HarmonicDrive®

Speed Reducers for Precision Motion Control

HarmonicDrive®

Reducer Catalog

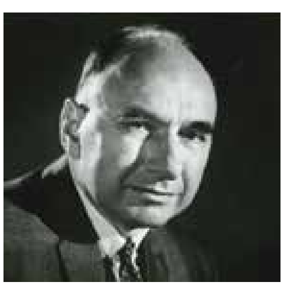
- Engineering Data
- Component Sets
- Gear Units
- Phase Adjusters
- Gearheads and Actuators

Excellent Technology for Evolving Industries

Harmonic Drive® actuators utilize high-precision, zero-backlash Harmonic Drive® precision gears and play critical roles in robotics, semiconductor manufacturing equipment, factory automation equipment, medical diagnostics and surgical robotics. Additionally, our products are frequently used in mission-critical spaceflight applications which capture the human spirit.

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.

Harmonic Drive LLC continues to develop enabling technologies for the evolving motion control market, which drives the pace of global innovation.



C. Walton Musser
Patented Strain Wave
Gearing in 1955

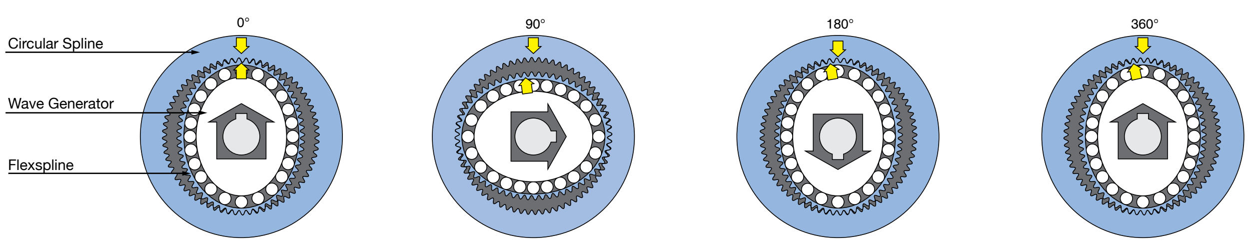
Operating Principle of HarmonicDrive® Gears

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-to-weight ratio, 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 counterclockwise by two teeth from its original position, relative to the Circular Spline. Normally, this motion is taken out as output.

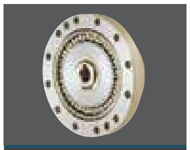
■ Development of HarmonicDrive® Speed Reducers

Harmonic Drive® gears have been evolving since the strain wave gear was first patented in 1955. Our innovative development and engineering teams have led us to significant advances in our gear technology. In 1988, Harmonic Drive successfully designed and manufactured a new tooth profile, the "S" tooth. Since implementing the "S" tooth profile, improvement in life, strength and torsional stiffness have been realized. In the 1990s, we focused engineering efforts on designing gears featuring space savings, higher speed, higher load capacity and higher reliability. Then in the 2000s, significant reduction in size and thickness were achieved, all while maintaining high precision specifications.

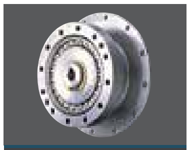
Series

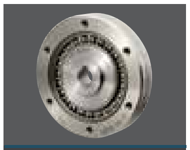
HarmonicDrive®

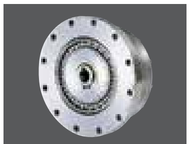
		Series	
Component Sets – Consisting of three basic components: flexspline, circular spline and wave generator; component gear sets offer ultimate design flexibility and can be tightly integrated in equipment sub-structures.	Cup	CSG	High Torque
		CSF	Standard
		CSD	Super Flat
	Silk Hat	SHG	High Torque
		SHF	Standard
	Pancake	FB	Standard
		FR	Standard
Gear Unit – Housed component gearing combined with precision cross roller output bearing & flange. Very compact, robust and easy to use gearhead solution.	Cup	CSG-2UH	High Torque
		CSG-2UH-LW	High Torque Lightweight
		CSG-2UK	High Torque Sealed Spline Input
		CSF-2UH	Standard
		CSF-2UH-LW	Standard Lightweight
		CSF-2UP	Standard Square Housing
		CSF mini	Compact
		CSF supermini	Super Compact
		CSD-2UH	Super Flat
		CSD-2UF	Super Flat Hollow Shaft
	Silk Hat	SHG-2UH	High Torque Hollow Shaft
		SHG-2UH-LW	High Torque Lightweight Hollow Shaft
		SHF-2UH	Hollow Shaft
		SHF-2UH-LW	Lightweight Hollow Shaft
		SHG-2UJ	HighTorque Shaft Input
		SHF-2UJ	Shaft Input
		SHD-2UH-LW	Super Flat Lightweight Hollow Shaft
Simplicity Gear Unit – Non-housed component gearing combined with a precision cross roller output bearing. Similar to Gear Units (above), without the housing and output flange, for tighter integration into the customer's housing or machine structure.	Silk Hat	SHG-2SH	High Torque Flat Hollow Shaft
		SHF-2SH	Flat Hollow Shaft
		SHG-2SO	High Torque Flat
		SHF-2SO	Flat
		SHD-2SH	Super Flat Hollow Shaft
		FBS-2UH	Super Flat Hollow Shaft
Shaft Phase Adjusters – Harmonic Drive® unit that allows you to fine tune the phase and timing during operation.		FD-0	Unit
		FD-2	Component
		FBB	1:1 Differential
		HDI	Phase Adjuster

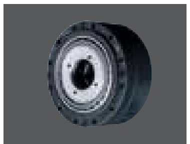

CSG / CSF


CSD


SHG / SHF


FB / FR


CSG-2UH / CSF-2UH
CSG-2UH-LW / CSF-2UH-LW


CSD-2UH / CSD-2UF


SHG-2UH / SHF-2UH
SHG-2UH-LW / SHF-2UH-LW

Example ◎：Best ○：Better △：Good

Peak Torque (Nm)	Reduction Ratio	Torque-Weight Ratio	Torsional Stiffness	Positional Accuracy	Lightweight	Flat Shape	Hollow Shaft	Customization	Life	Page
23～3400	50～160	◎	◎	◎	○	○	△	◎	◎	035
1.8～9200	30～160	○	◎	◎	○	○	△	◎	○	035
12～820	50～100	○	○	○	◎	◎	○	◎	○	061
23～3400	50～160	◎	◎	◎	○	○	◎	◎	◎	079
9.0～1840	30～160	○	◎	◎	○	○	◎	◎	○	079
7.8～330	50～160	△	△	△	◎	◎	◎	◎	△	103
9.8～4000	50～320	△	△	△	△	△	◎	◎	△	111

Peak Torque (Nm)	Reduction Ratio	Torque-Weight Ratio	Torsional Stiffness	Positional Accuracy	Lightweight	Flat Shape	Hollow Shaft	Customization	Life	Page
23～3400	50～160	◎	○	◎	○	○	△	○	◎	123
23～3400	50～160	◎	○	◎	◎	○	△	○	◎	123
127~3400	50～160	○	○	◎	△	○	–	○	○	145
9.0～2600	30～160	○	○	◎	○	○	△	○	○	123
9.0～2600	30～160	◎	○	◎	◎	○	△	○	○	123
1.8~28	30～100	○	◎	◎	○	◎	–	○	◎	157
0.13～0.30	30～100	○	△	◎	◎	○	–	○	○	169
0.5～28	30～100	○	△	◎	◎	○	–	○	○	195
12～823	50～100	◎	◎	◎	○	◎	○	○	○	209
12～453	50～100	◎	◎	◎	○	◎	◎	○	○	209
23～3400	50～160	◎	◎	◎	△	△	◎	○	◎	227
23～3400	50～160	◎	◎	◎	○	△	◎	○	◎	227
9.0～1800	30～160	○	◎	◎	△	△	◎	○	○	227
9.0～1800	30～160	◎	◎	◎	○	△	◎	○	○	227
23～3400	50～160	◎	◎	◎	△	△	–	○	◎	227
9.0～1800	30～160	○	◎	◎	△	△	–	○	○	227
12～450	50～100	◎	○	◎	◎	◎	◎	○	○	267
23～3400	50～160	◎	◎	◎	○	○	◎	◎	◎	227
9.0～1800	30～160	○	◎	◎	○	○	◎	◎	○	227
23～3400	50～160	◎	◎	◎	○	○	–	◎	◎	227
9.0～1800	30～160	○	◎	◎	○	◎	–	◎	○	227
12～450	50～100	◎	○	◎	◎	◎	◎	◎	○	267
25～106	30～100	○	◎	◎	○	○	◎	○	◎	287

Peak Torque (Nm)	Reduction Ratio	Torque-Weight Ratio	Torsional Stiffness	Positional Accuracy	Lightweight	Flat Shape	Hollow Shaft	Customization	Life	Page
9.0～1800	30～160	△	△	△	△	○	–	△	△	287
23～3400	50～160	△	△	△	○	◎	◎	○	△	287
28～655	80～160	△	△	△	△	○	–	△	△	303
100～500	50～100	△	△	△	○	◎	◎	○	△	311


SHG-2UJ ／ SHF-2UJ


CSF supermini ／ CSF-mini


SHG-2SO ／ SHF-2SO
SHG-2SH ／ SHF-2SH


SHD-2SH


FD


FBS-2UH

Engineering Data

Engineering Data

Tooth Profile

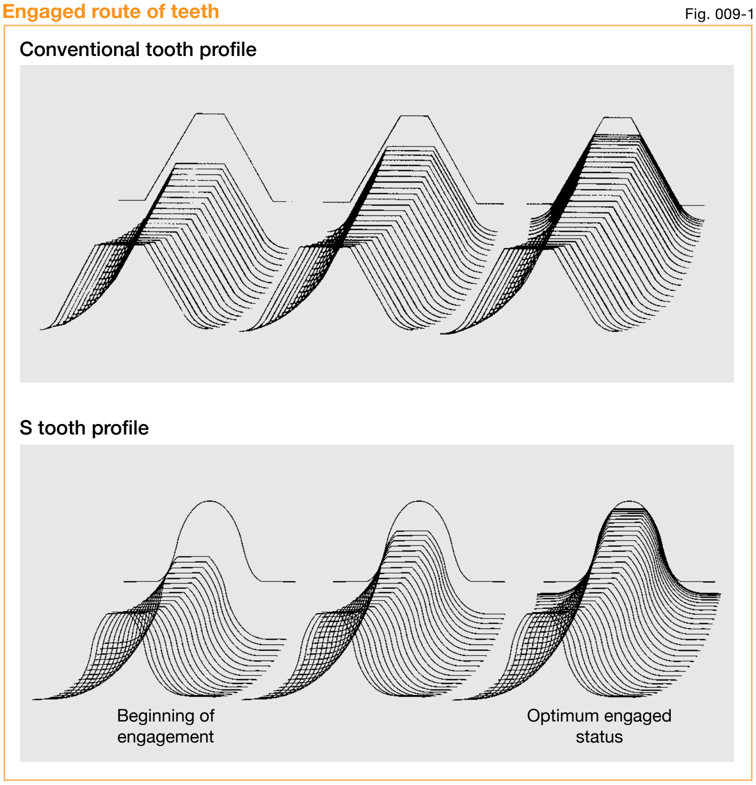
■ S tooth profile

Harmonic Drive developed a unique gear tooth profile that optimizes the tooth engagement. It has a special curved surface unique to the S tooth profile that allows continuous contact with the tooth profile. It also alleviates the concentration of stress by widening the width of the tooth groove against the tooth thickness and enlarging the radius on the bottom. This tooth profile (the “S tooth”) enables up to 30% of the total number of teeth to be engaged simultaneously.

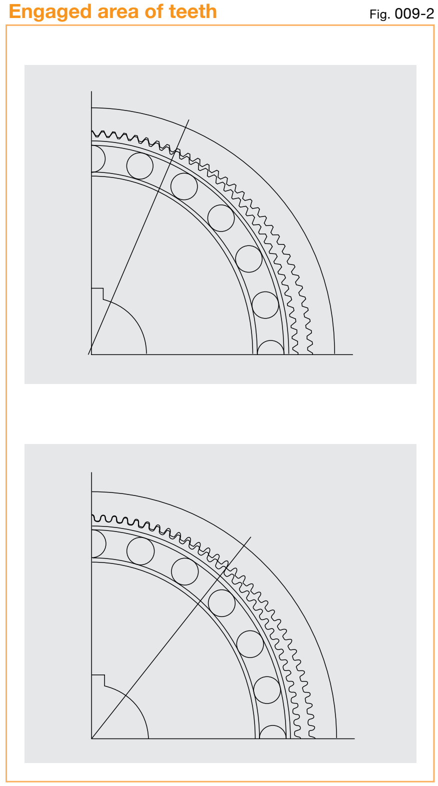
Additionally the large tooth root radius increases the tooth strength compared with an involute tooth. This technological innovation results in high torque, high torsional stiffness, long life and smooth rotation.

*Patented

Engaged route of teeth — Fig. 009-1



Engaged area of teeth — Fig. 009-2



Rotational direction and reduction ratio

Cup Style

Series: CSG, CSF, CSD, CSF-mini

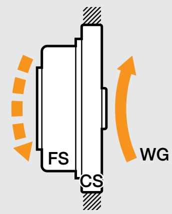
■ Rotational direction

Fig. 010-1

Input Output

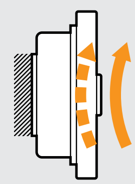
*R indicates the reduction ratio value from the ratings table.

(Note) Contact us if you use the product as Accelerator (5) and (6).



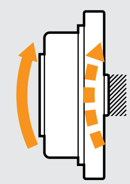
(1) Reducer
Input: Wave Generator (WG)
Output: Flexspline (FS)
Fixed: Circular Spline (CS)

$i = \frac{-1}{R}$



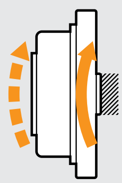
(2) Reducer
Input: Wave Generator
Output: Circular Spline
Fixed: Flexspline

$i = \frac{1}{R+1}$



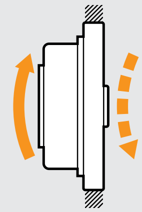
(3) Reducer
Input: Flexspline
Output: Circular Spline
Fixed: Wave Generator

$i = \frac{R}{R+1}$



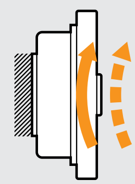
(4) Overdrive
Input: Circular Spline
Output: Flexspline
Fixed: Wave Generator

$i = \frac{R+1}{R}$



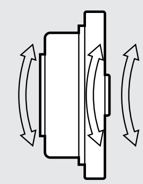
(5) Overdrive
Input: Flexspline
Output: Wave Generator
Fixed: Circular Spline

$i = -R$



(6) Overdrive
Input: Circular Spline
Output: Wave Generator
Fixed: Flexspline

$i = R+1$



(7) Differential
When all of the wave generator, the flexspline and the circular spline rotate, combinations (1) through (6) are available.

Silk hat

Series: SHG, SHF, SHD

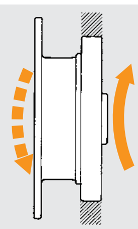
■ Rotational direction

Fig. 010-2

Input Output

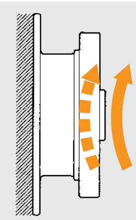
*R indicates the reduction ratio value from the ratings. table

(Note) Contact us if you use the product as an overdrive of (5) or (6).



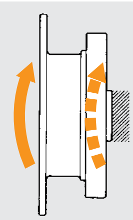
(1) Reducer
Input: Wave Generator
Output: Flexspline
Fixed: Circular Spline

$i = \frac{-1}{R}$



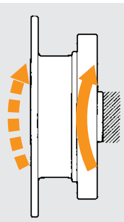
(2) Reducer
Input: Wave Generator
Output: Circular Spline
Fixed: Flexspline

$i = \frac{1}{R+1}$



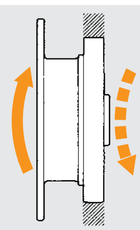
(3) Reducer
Input: Flexspline
Output: Circular Spline
Fixed: Wave Generator

$i = \frac{R}{R+1}$



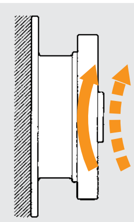
(4) Overdrive
Input: Circular Spline
Output: Flexspline
Fixed: Wave Generator

$i = \frac{R+1}{R}$



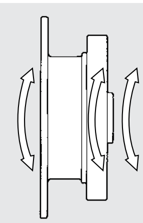
(5) Overdrive
Input: Flexspline
Output: Wave Generator
Fixed: Circular Spline

$i = -R$



(6) Overdrive
Input: Circular Spline
Output: Wave Generator
Fixed: Flexspline

$i = R+1$



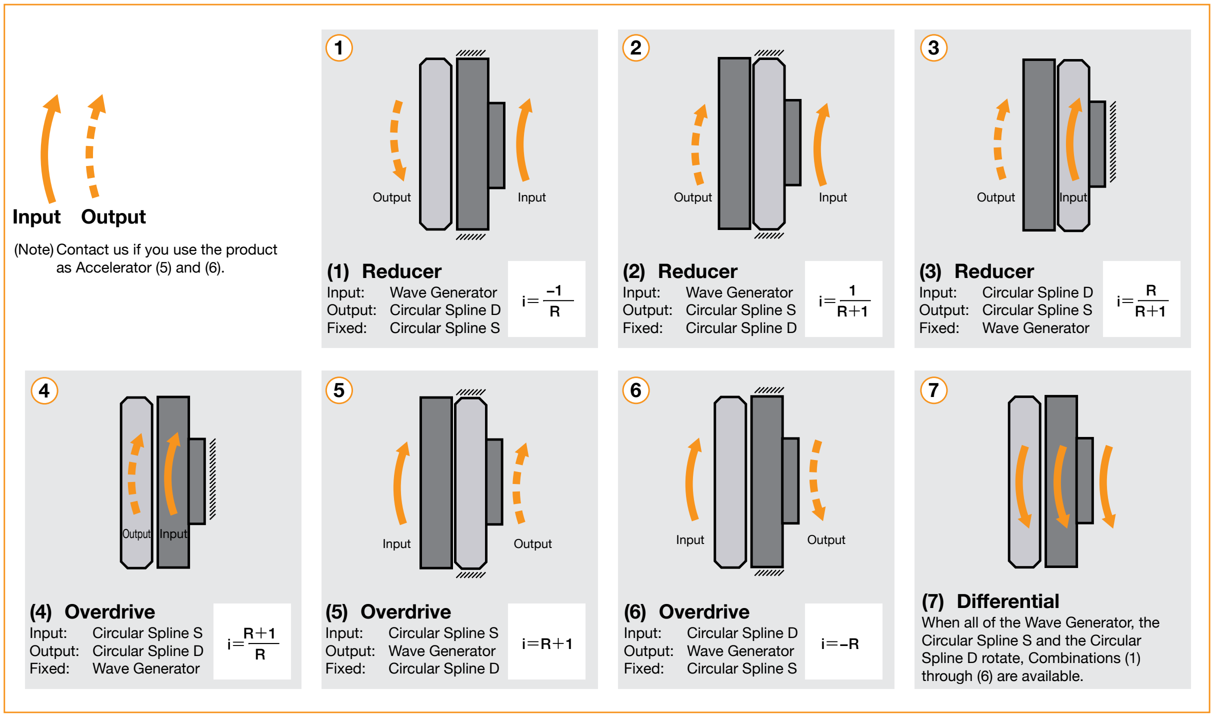
(7) Differential
When all of the wave generator, the flexspline and the circular spline rotate, Combinations (1) through (6) are available.

Pancake

Series: FB and FR

Rotational direction

Fig. 11-1



Reduction ratio

The reduction ratio is determined by the number of teeth of the Flexspline and the Circular Spline

Number of teeth of the Flexspline: Zf
Number of teeth of the Circular Spline: Zc

▶ Input: Wave Generator
Output: Flexspline
Fixed: Circular Spline
} Reduction ratio $i_1 = \frac{1}{R_1} = \frac{Zf-Zc}{Zf}$

▶ Input: Wave Generator
Output: Circular Spline
Fixed: Flexspline
} Reduction ratio $i_2 = \frac{1}{R_2} = \frac{Zc-Zf}{Zc}$

■ R_1 indicates the reduction ratio value from the ratings table.

Example

Number of teeth of the Flexspline: 200
Number of teeth of the Circular Spline: 202

▶ Input: Wave Generator
Output: Flexspline
Fixed: Circular Spline
} Reduction ratio $i_1 = \frac{1}{R_1} = \frac{200-202}{200} = \frac{-1}{100}$

▶ Input: Wave Generator
Output: Circular Spline
Fixed: Flexspline
} Reduction ratio $i_2 = \frac{1}{R_2} = \frac{202-200}{202} = \frac{1}{101}$

Rating Table Definitions

See the corresponding pages of each series for values.

■ Rated torque

Rated torque indicates allowable continuous load torque at rated input speed.

■ Limit for Repeated Peak Torque (see Graph 12-1)

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 14)

■ Limit for Momentary Peak Torque (see Graph 12-1)

The gear may be subjected to momentary peak torques in the event of a collision or emergency stop. The magnitude and frequency of occurrence of such peak torques must be kept to a minimum and they should, under no circumstance, occur during normal operating cycle. The allowable number of occurrences of the momentary peak torque may be calculated by using formula 13-1.

■ Maximum Average Input Speed
Maximum Input Speed

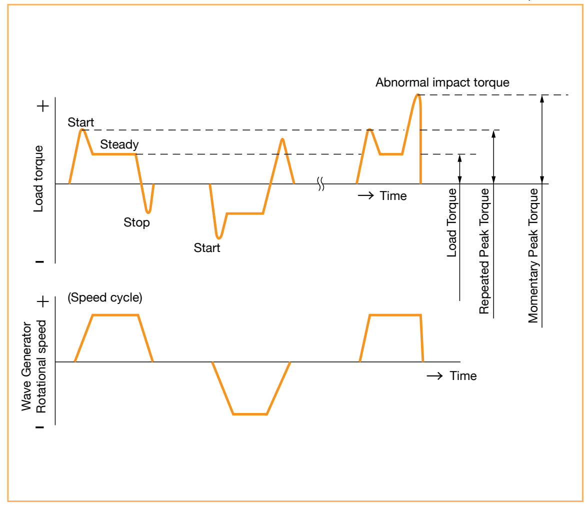
Do not exceed the allowable rating. (calculation formula of the average input speed: Page 14).

■ Moment of Inertia

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

Example of application motion profile

Graph 012-1



Life

■ Life of the wave generator

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

Table 012-1

Series name	Life	
	CSF, CSD, SHF, SHD, CSF-mini	CSG, SHG
L_{10}	7,000 hours	10,000 hours
L_{50} (average life)	35,000 hours	50,000 hours

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

Calculation formula for Rated Lifetime

Formula 012-1

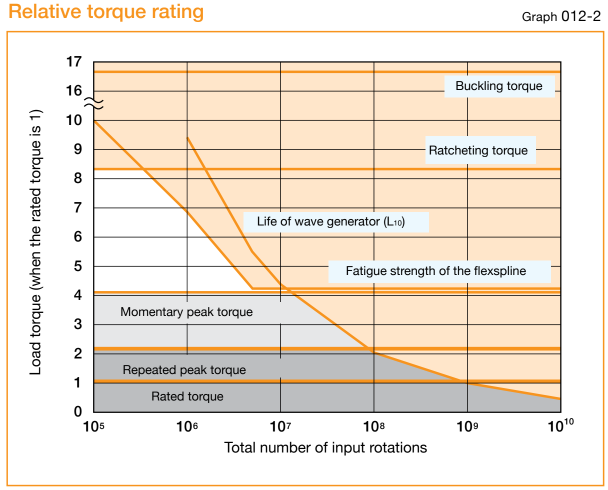
$$L_h = L_n \cdot \left(\frac{T_r}{T_{av}}\right)^3 \cdot \left(\frac{N_r}{N_{av}}\right)$$

Table 012-2

Ln	Life of L_{10} or L_{50}
Tr	Rated torque
Nr	Rated input speed
Tav	Average load torque on the output side (calculation formula: Page 14)
Nav	Average input speed (calculation formula: Page 14)

Relative torque rating

Graph 012-2



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

Torque Limits

■ Strength of flexspline

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

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

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

Calculation formula

Formula 013-1

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

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

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

■ Buckling torque

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

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

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

■ Ratcheting torque

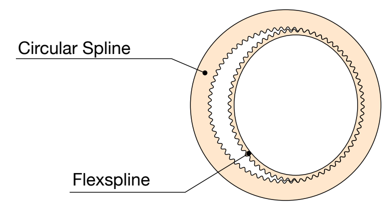
When excessive torque (8 to 9 times rated torque) is applied while the gear is in motion, the teeth between the Circular Spline and Flexspline may not engage properly.
This phenomenon is called ratcheting and the torque at which this occurs is called ratcheting torque. Ratcheting may cause the Flexspline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

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

Caution When ratcheting occurs, the teeth may not be correctly engaged and become out of alignment as shown in Figure 013-1. Operating the drive in this condition will cause vibration and damage the flexspline.

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

Figure 013-1



"Dedoidal" condition.

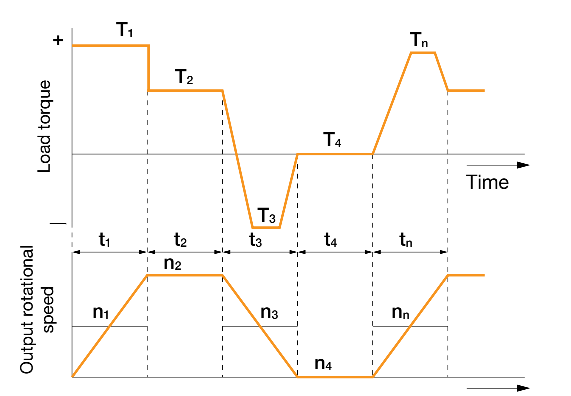
Product Sizing & Selection

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

■ Checking the application motion profile

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

Graph 14-1



* n_1, n_2 and n_n indicate the average values.

Obtain the value of each application motion profile.

Load torque	T_n (Nm)
Time	t_n (sec)
Output rotational speed	n_n (rpm)
Normal operation pattern	
Starting (acceleration)	T_1, t_1, n_1
Steady operation (constant velocity)	T_2, t_2, n_2
Stopping (deceleration)	T_3, t_3, n_3
Dwell	T_4, t_4, n_4
Maximum rotational speed	
Max. output speed	no ***max***
Max. input rotational speed (Restricted by motors)	ni ***max***
Emergency stop torque	
When impact torque is applied	T_s, t_s, n_s
Required life	
	L_{10} = L (hours)

■ Flowchart for selecting a size

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

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

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

↓

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

↓

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

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

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

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

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

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

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

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

↓

Check whether the preliminary model number satisfies the following condition from the rating table.
Ni ***av*** ≦ Limit for average speed (rpm)
Ni ***max*** ≦ Limit for maximum speed (rpm)
→ NG / OK

Check whether T_1 and T_3 are less than the repeated peak torque specification.
→ NG / OK

Check whether T_s is less than the the momentary peak torque specification.
→ NG / OK

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

$$N_S = \frac{10^4}{2 \cdot \frac{n_S \cdot R}{60} \cdot t} \quad \cdots\cdots N_S \leqq 1.0\times10^4$$

→ NG / OK

Calculate the lifetime.

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

Check whether the calculated life is equal to or more than the life of the wave generator (see Page 13).
→ NG / OK

The model number is confirmed.

NG: Review the operation conditions and model number

Example of model number selection

Value of each application motion profile
Load torque T_n (Nm)
Time t_n (sec)
Output speed n_n (rpm)

Normal operation pattern
Starting (acceleration) T1 = 400 Nm, t1 = 0.3sec, n1 = 7rpm
Steady operation (constant velocity) T2 = 320 Nm, t2 = 3sec, n2 = 14rpm
Stopping (deceleration) T3 = 200 Nm, t3 = 0.4sec, n3 = 7rpm
Dwell T_4 = 0 Nm, t_4 = 0.2 sec, n_4 = 0 rpm

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

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

Required life
L_{10} = 7000 (hours)

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

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

Make a preliminary model selection with the following conditions. T***av*** = 319 Nm ≦ 451 Nm
(Limit for average torque for model number CSF-40-120-2A-GR: See the rating table on Page 39.)
Thus, **CSF-40-120-2A-GR** is tentatively selected.

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

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

Obtain the reduction ratio (R).

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

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

$$n_{i\,av} = 12\ \text{rpm}\cdot 120 = 1440\ \text{rpm}$$

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

$$n_{i\,max} = 14\ \text{rpm}\cdot 120 = 1680\ \text{rpm}$$

Check whether the preliminary selected model number satisfies the following condition from the rating table.
Ni ***av*** = 1440 rpm ≦ 3600 rpm (Max average input speed of size 40)
Ni ***max*** = 1680 rpm ≦ 5600 rpm (Max input speed of size 40)

NG / OK

Check whether T_1 and T_3 are equal to or less than the repeated peak torque specification.
T_1 = 400 Nm ≦ 617 Nm (Limit of repeated peak torque of size 40)
T_3 = 200 Nm ≦ 617 Nm (Limit of repeated peak torque of size 40)

NG / OK

Check whether Ts is equal to or less than the momentary peak torque specification.
T_s = 500 Nm ≦ 1180 Nm (Limit for momentary torque of size 40)

NG / OK

Calculate the allowable number (Ns) rotation during impact torque and confirm ≦ 1.0×10^4

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

NG / OK

Calculate the lifetime.

$$L_{10} = 7000\cdot\left(\frac{294\ \text{Nm}}{319\ \text{Nm}}\right)^3\cdot\left(\frac{2000\ \text{rpm}}{1440\ \text{rpm}}\right)\ \text{(hours)}$$

Check whether the calculated life is equal to or more than the life of the wave generator (see Page 12).
L_{10} =7610 hours ≧ 7000 (life of the wave generator: L_{10})

NG / OK

The selection of model number **CSF-40-120-2A-GR** is confirmed from the above calculations.

Review the operation conditions, size and reduction ratio

Lubrication

Component Sets: CSD-2A, CSF-2A, CSG-2A, FB-2, FB-0, FR-2, SHF-2A, SHG-2A and SHD and SHG/SHF -2SO and -2SH gear units: Grease lubricant and oil lubricant are available for lubricating the component sets and SHD gear unit. It is extremely important to properly grease your component sets and SHD gear unit. Proper lubrication is essential for high performance and reliability. Harmonic Drive® component sets are shipped with a rust- preventative oil. The characteristics of the lubricating grease and oil types approved by Harmonic Drive are not changed by mixing with the preservation oil. It is therefore not necessary to remove the preservation oil completely from the gear components. However, the mating surfaces must be degreased before the assembly.

Gear Units: CSG/CSF 2UH and 2UH-LW; CSD-2UF and -2UH; SHG/SHF-2UH and 2UH- LW; SHG/SHF-2UJ; CSF Supermini, CSF Mini, and CSF-2UP.
Grease lubricant is standard for lubricating the gear units. You do not need to apply grease during assembly as the product is lubricated and shipped.
See Page 19 for using lubricant beyond the temperature range in table 16-2.

* Contact us if you want consistency zero (NLGI No.0) for maintenance reasons.

Name of lubricant — Table 016-1

Grease	Harmonic Grease® SK-1A
	Harmonic Grease® SK-2
	Harmonic Grease® 4B No.2
Oil	Industrial gear oil class-2 (extreme pressure) ISO VG68

Temperature — Table 016-2

Grease	SK-1A 0ºC to + 40ºC
	SK-2 0ºC to + 40ºC
	4B No.2 –10ºC to + 70ºC
Oil	ISO VG68 0ºC to + 40ºC

* The hottest section should not be more than 40° above the ambient temperature.

Note: The three basic components of the gear - the Flexspline, Wave Generator and Circular Spline - are matched and serialized in the factory. Depending on the product they are either greased or prepared with preservation oil. Then the individual components are assembled. If you receive several units, please be careful not to mix the matched components. This can be avoided by verifying that the serial numbers of the assembled gear components are identical.

Grease lubricant

■ Types of lubricant

Harmonic Grease® SK-1A

This grease was developed for Harmonic Drive® gears and features good durability and efficiency.

Harmonic Grease® SK-2

This grease was developed for small sized Harmonic Drive® gears and features smooth rotation of the Wave Generator since high pressure additive is liquefied.

Harmonic Grease® 4B No.2

This has been developed exclusively for the CSF and CSG and features long life and can be used over a wide range of temperature.

(Note)
1. Grease lubrication must have proper sealing, this is essential for 4B No.2.
   Rotating part: Oil seal with spring is needed.
   Mating part: O ring or seal adhesive is needed.

2. The grease has the highest deterioration rate in the region where the grease is subjected to the greatest shear (near wave generator).
   Its viscosity is between JIS No.0 and No.00 depending on the operation.

Table 016-3

NLGI consistency No.	Mixing consistency range
0	355 to 385
00	400 to 430

Grease specification — Table 016-4

Grease	SK-1A	SK-2	4B No.2
Base oil	Refined oil	Refined oil	Composite hydrocarbon oil
Base Viscosity cSt (25ºC)	265 to 295	265 to 295	290 to 320
Thickening agent	Lithium soap base	Lithium soap base	Urea
NLGI consistency No.	No. 2	No. 2	No. 1.5
Additive	Extreme-pressure additive, others	Extreme-pressure additive, others	Extreme-pressure additive, others
Drop Point	197ºC	198ºC	247ºC
Appearance	Yellow	Green	Light yellow
Storage life	5 years in sealed condition	5 years in sealed condition	5 years in sealed condition

■ Compatible grease by size

Compatible grease varies depending on the size and reduction ratio. See the following compatibility table. We recommend SK-1A and SK-2 for general use.

