 5, 7, 10, two stage reduction ratio - 15, 20, 25, 30, 35, 40, 45, 50.
### HarmonicDrive™

#### CSG-GH High Torque Series
(Peak torque 18Nm to 2200Nm)

Zero-Backlash

<table>
<thead>
<tr>
<th>Size</th>
<th>Outline Dimension (mm)</th>
<th>Reduction ratio</th>
<th>Repeatability (\text{arc sec})*</th>
<th>Transmission Accuracy (\text{arc min})*</th>
<th>Motor power</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>Ø60</td>
<td>50, 80, 100</td>
<td>±10</td>
<td>1.5</td>
<td>30W~100W</td>
</tr>
<tr>
<td>20</td>
<td>Ø90</td>
<td>50, 80, 100, 120, 160</td>
<td>±8</td>
<td>1.0</td>
<td>100W~400W</td>
</tr>
<tr>
<td>32</td>
<td>Ø120</td>
<td>50, 80, 100, 120, 160</td>
<td>±6</td>
<td>1.0</td>
<td>300W~15kW</td>
</tr>
<tr>
<td>45</td>
<td>Ø170</td>
<td>50, 80, 100, 120, 160</td>
<td>±5</td>
<td>1.0</td>
<td>450W~2kW</td>
</tr>
<tr>
<td>65</td>
<td>Ø230</td>
<td>80, 100, 120, 160</td>
<td>±4</td>
<td>1.0</td>
<td>850W~5kW</td>
</tr>
</tbody>
</table>

*1 For details of repeatability and transmission accuracy, refer to CSG-GH performance table on page 98.

#### CSF-GH Standard Series
(Peak torque 18Nm to 2200Nm)

Zero-Backlash

<table>
<thead>
<tr>
<th>Size</th>
<th>Outline Dimension (mm)</th>
<th>Reduction ratio</th>
<th>Repeatability (\text{arc sec})*</th>
<th>Transmission Accuracy (\text{arc min})*</th>
<th>Motor power</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>Ø60</td>
<td>50, 80, 100</td>
<td>±10</td>
<td>1.5</td>
<td>30W~100W</td>
</tr>
<tr>
<td>20</td>
<td>Ø90</td>
<td>50, 80, 100, 120, 160</td>
<td>±8</td>
<td>1.0</td>
<td>100W~400W</td>
</tr>
<tr>
<td>32</td>
<td>Ø120</td>
<td>50, 80, 100, 120, 160</td>
<td>±6</td>
<td>1.0</td>
<td>300W~15kW</td>
</tr>
<tr>
<td>45</td>
<td>Ø170</td>
<td>50, 80, 100, 120, 160</td>
<td>±5</td>
<td>1.0</td>
<td>450W~2kW</td>
</tr>
<tr>
<td>65</td>
<td>Ø230</td>
<td>80, 100, 120, 160</td>
<td>±4</td>
<td>1.0</td>
<td>850W~5kW</td>
</tr>
</tbody>
</table>

*1 For details of repeatability and transmission accuracy, refer to CSF-GH performance table on page 98.

### HarmonicPlanetary™

#### HP/CP 8 Series

<table>
<thead>
<tr>
<th>Size</th>
<th>Ratio</th>
<th>Outline Dimension (mm)</th>
<th>Backlash</th>
<th>Motor power</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>5, 16, 25</td>
<td>Ø25</td>
<td>≤30 arc-min</td>
<td>5W ~ 30W</td>
</tr>
</tbody>
</table>

### HarmonicPlanetary™ Gear Units

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

<table>
<thead>
<tr>
<th>Size</th>
<th>Outline Dimension (mm)</th>
<th>Hollow shaft diameter</th>
<th>Reduction ratio</th>
<th>Backlash*</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>Ø136</td>
<td>Ø25</td>
<td>11</td>
<td>≤3 arc-min</td>
</tr>
<tr>
<td>32</td>
<td>Ø167</td>
<td>Ø30</td>
<td>11</td>
<td>≤3 arc-min</td>
</tr>
</tbody>
</table>

*1 For details of repeatability and transmission accuracy, refer to HPF Hollow shaft performance table on page 117.

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

<table>
<thead>
<tr>
<th>Size</th>
<th>Outline Dimension (mm)</th>
<th>Reduction ratio</th>
<th>Backlash**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Standard</td>
<td>Reduced</td>
</tr>
<tr>
<td>11</td>
<td>Ø40</td>
<td>5, 9, 21, 37, 45</td>
<td>≤3 arc-min</td>
</tr>
<tr>
<td>14, 20, 32</td>
<td>Ø60, Ø90, Ø120</td>
<td>3, 5, 11, 15, 21, 33, 45</td>
<td>≤3 arc-min</td>
</tr>
<tr>
<td>50</td>
<td>Ø170</td>
<td>4, 5, 12, 15, 20, 25, 40, 50</td>
<td>≤3 arc-min</td>
</tr>
</tbody>
</table>

*1 For details of repeatability and transmission accuracy, refer to HPG Input shaft performance table on page 124.
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

Harmonic Drive® 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.

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.

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)
Harmonic Planetary® Gearheads

### HPGP - 11 A 05 - BL3 Z F0 - Motor Code

<table>
<thead>
<tr>
<th>Model Name</th>
<th>Size</th>
<th>Design Revision</th>
<th>Reduction Ratio</th>
<th>Backlash</th>
<th>Input Side Bearing</th>
<th>Output Configuration</th>
<th>Input Configuration &amp; Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPGP High Torque</td>
<td>11</td>
<td>A</td>
<td>5, 21, 37, 45</td>
<td>BL1: Backlash less than 1 arc-min (Sizes 14 to 60)</td>
<td>F1: Flange output</td>
<td>This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.</td>
<td></td>
</tr>
<tr>
<td>HPGP Standard</td>
<td>14</td>
<td>B</td>
<td>5, 9, 21, 37, 45</td>
<td>BL1: Backlash less than 1 arc-min (Sizes 14 to 60)</td>
<td>F1: Flange output</td>
<td>This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20</td>
<td></td>
<td>5, 11, 15, 21, 33, 45</td>
<td>BL1: Backlash less than 1 arc-min (Sizes 14 to 60)</td>
<td>F1: Flange output</td>
<td>This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>32</td>
<td></td>
<td>5, 11, 15, 21, 33, 45</td>
<td>BL1: Backlash less than 1 arc-min (Sizes 14 to 60)</td>
<td>F1: Flange output</td>
<td>This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>55</td>
<td></td>
<td>4, 5, 12, 15, 20, 25</td>
<td>BL1: Backlash less than 1 arc-min (Sizes 14 to 60)</td>
<td>F1: Flange output</td>
<td>This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>65</td>
<td></td>
<td>4, 5, 12, 15, 20, 25</td>
<td>BL1: Backlash less than 1 arc-min (Sizes 14 to 60)</td>
<td>F1: Flange output</td>
<td>This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.</td>
<td></td>
</tr>
</tbody>
</table>

### HPG - 20 A 05 - BL3 Z F0 - Motor Code

<table>
<thead>
<tr>
<th>Model Name</th>
<th>Size</th>
<th>Design Revision</th>
<th>Reduction Ratio</th>
<th>Backlash</th>
<th>Input Side Bearing</th>
<th>Output Configuration</th>
<th>Input Configuration &amp; Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPG Helical</td>
<td>11</td>
<td>R</td>
<td>4, 5, 6, 7, 8, 9, 10</td>
<td>BL1: Backlash less than 1 arc-min (Sizes 14 to 60)</td>
<td>F1: Flange output</td>
<td>This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>14</td>
<td></td>
<td>3, 4, 5, 6, 7, 8, 9, 10</td>
<td>BL1: Backlash less than 1 arc-min (Sizes 14 to 60)</td>
<td>F1: Flange output</td>
<td>This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20</td>
<td></td>
<td>3, 4, 5, 6, 7, 8, 9, 10</td>
<td>BL1: Backlash less than 1 arc-min (Sizes 14 to 60)</td>
<td>F1: Flange output</td>
<td>This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>32</td>
<td></td>
<td>3, 4, 5, 6, 7, 8, 9, 10</td>
<td>BL1: Backlash less than 1 arc-min (Sizes 14 to 60)</td>
<td>F1: Flange output</td>
<td>This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>55</td>
<td></td>
<td>4, 5, 12, 15, 20, 25</td>
<td>BL1: Backlash less than 1 arc-min (Sizes 14 to 60)</td>
<td>F1: Flange output</td>
<td>This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>65</td>
<td></td>
<td>4, 5, 12, 15, 20, 25</td>
<td>BL1: Backlash less than 1 arc-min (Sizes 14 to 60)</td>
<td>F1: Flange output</td>
<td>This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.</td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Model Name</th>
<th>Size</th>
<th>Design Revision</th>
<th>Reduction Ratio</th>
<th>Output Configuration</th>
<th>Right Angle Specification</th>
<th>Input Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPG Right Angle</td>
<td>32</td>
<td>A</td>
<td>5, 11, 15, 21, 33, 45</td>
<td>F0: Flange output</td>
<td>RA3</td>
<td>This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.</td>
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<td>5, 11, 15, 21, 33, 45</td>
<td>F0: Flange output</td>
<td>RA3, RA5</td>
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<td>F0: Flange output</td>
<td>RA5</td>
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### HP - 8 F 05

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### Harmonic Planetary® Gearheads

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

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<td>Z: Input side bearing with double non-contact shields</td>
<td>J6: Shaft output with key and center tapped hole</td>
<td>This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.</td>
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### Harmonic Drive® Gearheads

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

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

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### Harmonic Planetary® Gear Units

**HPF - 25 A 11 F0 U1 SP1**

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

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<th>Options</th>
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<td>HarmonicPlanetary® HPG Input Shaft</td>
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<td>5, 9, 21, 37, 45</td>
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<td>U1: Input shaft (with key; no center tapped hole)</td>
<td>None: Standard item SP: Special specification</td>
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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.

Applications

- 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

<table>
<thead>
<tr>
<th>Index tables</th>
<th>Roller drive</th>
<th>Linear axis drive</th>
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<tbody>
<tr>
<td><img src="imagex.png" alt="Index tables" /></td>
<td><img src="imagey.png" alt="Roller drive" /></td>
<td><img src="imagez.png" alt="Linear axis drive" /></td>
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</table>

- **Index tables**: Harmonic Planetary® Right Angle Gearhead
- **Roller drive**: Harmonic Planetary® Right Angle Gearhead
- **Linear axis drive**: Harmonic Planetary® Right Angle Gearhead

<table>
<thead>
<tr>
<th>Input shaft with belt drive</th>
<th>LCD transfer robots</th>
<th>Tensile strength testers</th>
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<td><img src="imagea.png" alt="Input shaft with belt drive" /></td>
<td><img src="imageb.png" alt="LCD transfer robots" /></td>
<td><img src="imagec.png" alt="Tensile strength testers" /></td>
</tr>
</tbody>
</table>

- **Input shaft with belt drive**: Harmonic Planetary® Gearhead with Input Shaft
- **LCD transfer robots**: Harmonic Planetary® Gearhead
- **Tensile strength testers**: Harmonic Planetary® Gearhead

<table>
<thead>
<tr>
<th>Overhead transport system</th>
<th>Automated guided vehicle</th>
<th>High-speed articulated robots</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Overhead transport system" /></td>
<td><img src="image2.png" alt="Automated guided vehicle" /></td>
<td><img src="image3.png" alt="High-speed articulated robots" /></td>
</tr>
</tbody>
</table>

- **Overhead transport system**: Harmonic Planetary® Gearhead
- **Automated guided vehicle**: Harmonic Planetary® Gearhead
- **High-speed articulated robots**: Harmonic Planetary® Gearhead
### 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.

<table>
<thead>
<tr>
<th>X-Y axes of machine tools</th>
<th>Linear Drive (XY table)</th>
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<tr>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
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<th>Rotation</th>
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<td><img src="image4.png" alt="Image" /></td>
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<th>Index table positioning</th>
<th>Roller drive</th>
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<tbody>
<tr>
<td><img src="image5.png" alt="Image" /></td>
<td><img src="image6.png" alt="Image" /></td>
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### 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.

<table>
<thead>
<tr>
<th>Pipe benders</th>
<th>Electric presses</th>
<th>Printed circuit board inspection</th>
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<tbody>
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<td><img src="image7.png" alt="Image" /></td>
<td><img src="image8.png" alt="Image" /></td>
<td><img src="image9.png" alt="Image" /></td>
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</table>
Harmonic Planetary®

Gearheads for Servomotors

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

Shielded or sealed input bearing

Motor mounting flange

Robust cross roller bearing and output flange are integrated to provide high moment stiffness, high load capacity, and precise positioning accuracy.

The cross roller bearing output flange serves as the second stage carrier for a rugged, compact design.

Backlash compensating internal gear

Quick Connect® servo coupling machined and balanced to match the motor shaft diameter (single bolt clamping design)
High-Performance Gear Heads for Servo Motors

- **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® motor adaptation system includes a clamshell style servo coupling and piloted adapter flange.

**Contents**

- **Rating Table**: 19
- **Performance Table**: 20
- **Backlash and Torsional Stiffness**: 21
- **Outline Dimensions**: 22-27
- **Product Sizing & Selection**: 28-29
## Rating Table

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[^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. 28
[^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>
<thead>
<tr>
<th>Size</th>
<th>Ratio</th>
<th>Transmission Accuracy *1</th>
<th>Repeatability *2</th>
<th>Starting torque *4</th>
<th>Backdriving torque *4</th>
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<td>36</td>
<td>7.6</td>
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<td>7.8</td>
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<td>45</td>
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<td>20</td>
<td>8.9</td>
<td>20</td>
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<td>12</td>
<td>420</td>
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<td>17</td>
<td>160</td>
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<td>25</td>
<td></td>
<td>90</td>
<td>19</td>
<td>130</td>
<td></td>
</tr>
</tbody>
</table>

*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.

*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 $\frac{1}{7}$ 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.

*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.

*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.

\[ \theta_{er} = \theta_2 - \frac{\theta_2}{R} \]

Where:

- $\theta_{er}$ : Transmission accuracy
- $\theta_2$ : Input angle
- $\theta_2$ : Actual output angle
- $R$ : Gear reduction ratio

Figure 020-1

Figure 020-2
Backlash and Torsional Stiffness

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 load torque $-T_r$.
4. Return to Zero.
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 $0.15 \times T_r$ to $T_r$ is calculated using the average value of this slope. The torsional stiffness in the region from “zero torque” to $0.15 \times T_r$ 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

$$\theta = D + \frac{T - T_{lr}}{A/B} \times (0.015 \times D)$$

- $\theta$: Total torsion angle
- $D$: Torsion angle in one direction (See Fig. 021-1, Table 021-1, Table 021-2)
- $T$: Load torque
- $T_{lr}$: Output torque x 0.15 torque (at output torque x 0.15 torque, Table 021-1, Table 021-2)
- $A/B$: 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

For the HPGP series gearheads, backlash is 1 arc-min up to 3 arc-min. Backlash is less than 3 arc-min (1 arc-min is also available).

Table 021-1: Gearhead - Standard backlash (BL3) (≤ 3 arc-min)

<table>
<thead>
<tr>
<th>Size</th>
<th>Ratio</th>
<th>Backlash</th>
<th>Torque angle in one direction ≤ 3 arc-min</th>
<th>Torsional stiffness A/B</th>
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</thead>
<tbody>
<tr>
<td>11</td>
<td>5</td>
<td>3</td>
<td>2.5</td>
<td>.64</td>
</tr>
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<td>14</td>
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<td>5.39</td>
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<td>1.7</td>
<td>21.56</td>
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<td>3</td>
<td>1.7</td>
<td>137.2</td>
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</tr>
<tr>
<td>65</td>
<td>3</td>
<td>1.7</td>
<td>372.4</td>
<td></td>
</tr>
</tbody>
</table>

Table 022-1: Gearhead - Reduced backlash (BL1) (≤ 1 arc-min)

<table>
<thead>
<tr>
<th>Size</th>
<th>Ratio</th>
<th>Backlash</th>
<th>Torque angle in one direction ≤ 3 arc-min</th>
<th>Torsional stiffness A/B</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>5</td>
<td>1</td>
<td>1.1</td>
<td>1.372</td>
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<tr>
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<td>3</td>
<td>1.1</td>
<td>5.39</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>3</td>
<td>1.0</td>
<td>21.56</td>
<td></td>
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<td>32</td>
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</tr>
<tr>
<td>50</td>
<td>3</td>
<td>1.0</td>
<td>372.4</td>
<td></td>
</tr>
</tbody>
</table>

Note:

- $D$: Torsion angle in one direction (See Fig. 021-1, Table 021-1, Table 021-2)
- $T$: Load torque
- $T_{lr}$: Output torque x 0.15 torque (at output torque x 0.15 torque, Table 021-1, Table 021-2)
- $A/B$: Torsional stiffness
- $\theta$: Total torsion angle

Recommended clearance

When using a gearhead with an oil seal (non-rotating) is small (min. 0.4 (Min.0.2)) between the output flange and the housing face as shown in the dimension for customer’s part. Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable.

Table 021-1

<table>
<thead>
<tr>
<th>Size</th>
<th>Ratio</th>
<th>Flange</th>
<th>Min.</th>
<th>Max.</th>
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<td>9</td>
<td>11</td>
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<td>3</td>
<td>Ø24</td>
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<td>14</td>
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<td>50</td>
<td>3</td>
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<td>3</td>
<td>ØØ46</td>
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<td>18</td>
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**HPGP-11 Outline Dimensions**

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

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.

**Dimension Table**

<table>
<thead>
<tr>
<th>Flange Type</th>
<th>Coupling Type</th>
<th>A (H7)</th>
<th>B</th>
<th>C</th>
<th>F (H7)</th>
<th>G</th>
<th>H</th>
<th>Mass (kg)</th>
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</thead>
<tbody>
<tr>
<td>Single Stage</td>
<td>1</td>
<td>1</td>
<td>20</td>
<td>55</td>
<td>4</td>
<td>25</td>
<td>75</td>
<td>5</td>
</tr>
<tr>
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<td>55</td>
<td>4</td>
<td>25</td>
<td>75</td>
<td>5</td>
</tr>
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</table>

- **(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.

**Moment of Inertia**

<table>
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<th>Coupling Ratio</th>
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<th>37</th>
<th>45</th>
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<td>0.004</td>
<td>0.0027</td>
<td>0.0025</td>
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**HPGP-14 Outline Dimensions**

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

![Diagram](image)

**Dimension Table**

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<th>Coupling Type</th>
<th>A (H7)</th>
<th>B</th>
<th>C</th>
<th>F (H7)</th>
<th>G</th>
<th>H</th>
<th>Mass (kg)</th>
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<td>30</td>
<td>55</td>
<td>7</td>
<td>35</td>
<td>75</td>
<td>6.0</td>
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<tr>
<td>2</td>
<td>2</td>
<td>35</td>
<td>75</td>
<td>7</td>
<td>40</td>
<td>100</td>
<td>9.0</td>
<td>14.2</td>
</tr>
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</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^-6 kgm²) **Table 023-2**

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<th>HPGP 14</th>
<th>Coupling Ratio</th>
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<th>21</th>
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<th>45</th>
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<td>0.058</td>
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<td>0.197</td>
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</table>
HPGP-20 Outline Dimensions

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

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<th>A (H7)</th>
<th>B</th>
<th>C</th>
<th>F (H7)</th>
<th>G</th>
<th>H</th>
<th>Mass (kg)</th>
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<tr>
<td>1</td>
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<td>68</td>
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<td>80</td>
<td>95</td>
<td>10</td>
<td>85</td>
<td>125</td>
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<td>19.6</td>
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<td>1</td>
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<td>45</td>
<td>100 ^*</td>
<td>7.0</td>
<td>19.6</td>
</tr>
</tbody>
</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 kg*m²) Table 024-2

<table>
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<th>5</th>
<th>11</th>
<th>15</th>
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<th>45</th>
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<td>1</td>
<td>0.69</td>
<td>0.62</td>
<td>0.58</td>
<td>0.5</td>
<td>0.45</td>
<td>0.45</td>
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</table>
### HPGP-32 Outline Dimensions

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

![Diagram](image)

### Dimension Table

(Unit: mm) Table 025-1

<table>
<thead>
<tr>
<th>Flange Type</th>
<th>Coupling Type</th>
<th>A (H7) *</th>
<th>B *</th>
<th>C *</th>
<th>F (H7) *</th>
<th>G *</th>
<th>H *</th>
<th>Mass (kg) *2</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1</td>
<td>70</td>
<td>100</td>
<td>7</td>
<td>80</td>
<td>112</td>
<td>10.0</td>
<td>28.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>29.0</td>
<td>56.5</td>
</tr>
<tr>
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</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 025-2

<table>
<thead>
<tr>
<th>HPGP 32 Coupling</th>
<th>5</th>
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<td>3</td>
<td>2.8</td>
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</tbody>
</table>
HPGP-50 Outline Dimensions

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

Dimension Table

(Unit: mm) Table 026-1

<table>
<thead>
<tr>
<th>Flange Type</th>
<th>Coupling Type</th>
<th>A (H7) **</th>
<th>B ***</th>
<th>C ***</th>
<th>F (H7) ***</th>
<th>G ***</th>
<th>H ***</th>
<th>Mass (kg) ***</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>65</td>
<td>175**</td>
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<td>75</td>
<td>235***</td>
<td>19.0</td>
<td>41.0</td>
</tr>
</tbody>
</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 kgm²) Table 026-2

<table>
<thead>
<tr>
<th>HPGP 50</th>
<th>Coupling</th>
<th>5</th>
<th>11</th>
<th>15</th>
<th>21</th>
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</tr>
</thead>
<tbody>
<tr>
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<td>9.1</td>
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<td>5.9</td>
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<td>5.8</td>
<td>4.9</td>
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</table>
HPGP Series

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

<table>
<thead>
<tr>
<th>Flange Type</th>
<th>Coupling Type</th>
<th>A (H7)</th>
<th>B (H7)</th>
<th>C (H7)</th>
<th>F (H7)</th>
<th>G (H7)</th>
<th>H (H7)</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Stage</td>
<td>2</td>
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<td>140</td>
<td>290</td>
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<td>75</td>
<td>225</td>
<td>24.0</td>
<td>36.5</td>
<td>52.0</td>
<td>85.0</td>
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<tr>
<td>Two Stage</td>
<td>2</td>
<td>230</td>
<td>240</td>
<td>290</td>
<td>35.0</td>
<td>44</td>
<td>52.0</td>
<td>85.0</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>65</td>
<td>75</td>
<td>225</td>
<td>24.0</td>
<td>36.5</td>
<td>52.0</td>
<td>85.0</td>
</tr>
</tbody>
</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

<table>
<thead>
<tr>
<th>Coupling Ratio</th>
<th>4</th>
<th>5</th>
<th>12</th>
<th>15</th>
<th>20</th>
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<tr>
<td>HPGP 65</td>
<td></td>
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<td>92</td>
<td>77</td>
<td>70</td>
<td>69</td>
<td>57</td>
<td>56</td>
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</tbody>
</table>

(10⁻⁴ kgm²) Table 027-2
**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.

**Obtain the value of each application motion profile.**

<table>
<thead>
<tr>
<th>Load torque T1 to Tn (Nm)</th>
<th>Time t1 to tn (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output rotational speed</td>
<td>n1 to n1 (rpm)</td>
</tr>
</tbody>
</table>

**Normal operation pattern**

Starting (acceleration) T1, t1, n1

Steady operation (constant velocity) T2, t2, n2

Stopping (deceleration) T3, t3, n3

Dwell T4, t4, n4

**Maximum rotational speed**

Max. output rotational speed nO max ≥ n1 to n1

Max. input rotational speed ni max = nO R = no R

(Restricted by motors) R: Reduction ratio

**Emergency stop torque**

When impact torque is applied Ts

**Required life**

Lso = L (hours)

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

**Flowchart for selecting a size**

1. Calculate the average load torque applied on the output side from the application motion profile: Tav (Nm).
2. Calculate the average output speed based on the application motion profile: no av (rpm)
3. Make a preliminary model selection with the following condition: Tav ≥ Backlash of the HPGP series.
4. Backlash of the HPGP series is less than the momentary max. torque (Nm) and maximum input rotational speed (ni max).
5. Calculate the maximum input speed (ni max) from the maximum output speed (no max) and the reduction ratio (R).
6. Calculate the average input speed (ni av) from the average output speed (no av) and the reduction ratio (R).
7. Check whether Ts is less than limit for momentary torque (Nm) in the rating table.
8. Check whether T1 and T3 are within peak torques (Nm) on start and stop in the rating table.
9. Check whether T1 and T3 are within peak torques (Nm) on start and stop in the rating table.

**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.

1. Actual average load torque (Tav) > Permissible maximum value of average load torque or
2. Actual average input rotational speed (ni av) > Permissible average input rotational speed (ni).
3. Gearhead housing temperature > 70°C.
**Application sizing example**

<table>
<thead>
<tr>
<th>Load torque</th>
<th>Tn (Nm)</th>
<th>Max. rotational speed</th>
<th>Maximum rotational speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>t₀ (sec)</td>
<td>Max. output rotational speed</td>
<td>no max = 120 rpm</td>
</tr>
<tr>
<td>Output rotational speed</td>
<td>n₀ (rpm)</td>
<td>Max. input rotational speed</td>
<td>ni max = 5,000 rpm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(Restricted by motors)</td>
</tr>
</tbody>
</table>

**Normal operation pattern**

Starting (acceleration)  T₁ = 70 Nm, t₁ = 0.3 sec, n₁ = 60 rpm  
Steady operation (constant velocity)  T₂ = 18 Nm, t₂ = 3 sec, n₂ = 120 rpm  
Stopping (deceleration)  T₃ = 35 Nm, t₃ = 0.4 sec, n₃ = 60 rpm  
Dwell  T₄ = 0 Nm, t₄ = 5 sec, n₄ = 0 rpm

Calculate the average load torque applied to the output side based on the application motion profile: Tav (Nm).

\[
Tav = \frac{1}{15} \left( 60rpm \cdot 0.3sec \cdot 70Nm + 120rpm \cdot 3sec \cdot 18Nm + 60rpm \cdot 0.4sec \cdot 35Nm \right) = 60rpm \cdot 0.3sec \cdot 120rpm \cdot 3sec \cdot 60rpm \cdot 0.4sec \cdot 5sec
\]

Calculate the average output speed based on the application motion profile: no av (rpm)

\[
no av = \frac{1}{15} \left( 60rpm \cdot 0.3sec + 120rpm + 3sec + 60rpm + 0.4sec + 10rpm \right) \cdot 5sec = 0.3sec + 3sec + 0.4sec + 5sec
\]

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.)

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

\[
\frac{5,000 \text{ rpm}}{120 \text{ rpm}} = 41.7 \Rightarrow 33
\]

Calculate the maximum input speed (ni max) from the maximum output speed (no av) 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

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)

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

T₁ = 70 Nm ≤ 156 Nm (Limit for repeated peak torque, size 20)  
T₃ = 35 Nm ≤ 156 Nm (Limit for repeated peak torque, size 20)

Check whether Tₛ is less than limit for momentary torque (Nm) in the rating table.

Tₛ = 180 Nm ≤ 217 Nm (momentary max. torque of size 20)

Calculate life and check whether the value meets the requirement.

\[
Lₕ = 20,000 \cdot \left( \frac{72 \text{Nm}}{30.2 \text{Nm}} \right)^{10^5} \cdot \left( \frac{3,000 \text{rpm}}{1,525 \text{rpm}} \right) = 712,251 \text{ (hours)} \geq 30,000 \text{ (hours)}
\]

The selection of model number HPGP-20A-33 is confirmed from the above calculations.
Harmonic Planetary®
HPG Standard Series

Size
11, 14, 20, 32, 50, 65

6 Sizes

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® motor adaptation system includes a clamshell style servo coupling and piloted adapter flange.