Ratios 30:1 — Table 016-5

Size	8	11	14	17	20	25	32
SK-1A	—	—	—	—	○	○	○
SK-2	○	○	○	○	—	—	—
4B No.2	△	△	△	△	□	□	□

Ratios 50:1* and above — Table 016-6

Size	8	11	14	17	20	25	32
SK-1A	—	—	—	—	○	○	○
SK-2	○	○	○	○	△	△	△
4B No.2	—	—	□	□	□	□	□

Size	40	45	50	58	65	80	90	100
SK-1A	○	○	○	○	○	○	○	○
SK-2	△	—	—	—	—	—	—	—
4B No.2	□	□	□	□	□	□	□	□

○: Standard grease
△: Semi-standard grease
□: Recommended grease for long life and high load

* **Oil lubrication is required for component-sets size 50 or larger with a reduction ratio of 50:1.**

Grease characteristics — Table 016-7

Grease	SK-1A	SK-2	4B No.2
Durability	○	○	◎
Fretting resistance	○	○	◎
Low-temperature performance	△	△	◎
Grease leakage	◎	◎	△

Excellent :◎
Good :○
Use Caution :△

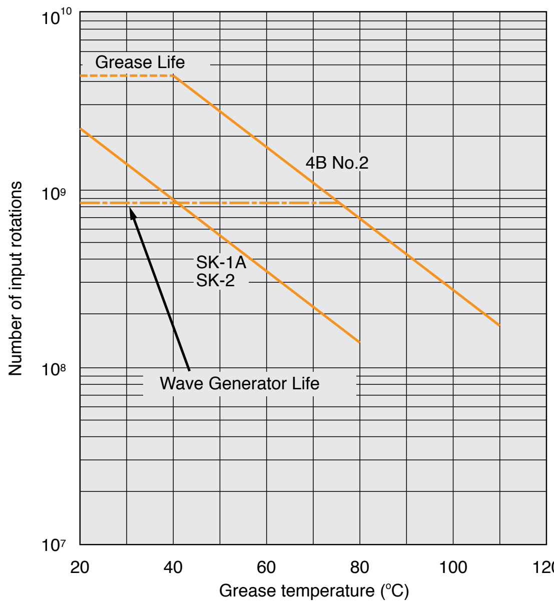
■ When to replace grease

The wear characteristics of the gear are strongly influenced by the condition of the grease lubrication. The condition of the grease is affected by the ambient temperature. The graph 017-1 shows the maximum number of input rotations for various temperatures. This graph applies to applications where the average load torque does not exceed the rated torque.

Note: Recommended Grease: SK-1A or SK-2

When to replace grease: L_{GTn} (when the average load torque is equal to or less than the rated torque)

Graph 017-1



Calculation formula when the average load torque exceeds the rated torque

Formula 017-1

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

Formula Symbols

Table 017-1

L_{GT}	Grease change (if average load torque exceeds rated torque)	input revolutions	————
L_{GTn}	Grease change (if average load torque is equal to or less than rated torque)	input revolutions (From Graph)	See the Graph 017-1.
Tr	Rated torque	Nm	See the "Ratings Table" of each series.
T_{av}	Average load torque	Nm	Calculation formula: See Page 014.

■ Other precautions

1. Avoid mixing different kinds of grease. The gear should be in an individual case when installed.

2. Please contact us when you use HarmonicDrive® gears at constant load or in one direction continuously, as it may cause lubrication problems.

3. Grease leakage. A sealed structure is needed to maintain the high durability of the gear and prevent grease leakage.

■ See the corresponding pages of the design guide of each series for "Recommended minimum housing clearance," Application guide" and "Application quantity."

Precautions on using Harmonic Grease® 4B No.2

Harmonic Grease® 4B No.2 lubrication is ideally suited for Harmonic Drive® gears.

(1) Apply the grease to each contacting joint at the beginning of operation.
(2) Remove any contaminants created by abrasion during running-in period.

■ See the corresponding pages of the design guide of each series for "recommended minimum housing clearance," Application guide" and "Application quantity."

■ Precautions

(1) Stir Grease
When storing Harmonic Grease 4B No.2 lubrication in the container, it is common for the oil to weep from the thickener.
Before greasing, stir the grease in the container to mix and soften.

(2) Aging (running-in)
The aging before the main operation softens the applied grease. More effective greasing performance can be realized when the grease is distributed around each contact surface.
Therefore, the following aging methods are recommended.

- Keep the internal temperature at 80ºC or cooler. Do not start the aging at high temperature rapidly.
- Input rotational speed should be 1000rpm to 3000rpm. However, the lower rotational speed of 1000rpm is more effective. Set the speed as low as possible within the indicated range.
- The time required for aging is 20 minutes or longer.
- Operation range for aging: Keep the output rotational angle as large as possible.

Contact us if you have any questions for handling Harmonic Grease 4B No.2 lubrication.

Note: Strict sealing is required to prevent grease leakage.

Oil lubricant

■ Types of oil

The specified standard lubricant is "Industrial gear oil class-2 (extreme pressure) ISO VG68."
We recommend the following brands as a commercial lubricant.

Table 018-1

Standard	Mobil Oil	Exxon	Shell	COSMO Oil	Japan Energy	NIPPON Oil	Idemitsu Kosan	General Oil	Klüber
Industrial gear oil class-2 (extreme pressure) ISO VG68	Mobilgear 600XP68	Spartan EP68	Omala Oil 68	Cosmo gear SE68	ES gear G68	Bonock M68, Bonock AX68	Daphne super gear LW68	General Oil SP gear roll 68	Syntheso D-68EP

■ When to replace oil

First time ························ 100 hours after starting operation
Second time or after ······· Every 1000 operation hours or every 6 months
Note that you should replace the oil earlier than specified if the operating condition is demanding.

■ See the corresponding pages of the design guide of each series for specific details.

■ Other precautions

1. Avoid mixing different kinds of oil. The gear should be in an individual case when installed.

2. When you use size 50 or above at max allowable input speed, please contact us as it may cause lubrication problems.

*** Oil lubrication is required for component-sets size 50 or larger with a reduction ratio of 50:1.**

Lubricant for special environments

When the ambient temperature is special (other than the "temperature range of the operating environment" on Page 016-2), you should select a lubricant appropriate for the operating temperature range.

Harmonic Grease 4B No.2

Table 019-1

Type of lubricant	Operating temperature range	Available temperature range
Grease	–10˚C to + 110˚C	–50˚C to + 130˚C

High temperature lubricant

Table 019-2

Type of lubricant	Lubricant and manufacturer	Available temperature range
Grease	Mobil grease 28: Mobil Oil	–5˚C to + 160˚C
Oil	Mobil SHC-626: Mobil Oil	–5˚C to + 140˚C

Low temperature lubricant

Table 019-3

Type of lubricant	Lubricant and manufacturer	Available temperature range
Grease	Multemp SH-KII: Kyodo Oil	–30˚C to + 50˚C
	Isoflex LDS-18 special A: KLÜBER	–25˚C to + 80˚C
Oil	SH-200-100CS: Toray Silicon	–40˚C to + 140˚C
	Syntheso D-32EP: KLÜBER	–25˚C to + 90˚C

Harmonic Grease 4B No.2

The operating temperature range of Harmonic Grease 4B No.2 lubrication is the temperature at the lubricating section with the performance and characteristics of the gear taken into consideration. (It is not ambient temperature.)

As the available temperature range indicates the temperature of the independent lubricant, restriction is added on operating conditions (such as load torque, rotational speed and operating cycle) of the gear. When the ambient temperature is very high or low, materials of the parts of the gear need to be reviewed for suitability. Contact us if operating in high temperature.

Harmonic Grease 4B No.2 can be used in the available temperature range shown in table 019-1. However, input running torque will increase at low temperatures, and grease life will be decreased at high temperatures due to oxidation and lubricant degradation.

Engineering Data
Component Sets
Gear Units
Phase Adjusters
Gearheads & Actuators

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 a torsional angle almost proportional to the torque on the output side. Figure 020-1 shows the torsional angle at the output side when the torque applied on the output side starts from zero, increases up to $+T_0$ and decreases down to $-T_0$. This is called the "Torque – torsion angle diagram," which normally draws a loop of 0 – A – B – A′ – B′ – A. The slope described in the "Torque – torsion angle diagram" is represented as the spring constant for the stiffness of the HarmonicDrive® gear (unit: Nm/rad).
As shown in Figure 020-2 "Spring Constant Diagram" is divided into 3 regions, and the spring constants in the area are represented by K_1, K_2 and K_3.

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

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

■ Example for calculating the torsion angle

The torsion angle (θ) is calculated here using CSF-25-100-2A-GR as an example.

When the applied torque is T_1 or less, the torsion angle θ_{L1} is calculated as follows:
When the load torque T_{L1}=2.9 Nm

$$\theta_{L1} = T_{L1}/K_1 = 2.9/3.1\times10^4 = 9.4\times10^{-5}\ \text{rad (0.33 arc min)}$$

When the applied torque is between T_1 and T_2, the torsion angle θ_{L2} is calculated as follows:
When the load torque is T_{L2}=39 Nm

$$\theta_{L2} = \theta_1 + (T_{L2} - T_1)/K_2 = 4.4\times10^{-4} + (39-14)/5.0\times10^4 = 9.4\times10^{-4}\ \text{rad (3.2 arc min)}$$

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

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

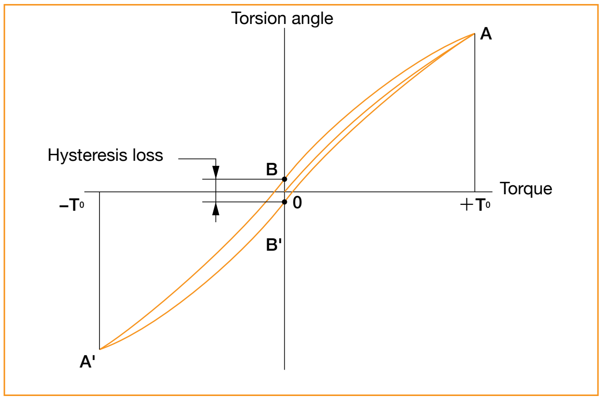
Note: See p.120 for torsional stiffness for pancake gearing .

■ Hysteresis loss (Silk hat and cup style only)

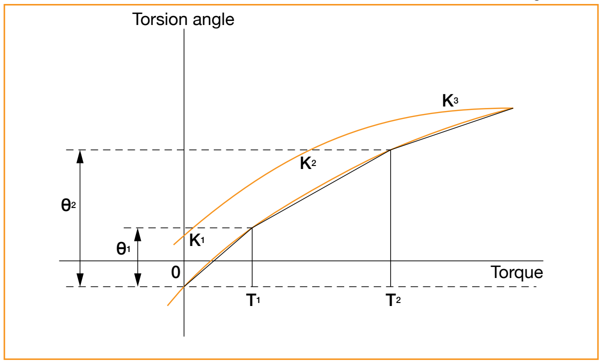
As shown in Figure 020-1, when the applied torque is increased to the rated torque and is brought back to [zero], the torsional angle does not return exactly back to the zero point This small difference (B – B') is called hysteresis loss.

■ See the corresponding page of each series for the hysteresis loss value.

Torque - torsion angle diagram Figure 020-1



Spring constant diagram Figure 020-2



■ Backlash (Silk hat and cup style only)

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

Positional Accuracy

Positional 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.

- See the corresponding pages of each series for transmission accuracy values.

Table 021-1

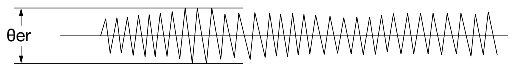
θer	Transmission accuracy
θ_1	Input angle
θ_2	Actual output angle
R	Reduction ratio

Formula 021-1

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

Example of measurement

Graph 021-1



Vibration

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

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

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

Formula 021-2

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

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

How to the calculate resonant frequency of the system

Formula 021-3

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

Formula variables

Table 021-2

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

Starting Torque

Starting torque is the torque value applied to the input side at which the output first starts to rotate. The values in the table of each series indicate the maximum value, and the lower-limit value indicates approximately $^1/_2$ to $^1/_3$ of the maximum value.

Measurement conditions:
No-load, ambient temperature: +20ºC

■ See the corresponding pages of each series for starting torque values.

* Use the values in the table of each series as reference values as they vary depending on the usage conditions.

Backdriving Torque

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, typical values are approximately $^1/_2$ of the maximum values.
Note: Never rely on these values as a margin in a system that must hold an external load. A brake must be used where back driving is not permissible.

Measurement conditions:
No-load, ambient temperature: +20ºC

■ See the corresponding pages of each series for backdriving torque values.

* Use the values in the table of each series as reference values as they vary depending on the usage conditions.

No-Load Running Torque

No-load running torque is the torque which is required to rotate the input side (high speed side), when there is no load on the output side (low speed side). The graph of the no-load running torque shown in this catalog depends on the measurement conditions shown in Table 023-1.
Add the compensation values shown by each series to all reduction ratios except 100:1.

■ See the corresponding pages of each series for no-load running torque values.

Measurement condition

Table 023-1

Reduction ratio 100			
Lubricant	Grease lubrication	Name	Harmonic Grease SK-1A
			Harmonic Grease SK-2
		Quantity	(See pages of each series)
Torque value is measured after 2 hours at 2000 rpm input			

* Contact us for oil lubrication.

Efficiency

The efficiency varies depending on the following conditions.
- Reduction ratio
- Input speed
- Load torque
- Temperature
- Lubrication (type and quantity)

The efficiency characteristics of each series shown in this catalog depends on the measurement condition shown in Table 023-2.

■ See the corresponding pages of each series for efficiency values.

Measurement condition

Table 023-2

Installation	Based on recommended tolerance		
Load torque	The rated torque shown in the rating table (see the corresponding pages on each series)		
Lubricant	Grease lubrication	Name	Harmonic Grease SK-1A
			Harmonic Grease SK-2
		Quantity	Recommended quantity (see the pages on each series)

* Contact us for oil lubrication.

■ Efficiency compensation coefficient

If load torque is below rated torque, a compensation factor must be employed. Calculate the compensation coefficient Ke from the efficiency compensation coefficient graph of each series and use the following example for calculation.

Example of calculation

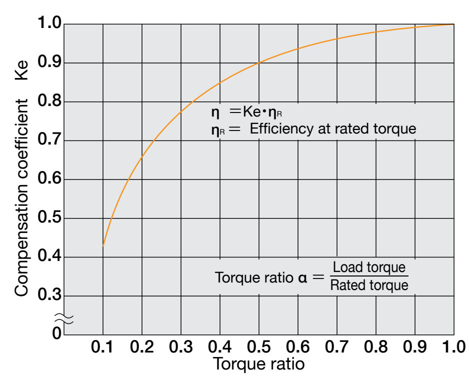
Efficiency **η** (%) under the following condition is obtained from the example of CSF-20-80-2A-GR.
Input rotational speed: 1000 rpm
Load torque: 19.6 Nm
Lubrication method: Grease lubrication (Harmonic Grease SK-1A)
Lubricant temperature: 20°C
Since the rated torque of size 20 with a reduction ratio of 80 is 34 Nm (Ratings: Page 039), the torque ratio **α** is 0.58.
(**α**=19.6/34=0.58)

■ The efficiency compensation coefficient is Ke=0.93 from Graph 023-1.

■ Efficiency **η** at load torque 19.6 Nm: **η**=Ke•**η**R=0.93 x 78=73%

Efficiency compensation coefficient (CSF series)

Graph 023-1



* Efficiency compensation coefficient Ke=1 when the load torque is greater than the rated torque.

Design Guidelines

Design guideline

The relative perpendicularity and concentricity of the three basic Harmonic Drive® elements have an important influence on accuracy and service life.

Misalignments will adversely affect performance and reliability. Compliance with recommended assembly tolerances is essential in order for the advantages of Harmonic Drive® gearing to be fully realized. Please consider the following when designing:

(1) Input shaft, Circular Spline and housing must be concentric.

(2) When operating, an axial force is generated on the wave generator. Input bearings must be selected to accommodate this axial load. See page 27.

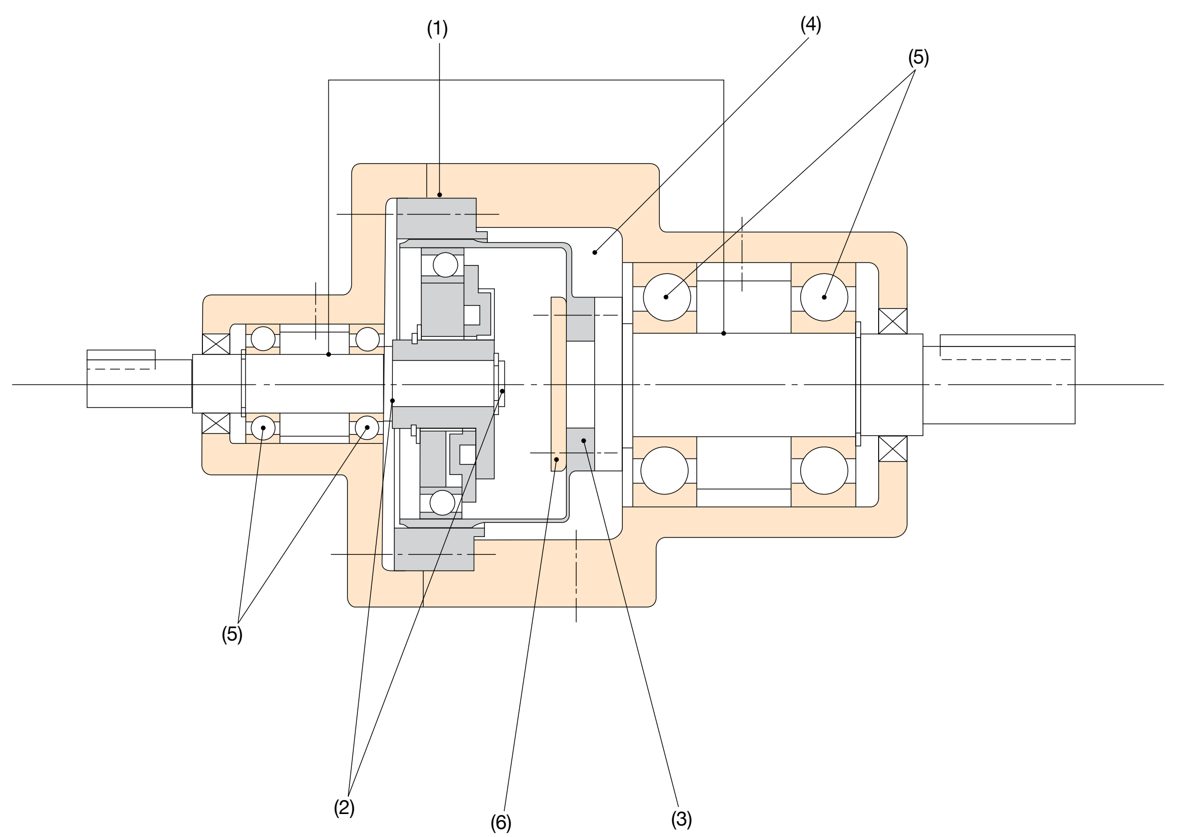
(3) Even though a HarmonicDrive® gear is compact, it transmits large torques. Therefore, assure that all required bolts are used to fasten the circular spline and flexspline and that they are tightened to the recommended torque.

(4) As the flexspline is subject to elastic deformation, the A minimal clearance between the flexspline and housing is required. Refer to "Minimum Housing Clearance" on the drawing dimension tables.

(5) The input shaft and output shaft are supported by anti-friction bearings. As the wave generator and flexspline elements are meant to transmit pure torque only, the bearing arrangement needs to isolate the harmonic gearing from external forces applied to either shaft. A common bearing arrangement is depicted in the diagram.

(6) A clamping plate is recommended (item 6). Its purpose is to spread fastening forces and to avoid any chance of making physical contact with the thin section of the flexspline diaphragm. The clamping plate shall not exceed the diaphragm's boss diameter and is to be designed in accordance with catalog recommendations.

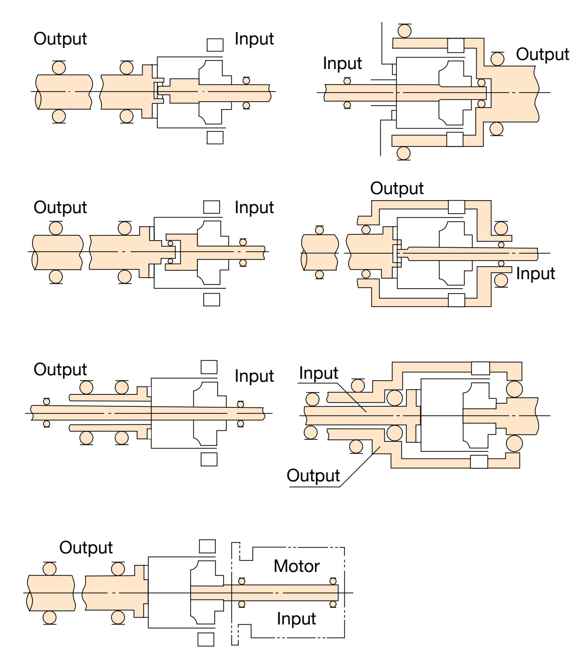
Fig. 024-1



Bearing support for the input and output shafts

For the component sets, both input and output shafts must be supported by two adequately spaced bearings in order to withstand external radial and axial forces without excessive deflection.
In order to avoid damage to the component set when limited external loads are anticipated, both input and output shafts must be axially fixed.
Bearings must be selected whose radial play does not exceed ISO-standard C 2 class or “normal” class. The bearings should be axially and radially preloaded to eliminate backlash.
Examples of correct bearing arrangements are shown in fig 025-1.

Fig. 025-1

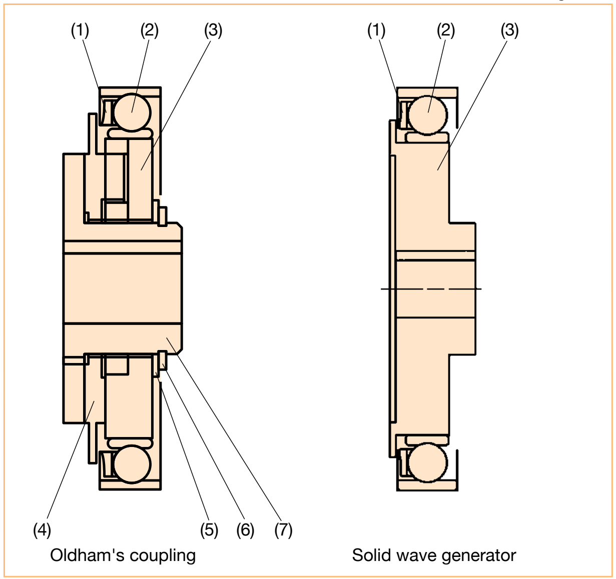


Wave generator

■ Structure of the wave generator

The wave generator includes an Oldham's coupling type with a self-aligning structure and an integrated solid wave generator without a self-aligning structure, and which is used depends on the series.
See the diagram of each series for details. The basic structure of the wave generator and the shape are shown below.

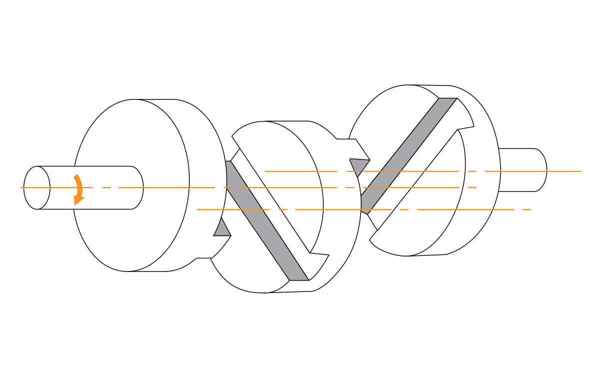
Fig. 026-1



(1) Ball Separator
(2) Wave generator bearing
(3) Wave generator plug
(4) Insert
(5) Rubwasher
(6) Snap ring
(7) Wave generator hub

Structure of Oldham's coupling

Fig. 026-2



Maximum hole diameter of wave generator

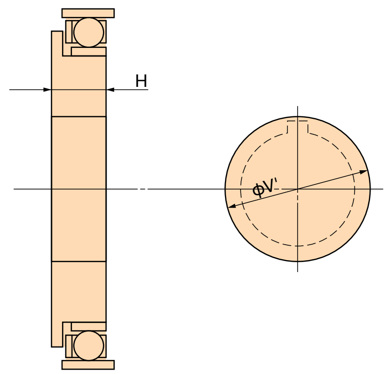
The standard hole dimension of the wave generator is shown for each size. The dimension can be changed within a range up to the maximum hole dimension. We recommend the dimension of keyway based on JIS standard. It is necessary that the dimension of keyways should sustain the transmission torque.

* Tapered holes are also available.

In cases where a larger hole is required, use the wave generator without the Oldham coupling. The maximum diameter of the hole should be considered to prevent deformation of the Wave Generator plug by load torque. The dimension is shown in the table below and includes the dimension of depth of keyway.
(This is the value including the dimension of the depth of keyway.)

Hole diameter of the wave generator

Fig. 027-1



Hole diameter of the wave generator hub with Oldham coupling

Table 027-1
Unit: mm

Size	8	11	14	17	20	25	32	40	45	50	58	65	80	90	100
Standard dim. (H7)	3	5	6	8	9	11	14	14	19	19	22	24	28	28	28
Minimum hole dim.	—	—	3	4	5	6	6	10	10	10	13	16	16	19	22
Maximum hole dim.	—	—	8	10	13	15	15	20	20	20	25	30	35	37	40

Maximum hole diameter without Oldham Coupling

Table 027-2
Unit: mm

Size	8	11	14	17	20	25	32	40	45	50	58	65	80	90	100
Max. hole dia.ϕV'	10	14	17	20	23	28	36	42	47	52	60	67	72	84	95
Min. plug thick.$H^{0}_{-0.1}$	5.7	6.7	7.2	7.6	11.3	11.3	13.7	15.9	17.8	19	21.4	23.5	28.5	31.3	34.9

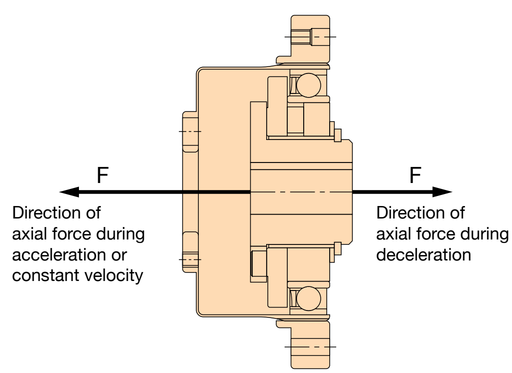
Axial Force of Wave Generator

When the gear is used to accelerate a load, the deflection of the Flexspline leads to an axial force acting on the Wave Generator. This axial force, which acts in the direction of the closed end of the Flexspline, must be supported by the bearings of the input shaft (motor shaft). When the gear is used to decelerate a load, an axial force acts to push the Wave Generator out of the Flexspline cup. Maximum axial force of the Wave Generator can be calculated by the equation shown below. The axial force may vary depending on its operating condition. The value of axial force tends to be a larger number when using high torque, extreme low speed and constant operation. The force is calculated (approximately) by the equation. In all cases, the Wave Generator must be axially (in both directions), as well as torsionally, fixed to the input shaft.

(Note)
Please contact us for further information on attaching the Wave Generator to the input (motor) shaft.

Axial force direction of the wave generator

Fig. 027-2



Formula for Axial Force

Table 027-3

Reduction ratio	Calculation formula
30	$F=2\times\frac{T}{D}\times0.07\times\tan 32°$
50	$F=2\times\frac{T}{D}\times0.07\times\tan 30°$
80 or more	$F=2\times\frac{T}{D}\times0.07\times\tan 20°$

Symbols for Formula

Table 027-4

F	Axial force	N	See Figure 027-2
D	Size	m	
T	Output torque	Nm	

Calculation example

Formula 027-1

Model name: CSF series
Size: 32
Reduction ratio: 50
Output torque: 382 Nm
(maximum allowable momentary torque)

$$F=2\times\frac{382}{(32\times0.00254)}\times0.07\times\tan 30°$$

$$F=380N$$

Assembly Precautions

Sealing

Sealing is needed to maintain the high durability of the gear and prevent grease leakage. Recommended for all mating surfaces, if the o-ring is not used. Flanges provided with o-ring grooves must be sealed when a proper seal cannot be achieved using the o-ring alone.

- Rotating Parts .... Oil seal with spring is needed.
- Mating flange .... O-ring or seal adhesive is needed.
- Screw hole area .... Screws should have a thread lock (LOCTITE® 242 is recommended) or seal adhesive.

(Note) If you use Harmonic Grease 4BNo.2, strict sealing is required.

Sealing recommendations for gear units

Table 028-1

Area requiring sealing		Recommended sealing method
Output side	Holes which penetrate housing	Use O-ring (supplied with the product)
	Installation screw / bolt	Screw lock adhesive which has effective seal (LOCTITE® 242 is recommended)
Input side	Flange surfaces	Use O-ring (supplied with the product)
	Motor output shaft	Please select a motor which has an oil seal on the output shaft.

Assembly precautions

The wave generator is installed after the flexspline and circular spline. If the wave generator is not inserted into the flexspline last, gear teeth scuffing damage or improper eccentric gear mesh may result. Installation resulting in an eccentric tooth mesh (Dedoidal) will cause noise and vibration, and can lead to early failure of the gear. For proper function, the teeth of the flexspline and Circular Spline mesh symmetrically.

■ Precautions on the wave generator

1. Avoid applying undue axial force to the wave generator during installation. Rotating the wave generator bearing while inserting it is recommended and will ease the process.
2. If the wave generator does not have an Oldham coupling, extra care must be given to ensure that concentricity and inclination are within the specified limits

■ Precautions on the circular spline

The circular Spline must not be deformed in any way during the assembly. It is particularly important that the mounting surfaces are prepared correctly

1. Mounting surfaces need to have adequate flatness, smoothness, and no distortion.
2. Especially in the area of the screw holes, burrs or foreign matter should not be present.
3. Adequate relief in the housing corners is needed to prevent interference with the corner of the circular spline.
4. The circular spline should be rotatable within the housing. Be sure there is not interference and that it does not catch on anything.
5. When a bolt is inserted into a bolt hole during installation, make sure that the bolt fits securely and is not in an improper position or inclination.
6. Do not apply torque at recommended torque all at once. First, apply torque at about half of the recommended value to all bolts, then tighten at recommended torque. Order of tightening bolts must be diagonal.
7. Avoid pinning the circular spline if possible as it can reduce the rotational precision and smoothness of operation.

■ Precautions on the flexspline

1. Mounting surfaces need to have adequate flatness, smoothness, and no distortion.
2. Especially in the area of the screw holes, burrs or foreign matter should not be present.
3. Adequate clearance with the housing is needed to ensure no interference especially with the major axis of flexspline
4. Bolts should rotate freely when installing through the mounting holes of the flexspline and should not have any irregularity due to the shaft bolt holes being misaligned or oblique.
5. Do not tighten the bolts with the specified torque all at once. Tighten the bolts temporarily with about half the specified torque, and then tighten them to the specified torque. Tighten them in an even, crisscross pattern.
6. The flexspline and circular spline are concentric after assembly. After installing the wave generator bearing, if it rotates in unbalanced way, check the mounting for dedoidal or non-concentric installation.
7. Care should be taken not to damage the flexspline diaphragm or gear teeth during assembly.

   Avoid hitting the tips of the flexpline teeth and circular spline teeth. Avoid installing the CS from the open side of the flexspline after the wave generator has been installed.

■ Rust prevention

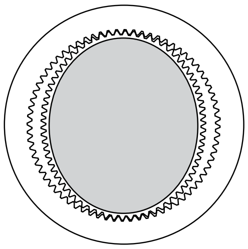
Although the Harmonic Drive® gears come with some corrosion protection, the gear can rust if exposed to the environment. The gear external surfaces typically have only a temporary corrosion inhibitor and some oil applied. If an anti-rust product is needed, please contact us to review the options.

"Dedoidal" state

It is normal for the flexspline to engage with the circular spline symmetrically as shown in Figure 029-1. However, if the ratcheting phenomenon, which is described on Page 013, is caused or if the three parts are forcibly inserted and assembled, engagement of the teeth may be out of alignment as shown in Figure 029-2. This is called "dedoidal". Note: Early failure of the gear will occur.

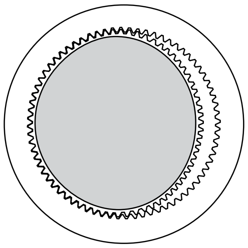
Normal engagement status

Fig. 029-1



"Dedoidal" status

Fig. 029-2



■ How to check "dedoidal"

By performing the following methods, check whether the gear engagement is "dedoidal".

(1) Judging by the irregular torque generated when the wave generator turns

1) Slowly turn the input shaft with your hand in a no-load condition. If you can turn it with average force, it is normal. If it turns irregularly, it may be "dedoidal".

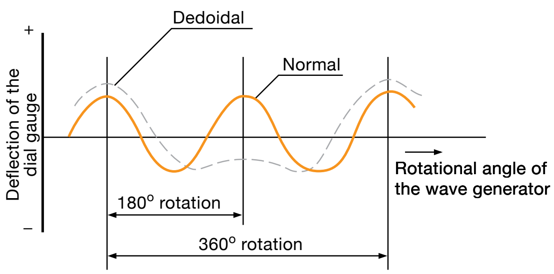
2) Turn the wave generator in a no-load condition if it is attached to a motor. If the average current value of the motor is about 2 to 3 times the normal value, it may be "dedoidal".

(2) Judging by measuring vibration on the body of the flexspline

The scale deflection of the dial gauge draws a sine wave as shown by the solid line in Graph 029-3 when it is normally assembled. When "dedoidal" occurs, the gauge draws a deflected wave shown by the dotted line as the flexspline is out of alignment.

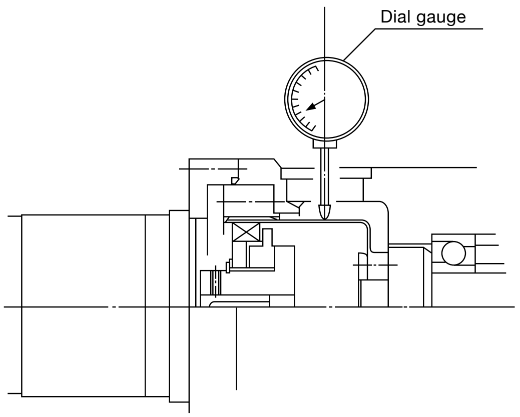
Deflection of the dial gauge

Graph 029-3



Measuring the deflection on the body of the flexspline

Fig. 029-4



Checking Output Bearing

A precision cross roller bearing is built in the unit type and the gear head type to directly support the external load (output flange) (precision 4-point contact ball bearing for the CSF-mini series).
Please calculate maximum moment load, life of cross roller bearing, and static safety factor to fully maximize the performance of a housed unit (gearhead).

■ See the corresponding pages on each series for cross roller bearing specifications.

Checking procedure

(1) Checking the maximum moment load (M_{max})

Calculate maximum moment load (M_{max}). → Maximum moment load (M_{max}) ≦ allowable moment (Mc)

(2) Checking the life

Calculate the radial load (Fr_{av}) and the average axial load (Fa_{av}). → Calculate the radial load coefficient (x) and the axial load coefficient (y). → Calculate lifetime

(3) Checking the static safety coefficient

Calculate the static equivalent radial load coefficient (Po). → Check the static safety coefficient. (fs)

How to calculate the maximum moment load

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

Formula 030-1

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

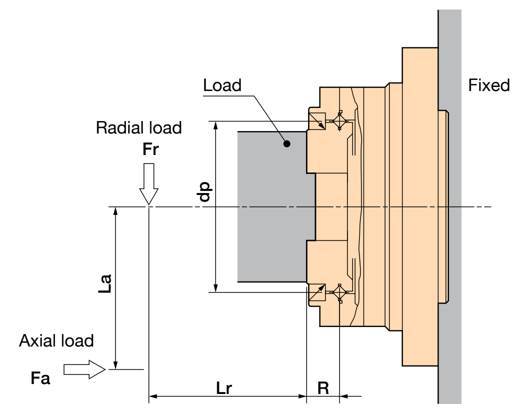
Symbols for Formula 030-1

Table 030-1

Fr_{max}	Max. radial load	N(kgf)	See Fig. 030-1.
Fa_{max}	Max. axial load	N(kgf)	See Fig. 030-1.
Lr, La	————	m	See Fig. 030-1.
R	Offset amount	m	See Fig. 030-1 and "Specification of the output bearing" of each series.

External load influence diagram

Fig. 030-1



How to calculate the average load

(Average radial load, average axial load, average output speed)

When the radial load and axial load vary, the life of cross roller bearing can be determined by converting to an average load.

How to calculate the average radial load (Fr_{av})

Formula 031-1

(Cross roller bearing)

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

(4-point contact ball bearing)

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

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

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

Formula 031-2

(Cross roller bearing)

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

(4-point contact ball bearing)

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

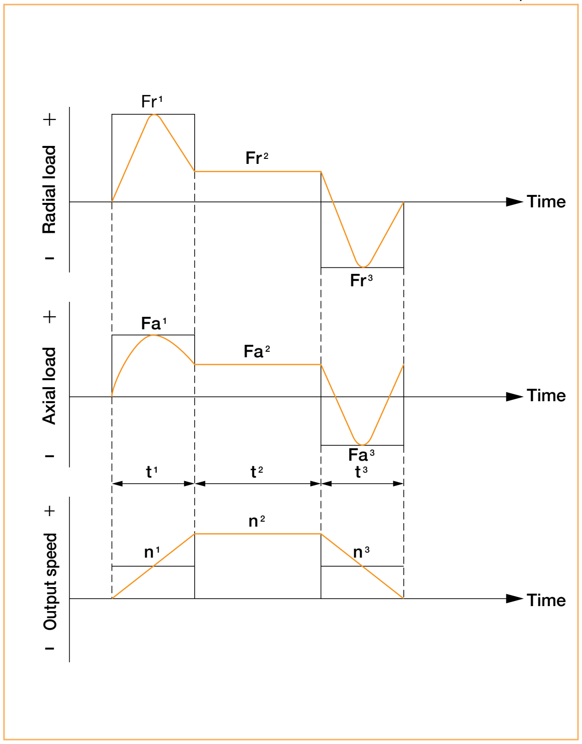
Note that the maximum axial load in t_1 is Fa_1 and the maximum axial load in t_3 is Fa_3.

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

Formula 031-3

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

Graph 031-1



How to calculate the radial load coefficient (X) and axial load coefficient (Y)

Formula 031-4

How to calculate the load coefficient		X	Y
$\frac{Fa_{av}}{Fr_{av} + 2(Fr_{av}(Lr+R) + Fr_{av} \cdot La)/dp}$	<=1.5	1	0.45
$\frac{Fa_{av}}{Fr_{av} + 2(Fr_{av}(Lr+R) + Fr_{av} \cdot La)/dp}$	>1.5	0.67	0.67

Symbols for Formula 031-4

Table 031-1

Fr_{av}	Average radial load	N(kgf)	See "How to calculate the average load." See Formula 031-1.
Fa_{av}	Average axial load	N(kgf)	See "How to calculate the average load." See Formula 031-2.
Lr, La	————	m	See fig. 030-1
R	Offset amount	m	See Fig. 030-1 and "Main roller bearing specifications" of each series
dp	Pitch circle diameter of a roller	m	See Fig. 030-1 and "Specification of the output bearing" of each series.

Life of the output bearing

Calculate life of the output bearing by Formula 032-1.
You can calculate the dynamic equivalent radial load (Pc) by Formula 032-2.

Formula 032-1

(Cross roller bearing)

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

(4-point contact ball bearing)

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

Formula 032-2

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

Symbols for Formula 032-1

Table 032-1

L_{10}	Life	hour	―――
N_{av}	Average output rated load speed	rpm	See "How to calculate the average load."
C	Basic dynamic rated load	N (kgf)	See "Specification of the output bearing" of each series.
Pc	Dynamic equivalent	N (kgf)	See Formula 032-2.
fw	Load coefficient	――	See Table 032-3.

Symbols for Formula 032-2

Table 032-2

Fr_{av}	Average radial load	N (kgf)	See "How to calculate the average load." See Formula 031-1.
Fa_{av}	Average axial load	N (kgf)	See "How to calculate the average load." See Formula 031-2.
dp	Pitch circle diameter	m	See Fig. 030-1 and "Specification of the output bearing" of each series.
X	Radial load coefficient	――	See Formula 031-4.
Y	Axial load coefficient	――	See Formula 031-4.
Lr, La	―――	m	See Figure 030-1.
R	Offset	m	See Fig. 030-1 and "Specification of the output bearing" of each series.

Load coefficient

Table 032-3

Load status	fw
Steady operation without impact and vibration	1 to 1.2
Normal operation	1.2 to 1.5
Operation with impact and vibration	1.5 to 3

How to calculate life during oscillating motion

Calculate the life of the cross roller bearing during oscillating motion by Formula 033-1.

Formula 033-1

(Cross roller bearing)

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

(4-point contact ball bearing)

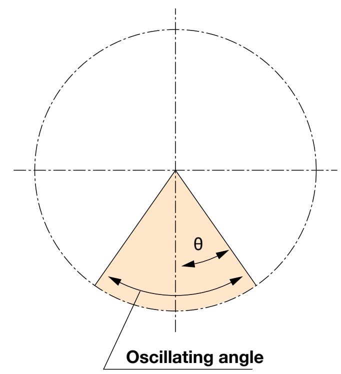
$$Loc = \frac{10^6}{60 \times n1} \times \frac{90}{\theta} \times \left(\frac{C}{fw \cdot Pc}\right)^{3}$$

Symbols for Formula 033-1

Table 033-1

Loc	Rated life for oscillating motion	hour	―――
n1	Round trip oscillation each minute	cpm	―――
C	Basic dynamic rated load	N (kgf)	―――
Pc	Dynamic equivalent radial load	N (kgf)	See Formula 032-2.
fw	Load coefficient	――	See Table 032-3.
θ	Oscillating angle /2	Degree	See Fig. 033-1.

Fig. 033-1



(Note) A small angle of oscillation (less than 5 degrees) may cause fretting corrosion to occur since lubrication may not circulate properly. Contact us if this happens.

How to calculate the static safety coefficient

Basic static rated load is an allowable limit for static load, but its limit is determined by usage. In this case, static safety coefficient of the cross roller bearing can be calculated by Formula 034-2.

Formula 034-1

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

Formula 034-2

$$Po = Fr\,max + \frac{2M\,max}{dp} + 0.44Fa\,max$$

Symbols for Formula 034-1

Table 034-1

Co	Basic static rated load	N(kgf)	See "Specification of the output bearing" of each series.
Po	Static equivalent radial load	N(kgf)	See Formula 034-2.

Static Safety Coefficient

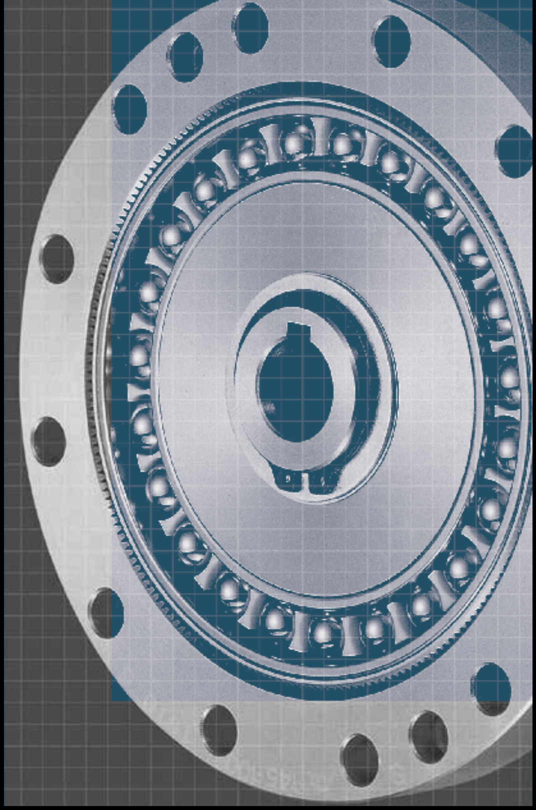
Table 034-3

Operating condition of the roller bearing	fs
When high rotation precision is required	≧3
When shock and vibration are expected	≧2
Under normal operating condition	≧1.5

Symbols for Formula 034-2

Table 034-2

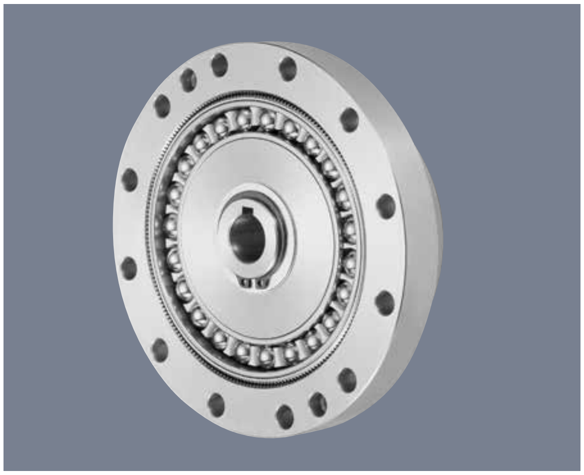
Fr*max*	Max. radial load	N(kgf)	See "How to calculate the maximum moment load" on Page 030.
Fa*max*	Max. axial load	N(kgf)	
M*max*	Max. moment load	Nm(kgfm)	
dp	Pitch circle diameter of a roller	m	See Fig. 030-1 and "Specification of the output bearing" of each series.



CSG/CSF Series

Component Set CSG/CSF

Features



CSG/CSF component set

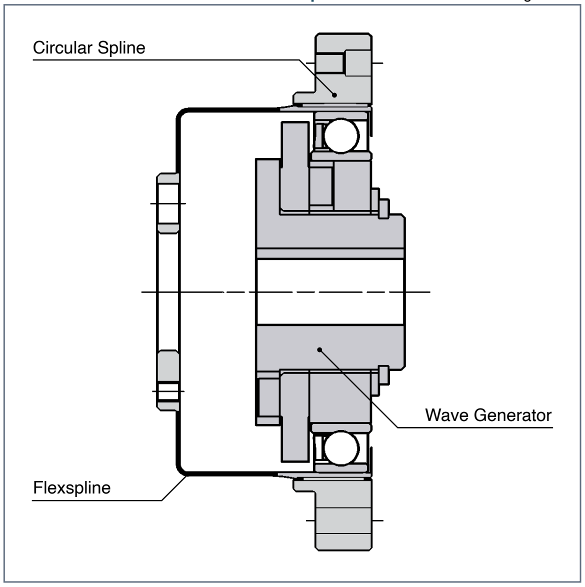
Harmonic Drive® zero backlash, precision component sets are the core motion control mechanisms. The CSF standard torque version, and CSG high-torque version component sets are available in a wide variety of sizes and ratios. These high accuracy gearing components are often used as the core building block for high performance, custom servo actuators and motion control systems. Customer-supplied servo motors can also be easily integrated. These compact gears are extremely customizable and can be seamlessly integrated into your design.

Features

- Zero backlash
- Compact and simple design
- High torque capacity
- High stiffness
- High positioning and rotational accuracies
- Coaxial input and output

Structure of CSG/CSF series component set

Fig. 036-1



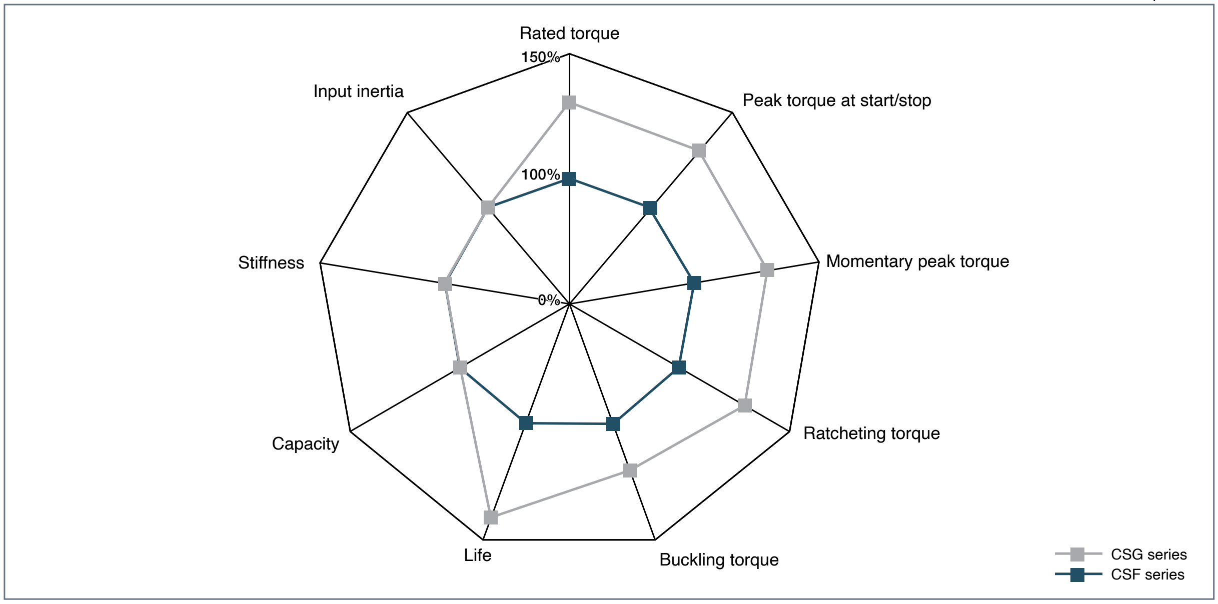
Series

CSG
- CSG high torque version offers 30% higher torque than CSF series.
- Life for CSG series has been improved by 43% (10,000 hours) compared to the CSF series
- Ratios: 50:1 ~160:1
- Peak Torque 1.8~9200 Nm
- Sizes 73~260mm

CSF
- Ratios 30:1 ~ 160:1 (30:1 reduction ratio on 7 sizes)
- Peak Torque 23~3400 Nm
- Sizes 30~330mm

Comparison between CSG series and CSF series

Graph 036-1



Ordering Code

CSG - 25 - 100 - 2A - GR - SP

Table 037-1

Series	Size	Ratio*1					Model		Special specification
CSG = High Torque	14	50	80	100	—	—	2A=component set 2UH=housed unit	GR= component set * (2A-R for Size 14, 17) * Not indicated on 2UH	SP= Special specification code Blank= Standard product
	17	50	80	100	120	—			
	20	50	80	100	120	160			
	25	50	80	100	120	160			
	32	50	80	100	120	160			
	40	50	80	100	120	160			
	45	50	80	100	120	160			
	50	—	80	100	120	160			
	58	—	80	100	120	160			
	65	—	80	100	120	160			

*1 The reduction ratio value is based on the following configuration:
Input: wave generator, fixed: circular spline, output: flexspline

CSF - 25 - 100 - 2A - GR - SP

Table 037-2

Series	Size	Ratio*1						Model		Special specification
CSF = Standard Torque	8	30	50	—	100	—	—	2A=component set 2UH=housed unit	GR= component set * 2A-R for Size 8, 14, 17 * Not indicated on 2UH	SP= Special specification code Blank= Standard product
	11	30	50	—	100	—	—			
	14	30	50	80	100	—	—			
	17	30	50	80	100	120	—			
	20	30	50	80	100	120	160			
	25	30	50	80	100	120	160			
	32	30	50	80	100	120	160			
	40	—	50	80	100	120	160			
	45	—	50	80	100	120	160			
	50*2	—	50	80	100	120	160			
	58*2	—	50	80	100	120	160			
	65*2	—	50	80	100	120	160			
	80*2	—	50	80	100	120	160			
	90*2	—	50	80	100	120	160			
	100*2	—	50	80	100	120	160			

*1 The reduction ratio value is based on the following configuration:
Input: wave generator, fixed: circular spline, output: flexspline
*2 Oil lubrication is required for component-sets size 50 or larger with a reduction ratio of 50:1.

Technical Data

Rating table

CSG series

Table 038-1

Size	Ratio	Rated Torque at 2000rpm		Limit for Repeated Peak Torque		Limit for Average Torque		Limit for Momentary Peak Torque		Maximum Input Speed (rpm)		Limit for Average Input Speed (rpm)		Moment of Inertia	
		Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm	Oil	Grease	Oil	Grease	I $\times10^{-4}$kgm^2	J $\times10^{-5}$kgfms^2
14	50	7.0	0.7	23	2.3	9.0	0.9	46	4.7	14000	8500	6500	3500	0.033	0.034
	80	10	1.0	30	3.1	14	1.4	61	6.2						
	100	10	1.0	36	3.7	14	1.4	70	7.2						
17	50	21	2.1	44	4.5	34	3.4	91	9	10000	7300	6500	3500	0.079	0.081
	80	29	2.9	56	5.7	35	3.6	113	12						
	100	31	3.2	70	7.2	51	5.2	143	15						
	120	31	3.2	70	7.2	51	5.2	112	11						
20	50	33	3.3	73	7.4	44	4.5	127	13	10000	6500	6500	3500	0.193	0.197
	80	44	4.5	96	9.8	61	6.2	165	17						
	100	52	5.3	107	10.9	64	6.5	191	20						
	120	52	5.3	113	11.5	64	6.5	191	20						
	160	52	5.3	120	12.2	64	6.5	191	20						
25	50	51	5.2	127	13	72	7.3	242	25	7500	5600	5600	3500	0.413	0.421
	80	82	8.4	178	18	113	12	332	34						
	100	87	8.9	204	21	140	14	369	38						
	120	87	8.9	217	22	140	14	395	40						
	160	87	8.9	229	23	140	14	408	42						
32	50	99	10	281	29	140	14	497	51	7000	4800	4600	3500	1.69	1.72
	80	153	16	395	40	217	22	738	75						
	100	178	18	433	44	281	29	841	86						
	120	178	18	459	47	281	29	892	91						
	160	178	18	484	49	281	29	892	91						
40	50	178	18	523	53	255	26	892	91	5600	4000	3600	3000	4.50	4.59
	80	268	27	675	69	369	38	1270	130						
	100	345	35	738	75	484	49	1400	143						
	120	382	39	802	82	586	60	1530	156						
	160	382	39	841	86	586	60	1530	156						
45	50	229	23	650	66	345	35	1235	126	5000	3800	3300	3000	8.68	8.86
	80	407	41	918	94	507	52	1651	168						
	100	459	47	982	100	650	66	2041	208						
	120	523	53	1070	109	806	82	2288	233						
	160	523	53	1147	117	819	84	2483	253						
50	80	484	49	1223	125	675	69	2418	247	4500	3500	3000	2500	12.5	12.8
	100	611	62	1274	130	866	88	2678	273						
	120	688	70	1404	143	1057	108	2678	273						
	160	688	70	1534	156	1096	112	3185	325						
58	80	714	73	1924	196	1001	102	3185	325	4000	3000	2700	2200	27.3	27.9
	100	905	92	2067	211	1378	141	4134	422						
	120	969	99	2236	228	1547	158	4329	441						
	160	969	99	2392	244	1573	160	4459	455						
65	80	969	99	2743	280	1352	138	4836	493	3500	2800	2400	1900	46.8	47.8
	100	1236	126	2990	305	1976	202	6175	630						
	120	1236	126	3263	333	2041	208	6175	630						
	160	1236	126	3419	349	2041	208	6175	630						

(Note) 1. Oil lubrication is required for size 50 or higher with a reduction ratio of 50:1. Use grease lubrication within half the rated torque.
2. Moment of inertia: $I=\frac{1}{4}GD^2$
3. See Rating Table Definitions on Page 12 for details of the terms.
4. If maximum allowable momentary torque is applied, see "Installation of the flexspline" of each series.

CSF series

Table 038-2

Size	Ratio	Rated Torque at 2000rpm		Limit for Repeated Peak Torque		Limit for Average Torque		Limit for Momentary Peak Torque		Maximum Input Speed (rpm)		Limit for Average Input Speed (rpm)		Moment of Inertia	
		Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm	Oil	Grease	Oil	Grease	I $\times10^{-4}$kgm^2	J $\times10^{-5}$kgfms^2
8	30	0.9	0.09	1.8	0.18	1.4	0.14	3.3	0.34	14000	8500	6500	3500	0.003	0.0031
	50	1.8	0.18	3.3	0.34	2.3	0.24	6.6	0.67						
	100	2.4	0.25	4.8	0.49	3.3	0.34	9.0	0.92						
11	30	2.2	0.22	4.5	0.46	3.4	0.35	8.5	0.87	14000	8500	6500	3500	0.012	0.012
	50	3.5	0.36	8.3	0.85	5.5	0.56	17	1.7						
	100	5.0	0.51	11	1.1	8.9	0.91	25	2.6						
14	30	4.0	0.41	9.0	0.92	6.8	0.69	17	1.7	14000	8500	6500	3500	0.033	0.034
	50	5.4	0.55	18	1.8	6.9	0.70	35	3.6						
	80	7.8	0.80	23	2.4	11	1.1	47	4.8						
	100	7.8	0.80	28	2.9	11	1.1	54	5.5						

■ CSF series

Table 039-1

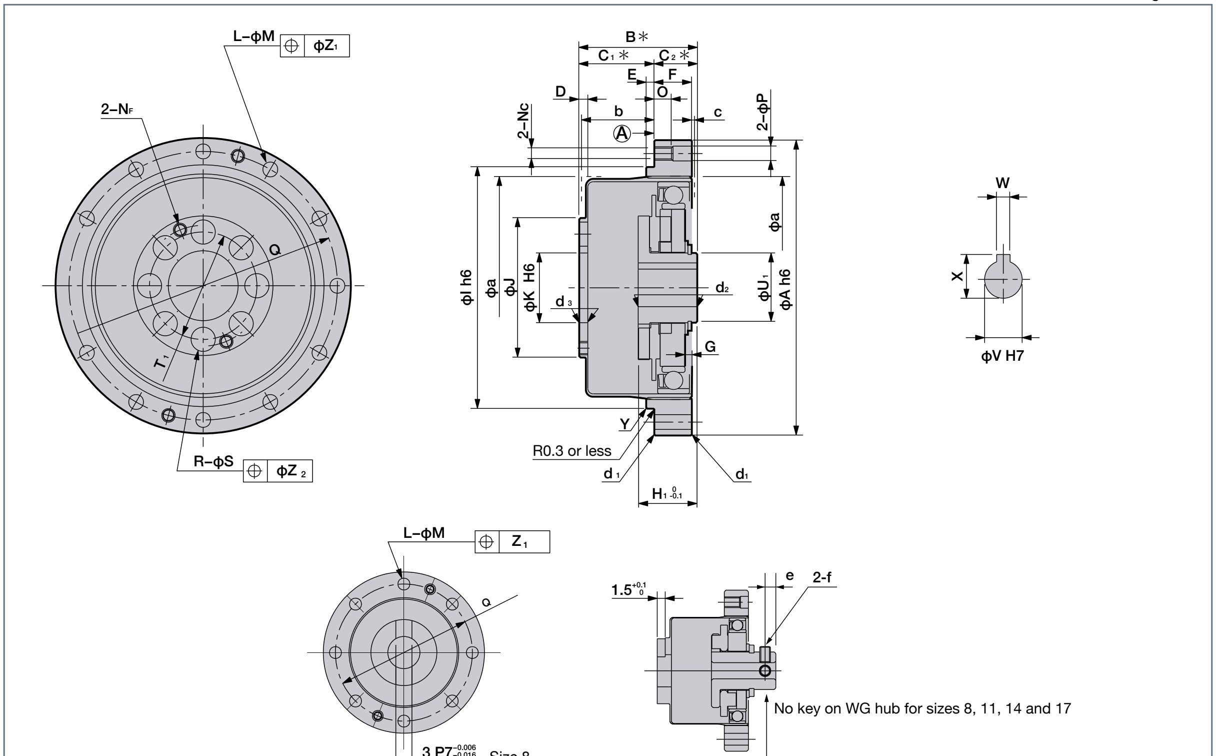
Size	Ratio	Rated Torque at 2000rpm		Limit for Repeated Peak Torque		Limit for Average Torque		Limit for Momentary Peak Torque		Maximum Input Speed (rpm)		Limit for Average Input Speed (rpm)		Moment of Inertia	
		Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm	Oil	Grease	Oil	Grease	I $\times10^{-4}kgm^2$	J $\times10^{-5}kgfms^2$
17	30	8.8	0.9	16	1.6	12	1.2	30	3.1	10000	7300	6500	3500	0.079	0.081
	50	16	1.6	34	3.5	26	2.6	70	7.1						
	80	22	2.2	43	4.4	27	2.7	87	8.9						
	100	24	2.4	54	5.5	39	4.0	108	11						
	120	24	2.4	54	5.5	39	4.0	86	8.8						
20	30	15	1.5	27	2.8	20	2.0	50	5.1	10000	6500	6500	3500	0.193	0.197
	50	25	2.5	56	5.7	34	3.5	98	10						
	80	34	3.5	74	7.5	47	4.8	127	13						
	100	40	4.1	82	8.4	49	5.0	147	15						
	120	40	4.1	87	8.9	49	5.0	147	15						
	160	40	4.1	92	9.4	49	5.0	147	15						
25	30	27	2.8	50	5.1	38	3.9	95	9.7	7500	5600	5600	3500	0.413	0.421
	50	39	4.0	98	10	55	5.6	186	19						
	80	63	6.4	137	14	87	8.9	255	26						
	100	67	6.8	157	16	108	11	284	29						
	120	67	6.8	167	17	108	11	304	31						
	160	67	6.8	176	18	108	11	314	32						
32	30	54	5.5	100	10	75	7.7	200	20	7000	4800	4600	3500	1.69	1.72
	50	76	7.8	216	22	108	11	382	39						
	80	118	12	304	31	167	17	568	58						
	100	137	14	333	34	216	22	647	66						
	120	137	14	353	36	216	22	686	70						
	160	137	14	372	38	216	22	686	70						
40	50	137	14	402	41	196	20	686	70	5600	4000	3600	3000	4.50	4.59
	80	206	21	519	53	284	29	980	100						
	100	265	27	568	58	372	38	1080	110						
	120	294	30	617	63	451	46	1180	120						
	160	294	30	647	66	451	46	1180	120						
45	50	176	18	500	51	265	27	950	97	5000	3800	3300	3000	8.68	8.86
	80	313	32	706	72	390	40	1270	130						
	100	353	36	755	77	500	51	1570	160						
	120	402	41	823	84	620	63	1760	180						
	160	402	41	882	90	630	64	1910	195						
50	50	245	25	715	73	350	36	1430	146	4500	3500	3000	2500	12.5	12.8
	80	372	38	941	96	519	53	1860	190						
	100	470	48	980	100	666	68	2060	210						
	120	529	54	1080	110	813	83	2060	210						
	160	529	54	1180	120	843	86	2450	250						
58	50	353	36	1020	104	520	53	1960	200	4000	3000	2700	2200	27.3	27.9
	80	549	56	1480	151	770	79	2450	250						
	100	696	71	1590	162	1060	108	3180	325						
	120	745	76	1720	176	1190	121	3330	340						
	160	745	76	1840	188	1210	123	3430	350						
65	50	490	50	1420	145	720	73	2830	289	3500	2800	2400	1900	46.8	47.8
	80	745	76	2110	215	1040	106	3720	380						
	100	951	97	2300	235	1520	155	4750	485						
	120	951	97	2510	256	1570	160	4750	485						
	160	951	97	2630	268	1570	160	4750	485						
80	50	872	89	2440	249	1260	129	4870	497	2900	2300	2200	1500	122	124
	80	1320	135	3430	350	1830	187	6590	672						
	100	1700	173	4220	431	2360	241	7910	807						
	120	1990	203	4590	468	3130	319	7910	807						
	160	1990	203	4910	501	3130	319	7910	807						
90	50	1180	120	3530	360	1720	176	6660	680	2700	2000	2100	1300	214	218
	80	1550	158	3990	407	2510	256	7250	740						
	100	2270	232	5680	580	3360	343	9020	920						
	120	2570	262	6160	629	4300	439	9800	1000						
	160	2700	276	6840	698	4300	439	11300	1150						
100	50	1580	161	4450	454	2280	233	8900	908	2500	1800	2000	1200	356	363
	80	2380	243	6060	618	3310	338	11600	1180						
	100	2940	300	7350	750	4630	472	14100	1440						
	120	3180	324	7960	812	5720	584	15300	1560						
	160	3550	362	9180	937	5720	584	15500	1580						

(Note) 1. Oil lubrication is required for size 50 or higher with a reduction ratio of 50:1. Use grease lubrication within half the rated torque.
2. Moment of inertia: $I = \frac{1}{4} GD^2$
3. See Rating Table Definitions on Page 12 for details of the terms.
4. If maximum allowable momentary torque is applied, see "Installation of the flexspline" of each series.

Outline Dimensions

You can download the CAD files from our website: harmonicdrive.net

Fig. 040-1

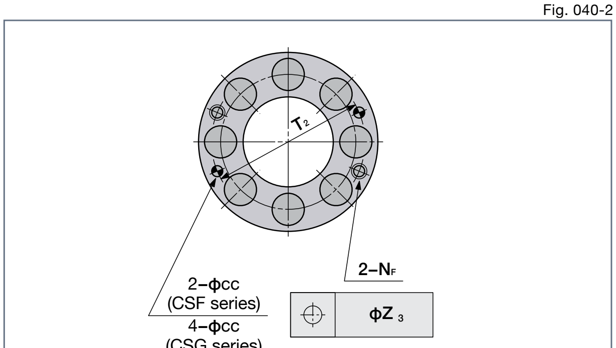


* Please refer to the confirmation drawing for detailed dimensions.

■ Dowel Pins

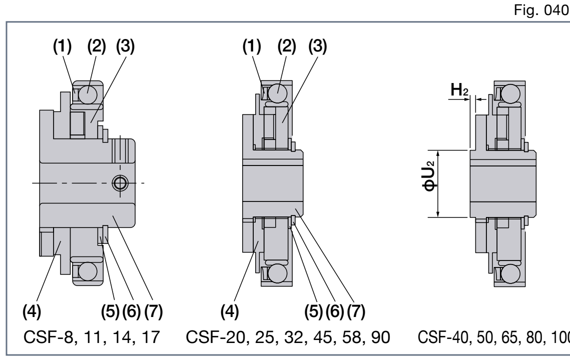
In cases where the gear will see loads near the Momentary Peak Torque level, the use of additional dowel pins in addition to the screws is recommended. Dowel pin holes are manufactured by reamer and the dimensions are shown. Note: the CSF has a different number of dowel pin holes than the CSG. It is important to note that Dowel Pins are always included with LW versions.

Fig. 040-2



* Provision is possible for the holes under pins. Please specify when ordering.