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- Performance Table....................... 32
- Backlash and Torsional Stiffness........... 33
- Outline Dimensions.................... 34-39
- Product Sizing & Selection............ 40-41

<table>
<thead>
<tr>
<th>Model Name</th>
<th>Size</th>
<th>Design Revision</th>
<th>Reduction Ratio</th>
<th>Backlash</th>
<th>Input Side Bearing</th>
<th>Output Configuration</th>
<th>Input Configuration &amp; Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPG Standard</td>
<td>11</td>
<td>B</td>
<td>5, 9, 21, 37, 46</td>
<td>BL1: Backlash less than 1 arc-min (Sizes 14 to 65)</td>
<td>Z: Input side bearing with double non-contact shields</td>
<td>F0: Flange output</td>
<td>This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.</td>
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<tr>
<td>HPG Standard</td>
<td>14</td>
<td>A</td>
<td>5, 9, 11, 15, 21, 33, 45</td>
<td>BL3: Backlash less than 3 arc-min</td>
<td>Z: Input side bearing with double contact seals. (Recommended for output flange up orientation)</td>
<td>F0: Flange output</td>
<td></td>
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<td>HPG Standard</td>
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<td>F0: Flange output</td>
<td></td>
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<tr>
<td>HPG Standard</td>
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<td></td>
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<td>F0: Flange output</td>
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<td>F0: Flange output</td>
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<td>HPG Standard</td>
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<td>F0: Flange output</td>
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Gearhead Construction

Mounting pilot
Output flange
Output rotational direction
Output side oil seal
Cross roller bearing
Shielded bearing
Rubber cap
Quick Connect® coupling
Input rotational direction
Motor mounting flange
Mounting bolt hole

Figure 030-1

**Notes**

- High-performance Gear Heads for Servo Motors series
- HPGP series
- CSG-GH series
- CSF-GH series
- HPG Right Angle

**Figure 030-1**

- Gearhead Construction
- Mounting pilot
- Output flange
- Output rotational direction
- Output side oil seal
- Cross roller bearing
- Shielded bearing
- Rubber cap
- Quick Connect® coupling
- Input rotational direction
- Motor mounting flange
- Mounting bolt hole
## Rating Table

<table>
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<tr>
<th>Size</th>
<th>Ratio</th>
<th>Rated Torque L10</th>
<th>Rated Torque L50</th>
<th>Limit for Average Load Torque</th>
<th>Limit for Repeated Peak Torque</th>
<th>Limit for Momentary Torque</th>
<th>Max. Average Input Speed</th>
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<td>3200</td>
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<td>1650</td>
<td>1500</td>
<td>2200</td>
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<td></td>
<td></td>
</tr>
</tbody>
</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. 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>
<thead>
<tr>
<th>Size</th>
<th>Ratio</th>
<th>Accuracy *1</th>
<th>Repeatability *2</th>
<th>Starting torque *3</th>
<th>Backdriving torque *4</th>
<th>No-load running torque *5</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>5</td>
<td>±30</td>
<td>arc min</td>
<td>arc sec</td>
<td>Nm</td>
<td>Nm</td>
</tr>
<tr>
<td>14</td>
<td>4</td>
<td>±20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>4</td>
<td>±15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>4</td>
<td>±15</td>
<td></td>
<td></td>
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<tr>
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<td>3</td>
<td>±15</td>
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<td></td>
</tr>
<tr>
<td>65</td>
<td>3</td>
<td>±15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*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.

*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.

*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.

*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.

---

* 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.

* 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.

* 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.

* 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.

* 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.

---

![Figure 032-1](image1)

![Figure 032-2](image2)

\[
\theta_{er} = \frac{\theta_1 - \theta_2}{R}
\]

\[
\theta_{er} : \text{Accuracy} \\
\theta_1 : \text{Input angle} \\
\theta_2 : \text{Actual output angle} \\
R : \text{Gear reduction ratio}
\]
**Backlash and Torsional Stiffness**

### 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. Counterclockwise torque to \(-T_R\).
4. Return to Zero.
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 \( 0.15 \times T_R \) to \( T_R \) is calculated using the average value of this slope. The torsional stiffness in the region from "zero torque" to \( 0.15 \times T_R \) 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**

\[
\theta = D + \frac{T - T_R}{A/B}
\]

- \( \theta \): Total torsion angle
- \( D \): Torsion angle in one direction at \( T_R \times 0.15 \) load torque
- \( T \): Load torque
- \( T_R \): Output torque \( \times 0.15 \) torque
- \( A/B \): Torsional stiffness

### 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 “Counterclockwise 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**

![Torque-torsion angle diagram](image-url)

- \( T_R \): Rated output torque
- \( A/B \): Torsional stiffness
- \( D \): Torsion angle in one direction at \( T_R \times 0.15 \)
- \( \theta \): Total torsion angle
- \( \text{Hysteresis loss} = \text{Backlash} \)

### Table 033-1: Gearhead - Standard backlash (BL3) (-3 arc-min)

<table>
<thead>
<tr>
<th>Size</th>
<th>Ratio</th>
<th>Backlash</th>
<th>Torsion angle in one direction ( \times 0.15 )</th>
<th>Torsional stiffness ( A/B )</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>0.25</td>
<td>2.5</td>
<td>0.637</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.5</td>
<td>2.2</td>
<td>1.37</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>0.66</td>
<td>1.7</td>
<td>5.39</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>1.15</td>
<td>1.3</td>
<td>21.56</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>2.2</td>
<td>1.7</td>
<td>137.2</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>5</td>
<td>1.3</td>
<td>372.4</td>
<td></td>
</tr>
</tbody>
</table>

### Table 033-2: Gearhead - Reduced backlash (BL1) (-1 arc-min)

<table>
<thead>
<tr>
<th>Size</th>
<th>Ratio</th>
<th>Backlash</th>
<th>Torsion angle in one direction ( \times 0.15 )</th>
<th>Torsional stiffness ( A/B )</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>0.25</td>
<td>1</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.5</td>
<td>1.7</td>
<td>1.7</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>0.66</td>
<td>1</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>1.15</td>
<td>1</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>2.2</td>
<td>1</td>
<td>1.0</td>
<td></td>
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<tr>
<td>50</td>
<td>5</td>
<td>1</td>
<td>1.0</td>
<td></td>
</tr>
</tbody>
</table>

**Note:**
- May vary depending on motor interface dimensions.
- The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling.
- 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 shown on the drawing above.
HPG-11 Outline Dimensions

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

(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

<table>
<thead>
<tr>
<th>Flange Coupling</th>
<th>A (H7)</th>
<th>B</th>
<th>C</th>
<th>F (H7)</th>
<th>G</th>
<th>H</th>
<th>Typical Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Stage</td>
<td>1</td>
<td>1</td>
<td>20</td>
<td>55</td>
<td>4</td>
<td>25</td>
<td>75</td>
</tr>
<tr>
<td>Two Stage</td>
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<td>20</td>
<td>55</td>
<td>4</td>
<td>25</td>
<td>75</td>
</tr>
</tbody>
</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 may 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

<table>
<thead>
<tr>
<th>HPG 11 Coupling</th>
<th>Ratio</th>
<th>5</th>
<th>9</th>
<th>21</th>
<th>37</th>
<th>45</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>0.005</td>
<td>0.003</td>
<td>0.004</td>
<td>0.0027</td>
<td>0.0025</td>
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</table>
### HPG-14 Outline Dimensions

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

![Figure 035-1](image_url)

(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

<table>
<thead>
<tr>
<th>Flange</th>
<th>Coupling</th>
<th>A (H7)</th>
<th>B</th>
<th>C</th>
<th>F (H7)</th>
<th>G</th>
<th>H</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>30</td>
<td>55</td>
<td>7</td>
<td>35</td>
<td>75</td>
<td>6.0</td>
<td>7.8</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>35</td>
<td>75</td>
<td>7</td>
<td>40</td>
<td>100</td>
<td>9.0</td>
<td>14.2</td>
</tr>
</tbody>
</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

<table>
<thead>
<tr>
<th>Ratio</th>
<th>3</th>
<th>5</th>
<th>11</th>
<th>15</th>
<th>21</th>
<th>33</th>
<th>45</th>
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</thead>
<tbody>
<tr>
<td>HPG 14</td>
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<tr>
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<td>-</td>
<td>-</td>
<td>0.06</td>
<td>0.058</td>
<td>0.05</td>
<td>0.044</td>
<td>0.044</td>
</tr>
<tr>
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<td>0.26</td>
<td>0.207</td>
<td>0.197</td>
<td>0.180</td>
<td>0.171</td>
<td>0.167</td>
<td>0.165</td>
</tr>
</tbody>
</table>

(Unit: mm) Table 035-1

(Unit: $10^{-4}$ kgm²) Table 035-2
### HPG-20 Outline Dimensions

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

**Flange**

<table>
<thead>
<tr>
<th>Flange</th>
<th>Coupling</th>
<th>A (H7) 1</th>
<th>B 3</th>
<th>C 1</th>
<th>F (H7) 1</th>
<th>G 3</th>
<th>H 1</th>
<th>Mass (kg) 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>50</td>
<td>68</td>
<td>8</td>
<td>55</td>
<td>84</td>
<td>7.0</td>
<td>19.6</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>80</td>
<td>95</td>
<td>10</td>
<td>85</td>
<td>125</td>
<td>7.0</td>
<td>19.6</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
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<td>45</td>
<td>10</td>
<td>35</td>
<td>50</td>
<td>6.0</td>
<td>7.8</td>
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<tr>
<td>4</td>
<td>1</td>
<td>40</td>
<td>75</td>
<td>10</td>
<td>45</td>
<td>100</td>
<td>7.0</td>
<td>19.6</td>
</tr>
</tbody>
</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 kgm²) Table 036-2

<table>
<thead>
<tr>
<th>HPG 20</th>
<th>Ratio Coupling</th>
<th>3</th>
<th>5</th>
<th>11</th>
<th>15</th>
<th>21</th>
<th>33</th>
<th>45</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.1</td>
<td>0.7</td>
<td>0.6</td>
<td>0.56</td>
<td>0.49</td>
<td>0.45</td>
<td>0.45</td>
<td>0.45</td>
</tr>
<tr>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.11</td>
<td>0.065</td>
<td>0.063</td>
</tr>
</tbody>
</table>
### HPG-32 Outline Dimensions

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

- **Flange Coupling**
  - 1
  - 2
  - 4
  - 5

#### Dimension Table

<table>
<thead>
<tr>
<th>Flange</th>
<th>Coupling</th>
<th>A (H7)</th>
<th>B</th>
<th>C</th>
<th>F (H7)</th>
<th>G</th>
<th>H</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>45</td>
<td>73</td>
<td>96</td>
<td>2.4</td>
<td>2.6</td>
<td>2.8</td>
<td>4.0</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>45</td>
<td>73</td>
<td>96</td>
<td>2.4</td>
<td>2.6</td>
<td>2.8</td>
<td>4.0</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>45</td>
<td>73</td>
<td>96</td>
<td>2.4</td>
<td>2.6</td>
<td>2.8</td>
<td>4.0</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>45</td>
<td>73</td>
<td>96</td>
<td>2.4</td>
<td>2.6</td>
<td>2.8</td>
<td>4.0</td>
</tr>
</tbody>
</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.

- **Ratio**
  - 3
  - 5
  - 11
  - 15
  - 21
  - 33
  - 45

**Moment of Inertia**

<table>
<thead>
<tr>
<th>HPG 32</th>
<th>Coupling</th>
<th>3</th>
<th>5</th>
<th>11</th>
<th>15</th>
<th>21</th>
<th>33</th>
<th>45</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.6</td>
<td>3.9</td>
<td>3.4</td>
<td>3.2</td>
<td>3</td>
<td>2.8</td>
<td>2.8</td>
<td></td>
</tr>
</tbody>
</table>
HPG-50 Outline Dimensions

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

<table>
<thead>
<tr>
<th>Dimension Table</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Flange</th>
<th>Coupling</th>
<th>A (H7)</th>
<th>B</th>
<th>C</th>
<th>F (H7)</th>
<th>G</th>
<th>H</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>65</td>
<td>175</td>
<td>15</td>
<td>75</td>
<td>235</td>
<td>19.0</td>
<td>41.0</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>80</td>
<td>130</td>
<td>10</td>
<td>90</td>
<td>160</td>
<td>19.0</td>
<td>41.0</td>
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<tr>
<td>3</td>
<td>1</td>
<td>65</td>
<td>175</td>
<td>15</td>
<td>75</td>
<td>235</td>
<td>19.0</td>
<td>41.0</td>
</tr>
</tbody>
</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. Use flange type 3 for motors weighing over 65 kg.
3 Tapped hole for motor mounting screw.

Moment of Inertia

<table>
<thead>
<tr>
<th>HPG 50 Coupling</th>
<th>4</th>
<th>5</th>
<th>11</th>
<th>15</th>
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<th>33</th>
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</tr>
</thead>
<tbody>
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<td>23</td>
<td>12</td>
<td>8.8</td>
<td>8.8</td>
<td>7</td>
<td>6</td>
<td>5.9</td>
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<tr>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>7.7</td>
<td>5.8</td>
</tr>
</tbody>
</table>

(10^-4 kgm^2)
**HPG-65 Outline Dimensions**

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

(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

<table>
<thead>
<tr>
<th>Flange</th>
<th>Coupling</th>
<th>A (H7)</th>
<th>B</th>
<th>C</th>
<th>F (H7)</th>
<th>G</th>
<th>H</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Stage</td>
<td>2 2</td>
<td>130</td>
<td>245</td>
<td>15</td>
<td>140</td>
<td>290</td>
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<td>43.9</td>
</tr>
<tr>
<td>Two Stage</td>
<td>1 1</td>
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<td>175</td>
<td>15</td>
<td>75</td>
<td>225</td>
<td>24.0</td>
<td>36.5</td>
</tr>
<tr>
<td></td>
<td>2 2</td>
<td>130</td>
<td>245</td>
<td>15</td>
<td>140</td>
<td>290</td>
<td>35.0</td>
<td>43.9</td>
</tr>
<tr>
<td></td>
<td>3 1</td>
<td>65</td>
<td>175</td>
<td>15</td>
<td>75</td>
<td>225</td>
<td>24.0</td>
<td>36.5</td>
</tr>
</tbody>
</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 km^2) Table 039-2

<table>
<thead>
<tr>
<th>Coupling</th>
<th>4</th>
<th>5</th>
<th>12</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>40</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPG 65</td>
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<td>25</td>
<td>24</td>
<td>15</td>
<td>14</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>89</td>
<td>74</td>
<td>67</td>
<td>65</td>
<td>53</td>
<td>53</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
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).

**Flowchart for selecting a size**

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

**Application motion profile**

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

### Obtain the value of each application motion profile

| Load torque | T1 to Tn (Nm) |
| Time | t1 to tn (sec) |
| Output rotational speed | n1 to nn (rpm) |

**Normal operation pattern**

Starting (acceleration) | T1, t1, n1
Steady operation (constant velocity) | T2, t2, n2
Stopping (deceleration) | T3, t3, n3
Dwell | T4, t4, n4

**Maximum rotational speed**

Max. output rotational speed | \( n_0 \ max \ \leq n_1 \ \text{to} \ n_n \) (Restricted by motors)
Max. input rotational speed | \( n_i \ max \ \leq n_i \ max \ \times R \ \text{to} \ n_i \ max \ \times R \)

**Emergency stop torque**

When impact torque is applied | Ts

**Required life**

\( L_{50} = L \) (hours)

---

**Calculate the average load torque applied on the output side from the application motion profile:**

\[ T_{av} = \frac{1}{t} \sum_{i=1}^{n} T_i \times t_i \]  

**Calculate the average output speed based on the application motion profile:**

\[ n_{av} = \frac{n_1 \times t_1 + n_2 \times t_2 + \ldots + n_n \times t_n}{t_1 + t_2 + \ldots + t_n} \]

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

\[ R = \frac{n_{max}}{n_{max} - ni_{max} \ max + R} \]

**Check whether the maximum input speed is equal to or less than the values specified in the rating table:**

\[ ni_{max} \ \leq max \ \times R \]

**Check whether T1 and T3 are within peak torques (Nm) on start and stop in the rating table:**

**Check whether T5 is than the momentary max. torque (Nm) value from the ratings:**

**Calculate the life and check whether it meets the specification requirement:**

\[ L = 20,000 \times \frac{T_{r} \ \times \ n_i \ \times R}{T_{av} \ \times \ n_{av}} \] (Hour)

---

**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:
  1. Actual average load torque (Tav) > Permissible maximum value of average load torque or
  2. Actual average input rotational speed (ni av) > Permissible average input rotational speed (ni),
  3. Gearhead housing temperature > 70°C
**Example of size selection**

<table>
<thead>
<tr>
<th>Load torque</th>
<th>T₁ (Nm)</th>
<th>Maximum rotational speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>t₁ (sec)</td>
<td>Max. output rotational speed</td>
</tr>
<tr>
<td>Output rotational speed</td>
<td>n₁ (rpm)</td>
<td>Max. input rotational speed</td>
</tr>
</tbody>
</table>

**Normal operation pattern**

- Starting (acceleration): T₁ = 70 Nm, t₁ = 0.3 sec, n₁ = 60 rpm
- Steady operation (constant velocity): T₂ = 18 Nm, t₂ = 3 sec, n₂ = 120 rpm
- Stopping (deceleration): T₃ = 35 Nm, t₃ = 0.4 sec, n₃ = 60 rpm
- Dwell: T₄ = 0 Nm, t₄ = 5 sec, n₄ = 0 rpm

**Load torque**

- Traction torque (see the rating table): Tr: Rated torque
- Average load torque (Refer to rating table).

**Output rotational speed**

- n₁ to nₙ (rpm)

**Load torque**

- Maximum rotational speed

**Output rotational speed**

- n₀ = 120 rpm

**Max. input rotational speed**

- nᵢ max = 5,000 rpm

**Emergency stop torque**

- Tₛ = 180 Nm

**Required life**

- Lₛ₀ = 30,000 (hours)

---

**Calculate the average load torque applied to the output side based on the application motion profile: Tₐv(Nm).**

\[
T_{av} = \frac{1}{10} \left( \frac{60 \text{rpm} \cdot 0.3 \text{sec} \cdot 70 \text{Nm}}{120 \text{rpm} \cdot 3 \text{sec} \cdot 18 \text{Nm}} + \frac{60 \text{rpm} \cdot 0.4 \text{sec} \cdot 35 \text{Nm}}{60 \text{rpm} \cdot 0.3 \text{sec} + 120 \text{rpm} \cdot 3 \text{sec} + 60 \text{rpm} \cdot 0.4 \text{sec} + 0 \text{rpm} \cdot 5 \text{sec}} \right)
\]

**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)

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

- T₁ = 70 Nm ≤ 117 Nm (Limit for repeated peak torque, size 20)
- T₃ = 35 Nm ≤ 117 Nm (Limit for repeated peak torque, size 20)

**Check whether the selection number HPG-20A-33 is confirmed from the above calculations.**

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

Size
11, 14, 20, 32

Peak torque
5Nm – 400Nm

Reduction ratio
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® motor adaptation system includes a
clamshell style servo coupling and piloted adapter flange.

Rating Table .................................................. 43
Performance Table ........................................... 44
Backlash and Torsional Stiffness ..................... 45
Outline Dimensions ........................................ 46-49
Product Sizing & Selection .............................. 50-51

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)
14 R 3, 4, 5, 6, 7, 8, 9, 10 BL3: Backlash less than 3 arc-min
20 R
32 R

This code represents the
motor mounting configuration.
Please contact us for a unique
part number based on the
motor you are using.

Gearhead Construction

Mounting pilot
Output flange
Shielded bearing
Rubber cap
Quick Connect® coupling
Input rotational direction
Output rotational direction
Output side oil seal
Cross roller bearing
Mounting bolt hole
Motor mounting flange

Figure 042-1
### Rating Table

<table>
<thead>
<tr>
<th>Size</th>
<th>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>
</thead>
<tbody>
<tr>
<td>11</td>
<td>4</td>
<td>2.8 Nm</td>
<td>4.0 Nm</td>
<td>6.3 Nm</td>
<td>10 Nm</td>
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<td>10000 rpm</td>
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<td>2.9 Nm</td>
<td>5.0 Nm</td>
<td>6.5 Nm</td>
<td>10 Nm</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>6</td>
<td>2.9 Nm</td>
<td>5.0 Nm</td>
<td>6.5 Nm</td>
<td>10 Nm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>3.1 Nm</td>
<td>5.0 Nm</td>
<td>7.0 Nm</td>
<td>9.0 Nm</td>
<td></td>
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<td>5.0 Nm</td>
<td>7.0 Nm</td>
<td>7.0 Nm</td>
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<td>3.1 Nm</td>
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<td>6.0 Nm</td>
<td>6.0 Nm</td>
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</tr>
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<td>5.0 Nm</td>
<td>5.0 Nm</td>
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<td>3</td>
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<td>7.0 Nm</td>
<td>9.0 Nm</td>
<td>20 Nm</td>
<td>37 Nm</td>
<td>5000 rpm</td>
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</tr>
<tr>
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<td>4</td>
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<td>11 Nm</td>
<td>16 Nm</td>
<td>30 Nm</td>
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<td>7.2 Nm</td>
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<td>7.3 Nm</td>
<td>11 Nm</td>
<td>16 Nm</td>
<td>30 Nm</td>
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</tr>
<tr>
<td></td>
<td>7</td>
<td>7.8 Nm</td>
<td>12 Nm</td>
<td>18 Nm</td>
<td>20 Nm</td>
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<td></td>
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</tr>
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<td>7.8 Nm</td>
<td>12 Nm</td>
<td>18 Nm</td>
<td>20 Nm</td>
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<tr>
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<td>9</td>
<td>7.9 Nm</td>
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<td>17 Nm</td>
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<tr>
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<td>3</td>
<td>11 Nm</td>
<td>17 Nm</td>
<td>25 Nm</td>
<td>90 Nm</td>
<td>124 Nm</td>
<td>4000 rpm</td>
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<td>23 Nm</td>
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<td>133 Nm</td>
<td>217 Nm</td>
<td>3000 rpm</td>
<td>6000 rpm</td>
</tr>
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<td>37 Nm</td>
<td>53 Nm</td>
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<td>25 Nm</td>
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<tr>
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<td>60 Nm</td>
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<td>77 Nm</td>
<td>120 Nm</td>
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<td>400 Nm</td>
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<td></td>
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<td>180 Nm</td>
<td>400 Nm</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>80 Nm</td>
<td>130 Nm</td>
<td>180 Nm</td>
<td>390 Nm</td>
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</tr>
<tr>
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<td>85 Nm</td>
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<td>92 Nm</td>
<td>149 Nm</td>
<td>200 Nm</td>
<td>200 Nm</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</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. 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>
<thead>
<tr>
<th>Size</th>
<th>Ratio</th>
<th>Transmission Accuracy</th>
<th>Repeatability</th>
<th>Starting Torque</th>
<th>Backdriving Torque</th>
<th>No-Load Running Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>arc min</td>
<td>arc sec</td>
<td>Ncm</td>
<td>Nm</td>
<td>Ncm</td>
</tr>
<tr>
<td>11</td>
<td>5</td>
<td>±20</td>
<td></td>
<td>4.7</td>
<td>0.19</td>
<td>6.8</td>
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<td></td>
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</tr>
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<td></td>
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<td></td>
</tr>
<tr>
<td></td>
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<td>0.24</td>
<td>3.4</td>
<td></td>
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<tr>
<td></td>
<td>9</td>
<td>2.8</td>
<td>0.25</td>
<td>3.0</td>
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</tr>
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</tr>
<tr>
<td>14</td>
<td>4</td>
<td>±15</td>
<td></td>
<td>13</td>
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<tr>
<td></td>
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<td>0.45</td>
<td>17</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>9.5</td>
<td>0.57</td>
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<td></td>
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<tr>
<td></td>
<td>8</td>
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<td>0.68</td>
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<tr>
<td></td>
<td>9</td>
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<td></td>
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<tr>
<td>20</td>
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<td></td>
<td>31</td>
<td>0.93</td>
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<td>1.0</td>
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<td>30</td>
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</tr>
<tr>
<td></td>
<td>7</td>
<td>20</td>
<td>1.2</td>
<td>25</td>
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</tr>
<tr>
<td></td>
<td>8</td>
<td>18</td>
<td>1.3</td>
<td>21</td>
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<tr>
<td></td>
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<tr>
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<td>10</td>
<td>16</td>
<td>1.5</td>
<td>17</td>
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</tr>
<tr>
<td>32</td>
<td>4</td>
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<td></td>
<td>56</td>
<td>1.7</td>
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<tr>
<td></td>
<td>5</td>
<td>52</td>
<td>2.1</td>
<td>101</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>6</td>
<td>49</td>
<td>2.5</td>
<td>81</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>47</td>
<td>2.8</td>
<td>68</td>
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</tr>
<tr>
<td></td>
<td>8</td>
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<td>58</td>
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<tr>
<td></td>
<td>9</td>
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<td>3.5</td>
<td>51</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>43</td>
<td>3.9</td>
<td>45</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>42</td>
<td>4.2</td>
<td>41</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*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.

*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

**HPG Helical Gearhead Series**

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

<table>
<thead>
<tr>
<th>Size</th>
<th>Backlash</th>
<th>Torsion angle in one direction at TR x 0.15 D</th>
<th>Torsional stiffness A/B</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>3</td>
<td>2.5</td>
<td>0.64</td>
</tr>
<tr>
<td>14</td>
<td>3</td>
<td>2.2</td>
<td>1.37</td>
</tr>
<tr>
<td>20</td>
<td>3</td>
<td>1.5</td>
<td>5.39</td>
</tr>
<tr>
<td>32</td>
<td>3</td>
<td>1.3</td>
<td>21.56</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Size</th>
<th>Backlash</th>
<th>Torsion angle in one direction at TR x 0.15 D</th>
<th>Torsional stiffness A/B</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>14</td>
<td>1</td>
<td>1.1</td>
<td>1.37</td>
</tr>
<tr>
<td>20</td>
<td>1</td>
<td>0.6</td>
<td>5.39</td>
</tr>
<tr>
<td>32</td>
<td>1</td>
<td>0.5</td>
<td>21.56</td>
</tr>
</tbody>
</table>

**Torsional stiffness curve**

With the input of the gear locked in place, a torque applied to the output flange will torsionally deflect in proportion to the applied torque.

We generate a torsional stiffness curve by slowly applying torque to the output in the following sequence:

1. Clockwise torque to TR
2. Return to Zero
3. Counter-Clockwise torque to -TR
4. Return to Zero
5. Again Clockwise torque to TR

A loop of (1) > (2) > (3) > (4) > (5) will be drawn as in Fig. 045-1. The torsional stiffness in the region from “0.15 x TR” to “TR” is calculated using the average value of this slope. The torsional stiffness in the region from “zero torque” to “0.15 x TR” is lower. This is caused by the small amount of backlash plus engagement of the mating parts and loading of the planet gears under the initial torque applied.

**Calculation of total torsion angle**

The method to calculate the total torsion angle (average value) in one direction when a load is applied from a load in a no-load state.

**Formula 045-1**

\[
\theta = D + \frac{T - T_L}{A/B}
\]

- \( \theta \): Total torsion angle
- \( D \): Torsion angle in one direction at output torque x 0.15 torque  
  - Figure 045-1, Table 045-1  
  - See Figure 045-1 and Tables 045-1 and 045-2.
- \( T \): Load torque
- \( T_L \): Output torque x 0.15 torque (≈ TR 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 TR” and “Counter Clockwise load torque -TR” 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).