Fig. 040-3

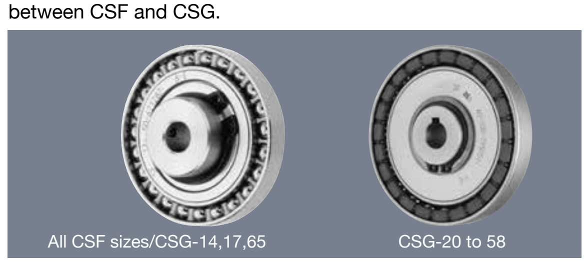


■ Wave generator components

The wave generator utilizes an Oldham coupling.

(1) Ball separator
(2) Wave generator bearing
(3) Wave generator plug
(4) Insert
(5) Rub washer
(6) Snap ring
(7) Wave generator hub

There is a difference in appearance of the the ball separator between CSF and CSG.



Dimensions

Table 041-1

Unit : mm

Symbol		8	11	14	17	20	25	32	40	45	50	58	65	80	90	100
ϕA h6		30	40	50	60	70	85	110	135	155	170	195	215	265	300	330
B∗	CSG Series	—	—	$28.5^{0}_{-0.4}$	$32.5^{0}_{-0.4}$	$33.5^{0}_{-0.4}$	$37^{0}_{-0.5}$	$44^{0}_{-0.6}$	$53^{0}_{-0.6}$	$58.5^{0}_{-0.6}$	$64^{0}_{-0.6}$	$75.5^{0}_{-0.6}$	$83^{0}_{-0.6}$	—	—	—
	CSF Series	$22.1^{0}_{-0.3}$	$25.8^{0}_{-0.7}$	$28.5^{0}_{-0.8}$	$32.5^{0}_{-0.9}$	$33.5^{0}_{-1.0}$	$37^{0}_{-1.0}$	$44^{0}_{-1.1}$	$53^{0}_{-1.1}$	$58.5^{0}_{-1.2}$	$64^{0}_{-1.3}$	$75.5^{0}_{-1.3}$	$83^{0}_{-1.3}$	$101^{0}_{-1.3}$	$112.5^{0}_{-1.4}$	$125^{0}_{-1.6}$
C_1∗		$12.5^{+0.2}_{0}$	$14.5^{+0.4}_{0}$	$17.5^{+0.4}_{0}$	$20^{+0.5}_{0}$	$21.5^{+0.6}_{0}$	$24^{+0.6}_{0}$	$28^{+0.6}_{0}$	$34^{+0.6}_{0}$	$38^{+0.6}_{0}$	$41^{+0.6}_{0}$	$48^{+0.6}_{0}$	$52.5^{+0.6}_{0}$	$64^{+0.6}_{0}$	$71.5^{+0.8}_{0}$	$79^{+1.0}_{0}$
C_2∗		9.6	11.3	11	12.5	12	13	16	19	20.5	23	27.5	30.5	37	41	46
D		2.7	2	2.4	3	3	3	3.2	4	4.5	5	5.8	6.5	8	9	10
E		—	2	2	2.5	3	3	3	4	4	4	5	5	6	6	6
F		4.5	5	6	6.5	7.5	10	14	17	19	22	25	29	36	41	46
G	CSG Series	—	—	1.4	1.6	1.5	3.5	4.2	5.6	6.3	7	8.2	9.5	—	—	—
	CSF Series	—	—	0.4	0.3	0.1	2.1	2.5	3.3	3.7	4.2	4.8	5.8	6.6	7.5	8.3
$H_1{}^{0}_{-0.1}$	CSG Series	—	—	18.5	20.7	21.5	21.6	23.6	29.7	30.5	34.8	38.3	44.6	—	—	—
	CSF Series	12	16	17.6	19.5	20.1	20.2	22	27.5	27.9	32	34.9	40.9	49.1	48.2	56.7
H_2		—	—	—	—	—	—	—	0.4	—	0.8	—	2.2	3.1	—	4.5
ϕI h6	Ratios > 30:1	—	31	38	48	54	67	90	110	124	135	156	177	218	245	272
	Ratio 30:1	—	31	38	48	55	68	90	—	—	—	—	—	—	—	—
ϕJ		12.3	17.8	23	27.2	32	40	52	64	72	80	92.8	104	128	144	160
ϕK H6		6	6	11	10	16	20	26	32	36	40	46	52	65	72	80
L	CSG Series	—	—	8	16	16	16	16	16	16	16	16	16	—	—	—
	CSF Series	8	8	6	12	12	12	12	12	12	12	12	12	16	16	16
ϕM		2.2	2.9	3.5	3.4	3.5	4.5	5.5	6.6	9	9	11	11	11	14	14
N_C		M2	M2.5	M3	M3	M3	M4	M5	M6	M8	M8	M10	M10	M10	M12	M12
N_F		—	—	M3	M3	M3	M4	M5	M6	M6	M8	M8	M8	M8	M12	M10
O		3	3	6	6.5	4	6	7	9	12	13	15	15	15	18	20
ϕP		2.2	2.9	—	—	3.5	4.5	5.5	6.6	9	9	11	11	11	14	14
Q (PCD)		25.5	35	44	54	62	75	100	120	140	150	175	195	240	270	300
R		—	6	6	6	8	8	8	8	8	8	8	8	10	8	12
ϕS		—	3.4	4.5	5.5	5.5	6.6	9	11	13.5	15.5	15.5	18	18	22	22
T_1 (PCD)		—	12	17	19	24	30	40	50	54	60	70	80	100	110	130
T_2 (PCD)		—	15.2	18.5	21.5	27	34	45	56	61	68	79	90	114	120	142
ϕU_1		7	11	14	18	21	26	26	32	32	32	40	48	55	60	65
ϕU_2		—	—	—	—	—	—	—	32	—	32	—	48	55	—	65
ϕV	Standard (H7)	3	5	6	8	9	11	14	14	19	19	22	24	28	28	28
	Max. size	—	—	8	10	13	15	16	20	20	20	25	30	35	37	40
WJs9		—	—	—	—	3	4	5	5	6	6	6	8	8	8	8
X		—	—	—	—	$10.4^{+0.1}_{0}$	$12.8^{+0.1}_{0}$	$16.3^{+0.1}_{0}$	$16.3^{+0.1}_{0}$	$21.8^{+0.1}_{0}$	$21.8^{+0.1}_{0}$	$24.8^{+0.1}_{0}$	$27.3^{+0.2}_{0}$	$31.3^{+0.2}_{0}$	$31.3^{+0.2}_{0}$	$31.3^{+0.2}_{0}$
Y		—	C0.2	C0.3	C0.4	C0.4	C0.4	C0.4	C0.4	C0.4	C0.8	C0.8	C0.8	C0.8	C0.8	C0.8
ϕZ_1		0.1	0.20	0.20	0.20	0.25	0.25	0.25	0.30	0.50	0.50	0.5	0.5	0.5	1.0	1.0
ϕZ_2		—	0.20	0.25	0.25	0.25	0.30	0.50	0.50	0.75	0.75	0.75	1.0	1.0	1.0	1.0
ϕZ_3		—	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
ϕa	minimum housing clearance	21.5	30	38	45	53	66	86	106	119	133	154	172	212	239	265
b		11.34	14	17.1	19	20.5	23	26.8	33	36.5	39	46.2	50	61	68.5	76
c		—	—	1	1	1.5	1.5	1.5	2	2	2	2.5	2.5	3	3	3
ϕcc H7	CSG Series	—	—	3	3	3	4	5	6	6	8	8	8	—	—	—
	CSF Series	—	2	3	3	3	4	5	6	6	8	8	8	8	12	10
d_1		C0.3	C0.4	C0.4	C0.4	C0.4	C0.4	C0.4	C0.4	C0.4	C0.4	C0.4	C0.4	C0.4	C0.4	C0.4
d_2		C0.3	C0.3	C0.4	C0.4	C0.4	C0.4	C0.4	C0.4	C0.4	C0.4	C0.4	C0.4	C0.4	C0.4	C0.4
d_3		C0.3	C0.3	C0.5	C0.5	C0.5	C0.5	C0.5	C0.5	C0.5	C0.5	C0.5	C0.5	C0.5	C0.5	C0.5
e		2	3	2.5	3	—	—	—	—	—	—	—	—	—	—	—
f		M2×3	M3×4	M3×4	M3×6	—	—	—	—	—	—	—	—	—	—	—
Mass (kg)		0.026	0.05	0.09	0.15	0.28	0.42	0.89	1.7	2.3	3.2	4.7	6.7	12.4	17.6	23.5

- The pilot diameter for the Circular spline can be either ØI or ØA. Surface A is the recommended mounting surface.
- The following dimensions can be modified to accommodate customer-specific requirements.

  Wave Generator: ØV, X, W
  Flexspline: R, ØS
  Circular Spline: ØM, L
- *Dimensions B, C_1 and C_2 must meet the tolerance values shown above.
- Due to the deformation of the Flexspline during operation, it is necessary to provide a minimum housing clearance, dimensions ϕa, b, c.

Engineering Data
Component Sets
Gear Units
Phase Adjusters
Gearheads & Actuators

Positional accuracy

See "Engineering data" for a description of terms.

Table 042-1

Ratio	Specification	Size	8	11	14	17	20	25	32	40～100
30	Standard	$\times10^{-4}$rad	5.8	5.8	5.8	4.4	4.4	4.4	4.4	—
		arc min	2	2	2	1.5	1.5	1.5	1.5	—
	Special	$\times10^{-4}$rad	—	—	—	—	2.9	2.9	2.9	—
		arc min	—	—	—	—	1	1	1	—
50 or more	Standard	$\times10^{-4}$rad	5.8	5.8	4.4	4.4	2.9	2.9	2.9	2.9
		arc min	2	2	1.5	1.5	1	1	1	1
	Special	$\times10^{-4}$rad	—	—	2.9	2.9	1.5	1.5	1.5	1.5
		arc min	—	—	1	1	0.5	0.5	0.5	0.5

*Positioning accuracy for Size 11, 100:1 is 4.4×10^{-4} rad/1.5arc min.

Hysteresis loss

See "Engineering data" for a description of terms.

Table 042-2

Ratio	Size	8	11	14	17	20	25	32	40 or more
30	$\times10^{-4}$rad	8.7	8.7	8.7	8.7	8.7	8.7	8.7	—
	arc min	3.0	3.0	3.0	3.0	3.0	3.0	3.0	—
50	$\times10^{-4}$rad	8.7	5.8	5.8	5.8	5.8	5.8	5.8	5.8
	arc min	3.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
80 or more	$\times10^{-4}$rad	5.8	5.8	2.9	2.9	2.9	2.9	2.9	2.9
	arc min	2.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0

Backlash

See "Engineering data" for a description of terms.

Table 042-3

Ratio	Size	8	11	14	17	20	25	32	40	45	50	58	65	80	90	100
30	$\times10^{-5}$rad	28.6	23.8	29.1	16.0	13.6	13.6	11.2	—	—	—	—	—	—	—	—
	arc sec	59	49	60	33	28	28	23	—	—	—	—	—	—	—	—
50	$\times10^{-5}$rad	17.0	14.1	17.5	9.7	8.2	8.2	6.8	6.8	5.8	5.8	4.8	4.8	4.8	3.9	2.9
	arc sec	35	24	36	20	17	17	14	14	12	12	10	10	10	8	6
80	$\times10^{-5}$rad	—	—	11.2	6.3	5.3	5.3	4.4	4.4	3.9	3.9	2.9	2.9	2.9	2.4	2.4
	arc sec	—	—	23	13	11	11	9	9	8	8	6	6	6	5	5
100	$\times10^{-5}$rad	8.7	7.3	8.7	4.8	4.4	4.4	3.4	3.4	2.9	2.9	2.4	2.4	2.4	1.9	1.5
	arc sec	18	15	18	10	9	9	7	7	6	6	5	5	5	4	3
120	$\times10^{-5}$rad	—	—	—	3.9	3.9	3.9	2.9	2.9	2.4	2.4	1.9	1.9	1.9	1.5	1.5
	arc sec	—	—	—	8	8	8	6	6	5	5	4	4	4	3	3
160	$\times10^{-5}$rad	—	—	—	—	2.9	2.9	2.4	2.4	1.9	1.9	1.5	1.5	1.5	1.0	1.0
	arc sec	—	—	—	—	6	6	5	5	4	4	3	3	3	2	2

Torsional stiffness

See "Engineering data" for a description of terms.

Table 042-4

Symbol		Size	8	11	14	17	20	25	32	40	45	50	58	65	80	90	100
T_1		Nm	0.29	0.80	2.0	3.9	7.0	14	29	54	76	108	168	235	430	618	843
		kgfm	0.03	0.082	0.20	0.40	0.70	1.4	3.0	5.5	7.8	11	17	24	44	63	86
T_2		Nm	0.75	2.0	6.9	12	25	48	108	196	275	382	598	843	1570	2260	3040
		kgfm	0.077	0.20	0.7	1.2	2.5	4.9	11	20	28	39	61	86	160	230	310
Ratio 30	K_1	$\times10^4$Nm/rad	0.034	0.084	0.19	0.34	0.57	1.0	2.4	—	—	—	—	—	—	—	—
		kgfm/arc min	0.010	0.025	0.056	0.10	0.17	0.30	0.70	—	—	—	—	—	—	—	—
	K_2	$\times10^4$Nm/rad	0.044	0.13	0.24	0.44	0.71	1.3	3.0	—	—	—	—	—	—	—	—
		kgfm/arc min	0.013	0.037	0.07	0.13	0.21	0.40	0.89	—	—	—	—	—	—	—	—
	K_3	$\times10^4$Nm/rad	0.054	0.16	0.34	0.67	1.1	2.1	4.9	—	—	—	—	—	—	—	—
		kgfm/arc min	0.016	0.047	0.10	0.20	0.32	0.62	1.5	—	—	—	—	—	—	—	—
	θ_1	$\times10^{-4}$rad	8.5	9.5	10.5	11.5	12.3	14	12.1	—	—	—	—	—	—	—	—
		arc min	3.0	3.3	3.6	4.0	4.1	4.7	4.3	—	—	—	—	—	—	—	—
	θ_2	$\times10^{-4}$rad	19	19	31	30	38	40	38	—	—	—	—	—	—	—	—
		arc min	6.6	6.5	10.7	10.2	12.7	13.4	13.3	—	—	—	—	—	—	—	—
Ratio 50	K_1	$\times10^4$Nm/rad	0.044	0.22	0.34	0.81	1.3	2.5	5.4	10	15	20	31	44	81	118	162
		kgfm/arc min	0.013	0.066	0.1	0.24	0.38	0.74	1.6	3.0	4.3	5.9	9.3	13	24	35	48
	K_2	$\times10^4$Nm/rad	0.067	0.30	0.47	1.1	1.8	3.4	7.8	14	20	28	44	61	115	162	222
		kgfm/arc min	0.020	0.090	0.14	0.32	0.52	1.0	2.3	4.2	6.0	8.2	13	18	34	48	66
	K_3	$\times10^4$Nm/rad	0.084	0.32	0.57	1.3	2.3	4.4	9.8	18	26	34	54	78	145	206	283
		kgfm/arc min	0.025	0.096	0.17	0.4	0.67	1.3	2.9	5.3	7.6	10	16	23	43	61	84
	θ_1	$\times10^{-4}$rad	6.6	3.6	5.8	4.9	5.2	5.5	5.5	5.2	5.2	5.5	5.2	5.2	5.2	5.2	5.2
		arc min	2.3	1.2	2.0	1.7	1.8	1.9	1.9	1.8	1.8	1.9	1.8	1.8	1.8	1.8	1.8
	θ_2	$\times10^{-4}$rad	13	8	16	12	15.4	15.7	15.7	15.4	15.1	15.4	15.1	15.1	15.1	15.4	15.1
		arc min	4.7	2.6	5.6	4.2	5.3	5.4	5.4	5.3	5.2	5.3	5.2	5.2	5.2	5.2	5.2

* The values in this table are reference values. The minimum value is approximately 80% of the displayed value.

Table 043-1

Symbol		Size	8	11	14	17	20	25	32	40	45	50	58	65	80	90	100
T_1		Nm	0.29	0.80	2.0	3.9	7.0	14	29	54	76	108	168	235	430	618	843
		kgfm	0.03	0.082	0.2	0.4	0.7	1.4	3.0	5.5	7.8	11	17	24	44	63	86
T_2		Nm	0.75	2.0	6.9	12	25	48	108	196	275	382	598	843	1570	2260	3040
		kgfm	0.077	0.2	0.7	1.2	2.5	4.9	11	20	28	39	61	86	160	230	310
Reduction ratio 80 or more	K_1	$\times10^4$Nm/rad	0.091	0.27	0.47	1	1.6	3.1	6.7	13	18	25	40	54	100	145	200
		kgfm/arc min	0.027	0.080	0.14	0.3	0.47	0.92	2.0	3.8	5.4	7.4	12	16	30	43	59
	K_2	$\times10^4$Nm/rad	0.10	0.34	0.61	1.4	2.5	5.0	11	20	29	40	61	88	162	230	310
		kgfm/arc min	0.031	0.10	0.18	0.4	0.75	1.5	3.2	6.0	8.5	12	18	26	48	68	93
	K_3	$\times10^4$Nm/rad	0.12	0.44	0.71	1.6	2.9	5.7	12	23	33	44	71	98	185	263	370
		kgfm/arc min	0.036	0.13	0.21	0.46	0.85	1.7	3.7	6.8	9.7	13	21	29	55	78	110
	θ_1	$\times10^{-4}$rad	3.2	3.0	4.1	3.9	4.4	4.4	4.4	4.1	4.1	4.4	4.1	4.4	4.4	4.4	4.4
		arc min	1.1	1.0	1.4	1.3	1.5	1.5	1.5	1.4	1.4	1.5	1.4	1.5	1.5	1.5	1.5
	θ_2	$\times10^{-4}$rad	8	6	12	9.7	11.3	11.1	11.6	11.1	11.1	11.1	11.1	11.3	11.3	11.6	11.3
		arc min	2.6	2.2	4.2	3.3	3.9	3.8	4.0	3.8	3.8	3.8	3.8	3.9	3.9	4.0	3.9

* The values in this table are reference values. The minimum value is approximately 80% of the displayed value.

Starting torque

See "Engineering data" for a description of terms. Values shown vary depending on condition. Please use values as a reference.

CSG Series

Table 043-2
Unit: Ncm

Ratio \ Size	14	17	20	25	32	40	45	50	58	65
30	—	—	—	—	—	—	—	—	—	—
50	3.6	5.6	7.3	13	29	51	69	—	—	—
80	2.6	3.6	4.5	8.5	18	32	45	59	90	121
100	2.3	3.2	4.1	7.6	17	29	40	53	80	108
120	—	3.0	3.6	6.9	14	26	36	50	74	101
160	—	—	3.2	6.1	13	23	32	43	64	88

CSF Series

Table 043-3
Unit: Ncm

Ratio \ Size	8	11	14	17	20	25	32	40	45	50	58	65	80	90	100
30	1.3	2.7	4.3	6.5	11	19	45	—	—	—	—	—	—	—	—
50	0.8	1.6	3.3	5.1	6.6	12	26	46	63	86	130	180	320	450	590
80	—	—	2.4	3.3	4.1	7.7	16	29	41	54	82	110	200	280	380
100	0.59	1.1	2.1	2.9	3.7	6.9	15	26	36	48	73	98	180	250	340
120	—	—	—	2.7	3.3	6.3	13	24	33	45	67	92	170	230	310
160	—	—	—	—	2.9	5.5	12	21	29	39	58	80	140	200	270

Backdriving torque

See "Engineering data" for a description of terms. Values shown vary depending on condition. Please use values as a reference.

CSG Series

Table 043-4
Unit: Nm

Ratio \ Size	14	17	20	25	32	40	45	50	58	65
30	—	—	—	—	—	—	—	—	—	—
50	1.5	2.8	4.4	8.3	18	31	41	—	—	—
80	1.5	2.8	4.6	8.5	18	31	43	58	89	132
100	1.9	3.1	5.0	9.2	20	34	46	63	97	143
120	—	3.4	5.4	10	21	37	52	69	107	154
160	—	—	6.4	12	25	44	63	85	132	187

CSF Series

Table 043-5
Unit: Nm

Ratio \ Size	8	11	14	17	20	25	32	40	45	50	58	65	80	90	100
30	0.65	1.3	2	3.2	5.5	10	21	—	—	—	—	—	—	—	—
50	0.5	1	1.4	2.5	4	7.5	16	28	37	52	80	110	200	270	360
80	—	—	1.4	2.5	4.2	7.7	16	28	39	53	81	120	200	270	370
100	0.7	1.4	1.7	2.8	4.5	8.4	18	31	42	57	88	130	220	300	400
120	—	—	—	3.1	4.9	9.2	19	34	47	63	97	140	240	330	440
160	—	—	—	—	5.8	11	23	40	57	77	120	170	290	390	540

Component Set CSG/CSF

Ratcheting torque

See "Engineering data" for a description of terms.

CSG Series

Table 044-1
Unit: Nm

Ratio \ Size	14	17	20	25	32	40	45	50	58	65
50	110	190	280	580	1200	2300	3500	—	—	—
80	140	260	450	880	1800	3600	5000	7000	10000	14000
100	100	200	330	650	1300	2700	4000	5300	8300	12000
120	—	150	310	610	1200	2400	3600	4900	7500	10000
160	—	—	280	580	1200	2300	3300	4600	7200	10000

CSF Series

Table 044-2
Unit: Nm

Ratio \ Size	8	11	14	17	20	25	32	40	45	50	58	65	80	90	100
30	11	29	59	100	170	340	720	—	—	—	—	—	—	—	—
50	12	34	88	150	220	450	980	1800	2700	3700	5800	7800	14000	20000	29000
80	—	—	110	200	350	680	1400	2800	3900	5400	8200	11000	22000	30000	44000
100	14	43	84	160	260	500	1000	2100	3100	4100	6400	9400	16000	23000	33000
120	—	—	—	120	240	470	980	1900	2800	3800	5800	8300	15000	21000	30000
160	—	—	—	—	220	450	980	1800	2600	3600	5600	8000	14000	20000	28000

Buckling torque

See "Engineering data" for a description of terms.

CSG Series

Table 044-3
Unit: Nm

Size	14	17	20	25	32	40	45	50	58	65
All ratios	260	500	800	1700	3500	6700	8900	12200	19000	26600

CSF Series

Table 044-4
Unit: Nm

Size	8	11	14	17	20	25	32	40	45	50	58	65	80	90	100
All ratios	35	90	190	330	560	1000	2200	4300	5800	8000	12000	17000	31000	45000	58000

No-load running torque

No-load running torque is the torque which is required to rotate the input side (high speed side), when there is no load on the output side (low speed side).

* Contact us for detailed values.

Measurement condition

Table 044-5

Ratio 100:1			
Lubricant	Grease lubrication	Name	Harmonic Grease SK-1A
			Harmonic Grease SK-2
		Quantity	Recommended quantity (See page 049)
Torque value is measured after 2 hours at 2000rpm input.			

* Contact us for oil lubrication.

Compensation Value in Each Ratio

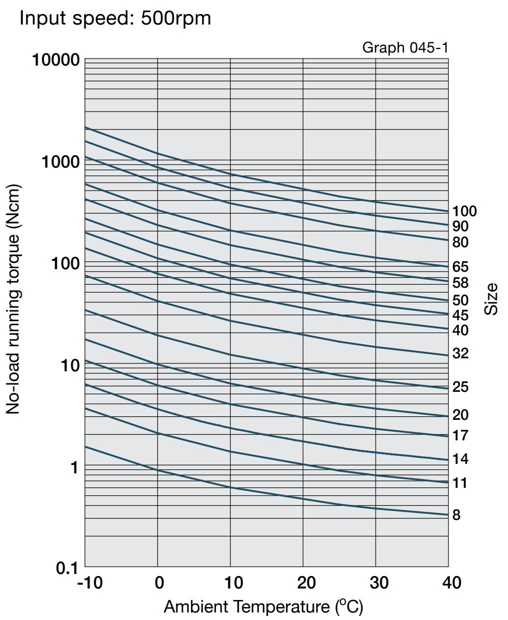
No load running torque of the gear varies with ratio.
The graphs indicate a value for ratio 100.
For other gear ratios, add the compensation values from table on the right.

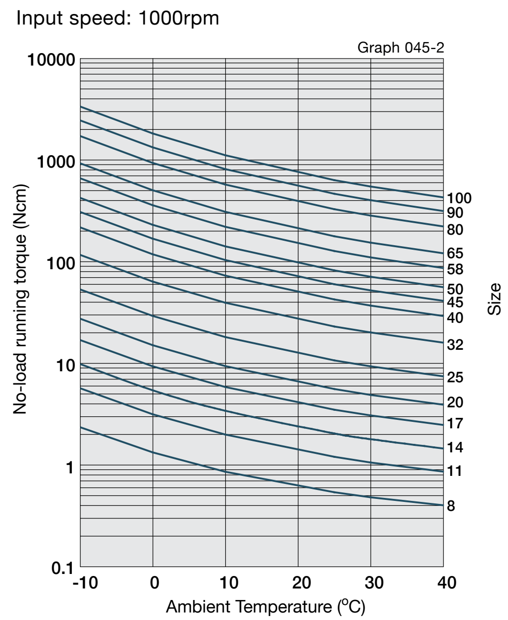
Component Set No Load Torque Compensation

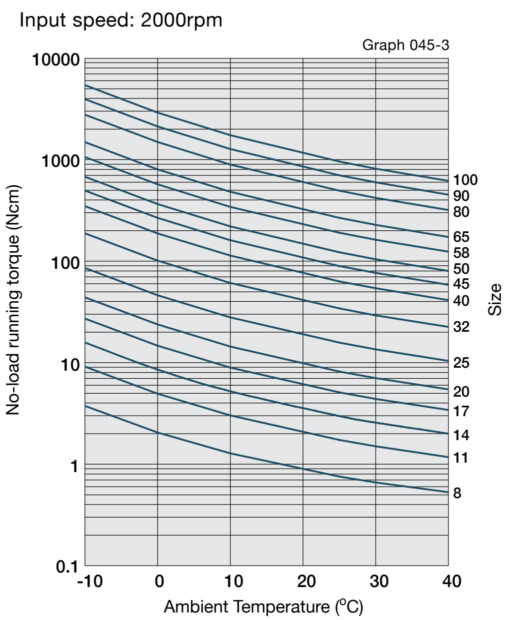
Table 044-6
Unit: Ncm

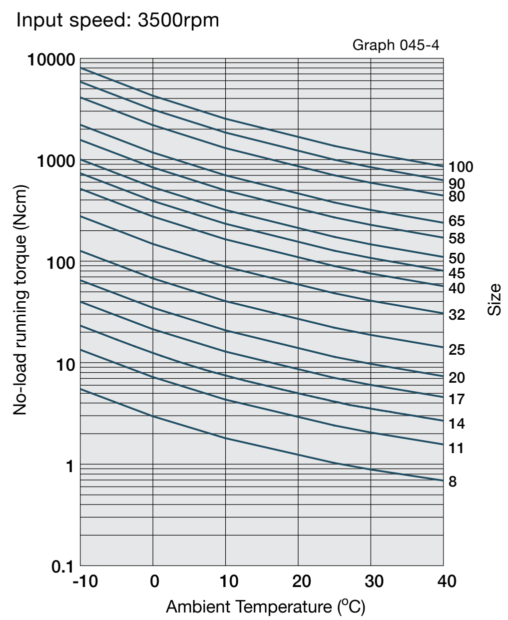
Size \ Ratio	30	50	80	120	160
8	0.4	0.2	—	—	—
11	0.7	0.3	—	—	—
14	1.1	0.5	0.1	—	—
17	1.8	0.8	0.1	-0.1	—
20	2.7	1.2	0.2	-0.1	-0.3
25	5.0	2.2	0.3	-0.2	-0.6
32	10	4.5	0.7	-0.5	-1.2
40	—	8.0	1.2	-0.9	-2.2
45	—	11	1.7	-1.3	-3.0
50	—	15	2.3	-1.7	-4.0
58	—	22	3.4	-2.5	-6.1
65	—	31	4.7	-3.5	-8.4
80	—	55	8.5	-6.2	-15
90	—	77	12	-8.7	-21
100	—	100	16	-12	-28

■ **No-load running torque for a reduction ratio of 100:1**









*The values in this graph are average values ($\overline{X}$). σ≈20%

Efficiency

The efficiency varies depending on the following conditions.

- Reduction ratio
- Input rotational speed
- Load torque
- Temperature
- Lubrication (type and quantity)

Measurement condition Table 046-1

Installation	Based on recommended tolerance.		
Load torque	The rated torque (see page 038 and 039)		
Lubricant	Grease lubrication	Name	Harmonic Grease SK-1A
			Harmonic Grease SK-2
		Quantity	Recommended quantity (see page 049)

* Contact us for oil lubrication.

■ Efficiency compensation coefficient

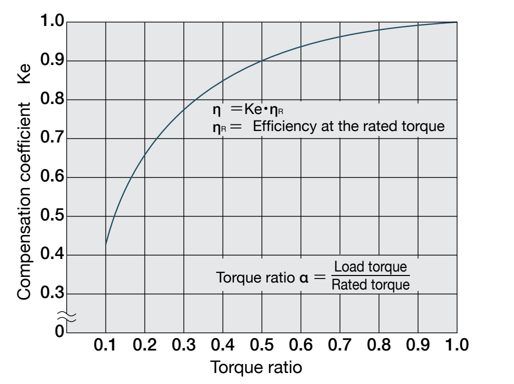
Find the Compensation Coefficient (Ke) and calculate the efficiency.

Example of calculation

Efficiency η (%) under the following condition is obtained from the example of CSF-20-80-2A-GR.
Input speed: 1000 rpm
Load torque: 19.6 Nm
Lubrication: Harmonic Grease SK-1A
Lubricant temperature: 20°C
Since the rated torque of size 20 with a reduction ratio of 80 is 34 Nm (Ratings: Page 039), the torque ratio α is 0.58.
(α=19.6/34=0.58)

- The efficiency compensation coefficient is Ke=0.93 from Graph 046-1.
- Efficiency η at load torque 19.6 Nm: η=Ke•ηR=0.93 x 78=73%

Efficiency compensation coefficient Graph 046-1

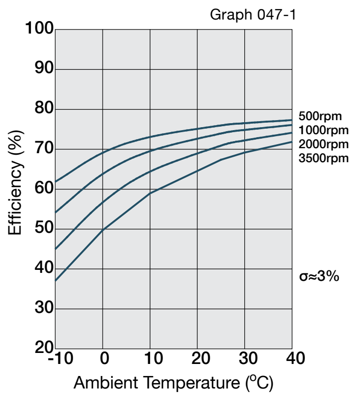


* Efficiency compensation coefficient Ke=1 holds when the load torque is greater than the rated torque.

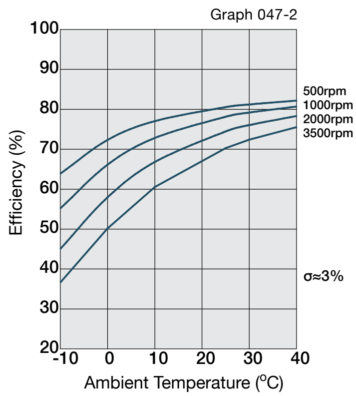
■ Efficiency at rated torque

Size: 8, 11, 14

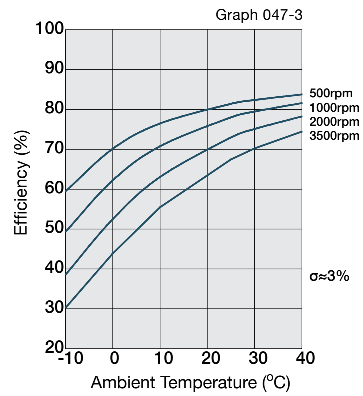
Reduction ratio 30



Reduction ratio 50, 80

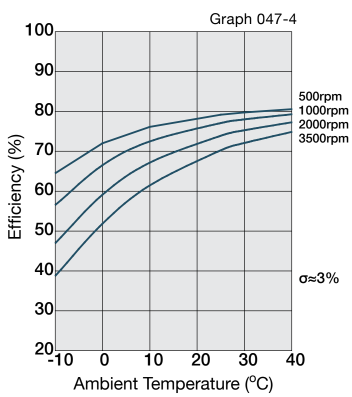


Reduction ratio 100

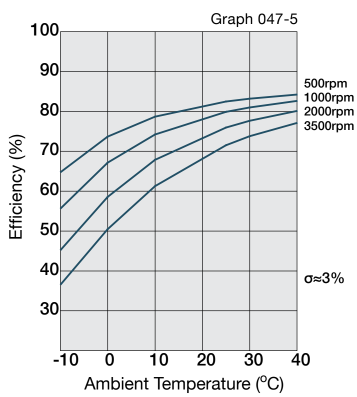


Size: 17 to 100

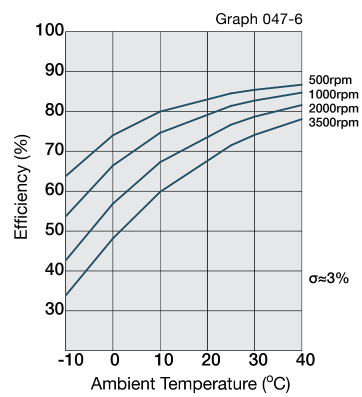
Reduction ratio 30



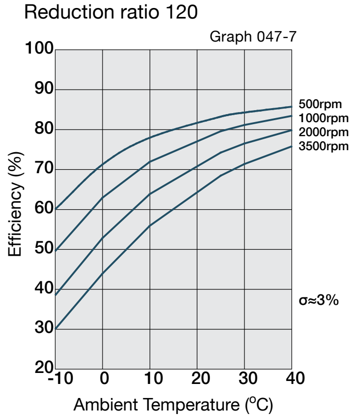
Reduction ratio 50



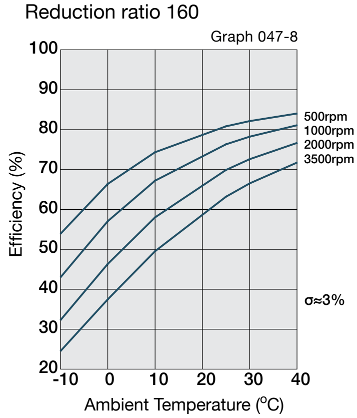
Reduction ratio 80, 100



Reduction ratio 120



Reduction ratio 160



Design Guide

Lubrication

■ Grease lubrication*1

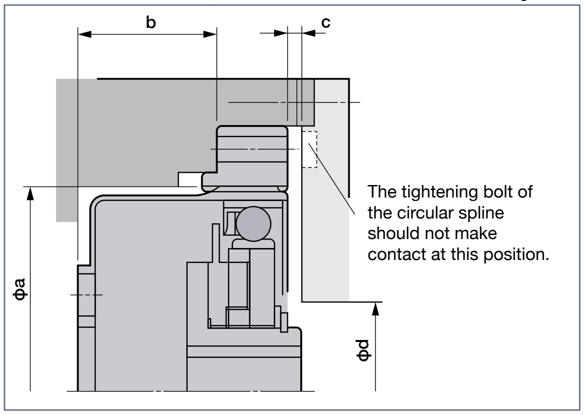
See "Engineering data" on Page 016 for details of the lubricant.

Recommended housing dimensions

See table below for recommended housing dimensions. These dimensions must be maintained to prevent damage to the gear and to maintain a proper grease cavity.

Recommended housing dimensions

Fig. 048-1



Recommended housing dimensions

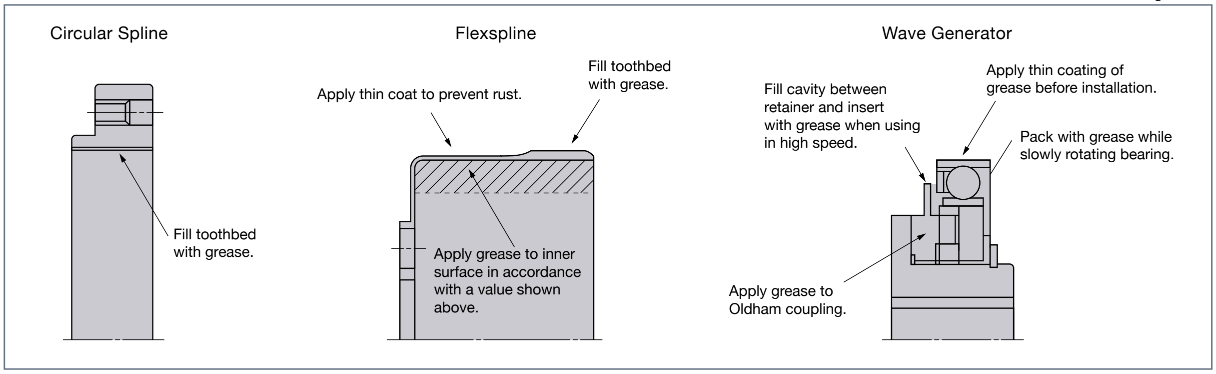
Table 048-1
Unit: mm

Symbol \ Size	8	11	14	17	20	25	32	40	45	50*1	58*1	65*1	80*1	90*1	100*1
φa	21.5	30	38	45	53	66	86	106	119	133	154	172	212	239	265
b	11.34	14	17.1	19	20.5	23	26.8	33	36.5	39	46.2	50	61	68.5	76
c	0.5	0.5	1	1	1.5	1.5	1.5	2	2	2	2.5	2.5	3	3	3
φd	13	16	16	26	30	37	37	45	45	45	56	62	67	73	79

(Note) Double Size c if you use the wave generator facing upward.
*1 Oil lubrication is required for component-sets size 50 or larger with a reduction ratio of 50:1.

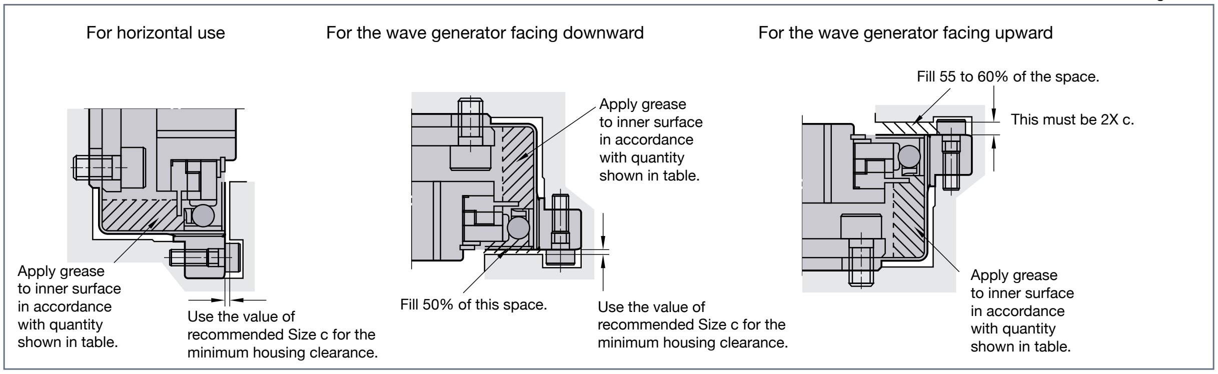
Application guide

Fig. 048-2



Application guide by usage

Fig. 048-3



Application quantity

Table 049-1
Unit: g

Usage \ Size		8	11	14	17	20	25	32	40	45	50	58	65	80	90	100
Horizontal use		1.2	2.9	5.5	10	16	30	60	110	170	220	360	460	850	1150	1500
Vertical use	Output shaft facing upward	1.4	3.5	7	12	18	35	70	125	190	240	380	500	900	1300	1700
	Output shaft facing downward	1.8	4.4	8.5	14	21	40	80	145	220	275	460	600	1000	1500	1900

When to replace grease

The wear characteristics of the gear are strongly influenced by the condition of the grease lubrication. The condition of the grease is affected by the ambient temperature. The graph shows the maximum number of input rotations for various temperatures. This graph applies to applications where the average load torque does not exceed the rated torque.

In cases where the rated torque is exceeded, calculate the grease change interval using the equation shown below.
(Note) Recommended Grease: SK-1A or SK-2

Formula when load torque exceeds rated torque

Formula 049-1

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

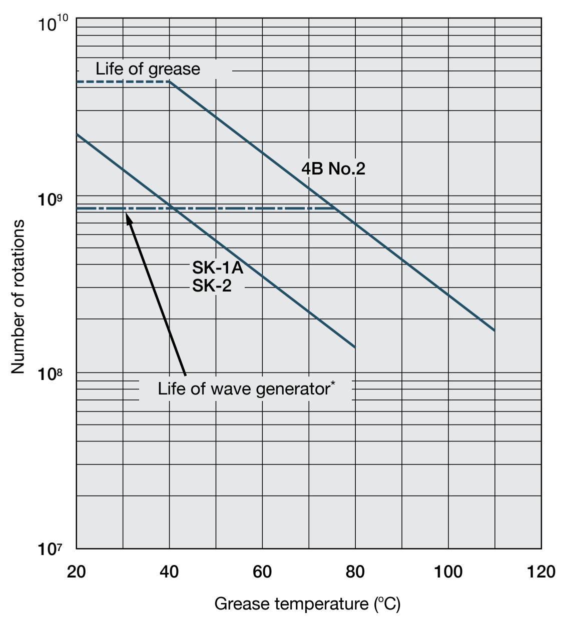
Symbols for Formula 049-1

Table 049-2

L_{GT}	Replacement timing if average load torque exceeds rated torque	Number of input revolutions	—————
L_{GTn}	Replacement timing if average load torque is equal to or less than rated torque (or use formulas, i.e. Tav ≤ Tr)	Number of input revolutions	See the right-hand figure.
Tr	Rated torque	Nm	See the "Rating table" on page 38 and 39.
T_{av}	Average load torque	Nm	Calculation formula: See Page 14.

When to replace grease: L_{GTn} (when the average load torque is equal to or less than the rated torque)

Graph 049-1



* Life of wave generator is based on L10 life of the bearing.

■ Other precautions

1. Avoid using it with other grease. The gear should be in an individual case when installed.

2. If you use the gear with the wave generator facing upward (see Figure 050-2 on Page 50) at low-speed rotation (input rotational speed: 1000 rpm or less) and in one direction, please contact us as it may cause lubrication problems.

3. Oil lubrication is required for component-sets size 50 or larger with a reduction ratio of 50:1. Use grease lubrication within half the rated torque.

■ Oil lubrication

See "Engineering data" on Page 18 for details of the lubricant.

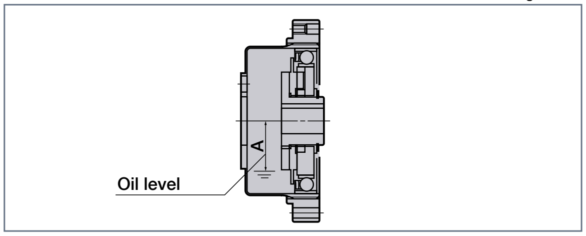
Usage and oil level

1. For horizontal installation

Oil level should be maintained at the level "A" as shown. Figure 050-1.

Oil level for horizontal use

Fig. 050-1



Oil level for horizontal use

Table 050-1
Unit: mm

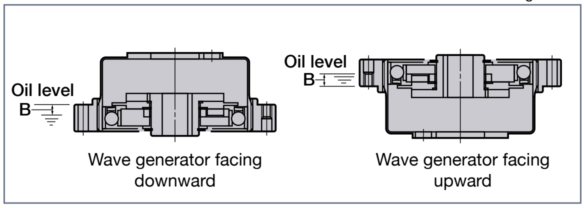
Size	8	11	14	17	20	25	32	40	45	50	58	65	80	90	100
A	6	8	10	12	14	17	24	31	35	38	44	50	59	66	74

2. For vertical installation

Fill the center of the ball of the wave generator facing upward or downward with oil (Oil level "B" of Figure 050-2). An oil groove should be added to the flexspline. Contact us for details.

Oil level for vertical use

Fig. 050-2



Oil level for vertical use

Table 050-2
Unit: mm

Size	8	11	14	17	20	25	32	40	45	50	58	65	80	90	100
B	2	2.3	2.5	3	3	5	7	9	10	12	13	15	19	22	25

Dimension of lube hole of the flexspline

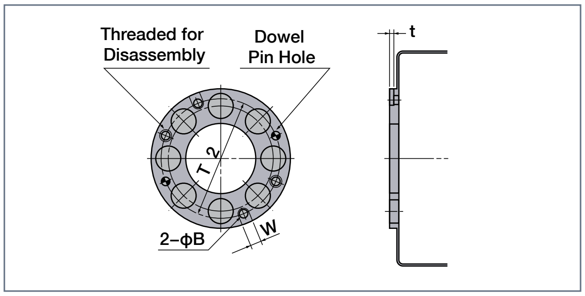
Table 050-3
Unit: mm

Symbol \ Size	20	25	32	40	45	50	58	65	80	90	100
T_2	27	34	45	56	61	68	79	90	114	120	142
B	2.5	2.5	3.5	3.5	3.5	5.5	5.5	5.5	6.5	6.5	6.5
W	2.8	3.5	4.0	4.0	4.0	6.0	6.0	6.0	7.0	7.0	7.0
t	1.2	1.2	1.4	1.4	1.4	2	2	2	3	3	3

Size 8, 11, 14, 17 do not have any lube holes.

Dimension of lube hole of the flexspline

Fig. 050-3



Oil quantity

Table 050-4
Unit: ℓ

Size	8	11	14	17	20	25	32	40	45	50	58	65	80	90	100
Oil quantity	0.004	0.006	0.01	0.02	0.03	0.07	0.13	0.25	0.32	0.4	0.7	1.0	2.0	2.8	3.8

When to replace oil

First time ·····························100 hours after starting operation
Second time or later ···········Every 1000 operation hours or every 6 months
Note that you should replace oil earlier than specified if the operating conditions are demanding.

Other precautions

1. Avoid mixing different kinds of oil. The gear should be in an individual case when installed.

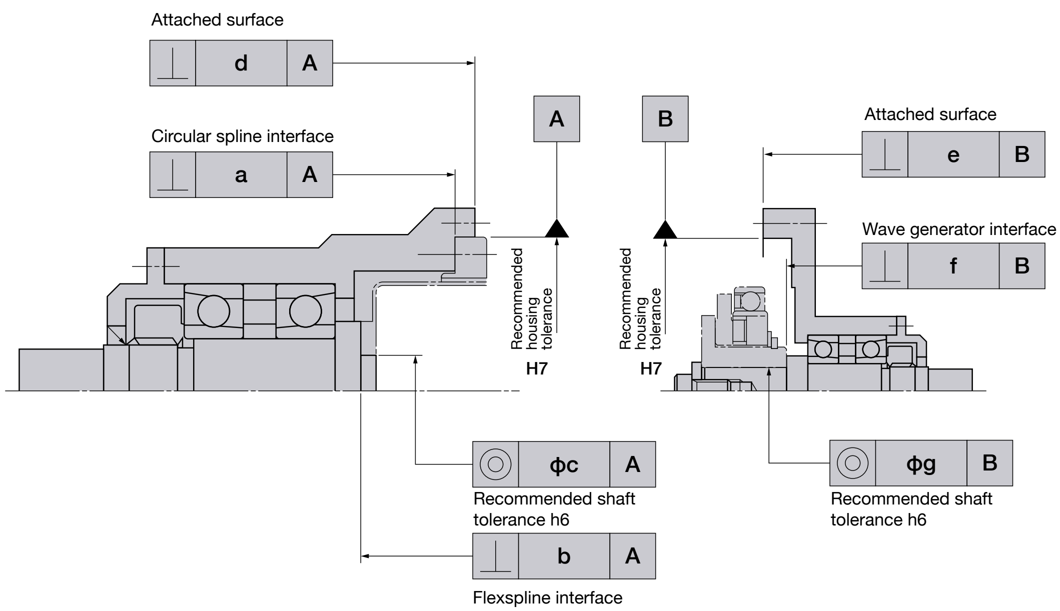
2. If you use size 50 or above at allowable input speed, please contact us as it may cause lubrication problems.

Recommended tolerances for assembly

Maintain the recommended tolerances shown in Figure 051-1 and Table 051-1 for peak performance.

Recommended tolerances for assembly

Fig. 051-1



Tolerances for assembly

Table 051-1
Unit: mm

Symbol \ Size	8	11	14	17	20	25	32	40	45	50	58	65	80	90	100
a	0.008	0.011	0.011	0.012	0.013	0.014	0.016	0.016	0.017	0.018	0.020	0.023	0.027	0.029	0.031
b	0.006	0.006	0.008	0.011	0.014	0.018	0.022	0.025	0.028	0.030	0.032	0.035	0.040	0.043	0.045
φc	0.005	0.008	0.015	0.018	0.019	0.022	0.022	0.024	0.027	0.030	0.032	0.035	0.043	0.046	0.049
d	0.010	0.010	0.011	0.015	0.017	0.024	0.026	0.026	0.027	0.028	0.031	0.034	0.043	0.050	0.057
e	0.010	0.010	0.011	0.015	0.017	0.024	0.026	0.026	0.027	0.028	0.031	0.034	0.043	0.050	0.057
f	0.012	0.012	0.017 (0.008)	0.020 (0.010)	0.020 (0.010)	0.024 (0.012)	0.024 (0.012)	0.032 (0.012)	0.032 (0.013)	0.032 (0.015)	0.032 (0.015)	0.032 (0.015)	0.036 (0.015)	0.036 (0.015)	0.036 (0.015)
φg	0.015	0.015	0.030 (0.016)	0.034 (0.018)	0.044 (0.019)	0.047 (0.022)	0.050 (0.022)	0.063 (0.024)	0.065 (0.027)	0.066 (0.030)	0.068 (0.033)	0.070 (0.035)	0.090 (0.043)	0.091 (0.046)	0.092 (0.049)

* The values in parentheses indicate that Wave Generator does not have an Oldham coupling.

Sealing

Sealing is needed to maintain the high durability of the gear and prevent grease leakage.

- Rotating parts should have an oil seal (with spring), surface should be smooth (no scratches).
- Mating flanges should have an O Ring, seal adhesive.
- Screws should have a thread lock (LOCTITE® 242 recommended) or seal adhesive.

(Note) If you use Harmonic Grease® 4BNo.2, strict sealing is required.

Engineering Data
Component Sets
Gear Units
Phase Adjusters
Gearheads & Actuators

Installation of the three basic elements

■ Installation of the wave generator

Maximum hole diameter size

Hole diameter range of the wave generator hub with Oldham coupling

Table 052-1
Unit: mm

Item \ Size	8	11	14	17	20	25	32	40	45	50	58	65	80	90	100
Stand. dimension (H7)	3	5	6	8	9	11	14	14	19	19	22	24	28	28	28
Minimum hole dimension	—	—	3	4	5	6	6	10	10	10	13	16	16	19	22
Maximum hole dimension	—	—	8	10	13	15	15	20	20	20	25	30	35	37	40

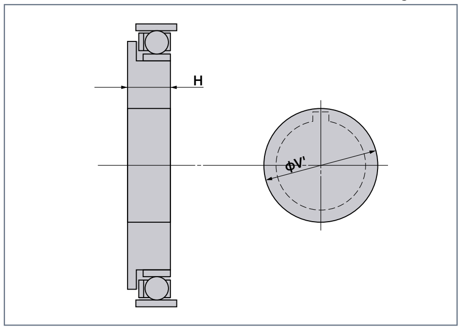
The standard hole diameter of the wave generator is as shown in the dimensional outline drawing (fig 040-01) and may be changed within a range up to the maximum dimension shown in the table. The JIS standard is recommended for the keyway. It is necessary that the dimension of keyways should sustain the transmission torque.

Please note: Tapered holes are also available.

In cases where a larger hole is required, use the Wave Generator without the Oldham coupling. The maximum diameter of the hole should be considered to prevent deformation of the Wave Generator plug by load torque.
(This is the value including the dimension of the keyway.)

Hole diameter of the wave generator with Oldham coupling

Fig. 052-1



Maximum hole diameter without Oldham Coupling

Table 052-2
Unit: mm

Item \ Size	8	11	14	17	20	25	32	40	45	50	58	65	80	90	100
Maximum Diameter ϕV'	10	14	17	20	23	28	36	42	47	52	60	67	72	84	95
Min. plug thickness $H^{0}_{-0.1}$	5.7	6.7	7.2	7.6	11.3	11.3	13.7	15.9	17.8	19	21.4	23.5	28.5	31.3	34.9

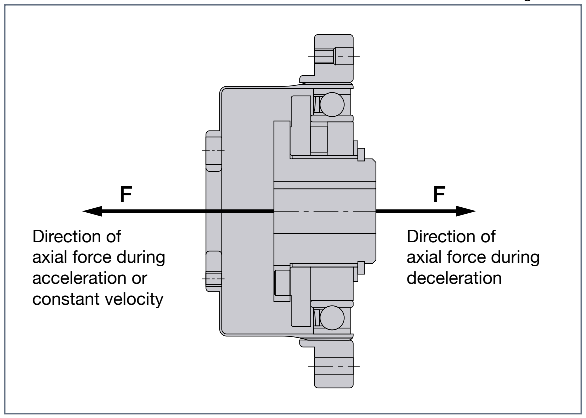
Axial force of the wave generator

When a CSF/CSG gear is used to accelerate a load, the deflection of the Flexspline leads to an axial force acting on the Wave Generator. This axial force, which acts in the direction of the closed end of the Flexspline, must be supported by the bearings of the input shaft (motor shaft). When a CSF/CSG gear is used to decelerate a load, an axial force acts to push the Wave Generator out of the Flexspline cup. Maximum axial force of the Wave Generator can be calculated by the equation shown below.
The axial force may vary depending on its operating condition. The value of axial force tends to be a larger number when using high torque, extreme low speed and constant operation. The force is calculated (approximately) by the equation. In all cases, the Wave Generator must be axially (in both directions), as well as torsionally, fixed to the input shaft.

(Note) Please contact us if you plan to attach the Wave Generator to the input (motor) shaft using bolts.

Axial force direction of the wave generator

Fig. 052-2



Formula for Axial Force

Table 052-3

Ratio	Calculation formula
30	$F=2\times\frac{T}{D}\,0.07\times\tan32°$
50	$F=2\times\frac{T}{D}\,0.07\times\tan30°$
80 or more	$F=2\times\frac{T}{D}\,0.07\times\tan20°$

Symbols for Formula

Table 052-4

F	Axial force	N	See Fig. 052-2.
D	(Size) ×0.00254	m	
T	Output torque	Nm	

Example of Calculation

Formula 052-1

Model name : CSF series
Size : 32
Ratio : i = 50:1
Output torque : 382 Nm (max. allowable momentary torque)

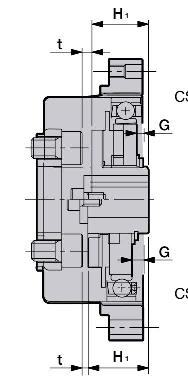
$$F=2\times\frac{382}{(32\times0.00254)}\times0.07\times\tan30°$$

F =380N

Shapes and dimensions of the wave generator

The shapes and dimensions of the wave generator of the CSF series are different from those of the CSG series. Exercise extreme care in design and installation. Please ensure there is no interference between the bolt of the Wave Generator and Flexspline.
Table 053-1 and Figure 053-1 show a comparison of the shapes and sizes of the wave generator.

Comparison of shapes and sizes of the wave generator Fig. 053-1



Comparison of Dimension of Wave Generator

Table 053-1
Unit: mm

Symbol		14	17	20	25	32	40	45	50	58	65
G	CSG Series	1.4	1.6	1.5	3.5	4.2	5.6	6.3	7	8.2	9.5
	CSF Series	0.4	0.3	0.1	2.1	2.5	3.3	3.7	4.2	4.8	5.8
$H1^{0}_{-0.1}$	CSG Series	18.5	20.7	21.5	21.6	23.6	29.7	30.5	34.8	38.3	44.6
	CSF Series	17.6	19.5	20.1	20.2	22	27.5	27.9	32	34.9	40.9
t	CSG Series	1.6	1.3	1.5	1.4	2.2	2.3	3.5	2.2	5.4	3.9
	CSF Series	2.5	2.5	2.9	2.8	3.8	4.5	6.1	5.0	8.8	7.6

(Note) "t" indicates the size for Table 054-1 of the flexspline mounting flange.

■ Installation of the flexspline

For size 8

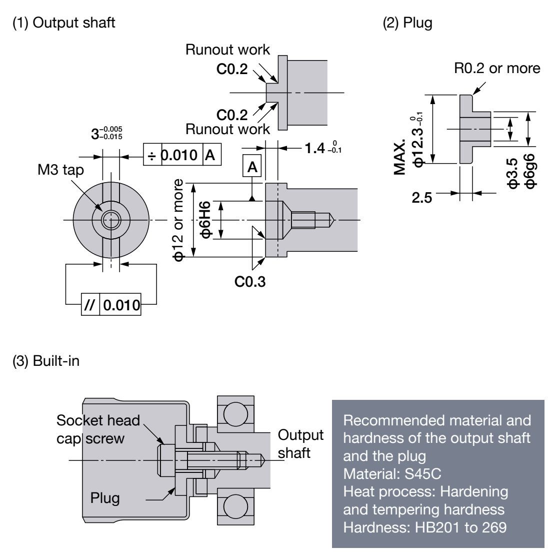
(a) For installation of the Flexspline on the output shaft use the plug shown on the right.

(b) The positioning of the output shaft and the Flexspline should be determined using the plug.

(c) We recommend using an M3 socket head cap screw for connecting the plug to the output shaft. We also recommend using LOCTITE® 242.

d) The open end of the Flexspline must be located axially on the same plane as the top surface of the circular spline.

Installation of flexspline for size 8 Fig. 053-2



Recommended size for the mounting flange for size 11 or larger

The mounting flange diameter should not exceed the boss diameter of the flexspline as shown in Figure 054-1. The flange which contacts the diaphragm should have radius, R. A large diameter and flange without a radius may cause damage to the diaphragm.

Table 054-1

Unit: mm

Flexspline Clamp Ring Dimensions

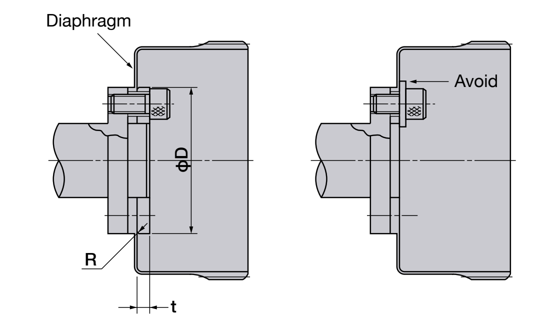
Symbol \ Size	11	14	17	20	25	32	40	45	50	58	65	80	90	100
$\phi D^{0}_{-0.1}$	17.8	24.5	29	34	42	55	68	74	83	95.8	106	130	145	162
$R^{+0.1}_{0}$	0.5	1.2	1.2	1.4	1.5	2	2.5	2	2.5	2.5	2.5	2.5	2.5	2.5
t	2	2	2.5	2.5	5	7	7	8	8	12	12	15	20	25

Material and hardness of the mounting flange

Use the following material and hardness.

Material: S45C (DINHC45)
Heat process: Hardening and tempering
Hardness: HB200 to 270

Recommended Dimension of Flexspline Clamp Ring Fig. 054-1



Warning: The bolt head, nut and washer should not exceed Size D.

Installation of the flexspline

Use bolts or bolts and pins (pin: option) for installing the flexspline.

- Strength of the selected bolt
- Tightening of bolts and the tightening torque
- Surface condition of bolts and tapped holes
- Friction coefficient of the contact surface

The load is normally attached to the Flexspline using a bolt or screw. For high load torques dowel pins can be used in addition to bolts or screws. The strength of the selected bolt, clamp torque, surface condition of bolt and thread, and coefficient of friction on the contact surface are important factors to consider. To determine transmission torque of the fastened part consider conditions indicated below. Please fasten bolts with the proper torque for each size as indicated. Please use the tables to determine if dowel pins are needed.

(1) If the load torque is less than momentary peak torque shown in tables 055-1 and 056-1 then only bolts are needed.
(2) If load torque is expected to reach momentary peak torque, both bolts and pins should be used. see Table 055-2 and Figure 055-1 and Table 056-2 and Figure 056-1.

* Use the value in the table as a reference value.

CSF series: Flexspline bolts

Table 055-1

Item \ Size		11	14	17	20	25	32	40	45	50	58	65	80	90	100
Number of bolts		6	6	6	8	8	8	8	8	8	8	8	8	8	12
Bolt size		M3	M4	M5	M5	M6	M8	M10	M12	M14	M14	M16	M16	M20	M20
Pitch circle	mm	12	17	19	24	30	40	50	54	60	70	80	100	110	130
Clamp torque	Nm	2.0	4.5	9.0	9.0	15.3	37	74	128	205	205	319	319	622	622
Torque transmission capacity (bolt only)	Nm	15	35	64	108	186	460	910	1440	2160	2550	3980	6220	8560	15170

CSF series: Flexspline bolts and optional dowel pins

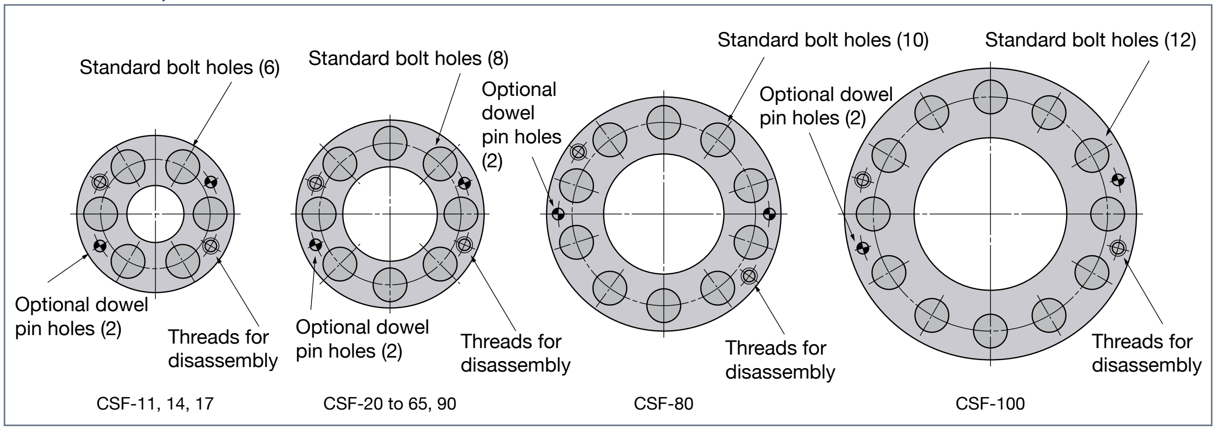
Table 055-2

Item \ Size		11	14	17	20	25	32	40	45	50	58	65	80	90	100
Number of pins		2	2	2	2	2	2	2	2	2	2	2	2	2	2
Diameter	mm	2	3	3	3	4	5	6	6	8	8	8	8	12	10
Pitch circle	mm	15.2	18.5	21.5	27	34	45	56	61	68	79	90	114	120	142
Torque transmission capacity (bolt only)	Nm	29	74	108	167	314	725	1370	1950	3160	3710	5310	7910	12540	18450

(Table 055-1, 055-2/Notes)
1. The material of the thread must withstand the clamp torque.
2. Recommended bolt: JIS B 1176 socket head cap screw / Strength range: JIS B 1051 over 12.9
3. Torque coefficient: K=0.2
4. Clamp coefficient: A=1.4
5. Friction coefficient on the surface contacted: μ=0.15
6. Dowel Pin: Parallel pin, material: S45C-Q, shearing stress: τ=30 kg/mm^2

CSF series: Flexspline Bolts

Fig. 055-1



CSG series: Flexspline bolts

Table 056-1

Item \ Size		14	17	20	25	32	40	45	50	58	65
Number of bolts		6	6	8	8	8	8	8	8	8	8
Bolt size		M4	M5	M5	M6	M8	M10	M12	M14	M14	M16
Pitch circle	mm	17	19	24	30	40	50	54	60	70	80
Clamp torque	Nm	5.4	10.8	10.8	18.4	44.4	88.8	154	246	246	383
Torque transmission capacity (bolt only)	Nm	43	77	130	230	555	1110	1728	2636	3075	4785

CSG series: Flexspline, bolts and optional dowel pins

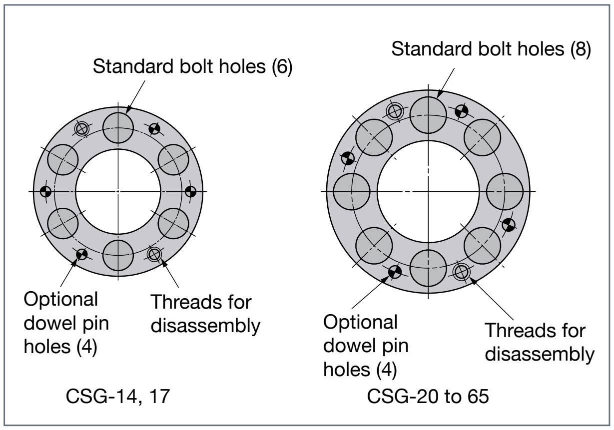
Table 056-2

Item \ Size		14	17	20	25	32	40	45	50	58	65
Number of pins		4	4	4	4	4	4	4	4	4	4
Pin size	mm	3	3	3	4	5	6	6	8	8	8
Pitch circle	mm	18.5	21.5	27	34	45	56	61	68	79	90
Torque transmission capacity	Nm	120	166	242	481	1070	2040	2742	4646	5410	7445

(Table 056-1, 056-2/Notes)
1. The material of the thread must withstand the clamp torque.
2. Recommended bolt: JIS B 1176 socket head cap screw / Strength range: JIS B 1051 over 12.9.
3. Torque coefficient: K=0.2
4. Clamp coefficient: A=1.4
5. Tightening friction coefficient μ=0.15
6. Pin type: Parallel pin, material: S45C-Q, shearing stress: τ=30 kg/mm^2

CSF series: Hole positions of bolts and optional dowel pins

Fig. 056-1



■ Installation of the circular spline

Perform design and part control corresponding to the load condition for installation of the circular spline in the same way as the flexspline. Transmission torques by the recommended bolts and tightening torque are shown in Table 058-2. When the transmission torque is lower than the load torque, the additional use of pins and bolts should be reviewed. Perform installation to meet the requirements of each series.