**Torque - Torsional Angle Diagram**

![Figure 045-1](image-url)
HPG-11R Outline Dimensions

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

(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

<table>
<thead>
<tr>
<th>Flange</th>
<th>Coupling</th>
<th>A (H7)</th>
<th>B</th>
<th>C</th>
<th>F (H7)</th>
<th>G</th>
<th>H</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Min</td>
<td>Max</td>
<td>Min</td>
<td>Max</td>
<td>Min</td>
<td>Max</td>
<td>Typical</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>20</td>
<td>55</td>
<td>4</td>
<td>25</td>
<td>75</td>
<td>5</td>
<td>8</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>18.5</td>
<td>29</td>
</tr>
</tbody>
</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 kgm²) Table 046-2

<table>
<thead>
<tr>
<th>HPG-11R</th>
<th>Coupling</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0156</td>
<td>0.0125</td>
<td>0.0108</td>
<td>0.0099</td>
<td>0.0092</td>
<td>0.0088</td>
<td>0.0085</td>
<td></td>
</tr>
</tbody>
</table>
HPG-14R Outline Dimensions

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

(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

<table>
<thead>
<tr>
<th>Flange</th>
<th>Coupling</th>
<th>A (H7)</th>
<th>B</th>
<th>C (E7)</th>
<th>F (H7)</th>
<th>G</th>
<th>H</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>30</td>
<td>55</td>
<td>7</td>
<td>35</td>
<td>75</td>
<td>5.8</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Min</td>
<td>Max</td>
<td>Min</td>
<td>Max</td>
<td>Min</td>
<td>Max</td>
<td>Typical</td>
</tr>
</tbody>
</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

<table>
<thead>
<tr>
<th>HPG-14R</th>
<th>Ratio</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
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<th>10</th>
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<td>0.069</td>
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<td>0.056</td>
<td>0.054</td>
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</table>
HPG-20R Outline Dimensions

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

![Diagram of HPG-20R Outline Dimensions]

**Dimension Table**

<table>
<thead>
<tr>
<th>Flange</th>
<th>Coupling</th>
<th>A (H7)</th>
<th>B</th>
<th>C</th>
<th>F (H7)</th>
<th>G</th>
<th>H</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Min</td>
<td>Max</td>
<td>Min</td>
<td>Max</td>
<td>Min</td>
<td>Max</td>
<td>Typical</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>50</td>
<td>68</td>
<td>8</td>
<td>55</td>
<td>8</td>
<td>19.6</td>
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</tr>
<tr>
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<td>1</td>
<td>80</td>
<td>95</td>
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<td>85</td>
<td>125</td>
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<td>29</td>
</tr>
<tr>
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<td>45</td>
<td>100</td>
<td>19.6</td>
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</tbody>
</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**

<table>
<thead>
<tr>
<th>Ratio Coupling</th>
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<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPG-20R</td>
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<td></td>
</tr>
<tr>
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<td>0.665</td>
<td>0.609</td>
<td>0.572</td>
<td>0.549</td>
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<td>0.597</td>
<td>0.560</td>
<td>0.537</td>
<td>0.522</td>
<td>0.513</td>
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</tbody>
</table>
HPG-32R Outline Dimensions

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

![Diagram of HPG-32R Gearhead]

(Nota) 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.

<table>
<thead>
<tr>
<th>Dimension Table</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Flange</th>
<th>Coupling</th>
<th>A (H7)</th>
<th>B</th>
<th>C</th>
<th>F (H7)</th>
<th>G</th>
<th>H</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Min</td>
<td>Max</td>
<td>Max</td>
<td>Min</td>
<td>Max</td>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
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<td>1</td>
<td>70</td>
<td>81</td>
<td>7</td>
<td>80</td>
<td>112</td>
<td>15.8</td>
<td>26</td>
</tr>
<tr>
<td>4</td>
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</tr>
<tr>
<td>5</td>
<td>1</td>
<td>55</td>
<td>175</td>
<td>10</td>
<td>65</td>
<td>225</td>
<td>15.8</td>
<td>26</td>
</tr>
</tbody>
</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

<table>
<thead>
<tr>
<th>HPG-32R Coupling</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratio</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>3.23</td>
<td>3.09</td>
<td>3.01</td>
<td>2.94</td>
<td>2.90</td>
</tr>
</tbody>
</table>
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 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.

Flowchart for selecting a size

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

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 T1 to T5 (Nm)
Time t1 to t5 (sec)
Output rotational speed n1 to n5 (rpm)

Normal operation pattern
Starting (acceleration) T1, t1, n1
Steady operation (constant velocity) T2, t2, n2
Stopping (deceleration) T3, t3, n3
Dwell T4, t4, n4

Maximum rotational speed
Max. output rotational speed nmax Nm to n5
Max. input rotational speed nimax R to nmax R
(Restricted by motors) R: Reduction ratio

Emergency stop torque
When impact torque is applied T5

Required life
L50 = L (hours)

Calculate the average load torque applied on the output side from the application motion profile: Tav (Nm).

\[
T_{av} = \frac{1}{t_1+t_2+t_3+\cdots+t_5} \left( T_1t_1 + T_2t_2 + T_3t_3 + \cdots + T_5t_5 \right)
\]

Calculate the average output speed based on the application motion profile: n_{av} (rpm)

\[
n_{av} = \frac{1}{t_1+t_2+t_3+\cdots+t_5} \left( n_1t_1 + n_2t_2 + n_3t_3 + \cdots + n_5t_5 \right)
\]

Make a preliminary model selection with the following condition: T_{av} \leq T_{peak} \text{ (Refer to rating table).}

Determine the reduction ratio (R) based on the maximum output rotational speed (no max) and maximum input rotational speed (n{max}).

n_{max} = n_{max} \cdot R

(A limit is placed on n_{max} by motors.)

Calculate the average input speed (n_{av}) from the maximum output speed (no max) and the reduction ratio (R).

n_{av} = \frac{n_{max}}{R}

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

Calculate the average input speed (n_{av}) from the average output speed (no av) and the reduction ratio (R).

n_{av} = \frac{n_0 \cdot R}{R + 1}

Check whether the maximum input speed is equal to or less than the values specified in the rating table.

n_{max} = \frac{n_{max} \cdot R}{R + 1}

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

L_{50} = 20,000 \cdot \frac{T_{av}}{T_{peak}} \cdot \frac{n_{av}}{n_{max}} \text{ (Hour)}

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:

1. Actual average load torque (Tav) > Permissible maximum value of average load torque or
2. Actual average input rotational speed (n_{av}) > Permissible average input rotational speed (n_{av})
3. Gearhead housing temperature > 70°C
Example of size selection

<table>
<thead>
<tr>
<th>Load torque (Tn (Nm))</th>
<th>Time (tn (sec))</th>
<th>Output rotational speed (n1 (rpm))</th>
<th>Maximum rotational speed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Normal operation pattern

- Starting (acceleration): T1 = 70 Nm, t1 = 0.3 sec, n1 = 60 rpm
- Steady operation (constant velocity): T2 = 18 Nm, t2 = 3 sec, n2 = 120 rpm
- Stopping (deceleration): T3 = 35 Nm, t3 = 0.4 sec, n3 = 60 rpm
- Dwell: T4 = 0 Nm, t4 = 5 sec, n4 = 0 rpm

Calculate the average load torque applied to the output side based on the application motion profile: Tav (Nm).

\[
T_{av} = \frac{T_1 \times t_1 + T_2 \times t_2 + T_3 \times t_3 + T_4 \times t_4}{t_1 + t_2 + t_3 + t_4}
\]

Calculate the average output speed based on the application motion profile: no av (rpm)

\[
no_{av} = \frac{n_1 \times t_1 + n_2 \times t_2 + n_3 \times t_3 + n_4 \times t_4}{t_1 + t_2 + t_3 + t_4}
\]

Make a preliminary model selection with the following conditions. Tav = 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.)

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

\[
R = \frac{ni_{max}}{no_{max}}
\]

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):

\[
i_{av} = \frac{ni_{max} \times R}{R + 1}
\]

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)

Check whether Ti and Ts are within peak torques (Nm) on start and stop in the rating table. T1 = 70 Nm ≤ 108 Nm (Limit for repeated peak torque, size 20)

Ts = 35 Nm ≤ 108 Nm (Limit for repeated peak torque, size 20)

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

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

\[
L_{so} = 20,000 \times \frac{T_{so}}{T_{av}} \times \frac{ni_{av}}{ni_{max}} = 100,398 \text{ (hours)} \geq 30,000 \text{ (hours)}
\]

The selection of model number HPG-20R-7 is confirmed from the above calculations.
Harmonic Planetary®
HPG Right Angle Series

<table>
<thead>
<tr>
<th>Size</th>
<th>32, 50, 65</th>
</tr>
</thead>
</table>

**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® motor adaptation system includes a clamshell style servo coupling and piloted adapter flange.

**Contents**
Rating Table ........................................... 53
Performance Table .................................... 54
Backlash and Torsional Stiffness .................... 55
Outline Dimensions .................................. 56–59
Product Sizing & Selection ......................... 60–61

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

<table>
<thead>
<tr>
<th>Model Name</th>
<th>Size</th>
<th>Design Revision</th>
<th>Reduction Ratio</th>
<th>Output Configuration</th>
<th>Right Angle Specification</th>
<th>Input Configuration</th>
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</table>
| **Harmonic Planetary**<supolygon>®</supolygon>  
**HPG Right Angle** | 32 | A | 5, 11, 15, 21, 33, 45 | F0: Flange output  
J2: Shaft output with key  
J6: Shaft output with key and center tapped hole | RA3 | RA3 |
| | 50 | | | | RA3, RA5 |
| | 65 | | 5, 12, 15, 20, 25, 40 | | RA5 |

Motor Code:

- This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.

**Gearhead Construction**

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

---

**NOTES**

- Do not remove the screw plug and seal cap. Removing them may cause leakage of grease or deterioration in precision.
## Rating Table

<table>
<thead>
<tr>
<th>Size</th>
<th>Model</th>
<th>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>
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</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. 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>
<thead>
<tr>
<th>Size</th>
<th>Model</th>
<th>Ratio</th>
<th>Accuracy*1</th>
<th>Repeatability*2</th>
<th>Starting torque*3</th>
<th>Backdriving torque*4</th>
<th>No-load running torque*5</th>
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<td>122</td>
<td>61</td>
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</table>

*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.

*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.

*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 1,500 rpm for RA3.
Backlash and Torsional Stiffness

### 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. Counterclockwise torque to $-T_R$.
4. Return to Zero.
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 "zero torque" to "0.15 x $T_R$" is lower. This is caused by the small amount of backlash plus engagement 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.

#### 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.

#### Calculation formula

$$\theta = D \times \frac{T - T_R}{A/B}$$

- $\theta$: Total torsion angle
- $D$: Torsion angle in one direction at output torque x 0.15 torque
- $T$: Load torque
- $T_R$: Output torque x 0.15 torque (=$T$ x 0.15)
- $A/B$: Torsional stiffness

---

### Table 055-1

<table>
<thead>
<tr>
<th>Size</th>
<th>Model</th>
<th>Ratio</th>
<th>Backlash</th>
<th>Torsion angle in one direction at $T_R \times 0.15$</th>
<th>Torsional stiffness</th>
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#### 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.
### HPG-32RA Outline Dimensions

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

![HPG-32RA Outline Dimensions](image)

(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

<table>
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<th>Flange</th>
<th>Coupling</th>
<th>A (H7) *1</th>
<th>B *2</th>
<th>C *2</th>
<th>F (H7) *1</th>
<th>G *3</th>
<th>N</th>
<th>Mass (kg) *4</th>
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*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

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HPG 50RA3 Outline Dimensions

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

Diagram of HPG 50RA3

Dimension Table

<table>
<thead>
<tr>
<th>Flange</th>
<th>Coupling</th>
<th>A (H7)</th>
<th>B</th>
<th>C</th>
<th>F (H7)</th>
<th>G</th>
<th>N</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>70</td>
<td>200</td>
<td>10</td>
<td>115</td>
<td>235</td>
<td>10</td>
<td>24</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>110</td>
<td>200</td>
<td>6.5</td>
<td>125</td>
<td>235</td>
<td>10</td>
<td>35</td>
</tr>
</tbody>
</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 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

<table>
<thead>
<tr>
<th>HPG 50RA3</th>
<th>Coupling Ratio</th>
<th>5</th>
<th>11</th>
<th>15</th>
<th>21</th>
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<tbody>
<tr>
<td>1</td>
<td>-</td>
<td>9.4</td>
<td>8.8</td>
<td>7.5</td>
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<tr>
<td>2</td>
<td>-</td>
<td>10.8</td>
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<td>8.9</td>
<td>7.8</td>
<td>7.73</td>
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</tbody>
</table>
HPG-50RA5 Outline Dimensions

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

(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.

<table>
<thead>
<tr>
<th>Flange</th>
<th>Coupling</th>
<th>A (H7)</th>
<th>B</th>
<th>C</th>
<th>F (H7)</th>
<th>G</th>
<th>N</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>70</td>
<td>200</td>
<td>6.5</td>
<td>115</td>
<td>235</td>
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<td>42</td>
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<td>2</td>
<td>2</td>
<td>110</td>
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<td>6.5</td>
<td>125</td>
<td>235</td>
<td>19</td>
<td>42</td>
</tr>
</tbody>
</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 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.

Dimension Table

Moment of Inertia, Input Side

<table>
<thead>
<tr>
<th>HPG 50RA5</th>
<th>Coupling</th>
<th>5</th>
<th>11</th>
<th>15</th>
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<th>45</th>
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<tbody>
<tr>
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<td>33.9</td>
<td>33.3</td>
<td>32</td>
<td>-</td>
<td>-</td>
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</tbody>
</table>
HPG-65RA Outline Dimensions

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

(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

<table>
<thead>
<tr>
<th>Flange Coupling</th>
<th>A (H7)</th>
<th>B (H7)</th>
<th>C (H7)</th>
<th>F (H7)</th>
<th>G (H7)</th>
<th>N</th>
<th>P</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1 / 1</td>
<td>70</td>
<td>200</td>
<td>6.5</td>
<td>115</td>
<td>235</td>
<td>19</td>
<td>42</td>
<td>45</td>
</tr>
<tr>
<td>2 / 2</td>
<td>110</td>
<td>200</td>
<td>6.5</td>
<td>125</td>
<td>235</td>
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<tr>
<td>Two Stage</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 / 1</td>
<td>70</td>
<td>200</td>
<td>6.5</td>
<td>115</td>
<td>235</td>
<td>19</td>
<td>42</td>
<td>45</td>
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<tr>
<td>2 / 2</td>
<td>110</td>
<td>200</td>
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<td>125</td>
<td>235</td>
<td>19</td>
<td>42</td>
<td>45</td>
</tr>
</tbody>
</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 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

<table>
<thead>
<tr>
<th>HPG 65RA</th>
<th>5</th>
<th>12</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>40</th>
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</thead>
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<td>48.8</td>
<td>47.8</td>
<td>37.9</td>
<td>37.3</td>
<td>32.3</td>
<td>32.1</td>
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<tr>
<td>2</td>
<td>60.6</td>
<td>49.2</td>
<td>48.2</td>
<td>38.3</td>
<td>37.7</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
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.

Flowchart for selecting a size

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

Application motion profile

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

Obtain the value of each application motion profile

| Load torque | T1 to Tn (Nm) |
| Time | t1 to tn (sec) |
| Output rotational speed | n1 to nn (rpm) |

Normal operation pattern

Starting (acceleration) | T1, t1, n1 |
Steady operation | constant velocity | T2, t2, n2 |
Stopping (deceleration) | T3, t3, n3 |
Dwell | T4, t4, n4 |

Maximum rotational speed

Max. output rotational speed | no max | n1 to nn |
Max. input rotational speed | n1 max | n1+R to nnnR |
(Restricted by motors) | R: Reduction ratio |

Impact torque

When impact torque is applied | T5 |

Required life

L50 = L (hours)

Flowchart:

1. Calculate the average load torque applied on the output side from the application motion profile: \( Tav = \frac{1}{T} \sum_{i=1}^{n} T_i \cdot t_i \cdot n_i \) (Nm).
2. Calculate the average output speed based on the application motion profile: \( n_{av} = \frac{1}{T} \sum_{i=1}^{n} n_i \cdot t_i \cdot R \) (rpm).
3. Make a preliminary model selection with the following condition: \( Tav \leq \text{Average load torque} \) (Refer to rating table).
4. Determine the reduction ratio (R) based on the maximum output rotational speed (no max) and maximum input rotational speed (ni max).
5. Check whether T1 and T3 are within peak torques (Nm) on start and stop in the rating table.
6. Check whether T5 is less than the momentary max. torque (Nm) from the average output speed and maximum input speed.
7. Calculate the average input speed (ni av) from the average output speed (no av) and the reduction ratio (R).
8. Calculate the life and check whether it meets the specification requirement. \( L = 20,000 \cdot \frac{Tav}{T} \cdot \frac{n_{av}}{n_i} \) (Hour).
9. 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.
   a) Actual average load torque (Tav) > Permissible average maximum of average load torque or
   b) Actual average input rotational speed (ni av) > Permissible average input rotational speed (ni),
   c) Gearhead housing temperature > 70°C

Caution

Refer to the Caution note at the bottom of page 60. Review the operation conditions, size and reduction ratio.

The model number is confirmed.
### Example of model number Selection

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load torque</td>
<td>$T_n$ (Nm)</td>
<td>Maximum rotational speed: $n_{max} = 120$ rpm</td>
</tr>
<tr>
<td>Time</td>
<td>$t_n$ (sec)</td>
<td>Max. output rotational speed: $n_{max} = 5,000$ rpm (Restricted by motors)</td>
</tr>
<tr>
<td>Output rotational speed</td>
<td>$n_n$ (rpm)</td>
<td>Maximum input rotational speed: $n_{max} = 3,000$ rpm</td>
</tr>
</tbody>
</table>

#### Normal operation pattern

<table>
<thead>
<tr>
<th>Mode</th>
<th>$T_1$ (Nm), $t_1$ (sec), $n_1$ (rpm)</th>
<th>$T_2$ (Nm), $t_2$ (sec), $n_2$ (rpm)</th>
<th>$T_3$ (Nm), $t_3$ (sec), $n_3$ (rpm)</th>
<th>$T_4$ (Nm), $t_4$ (sec), $n_4$ (rpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starting (acceleration)</td>
<td>70 Nm, 0.3 sec, 60 rpm</td>
<td>18 Nm, 3 sec, 120 rpm</td>
<td>35 Nm, 0.4 sec, 60 rpm</td>
<td>0 Nm, 5 sec, 0 rpm</td>
</tr>
<tr>
<td>Steady operation (constant velocity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stopping (deceleration)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dwell</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Calculate the average load torque applied to the output side based on the application motion profile: $T_{av}$ (Nm).

$$T_{av}^{1/3} = \frac{[600 \text{rpm} \cdot 0.3 \text{sec} \cdot 70 \text{Nm}]^{1/3} + [120 \text{rpm} \cdot 3 \text{sec} \cdot 18 \text{Nm}]^{1/3} + [10 \text{Nm} \cdot 0.4 \text{sec} \cdot 160 \text{Nm}]^{1/3}}{[600 \text{rpm} \cdot 0.3 \text{sec} + 120 \text{rpm} \cdot 3 \text{sec} + 10 \text{rpm} \cdot 0.4 \text{sec} + 1 \text{rpm} \cdot 5 \text{sec}]}^{1/3}$$

#### Calculate the average output speed based on the application motion profile: $n_{av}$ (rpm).

$$n_{av} = \frac{[600 \text{rpm} \cdot 0.3 \text{sec} + 120 \text{rpm} \cdot 3 \text{sec} + 10 \text{rpm} \cdot 0.4 \text{sec} + 1 \text{rpm} \cdot 5 \text{sec}]}{0.3 \text{sec} + 3 \text{sec} + 0.4 \text{sec} + 5 \text{sec}}$$

#### Make a preliminary model selection with the following conditions. $T_{av} = 30.2$ Nm $\leq$ 120 Nm. (HPG-32A-5-R23 is tentatively selected based on the average load torque (see the rating table) of size 32 and reduction ratio of 5.)

OK

#### Determine a reduction ratio (R) from the maximum output speed (no $n_{max}$) and maximum input speed (ni $max$).

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

Calculate the maximum input speed (ni $max$) from the maximum output speed (no $n_{max}$) and reduction ratio (R): $n_{max} = 120$ rpm $\times 5 = 600$ rpm

OK

#### Calculate the average input speed (ni $av$) from the average output speed (no $n_{av}$) and reduction ratio (R): $n_{av} = 46.2$ rpm $\times 5 = 1,025$ rpm $\leq$ Max. average input speed of size 32 = 1,500 rpm

OK

#### Check whether the maximum input speed is equal to or less than the values specified in the rating table. $n_{max} = 3,960$ rpm $\leq$ 600 rpm (maximum input speed of size 32)

OK

#### Check whether $T_1$ and $T_2$ are within peak torques (Nm) on start and stop in the rating table. $T_1 = 70$ Nm $\leq$ 120 Nm (Limit for repeated peak torque, size 32) $T_2 = 18$ Nm $\leq$ 120 Nm (Limit for repeated peak torque, size 32)

OK

#### Check whether $T_3$ is less than limit for momentary torque (Nm) in the rating table. $T_3 = 35$ Nm $\leq$ 200 Nm (momentary max. torque of size 32)

OK

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

$$L_{50} = 20,000 \times \left(\frac{120 \text{ Nm}}{30.2 \text{ Nm}}\right)^{1/3} \times \left(\frac{3,000 \text{ rpm}}{231 \text{ rpm}}\right) = 25,932.572 \text{ (hours)} \leq 30,000 \text{ (hours)}$$

OK

The selection of model number HPG-32A-5-R23 is confirmed from the above calculations.
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 50:1.

- Backlash: One Stage <5 arc-min
  Two Stage <7 arc-min
- Low gear ratios, 3:1 to 50:1
- High efficiency
- Helical gearing
- Quiet design: Noise <56

New face-mount HPN-L
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 50:1.

- Backlash: One Stage <5 arc-min
- Two Stage <7 arc-min
- Low gear ratios, 3:1 to 50:1
- High efficiency
- Helical gearing
- Quiet design: Noise <56

Input mounting flange with active centering ensures concentric motor shaft engagement.

Single piece output shaft and planet carrier

Deep groove ball bearings straddle the planet carrier, providing high-shaft loading capacity.

Ground helical gearing for accurate, low-noise operation; planet gears supported by a full complement of needle rollers for long life.

Shielded or sealed input bearing

Quick Connect® servo coupling machined and balanced to match the motor shaft diameter (single bolt clamping design).
HarmonicPlanetary®
HPN Value Series

**Size**
11, 14, 20, 32, 40

**Peak Torque**
9Nm ~ 752Nm

**Reduction Ratio**
Single stage: 3:1 to 10:1, Two stage: 15:1 to 50:1

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

**High Efficiency**
Up to 97%

**Output Bearing**
Output shaft supported by dual radial ball bearing system. The two bearings straddle the planet carrier maximizing tilting moment capacity.

Easy mounting to a wide variety of servomotors
Quick Connect® motor adaptation system includes a clamshell style servo coupling and piloted adapter flange.

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

<table>
<thead>
<tr>
<th>Model Name</th>
<th>Size</th>
<th>Design Revision</th>
<th>Reduction Ratio</th>
<th>Input Side Bearing</th>
<th>Output Configuration</th>
<th>Input Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>HarmonicPlanetary® High Torque</td>
<td>11</td>
<td>A</td>
<td>4, 6, 7, 10, 15, 20, 25, 30, 35, 40, 45, 50</td>
<td>Z: Input side bearing with double non-contact shields</td>
<td>J6: Shaft output with key and center tapped hole</td>
<td>This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.</td>
</tr>
<tr>
<td>HarmonicPlanetary® High Torque</td>
<td>14</td>
<td>A</td>
<td>3, 4, 5, 7, 10, 15, 20, 25, 30, 35, 40, 45, 50</td>
<td>J6: Shaft output with key and center tapped hole</td>
<td>J8: Shaft output with center tapped hole</td>
<td></td>
</tr>
<tr>
<td>HarmonicPlanetary® High Torque</td>
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<td>A</td>
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<tr>
<td>HarmonicPlanetary® High Torque</td>
<td>32</td>
<td>A</td>
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<td>HarmonicPlanetary® High Torque</td>
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<td>A</td>
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</tbody>
</table>

**Gearhead Construction**

Figure 064-1
### Rating Table

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<tbody>
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<td>4</td>
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<td>640</td>
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[^1]: Rated torque is based on life of 20,000 hours at max average input speed.
[^2]: The limit for torque during start and stop cycles.
[^3]: The limit for torque during emergency stops or from external shock loads. Always operate below this value.
[^4]: Max value of average input rotational speed during operation.
[^5]: Maximum instantaneous input speed.
[^6]: The load at which the output bearing will have 20,000 hour life at 100 rpm output speed (Axial load = 0 and radial load point is in the center of the output shaft).
[^7]: The load at which the output bearing will have 20,000 hour life at 100 rpm output speed (Radial load = 0 and axial load point is in the center of the output shaft).
## HPN-A Gearhead Series

### High-Performance Gearhead for Servomotors

<table>
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<tr>
<th>Size</th>
<th>Number of Stages</th>
<th>Ratio</th>
<th>Backlash</th>
<th>Noise*</th>
<th>Torsional Stiffness</th>
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<td>x100N•m/rad</td>
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| 11   | 1                | 4     | < 5      | < 56   | 0.060               | 20    |
|      | 1                | 5     | < 5      | < 56   | 0.060               | 20    |
|      | 1                | 7     | < 5      | < 56   | 0.060               | 20    |
|      | 1                | 10    | < 5      | < 56   | 0.060               | 20    |
|      | 2                | 15    | < 7      | < 56   | 0.060               | 20    |
|      | 2                | 20    | < 7      | < 56   | 0.060               | 20    |
|      | 2                | 25    | < 7      | < 56   | 0.060               | 20    |
|      | 2                | 30    | < 7      | < 56   | 0.060               | 20    |
|      | 2                | 35    | < 7      | < 56   | 0.060               | 20    |
|      | 2                | 40    | < 7      | < 56   | 0.060               | 20    |
|      | 2                | 45    | < 7      | < 56   | 0.060               | 20    |
|      | 2                | 50    | < 7      | < 56   | 0.060               | 20    |

| 14   | 1                | 3     | < 5      | < 58   | 0.27                | 93    |
|      | 2                | 4     | < 5      | < 58   | 0.27                | 93    |
|      | 2                | 5     | < 5      | < 58   | 0.27                | 93    |
|      | 2                | 7     | < 5      | < 58   | 0.27                | 93    |
|      | 2                | 10    | < 5      | < 58   | 0.27                | 93    |
|      | 2                | 15    | < 7      | < 58   | 0.27                | 93    |
|      | 2                | 20    | < 7      | < 58   | 0.27                | 93    |
|      | 2                | 25    | < 7      | < 58   | 0.27                | 93    |
|      | 2                | 30    | < 7      | < 58   | 0.27                | 93    |
|      | 2                | 35    | < 7      | < 58   | 0.27                | 93    |
|      | 2                | 40    | < 7      | < 58   | 0.27                | 93    |
|      | 2                | 45    | < 7      | < 58   | 0.27                | 93    |
|      | 2                | 50    | < 7      | < 58   | 0.27                | 93    |

| 20   | 1                | 3     | < 5      | < 60   | 0.77                | 260   |
|      | 1                | 4     | < 5      | < 60   | 0.77                | 260   |
|      | 1                | 5     | < 5      | < 60   | 0.77                | 260   |
|      | 1                | 7     | < 5      | < 60   | 0.77                | 260   |
|      | 1                | 10    | < 5      | < 60   | 0.77                | 260   |
|      | 2                | 15    | < 7      | < 60   | 0.77                | 260   |
|      | 2                | 20    | < 7      | < 60   | 0.77                | 260   |
|      | 2                | 25    | < 7      | < 60   | 0.77                | 260   |
|      | 2                | 30    | < 7      | < 60   | 0.77                | 260   |
|      | 2                | 35    | < 7      | < 60   | 0.77                | 260   |
|      | 2                | 40    | < 7      | < 60   | 0.77                | 260   |
|      | 2                | 45    | < 7      | < 60   | 0.77                | 260   |
|      | 2                | 50    | < 7      | < 60   | 0.77                | 260   |

### Table 065-2

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<th>Backlash</th>
<th>Noise*</th>
<th>Torsional Stiffness</th>
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<tbody>
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<td></td>
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<td>dB</td>
<td>kgfm/arc-min</td>
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<td>x100N•m/rad</td>
</tr>
</tbody>
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| 32   | 1                | 3     | < 5      | < 63   | 2.8                | 940   |
|      | 2                | 4     | < 5      | < 63   | 2.8                | 940   |
|      | 2                | 5     | < 5      | < 63   | 2.8                | 940   |
|      | 2                | 7     | < 5      | < 63   | 2.8                | 940   |
|      | 2                | 10    | < 5      | < 63   | 2.8                | 940   |
|      | 2                | 15    | < 7      | < 63   | 2.8                | 940   |
|      | 2                | 20    | < 7      | < 63   | 2.8                | 940   |
|      | 2                | 25    | < 7      | < 63   | 2.8                | 940   |
|      | 2                | 30    | < 7      | < 63   | 2.8                | 940   |
|      | 2                | 35    | < 7      | < 63   | 2.8                | 940   |
|      | 2                | 40    | < 7      | < 63   | 2.8                | 940   |
|      | 2                | 45    | < 7      | < 63   | 2.8                | 940   |
|      | 2                | 50    | < 7      | < 63   | 2.8                | 940   |