CSG series: Bolt installation

Table 057-1

Item \ Size		14	17	20	25	32	40	45	50	58	65
Number of bolts		8	16	16	16	16	16	16	16	16	16
Bolt size		M3	M3	M3	M4	M5	M6	M8	M8	M10	M10
Pitch circle	mm	44	54	62	75	100	120	140	150	175	195
Clamp torque	Nm	2.0	2.0	2.0	4.5	9.0	15.3	37	37	74	74
Torque transmission capacity	Nm	72	175	196	419	901	1530	3238	3469	6475	7215

CSF series: Bolt installation

Table 057-2

Item \ Size		8	11	14	17	20	25	32	40	45	50	58	65	80	90	100
Number of bolts		8	8	6	12	12	12	12	12	12	12	12	12	16	16	16
Bolt size		M2	M2.5	M3	M3	M3	M4	M5	M6	M8	M8	M10	M10	M10	M12	M12
Pitch circle	mm	25.5	35	44	54	62	75	100	120	140	150	175	195	240	270	300
Clamp torque	Nm	0.54	1.1	2.0	2.0	2.0	4.5	9.0	15.3	37	37	74	74	74	128	128
Torque transmission capacity	Nm	17	39	54	131	147	314	676	1150	2440	2620	4820	5370	8820	14450	16050

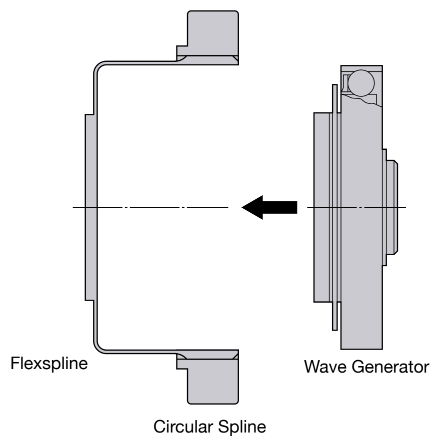
(Table 057-1, 057-2/Notes)
1. The material of the thread must withstand the clamp torque.
2. Recommended bolt: JIS B 1176 socket head cap screw / Strength range: JIS B 1051 over 12.9.
3. Torque coefficient: K=0.2
4. Clamp coefficient: A=1.4
5. Tightening friction coefficient μ=0.15

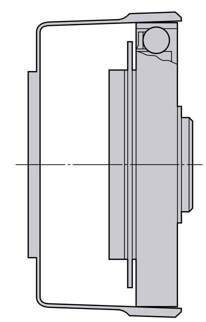
■ Assembly order for basic three elements

The wave generator is installed after the flexspline and circular spline. If the wave generator is not inserted into the flexspline last, gear teeth scuffing damage or improper eccentric gear mesh may result. Installation resulting in an eccentric tooth mesh (Dedoidal) will cause noise and vibration, and can lead to early failure of the gear. For proper function, the teeth of the flexspline and Circular Spline mesh symmetrically.

Assembly order for basic three elements

Table 058-1





When the flexspline and wave generator are assembled, the open end of the flexspline will expand at the major axis.

■ Precautions on assembly

It is extremely important to assemble the gear accurately and in proper sequence. For each of the three components, utilize the following precautions.

Wave generator

1. Avoid applying undue axial force to the wave generator during installation. Rotating the wave generator bearing while inserting it is recommended and will ease the process.
2. If the wave generator does not have an Oldham coupling, extra care must be given to ensure that concentricity and inclination are within the specified limits (see page 51).

Circular spline

The circular Spline must not be deformed in any way during the assembly. It is particularly important that the mounting surfaces are prepared correctly.

1. Mounting surfaces need to have adequate flatness, smoothness, and no distortion.
2. Especially in the area of the screw holes, burrs or foreign matter should not be present.
3. Adequate relief in the housing corners is needed to prevent interference with the corner of the circular spline.
4. The circular spline should be rotatable within the housing. Be sure there is not interference and that it does not catch on anything.
5. Bolts should not rotate freely when tightening and should not have any irregularity due to the bolt hole being misaligned or oblique.
6. Do not tighten the bolts with the specified torque all at once. Tighten the bolts temporarily with about half the specified torque, and then tighten them with the specified torque. Tighten them in an even, crisscross pattern.
7. Avoid pinning the circular spline if possible as it can reduce the rotational precision and smoothness of operation.

Flexspline

1. Mounting surfaces need to have adequate flatness, smoothness, and no distortion.
2. Especially in the area of the screw holes, burrs or foreign matter should not be present.
3. Adequate clearance with the housing is needed to ensure no interference especially with the major axis of flexspline
4. Bolts should rotate freely when installing through the mounting holes of the flexspline and should not have any irregularity due to the shaft bolt holes being misaligned or oblique.
5. Do not tighten the bolts with the specified torque all at once. Tighten the bolts temporarily with about half the specified torque, and then tighten them to the specified torque. Tighten them in an even, crisscross pattern.
6. The flexspline and circular spline are concentric after assembly. After installing the wave generator bearing, if it rotates in unbalanced way, check the mounting for dedoidal or non-concentric installation.
7. Care should be taken not to damage the flexspline diaphragm or gear teeth during assembly.

   Avoid hitting the tips of the flexpline teeth and circular spline teeth. Avoid installing the CS from the open side of the flexspline after the wave generator has been installed.

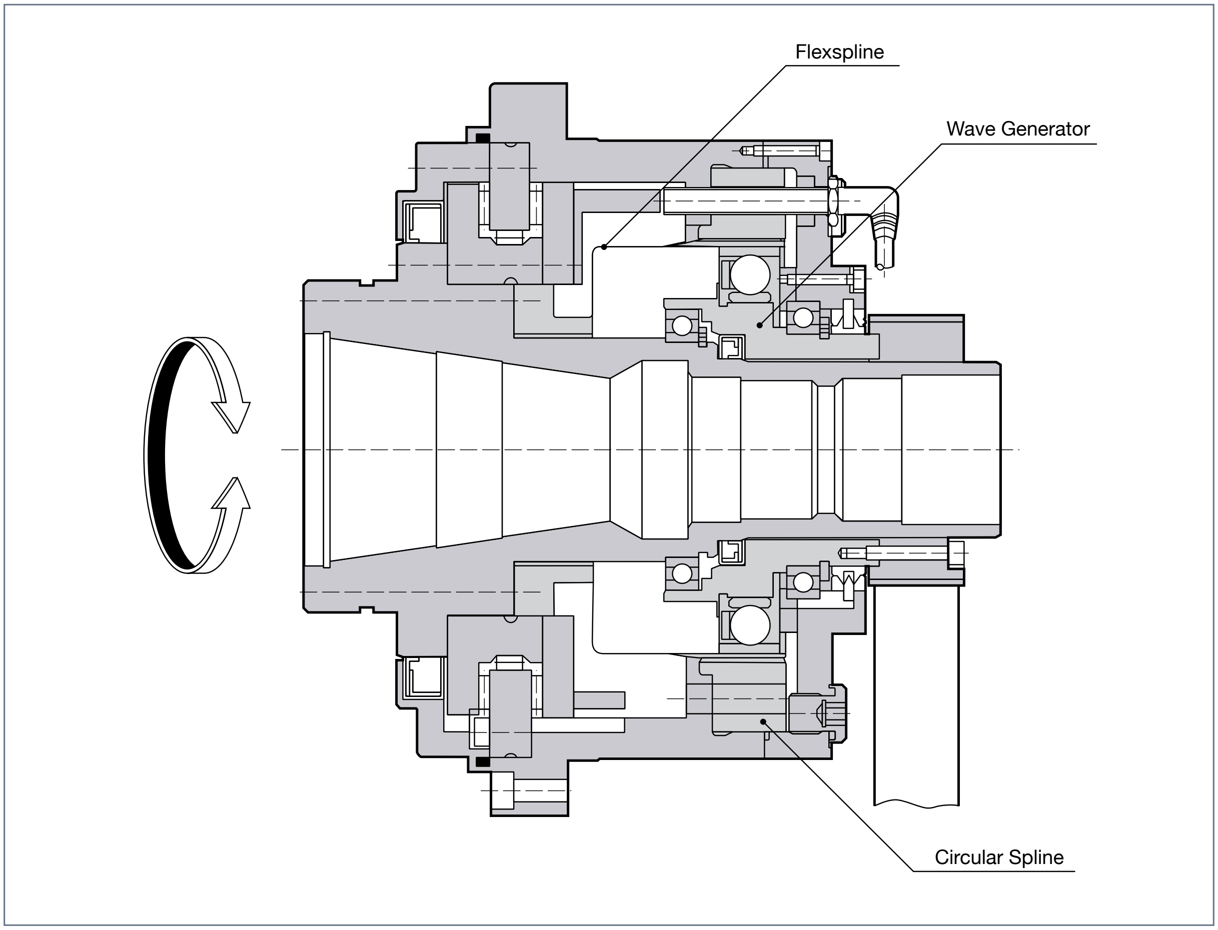
Rust prevention

Although Harmonic Drive® gears come with some corrosion protection, the gear can rust if exposed to the environment. The gear external surfaces typically have only a temporary corrosion inhibitor and some oil applied. If an anti-rust product is needed, please contact us to review the options.

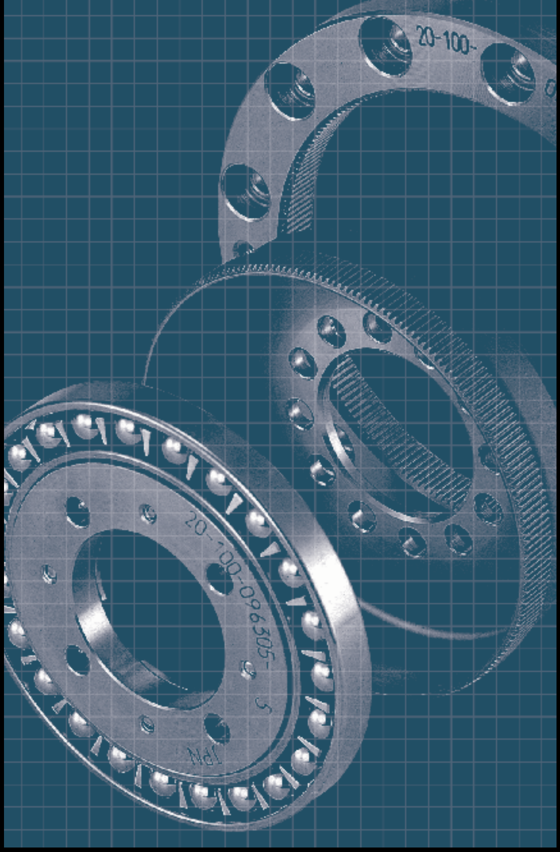
Application

Tool changer

Fig. 059-1



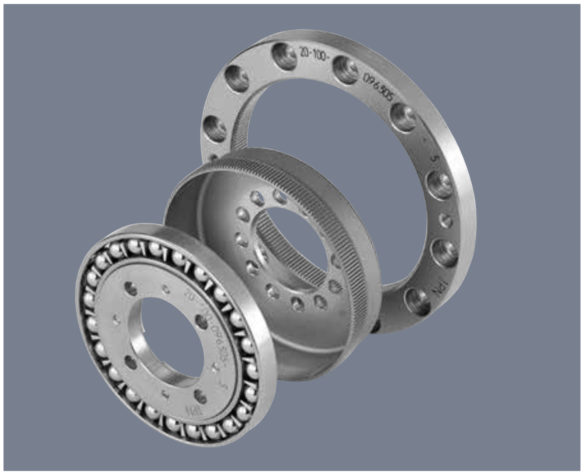
MEMO



CSD Series

Component Set CSD

Features



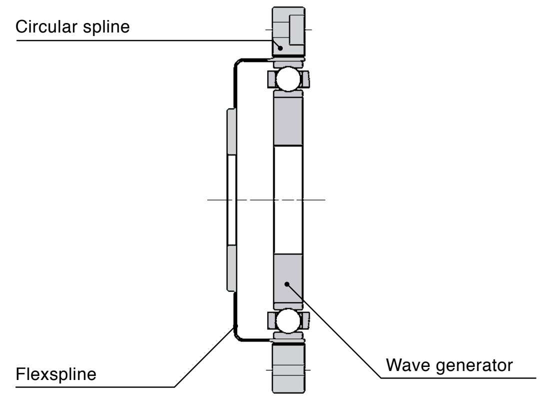
CSD Series component set

The ultra-flat CSD component set features a compact design enabling it to be used in a variety of tight spaces for applications that require high precision, like robotics. The CSD component set is made up of 3 basic parts: circular spline, flexspline and wave generator.

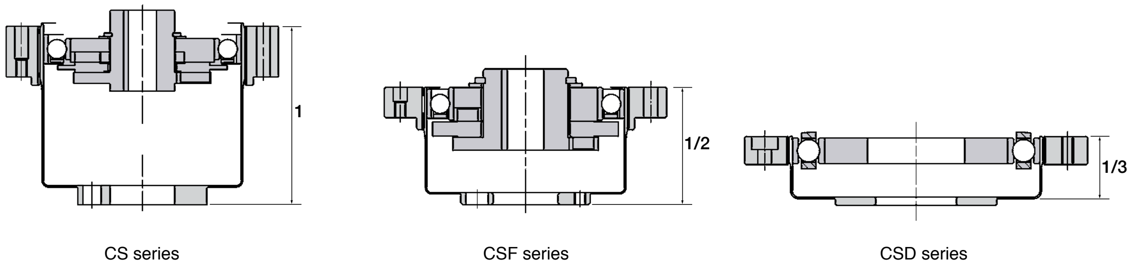
Features

- Zero backlash
- Compact and simple design
- High torque capacity
- High stiffness
- High positioning and rotational accuracies
- Coaxial input and output

Structure of CSD series component set — Fig. 062-1

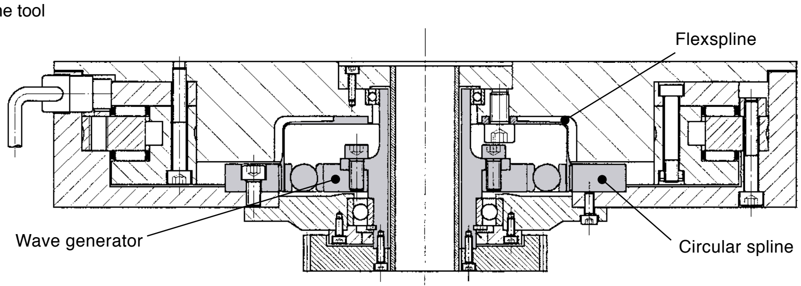


Size comparison — Fig. 062-2



Application example — Fig. 062-3

Rotary table for machine tool



Note: Sealing required to prevent grease leakage.

Ordering Code

CSD - 20 - 100 - 2A - GR - SP

Table 063-1

Series	Size	Ratio*			Model	Special specification
CSD	14	50	80	100	2A-GR = component type (2A-R for Size 14, 17)	Blank= Standard product SP= Special specification code BB= Big Bore
	17	50	80	100		
	20	50	80	100		
	25	50	80	100		
	32	50	80	100		
	40	50	80	100		
	50	50	80	100		

* The reduction ratio value is based on the following configuration:
Input: wave generator, fixed: circular spline, output: flexspline

Technical Data

Rating Table CSD-2A Component Set

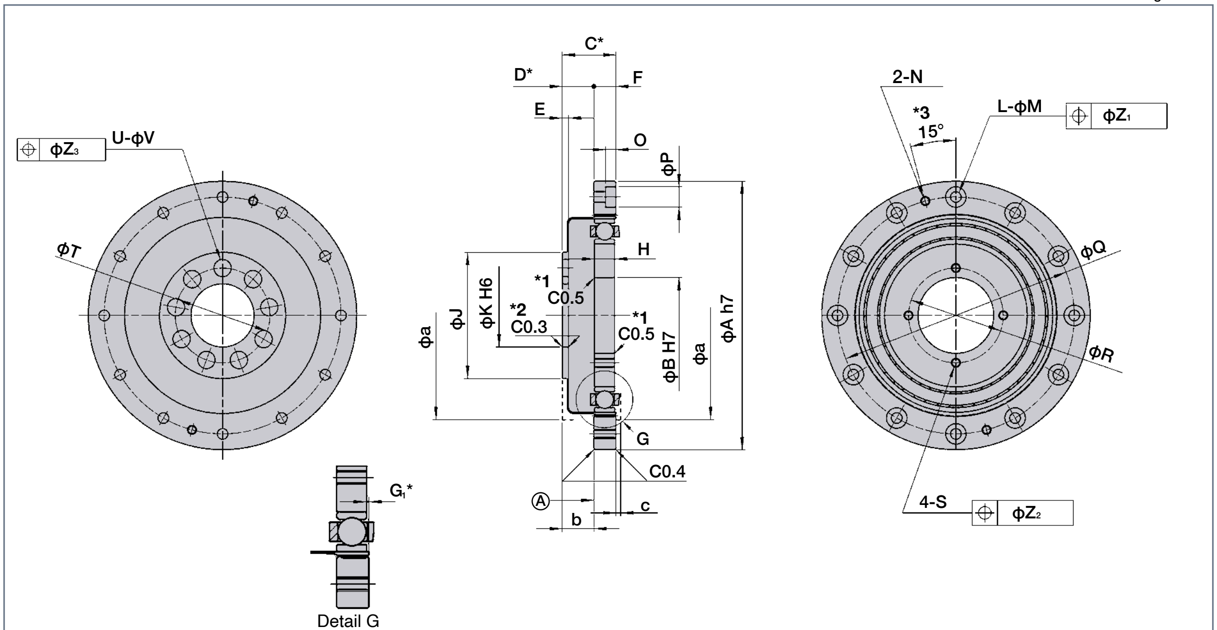
Size	Gear ratio	Rated torque at input speed 2000rpm		Limit for repeated peak torque		Limit for average torque		Limit for momentary peak torque		Maximum input speed (rpm)		Limit for average input speed (rpm)		Moment of inertia	
		Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm	Oil	Grease	Oil	Grease	I x 10^{-4}kgm^2	J x 10^{-5}kgfms^2
14	50	3.7	0.38	12	1.2	4.8	0.49	24	2.4	14000	8500	6500	3500	0.021	0.021
	80	5.4	0.55	16	1.6	7.7	0.79	31	3.2						
	100	5.4	0.55	19	1.9	7.7	0.79	31	3.2						
17	50	11	1.1	23	2.3	18	1.8	48	4.9	10000	7300	6500	3500	0.054	0.055
	80	15	1.5	29	3.0	19	1.9	55	5.6						
	100	16	1.6	37	3.8	27	2.8	55	5.6						
20	50	17	1.7	39	4.0	24	2.4	69	7.0	10000	6500	6500	3500	0.090	0.092
	80	24	2.4	51	5.2	33	3.4	76 (65)	7.7 (6.6)						
	100	28	2.9	57	5.8	34	3.5	76 (65)	7.7 (6.6)						
25	50	27	2.8	69	7.0	38	3.9	127	13	7500	5600	5600	3500	0.282	0.288
	80	44	4.5	96	9.8	60	6.1	152 (135)	15 (14)						
	100	47	4.8	110	11	75	7.6	152 (135)	15 (14)						
32	50	53	5.4	151	15	75	7.6	268	27	7000	4800	4600	3500	1.09	1.11
	80	83	8.5	213	22	117	12	359 (331)	37 (34)						
	100	96	9.8	233	24	151	15	359 (331)	37 (34)						
40	50	96	9.8	281	29	137	14	480	49	5600	4000	3600	3000	2.85	2.91
	80	144	15	364	37	198	20	685 (580)	70 (59)						
	100	185	19	398	41	260	27	694 (580)	71 (59)						
50	50	172	18	500	51	247	25	1000	102	4500	3500	3000	2500	8.61	8.78
	80	260	27	659	67	363	37	1300	133						
	100	329	34	686	70	466	48	1440 (1315)	147 (134)						

1. Moment of inertia: $I = \frac{1}{4} GD^2$
2. *The maximum allowable momentary torque value marked by an asterisk(*) is restricted by the tightening torque of the flexspline.
3. The parenthesized value indicates the value when the bore of the flexspline has the maximum value (BB type).
4. See “Rating Table Definitions” on Page 12 for details of the terms.
5. When the max allowable momentary torque is expected to be applied, see “Bolt tightening of the flexspline” on p. 75.

Outline Dimensions

You can download the CAD files from our website: harmonicdrive.net

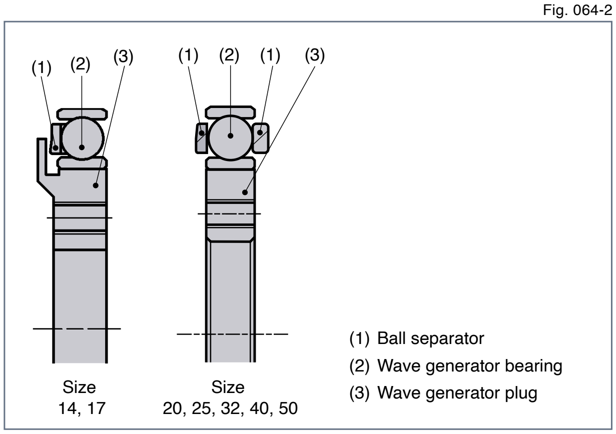
Fig. 064-1



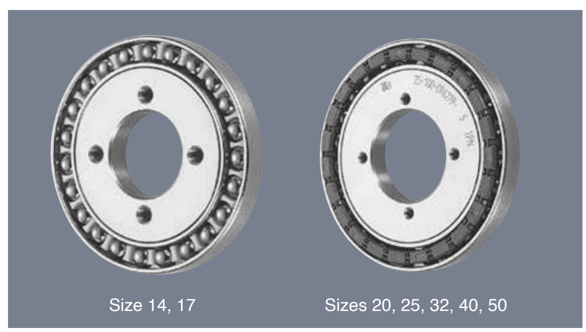
*1: Sizes 14 and 17 are C0.4.
*2: Sizes 40 and 50 are C0.5.
*3: Size 14 is 30° and Size 17 is 22.5°.
* Refer to confirmation drawing provided by Harmonic Drive LLC.

■ Structure and shape of the wave generator

Fig. 064-2



There is a difference in appearance of the the ball separator depending on the size.



Dimensions

Table 065-1
Unit : mm

Symbol		Size 14	17	20	25	32	40	50
φA h7		$50^{0}_{-0.025}$	$60^{0}_{-0.030}$	$70^{0}_{-0.030}$	$85^{0}_{-0.035}$	$110^{0}_{-0.035}$	$135^{0}_{-0.040}$	$170^{0}_{-0.040}$
φB H7		$11^{+0.018}_{0}$	$15^{+0.018}_{0}$	$20^{+0.021}_{0}$	$24^{+0.021}_{0}$	$32^{+0.025}_{0}$	$40^{+0.025}_{0}$	$50^{+0.025}_{0}$
C∗		11	12.5	14	17	22	27	33
D∗		$6.5^{+0.2}_{0}$	$7.5^{+0.2}_{0}$	$8^{+0.3}_{0}$	$10^{+0.3}_{0}$	$13^{+0.3}_{0}$	$16^{+0.3}_{0}$	$19.5^{+0.3}_{0}$
E		1.4	1.7	2	2	2.5	3	3.5
F		4.5	5	6	7	9	11	13.5
G_1∗		$0.3^{+0.2}_{0}$	$0.3^{+0.2}_{0}$	$0.3^{+0.2}_{0}$	$0.4^{+0.2}_{0}$	$0.5^{+0.2}_{0}$	$0.6^{+0.2}_{0}$	$0.8^{+0.2}_{0}$
H		$4^{0}_{-0.1}$	$5^{0}_{-0.1}$	$5.2^{0}_{-0.1}$	$6.3^{0}_{-0.1}$	$8.6^{0}_{-0.1}$	$10.3^{0}_{-0.1}$	$12.7^{0}_{-0.1}$
φJ		23	27.2	32	40	52	64	80
φK H6	Standard	$11^{+0.011}_{0}$	$11^{+0.011}_{0}$	$16^{+0.011}_{0}$	$20^{+0.013}_{0}$	$30^{+0.013}_{0}$	$32^{+0.016}_{0}$	$44^{+0.016}_{0}$
	BB spec.	$11^{+0.011}_{0}$	$11^{+0.011}_{0}$	$20^{+0.013}_{0}$	$24^{+0.013}_{0}$	$32^{+0.016}_{0}$	$40^{+0.016}_{0}$	$50^{+0.016}_{0}$
L		6	8	12	12	12	12	12
φM		3.4	3.4	3.4	3.4	4.5	5.5	6.6
N		M3	M3	M3	M3	M4	M5	M6
O		—	—	3.3	3.3	4.4	5.4	6.5
φP		—	—	6.5	6.5	8	9.5	11
φQ		44	54	62	75	100	120	150
φR		17	21	26	30	40	50	60
S		M3	M3	M3	M3	M4	M5	M6
φT	Standard	17	19.5	24	30	41	48	62
	BB spec.	17	19.5	26	32	42	52	65
U	Standard	9	8	9	9	11	10	11
	BB spec.	9	8	12	12	14	14	14
φV	Standard	3.4	4.5	4.5	5.5	6.6	9	11
	BB spec.	3.4	4.5	3.4	4.5	5.5	6.6	9
φZ_1		0.2	0.2	0.2	0.2	0.25	0.25	0.3
φZ_2		0.25	0.25	0.2	0.2	0.25	0.25	0.3
φZ_3	Standard	0.2	0.25	0.25	0.25	0.3	0.5	0.5
	BB spec.	0.2	0.25	0.2	0.25	0.25	0.3	0.5
Minimum housing clearance	φa	38	45	53	66	86	106	133
	b	6.5	7.5	8	10	13	16	19.5
	c	1	1	1.5	1.5	2	2.5	3.5
Mass (kg)		0.06	0.10	0.13	0.24	0.51	0.92	1.9

(Note) Standard dimension for size 14 and 17 is the maximum bore.

- Surface A is the recommended mounting surface.
- The following dimensions can be modified to accommodate customer-specific requirements.

Wave Generator: B
Flexspline: U and V
Circular Spline: L and M

- *C, D and G_1 values indicate relative position of individual gearing components (wave generator, flexspline, circular spline). Please strictly adhere to these values when designing your housing and mating parts.
- Due to the deformation of the Flexspline during operation, it is necessary to provide a minimum housing clearance, dimensions φa, b, c

The wave generator, flexspline, and circular spline are not assembled when delivered.

Positional accuracy

See "Engineering data" for a description of terms.

Table 066-1

Ratio		14	17	20	25	32	40	50
Positional Accuracy	$\times 10^{-4}$rad	4.4	4.4	2.9	2.9	2.9	2.9	2.9
	arc min	1.5	1.5	1.0	1.0	1.0	1.0	1.0

Hysteresis loss

See "Engineering data" for a description of terms.

Table 066-2

Ratio \ Size		14	17	20	25	32	40	50
50	$\times 10^{-4}$rad	7.3	5.8	5.8	5.8	5.8	5.8	5.8
	arc min	2.5	2.0	2.0	2.0	2.0	2.0	2.0
80 or more	$\times 10^{-4}$rad	5.8	2.9	2.9	2.9	2.9	2.9	2.9
	arc min	2.0	1.0	1.0	1.0	1.0	1.0	1.0

Torsional stiffness

See "Engineering data" for a description of terms.

Table 066-3

Symbol \ Size			14	17	20	25	32	40	50
	T_1	Nm	2.0	3.9	7.0	14	29	54	108
		kgfm	0.2	0.4	0.7	1.4	3.0	5.5	11
	T_2	Nm	6.9	12	25	48	108	196	382
		kgfm	0.7	1.2	2.5	4.9	11	20	39
Reduction ratio 50	K_1	$\times 10^4$Nm/rad	0.29	0.67	1.1	2.0	4.7	8.8	17
		kgfm/arc min	0.085	0.2	0.32	0.6	1.4	2.6	5.0
	K_2	$\times 10^4$Nm/rad	0.37	0.88	1.3	2.7	6.1	11	21
		kgfm/arc min	0.11	0.26	0.4	0.8	1.8	3.4	6.3
	K_3	$\times 10^4$Nm/rad	0.47	1.2	2.0	3.7	8.4	15	30
		kgfm/arc min	0.14	0.34	0.6	1.1	2.5	4.5	9
	θ_1	$\times 10^{-4}$rad	6.9	5.8	6.4	7.0	6.2	6.1	6.4
		arc min	2.4	2.0	2.2	2.4	2.1	2.1	2.2
	θ_2	$\times 10^{-4}$rad	19	14	19	18	18	18	18
		arc min	6.4	4.6	6.6	6.1	6.1	5.9	6.2
Reduction ratio 80 or more	K_1	$\times 10^4$Nm/rad	0.4	0.84	1.3	2.7	6.1	11	21
		kgfm/arc min	0.12	0.25	0.4	0.8	1.8	3.2	6.3
	K_2	$\times 10^4$Nm/rad	0.44	0.94	1.7	3.7	7.8	14	29
		kgfm/arc min	0.13	0.28	0.5	1.1	2.3	4.2	8.5
	K_3	$\times 10^4$Nm/rad	0.61	1.3	2.5	4.7	11	20	37
		kgfm/arc min	0.18	0.39	0.75	1.4	3.3	5.8	11
	θ_1	$\times 10^{-4}$rad	5.0	4.6	5.4	5.2	4.8	4.9	5.1
		arc min	1.7	1.6	1.8	1.8	1.7	1.7	1.7
	θ_2	$\times 10^{-4}$rad	16	13	15	13	14	14	13
		arc min	5.4	4.3	5.0	4.5	4.8	4.8	4.6

* The values in this table are reference values. The minimum value is approximately 80% of the displayed value.

Starting torque

See "Engineering data" for a description of terms. Please use as reference values; the values vary based on use conditions.

Table 067-1
Unit: Ncm

Ratio \ Size	14	17	20	25	32	40	50
50	3.7	5.7	7.3	14	28	50	94
80	2.7	3.8	4.8	8.8	19	32	63
100	2.4	3.3	4.3	7.9	18	29	56

Backdriving torque

See "Engineering data" for a description of terms. Please use as reference values; the values vary based on use conditions.

Table 067-2
Unit: Nm

Ratio \ Size	14	17	20	25	32	40	50
50	2.5	3.8	4.4	8.3	17	30	57
80	2.6	3.7	4.9	8.8	19	32	62
100	3.1	4.1	5.2	9.6	21	35	67

Ratcheting torque

See "Engineering data" for a description of terms.

Table 067-3
Unit: Nm

Ratio \ Size	14	17	20	25	32	40	50
50	60	105	150	315	685	1260	2590
80	75	140	245	475	980	1960	3780
100	55	110	180	350	700	1470	2870

Buckling torque

See "Engineering data" for a description of terms.

Table 067-4
Unit: Nm

Size	14	17	20	25	32	40	50
All ratios	190	330	560	1000	2200	4300	8000

No-load running torque

No-load running torque is the torque which is required to rotate the input side (high speed side), when there is no load on the output side (low speed side).

Measurement condition Table 068-1

Ratio 100:1			
Lubricant	Grease lubrication	Name	Harmonic Grease SK-1A (size 20 or larger)
			Harmonic Grease SK-2 (size 14, 17)
		Quantity	Recommended quantity (See page 71)
Torque value is measured after 2 hours at 2000rpm input.			

* Contact us for oil lubrication.

■ Compensation value in each ratio

No load running torque of the gear varies with ratio.
The graphs indicate a value for ratio 100.
For other gear ratios, add the compensation values from table on the right.

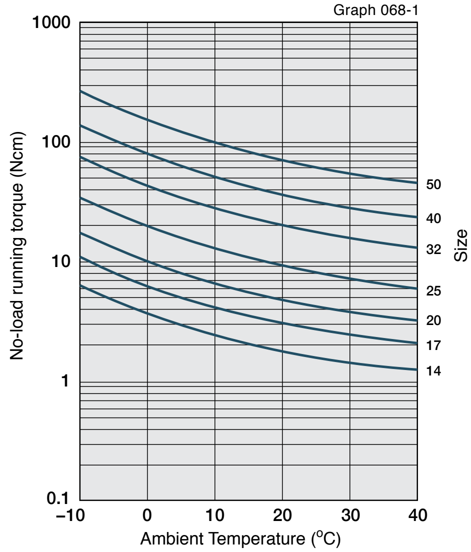
Compensation coefficient for no-load running torque Table 068-2 Unit: Ncm

Size \ Ratio	50
14	+0.56
17	+0.95
20	+1.4
25	+2.6
32	+5.4
40	+9.6
50	+18

■ No-load running torque for a reduction ratio of 100

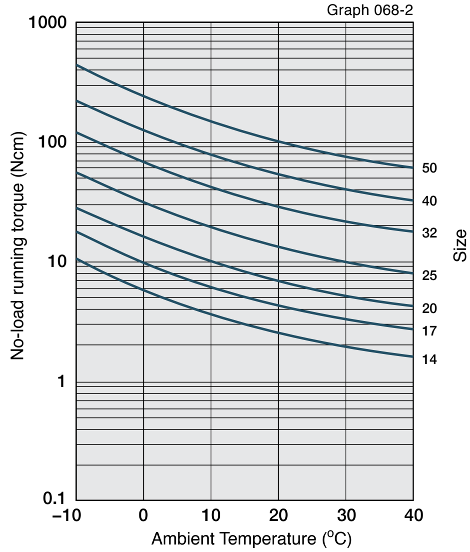
Input rotational speed: 500rpm

Graph 068-1



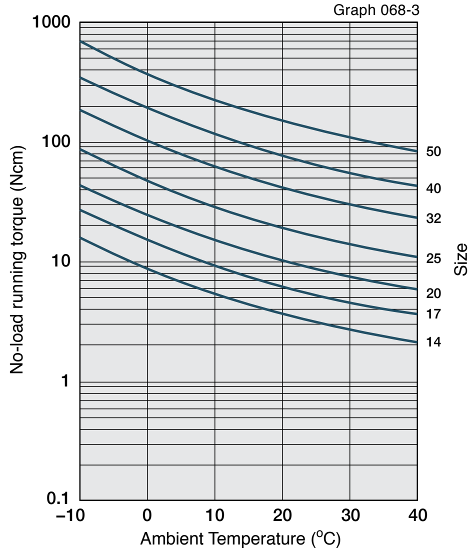
Input rotational speed: 1000rpm

Graph 068-2



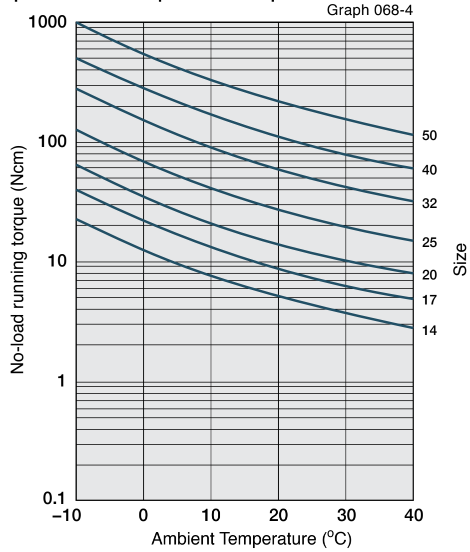
Input rotational speed: 2000rpm

Graph 068-3



Input rotational speed: 3500rpm

Graph 068-4



* The values in this graph are average value "X̄".