### Table 065-3

<table>
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<th>Ratio</th>
<th>Backlash</th>
<th>Noise*</th>
<th>Torsional Stiffness</th>
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| 40   | 1                | 3     | < 5      | < 65   | 4.2                | 1430  |
|      | 2                | 4     | < 5      | < 65   | 4.2                | 1430  |
|      | 2                | 5     | < 5      | < 65   | 4.2                | 1430  |
|      | 2                | 7     | < 5      | < 65   | 4.2                | 1430  |
|      | 2                | 10    | < 5      | < 65   | 4.2                | 1430  |
|      | 2                | 15    | < 7      | < 65   | 4.2                | 1430  |
|      | 2                | 20    | < 7      | < 65   | 4.2                | 1430  |
|      | 2                | 25    | < 7      | < 65   | 4.2                | 1430  |
|      | 2                | 30    | < 7      | < 65   | 4.2                | 1430  |
|      | 2                | 35    | < 7      | < 65   | 4.2                | 1430  |
|      | 2                | 40    | < 7      | < 65   | 4.2                | 1430  |
|      | 2                | 45    | < 7      | < 65   | 4.2                | 1430  |
|      | 2                | 50    | < 7      | < 65   | 4.2                | 1430  |

*1: The above noise values are reference values.
HPN-11A Outline Dimensions

Dimension Table

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<thead>
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<th>(Unit: mm)</th>
<th>Table 067-1</th>
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<td><strong>A (H7)</strong></td>
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<td>Single Stage</td>
<td>Min.</td>
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<tr>
<td>Two Stage</td>
<td>Min.</td>
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</tbody>
</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 067-2

<table>
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<tr>
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HPN-14A 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

<table>
<thead>
<tr>
<th></th>
<th>Flange</th>
<th>Coupling</th>
<th>A (H7)*1</th>
<th>B*2</th>
<th>C*2</th>
<th>F (H7)*3</th>
<th>G*3</th>
<th>H*4</th>
<th>K</th>
<th>Mass (kg)*5</th>
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<tbody>
<tr>
<td>Single</td>
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</tr>
<tr>
<td>Two Stage</td>
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<td></td>
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<td>75</td>
<td>5</td>
<td>40</td>
<td>100</td>
<td>6</td>
<td>14</td>
<td>28</td>
</tr>
</tbody>
</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
(Unit: $10^{-4}$ kgm$^2$) Table 068-2

<table>
<thead>
<tr>
<th>HPN-14A</th>
<th>Ratio</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>7</th>
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<tr>
<td></td>
<td>Coupling</td>
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</tbody>
</table>
**HPN-20A Outline Dimensions**

![Figure 069-1](image)

**Dimension Table**

<table>
<thead>
<tr>
<th>Coupling</th>
<th>A (H7)<strong>1</strong></th>
<th>B<strong>1</strong></th>
<th>C<strong>1</strong></th>
<th>F (H7)<strong>1</strong></th>
<th>G<strong>1</strong></th>
<th>H<strong>1</strong></th>
<th>K</th>
<th>Mass (kg)<strong>2</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Stage</td>
<td>1</td>
<td>1</td>
<td>50</td>
<td>85</td>
<td>7</td>
<td>55</td>
<td>115</td>
<td>13.5</td>
</tr>
<tr>
<td>Two Stage</td>
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<td>1</td>
<td>50</td>
<td>125</td>
<td>7</td>
<td>60</td>
<td>155</td>
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<tr>
<td>Single Stage</td>
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<td>2</td>
<td>35</td>
<td>75</td>
<td>7</td>
<td>40</td>
<td>100</td>
<td>9.5</td>
</tr>
<tr>
<td>Two Stage</td>
<td>4</td>
<td>3</td>
<td>35</td>
<td>75</td>
<td>5</td>
<td>40</td>
<td>100</td>
<td>6</td>
</tr>
</tbody>
</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**

<table>
<thead>
<tr>
<th>Ratio Coupling</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>7</th>
<th>10</th>
<th>15</th>
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<tbody>
<tr>
<td>HPN-20A</td>
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<td>0.53</td>
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<tr>
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<td>-</td>
<td>-</td>
<td>0.23</td>
<td>0.22</td>
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<td>0.21</td>
<td>0.20</td>
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</tr>
</tbody>
</table>

(Unit: mm) Table 069-1

(Unit: kgm²) Table 069-2
HPN-32A Outline Dimensions

Dimension Table

<table>
<thead>
<tr>
<th>Flange</th>
<th>Coupling</th>
<th>A (H7)</th>
<th>B*</th>
<th>C*</th>
<th>F (H7)</th>
<th>G*</th>
<th>H*</th>
<th>K</th>
<th>Mass(kg)*2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Stage</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>50</td>
<td>85</td>
<td>7</td>
<td>55</td>
<td>115</td>
<td>13.5</td>
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<td>2</td>
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<tr>
<td>3</td>
<td>3</td>
<td>65</td>
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<td></td>
<td></td>
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<tr>
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<td>4</td>
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<td>7</td>
<td>55</td>
<td>115</td>
<td>13.5</td>
<td>25.4</td>
<td>26</td>
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<td>100</td>
<td>9.5</td>
<td>14.2</td>
<td>25.5</td>
</tr>
</tbody>
</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

<table>
<thead>
<tr>
<th>Ratio</th>
<th>HPN-32A</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
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<tr>
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<tr>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
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</tr>
</tbody>
</table>
**HPN-40A Outline Dimensions**

![HPN-40A Diagram](image)

(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). J6 configuration has no key.

**Dimension Table**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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<tbody>
<tr>
<td>Single Stage</td>
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<td>125</td>
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<td>125</td>
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<td>65</td>
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<td>6.5</td>
<td>75</td>
<td>260</td>
<td>21.5</td>
</tr>
</tbody>
</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**

<table>
<thead>
<tr>
<th>Ratio Coupling</th>
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<th>4</th>
<th>5</th>
<th>7</th>
<th>10</th>
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</tr>
<tr>
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<td>-</td>
<td>-</td>
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<td>5.6</td>
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<td>3.8</td>
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<td>5.9</td>
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<td>5.1</td>
<td>5.0</td>
<td>4.9</td>
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</tr>
</tbody>
</table>
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.

Obtain the value of each application motion profile

| Load torque | T1 to Tn (Nm) |
| Time | t1 to tn (sec) |
| Output rotational speed | n1 to nn (rpm) |

Normal operation pattern

Starting (Acceleration) | T1, t1, n1 |
Steady operation (constant velocity) | T2, t2, n2 |
Stopping (deceleration) | T3, t3, n3 |
Dwell | T4, t4, n4 |

Maximum rotational speed

Max. output rotational speed | nmax ≤ n1 to nn |
Max. input rotational speed | nmax = n1×R to nn×R |
(Restricted by motors) |

Emergency stop torque

When impact torque is applied | Ts |

Required life | L10 = 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.

1. Make a preliminary model selection with the following condition: 
   Tav ≥ T1, t1, T3, t3, T4, t4, n1, n2, n3, n4 (Refer to rating table).

2. Calculate the average output speed based on the application motion profile: no av (rpm)
   no av = \( \frac{\sum T \times n}{\sum T} \)

3. Calculate the average load torque applied on the output side from the application motion profile: Tav (Nm)
   Tav = \( \frac{\sum T \times n}{\sum T} \)

4. Determine the reduction ratio (R) based on the maximum output rotational speed (no max) and maximum input rotational speed (ni max)
   ni max = \( \frac{\text{no max}}{R} \)
   (A limit is placed on ni max by motors.)

5. Calculate the maximum input speed (ni max) from the maximum output speed (no max) and the reduction ratio (R): 
   ni max = no max × R

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

   \[ L_{10} = 20,000 \times \left( \frac{T_{av}}{T_{r}} \right)^{\frac{1}{10}} 
   \]

   R: Reduction ratio
   \( T_{av} \): Average load torque
   \( T_{r} \): Rated torque

7. 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) > rated torque or
ii) Actual average input rotational speed (ni av) > max average input speed (ni)
iii) Gearhead housing temperature > 70°C.
**Example of size selection**

<table>
<thead>
<tr>
<th>Load torque</th>
<th>T&lt;sub&gt;n&lt;/sub&gt; (Nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>t&lt;sub&gt;n&lt;/sub&gt; (sec)</td>
</tr>
<tr>
<td>Output rotational speed</td>
<td>n&lt;sub&gt;n&lt;/sub&gt; (rpm)</td>
</tr>
</tbody>
</table>

**Normal operation pattern**
- Starting (acceleration): T<sub>1</sub> = 70 Nm, t<sub>1</sub> = 0.3 sec, n<sub>1</sub> = 60 rpm
- Steady operation (constant velocity): T<sub>2</sub> = 18 Nm, t<sub>2</sub> = 3 sec, n<sub>2</sub> = 120 rpm
- Stopping (deceleration): T<sub>3</sub> = 35 Nm, t<sub>3</sub> = 0.4 sec, n<sub>3</sub> = 60 rpm
- Dwell: T<sub>4</sub> = 0 Nm, t<sub>4</sub> = 5 sec, n<sub>4</sub> = 0 rpm

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

**Emergency stop torque**
- When impact torque is applied: T<sub>s</sub> = 180 Nm

**Required life**
- L<sub>10</sub> = 30,000 (hours)

---

**Calculate the average load torque applied to the output side based on the load torque pattern:**

\[
T_{av} = \frac{\left(60 \text{rpm} \cdot 0.3 \text{sec} + 120 \text{rpm} \cdot 3 \text{sec} + 80 \text{rpm} \cdot 0.4 \text{sec} + 1 \text{rpm} \cdot 0.5 \text{sec}\right) \cdot 0.3 \text{sec} + 3 \text{sec} + 0.4 \text{sec} + 5 \text{sec}}{0.3 \text{sec} + 3 \text{sec} + 0.4 \text{sec} + 5 \text{sec}}
\]

**Calculate the average output speed based on the load torque pattern:**

\[
no_{av} = \frac{60 \text{rpm} + 120 \text{rpm} + 80 \text{rpm} + 1 \text{rpm}}{4} = 60 \text{rpm}
\]

**Make a preliminary model selection with the following conditions.**
- T<sub>av</sub> = 30.2 Nm ≤ 80 Nm. **(HPN-20A-30)** is tentatively selected based on the average load torque (see the rating table) of size 20 and reduction ratio of 30.

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

\[
R = \frac{5,000 \text{ rpm}}{120 \text{ rpm}} = 41.7 \approx 30
\]

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

\[
ni_{max} = no_{max} \cdot R = 60 \text{ rpm} \cdot 30 = 1,800 \text{ rpm} ≤ 3,720 \text{ rpm}
\]

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

\[
ni_{av} = no_{av} \cdot \frac{R}{R + 1} = 60 \text{ rpm} \cdot \frac{30}{31} = 58.1 \text{ rpm}
\]

**Check whether the maximum input speed is less than the values specified in the rating table.**

\[
ni_{max} = 1,800 \text{ rpm} ≤ 2,500 \text{ rpm}
\]

**Check whether T<sub>1</sub> and T<sub>3</sub> are within limit for repeated peak torque (Nm) on start and stop in the rating table.**

\[
T_1 = 70 \text{ Nm} ≤ 139 \text{ Nm} \quad \text{(Limit for repeated peak torque, size 20)}
\]

**Check whether T<sub>s</sub> is less than limit for momentary torque (Nm) in the rating table.**

\[
T_s = 180 \text{ Nm} ≤ 258 \text{ Nm} \quad \text{(momentary max. torque of size 20)}
\]

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

\[
L_{10} = 20,000 \cdot \frac{80 \text{ Nm}}{30.2 \text{ Nm}} \cdot \frac{3,000 \text{ rpm}}{1,432 \text{ rpm}} = 25,809,937 \text{ (hours)} ≥ 30,000 \text{ (hours)}
\]

The selection of model number HPN-20A-30 is confirmed from the above calculations.
HPN-L Series
High-Performance Gearhead for Servomotors

Size
14, 20, 32

Peak Torque
18Nm ~ 300Nm

Reduction Ratio
Single stage: 3:1 to 10:1, Two stage: 15:1 to 50:1

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

High Efficiency
Up to 97%

Output Bearing System
Output shaft supported by dual radial ball bearing system. The two bearings straddle the planet carrier maximizing tilting moment capacity.

Easy mounting to a wide variety of servomotors
Quick Connect® motor adaptation system includes a clamshell style servo coupling and piloted adapter flange.

Rating Table: 75
Performance Table: 76
Outline Dimensions: 77-79
Product Sizing & Selection: 80-81

HPN Face-Mount Series
High-Performance Gearhead for Servomotors

Model Name | Size | Design Revision | Reduction Ratio | Input Side Bearing | Output Configuration | Input Configuration
--- | --- | --- | --- | --- | --- | ---
HPN | 14 | L | 3, 4, 5, 7, 10, 15, 20, 25, 30, 35, 40, 45, 50 | J6: Shaft output with key and center tapped hole | J6: 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.
HPN | 20 |
HPN | 32 |

Gearhead Construction

Figure 074-1
## Rating Table

<table>
<thead>
<tr>
<th>Size</th>
<th>Number of Stages</th>
<th>Ratio</th>
<th>Rated Torque L10 <strong>1</strong> (Nm)</th>
<th>Rated Torque L50 <strong>2</strong> (Nm)</th>
<th>Limit for Repeated Peak Torque <strong>3</strong> (Nm)</th>
<th>Limit for Momentary Torque <strong>4</strong> (Nm)</th>
<th>Max. Average Input Speed <strong>5</strong> (rpm)</th>
<th>Max. Input Speed <strong>6</strong> (rpm)</th>
<th>Allowable Radial Load <strong>7</strong> (N)</th>
<th>Allowable Axial Load <strong>8</strong> (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>1</td>
<td>3</td>
<td>14</td>
<td>22</td>
<td>25</td>
<td>88</td>
<td>3,000</td>
<td>10,000</td>
<td>840</td>
<td>900</td>
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<tr>
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</table>

**1:** Rated torque is based on life of 20,000 hours at max average input speed.

**2:** The limit for torque during start and stop cycles.

**3:** The limit for torque during emergency stops or from external shock loads. Always operate below this value.

**4:** Max value of average input rotational speed during operation.

**5:** Maximum instantaneous input speed.

**6:** The load at which the output bearing will have 20,000 hour life at 100 rpm output speed (Axial load = 0 and radial load point is in the center of the output shaft)

**7:** The load at which the output bearing will have 20,000 hour life at 100 rpm output speed (Radial load = 0 and axial load point is in the center of the output shaft)
## Performance

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<th>Torsional Stiffness</th>
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*1: The above noise values are reference values.
HPN-14L Outline Dimensions

![Figure 077-1](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

<table>
<thead>
<tr>
<th>Flange Coupling</th>
<th>A (H7)**</th>
<th>B**</th>
<th>C**</th>
<th>F (H7)**</th>
<th>G**</th>
<th>H**</th>
<th>K</th>
<th>Mass(kg)**</th>
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<tr>
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<td>75</td>
<td>5</td>
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<td>100</td>
<td>6</td>
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</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

<table>
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<tr>
<th>HPN-14L Coupling</th>
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**HPN-L Gearhead Series**

**HPN-20L Outline Dimensions**

![Diagram of HPN-20L Gearhead](image)

(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

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<th>Flange</th>
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<th>A (H7)*1</th>
<th>B*1</th>
<th>C*1</th>
<th>F (H7)*1</th>
<th>G*2</th>
<th>H*1</th>
<th>K Mass (kg)*3</th>
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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

<table>
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<tr>
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<tr>
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<td>0.20</td>
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</tbody>
</table>
**HPN-32L Outline Dimensions**

(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 079-1

<table>
<thead>
<tr>
<th>Flange</th>
<th>Coupling</th>
<th>A (H7)**</th>
<th>B**</th>
<th>C**</th>
<th>F (H7)**</th>
<th>G**</th>
<th>H**</th>
<th>K</th>
<th>Mass(kg)**</th>
</tr>
</thead>
<tbody>
<tr>
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<td>1</td>
<td>50</td>
<td>85</td>
<td>7</td>
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<td>115</td>
<td>13.5</td>
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<td>2</td>
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<tr>
<td>Two Stage</td>
<td>4</td>
<td>4</td>
<td>50</td>
<td>85</td>
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<td>115</td>
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<td>100</td>
<td>9.5</td>
<td>14.2</td>
<td>25.5</td>
</tr>
</tbody>
</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**

(Unit: kgm^2) Table 079-2

<table>
<thead>
<tr>
<th>Ratio</th>
<th>HPN-32L</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>30</th>
<th>35</th>
<th>40</th>
<th>45</th>
<th>50</th>
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<tbody>
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<td>-</td>
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<td>-</td>
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<tr>
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<td>2</td>
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<tr>
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<td>-</td>
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<td>0.28</td>
<td>0.30</td>
<td>0.28</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
</tbody>
</table>
**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.

### Flowchart for selecting a size

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

**Example of size selection**

Consider a scenario where the average load torque applied on the output side from the application motion profile is $T_{av} = 80$ Nm. Calculate the average output speed based on the application motion profile: $n_{av} = \frac{10}{3}$ rpm.

Graph 080-1

Check whether $T_{av}$ is less than the limit for momentary torque (Nm) in the rating table.

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 narrow 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:

- Actual average load torque ($T_{av}$) > Rated Torque
- Actual average input rotational speed ($n_{av}$) > Max. average input speed (rpm)
- Gearhead housing temperature > 70°C

Make a preliminary model selection with the following condition:

- Torque (Nm)
- Rated speed (rpm)
- Repeated load ratio (R)

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 $n_{max} \leq n_1$ to $n_n$
- Max. input rotational speed $n_{max} R \leq n_v R$

Emergency stop torque when impact torque is applied $T_s$

Required life $L_{10} = L$ (hours)

**Review the application motion profile.**

Check whether the maximum input speed is equal to or less than the values in the rating table. $n_{max} \geq n_{max}$

Check whether the maximum input speed is equal to or less than the values in the rating table. $n_{max} \geq n_{max}$

Check whether $T_1$ and $T_3$ are within Limit for Repeated Peak Torque (Nm) on start and stop in the rating table.

Check whether $T_3$ is less than the Limit for Momentary Peak Torque (Nm) value from the ratings.

Calculate the life and check whether it meets the specification requirement. $R$: Reduction ratio

**Review the operation conditions, size and reduction ratio.**

Refer to the Caution note below. Review the operation conditions, size and reduction ratio.
Example of size selection

<table>
<thead>
<tr>
<th>Load torque (Nm)</th>
<th>Time (sec)</th>
<th>Output rotational speed (rpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>T2</td>
<td>T3</td>
</tr>
<tr>
<td>T1 = 70 Nm,</td>
<td>T2 = 18 Nm,</td>
<td>T3 = 35 Nm,</td>
</tr>
<tr>
<td>t1 = 0.3 sec,</td>
<td>t2 = 3 sec,</td>
<td>t3 = 0.4 sec,</td>
</tr>
<tr>
<td>n1 = 60 rpm,</td>
<td>n2 = 120 rpm,</td>
<td>n3 = 60 rpm,</td>
</tr>
</tbody>
</table>

Normal operation pattern

- Starting (acceleration)
  - T1 = 70 Nm, t1 = 0.3 sec, n1 = 60 rpm

- Steady operation (constant velocity)
  - T2 = 18 Nm, t2 = 3 sec, n2 = 120 rpm

- Stopping (deceleration)
  - T3 = 35 Nm, t3 = 0.4 sec, n3 = 60 rpm

- Dwell
  - T4 = 0 Nm, t4 = 5 sec, n4 = 0 rpm

Maximum rotational speed

- Max. output rotational speed
  - nmax = 120 rpm

- Max. input rotational speed
  - nmax = 5,000 rpm (Restricted by motors)

Emergency stop torque

- When impact torque is applied
  - Ts = 180 Nm

Required life

- L50 = 30,000 (hours)

Make a preliminary model selection with the following conditions. 

- Tav = 30.2 Nm ≤ 80 Nm
- (HPN-20L-30 is tentatively selected based on the average load torque (see the rating table) of size 20 and reduction ratio of 30.)

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

\[
T_{av} = \frac{160 \text{rpm} \cdot 0.3 \text{sec} \cdot 0.7 \text{Nm}}{[120 \text{rpm} \cdot 0.3 \text{sec} \cdot 18 \text{Nm}] + [60 \text{rpm} \cdot 0.4 \text{sec} \cdot 35 \text{Nm}] + [60 \text{rpm} \cdot 0.3 \text{sec} \cdot 1.386 \text{rpm} \cdot 0.4 \text{sec}] + [60 \text{rpm} \cdot 0.3 \text{sec} \cdot 0.4 \text{sec} \cdot 0.5 \text{sec}]
\]

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

\[
no_{av} = \frac{[60 \text{rpm} \cdot 0.3 \text{sec} \cdot 120 \text{rpm} \cdot 0.3 \text{sec} \cdot 60 \text{rpm} \cdot 0.4 \text{sec} \cdot 0 \text{rpm} \cdot 0.5 \text{sec}]}{0.3 \text{sec} \cdot 3 \text{sec} \cdot 0.4 \text{sec} \cdot 0.5 \text{sec}}
\]

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

\[
T_{av} = \frac{160 \text{rpm} \cdot 0.3 \text{sec} \cdot 0.7 \text{Nm}}{[120 \text{rpm} \cdot 0.3 \text{sec} \cdot 18 \text{Nm}] + [60 \text{rpm} \cdot 0.4 \text{sec} \cdot 35 \text{Nm}] + [60 \text{rpm} \cdot 0.3 \text{sec} \cdot 1.386 \text{rpm} \cdot 0.4 \text{sec}] + [60 \text{rpm} \cdot 0.3 \text{sec} \cdot 0.4 \text{sec} \cdot 0.5 \text{sec}]
\]

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

\[
no_{av} = \frac{[60 \text{rpm} \cdot 0.3 \text{sec} \cdot 120 \text{rpm} \cdot 0.3 \text{sec} \cdot 60 \text{rpm} \cdot 0.4 \text{sec} \cdot 0 \text{rpm} \cdot 0.5 \text{sec}]}{0.3 \text{sec} \cdot 3 \text{sec} \cdot 0.4 \text{sec} \cdot 0.5 \text{sec}}
\]

Check whether the maximum input speed is less than the values specified in the rating table.

- ni max = 3,720 rpm (maximum input speed of size 20)
- ni max = 3,720 rpm (maximum input speed of size 20)

Check whether T1 and T3 are within limit for repeated peak torque (Nm) on start and stop in the rating table.

- T1 = 70 Nm ≤ 139 Nm (Limit for repeated peak torque, size 20)
- T3 = 35 Nm ≤ 139 Nm (Limit for repeated peak torque, size 20)

Check whether Ts is less than limit for momentary torque (Nm) in the rating table.

- Ts = 180 Nm ≤ 250 Nm (momentary max. torque of size 20)

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

\[
L_{50} = 20,000 \cdot \frac{80 \text{Nm}}{30.2 \text{Nm}} \cdot \frac{3,000 \text{rpm}}{1,432 \text{rpm}} = 25,809,957 \text{ hours} \approx 30,000 \text{ hours}
\]

The selection of model number HPN-20L-30 is confirmed from the above calculations.
NOTES
HarmonicDrive®
Gearheads for Servomotors

CSG-GH High Torque Series
CSF-GH Standard 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.

- 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
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.

Quick Connect® servo coupling machined and balanced to match the motor shaft diameter (single bolt clamping design)
HarmonicDrive®  
CSG-GH High Torque Series

Size  
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® motor adaptation system includes a clamshell style servo coupling and piloted adapter flange.

Model Name  
Model  
Output Configuration  
Input Configuration

HarmonicDrive® CSG High Torque

<table>
<thead>
<tr>
<th>Size</th>
<th>Reduction Ratio</th>
<th>Model</th>
<th>Output Configuration</th>
<th>Input Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>50, 80, 100</td>
<td>GH</td>
<td>F0: Flange output</td>
<td>This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.</td>
</tr>
<tr>
<td>20</td>
<td>50, 80, 100, 120, 160</td>
<td>GH</td>
<td>J2: Shaft output without key and center tapped hole</td>
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<tr>
<td>32</td>
<td>50, 80, 100, 120, 160</td>
<td>GH</td>
<td>J6: Shaft output with key</td>
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<td>45</td>
<td>50, 80, 100, 120, 160</td>
<td>GH</td>
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<td>80, 100, 120, 160</td>
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</table>

Gearhead Construction

(Output shaft type.)
**HPG series (Orthogonal Shaft Type)**

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<th>Size</th>
<th>Ratio</th>
<th>Buckling Torque</th>
<th>Rated Torque at 2000 rpm</th>
<th>Rated Torque at 3000 rpm</th>
<th>Limit for Average Torque</th>
<th>Limit for Repeated Peak Torque</th>
<th>Limit for Momentary Torque</th>
<th>Max. Average Input Speed</th>
<th>Max. Input Speed</th>
<th>Mass</th>
<th>Shaft</th>
<th>Flange</th>
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<td>1200</td>
<td>3600</td>
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<td>—</td>
<td>280</td>
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<td>—</td>
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<td></td>
</tr>
</tbody>
</table>

*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. 102.
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**

<table>
<thead>
<tr>
<th>Ratio</th>
<th>14</th>
<th>20</th>
<th>32</th>
<th>45</th>
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<tbody>
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<td>110</td>
<td>280</td>
<td>1200</td>
<td>3500</td>
<td>—</td>
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<td>80</td>
<td>140</td>
<td>450</td>
<td>1800</td>
<td>5000</td>
<td>14000</td>
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<td>330</td>
<td>1300</td>
<td>4000</td>
<td>12000</td>
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<td>100</td>
<td>310</td>
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<td>100</td>
<td>280</td>
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**Buckling Torque**

<table>
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<tr>
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## Performance Table  CSG-GH

<table>
<thead>
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<th>Size</th>
<th>Flange Type</th>
<th>Ratio</th>
<th>Accuracy *1</th>
<th>Repeatability *2</th>
<th>Starting torque *3</th>
<th>Backdriving torque *4</th>
<th>No-load running torque *5</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>arc min</td>
<td>arc sec</td>
<td>Ncm</td>
<td>Nm</td>
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<td>3.0</td>
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<td>4.0</td>
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<td>6.8</td>
<td>4.9</td>
<td>4.6</td>
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<td>9.4</td>
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<td>9.6</td>
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<td>81</td>
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<td>47</td>
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<td>285</td>
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<td>278</td>
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<td>80</td>
<td>1.0</td>
<td>±4</td>
<td>197</td>
<td>191</td>
<td>297</td>
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<td></td>
<td>160</td>
<td></td>
<td></td>
<td>147</td>
<td>285</td>
<td>278</td>
</tr>
</tbody>
</table>

*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.

*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.

*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.

*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.

*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 088-1

#### CSG-GH Gearhead Series

#### Performance Table

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.

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.

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.

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.

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 088-2

<table>
<thead>
<tr>
<th>Load</th>
<th>Speed reducer surface temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>No load</td>
<td>25°C</td>
</tr>
</tbody>
</table>

### Table 088-3

<table>
<thead>
<tr>
<th>Load</th>
<th>Speed reducer surface temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>No load</td>
<td>25°C</td>
</tr>
</tbody>
</table>

### Table 088-4

<table>
<thead>
<tr>
<th>Input speed</th>
<th>Load</th>
<th>Speed reducer surface temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000 rpm</td>
<td>No load</td>
<td>25°C</td>
</tr>
</tbody>
</table>
# CSG-GH Gearhead Series

## Torsional Stiffness CSG-GH

<table>
<thead>
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<th>Symbol</th>
<th>Size</th>
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<th>20</th>
<th>32</th>
<th>45</th>
<th>65</th>
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<tbody>
<tr>
<td>T.</td>
<td>Nm</td>
<td>2.0</td>
<td>7.0</td>
<td>29</td>
<td>76</td>
<td>235</td>
</tr>
<tr>
<td></td>
<td>kgfcm</td>
<td>0.2</td>
<td>0.7</td>
<td>3.0</td>
<td>7.8</td>
<td>24</td>
</tr>
<tr>
<td>T.</td>
<td>Nm</td>
<td>6.9</td>
<td>25</td>
<td>108</td>
<td>276</td>
<td>843</td>
</tr>
<tr>
<td></td>
<td>kgfcm</td>
<td>0.7</td>
<td>2.5</td>
<td>11</td>
<td>28</td>
<td>86</td>
</tr>
</tbody>
</table>

Reduction

| Reduction ratio 50 | K. | +107Nm/rad | kgfcm/arc min | 0.34 | 1.3 | 5.4 | 15 | — |
|                   | K. | +107Nm/rad | kgfcm/arc min | 0.1 | 0.38 | 1.6 | 4.3 | — |
|                   | K. | +107Nm/rad | kgfcm/arc min | 0.14 | 0.52 | 2.3 | 6.0 | — |
|                   | K. | +107Nm/rad | kgfcm/arc min | 0.57 | 2.3 | 9.8 | 26 | — |
|                   | K. | +107Nm/rad | kgfcm/arc min | 0.17 | 0.67 | 2.9 | 7.6 | — |
|                   | B. | +107Nm/rad | arc min | 5.8 | 5.2 | 5.5 | 5.2 | — |
|                   | B. | +107Nm/rad | arc min | 2.0 | 1.8 | 1.9 | 1.8 | — |
|                   | B. | +107Nm/rad | arc min | 5.6 | 5.3 | 5.4 | 5.2 | — |

Reduction ratio 80 or more

| Reduction ratio 80 or more | K. | +107Nm/rad | kgfcm/arc min | 0.47 | 1.6 | 6.7 | 18 | 54 |
|                            | K. | +107Nm/rad | kgfcm/arc min | 0.14 | 0.47 | 2.0 | 5.4 | 16 |
|                            | K. | +107Nm/rad | kgfcm/arc min | 0.61 | 2.5 | 11 | 29 | 88 |
|                            | K. | +107Nm/rad | kgfcm/arc min | 0.18 | 0.75 | 3.2 | 8.5 | 26 |
|                            | K. | +107Nm/rad | kgfcm/arc min | 0.71 | 2.9 | 12 | 33 | 98 |
|                            | K. | +107Nm/rad | kgfcm/arc min | 0.21 | 0.85 | 3.7 | 9.7 | 29 |
|                            | B. | +107Nm/rad | arc min | 4.1 | 4.4 | 4.4 | 4.1 | 4.4 |
|                            | B. | +107Nm/rad | arc min | 1.4 | 1.5 | 1.5 | 1.4 | 1.5 |
|                            | B. | +107Nm/rad | arc min | 4.2 | 3.9 | 4.0 | 3.8 | 3.9 |

* The values in this table are average values. See page 108 for more information about torsional stiffness.

## Hysteresis Loss CSG-GH

Reduction ratio 50: Approx. 5.8X10⁻⁴ rad (2arc min)
Reduction ratio 80 or more: Approx. 2.9X10⁻⁴ 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.

#### Flange Type I

![Flange Type I Diagram](image)

#### Flange Type II

![Flange Type II Diagram](image)

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>
<thead>
<tr>
<th>Flange Type</th>
<th>Coupling</th>
<th>A (H7)</th>
<th>B</th>
<th>C</th>
<th>F (H7)</th>
<th>G</th>
<th>H</th>
<th>Moment of Inertia</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Min</td>
<td>Max</td>
<td>Min</td>
<td>Max</td>
<td>Min</td>
<td>Max</td>
<td>Typical (10^-4kgm²)</td>
<td>Shaft</td>
</tr>
<tr>
<td>Type I</td>
<td>1</td>
<td>1</td>
<td></td>
<td>8</td>
<td>20.5</td>
<td>32.5</td>
<td>76</td>
<td>0.88</td>
<td>0.76</td>
</tr>
<tr>
<td>Type II</td>
<td>1</td>
<td>1</td>
<td></td>
<td>8</td>
<td>20.5</td>
<td>32.5</td>
<td>76</td>
<td>0.90</td>
<td>0.78</td>
</tr>
</tbody>
</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.
**CSG-GH-20 Outline Dimensions**

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

---

### Dimension Table

<table>
<thead>
<tr>
<th>Flange</th>
<th>Coupling</th>
<th>A (H7)</th>
<th>B</th>
<th>C</th>
<th>F (H7)</th>
<th>G</th>
<th>H</th>
<th>Moment of Inertia (10^-4kgm²)</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I</td>
<td>1</td>
<td>30</td>
<td>45</td>
<td>5</td>
<td>35</td>
<td>50</td>
<td>7.0</td>
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<td>22.0</td>
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<tr>
<td>Type II</td>
<td>2</td>
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<td>79</td>
<td>10</td>
<td>55</td>
<td>84</td>
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</tr>
<tr>
<td>Type III</td>
<td>2</td>
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<td>100</td>
<td>10</td>
<td>55</td>
<td>105</td>
<td>8.0</td>
<td>14.6</td>
<td>24.0</td>
</tr>
</tbody>
</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.
CSG-GH-32 Outline Dimensions

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

<table>
<thead>
<tr>
<th>Dimension Table</th>
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</table>

<table>
<thead>
<tr>
<th>Flange</th>
<th>Coupling</th>
<th>A (H7)</th>
<th>B</th>
<th>C</th>
<th>F (H7)</th>
<th>G</th>
<th>H</th>
<th>Moment of Inertia</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Min.</td>
<td>Max.</td>
<td>Min.</td>
<td>Max.</td>
<td>Min.</td>
<td>Max.</td>
<td>(10^4kgm²)</td>
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</tr>
<tr>
<td>Type I</td>
<td>1</td>
<td>50</td>
<td>105</td>
<td>10</td>
<td>55</td>
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<td></td>
<td>3</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>8.8</td>
<td>19.6</td>
<td>27.0</td>
</tr>
<tr>
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(Note) The dimension tolerances are not specified depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.

*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 Gearhead Series

CSG-GH-45 Outline Dimensions

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

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<tr>
<th>Dimension Table</th>
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</tr>
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</tr>
<tr>
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</tr>
<tr>
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</tr>
</tbody>
</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.
CSG-GH-65 Outline Dimensions

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

| Dimension Table |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Flange Coupling | A (H7) ** | B ** | C ** | F (H7) ** | G ** | H ** | Moment of Inertia (10⁻⁶ kgm²) | Mass (kg) ** |
| 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 ** | 6.5 | 80 | 260 ** | 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.
Harmonic Drive®
CSG/CSF Gearhead Series
Servomotor Matching Table

Motor flanges and input couplings have been prepared for all motors listed in the servomotor matching table. Please contact Harmonic Drive Systems' sales office if using a motor which is not listed in the matching table.

The motor must be torque limited if using a motor capable of producing more output torque than the repeated peak torque listed in the rating table.

The gearheads listed in the servomotor matching table are selected based upon the peak torque of the motor.

Please contact Harmonic Drive Systems' sales office if you use a motor under the conditions when a load greater than the motor maximum torque is applied to the output shaft.

The gearheads listed in the servo matching table should be used for "preliminary" selection. Be sure to check the machine operating conditions before making the "final" selection of the gear size and ratio.

Please double check the dimensions shown on the gearhead confirmation drawing with the motor drawing before ordering.
HarmonicDrive®
CSF-GH Standard Series

**Size**
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® motor adaptation system includes a clamshell style servo coupling and piloted adapter flange.

---

**CSF-GH Gearhead Series**

**HPG Standard Series**
High-Performance Gearhead for Servomotors

**HPGP Series**
High-Performance Gearhead for Servomotors

---

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Rating Table Definitions, Life, Torque Limits..............105-107
Torsional Stiffness, Vibration, Efficiency..............108-109
Product Sizing & Selection.................................110-111

---

**Motor Code**

<table>
<thead>
<tr>
<th>Model Name</th>
<th>Size</th>
<th>Reduction Ratio</th>
<th>Model</th>
<th>Output Configuration</th>
<th>Input Configuration</th>
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<td>This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.</td>
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<td>J2: Shaft output without key</td>
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**Gearhead Construction**

---

(The figure indicates output shaft type.)
### Rating Table CSF-GH

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<th>(Nm)</th>
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*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.110.
*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

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### Buckling Torque CSF-GH

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<td></td>
<td></td>
<td>160</td>
<td></td>
<td></td>
<td>139</td>
<td>268</td>
<td>278</td>
</tr>
</tbody>
</table>

*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.

*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.

*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.

*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.

*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.
### Torsional Stiffness CSF-GH

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Size</th>
<th>14</th>
<th>20</th>
<th>32</th>
<th>45</th>
<th>65</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_1$</td>
<td>Nm</td>
<td>2.0</td>
<td>7.0</td>
<td>29</td>
<td>76</td>
<td>235</td>
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<tr>
<td>$T_1$</td>
<td>kgfmm</td>
<td>0.2</td>
<td>0.7</td>
<td>3.0</td>
<td>7.8</td>
<td>24</td>
</tr>
<tr>
<td>$T_1$</td>
<td>kgfmm</td>
<td>0.7</td>
<td>2.5</td>
<td>11</td>
<td>28</td>
<td>65</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reduction ratio 50</th>
<th>Symbol</th>
<th>$K_3$</th>
<th>$K_4$</th>
<th>$K_5$</th>
<th>$K_6$</th>
<th>$\theta_1$</th>
<th>$\theta_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\times 10^4$Nm/deg</td>
<td>$K_3$</td>
<td>0.34</td>
<td>1.3</td>
<td>5.4</td>
<td>15</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>$\times 10^4$Nm/deg</td>
<td>$K_4$</td>
<td>0.1</td>
<td>0.38</td>
<td>1.6</td>
<td>4.3</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>$\times 10^4$Nm/deg</td>
<td>$K_5$</td>
<td>0.47</td>
<td>1.8</td>
<td>7.8</td>
<td>20</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>$\times 10^4$Nm/deg</td>
<td>$K_6$</td>
<td>0.14</td>
<td>0.52</td>
<td>2.3</td>
<td>6.0</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>$\times 10^4$Nm/deg</td>
<td>$\theta_1$</td>
<td>0.57</td>
<td>2.3</td>
<td>9.8</td>
<td>26</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>$\times 10^4$Nm/deg</td>
<td>$\theta_2$</td>
<td>0.17</td>
<td>0.67</td>
<td>2.9</td>
<td>7.6</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>$\times 10^4$Nm/deg</td>
<td>arc min</td>
<td>5.6</td>
<td>5.2</td>
<td>5.5</td>
<td>5.2</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>$\times 10^4$Nm/deg</td>
<td>arc min</td>
<td>1.2</td>
<td>1.8</td>
<td>1.9</td>
<td>1.8</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>$\times 10^4$Nm/deg</td>
<td>arc min</td>
<td>16</td>
<td>15.4</td>
<td>15.7</td>
<td>15.1</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>$\times 10^4$Nm/deg</td>
<td>arc min</td>
<td>5.6</td>
<td>5.3</td>
<td>5.4</td>
<td>5.2</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

* The values in this table are average values. See page 108 for more information about torsional stiffness.

### Hysteresis Loss CSF-GH

- Reduction ratio 50: Approx. 5.8X10^-4 rad (2arc min)
- Reduction ratio 80 or more: Approx. 2.9X10^-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.

### Flange Type I

![Flange Type I Diagram]

### Flange Type II

![Flange Type II Diagram]

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

<table>
<thead>
<tr>
<th>Flange Coupling</th>
<th>A (17)</th>
<th>B</th>
<th>C</th>
<th>F (17)</th>
<th>G</th>
<th>H</th>
<th>Moment of inertia</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I</td>
<td>1</td>
<td>30</td>
<td>50</td>
<td>6.5</td>
<td>35</td>
<td>55</td>
<td>6.0</td>
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<tr>
<td>Type II</td>
<td>1</td>
<td>30</td>
<td>55</td>
<td>7</td>
<td>55</td>
<td>75</td>
<td>6.0</td>
<td>8</td>
</tr>
</tbody>
</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 mounting screw.
**CSF-GH-20 Outline Dimensions**

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

![Flange Type I Diagram](image1)

![Flange Type II Diagram](image2)

![Flange Type III Diagram](image3)

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

<table>
<thead>
<tr>
<th>Flange</th>
<th>Coupling</th>
<th>A (mm)¹</th>
<th>B (mm)²</th>
<th>C (mm)³</th>
<th>F (mm)¹</th>
<th>G (mm)²</th>
<th>H (mm)²</th>
<th>Moment of Inertia (10⁻⁵kgm²)</th>
<th>Mass (kg)³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I</td>
<td>1</td>
<td>30</td>
<td>45</td>
<td>5</td>
<td>35</td>
<td>50</td>
<td>7.0</td>
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<td></td>
<td>1.9</td>
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<tr>
<td>Type II</td>
<td>2</td>
<td>50</td>
<td>79</td>
<td>10</td>
<td>55</td>
<td>84</td>
<td>8.0</td>
<td>24</td>
<td>32</td>
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<td>0.42</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>2.6</td>
</tr>
<tr>
<td>Type III</td>
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<td>2.8</td>
</tr>
</tbody>
</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.
CSF-GH-32 Outline Dimensions

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

(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 102-1

<table>
<thead>
<tr>
<th>Flange Coupling</th>
<th>A (T1)</th>
<th>B</th>
<th>C</th>
<th>F (T1)</th>
<th>G</th>
<th>H</th>
<th>Moment of Inertia</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>50</td>
<td>10</td>
<td>55</td>
<td>100</td>
<td>10.8</td>
<td>19.6</td>
<td>27</td>
<td>57</td>
</tr>
<tr>
<td>3</td>
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<td></td>
<td></td>
<td>8.8</td>
<td>19.6</td>
<td>27</td>
<td>46</td>
</tr>
<tr>
<td>Type II</td>
<td>2</td>
<td>60</td>
<td>175</td>
<td>5</td>
<td>70</td>
<td>225</td>
<td>16</td>
<td>25.8</td>
</tr>
<tr>
<td>Type III</td>
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<td></td>
<td></td>
<td></td>
<td>10.8</td>
<td>19.6</td>
<td>35</td>
<td>65</td>
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<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</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.
**CSF-GH-45 Outline Dimensions**

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

(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>
<thead>
<tr>
<th>Flange</th>
<th>Coupling</th>
<th>A (HT)</th>
<th>B</th>
<th>C</th>
<th>F (HT)</th>
<th>G</th>
<th>H</th>
<th>Moment of Inertia</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Min</td>
<td>Max</td>
<td>Max</td>
<td>Min</td>
<td>Max</td>
<td>Min</td>
<td>Max</td>
<td>Typical</td>
</tr>
<tr>
<td>Type I</td>
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<td>70</td>
<td>119</td>
<td>7</td>
<td>80</td>
<td>157</td>
<td>14.0</td>
<td>29.4</td>
<td>30.5</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>17.3 14.3</td>
</tr>
<tr>
<td>Type I</td>
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<td>70</td>
<td>119</td>
<td>7</td>
<td>80</td>
<td>157</td>
<td>19.0</td>
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<td>30.5</td>
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<td></td>
<td></td>
<td></td>
<td>17.3 14.3</td>
</tr>
<tr>
<td>Type II</td>
<td>1</td>
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<td>175</td>
<td>6.5</td>
<td>80</td>
<td>225</td>
<td>14.0</td>
<td>29.4</td>
<td>44.5</td>
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<td></td>
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<td></td>
<td></td>
<td>17.7 14.7</td>
</tr>
<tr>
<td>Type II</td>
<td>2</td>
<td>70</td>
<td>175</td>
<td>6.5</td>
<td>80</td>
<td>225</td>
<td>19.0</td>
<td>41</td>
<td>44.5</td>
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<td>82 181</td>
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<td></td>
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<td>11</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>17.7 14.7</td>
</tr>
</tbody>
</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.
### CSF-GH-65 Outline Dimensions

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

**Flange Type I**

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

**Flange Type II**

Grease filling port
2 locations (symmetrical locations)
M6 P=1
M6 Hexagon socket head bolt

(Rubber cap)

(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

<table>
<thead>
<tr>
<th>Flange</th>
<th>Coupling</th>
<th>A (H7)</th>
<th>B</th>
<th>C</th>
<th>F (H7)</th>
<th>G</th>
<th>H</th>
<th>Moment of inertia</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Min.</td>
<td>Max.</td>
<td>Min.</td>
<td>Max.</td>
<td>Min.</td>
<td>Max.</td>
<td>10^-4kgm²</td>
<td></td>
</tr>
<tr>
<td>Type I</td>
<td></td>
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<td>95</td>
<td>110</td>
<td>10</td>
<td>105</td>
<td>125</td>
<td>19.0</td>
<td>39.3</td>
</tr>
<tr>
<td>Type II</td>
<td></td>
<td>1</td>
<td>70</td>
<td>215</td>
<td>6.5</td>
<td>80</td>
<td>260</td>
<td>19.0</td>
<td>39.3</td>
</tr>
</tbody>
</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.
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 106-1)
  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 111)

- **Limit for Momentary Torque**
  (see Graph 106-1)
  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 circumstances, occur during normal operating cycle. The allowable number of occurrence of the momentary torque may be calculated by using the formula on page 111.

- **Maximum Average Input Speed**

  **Maximum Input Speed**
  Do not exceed the allowable rating. (calculation formula of the average input speed: Page 111).

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

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>
<thead>
<tr>
<th>Series name</th>
<th>Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSF-GH</td>
<td>Lh</td>
</tr>
<tr>
<td></td>
<td>7,000 hours</td>
</tr>
<tr>
<td>CSG-GH</td>
<td>Ln</td>
</tr>
<tr>
<td></td>
<td>10,000 hours</td>
</tr>
<tr>
<td></td>
<td>Lna</td>
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<td>35,000 hours</td>
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<td>Lnaa</td>
</tr>
<tr>
<td></td>
<td>50,000 hours</td>
</tr>
</tbody>
</table>

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

**Calculation formula for Rated Lifetime**

\[ Lh = Ln \left( \frac{T_r}{T_{av}} \right) \left( \frac{N_r}{N_{av}} \right) \]

Table 106-1

**Relative torque rating**

Graph 106-2

* 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: \(1.0 \times 10^4\) cycles

\[
N = \frac{1.0 \times 10^4}{2 \times \frac{n}{60} \cdot t}
\]

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**

\[
N = \frac{1.0 \times 10^4}{2 \times \frac{n}{60} \cdot t}
\]

**Permissible occurrences**

<table>
<thead>
<tr>
<th>N occurrences</th>
<th>Time that impact torque is applied</th>
<th>Rotational speed of the wave generator</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(t) sec</td>
<td>n rpm</td>
</tr>
</tbody>
</table>

The flexspline bends two times per one revolution of the wave generator.

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

#### 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.

#### 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.

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

**Warning**

"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 108-1 shows the torsional angle at the output side when the torque applied on the output side starts from zero, increases up to +T₀ and decreases down to −T₀. 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 108-2, this “Torque – torsional angle diagram” is divided into 3 regions, and the spring constants in the area are represented by K₁, K₂, and K₃.

- K₁: the spring constant when the torque changes from [zero] to [T₁]
- K₂: the spring constant when the torque changes from [T₁] to [T₂]
- K₃: the spring constant when the torque changes from [T₂] to [T₃]

See the corresponding pages of each series for values of the spring constants (K₁, K₂, K₃) and the torque-torsional angles (T₁, T₂, T₃, θ₁, θ₂).

### Example for calculating the torsion angle

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

When the applied torque is T₁ or less, the torsion angle θ₁ is calculated as follows:

When the load torque T₁=6.0 Nm

θ₁ = T₁/K₁
= 6.0/6.7×10⁴
= 9.0×10⁻⁴ rad (0.31 arc min)

When the applied torque is between T₁ and T₂, the torsion angle θ₂ is calculated as follows:

When the load torque is T₂=50 Nm

θ₂ = θ₁ + (T₂−T₁)/K₂
= 4.4×10⁻⁴ + (50−29)/11.0×10⁴
= 4.4×10⁻⁴ + 1.9×10⁻⁴
= 6.3×10⁻⁴ rad (2.17 arc min)

When the applied torque is greater than T₂, the torsion angle θ₃ is calculated as follows:

When the load torque is T₃=178 Nm

θ₃ = θ₂ + θ₃ + (T₃−T₂)/K₃
= 4.4×10⁻⁴ + 11.6×10⁻⁴ + (178−108)/12.0×10⁴
= 4.4×10⁻⁴ + 11.6×10⁻⁴ + 5.8×10⁻⁴
= 2.18×10⁻³ rad (7.5 arc min)

When a bidirectional load is applied, the total torsion angle will be 2x θₓ 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 108-1, 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.

---

**Figure 108-1**

**Figure 108-2**
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.

\[
N = \frac{15}{2} \times 60 = 450 \text{ rpm}
\]

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

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)

### How to calculate the resonant frequency of the system

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

**Formula variables**

<table>
<thead>
<tr>
<th>( f )</th>
<th>The resonant frequency of the system</th>
<th>Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>( K )</td>
<td>Spring constant</td>
<td>Nm/rad</td>
</tr>
<tr>
<td>( J )</td>
<td>Load inertia</td>
<td>kgm²</td>
</tr>
</tbody>
</table>

Refer to the design guide of each series.
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 CSF-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.

![Application Motion Profile Diagram]

* $n_1$, $n_2$, and $n_3$ indicate the average values.

- **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** $n_{max}$
- **Max. input rotational speed** $n_{max}$ (Restricted by motors)

### 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.

![Flowchart for selecting a size]

1. **Calculate the average load torque applied on the output side from the load torque pattern:**
   $$T_{av} = \frac{\sum T_i \cdot t_i}{\sum t_i}$$

2. **Obtain the reduction ratio** ($R$). A limit is placed on $n_{max}$ by motors.

3. **Calculate the average output rotational speed** from the average output rotational speed ($n_{av}$) and the reduction ratio ($R$): $n_{av} = \frac{n_{max}}{R}$

4. **Calculate the maximum input rotational speed** from the max. output rotational speed ($n_{max}$) and the reduction ratio ($R$): $n_i = \frac{n_{max}}{R}$

5. **Check whether the preliminary model number satisfies the following condition from the ratings.**
   - $n_{av} \leq \text{Limit for average speed (rpm)}$
   - $n_{max} \leq \text{Limit for maximum speed (rpm)}$

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

7. **Calculate the lifetime.**
   $$L_{10} = \frac{7,000 \left( \frac{T_r}{T_{av}} \right)^2 \cdot \frac{n_r}{n_{av}}}{}$$ (hours)

8. **Check whether the calculated lifetime is equal to or more than the life of the wave generator (see Page 106).**

The model number is confirmed.
Example of model number selection

<table>
<thead>
<tr>
<th>Load torque</th>
<th>Tav (Nm)</th>
<th>Time</th>
<th>t (sec)</th>
<th>Output rotational speed</th>
<th>no av (rpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starting (acceleration)</td>
<td>T1 = 400 Nm, t1 = 0.3 sec, n1 = 7 rpm</td>
<td>7 rpm = 0.3 sec + 14 rpm = 3 sec + 7 rpm = 0.4 sec = 1200 Nm</td>
<td>12 rpm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steady operation (constant velocity)</td>
<td>T2 = 320 Nm, t2 = 3 sec, n2 = 14 rpm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steady operation (constant velocity)</td>
<td>T3 = 200 Nm, t3 = 0.4 sec, n3 = 7 rpm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dwell idle</td>
<td>T4 = 0 Nm, t4 = 0.2 sec, n4 = 0 rpm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Maximum rotational speed
- Max. output rotational speed: no max = 14 rpm
- Max. input rotational speed: ni max = 1800 rpm

Emergency stop torque
- When impact torque is applied: Ts = 500 Nm, ts = 0.15 sec, ns = 14 rpm

Required life
- L10 = 7000 (hours)

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

\[
Tav = \frac{7 \text{ rpm} \cdot 0.3 \text{ sec} + 14 \text{ rpm} \cdot 3 \text{ sec} + 320 \text{ Nm} \cdot 7 \text{ rpm} \cdot 0.4 \text{ sec} + 1200 \text{ Nm}^3}{7 \text{ rpm} \cdot 0.3 \text{ sec} + 14 \text{ rpm} \cdot 3 \text{ sec} + 7 \text{ rpm} \cdot 0.4 \text{ sec}}
\]

Make a preliminary model selection with the following conditions. Tav = 319 Nm ≤ 620 Nm (Limit for average torque for model number CSF-45-120-GH: See the ratings on Page 97.)

Thus, CSF-45-120-GH is tentatively selected.

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)

Check whether T1 and T3 are equal to or less than the repeated peak torque specification.
- T1 = 400 Nm ≤ 823 Nm (Limit of repeated peak torque of size 45)
- T3 = 200 Nm ≤ 823 Nm (Limit of repeated peak torque of size 45)

Check whether Ts is equal to or less than the momentary torque specification.
- Ts = 500 Nm ≤ 1760 Nm (Limit for momentary torque of size 45)

Calculate the allowable number (Ns) rotation during impact torque and confirm ≤ 1.0x10^4

\[
Ns = \frac{10^4}{2 \cdot \frac{14 \text{ rpm} \cdot 120}{60} \cdot 0.15 \text{ sec}} = 1190 \leq 1.0x10^4
\]

Calculate the lifetime.

\[
L_{10} = 7000 \cdot \left( \frac{402 \text{ Nm}}{319 \text{ Nm}} \right)^{1/3} \cdot \left( \frac{2000 \text{ rpm}}{1440 \text{ rpm}} \right) \text{ (hours)}
\]

Check whether the calculated life is equal to or more than the life of the wave generator (see Page 106).
- L10 = 19,457 hours ≥ 7000 (life of the wave generator: Lw)

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

Harmonic Drive®
CSG/CSF Gearhead Series
Servomotor Matching Table

Motor flanges and input couplings have been prepared for all motors listed in the
servomotor matching table. Please contact Harmonic Drive Systems' sales office
if using a motor which is not listed in the matching table.

The motor must be torque limited if using a motor capable of producing more
output torque than the repeated peak torque listed in the rating table.

The gearheads listed in the servomotor matching table are selected based upon
the peak torque of the motor.

Please contact Harmonic Drive Systems' sales office if you use a motor under the
conditions when a load greater than the motor maximum torque is applied to the
output shaft.

The gearheads listed in the servo matching table should be used for "preliminary"
selection. Be sure to check the machine operating conditions before making the
"final" selection of the gear size and ratio.

Please double check the dimensions shown on the gearhead confirmation
drawing with the motor drawing before ordering.

Figure 116-1

Unit Type
HPF series (Hollow Shaft Type)

Unit Type
HPG series (Input Shaft Type)

HPF Hollow Shaft Gear Unit

Size
25, 32

Sizes
2

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.

Backlash and Torsional Stiffness ………………118
Outline Dimensions…………………………….. 119
Product Sizing & Selection……………………...120

Planetary Gear Units
HP Miniature Planetary
HPF Series - Hollow Shaft
HPG Series - Input Shaft

A 11
25
32
U1:
Hollow shaft F0: Flange output

Hollow Shaft

HPF 25 A 11 F0 SP1U1 - - - -
Model Name  Size Design Revision Reduction Ratio Output Configuration Input Configuration Options

None
ɿ
SP
ɿ
Standard item
Special specification
HarmonicPlanetary®
Planetary Gear Units

HP Miniature Planetary
HPF Series - Hollow Shaft
HPG Series - Input Shaft

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.

Planetary Gear Units
HPF
HPG Series - Input Shaft
**Harmonic Planetary®**

**Miniature Planetary**

**Size**

- 8

**Peak Torque**

- 5.88 Nm

**Reduction Ratio**

- 5:1, 16:1, 25:1

**Backlash**

- Low Backlash ≤30 arc-min

**High Efficiency**

- Up to 97%

**Output Bearing**

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

**Easy mounting to a wide variety of servomotors**

Multiple motor mount arrangements available depending on motor face geometry and dimensions.