Efficiency

The efficiency varies depending on the following conditions.

- Reduction ratio
- Input rotational speed
- Load torque
- Temperature
- Lubrication (Type and quantity)

Measurement condition — Table 069-1

Installation	Based on recommended tolerance		
Load torque	The rated torque shown in the rating table (see page 63)		
* When load torque is smaller than rated torque, the efficiency value is lowered. See efficiency compensation coefficient below.			
Lubricant	Grease lubrication	Name	Harmonic Grease SK-1A (size 20 or larger)
			Harmonic Grease SK-2 (size 14, 17)
		Quantity	Recommended quantity (see page 71)

* Contact us for oil lubrication.

■ Efficiency compensation coefficient and efficiency compensation amount

Efficiency correction calculation formula

To determine efficiency due to “efficiency compensation coefficient due to load torque” and “efficiency compensation amount due to size.”, use formula 69-1.

Calculation formula — Formula 069-1

Efficiency $\eta = Ke \times (\eta_R + \eta e)$

Symbols of the calculation formula — Table 069-2

η	Efficiency	
Ke	Efficiency correction coefficient	Graph 69-1
η_R	Efficiency at rated torque	Graphs 070-1 to 070-6
ηe	Efficiency correction amount	Table 69-3

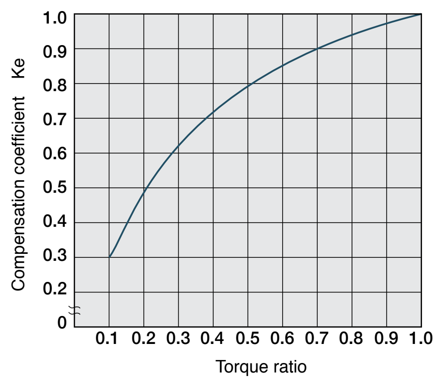
■ Efficiency compensation coefficient

If the load torque is lower than the rated torque, the efficiency value decreases. Calculate the compensation coefficient Ke from Graph 069-1 to calculate the efficiency using the following calculation example.

* Efficiency Compensation coefficient Ke=1 holds when the load torque is greater than the rated torque.

Efficiency compensation coefficient — Graph 069-1

Torque ratio α is the value of load torque/rated torque (Rating table: page 063).



■ Efficiency compensation amount by size

With the CSD-2A, input-side support bearings and oil seal are attached. The effect of these varies depending on the size.

Use Table 69-3 to determine the correction amount (ηe) for efficiency at rated torque for each size

Efficiency compensation amount — Table 069-3, Unit: %

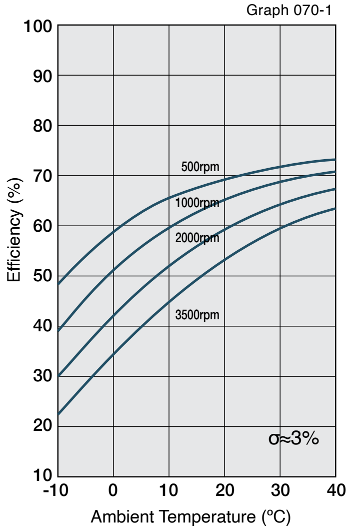
Size \ Reduction ratio	50	80	100	120	160
14	0.0	3.4	0.0	—	—
17	0.3	4.5	2.4	-0.2	—
20	-0.3	4.4	3.7	1.2	1.7
25	3.0	3.7	1.6	-1.0	-0.6
32	1.4	1.5	0.7	-2.0	-1.6
40	1.2	0.6	1.3	0.3	0.8
50	0.0	-0.5	0.0	-0.8	-0.3

■ **Efficiency at rated torque**

Reduction ratio 50:1

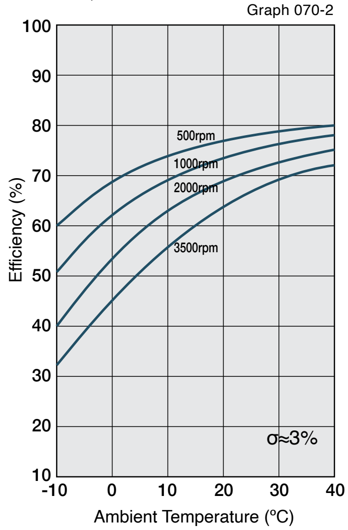
Size 14

Graph 070-1



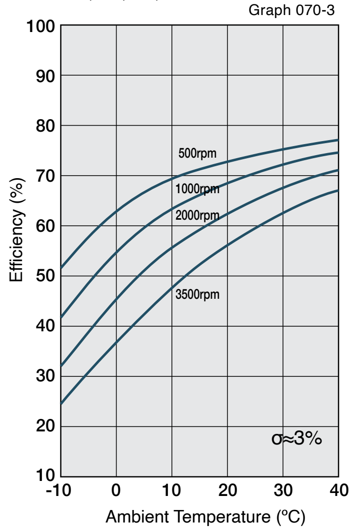
Size 17, 20

Graph 070-2



Size 25, 32, 40, 50

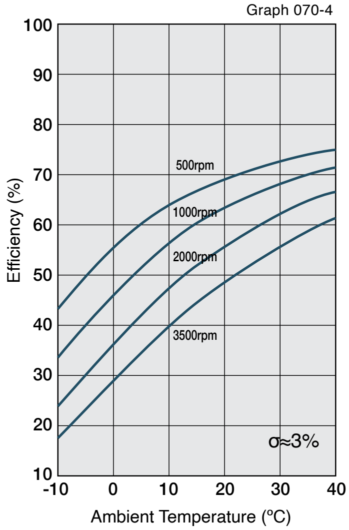
Graph 070-3



Reduction ratio 80, 100:1

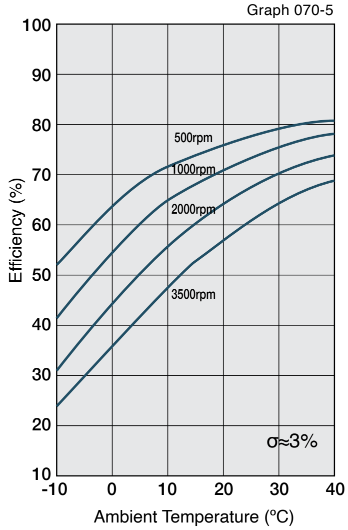
Size 14

Graph 070-4



Size 17, 20, 25, 32, 40, 50

Graph 070-5



Design Guide

Lubrication

■ Grease lubrication

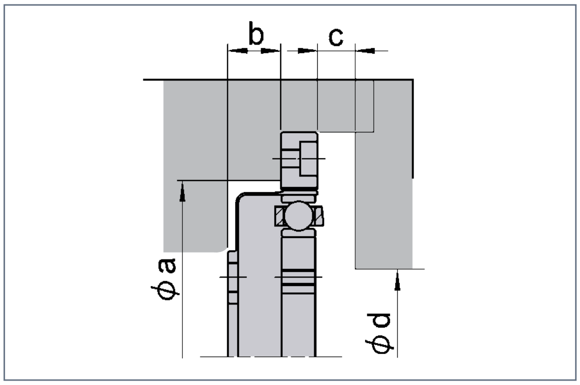
See "Engineering data" on Page 16 for details of the lubricant.

Recommended housing dimensions

See table below for recommended housing dimensions. These dimensions must be maintained to prevent damage to the gear and to maintain a proper grease cavity.

Recommended housing dimensions

Fig. 071-1



Recommended housing dimensions

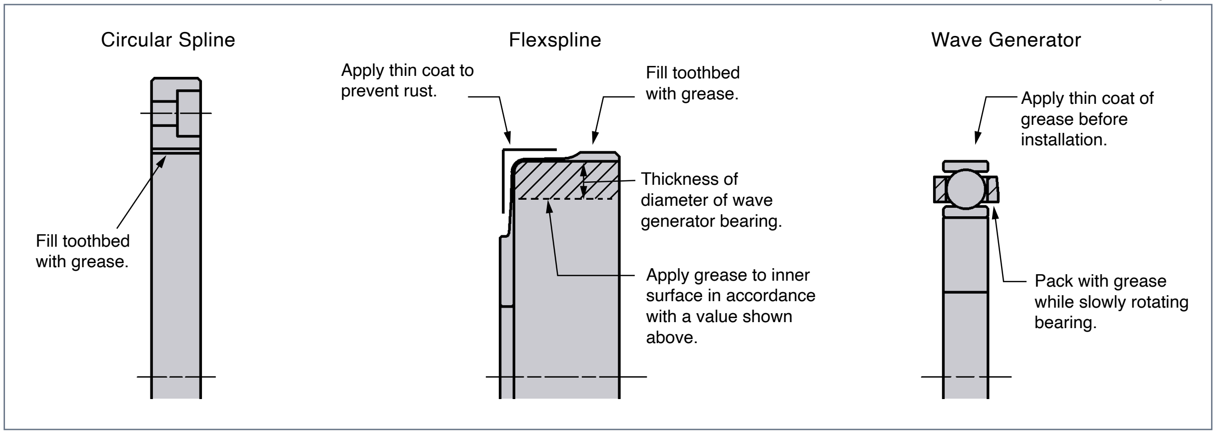
Table 071-1
Unit: mm

Symbol \ Size	14	17	20	25	32	40	50
φa	38	45	53	66	86	106	133
b	6.5	7.5	8	10	13	16	19.5
c	1 (3)	1 (3)	1.5 (4.5)	1.5 (4.5)	2 (6)	2.5 (7.5)	3.5 (10.5)
$\phi d^{+0.5}_{0}$	16	26	30	37	37	45	45

(Note) The value in parenthesis is the value when the wave generator is facing upward.

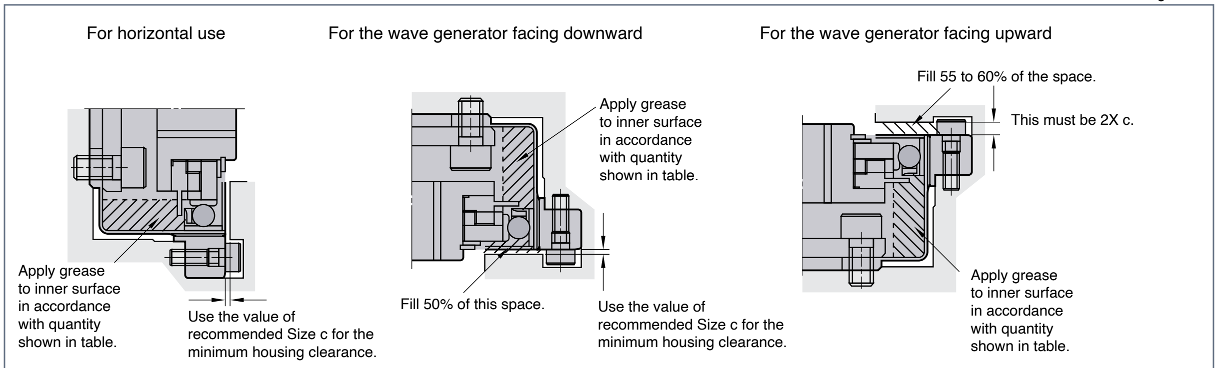
Application guide

Fig. 071-2



Application guide by usage

Fig. 071-3



Application quantity

Table 071-2
Unit: g

Usage \ Size		14	17	20	25	32	40	50
Horizontal use		3.5	5.2	9	17	37	68	131
Vertical use	Output up	3.9	6	10	19	42	78	149
	Output down	4.6	7.1	12	22	48	88	175

When to replace grease

The wear characteristics of the gear are strongly influenced by the condition of the grease lubrication. The condition of the grease is affected by the ambient temperature. The graph shows the maximum number of input rotations for various temperatures. This graph applies to applications where the average load torque does not exceed the rated torque.
In cases where the rated torque is exceeded, calculate the grease change interval using the equation shown below.

Formula when load torque exceeds rated torque

Formula 072-1

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

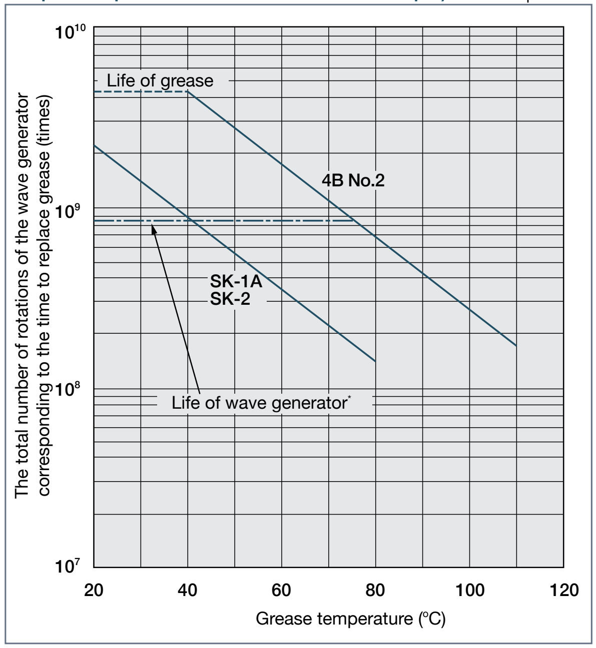
Symbols for Formula

Table 072-1

L_{GT}	Replacement timing if average load torque exceeds rated torque	Number of input revolutions	———
L_{GTn}	Replacement timing if average load torque is equal to or less than rated torque (or use formulas, i.e. Tav ≤ Tr)	Number of input revolutions	See the right-hand figure.
Tr	Rated torque	Nm	See the "Rating table" on page 63.
Tav	Average load torque	Nm	Calculation formula: See Page 14.

When to replace grease: LGTn (when the average load torque is equal to or less than the rated torque)

Graph 072-1



* Life of wave generator is based on L10 life of the bearing.

■ Other precautions

1. Avoid using it with other grease. The gear should be in an individual case when installed.

2. When you use the gear with the wave generator facing upward (see Figure 050-2 on Page 50) at low-speed rotation (input rotational speed: 1000 rpm or less) and in one direction, please contact us as it may cause lubrication problems.

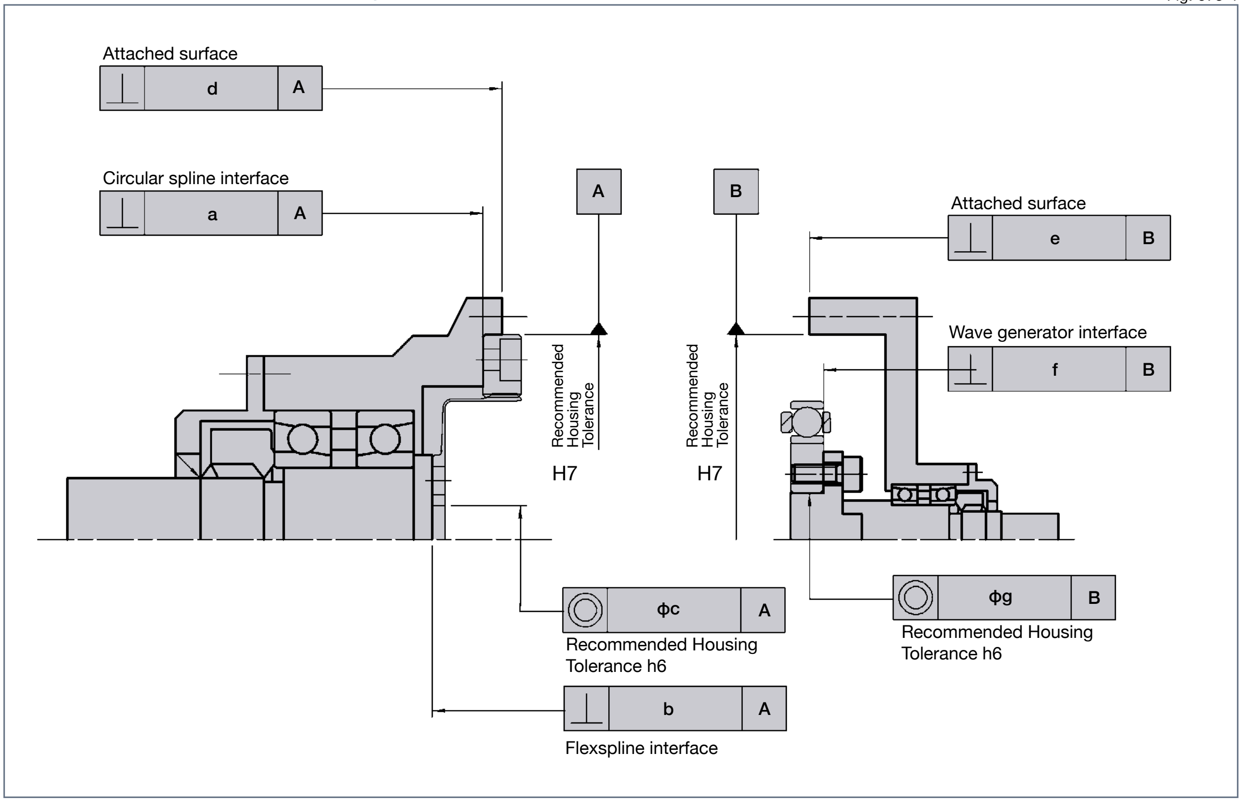
Recommended tolerances for assembly

For peak performance of the gear, it is essential that the following tolerances be observed when assembly is complete.
Pay careful attention to the following points and maintain the recommended assembly tolerances to avoid grease leakage.

- Warping and deformation on the mounting surface
- Contamination due to foreign matter
- Burrs, raised surfaces and location around the tap area of the mounting holes
- Insufficient chamfering on the mounting pilot joint
- Insufficient radii on the mounting pilot joint

Recommended Tolerances for Assembly

Fig. 073-1



Recommended tolerances for assembly

Table 073-1
Unit: mm

Symbol \ Size	14	17	20	25	32	40	50
a	0.011	0.012	0.013	0.014	0.016	0.016	0.018
b	0.008	0.011	0.014	0.018	0.022	0.025	0.030
ϕc	0.015	0.018	0.019	0.022	0.022	0.024	0.030
d	0.011	0.015	0.017	0.024	0.026	0.026	0.028
e	0.011	0.015	0.017	0.024	0.026	0.026	0.028
f	0.008	0.010	0.010	0.012	0.012	0.012	0.015
ϕg	0.016	0.018	0.019	0.022	0.022	0.024	0.030

Sealing

Sealing is needed to maintain the high durability of the gear and prevent grease leakage.
Rotating parts should have an oil seal (with spring), surface should be smooth (no scratches).
Mating flanges should have an O Ring, seal adhesive.
Screws should have a thread lock (LOCTITE® 242 recommended) or seal adhesive.

(Note) If you use Harmonic Grease® 4BNo.2, strict sealing is required.

Installation of the three basic elements

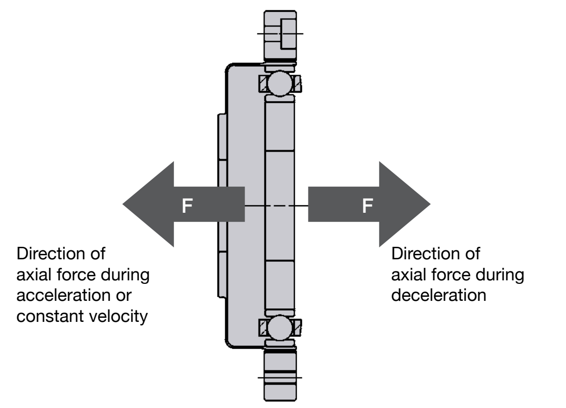
■ Installation of the wave generator

1. Axial force of the wave generator

When a CSD gear is used to accelerate a load, the deflection of the Flexspline leads to an axial force acting on the Wave Generator. This axial force, which acts in the direction of the closed end of the Flexspline, must be supported by the bearings of the input shaft (motor shaft). When a CSD gear is used to decelerate a load, an axial force acts to push the Wave Generator out of the Flexspline cup. Maximum axial force of the Wave Generator can be calculated by the equation shown below. The axial force may vary depending on its operating condition. The value of axial force tends to be a larger number when using high torque, extreme low speed and constant operation. The force is calculated (approximately) by the equation. In all cases, the Wave Generator must be axially (in both directions), as well as torsionally, fixed to the input shaft.

(Note) Please contact us for further information on attaching the Wave Generator to the input (motor) shaft.

Axial force direction of the wave generator　Fig. 074-1



Calculation formula for axial force　Table 074-1

Ratio	Calculation formula
50	$F=2\times\frac{T}{D}\times0.07\times\tan 30°+2\mu PF$
80 or more	$F=2\times\frac{T}{D}\times0.07\times\tan 20°+2\mu PF$

Symbols for Formula　Table 074-2

F	Axial force	N	See Fig. 074-1.
D	(Size) × 0.00254	m	
T	Output torque	Nm	
2μPF	Axial force by bearing	N	See Table 074-3.

Axial force by bearing　Table 074-3

Model	Size	2μPF (N)
CSD	14	2.1
	17	4.1
	20	5.6
	25	9.8
	32	16
	40	24
	50	39

Calculation Example　Formula 074-1

Model name : CSD
Size : 32
Ratio : i=50:1
Output torque : 268 Nm (max. allowable momentary torque)

$$F=2\times\frac{268}{(32\times0.00254)}\times0.07\times\tan 30°+16$$

$$F=266.5\text{ N}$$

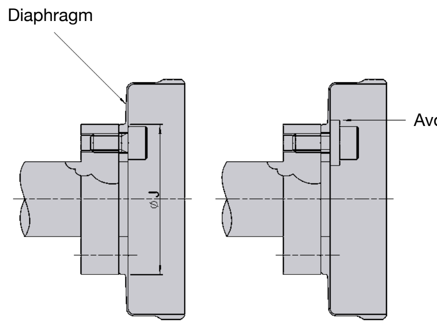
■ Installing the flexspline

1. Precautions on installation

We recommend that you install the flexspline directly with bolts. If you use a mounting flange or washer inside the flexspline, the mounting bolt may make contact with the wave generator and damage it when it is installed. Therefore, strictly observe installation of the flexspline with bolts.
Note that the head of the bolt should not exceed the boss diameter (ϕJ) of the flexspline as shown in Figure 075-1. Otherwise, the diaphragm may be damaged.

Installing the flexspline

Fig. 075-1



Warning	Head of bolt, nut and washer should not exceed Dimension J.

Diameter of the flexspline

Table 075-1
Unit: mm

Symbol \ Size	14	17	20	25	32	40	50
ϕJ	23	27.2	32	40	52	64	80

2. Bolt tightening of the flexspline

The flexspline should be tightened with bolts. As the transmission torque on the tightening area varies depending on the following conditions, design and part control corresponding to the load condition should be conducted.

- Strength of the selected bolt
- Tightening of bolts and the tightening torque
- Surface condition of bolts and tapped holes
- Friction coefficient of the contact surface

Installation with bolts

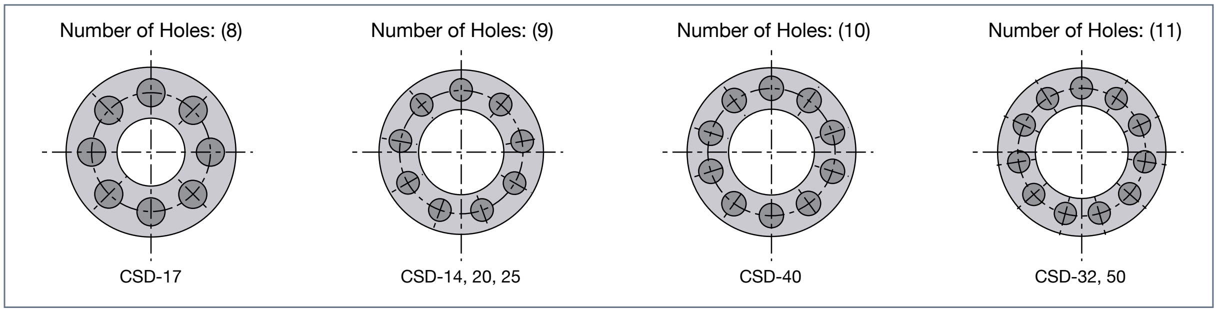
Table 075-2

Item \ Size		Standard							Big Bore				
		14	17	20	25	32	40	50	20	25	32	40	50
Number of bolts		9	8	9	9	11	10	11	12	12	14	14	14
Bolt size		M3	M4	M4	M5	M6	M8	M10	M3	M4	M5	M6	M8
Pitch Circle Diameter	mm	17	19.5	24	30	41	48	62	26	32	42	52	65
Clamp torque	Nm	2.0	4.5	4.5	9.0	15.3	37	74	2.0	4.5	9.0	15.3	37
Torque transmission	Nm	32	55	76	152	359	694	1577	65	135	331	580	1315

(Table 075-2/Notes)
1. The material of the thread must withstand the clamp torque.
2. Recommended bolt : JIS B 1176 socket head cap screw / Strength range: JIS B 1051 over 12.9
3. Torque coefficient: K=0.2
4. Clamp coefficient: A=1.4
5. Friction coefficient on the surface contacted: μ=0.15
6. Momentary peak torque is limited in Big Bore since bolt torque transmission of Big Bore is smaller than standard. (see "Rating Table" on Page 63).

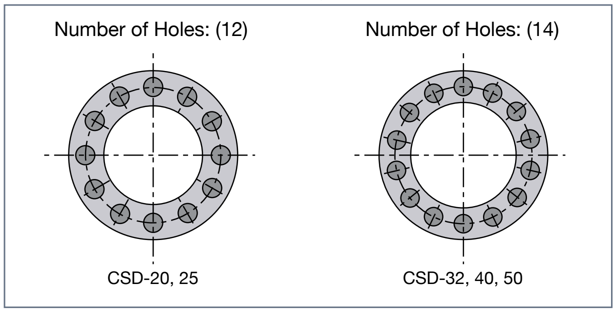
Numbers of holes and location

Fig. 076-1



Numbers of holes and location (Big Bore Option)

Fig. 076-2



■ Installation of the circular spline

Perform design and part control corresponding to the load condition for installation of the circular spline in the same way as the flexspline. Transmission torques by the recommended bolts and tightening torque are shown in Table 077-1. When the transmission torque is smaller than the load torque, the additional use of pins and bolts should be reviewed. Perform installation to meet the requirements of each series.

Installation with bolts

Table 077-1

Item \ Size		14	17	20	25	32	40	50
Number of bolts		6	8	12	12	12	12	12
Size		M3	M3	M3	M3	M4	M5	M6
Pitch Circle Diameter	mm	44	54	62	75	100	120	150
Clamp torque	Nm	2.0	2.0	2.0	2.0	4.5	9.0	15.3
Torque transmission	Nm	55	90	155	188	422	810	1434

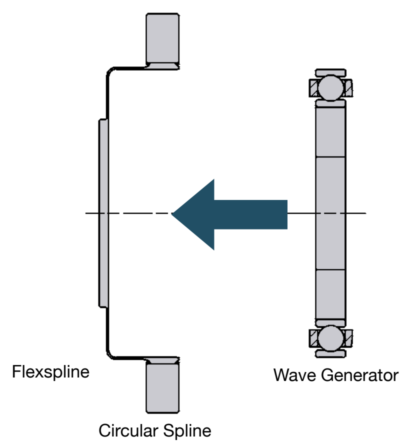
(Table 077-1/Notes)
1. The material of the thread must withstand the clamp torque.
2. Recommended bolt: JIS B 1176 socket head cap screw / Strength range: JIS B 1051 over 12.9
3. Torque coefficient: K=0.2
4. Clamp coefficient: A=1.4
5. Friction coefficient on the surface contacted μ=0.15

■ Assembly order for the basic three elements

The wave generator is installed after the flexspline and circular spline. If the wave generator is not inserted into the flexspline last, gear teeth scuffing damage or improper eccentric gear mesh may result. Installation resulting in an eccentric tooth mesh (Dedoidal) will cause noise and vibration, and can lead to early failure of the gear. For proper function, the teeth of the flexspline and Circular Spline mesh symmetrically.

Assembly order for basic three elements

Fig. 077-1



When the flexspline and wave generator are assembled, the open end of the flexspline will expand at the major axis.

■ Precautions on assembly

It is extremely important to assemble the gear accurately and in proper sequence. For each of the three components, utilize the following precautions.

Wave generator

1. Avoid applying undue axial force to the wave generator during installation. Rotating the wave generator bearing while inserting it is recommended and will ease the process.
2. Extra care must be given to ensure that concentricity and inclination are within the specified limits (see page 73).
3. Installation bolts on the Wave Generator and Flexspline should not interfere each other.

Circular spline

The circular Spline must not be deformed in any way during the assembly. It is particularly important that the mounting surfaces are prepared correctly.

1. Mounting surfaces need to have adequate flatness, smoothness, and no distortion.
2. Especially in the area of the screw holes, burrs or foreign matter should not be present.
3. Adequate relief in the housing corners is needed to prevent interference with the corner of the circular spline.
4. The circular spline should be rotatable within the housing. Be sure there is not interference and that it does not catch on anything.
5. Bolts should not rotate freely when tightening and should not have any irregularity due to the bolt hole being misaligned or oblique.
6. Do not tighten the bolts with the specified torque all at once. Tighten the bolts temporarily with about half the specified torque, and then tighten them with the specified torque. Tighten them in an even, crisscross pattern.
7. Avoid pinning the circular spline if possible as it can reduce the rotational precision and smoothness of operation.

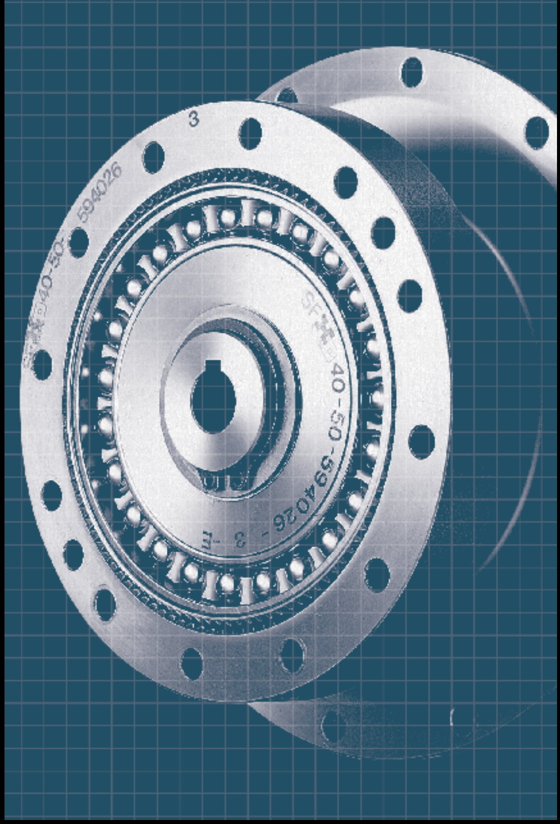
Flexspline

1. Mounting surfaces need to have adequate flatness, smoothness, and no distortion.
2. Especially in the area of the screw holes, burrs or foreign matter should not be present.
3. Adequate clearance with the housing is needed to ensure no interference especially with the major axis of flexspline
4. Bolts should rotate freely when installing through the mounting holes of the flexspline and should not have any irregularity due to the shaft bolt holes being misaligned or oblique.
5. Do not tighten the bolts with the specified torque all at once. Tighten the bolts temporarily with about half the specified torque, and then tighten them to the specified torque. Tighten them in an even, crisscross pattern.
6. The flexspline and circular spline are concentric after assembly. After installing the wave generator bearing, if it rotates in unbalanced way, check the mounting for dedoidal or non-concentric installation.
7. Care should be taken not to damage the flexspline diaphragm or gear teeth during assembly.

   Avoid hitting the tips of the flexspline teeth and circular spline teeth. Avoid installing the CS from the open side of the flexspline after the wave generator has been installed.

Rust prevention

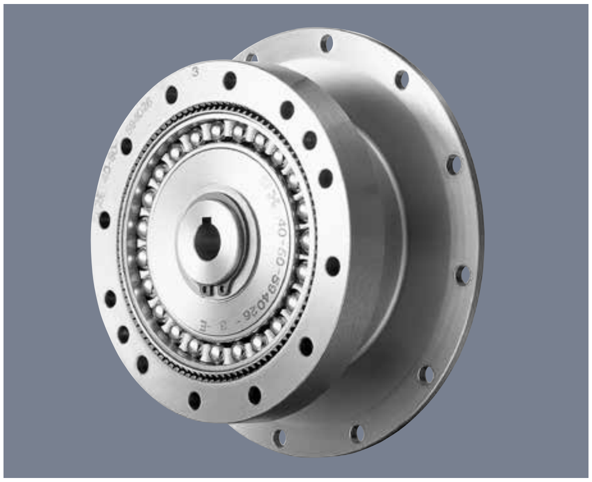
Although Harmonic Drive® gears come with some corrosion protection, the gear can rust if exposed to the environment. The gear external surfaces typically have only a temporary corrosion inhibitor and some oil applied. If an anti-rust product is needed, please contact us to review the options.