---

**Model Name**

**HP** - **8** - **F** - **05**

<table>
<thead>
<tr>
<th>HP or CP</th>
<th>Size</th>
<th>Design Revision</th>
<th>Reduction Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP-8</td>
<td>8</td>
<td>F</td>
<td>5, 16, 25</td>
</tr>
</tbody>
</table>

**Rating Table**

<table>
<thead>
<tr>
<th>Size</th>
<th>Ratio</th>
<th>Dimension</th>
<th>Rated Torque</th>
<th>Repeated Torque</th>
<th>Momentary Peak Torque</th>
<th>Allowable Max Speed</th>
<th>Allowable Radial Load</th>
<th>Allowable Axial Load</th>
<th>Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>mm</td>
<td>Nm</td>
<td>Nm</td>
<td>Nm</td>
<td>rpm</td>
<td>N</td>
<td>N</td>
<td>kg</td>
</tr>
<tr>
<td>HP-8F</td>
<td>5</td>
<td>25</td>
<td>0.40</td>
<td>2.26</td>
<td>5.88</td>
<td>5000</td>
<td>52</td>
<td>47</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>25</td>
<td>1.07</td>
<td>2.55</td>
<td>5.88</td>
<td>5000</td>
<td>76</td>
<td>47</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>25</td>
<td>1.57</td>
<td>2.26</td>
<td>5.88</td>
<td>5000</td>
<td>89</td>
<td>47</td>
<td>0.15</td>
</tr>
</tbody>
</table>

**Performance Table**

<table>
<thead>
<tr>
<th>Item</th>
<th>Measurement Condition</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backlash</td>
<td>±5% Rated Torque</td>
<td>≤30 arc-min</td>
</tr>
<tr>
<td>Efficiency 28°C</td>
<td>Rated Torque @ 3000 rpm</td>
<td>97%</td>
</tr>
<tr>
<td>Life_L10</td>
<td>Rated Torque</td>
<td>20,000 hrs</td>
</tr>
</tbody>
</table>
### Outline Dimensions

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

#### CP-8F-(5, 16, 25)

![Diagram of CP-8F-(5, 16, 25)]

- Includes removable HUB pinion assembly for motor shaft mounting
- Input pinion clamping hub

#### HP-8F-5

![Diagram of HP-8F-5]

#### HP-8F-16 / HP-8F-25

![Diagram of HP-8F-16 / HP-8F-25]
HarmonicPlanetary®
HPF Hollow Shaft Gear Unit

Size
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.

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Backlash and Torsional Stiffness 118
Outline Dimensions 119
Product Sizing & Selection 120

Gearhead Construction

HPF Hollow Shaft Gear Unit

<table>
<thead>
<tr>
<th>Size</th>
<th>Design Revision</th>
<th>Reduction Ratio</th>
<th>Output Configuration</th>
<th>Input Configuration</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>A</td>
<td>11</td>
<td>F0: Flange output</td>
<td>U1: Hollow shaft</td>
<td>None: Standard item, SP: Special specification</td>
</tr>
<tr>
<td>32</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 116-1
**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>
<thead>
<tr>
<th>Size</th>
<th>Ratio</th>
<th>Rated Torque at 2000 rpm</th>
<th>Rated Torque at 3000 rpm</th>
<th>Limit for Repeated Peak Torque</th>
<th>Limit for Momentary Torque</th>
<th>Max. Average Input Speed</th>
<th>Max. Input Speed</th>
<th>Input Moment of Inertia</th>
<th>Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>11</td>
<td>48</td>
<td>21</td>
<td>100</td>
<td>170</td>
<td>3000</td>
<td>6000</td>
<td>1.63</td>
<td>3.8</td>
</tr>
<tr>
<td>32</td>
<td>11</td>
<td>100</td>
<td>44</td>
<td>220</td>
<td>450</td>
<td>3000</td>
<td>4800</td>
<td>3.84</td>
<td>7.2</td>
</tr>
</tbody>
</table>

*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>
<thead>
<tr>
<th>Size</th>
<th>Ratio</th>
<th>Transmission accuracy</th>
<th>Repeatability</th>
<th>Starting torque</th>
<th>Backdriving torque</th>
<th>No-load running torque</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>arc min</td>
<td>arc sec</td>
<td>Ncm</td>
<td>Nm</td>
<td>Ncm</td>
</tr>
<tr>
<td>25</td>
<td>11</td>
<td>4</td>
<td>±15</td>
<td>59</td>
<td>6.5</td>
<td>78</td>
</tr>
<tr>
<td>32</td>
<td>11</td>
<td>4</td>
<td>±15</td>
<td>75</td>
<td>8.3</td>
<td>105</td>
</tr>
</tbody>
</table>

*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.

*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.

*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.

*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.

*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.
Backlash and Torsional Stiffness

### HPF Hollow Shaft Unit

<table>
<thead>
<tr>
<th>Size</th>
<th>Ratio</th>
<th>Backlash</th>
<th>Torsion angle in one direction at TR x 0.15</th>
<th>Torsional stiffness</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>11</td>
<td>3.0</td>
<td>2.0</td>
<td>16.66</td>
</tr>
<tr>
<td>32</td>
<td>11</td>
<td>3.0</td>
<td>1.7</td>
<td>34.3</td>
</tr>
</tbody>
</table>

#### 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
5. Again Clockwise torque to \( T_r \)

A loop of (1) > (2) > (3) > (4) > (5) will be drawn as in Fig. 118-1. The torsional stiffness in the region from "0.15 x Tr" to "Tr" is calculated using the average value of this slope. The torsional stiffness in the region from "zero torque" to "0.15 x Tr" is lower. This is caused by the small amount of backlash plus engagement of the mating parts and loading of the planet gears under the initial torque applied.

#### Calculation of total torsion angle

The method to calculate the total torsion angle (average value) in one direction when a load is applied from a no-load state.

#### Backlash (Hysteresis Loss)

The vertical distance between points (2) & (4) in Fig. 118-1 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.

**Formula 118-1**

\[
\theta = D \times \frac{T - T_L}{A/B}
\]

- \( \theta \): Total torsion angle
- \( D \): Torsion angle in one direction at output torque x 0.15 torque
- \( T \): Load torque
- \( T_L \): Output torque x 0.15 torque (\( = T_r \times 0.15 \))
- \( A/B \): Torsional stiffness

**Diagram 118-1**

- \( T_r \): Rated output torque
- \( A/B \): Torsional stiffness
- \( D \): Torsion angle in one direction at \( T_r \times 0.15 \)
- \( Hysteresis loss = Backlash \)
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 157.

HPF-25 Outline Dimensions

(Units: mm)

(Hollow shaft ID: 4.5 C 1.75)

12-M4×8
(For mounting output load)

6-M4×5.5
(Use caution regarding bolt length and interference)

(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

(Units: mm)

(Hollow shaft ID: 6 C 2)

12-M5×8
(For mounting output load)

6-M4×6
(Use caution regarding bolt length and interference)

(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.

Flowchart for selecting a size

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

Application motion profile

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

Graph 120-I

Obtain the value of each application motion profile

Load torque T1 to Tn (Nm)

Time t1 to tn (sec)

Output rotational speed n1 to nn (rpm)

Normal operation pattern

Starting (acceleration) T1, t1, n1

Steady operation (constant velocity) T2, t2, n2

Stopping (deceleration) T3, t3, n3

Dwell T4, t4, n4

Maximum rotational speed

Max. output rotational speed no max • n1 to nn

Max. input rotational speed ni max • nR to nR
(Restricted by motors)

Emergency stop torque

When impact torque is applied Ts

Required life L10 = L (hours)

Flowchart notes below.

Check whether the maximum input speed is equal to or less than the values specified in the rating table.

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

Check whether T2 is less than the maximum speed (N/m) from 21 rpm in the rating table.

Calculate the lifetime and check whether it meets the specification requirement.

R: Rated torque

R = Maximum average input speed

L = 20,000 • \( \frac{T1}{Tav} \) • \( \frac{n}{ni av} \) (hour)

The model number is confirmed.

Caution

If any of the following conditions exist, please contact Harmonic Drive LLC. Exercise caution especially when the duty cycle is close to continuous operation:

1. Actual average load torque (Tav) > Permissible maximum value of average load torque
2. Actual average input rotational speed (ni av) > Permissible average input rotational speed (ni)
3. Gearhead housing temperature > 70°C
### Example of size selection

<table>
<thead>
<tr>
<th>Normal operation pattern</th>
<th>Load torque ( T_n ) (Nm)</th>
<th>Time ( t_n ) (sec)</th>
<th>Output rotational speed ( n_e ) (rpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starting (acceleration)</td>
<td>( T_1 = 70 \text{ Nm} )</td>
<td>( t_1 = 0.3 \text{ sec} )</td>
<td>( n_1 = 60 \text{ rpm} )</td>
</tr>
<tr>
<td>Steady operation (constant velocity)</td>
<td>( T_2 = 18 \text{ Nm} )</td>
<td>( t_2 = 3 \text{ sec} )</td>
<td>( n_2 = 120 \text{ rpm} )</td>
</tr>
<tr>
<td>Stopping (deceleration)</td>
<td>( T_3 = 35 \text{ Nm} )</td>
<td>( t_3 = 0.4 \text{ sec} )</td>
<td>( n_3 = 60 \text{ rpm} )</td>
</tr>
<tr>
<td>Dwell</td>
<td>( T_4 = 0 \text{ Nm} )</td>
<td>( t_4 = 5 \text{ sec} )</td>
<td>( n_4 = 0 \text{ rpm} )</td>
</tr>
</tbody>
</table>

### Maximum rotational speed
- Max. output rotational speed \( \text{no max} = 120 \text{ rpm} \)
- Max. input rotational speed \( \text{ni max} = 5,000 \text{ rpm} \)
- (Restricted by motors)

### Emergency stop torque
- When impact torque is applied \( T_s = 120 \text{ Nm} \)

### Required life \( L_{10} = 30,000 \) (hours)

#### Calculations

1. **Average load torque**
   
   \[
   T_{av} = \sqrt{\frac{\text{initial load torque}}{\text{load factor}}} = \sqrt{\frac{\text{70 Nm}}{1.5}} = 20.4 \text{ Nm}
   \]

2. **Average output speed**
   
   \[
   n_{av} = \sqrt{\frac{\text{average input speed}}{\text{reduction ratio}}} = \sqrt{\frac{60 \text{ rpm}}{11}} = 22.9 \text{ rpm}
   \]

3. **Average load torque applied**
   
   \[
   T_{av} = (70 \text{ Nm} + 60 \text{ Nm} + 60 \text{ Nm}) / 3 = 60 \text{ Nm}
   \]

4. **Average output speed**
   
   \[
   n_{av} = (30 \text{ rpm} + 50 \text{ rpm} + 120 \text{ rpm}) / 3 = 60 \text{ rpm}
   \]

5. **Max. load factor**
   
   \[
   k_{max} = \sqrt{\frac{21 \text{ Nm}}{508 \text{ rpm}}} = 2.7 \text{ Nm} / \text{rpm}
   \]

6. **Life calculation**
   
   \[
   L_{10} = \frac{30,000 \text{ hours}}{20,000 \text{ hours}} = 15 \text{ hours}
   \]

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

**Size**
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.

---

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

**Gearhead Construction**

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Rating Table................................. 123
Performance Table............................ 124
Backlash and Torsional Stiffness............ 125
Outline Dimensions............................ 126-129
Product Sizing & Selection.................... 130-131

---

**Model Name**

<table>
<thead>
<tr>
<th>Size</th>
<th>Design Revision</th>
<th>Reduction Ratio</th>
<th>Backlash</th>
<th>Output Configuration</th>
<th>Input Configuration</th>
<th>Options</th>
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<td>B</td>
<td>5, 9, 21, 37, 45</td>
<td>BL1: Backlash less than 1 arc-min (Sizes 14 to 65)</td>
<td>FO: Flange output</td>
<td>U1: Input shaft (with key and center tapped hole)</td>
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<td></td>
<td>BL2: Backlash less than 3 arc-min</td>
<td>JE0: Shaft output without key and center tapped hole</td>
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<td>SP1: Standard item special specification</td>
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<td>3, 5, 11, 15, 21, 33, 45</td>
<td>BL3: Backlash less than 3 arc-min</td>
<td>J6: Shaft output without key</td>
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<td>J60: Shaft output with key and center tapped hole</td>
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<td>F0: Flange output</td>
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<td>65</td>
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<td>4, 5, 12, 15, 20, 25, 40, 50</td>
<td></td>
<td>U1: Input shaft (with key and center tapped hole)</td>
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</table>

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**Figure 122-1**

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**Figure 119-1**

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**Figure 122-1**

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**Figure 119-1**

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**Figure 122-1**
### Rating Table

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<th>Rated Torque L50</th>
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<th>Limit for Repeated Peak Torque</th>
<th>Limit for Momentary Torque</th>
<th>Max. Average Input Speed</th>
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</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.
*3: See p. 130.
*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: Size 65 is built-to-order.
### Performance Table

<table>
<thead>
<tr>
<th>Model</th>
<th>Ratio</th>
<th>Accuracy $^1$</th>
<th>Repeatability $^2$</th>
<th>Starting torque $^3$</th>
<th>Backdriving torque $^4$</th>
<th>No-load running torque $^5$</th>
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<td>8.9</td>
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<td></td>
</tr>
<tr>
<td>32</td>
<td>4</td>
<td>±15</td>
<td>92</td>
<td>2.8</td>
<td>146</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>±15</td>
<td>69</td>
<td>3.5</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>±15</td>
<td>63</td>
<td>6.9</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>±15</td>
<td>61</td>
<td>9.1</td>
<td>57</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>±15</td>
<td>58</td>
<td>12</td>
<td>52</td>
<td></td>
</tr>
<tr>
<td></td>
<td>33</td>
<td>±15</td>
<td>52</td>
<td>17</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td></td>
<td>45</td>
<td>±15</td>
<td>46</td>
<td>21</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>3</td>
<td>±15</td>
<td>197</td>
<td>5.9</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>±15</td>
<td>140</td>
<td>7.0</td>
<td>180</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>±15</td>
<td>110</td>
<td>12</td>
<td>110</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>±15</td>
<td>100</td>
<td>15</td>
<td>97</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>±15</td>
<td>98</td>
<td>21</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td></td>
<td>33</td>
<td>±15</td>
<td>88</td>
<td>29</td>
<td>74</td>
<td></td>
</tr>
<tr>
<td></td>
<td>45</td>
<td>±15</td>
<td>83</td>
<td>37</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>65</td>
<td>3</td>
<td>±15</td>
<td>406</td>
<td>16</td>
<td>576</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>±15</td>
<td>358</td>
<td>18</td>
<td>517</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>±15</td>
<td>243</td>
<td>29</td>
<td>341</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>±15</td>
<td>228</td>
<td>34</td>
<td>311</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>±15</td>
<td>213</td>
<td>43</td>
<td>282</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>±15</td>
<td>202</td>
<td>51</td>
<td>262</td>
<td></td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>±15</td>
<td>193</td>
<td>77</td>
<td>220</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>±15</td>
<td>188</td>
<td>94</td>
<td>219</td>
<td></td>
</tr>
</tbody>
</table>

$^1$: 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.

$^2$: 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 “$\pm$”. The values in the table are maximum values.

$^3$: 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.

$^4$: 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.

$^5$: No-load running torque is the torque value 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 124-2

<table>
<thead>
<tr>
<th>Load</th>
<th>No load</th>
<th>HPF speed reducer surface temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPF speed reducer surface temperature</td>
<td>25°C</td>
<td></td>
</tr>
</tbody>
</table>

#### Table 124-3

<table>
<thead>
<tr>
<th>Load</th>
<th>No load</th>
<th>HPF speed reducer surface temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPF speed reducer surface temperature</td>
<td>25°C</td>
<td></td>
</tr>
</tbody>
</table>

#### Table 124-4

| Input speed | 3000 rpm |
| Load | No load |
| HPF speed reducer surface temperature | 25°C |
Backlash and Torsional Stiffness

Table 125-1

<table>
<thead>
<tr>
<th>Size</th>
<th>Ratio</th>
<th>Backlash arc min</th>
<th>Torsion angle in one direction at T = 0.15 Torque arc min</th>
<th>Torsional stiffness A/B Nm/arc min</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>3</td>
<td>2.5</td>
<td>0.59</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>3</td>
<td>2.2</td>
<td>1.27</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>3</td>
<td>1.5</td>
<td>4.9</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>3</td>
<td>1.3</td>
<td>15.66</td>
<td>18.6</td>
</tr>
<tr>
<td>50</td>
<td>3</td>
<td>1.3</td>
<td>62.71</td>
<td>107.6</td>
</tr>
<tr>
<td>66</td>
<td>3</td>
<td>1.3</td>
<td>270</td>
<td></td>
</tr>
</tbody>
</table>

Table 125-2

<table>
<thead>
<tr>
<th>Size</th>
<th>Ratio</th>
<th>Backlash arc min</th>
<th>Torsion angle in one direction at T = 0.15 Torque arc min</th>
<th>Torsional stiffness A/B Nm/arc min</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>not available</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>1</td>
<td>1.1</td>
<td>1.27</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>1</td>
<td>0.6</td>
<td>4.9</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>1</td>
<td>0.5</td>
<td>16.66</td>
<td>19.6</td>
</tr>
<tr>
<td>50</td>
<td>1</td>
<td>0.5</td>
<td>62.71</td>
<td>107.6</td>
</tr>
<tr>
<td>66</td>
<td>1</td>
<td>0.5</td>
<td>270</td>
<td></td>
</tr>
</tbody>
</table>

Torsional stiffness curve

With the input of the gear locked in place, a torque applied to the output flange will torsionally deflect in proportion to the applied torque. We generate a torsional stiffness curve by slowly applying torque to the output in the following sequence:
(1) Clockwise torque to Tr, (2) Return to Zero, (3) Counter-Clockwise torque to -Tr, (4) Return to Zero and (5) again Clockwise torque to Tr.

A loop of (1) > (2) > (3) > (4) > (5) will be drawn as in Fig. 125-1. The torsional stiffness in the region from “0.15 x Tr” to “Tr” is calculated using the average value of this slope. The torsional stiffness in the region from “zero torque” to “0.15 x Tr” is lower. This is caused by the small amount of backlash plus engagement of the mating parts and loading of the planet gears under the initial torque applied.

Calculation of total torsion angle

The method to calculate the total torsion angle (average value) in one direction when a load is applied from a no-load state.

\[ \theta = D \times \frac{T - T_0}{A/B} \]

- \( \theta \): Total torsion angle
- D: Torsion angle in one direction at output torque x 0.15 Torque
- T: Load torque
- TL: Output torque x 0.15 torque (=TR x 0.15)
- A/B: Torsional stiffness

Backlash (Hysteresis loss)

The vertical distance between points (2) & (4) in Fig. 125-1 is called a hysteresis loss. The hysteresis loss between “Clockwise load torque Tr” and “Counter Clockwise load torque -Tr” is defined as the backlash of the HPG series. The backlash of the HPG series is less than 3 arc-min (1 arc-min or less available for sizes 14-65).

Torque-torsion angle diagram

[Diagram showing the relationship between torque and torsion angle]
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 157.

HPG-11 Outline Dimensions

(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 157.

HPG-14 Outline Dimensions

(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

(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 157.

**HPG-32 Outline Dimensions**

(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**

(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 157.

HPG-65 Outline Dimensions

[Reduction Ratio = 4, 5]

(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.

[Reduction Ratio = 12, 15, 20, 25, 40, 50]

(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).

Flowchart for selecting a size

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

Obtain the value of each application motion profile

<table>
<thead>
<tr>
<th>Load torque</th>
<th>T1 to Tn (Nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>t1 to tn (sec)</td>
</tr>
<tr>
<td>Output rotational speed</td>
<td>n1 to nn (rpm)</td>
</tr>
</tbody>
</table>

Normal operation pattern

- Starting (acceleration): T1, t1, n1
- Steady operation: T2, t2, n2
- Stopping (deceleration): T3, t3, n3
- Dwell: T4, t4, n4

Maximum rotational speed

| Max. output rotational speed | n2 max ≥ n1 to nn |
|                            | n1 max + n1×R to n0×R |

Emergency stop torque

- When impact torque is applied: T6
- Required life: L10 = L (hours)

Check the following conditions:

1. Actual average load torque (Tav) ≤ Limit for average torque or Max. average input speed (n max).
2. Actual average load torque (Tav) ≤ Limit for average torque or Max. average input speed (n max). (A limit is placed on n max by motors.)
3. Calculate the maximum input speed (n max) from the maximum output speed (no max) and the reduction ratio (R).
4. ni max = no max × R
5. Check whether the maximum input speed is equal to or less than the values specified in the rating table.
6. Calculate the average load torque applied on the output side from the application motion profile: Tan = \( \frac{\sum Ti \cdot Ti}{n1} \)
7. Check whether T1 and T3 are equal to or less than the limit for momentary torque in the rating table.
8. Calculate the average output speed based on the application motion profile: no av = \( \frac{\sum Ti \cdot Ti}{n1 + t1 + t2 + t3 + t4} \)
9. Select a preliminary model number with the following condition: T av ≥ Average load torque (See the rating table on page 123)
10. Determine the reduction ratio (R) based on the maximum output speed (no max) and maximum input speed (n max).
11. Calculate the average output speed based on the application motion profile: no av = \( \frac{\sum Ti \cdot Ti}{n1 + t1 + t2 + t3 + t4} \)

Refer to the Caution note at the bottom of page 130.

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 10%.

- Actual average load torque (Tav) > Limit for average torque
- Actual average input rotational speed (ni av) > Maximum average input speed (n max)
- Gearhead housing temperature > 70°C.
Example of size selection

<table>
<thead>
<tr>
<th>Load torque (T\textsubscript{r} (Nm))</th>
<th>Time (t\textsubscript{r} (sec))</th>
<th>Output rotational speed (n\textsubscript{r} (rpm))</th>
<th>Max. output rotational speed (no max = 120 rpm)</th>
<th>Max. input rotational speed (ni max = 5,000 rpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time (t\textsubscript{r} (sec))</td>
<td>T\textsubscript{r} = 70 Nm, t\textsubscript{r} = 0.3 sec, n\textsubscript{r} = 60 rpm</td>
<td>T\textsubscript{r} = 70 Nm, t\textsubscript{r} = 0.3 sec, n\textsubscript{r} = 60 rpm</td>
<td>T\textsubscript{r} = 70 Nm, t\textsubscript{r} = 0.3 sec, n\textsubscript{r} = 60 rpm</td>
<td>T\textsubscript{r} = 70 Nm, t\textsubscript{r} = 0.3 sec, n\textsubscript{r} = 60 rpm</td>
</tr>
<tr>
<td>Output rotational speed (n\textsubscript{r} (rpm))</td>
<td>T\textsubscript{r} = 18 Nm, t\textsubscript{r} = 3 sec, n\textsubscript{r} = 120 rpm</td>
<td>T\textsubscript{r} = 18 Nm, t\textsubscript{r} = 3 sec, n\textsubscript{r} = 120 rpm</td>
<td>T\textsubscript{r} = 18 Nm, t\textsubscript{r} = 3 sec, n\textsubscript{r} = 120 rpm</td>
<td>T\textsubscript{r} = 18 Nm, t\textsubscript{r} = 3 sec, n\textsubscript{r} = 120 rpm</td>
</tr>
<tr>
<td>Maximum rotational speed (R)</td>
<td>T\textsubscript{r} = 35 Nm, t\textsubscript{r} = 3 sec, n\textsubscript{r} = 60 rpm</td>
<td>T\textsubscript{r} = 35 Nm, t\textsubscript{r} = 3 sec, n\textsubscript{r} = 60 rpm</td>
<td>T\textsubscript{r} = 35 Nm, t\textsubscript{r} = 3 sec, n\textsubscript{r} = 60 rpm</td>
<td>T\textsubscript{r} = 35 Nm, t\textsubscript{r} = 3 sec, n\textsubscript{r} = 60 rpm</td>
</tr>
<tr>
<td>Dwell (T\textsubscript{d} = 0 Nm, t\textsubscript{d} = 5 sec, n\textsubscript{d} = 0 rpm)</td>
<td>T\textsubscript{d} = 0 Nm, t\textsubscript{d} = 5 sec, n\textsubscript{d} = 0 rpm</td>
<td>T\textsubscript{d} = 0 Nm, t\textsubscript{d} = 5 sec, n\textsubscript{d} = 0 rpm</td>
<td>T\textsubscript{d} = 0 Nm, t\textsubscript{d} = 5 sec, n\textsubscript{d} = 0 rpm</td>
<td>T\textsubscript{d} = 0 Nm, t\textsubscript{d} = 5 sec, n\textsubscript{d} = 0 rpm</td>
</tr>
</tbody>
</table>

Calculate the average load torque applied on the output side based on the application motion profile: \( T_{av} \) (Nm).

\[
T_{av} = \frac{\text{Load output torque}}{\text{Load output torque}} \times \frac{T_1}{T_1} \times \frac{T_2}{T_2} \times \frac{T_3}{T_3} \times \frac{T_4}{T_4}
\]

Calculate the average output speed based on the application motion profile: \( n_{av} \) (rpm).

\[
n_{av} = \frac{\text{Output speed}}{\text{Output speed}} \times \frac{n_1}{n_1} \times \frac{n_2}{n_2} \times \frac{n_3}{n_3} \times \frac{n_4}{n_4}
\]

Make a preliminary model selection with the following conditions. \( T_{av} = 30.2 Nm \leq 60Nm \). (HPG-20A-33 is tentatively selected based on the average load torque (see the rating table on page 123) of size 20 and reduction ratio of 33.)

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

\[
\frac{5,000 \text{ rpm}}{120 \text{ rpm}} = 41.7 \geq 33
\]

Calculate the average input rotational speed (ni av) from the average output speed (no av) and reduction ratio (R): ni av = 46.2 rpm - 33 = 1,525 rpm \leq 6,000 rpm (maximum input rotational speed of size 20)

Check whether the maximum input speed is equal to or less than the values specified in the rating table.

\[
n_i \text{ max} = 3,960 \text{ rpm} \leq 6,000 \text{ rpm}
\]

Check whether the maximum speed of size 20 is 3,960 rpm \leq 6,000 rpm (maximum input rotational speed of size 20)

Check whether \( T_1 \) and \( T_3 \) are less than the peak torques (Nm) on start and stop in the rating table.

\[
T_1 = 70 \text{ Nm} \leq 100 \text{ Nm} \text{ (Limit for repeated torque, size 20)}
\]

Check whether \( T_3 \) is equal to or less than the values of the momentary max. torque (Nm) in the rating table.

\[
T_3 = 35 \text{ Nm} \leq 217 \text{ Nm} \text{ (momentary max. torque of size 20)}
\]

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

\[
L_{10} = 20,000 \times \left( \frac{28 \text{ Nm}}{30.2 \text{ Nm}} \right)^{\frac{3,000 \text{ rpm}}{1,525 \text{ rpm}}} = 34,543 \text{ (hours)} \geq 30,000 \text{ (hours)}
\]

The selection of model number HPG-20A-33 is confirmed from the above calculations.
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>
<thead>
<tr>
<th>Input rotational speed</th>
<th>HPGP / HPG / HPF / HPN: 3000rpm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CSG-GH / CSF-GH: Indicated on each efficiency graph.</td>
</tr>
<tr>
<td>Ambiident temperature</td>
<td>25°C</td>
</tr>
<tr>
<td>Lubricant</td>
<td>Use standard lubricant for each model. (See pages 163-164 for details.)</td>
</tr>
</tbody>
</table>

### 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.

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

![Graph 134-1](image1)

**CSG-GH**

Graph 134-1

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

![Graph 134-2](image2)

**CSF-GH**

Graph 134-2
Technical Information / Handling Explanation

**Checking the life**

**Specification of input shaft bearing**

**Checking procedure**

- Maximum axial load (F_{ax})
- Maximum moment load (M_{m})
- Average axial load (F_{av})

- TR_{i} is an input torque corresponding to output torque at 25 °C.

- If moment load and axial load fluctuate, they should be converted into the average load to check the life of the bearing.

- To calculate the life and check it, use standard lubricant for each model. (See pages 163-164 for details.)

- The maximum moment load (M_{m}) is calculated as follows:

  
  
  \[ M_{m} = \frac{121 \times F_{ai}}{TR_{i}} \]

  
  \[ M_{m} = \frac{3.6 \times F_{ai}}{TR_{i}} \]

  
  \[ M_{m} = \frac{3.6 \times F_{ai} \times TR_{i}}{106} \]

  
  \[ M_{m} = \frac{1.232 \times F_{ai}}{TR_{i}} \]

- The allowable moment load (M_{c}) and allowable axial load (F_{a}) are indicated on each efficiency graph.

- The allowable radial load (F_{r}) is calculated as follows:

  
  
  \[ F_{r} = \frac{1538 \times F_{ai}}{TR_{i} \times 10} \]

  
  \[ F_{r} = \frac{5600 \times F_{ai}}{TR_{i} \times 25} \]

  
  \[ F_{r} = \frac{1510 \times F_{ai}}{TR_{i} \times 50} \]

  
  \[ F_{r} = \frac{320 \times F_{ai}}{TR_{i} \times 100} \]

- In general, the efficiency of a speed reducer depends on the reduction ratio, input rotational speed, load torque, temperature, and lubrication condition.

- Efficiency correction coefficient for low-temperature correction is applied to the efficiency at 25 °C or less by multiplying the efficiency at 25 °C by the low-temperature correction coefficient.

- Use standard lubricant for each model. (See pages 163-164 for details.)
**Technical Data**

**Size 20 : Gearhead**

---

### Technical Information / Handling Explanation

#### Gearhead with D bearing (double sealed)

- **Reduction ratio = 5**
- **Reduction ratio = 15, 21**
- **Reduction ratio = 33, 45**

#### Gearhead (standard item)

- **Reduction ratio = 11**
- **Reduction ratio = 15, 21**
- **Reduction ratio = 33, 45**

---

**Technical Data**

**Reduction ratio = 5**

- **Graph 136-1**

---

**Reduction ratio = 11**

- **Graph 136-2**

---

**Reduction ratio = 15, 21**

- **Graph 136-3**

---

**Reduction ratio = 33, 45**

- **Graph 136-4**

---

**Size 32 : Gearhead**

---

### Technical Information / Handling Explanation

#### Gearhead with D bearing (double sealed)

- **Reduction ratio = 5**
- **Reduction ratio = 15, 21**
- **Reduction ratio = 33, 45**

#### Gearhead (standard item)

- **Reduction ratio = 11**
- **Reduction ratio = 15, 21**
- **Reduction ratio = 33, 45**

---

**Technical Data**

**Reduction ratio = 5**

- **Graph 136-5**

---

**Reduction ratio = 11**

- **Graph 136-6**

---

**Reduction ratio = 15, 21**

- **Graph 136-7**

---

**Reduction ratio = 33, 45**

- **Graph 136-8**

---

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

---

**Input Bearing Specifications and Checking Procedure**

* The allowable radial load of HPG series is the value of a radial load applied at the mid-point of the input shaft.

* The allowable axial load is the value of an axial load applied along the axis of rotation.

---

**Input torque corresponding to output torque**

---

**Reduction ratio = 11**

- **Graph 136-2**

---

**Reduction ratio = 15, 21**

- **Graph 136-3**

---

**Reduction ratio = 33, 45**

- **Graph 136-4**

---

**Input torque**

---

**Efficiency %**

---

**Nm**

---

**kr**

---

**kgf**

---

**Graph 136-1**

---

**Graph 136-2**

---

**Graph 136-3**

---

**Graph 136-4**

---

**Graph 136-5**

---

**Graph 136-6**

---

**Graph 136-7**

---

**Graph 136-8**

---

**Table 157-1**

---

**Table 157-2**

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**Table 157-3**

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**Table 157-4**

---

**Table 158-1**

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**Table 158-2**

---

**Table 158-3**

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**Table 158-4**

---

**Formula 158-1**

---

**Formula 158-2**

---

**Formula 158-3**

---

**Formula 158-4**

---
Input Bearing Specifications and Checking Procedure

**Size 32**

**Specification of input bearing**

**Checking procedure**

1. **Maximum radial load (Fri)\_\text{max}**
2. **Maximum moment load (Mi)\_\text{av}**
3. **Average moment load (Mi)\_\text{av}**

**Table 157-2 and 157-4**

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

**Size 32 : Gearhead**

- **Efficiency %**
  - **Reduction ratio = 5**
  - **Efficiency %**: 100
  - **Efficiency %**: 90
  - **Efficiency %**: 80
  - **Efficiency %**: 70
  - **Efficiency %**: 60
  - **Efficiency %**: 50
  - **Efficiency %**: 40
  - **Efficiency %**: 30
  - **Efficiency %**: 20
  - **Efficiency %**: 10

- **Input torque corresponding to output torque**
  - **Reduction ratio = 5**
  - **Input torque**: [Graph 137-1]

- **Input torque corresponding to output torque**
  - **Reduction ratio = 11**
  - **Input torque**: [Graph 137-2]

- **Input torque corresponding to output torque**
  - **Reduction ratio = 15**
  - **Input torque**: [Graph 137-3]

- **Input torque corresponding to output torque**
  - **Reduction ratio = 21**
  - **Input torque**: [Graph 137-4]

- **Input torque corresponding to output torque**
  - **Reduction ratio = 33**
  - **Input torque**: [Graph 137-5]

- **Input torque corresponding to output torque**
  - **Reduction ratio = 45**
  - **Input torque**: [Graph 137-6]

- **Input torque corresponding to output torque**
  - **Reduction ratio = 45**
  - **Input torque**: [Graph 137-7]

- **Input torque corresponding to output torque**
  - **Reduction ratio = 45**
  - **Input torque**: [Graph 137-8]

---

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

*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**

**Technical Data**

**Reduction ratio = 5**  
Graph 138-1

**Reduction ratio = 21**  
Graph 138-3

**Reduction ratio = 9**  
Graph 138-2

**Reduction ratio = 37, 45**  
Graph 138-4

**Reduction ratio = 3, 5**  
Graph 138-5

**Reduction ratio = 15, 21**  
Graph 138-7

**Reduction ratio = 11**  
Graph 138-8

**Reduction ratio = 33, 45**  
Graph 138-9

---

**Technical Information / Handling Explanation**

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.

---

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

---

**Input Bearing Specifications and Checking Procedure**

**Size 11**

- **Reduction ratio = 5**, **Reduction ratio = 21**, **Reduction ratio = 9**
- **Efficiency %**
  - **96.9%** for **Reduction ratio = 5**
  - **97.0%** for **Reduction ratio = 21**
  - **97.0%** for **Reduction ratio = 9**

**Size 14**

- **Reduction ratio = 3, 5**, **Reduction ratio = 15, 21**, **Reduction ratio = 11**
- **Efficiency %**
  - **96.9%** for **Reduction ratio = 3**
  - **97.0%** for **Reduction ratio = 5**
  - **97.0%** for **Reduction ratio = 15**
  - **97.0%** for **Reduction ratio = 21**
  - **97.0%** for **Reduction ratio = 11**

---

**Note**

- *2* The allowable radial load of HPG series is the value of a radial load applied at the mid-point of the input shaft.
- *1* The allowable axial load is the value of an axial load applied along the axis of rotation.

---

**Gearhead & Input Shaft Unit**
The allowable radial load of HPG series is the value of a radial load applied at the mid-point of the input shaft.

Check the life of the bearing on the input side if the reducer is an HPG input shaft unit or an HPF hollow shaft unit.

**Technical Data**

### Gearhead & Input Shaft Unit

#### HPG

**Size 20**

**Reduction ratio = 3, 5**

<table>
<thead>
<tr>
<th>Reduction ratio</th>
<th>Input torque Nm</th>
<th>Efficiency %</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
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<td>100</td>
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<tr>
<td>5</td>
<td>0</td>
<td>100</td>
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</tbody>
</table>

See Fig. 139-1.

**Reduction ratio = 15, 21**

<table>
<thead>
<tr>
<th>Reduction ratio</th>
<th>Input torque Nm</th>
<th>Efficiency %</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
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<td>100</td>
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<tr>
<td>21</td>
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</table>

See Fig. 139-3.

**Reduction ratio = 11**

<table>
<thead>
<tr>
<th>Reduction ratio</th>
<th>Input torque Nm</th>
<th>Efficiency %</th>
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</thead>
<tbody>
<tr>
<td>11</td>
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</table>

See Fig. 139-2.

**Reduction ratio = 33, 45**

<table>
<thead>
<tr>
<th>Reduction ratio</th>
<th>Input torque Nm</th>
<th>Efficiency %</th>
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</thead>
<tbody>
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<td>33</td>
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<td>100</td>
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<tr>
<td>45</td>
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<td>100</td>
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</table>

See Fig. 139-4.

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

---

**Size 32**

**Reduction ratio = 3, 5**

<table>
<thead>
<tr>
<th>Reduction ratio</th>
<th>Input torque Nm</th>
<th>Efficiency %</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
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<tr>
<td>5</td>
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</table>

See Fig. 139-5.

**Reduction ratio = 15, 21**

<table>
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<th>Reduction ratio</th>
<th>Input torque Nm</th>
<th>Efficiency %</th>
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</thead>
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<td>100</td>
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<tr>
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See Fig. 139-7.

**Reduction ratio = 11**

<table>
<thead>
<tr>
<th>Reduction ratio</th>
<th>Input torque Nm</th>
<th>Efficiency %</th>
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<tr>
<td>11</td>
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See Fig. 139-6.

**Reduction ratio = 33, 45**

<table>
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<tr>
<th>Reduction ratio</th>
<th>Input torque Nm</th>
<th>Efficiency %</th>
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<tr>
<td>33</td>
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<tr>
<td>45</td>
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See Fig. 139-8.
**Technical Data**

### Gearhead & Input Shaft Unit : HPG

#### Size 50

- **Reduction ratio = 3, 5**
  - Graph 140-1
  - Efficiency %
  - Input torque Nm
  - Reducing ratio = 3
  - Gearhead (standard item)
  - Gearhead with D bearing (double sealed)
  - Input Shaft
  - Input torque corresponding to output torque

- **Reduction ratio = 11**
  - Graph 140-2
  - Efficiency %
  - Input torque Nm
  - Reducing ratio = 11
  - Gearhead (standard item)
  - Gearhead with D bearing (double sealed)
  - Input Shaft
  - Input torque corresponding to output torque

- **Reduction ratio = 15, 21**
  - Graph 140-3
  - Efficiency %
  - Input torque Nm
  - Reducing ratio = 15
  - Reducing ratio = 21
  - Gearhead (standard item)
  - Gearhead with D bearing (double sealed)
  - Input Shaft
  - Input torque corresponding to output torque

- **Reduction ratio = 33, 45**
  - Graph 140-4
  - Efficiency %
  - Input torque Nm
  - Reducing ratio = 33
  - Reducing ratio = 45
  - Gearhead (standard item)
  - Gearhead with D bearing (double sealed)
  - Input Shaft
  - Input torque corresponding to output torque

#### Size 65

- **Reduction ratio = 4, 5**
  - Graph 140-5
  - Efficiency %
  - Input torque Nm
  - Reducing ratio = 4
  - Reducing ratio = 5
  - Gearhead (standard item)
  - Gearhead with D bearing (double sealed)
  - Input Shaft
  - Input torque corresponding to output torque

- **Reduction ratio = 12**
  - Graph 140-6
  - Efficiency %
  - Input torque Nm
  - Reducing ratio = 12
  - Gearhead (standard item)
  - Gearhead with D bearing (double sealed)
  - Input Shaft
  - Input torque corresponding to output torque

- **Reduction ratio = 15, 20**
  - Graph 140-7
  - Efficiency %
  - Input torque Nm
  - Reducing ratio = 15
  - Reducing ratio = 20
  - Gearhead (standard item)
  - Gearhead with D bearing (double sealed)
  - Input Shaft
  - Input torque corresponding to output torque

- **Reduction ratio = 25**
  - Graph 140-8
  - Efficiency %
  - Input torque Nm
  - Reducing ratio = 25
  - Gearhead (standard item)
  - Gearhead with D bearing (double sealed)
  - Input Shaft
  - Input torque corresponding to output torque

- **Reduction ratio = 40**
  - Graph 140-9
  - Efficiency %
  - Input torque Nm
  - Reducing ratio = 40
  - Gearhead (standard item)
  - Gearhead with D bearing (double sealed)
  - Input Shaft
  - Input torque corresponding to output torque

- **Reduction ratio = 50**
  - Graph 140-10
  - Efficiency %
  - Input torque Nm
  - Reducing ratio = 50
  - Gearhead (standard item)
  - Gearhead with D bearing (double sealed)
  - Input Shaft
  - 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.

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

* 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).

* The allowable radial load of HPG series is the value of a radial load applied at the mid-point of the input shaft.

---

**Table 157-1 and 157-4**

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<thead>
<tr>
<th>Size 11</th>
<th>Gearhead</th>
<th>HPG-Helical</th>
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<tbody>
<tr>
<td><strong>Reduction ratio = 4</strong></td>
<td>Graph 141-1</td>
<td><strong>Reduction ratio = 5, 6</strong></td>
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**Technical Data**

**Size 20**: Gearhead  
**HPG-Helical**

**Input Bearing Specifications and Checking Procedure**

- **Size**: 65
- **Efficiency %**: 100
- **Maximum radial load (Fri)**: 100
- **Maximum axial load (Fai)**: 100
- **Maximum moment load (Mi)**: 100

To calculate:

- **Average input speed (Ni)**
- **Average axial load (Fai)**
- **Average moment load (Mi)**

Refer to Table 157-2 and 157-4 for specifications.

---

**Table 157-2** and **Table 157-4**

- **Reduction ratio**: 3, 4
- **Reduction ratio**: 5, 6
- **Reduction ratio**: 7, 8
- **Reduction ratio**: 9, 10

- **Efficiency %**: 100
- **Efficiency %**: 90
- **Efficiency %**: 80
- **Efficiency %**: 70
- **Efficiency %**: 60
- **Efficiency %**: 50
- **Efficiency %**: 40
- **Efficiency %**: 30
- **Efficiency %**: 20

---

**Gearhead with D bearing (double sealed)**

- **Allowable radial load (Frc)**
- **Allowable axial load (Fac)**
- **Allowable moment load (Mc)**

**Gearhead with Z bearing (Double shielded)**

- **Input torque corresponding to output torque**

---

**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.**

---

**Figure 158-1**

**Table 158-2**

- **Reduction ratio**: 3
- **Reduction ratio**: 4
- **Reduction ratio**: 5
- **Reduction ratio**: 6
- **Reduction ratio**: 7
- **Reduction ratio**: 8
- **Reduction ratio**: 9
- **Reduction ratio**: 10

---

**Technical Information / Handling Explanation**
Technical Data

**Size 32 RA3** : Right Angle Gearhead

<table>
<thead>
<tr>
<th>Reduction ratio = 5</th>
<th>Reduction ratio = 11</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Graph 143-1" /></td>
<td><img src="image2" alt="Graph 143-2" /></td>
</tr>
<tr>
<td><img src="image3" alt="Graph 143-3" /></td>
<td><img src="image4" alt="Graph 143-4" /></td>
</tr>
</tbody>
</table>

**Size 50 RA3** : Right Angle Gearhead

<table>
<thead>
<tr>
<th>Reduction ratio = 5</th>
<th>Reduction ratio = 11</th>
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<tbody>
<tr>
<td><img src="image5" alt="Graph 143-5" /></td>
<td><img src="image6" alt="Graph 143-6" /></td>
</tr>
<tr>
<td><img src="image7" alt="Graph 143-7" /></td>
<td><img src="image8" alt="Graph 143-8" /></td>
</tr>
</tbody>
</table>

T<sub>n</sub>: Input torque corresponding to output torque
Technical Data

**Technical Information / Handling Explanation**

*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).

### Checking Maximum Load

Shaft Unit.

#### Checking Procedure

1. 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.

#### Specification of Input Shaft Bearing

<table>
<thead>
<tr>
<th>Size</th>
<th>RA5</th>
<th>RA5</th>
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<tbody>
<tr>
<td></td>
<td>65</td>
<td>50</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Maximum Axial Load (Fai)</th>
<th>96.9</th>
<th>13.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Moment Load (Mi)</td>
<td>13.5</td>
<td>19</td>
</tr>
<tr>
<td>Average Input Speed (Ni)</td>
<td>210</td>
<td>29700</td>
</tr>
<tr>
<td>Average Moment Load (Mi)</td>
<td>14500</td>
<td>100</td>
</tr>
<tr>
<td>Efficiency %</td>
<td>30</td>
<td>6.3</td>
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</tbody>
</table>

#### Graphs

- **Reduction ratio = 5**: Graphs 144-1, 144-3, 144-5, 144-7
- **Reduction ratio = 11**: Graphs 144-2, 144-4, 144-6, 144-8
- **Reduction ratio = 15, 21**: Graphs 144-1, 144-3, 144-5, 144-7
- **Reduction ratio = 33, 45**: Graphs 144-2, 144-4, 144-6, 144-8

Tn: Input torque corresponding to output torque
### Specification of Input Shaft Bearing

#### Checking Procedure

- **Size**: 65, 50, 32
- **Maximum Radial Load (Fr) max**:
  - 65: 5800 N
  - 50: 9700 N
  - 32: 25100 N

- **Allowable Moment Load (Mc)**:
  - 65: 21.4 kgf
  - 50: 3030 kgf
  - 32: 1480 kgf

- **Efficiency %**:
  - Size 65: 1538 %
  - Size 50: 14800 %
  - Size 32: 29700 %

#### Formula 158-3

Calculation of Average Axial Load

- **Average Axial Load (Fai av)**:
  - (1/2) * (Fr max + Fa)

#### Formula 158-4

Calculation of Average Moment Load

- **Average Moment Load (Mi av)**:
  - (1/2) * (Mc + Mi)

#### Table 158-2

<table>
<thead>
<tr>
<th>Reduction Ratio</th>
<th>Efficiency %</th>
<th>Input Torque Nm</th>
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<tbody>
<tr>
<td>20</td>
<td>100</td>
<td>2050</td>
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<tr>
<td>50</td>
<td>100</td>
<td>2050</td>
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</tbody>
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#### Technical Data

- **Basic Load Rating**: 275 N
- **Basic Dynamic Load Rating**: 565 N
- **Basic Static Load Rating**: 335 N
- **Input Torque Nm**: 537 N
- **Graph 145-7**
- **Graph 145-8**

---

Non-technical sections have been omitted for brevity.

---

**Technical Information / Handling Explanation**

- **Allowable Axial Load**: The value of an axial load applied along the axis of rotation.
- **Allowable Radial Load**: The value of a radial load applied at the mid-point of the input shaft.
Size 20  HPN

**Technical Data**

- **Gearheads**

**Technical Data**

- See Table 157-1 and -3
- See Table 158-1 and -2

**Input Bearing Specifications and Checking Procedure**

- **Average input speed** ($N_{iav}$)
- **Average moment load** ($M_{iav}$)
- **Efficiency**

**Maximum radial load ($F_{rmax}$)**

**Maximum axial load ($F_{a_{max}}$)**

**Maximum moment load ($M_{i_{max}}$)**

- **Allowable moment load** ($M_{a_{max}}$)
- **Allowable axial load** ($F_{a_{max}}$)
- **Allowable radial load** ($F_{r_{max}}$)

---

**Formula 158-2**

$$L_{ri} = L_{ai} \times F_{ai}$$

**Graph 146-1**

**Graph 146-2**

**Graph 146-3**

**Graph 146-4**

**Graph 146-5**

**Graph 146-6**

**Graph 146-7**

**Graph 146-8**

**Graph 146-9**

---

*2 The allowable radial load of HPG series is the value of a radial load applied at the mid-point of the input shaft.
**Technical Data**

**Size 25**: Hollow Shaft Unit  
**HPF**

**Reduction ratio = 11**

- **Graph 148-1**

<table>
<thead>
<tr>
<th>Input torque (Nm)</th>
<th>Efficiency %</th>
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<td>3</td>
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<td>4</td>
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<td>5</td>
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<td>6</td>
<td>60</td>
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**Input torque corresponding to output torque** $T_{in}$  

**Efficiency**

- 100
- 90
- 80
- 70
- 60
- 50
- 40
- 30
- 20
- 10

**Size 32**: Hollow Shaft Unit  
**HPF**

**Reduction ratio = 11**

- **Graph 148-2**

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<th>Efficiency %</th>
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<td>50</td>
</tr>
<tr>
<td>6</td>
<td>60</td>
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</tbody>
</table>

**Input torque corresponding to output torque** $T_{in}$  

**Efficiency**

- 100
- 90
- 80
- 70
- 60
- 50
- 40
- 30
- 20
- 10

---

**Allowable moment load** $M_c$  

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<tr>
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<td>1206</td>
<td>5800</td>
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**Allowable axial load** $F_a$  

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<td>9.88</td>
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<td>2.0</td>
<td>0.98</td>
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**Allowable radial load** $F_r$  

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<tr>
<td>11</td>
<td>1538</td>
<td>7530</td>
<td>1538</td>
</tr>
</tbody>
</table>

---

**Average input speed** $n_{in}$  

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<tr>
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<td>7530</td>
<td>1538</td>
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**Average moment load** $M_{av}$  

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<td>3470</td>
<td>7070</td>
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</tbody>
</table>

---

**Average axial load** $F_{ai}$  

<table>
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</tr>
</thead>
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</tr>
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<td>14</td>
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<td>878</td>
</tr>
<tr>
<td>11</td>
<td>1538</td>
<td>7530</td>
<td>1538</td>
</tr>
</tbody>
</table>

---

**Effective load rating** $C_r$  

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<td>96.9</td>
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<td>44.4</td>
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<td>44.4</td>
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<tr>
<td>11</td>
<td>13.5</td>
<td>6.3</td>
<td>13.5</td>
</tr>
</tbody>
</table>

---

**Technical Information / Handling Explanation**

- The allowable radial load of HPG series is the value of a radial load applied at the mid-point of the input shaft.
- The allowable axial load is the value of an axial load applied along the axis of rotation.
- Calculating the life and checking it.
- See Fig. 158-1.
- See Formula 158-3.

---

**Figure 158-1**

**External load influence diagram**

- Dynamic equivalent load $N$ (kgf)
- Average input speed
- Moment load $M$ (Nm)
- Time: $t$
- How to calculate the average axial load $F_{ai}$

---

**Formula 158-3**

Average axial load $F_{ai}$

$$ F_{ai} = 0.041 \times M_{av} + 0.071 \times L_{ri} + 0.444 \times L_{ai} $$
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).

The allowable axial load is the value of an axial load applied along the axis of rotation.

(2) Checking the life

Average input speed (\(N_i\))

Average moment load (\(M_i\))

Calculate:

- Allowable moment load (\(M_{ac}\))
- Allowable axial load (\(F_{ac}\))
- Allowable radial load (\(F_{rc}\))

Check the life according to Calculation Formula (Average moment load, average axial load, average input speed).

If moment load and axial load fluctuate, they should be converted into the average load to check the life of the bearing.

Calculating life of input bearing

\[ L_{10} = \frac{1000 \times N_i \times M_{ac}}{F_{ac}} \]

See Table 157-1 and -3 and check the life.

Input rotational speed

<table>
<thead>
<tr>
<th>Reduction ratio = 50</th>
<th>Reduction ratio = 80</th>
<th>Reduction ratio = 100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graph 149-1</td>
<td>Graph 149-2</td>
<td>Graph 149-3</td>
</tr>
<tr>
<td>Efficiency %</td>
<td>Efficiency %</td>
<td>Efficiency %</td>
</tr>
<tr>
<td>Input torque Ncm</td>
<td>Input torque Ncm</td>
<td>Input torque Ncm</td>
</tr>
<tr>
<td>0 5 10 15 20 25</td>
<td>0 2 4 6 8 10 12</td>
<td>0 2 4 6 8 10 12</td>
</tr>
</tbody>
</table>

Input rotational speed

- 500 rpm
- 1000 rpm
- 2000 rpm
- 3500 rpm

Technical Data

Size 14: Gearhead

- CSG-GH
- CSF-GH

Reduction ratio = 50

Graph 149-1

Input rotational speed

- 500 rpm
- 1000 rpm
- 2000 rpm
- 3500 rpm

Size 20: Gearhead

- CSG-GH
- CSF-GH

Reduction ratio = 50

Graph 149-1

Input rotational speed

- 500 rpm
- 1000 rpm
- 2000 rpm
- 3500 rpm
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).

**Checking maximum load**

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.

**Specification of input shaft bearing**

<table>
<thead>
<tr>
<th>Size</th>
<th>65</th>
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<tbody>
<tr>
<td>8600</td>
<td>5540</td>
<td>3285</td>
<td>1538</td>
<td>157</td>
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<tr>
<td>8600</td>
<td>5540</td>
<td>3285</td>
<td>1538</td>
<td>157</td>
</tr>
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<td>3285</td>
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<td>157</td>
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**Specification of input bearing**

<table>
<thead>
<tr>
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<th>25</th>
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</thead>
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<td>10</td>
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<tr>
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<td>4.53</td>
<td>0.64</td>
<td>10</td>
<td>53.2</td>
</tr>
<tr>
<td>9.88</td>
<td>4.53</td>
<td>0.64</td>
<td>10</td>
<td>53.2</td>
</tr>
<tr>
<td>9.88</td>
<td>4.53</td>
<td>0.64</td>
<td>10</td>
<td>53.2</td>
</tr>
</tbody>
</table>

**Checking procedure**

Calculate:

- **Allowable moment load (Mc)**
- **Allowable axial load (Fac)**
- **Allowable radial load (Frc)**

Maximize the following formulas are established in all circumstances:

- **Input rotational speed**
- **Input torque**
- **Graph 151-1**

See Table 157-1 and -3.

See Fig. 158-1.
### Output Shaft Bearing Load Limits

HPN Series Output Shaft Load Limits are plotted below.

HPN uses deep groove 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.

**Graph 152-1**

- **HPN-11**
- **HPN-14**
- **HPN-20**

**Graph 152-4**

- **HPN-32**
- **HPN-40**

**Graph 152-5**

- **Load coefficient**
  - fw=1: 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** ($M_{\text{max}}$)
   
   Calculate the maximum moment load ($M_{\text{max}}$). 

2. **Checking the life**
   
   Calculate the life and check it.

3. **Checking the static safety coefficient**
   
   Calculate the static equivalent radial load coefficient ($P_o$).

### Specification of output bearing

**HPGP/HPG Series** Table 153-1, -2 and -3 indicate the cross roller bearing specifications for in-line, right angle and input shaft gears.

#### Technical Data

- **Basic dynamic load rating ($C_i$)**: $N$ (kgf), $Nm$ (kgf Nm), $Nm/kgf$ (kgf N m)
- **Basic static load rating ($C_o$)**: $N$ (kgf), $Nm$ (kgf Nm), $Nm/kgf$ (kgf N m)
- **Moment stiffness ($K$)**: $Kgf$ (kgf N m/rad), $Kgf$ (kgf N m/arc min)

<table>
<thead>
<tr>
<th>Size</th>
<th>Reduction ratio</th>
<th>Allowable radial load ($F_{\text{rmax}}$)</th>
<th>Allowable axial load ($F_{\text{axmax}}$)</th>
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<tbody>
<tr>
<td>11</td>
<td>5</td>
<td>280</td>
<td>430</td>
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<td>(9)</td>
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<td>830</td>
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<td>700</td>
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<td></td>
<td>11</td>
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<td>980</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>720</td>
<td>1080</td>
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<td>1880</td>
<td>2830</td>
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<table>
<thead>
<tr>
<th>Size</th>
<th>Reduction ratio</th>
<th>Allowable radial load ($F_{\text{rmax}}$)</th>
<th>Allowable axial load ($F_{\text{axmax}}$)</th>
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</table>

* The ratio specified in parentheses is for the HPG Series.

(Note: Table 153-1, -2 and -3 Table 154-1 and -2)

1. The basic dynamic load rating means a certain static radial load so that the basic dynamic rated life of the roller bearing is a million rotations.
2. The basic static load rating means a static load that gives a certain level of contact stress ($4kN/mm^2$) in the center of the contact area between rolling element receiving the maximum load and orbit.
3. The allowable moment load is a maximum moment load applied to the bearing. Within the allowable range, basic performance is maintained and the bearing is operable. Check the bearing life based on the calculations shown on the next page.
4. The value of the moment stiffness is the average value.
5. The allowable radial load and allowable axial load are the values that satisfy the life of a speed reducer when a pure radial load or an axial load applies to the main bearing. ($L_r + R = 0$ mm for radial load and $L_a = 0$ mm for axial load) If a compound load applies, refer to the calculations shown on the next page.
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.

**Technical Data**

### CSG-GH/CSF-GH Series

Table 154-1 indicates the specifications for cross roller bearing.

<table>
<thead>
<tr>
<th>Size</th>
<th>Pitch circle</th>
<th>Offset amount</th>
<th>Basic load rating</th>
<th>Allowable moment load Mc</th>
<th>Allowable axial load Fac</th>
<th>Allowable radial load Frc</th>
<th>Moment stiffness Km</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dp (m)</td>
<td>R (m)</td>
<td>Basic dynamic load rating C₁</td>
<td>Basic static load rating Co₁</td>
<td>x10⁴ Nm/rad</td>
<td>kgf/arc min</td>
<td>N</td>
</tr>
<tr>
<td>------</td>
<td>-------</td>
<td>------</td>
<td>----------------------------</td>
<td>---------------------------</td>
<td>-------------------</td>
<td>-----------------</td>
<td>-----</td>
</tr>
<tr>
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<td>0.011</td>
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<td>521</td>
<td>7060</td>
<td>720</td>
<td>27</td>
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<td>1082</td>
<td>17300</td>
<td>1765</td>
<td>145</td>
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<td>0.014</td>
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<td>2092</td>
<td>32800</td>
<td>3347</td>
<td>258</td>
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<tr>
<td>45</td>
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<td>76000</td>
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<td>797</td>
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<tr>
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<td>0.0225</td>
<td>81600</td>
<td>8327</td>
<td>149000</td>
<td>15204</td>
<td>2156</td>
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</table>

### HPF Series

Table 154-2 indicates the specifications for cross roller bearing.

<table>
<thead>
<tr>
<th>Size</th>
<th>Pitch circle</th>
<th>Offset amount</th>
<th>Basic load rating</th>
<th>Allowable moment load Mc</th>
<th>Allowable axial load Fac</th>
<th>Allowable radial load Frc</th>
<th>Moment stiffness Km</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dp (m)</td>
<td>R (m)</td>
<td>Basic dynamic load rating C₁</td>
<td>Basic static load rating Co₁</td>
<td>x10⁴ Nm/rad</td>
<td>kgf/arc min</td>
<td>N</td>
</tr>
<tr>
<td>------</td>
<td>-------</td>
<td>------</td>
<td>----------------------------</td>
<td>---------------------------</td>
<td>-------------------</td>
<td>-----------------</td>
<td>-----</td>
</tr>
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<td>2296</td>
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<td>4071</td>
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</table>

**Note:** Table 153-1, -2 and -3 Table 154-1 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 | CSF-GH | HPF |

Maximum moment load \((M_{\text{max}})\) is obtained as follows. Make sure that \(M_{\text{max}} \leq M_c\).

\[
M_{\text{max}} = Fr_{\text{max}}(L_r+R) + Fa_{\text{max}}L_a
\]

| Fr_{\text{max}} | Max. radial load N (kgf) | See Fig. 155-1. |
| Fa_{\text{max}} | Max. axial load N (kgf) | See Fig. 155-1. |
| L_r, L_a — m | See Fig. 155-1. |
| R | Offset amount m | See “Output Bearing Specifications” of each series, p. 153 & 154 |
| dp | Circular pitch of roller m | See “Output Bearing Specifications” of each series, p. 153 & 154 |

How to calculate the radial and the axial load coefficient

| HPGP | HPG | CSF-GH | HPF |

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

<table>
<thead>
<tr>
<th>Formula 155-2</th>
</tr>
</thead>
</table>
| \[
F_{a_{\text{av}}} = \frac{F_{a_{\text{av}}}L_r+R}{L_a} \leq 1.5
\]
| \[
F_{a_{\text{av}}} = \frac{F_{a_{\text{av}}}L_r+R}{L_a} > 1.5
\]
| | \(X\) | \(Y\) |
| 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.” |
| L_r, L_a — m | See Fig. 155-1. |
| R | Offset amount m | See Fig. 155-1. |
| dp | Circular pitch of roller m | See Fig. 155-1. |

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

| HPGP | HPG | CSF-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 calculate the average radial load (Fr_{av})**

\[
Fr_{av} = \frac{n_1(F_{r1})^{10/3} + n_2(F_{r2})^{10/3} + \cdots + n_t(F_{rt})^{10/3}}{n_1 + n_2 + \cdots + n_t}
\]

Note that the maximum radial load within the \(t_1\) section is \(F_{r1}\) and the maximum radial load within the \(t_t\) section is \(F_{rt}\).

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

\[
Fa_{av} = \frac{n_1(F_{a1})^{10/3} + n_2(F_{a2})^{10/3} + \cdots + n_t(F_{at})^{10/3}}{n_1 + n_2 + \cdots + n_t}
\]

Note that the maximum axial load within the \(t_1\) section is \(F_{a1}\) and the maximum axial load within the \(t_t\) section is \(F_{at}\).

**How to calculate the average output speed (Na_{av})**

\[
Na_{av} = \frac{n_1 + n_2 + \cdots + n_t}{t_1 + t_2 + \cdots + t_t}
\]
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 using Formula 156-1. You can obtain the dynamic equivalent load (Pc) using Formula 156-2.

\[ P_c = X \left( \frac{F_{rav} + 2(F_{rav}(L_r+R) + F_{aav} \cdot L_a)}{dp} \right) + Y \cdot F_{aav} \]

Load coefficient Table 156-1

<table>
<thead>
<tr>
<th>Load status</th>
<th>fw</th>
</tr>
</thead>
<tbody>
<tr>
<td>During smooth operation without impact or vibration</td>
<td>1 to 1.2</td>
</tr>
<tr>
<td>During normal operation</td>
<td>1.2 to 1.5</td>
</tr>
<tr>
<td>During operation with impact or vibration</td>
<td>1.5 to 3</td>
</tr>
</tbody>
</table>

How to calculate the life during oscillating motion

Calculate the life of the cross roller bearing during oscillating motion by Formula 156-3.

\[ L_{oc} = \frac{10^6 \cdot 90}{60 \cdot n_1} \times \left( \frac{C}{fw \cdot Pc} \right)^{1/3} \]

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.

How to calculate the static safety coefficient

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 156-4.

\[ fs = \frac{Co}{Po} \]

<table>
<thead>
<tr>
<th>Load status</th>
<th>fs</th>
</tr>
</thead>
<tbody>
<tr>
<td>When high precision is required</td>
<td>≥3</td>
</tr>
<tr>
<td>When impact or vibration is expected</td>
<td>≥2</td>
</tr>
<tr>
<td>Under normal operating condition</td>
<td>≥1.5</td>
</tr>
</tbody>
</table>

Technical Data
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

(1) Checking maximum load

Calculate:
- Maximum moment load \( M_{\text{max}} \)
- Maximum axial load \( F_{\text{ai}} \)
- Maximum radial load \( F_{\text{rc}} \)

Maximum moment load \( M_{\text{max}} \) \( \leq \) Allowable moment load \( M_{\text{c}} \)
Maximum axial load \( F_{\text{ai}} \) \( \leq \) Allowable axial load \( F_{\text{ac}} \)
Maximum radial load \( F_{\text{rc}} \) \( \leq \) Allowable radial load \( F_{\text{r}} \)

(2) Checking the life

Calculate:
- Average moment load \( M_{\text{av}} \)
- Average axial load \( F_{\text{ai}} \)
- Average input speed \( N_{\text{in}} \)

Calculate the life and check it.

Specification of input bearing

<table>
<thead>
<tr>
<th>Size (mm)</th>
<th>Basic load rating</th>
<th>Basic load rating</th>
<th>Basic load rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( C_r ) ( \text{kgf} )</td>
<td>( C_r ) ( \text{N} )</td>
<td>( C_r ) ( \text{kgf} )</td>
</tr>
<tr>
<td>11</td>
<td>2700</td>
<td>275</td>
<td>1270</td>
</tr>
<tr>
<td>14</td>
<td>5800</td>
<td>590</td>
<td>3150</td>
</tr>
<tr>
<td>20</td>
<td>9700</td>
<td>990</td>
<td>5600</td>
</tr>
<tr>
<td>32</td>
<td>22500</td>
<td>2300</td>
<td>14800</td>
</tr>
<tr>
<td>50</td>
<td>35500</td>
<td>3600</td>
<td>25100</td>
</tr>
<tr>
<td>65</td>
<td>51000</td>
<td>5200</td>
<td>39500</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Size (mm)</th>
<th>Allowable moment load ( M_{\text{c}} ) ( \text{Nm} )</th>
<th>Allowable axial load ( F_{\text{ac}} ) ( \text{kgf} )</th>
<th>Allowable radial load ( F_{\text{r}} ) ( \text{kgf} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>0.16 ( \text{Nm} ) ( \text{kgf} ) ( \text{kgf} )</td>
<td>245 ( \text{N} ) ( \text{kgf} )</td>
<td>20.6 ( \text{kgf} )</td>
</tr>
<tr>
<td>14</td>
<td>6.3 ( \text{Nm} ) ( \text{kgf} ) ( \text{kgf} )</td>
<td>1206 ( \text{kgf} )</td>
<td>123 ( \text{kgf} )</td>
</tr>
<tr>
<td>20</td>
<td>13.5 ( \text{Nm} ) ( \text{kgf} ) ( \text{kgf} )</td>
<td>3285 ( \text{kgf} )</td>
<td>335 ( \text{kgf} )</td>
</tr>
<tr>
<td>32</td>
<td>44.4 ( \text{Nm} ) ( \text{kgf} ) ( \text{kgf} )</td>
<td>537 ( \text{kgf} )</td>
<td>565 ( \text{kgf} )</td>
</tr>
<tr>
<td>50</td>
<td>96.9 ( \text{Nm} ) ( \text{kgf} ) ( \text{kgf} )</td>
<td>210 ( \text{Nm} ) ( \text{kgf} )</td>
<td>21.4 ( \text{Nm} ) ( \text{kgf} )</td>
</tr>
<tr>
<td>65</td>
<td>210 ( \text{Nm} ) ( \text{kgf} ) ( \text{kgf} )</td>
<td>20100 ( \text{Nm} ) ( \text{kgf} )</td>
<td>627 ( \text{Nm} ) ( \text{kgf} )</td>
</tr>
</tbody>
</table>

Specification of input shaft bearing

<table>
<thead>
<tr>
<th>Size (mm)</th>
<th>Basic load rating</th>
<th>Basic load rating</th>
<th>Basic load rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>14500</td>
<td>14800</td>
<td>10100</td>
</tr>
<tr>
<td>32</td>
<td>29700</td>
<td>30300</td>
<td>20100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Size (mm)</th>
<th>Allowable moment load ( M_{\text{c}} ) ( \text{Nm} )</th>
<th>Allowable axial load ( F_{\text{ac}} ) ( \text{kgf} )</th>
<th>Allowable radial load ( F_{\text{r}} ) ( \text{kgf} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>10 ( \text{Nm} ) ( \text{kgf} ) ( \text{kgf} )</td>
<td>1538 ( \text{N} ) ( \text{kgf} )</td>
<td>157 ( \text{kgf} )</td>
</tr>
<tr>
<td>32</td>
<td>19 ( \text{Nm} ) ( \text{kgf} ) ( \text{kgf} )</td>
<td>3263 ( \text{kgf} )</td>
<td>333 ( \text{kgf} )</td>
</tr>
</tbody>
</table>

(Note: Table 157-2 and 157-4:)

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

The maximum moment load \( (M_{\text{max}}) \) is calculated as follows.

Check that the following formulas are established in all circumstances:

\[
M_{\text{max}} = Fri_{\text{max}} \cdot L_{ri} + Fai_{\text{max}} \cdot L_{ai}
\]

\( M_{\text{max}} \leq M_c \) (Allowable moment load)

\( Fai_{\text{max}} \leq F_{\text{a}} \) (Allowable axial load)

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

If moment load and axial load fluctuate, they should be converted into the average load to check the life of the bearing.

Calculating life of input bearing

Calculate the bearing life according to Calculation Formula 158-5 and check the life.

Dynamic equivalent load

Table 158-1

<table>
<thead>
<tr>
<th>Size</th>
<th>( \text{Pci} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>0.444 × ( \text{Ma} ) + 1.426 × ( \text{Fai} )</td>
</tr>
<tr>
<td>14</td>
<td>0.137 × ( \text{Ma} ) + 1.232 × ( \text{Fai} )</td>
</tr>
<tr>
<td>20</td>
<td>0.109 × ( \text{Ma} ) + 1.232 × ( \text{Fai} )</td>
</tr>
<tr>
<td>32</td>
<td>0.071 × ( \text{Ma} ) + 1.232 × ( \text{Fai} )</td>
</tr>
<tr>
<td>50</td>
<td>0.053 × ( \text{Ma} ) + 1.232 × ( \text{Fai} )</td>
</tr>
<tr>
<td>65</td>
<td>0.041 × ( \text{Ma} ) + 1.232 × ( \text{Fai} )</td>
</tr>
</tbody>
</table>

Table 158-2

<table>
<thead>
<tr>
<th>Size</th>
<th>( \text{Pci} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>121 × ( \text{Ma} ) + 2.7 × ( \text{Fai} )</td>
</tr>
<tr>
<td>32</td>
<td>106 × ( \text{Ma} ) + 2.7 × ( \text{Fai} )</td>
</tr>
</tbody>
</table>

\( \text{Ma} \) Average moment load Nm (kgfm)

\( \text{Fai} \) Average axial load N (kgf)

See Formula 158-2

See Formula 158-3
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

To properly mount the motor to the gearhead, follow the procedure outlined below, refer to figure 159-1

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.

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

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

---

**Table 159-1**

<table>
<thead>
<tr>
<th>Bolt size</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M8</th>
<th>M10</th>
<th>M12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tightening torque</td>
<td>Nm</td>
<td>2.0</td>
<td>4.5</td>
<td>9.0</td>
<td>15.3</td>
<td>37.2</td>
<td>73.5</td>
</tr>
<tr>
<td>kgfm</td>
<td>0.20</td>
<td>0.46</td>
<td>0.92</td>
<td>1.56</td>
<td>3.8</td>
<td>7.5</td>
<td>13.1</td>
</tr>
</tbody>
</table>

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 159-2**

<table>
<thead>
<tr>
<th>Bolt size</th>
<th>M3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tightening torque</td>
<td>Nm</td>
</tr>
<tr>
<td>kgfm</td>
<td>0.07</td>
</tr>
</tbody>
</table>

*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.

---

**Table 159-3**

<table>
<thead>
<tr>
<th>Bolt size</th>
<th>M2.5</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M8</th>
<th>M10</th>
<th>M12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tightening torque</td>
<td>Nm</td>
<td>0.59</td>
<td>1.4</td>
<td>3.2</td>
<td>6.3</td>
<td>10.7</td>
<td>26.1</td>
<td>51.5</td>
</tr>
<tr>
<td>kgfm</td>
<td>0.06</td>
<td>0.14</td>
<td>0.32</td>
<td>0.64</td>
<td>1.09</td>
<td>2.66</td>
<td>5.25</td>
<td>9.17</td>
</tr>
</tbody>
</table>

---

**Figure 159-1**
**Speed reducer assembly**

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>
<thead>
<tr>
<th>Size</th>
<th>HPN</th>
<th>HPGP / HPG / CSG-GH / CSF-GH</th>
<th>HPF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>11</td>
<td>14</td>
<td>20</td>
</tr>
<tr>
<td>Number of bolts</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Bolt size</td>
<td>MM3</td>
<td>MM5</td>
<td>MM6</td>
</tr>
<tr>
<td>Mounting PCD</td>
<td>mm</td>
<td>50</td>
<td>70</td>
</tr>
<tr>
<td>Tightening torque</td>
<td>Nm</td>
<td>1.4</td>
<td>6.3</td>
</tr>
<tr>
<td>Transmission torque</td>
<td>kgf</td>
<td>M4</td>
<td>M5</td>
</tr>
<tr>
<td>Number of bolts</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Bolt size</td>
<td>MM3</td>
<td>MM5</td>
<td>MM6</td>
</tr>
<tr>
<td>Mounting PCD</td>
<td>mm</td>
<td>50</td>
<td>70</td>
</tr>
<tr>
<td>Tightening torque</td>
<td>Nm</td>
<td>1.4</td>
<td>6.3</td>
</tr>
<tr>
<td>Transmission torque</td>
<td>kgf</td>
<td>M4</td>
<td>M5</td>
</tr>
</tbody>
</table>

* 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.

#### Output flange mounting specifications

<table>
<thead>
<tr>
<th>Bolt tightening torque for output flange (Part B in the Figure 160-1)</th>
<th>HPGP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of bolts</td>
<td>11</td>
</tr>
<tr>
<td>Bolt size</td>
<td>M4</td>
</tr>
<tr>
<td>Mounting PCD</td>
<td>mm</td>
</tr>
<tr>
<td>Tightening torque</td>
<td>Nm</td>
</tr>
<tr>
<td>Transmission torque</td>
<td>kgf</td>
</tr>
</tbody>
</table>

* 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 160-1)

<table>
<thead>
<tr>
<th>Bolt tightening torque for output flange (Part B in the Figure 160-1)</th>
<th>HPG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of bolts</td>
<td>11</td>
</tr>
<tr>
<td>Bolt size</td>
<td>M4</td>
</tr>
<tr>
<td>Mounting PCD</td>
<td>mm</td>
</tr>
<tr>
<td>Tightening torque</td>
<td>Nm</td>
</tr>
<tr>
<td>Transmission torque</td>
<td>kgf</td>
</tr>
</tbody>
</table>

* 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 160-1)

<table>
<thead>
<tr>
<th>Size</th>
<th>14</th>
<th>20</th>
<th>32</th>
<th>45</th>
<th>55</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of bolts</td>
<td>8</td>
<td>8</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Bolt size</td>
<td>M4</td>
<td>M6</td>
<td>M8</td>
<td>M12</td>
<td>M16</td>
</tr>
<tr>
<td>Mounting PCD</td>
<td>mm</td>
<td>30</td>
<td>45</td>
<td>60</td>
<td>94</td>
</tr>
<tr>
<td>Tightening torque</td>
<td>Nm</td>
<td>4.5</td>
<td>15.3</td>
<td>37</td>
<td>128</td>
</tr>
<tr>
<td>Transmission torque</td>
<td>Nm</td>
<td>84</td>
<td>287</td>
<td>867</td>
<td>3067</td>
</tr>
</tbody>
</table>

* Recommended bolts: JIS B 1176 "Hexagon socket head bolts."  Strength classification 12.9 or higher in JIS B 1051.

Gearheads with an output shaft

Do not subject the output shaft to any impact when mounting a pulley, pinion or other parts. An impact to 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.

### Output Flange: F0 (flange)

*Recommended bolts: JIS B 1176 “Hexagon socket head bolts.” Strength classification 12.9 or higher in JIS B 1051.*

An impact to the output bearing may affect the speed reducer precision and may cause reduced life.

### Transmission Torque

<table>
<thead>
<tr>
<th>Size</th>
<th>Transmission Torque (kgf)</th>
<th>Tightening Torque (Nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>8.6</td>
<td>2.3</td>
</tr>
<tr>
<td>14</td>
<td>8.0</td>
<td>2.1</td>
</tr>
<tr>
<td>20</td>
<td>6.0</td>
<td>1.5</td>
</tr>
<tr>
<td>32</td>
<td>9.0</td>
<td>3.2</td>
</tr>
</tbody>
</table>

### Gearheads with an output shaft

#### Transmission Torque

<table>
<thead>
<tr>
<th>Size</th>
<th>Transmission Torque (kgf)</th>
<th>Tightening Torque (Nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>8.6</td>
<td>2.3</td>
</tr>
<tr>
<td>14</td>
<td>8.0</td>
<td>2.1</td>
</tr>
<tr>
<td>20</td>
<td>6.0</td>
<td>1.5</td>
</tr>
<tr>
<td>32</td>
<td>9.0</td>
<td>3.2</td>
</tr>
</tbody>
</table>

### Technical Information / Handling Explanation

- The allowable radial load of HPG series is the value of a radial load applied at the mid-point of the input shaft.
- The allowable axial load is the value of an axial load applied along the axis of rotation.
- The allowable axial load *Fai* (Allowable axial load) and the moment load *Mi* (Allowable moment load) are the maximum values of the axial load and moment load applied to the input shaft.

For calculating the average axial load and moment load, see the accompanying figures and formulas.
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 54 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  [HPG/HPG-14, 20, 32]
Manufacturer: Harmonic Drive Systems Inc.
| 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 |

PYRONOC UNIVERSAL 00 [HPG right angle gearhead/HPN]
Manufacturer: Nippon Oil Co.
| Base oil: Refined mineral oil | Consistency: 420 at 25°C |
| Thickening agent: Urea | Dropping point: 250°C or higher |
| Standard: NLGI No. 00 | Color: Light yellow |

EPNOC Grease AP (N) 2 [HPG/HPG-11, 50, 65, HPF-25, 32]
Manufacturer: Nippon Oil Co.
| Base oil: Refined mineral oil | Consistency: 282 at 25°C |
| Thickening agent: Lithium soap | Dropping point: 200°C |
| Additive: Extreme pressure agent and other | Color: Light brown |
| Standard: NLGI No. 2 |

MULTEMP AC-P [HPG-X-R]
Manufacturer: KYODO YUSHI CO, LTD
| Base oil: Composite hydrocarbon oil and diester | Standard: NLGI No. 2 |
| Thickening agent: Lithium soap | Consistency: 280 at 25°C |
| Additive: Extreme pressure and others | 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 70°C is the maximum allowable limit.
CSG-GH/CSF-GH Series

The standard lubrication for the CSG-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

<table>
<thead>
<tr>
<th>Gearheads</th>
<th>Manufacturer</th>
<th>Grease Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPG/HPGP/HPF/HPN Series</td>
<td>Harmonic Drive Systems Inc.</td>
<td>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 Additive: Extreme pressure agent and other Standard: NLGI No. 2</td>
</tr>
<tr>
<td>CSG/CSF-GH Series</td>
<td>Harmonic Drive Systems Inc.</td>
<td>This grease has been developed exclusively for smaller sized HarmonicDrive® gears and allows smooth wave generator rotation. Base oil: Refined mineral oil Additive: Extreme pressure agent and other Standard: NLGI No. 2</td>
</tr>
</tbody>
</table>

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). 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 164-1

\[
L_{CT} = L_{CTn} \times \left( \frac{T_r}{T_{av}} \right)^3
\]

Formula symbols

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>L_{CT}</td>
<td>Grease change interval when ( T_{av} &gt; T_r )</td>
</tr>
<tr>
<td>L_{CTn}</td>
<td>Grease change interval when ( T_{av} = T_r )</td>
</tr>
<tr>
<td>T_r</td>
<td>Output torque at 2000 rpm</td>
</tr>
<tr>
<td>T_{av}</td>
<td>Average load torque</td>
</tr>
</tbody>
</table>

Reference values for grease refill amount

Table 164-2

<table>
<thead>
<tr>
<th>Size</th>
<th>Amount (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>0.8</td>
</tr>
<tr>
<td>20</td>
<td>3.2</td>
</tr>
<tr>
<td>32</td>
<td>6.6</td>
</tr>
<tr>
<td>45</td>
<td>11.6</td>
</tr>
<tr>
<td>65</td>
<td>78.6</td>
</tr>
</tbody>
</table>

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 164-2 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
- Aircraft equipment
- Nuclear power equipment
- Equipment and apparatus used in residential dwellings
- Vacuum environments
- Automotive equipment
- Personal recreation equipment
- Equipment that directly works on human bodies
- Equipment for transport of humans
- 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.

<table>
<thead>
<tr>
<th>Design Precaution: Be certain to read the catalog when designing the equipment.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Caution</strong></td>
</tr>
<tr>
<td>Use only in the proper environment.</td>
</tr>
<tr>
<td>- Please ensure to comply with the following environmental conditions:</td>
</tr>
<tr>
<td>- Ambient temperature 0 to 40°C</td>
</tr>
<tr>
<td>- No splashing of water or oil</td>
</tr>
<tr>
<td>- Do not expose to corrosive or explosive gas</td>
</tr>
<tr>
<td>- No dust such as metal powder</td>
</tr>
<tr>
<td>Install the equipment properly.</td>
</tr>
<tr>
<td>- Carry out the assembly and installation precisely as specified in the catalog.</td>
</tr>
<tr>
<td>- Observe our recommended fastening methods (including bolts used and tightening torques).</td>
</tr>
<tr>
<td>- Operating the equipment without precise assembly can cause problems such as vibration, reduction in life, deterioration of precision and product failure.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Operational Precaution: Be certain to read the catalog before operating the equipment.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Caution</strong></td>
</tr>
<tr>
<td>Use caution when handling the product and parts.</td>
</tr>
<tr>
<td>- Do not hit the gear or any part with a hammer.</td>
</tr>
<tr>
<td>- 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.</td>
</tr>
<tr>
<td>Operate within the allowable torque range.</td>
</tr>
<tr>
<td>- 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.</td>
</tr>
<tr>
<td>- 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.</td>
</tr>
<tr>
<td>Do not alter or disassemble the product or parts.</td>
</tr>
<tr>
<td>- Harmonic Planetary® and Harmonic Drive® products are manufactured as matched sets. Catalog ratings may not be achieved if the component parts are interchanged.</td>
</tr>
<tr>
<td>Do not disassemble the products.</td>
</tr>
<tr>
<td>- Do not disassemble and reassemble the products. Original performance may not be achieved.</td>
</tr>
<tr>
<td>Do not use your finger to turn the gear.</td>
</tr>
<tr>
<td>- Do not insert your finger into the gear under any circumstances. The finger may get caught in the gear causing an injury.</td>
</tr>
<tr>
<td>Stop operating the system if any abnormality occurs.</td>
</tr>
<tr>
<td>- 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.</td>
</tr>
<tr>
<td>- Please contact our sales office or distributor if any anomaly is detected.</td>
</tr>
<tr>
<td>Large sizes (45, 50 and 65) are heavy. Use caution when handling.</td>
</tr>
<tr>
<td>- 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.</td>
</tr>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Handling Lubricant</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Warning</strong></td>
</tr>
<tr>
<td>Precautions on handling lubricants</td>
</tr>
<tr>
<td>- Lubricant in the eye can cause inflammation. Wear protective glasses to prevent it from getting into your eye.</td>
</tr>
<tr>
<td>- 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.</td>
</tr>
<tr>
<td>- Do not ingest (to avoid diarrhea and vomiting).</td>
</tr>
<tr>
<td>- Use caution when opening the container. There may be sharp edges that can cut your hand. Wear protective gloves.</td>
</tr>
<tr>
<td>- Keep lubricant out of reach of children.</td>
</tr>
<tr>
<td>Disposal of waste oil and containers</td>
</tr>
<tr>
<td>- Follow all applicable laws regarding waste disposal. Contact your distributor if you are unsure how to properly dispose of the material.</td>
</tr>
<tr>
<td>- Do not apply pressure to an empty container. The container may explode.</td>
</tr>
<tr>
<td>- Do not weld, heat, drill or cut the container. This may cause residual oil to ignite or cause an explosion.</td>
</tr>
<tr>
<td>Storage</td>
</tr>
<tr>
<td>- Tightly seal the container after use. Store in a cool, dry, dark place.</td>
</tr>
<tr>
<td>- Keep away from open flames and high temperatures.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>First-aid</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Warning</strong></td>
</tr>
<tr>
<td>Use caution when handling lubricants.</td>
</tr>
<tr>
<td>- Inhalation: Remove exposed person to fresh air if adverse effects are observed.</td>
</tr>
<tr>
<td>- Ingestion: Seek immediate medical attention and do not induce vomiting unless directed by medical personnel.</td>
</tr>
<tr>
<td>- Eyes: Flush immediately with water for at least 15 minutes. Get immediate medical attention.</td>
</tr>
<tr>
<td>- Skin: Wash with soap and water. Get medical attention if irritation develops.</td>
</tr>
<tr>
<td>Disposal of as industrial waste.</td>
</tr>
<tr>
<td>- Please dispose of as industrial waste.</td>
</tr>
</tbody>
</table>

166 HarmonicPlanetary® & HarmonicDrive® Gearheads
Sold & Serviced by: ELECTROMATE
Toll Free Phone: (877) SERV068
Toll Free Fax: (877) SERV098
www.electromate.com
sales@electromate.com
NOTES
Major Applications of Our Products

- **Metal Working Machines**
- **Processing Machine Tools**
- **Measurement, Analytical and Test Systems**
- **Medical Equipment**
- **Telescopes**
- **Energy**
- **Crating and Packaging Machines**
- **Communication Equipment**
- **Glass and Ceramic Manufacturing Systems**
- **Robots**
- **Humanoid Robots**
- **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**

*Sources:*
- National Observatory of Inter-University Research Institute Corporation
- Honda Motor Co., Ltd.
- NASA/JPL-Caltech
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.