SHG/SHF Series

Component Set SHG/SHF

Features



SHG/SHF series component set

The SHG/SHF series represents an advancement over the CSG/CSF series. While the basic performance of both series is the same,
the SHG/SHF series offers additional features not offered in the CSG/CSF series. Key among those is the shape of the flexspline in the SHG/SHF series – it opens outward to form a brim that acts as a perfect mounting surface, while leaving a large through-hole.

The SHG/SHF component set consists of three basic parts – the wave generator, the flexspline, and the circular spline.These compact gears are extremely customizable and can be seamlessly integrated into your design.

Features

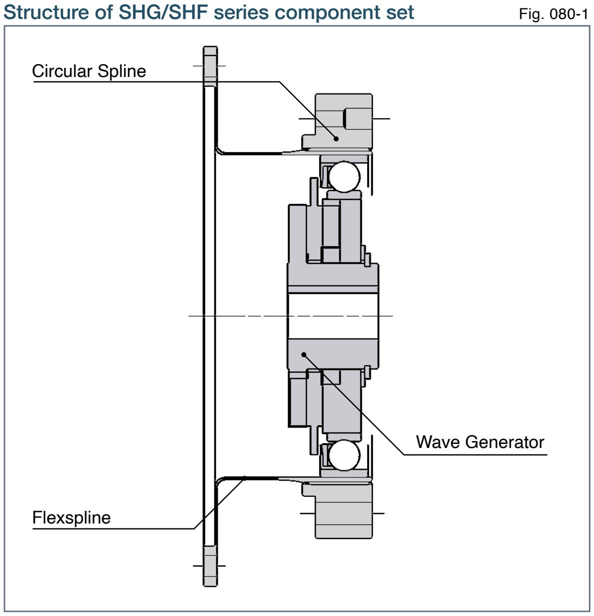
- Large hollow through bore
- Flat shape
- Zero backlash
- Compact and simple design
- High torque capacity
- High stiffness
- High positioning and rotational accuracies
- Coaxial input and output

Series

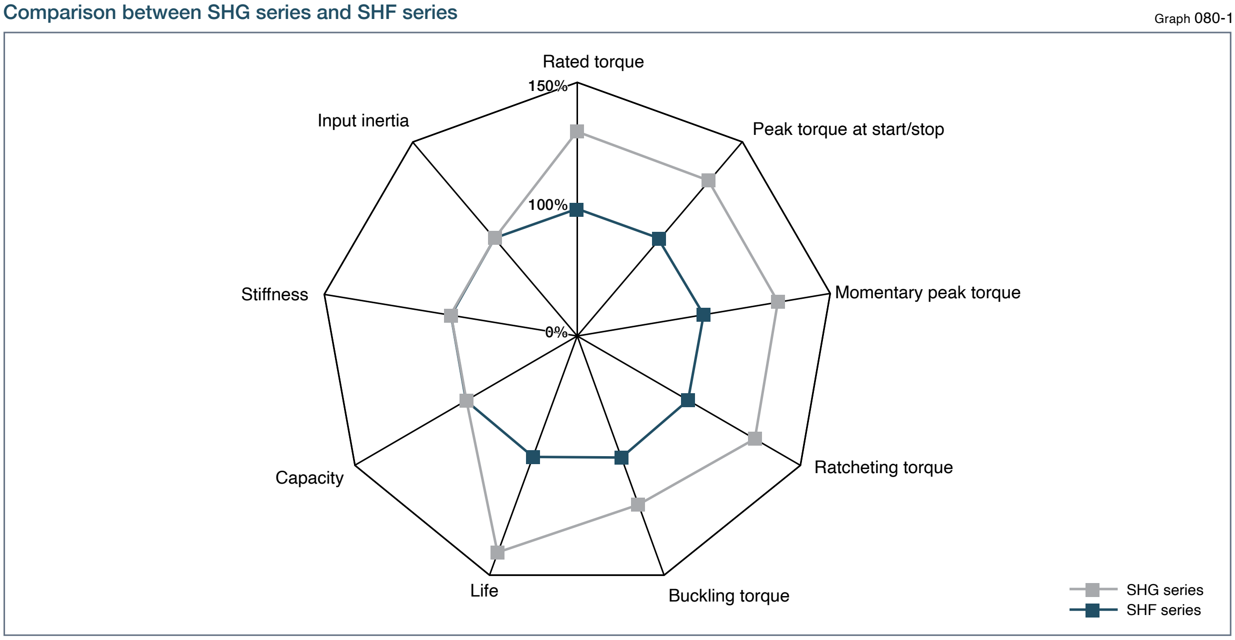
SHF: standard torque
- Reduction ratio of 30:1 added for high-speed

SHG: high torque
- 30% Higher torque than SHF series
- Improved life by 43% (10,000 hours) over SHF

Structure of SHG/SHF series component set — Fig. 080-1



Comparison between SHG series and SHF series — Graph 080-1



Ordering Code

SHG - 25 - 100 - 2A - GR - SP

Table 081-1

Series	Size	Ratio*					Model	Special specification
SHG High Torque	14	50	80	100	—	—	2A-GR= Component type (2A-R for size 14, 17)	SP= Special specification code Blank= Standard product
	17	50	80	100	120	—		
	20	50	80	100	120	160		
	25	50	80	100	120	160		
	32	50	80	100	120	160		
	40	50	80	100	120	160		
	45	50	80	100	120	160		
	50	—	80	100	120	160		
	58	—	80	100	120	160		
	65	—	80	100	120	160		

* The reduction ratio value is based on the following configuration:
Input: wave generator, fixed: circular spline, output: flexspline

SHF - 25 - 100 - 2A - GR - SP

Table 081-2

Series	Size	Ratio*						Model	Special specification
SHF Standard Torque	14	30	50	80	100	—	—	2A-GR= Component type (2A-R for size 14, 17)	SP= Special specification code Blank= Standard product
	17	30	50	80	100	120	—		
	20	30	50	80	100	120	160		
	25	30	50	80	100	120	160		
	32	30	50	80	100	120	160		
	40	—	50	80	100	120	160		
	45	—	50	80	100	120	160		
	50	—	50	80	100	120	160		
	58	—	50	80	100	120	160		

* The reduction ratio value is based on the following configuration:
Input: wave generator, fixed: circular spline, output: flexspline

Technical Data

Rating table

■ SHG series

Table 082-1

Size	Ratio	Rated Torque at 2000rpm		Limit for Repeated Peak Torque		Limit for Average Torque		Limit for Momentary Peak Torque		Maximum Input Speed (rpm)		Limit for Average Input Speed (rpm)		Moment of Inertia	
		Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm	Oil lubricant	Grease lubricant	Oil lubricant	Grease lubricant	I $\times10^{-4}kgm^2$	J $\times10^{-5}kgfms^2$
14	50	7.0	0.7	23	2.3	9	0.9	46	4.7	14000	8500	6500	3500	0.033	0.034
	80	10	1.0	30	3.1	14	1.4	61	6.2						
	100	10	1.0	36	3.7	14	1.4	70	7.2						
17	50	21	2.1	44	4.5	34	3.4	91	9	10000	7300	6500	3500	0.079	0.081
	80	29	2.9	56	5.7	35	3.6	113	12						
	100	31	3.2	70	7.2	51	5.2	143	15						
	120	31	3.2	70	7.2	51	5.2	112	11						
20	50	33	3.3	73	7.4	44	4.5	127	13	10000	6500	6500	3500	0.193	0.197
	80	44	4.5	96	9.8	61	6.2	165	17						
	100	52	5.3	107	10.9	64	6.5	191	20						
	120	52	5.3	113	11.5	64	6.5	191	20						
	160	52	5.3	120	12.2	64	6.5	191	20						
25	50	51	5.2	127	13	72	7.3	242	25	7500	5600	5600	3500	0.413	0.421
	80	82	8.4	178	18	113	12	332	34						
	100	87	8.9	204	21	140	14	369	38						
	120	87	8.9	217	22	140	14	395	40						
	160	87	8.9	229	23	140	14	408	42						
32	50	99	10	281	29	140	14	497	51	7000	4800	4600	3000	1.69	1.72
	80	153	16	395	40	217	22	738	75						
	100	178	18	433	44	281	29	841	86						
	120	178	18	459	47	281	29	892	91						
	160	178	18	484	49	281	29	892	91						
40	50	178	18	523	53	255	26	892	91	5600	4000	3600	3000	4.50	4.59
	80	268	27	675	69	369	38	1270	130						
	100	345	35	738	75	484	49	1400	143						
	120	382	39	802	82	586	60	1530	156						
	160	382	39	841	86	586	60	1530	156						
45	50	229	23	650	66	345	35	1235	126	5000	3800	3300	3000	8.68	8.86
	80	407	41	918	94	507	52	1651	168						
	100	459	47	982	100	650	66	2041	208						
	120	523	53	1070	109	806	82	2288	233						
	160	523	53	1147	117	819	84	2483	253						
50	80	484	49	1223	125	675	69	2418	247	4500	3500	3000	2500	12.5	12.8
	100	611	62	1274	130	866	88	2678	273						
	120	688	70	1404	143	1057	108	2678	273						
	160	688	70	1534	156	1096	112	3185	325						
58	80	714	73	1924	196	1001	102	3185	325	4000	3000	2700	2200	27.3	27.9
	100	905	92	2067	211	1378	141	4134	422						
	120	969	99	2236	228	1547	158	4329	441						
	160	969	99	2392	244	1573	160	4459	455						
65	80	969	99	2743	280	1352	138	4836	493	3500	2800	2400	1900	46.5	47.8
	100	1236	126	2990	305	1976	202	6175	630						
	120	1236	126	3263	333	2041	208	6175	630						
	160	1236	126	3419	349	2041	208	6175	630						

(Note) 1. Moment of inertia: $I=\frac{1}{4}GD^2$

2. See "Engineering data" on Page 12 for details of the terms.

3. Oil lubrication is standard for component-sets size 50 or larger with a reduction ratio of 50:1. Use grease lubrication within half the rated torque.

■ SHF series

Table 083-1

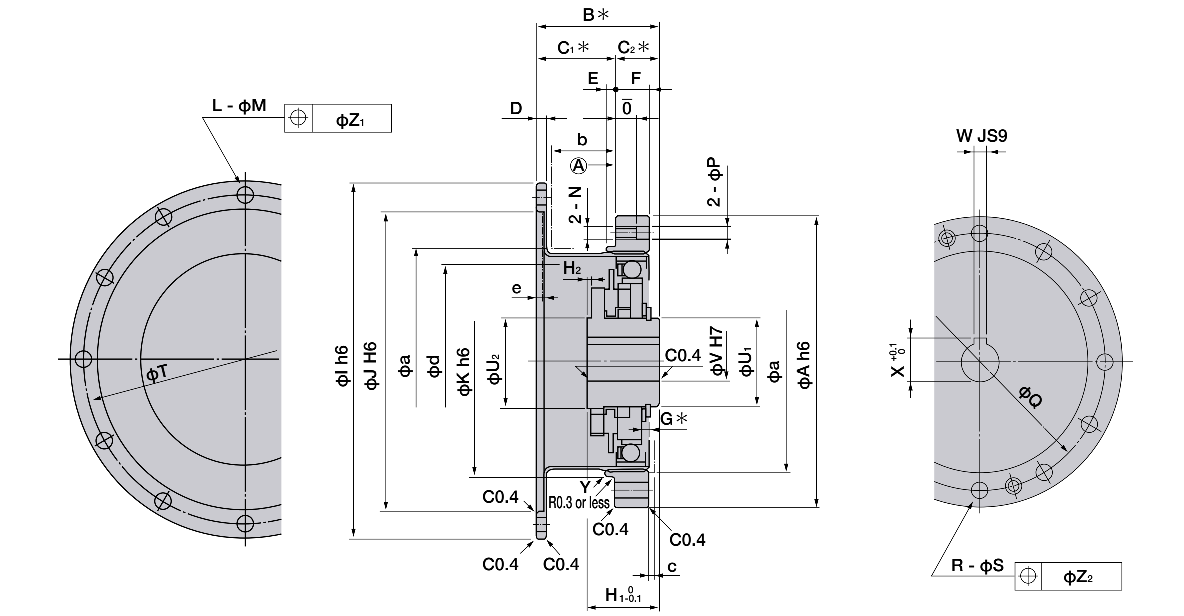
Size	Ratio	Rated Torque at 2000rpm		Limit for Repeated Peak Torque		Limit for Average Torque		Limit for Momentary Peak Torque		Maximum Input Speed (rpm)		Limit for Average Input Speed (rpm)		Moment of Inertia	
		Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm	Oil lubricant	Grease lubricant	Oil lubricant	Grease lubricant	I $\times10^{-4}kgm^2$	J $\times10^{-5}kgfms^2$
14	30	4.0	0.41	9.0	0.92	6.8	0.69	17	1.7	14000	8500	6500	3500	0.033	0.034
	50	5.4	0.55	18	1.8	6.9	0.70	35	3.6						
	80	7.8	0.80	23	2.4	11	1.1	47	4.8						
	100	7.8	0.80	28	2.9	11	1.1	54	5.5						
17	30	8.8	0.90	16	1.6	12	1.2	30	3.1	10000	7300	6500	3500	0.079	0.081
	50	16	1.6	34	3.5	26	2.6	70	7.1						
	80	22	2.2	43	4.4	27	2.7	87	8.9						
	100	24	2.4	54	5.5	39	4.0	110	11						
	120	24	2.4	54	5.5	39	4.0	86	8.8						
20	30	15	1.5	27	2.8	20	2.0	50	5.1	10000	6500	6500	3500	0.193	0.197
	50	25	2.5	56	5.7	34	3.5	98	10						
	80	34	3.5	74	7.5	47	4.8	127	13						
	100	40	4.1	82	8.4	49	5.0	147	15						
	120	40	4.1	87	8.9	49	5.0	147	15						
	160	40	4.1	92	9.4	49	5.0	147	15						
25	30	27	2.8	50	5.1	38	3.9	95	9.7	7500	5600	5600	3500	0.413	0.421
	50	39	4.0	98	10	55	5.6	186	19						
	80	63	6.4	137	14	87	8.9	255	26						
	100	67	6.8	157	16	108	11	284	29						
	120	67	6.8	167	17	108	11	304	31						
	160	67	6.8	176	18	108	11	314	32						
32	30	54	5.5	100	10	75	7.7	200	20	7000	4800	4600	3500	1.69	1.72
	50	76	7.8	216	22	108	11	382	39						
	80	118	12	304	31	167	17	568	58						
	100	137	14	333	34	216	22	647	66						
	120	137	14	353	36	216	22	686	70						
	160	137	14	372	38	216	22	686	70						
40	50	137	14	402	41	196	20	686	70	5600	4000	3600	3000	4.50	4.59
	80	206	21	519	53	284	29	980	100						
	100	265	27	568	58	372	38	1080	110						
	120	294	30	617	63	451	46	1180	120						
	160	294	30	647	66	451	46	1180	120						
45	50	176	18	500	51	265	27	950	97	5000	3800	3300	3000	8.68	8.86
	80	313	32	706	72	390	40	1270	130						
	100	353	36	755	77	500	51	1570	160						
	120	402	41	823	84	620	63	1760	180						
	160	402	41	882	90	630	64	1910	195						
50	50	245	25	715	73	350	36	1430	146	4500	3500	3000	2500	12.5	12.8
	80	372	38	941	96	519	53	1860	190						
	100	470	48	980	100	666	68	2060	210						
	120	529	54	1080	110	813	83	2060	210						
	160	529	54	1180	120	843	86	2450	250						
58	50	353	36	1020	104	520	53	1960	200	4000	3000	2700	2200	27.3	27.9
	80	549	56	1480	151	770	79	2450	250						
	100	696	71	1590	162	1060	108	3180	325						
	120	745	76	1720	176	1190	121	3330	340						
	160	745	76	1840	188	1210	123	3430	350						

(Note) 1. Oil lubrication is standard for sizes 50 and over with gear ratio 50:1. If it is necessary to use grease, the rated torque is reduced by 50%.
2. Moment of inertia: $I=\frac{1}{4}GD^2$
3. See "Rating Table Definitions" on Page 12 for details of the terms.

Outline Dimensions

You can download the CAD files from our website: harmonicdrive.net

Fig. 084-1



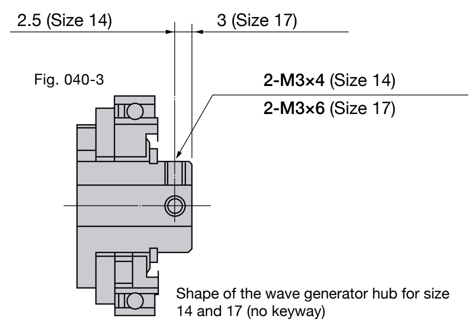


Fig. 040-3

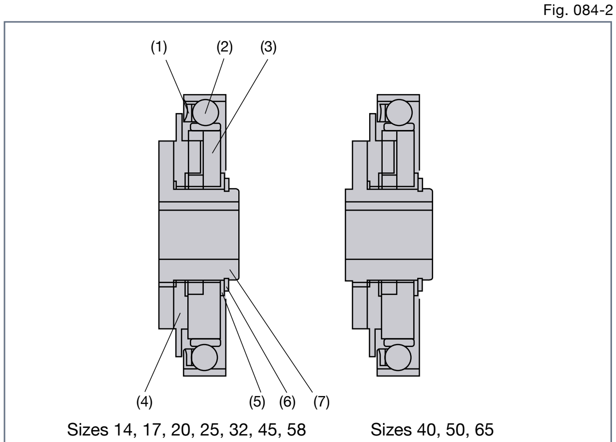
Shape of the wave generator hub for size 14 and 17 (no keyway)

* Please refer to the confirmation drawing for detailed dimensions.

■ Wave generator components

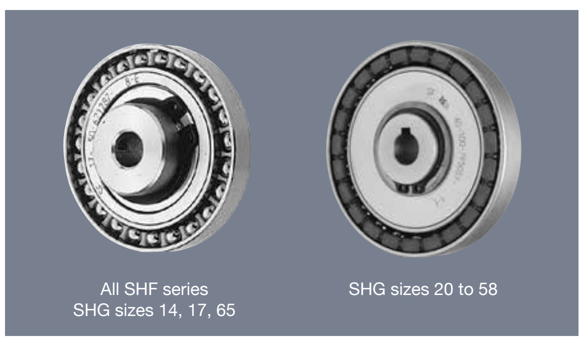
The wave generator utilizes an Oldham coupling.

Fig. 084-2



(1) Ball Separator
(2) Wave generator bearing
(3) Wave generator plug
(4) Insert
(5) Rub washer (unclear)
(6) C-type retaining ring
(7) Wave generator hub

There is a difference in appearance of the the ball separator between SHF and SHG. SHG size 14, 17 and 65 use the same ball separator as SHF



Dimensions

Table 085-1
Unit: mm

Symbol		14	17	20	25	32	40	45	50	58	65
ϕA h6		50	60	70	85	110	135	155	170	195	215
B*	SHG Series	$28.5^{0}_{-0.4}$	$32.5^{0}_{-0.4}$	$33.5^{0}_{-0.4}$	$37^{0}_{-0.5}$	$44^{0}_{-0.6}$	$53^{0}_{-0.6}$	$58.5^{0}_{-0.6}$	$64^{0}_{-0.7}$	$75.5^{0}_{-0.7}$	$83^{0}_{-0.7}$
	SHF Series	$28.5^{0}_{-0.8}$	$32.5^{0}_{-0.9}$	$33.5^{0}_{-1.0}$	$37^{0}_{-1.0}$	$44^{0}_{-1.1}$	$53^{0}_{-1.1}$	$58.5^{0}_{-1.2}$	$64^{0}_{-1.3}$	$75.5^{0}_{-1.3}$	—
C_1*		$17.5^{+0.4}_{0}$	$20^{+0.5}_{0}$	$21.5^{+0.8}_{0}$	$24^{+0.8}_{0}$	$28^{+0.8}_{0}$	$34^{+0.6}_{0}$	$38^{+0.6}_{0}$	$41^{+0.6}_{0}$	$48^{+0.6}_{0}$	$52.5^{+0.6}_{0}$
C_2*		11	12.5	12	13	16	19	20.5	23	27.5	30.5
D		2.4	3	3	3.3	3.6	4	4.5	5	5.8	6.5
E		2	2.5	3	3	3	4	4	4	5	5
F		6	6.5	7.5	10	14	17	19	22	25	29
G*	SHG Series	1.4	1.6	1.5	3.5	4.2	5.6	6.3	7	8.2	9.5
	SHF Series	0.4	0.3	0.1	2.1	2.5	3.3	3.7	4.2	4.8	—
H_1	SHG Series	$18.5^{0}_{-0.1}$	$20.7^{0}_{-0.1}$	$21.5^{0}_{-0.1}$	$21.6^{0}_{-0.1}$	$23.6^{0}_{-0.1}$	$29.7^{0}_{-0.1}$	$30.5^{0}_{-0.1}$	$34.8^{0}_{-0.1}$	$38.3^{0}_{-0.1}$	$44.6^{0}_{-0.1}$
	SHF Series	$17.6^{0}_{-0.1}$	$19.5^{0}_{-0.1}$	$20.1^{0}_{-0.1}$	$20.2^{0}_{-0.1}$	$22^{0}_{-0.1}$	$27.5^{0}_{-0.1}$	$27.9^{0}_{-0.1}$	$32^{0}_{-0.1}$	$34.9^{0}_{-0.1}$	—
H_2		—	—	—	—	—	0.4	—	0.8	—	2.2
ϕI h6	SHG Series	60	72	82	104	134	164	190	214	240	276
	SHF Series	60	72	82	104	134	164	182	205	233	—
ϕJ H6		48	60	70	88	114	140	158	175	203	232
ϕK h6	Ratios > 30:1	38	48	54	67	90	110	124	135	156	177
	Ratio 30:1	38	48	55	68	90	—	—	—	—	—
L		8	12	12	12	12	12	18	12	16	16
ϕM		3.5	3.4	3.5	4.5	5.5	6.6	6.6	9	9	11
N		M3	M3	M3	M4	M5	M6	M8	M8	M10	M10
O		6	6.5	4	6	7	9	12	13	15	15
ϕP		—	—	3.5	4.5	5.5	6.6	9	9	11	11
ϕQ		44	54	62	75	100	120	140	150	175	195
R	SHG Series	8	16	16	16	16	16	16	16	16	16
	SHF Series	6	12	12	12	12	12	12	12	12	—
ϕS		3.5	3.5	3.5	4.5	5.5	6.6	9	9	11	11
ϕT	SHG Series	54	66	76	96	124	152	180	200	226	258
	SHF Series	54	66	76	96	124	152	170	190	218	—
ϕU_1		14	18	21	26	26	32	32	32	40	48
ϕU_2		—	—	—	—	—	32	—	32	—	48
ϕV	Standard (H7)	6	8	9	11	14	14	19	19	22	24
	Max. size (H7)	8	10	13	15	16	20	20	20	25	30
WJs9		—	—	3	4	5	5	6	6	6	8
X		—	—	$10.4^{+0.1}_{0}$	$12.8^{+0.1}_{0}$	$16.3^{+0.1}_{0}$	$16.3^{+0.1}_{0}$	$21.8^{+0.1}_{0}$	$21.8^{+0.1}_{0}$	$24.8^{+0.1}_{0}$	$27.3^{+0.2}_{0}$
Y		C0.3	C0.4	C0.4	C0.4	C0.4	C0.4	C0.4	C0.8	C0.8	C0.8
ϕZ_1		0.25	0.20	0.25	0.25	0.25	0.3	0.3	0.5	0.5	0.5
ϕZ_2		0.25	0.25	0.25	0.25	0.25	0.3	0.5	0.5	0.5	0.5
Minimum housing clearance	ϕa	38	45	53	66	86	106	119	133	154	172
	b	14.6	16.4	17.8	19.8	23.2	28.6	31.9	34.2	40.1	43
	c	1	1	1.5	1.5	1.5	2	2	2	2.5	2.5
	ϕd	31	38	45	56	73	90	101	113	131	150
	e	1.7	2.1	2.0	2.0	2.0	2.0	2.3	2.5	2.9	3.5
Mass (kg)		0.11	0.18	0.31	0.48	0.97	1.87	2.64	3.53	5.17	7.04

- The clamp face of the circular spline is Face (A) in the drawing. Fit this face to install it on the case.
- The following dimensions can be modified to accommodate customer-specific requirements.

  Wave Generator : V

  Flexspline : L and M

  Circular Spline : R and S
- Since some dimensions are different between SHF series and SHG series, pay careful attention during installation.
- *B, C_1, C_2 and G values indicate relative position of individual gearing components (wave generator, flexspline, circular spline). Please strictly adhere to these values when designing your housing and mating parts.
- Due to the deformation of the Flexspline during operation, it is necessary to provide a minimum housing clearance, dimensions ϕa, b, c, and it should not exceed ϕd and e to prevent possible contact with the housing.

The wave generator, flexspline, and circular spline are not assembled when delivered.

Component Set SHG/SHF

Positional accuracy

See "Engineering data" for a description of terms.

Table 086-1

Ratio	Specification	Unit	14	17	20	25	32	40 to 65
30	Standard product	$\times10^{-4}$rad	5.8	4.4	4.4	4.4	4.4	—
		arc min	2	1.5	1.5	1.5	1.5	—
	Special product	$\times10^{-4}$rad	—	—	2.9	2.9	2.9	—
		arc min	—	—	1	1	1	—
50 or more	Standard product	$\times10^{-4}$rad	4.4	4.4	2.9	2.9	2.9	2.9
		arc min	1.5	1.5	1	1	1	1
	Special product	$\times10^{-4}$rad	2.9	2.9	1.5	1.5	1.5	1.5
		arc min	1	1	0.5	0.5	0.5	0.5

Hysteresis loss

See "Engineering data" for a description of terms.

Table 086-2

Ratio	Unit	14	17	20	25	32	40 or more
30	$\times10^{-4}$rad	8.7	8.7	8.7	8.7	8.7	—
	arc min	3.0	3.0	3.0	3.0	3.0	—
50	$\times10^{-4}$rad	5.8	5.8	5.8	5.8	5.8	5.8
	arc min	2.0	2.0	2.0	2.0	2.0	2.0
80 or more	$\times10^{-4}$rad	2.9	2.9	2.9	2.9	2.9	2.9
	arc min	1.0	1.0	1.0	1.0	1.0	1.0

Backlash

See "Engineering data" for a description of terms.

Table 086-3

Ratio	Unit	14	17	20	25	32	40	45	50	58	65
30	$\times10^{-5}$rad	29.1	16.0	13.6	13.6	11.2	—	—	—	—	—
	arc sec	60	33	28	28	23	—	—	—	—	—
50	$\times10^{-5}$rad	17.5	9.7	8.2	8.2	6.8	6.8	5.8	5.8	4.8	—
	arc sec	36	20	17	17	14	14	12	12	10	—
80	$\times10^{-5}$rad	11.2	6.3	5.3	5.3	4.4	4.4	3.9	3.9	2.9	2.9
	arc sec	23	13	11	11	9	9	8	8	6	6
100	$\times10^{-5}$rad	8.7	4.8	4.4	4.4	3.4	3.4	2.9	2.9	2.4	2.4
	arc sec	18	10	9	9	7	7	6	6	5	5
120	$\times10^{-5}$rad	—	3.9	3.9	3.9	2.9	2.9	2.4	2.4	1.9	1.9
	arc sec	—	8	8	8	6	6	5	5	4	4
160	$\times10^{-5}$rad	—	—	2.9	2.9	2.4	2.4	1.9	1.9	1.5	1.5
	arc sec	—	—	6	6	5	5	4	4	3	3

Torsional stiffness

See "Engineering data" for a description of terms.

Table 086-4

Symbol		Unit	14	17	20	25	32	40	45	50	58	65
T_1		Nm	2.0	3.9	7.0	14	29	54	76	108	168	235
		kgfm	0.2	0.4	0.7	1.4	3.0	5.5	7.8	11	17	24
T_2		Nm	6.9	12	25	48	108	196	275	382	598	843
		kgfm	0.7	1.2	2.5	4.9	11	20	28	39	61	86
Reduction ratio 30	K_1	$\times10^4$Nm/rad	0.19	0.34	0.57	1.0	2.4	—	—	—	—	—
		kgf•m/arc min	0.056	0.10	0.17	0.30	0.70	—	—	—	—	—
	K_2	$\times10^4$Nm/rad	0.24	0.44	0.71	1.3	3.0	—	—	—	—	—
		kgfm/arc min	0.07	0.13	0.21	0.40	0.89	—	—	—	—	—
	K_3	$\times10^4$Nm/rad	0.34	0.67	1.1	2.1	4.9	—	—	—	—	—
		kgfm/arc min	0.10	0.20	0.32	0.62	1.5	—	—	—	—	—
	θ_1	$\times10^{-4}$rad	10.5	11.5	12.3	14	12.1	—	—	—	—	—
		arc min	3.6	4.0	4.1	4.7	4.3	—	—	—	—	—
	θ_2	$\times10^{-4}$rad	31	30	38	40	38	—	—	—	—	—
		arc min	10.7	10.2	12.7	13.4	13.3	—	—	—	—	—
Reduction ratio 50	K_1	$\times10^4$Nm/rad	0.34	0.81	1.3	2.5	5.4	10	15	20	31	—
		kgfm/arc min	0.1	0.24	0.38	0.74	1.6	3.0	4.3	5.9	9.3	—
	K_2	$\times10^4$Nm/rad	0.47	1.1	1.8	3.4	7.8	14	20	28	44	—
		kgfm/arc min	0.14	0.32	0.52	1.0	2.3	4.2	6.0	8.2	13	—
	K_3	$\times10^4$Nm/rad	0.57	1.3	2.3	4.4	9.8	18	26	34	54	—
		kgfm/arc min	0.17	0.4	0.67	1.3	2.9	5.3	7.6	10	16	—
	θ_1	$\times10^{-4}$rad	5.8	4.9	5.2	5.5	5.5	5.2	5.2	5.5	5.2	—
		arc min	2.0	1.7	1.8	1.9	1.9	1.8	1.8	1.9	1.8	—
	θ_2	$\times10^{-4}$rad	16	12	15.4	15.7	15.7	15.4	15.1	15.4	15.1	—
		arc min	5.6	4.2	5.3	5.4	5.4	5.3	5.2	5.3	5.2	—

* The values in this table are reference values. The minimum value is approximately 80% of the displayed value.

Table 087-1

Symbol		Size	14	17	20	25	32	40	45	50	58	65
T_1		Nm	2.0	3.9	7.0	14	29	54	76	108	168	235
		kgfm	0.2	0.4	0.7	1.4	3.0	5.5	7.8	11	17	24
T_2		Nm	6.9	12	25	48	108	196	275	382	598	843
		kgfm	0.7	1.2	2.5	4.9	11	20	28	39	61	86
Reduction ratio 80 or more	K_1	$\times10^4$Nm/rad	0.47	1	1.6	3.1	6.7	13	18	25	40	54
		kgfm/arc min	0.14	0.3	0.47	0.92	2.0	3.8	5.4	7.4	12	16
	K_2	$\times10^4$Nm/rad	0.61	1.4	2.5	5.0	11	20	29	40	61	88
		kgfm/arc min	0.18	0.4	0.75	1.5	3.2	6.0	8.5	12	18	26
	K_3	$\times10^4$Nm/rad	0.71	1.6	2.9	5.7	12	23	33	44	71	98
		kgfm/arc min	0.21	0.46	0.85	1.7	3.7	6.8	9.7	13	21	29
	θ_1	$\times10^{-4}$rad	4.1	3.9	4.4	4.4	4.4	4.1	4.1	4.4	4.1	4.4
		arc min	1.4	1.3	1.5	1.5	1.5	1.4	1.4	1.5	1.4	1.5
	θ_2	$\times10^{-4}$rad	12	9.7	11.3	11.1	11.6	11.1	11.1	11.1	11.1	11.3
		arc min	4.2	3.3	3.9	3.8	4.0	3.8	3.8	3.8	3.8	3.9

* The values in this table are reference values. The minimum value is approximately 80% of the displayed value.

Starting torque

See "Engineering data" for a description of terms. Please use as reference values; the values vary based on use conditions.

SHG series

Table 087-2
Unit: Ncm

Ratio \ Size	14	17	20	25	32	40	45	50	58	65
30	4.8	7.2	12	18	50	—	—	—	—	—
50	3.7	5.7	7.3	14	28	50	70	94	140	—
80	2.8	3.8	4.8	8.9	19	33	47	63	94	128
100	2.4	3.3	4.3	7.9	18	29	41	56	83	114
120	—	3.1	3.9	7.3	15	27	37	51	76	104
160	—	—	3.4	6.4	14	24	33	44	68	94

SHF series

Table 087-3
Unit: Ncm

Ratio \ Size	14	17	20	25	32	40	45	50	58
30	4.8	7.2	12	18	50	—	—	—	—
50	3.7	5.7	7.3	14	28	50	70	94	140
80	2.8	3.8	4.8	8.9	19	33	47	63	94
100	2.4	3.3	4.3	7.9	18	29	41	56	83
120	—	3.1	3.9	7.3	15	27	37	51	76
160	—	—	3.4	6.4	14	24	33	44	68

Backdriving torque

See "Engineering data" for a description of terms. Please use as reference values; the values vary based on use conditions.

SHG series

Table 087-4
Unit: Nm

Ratio \ Size	14	17	20	25	32	40	45	50	58	65
30	2.3	3.5	6.1	11	23	—	—	—	—	—
50	2.2	3.4	4.4	8.2	17	30	42	56	84	—
80	2.7	3.7	4.6	8.6	18	32	45	60	90	123
100	2.8	4	5.2	9.5	21	35	49	67	100	137
120	—	4.5	5.6	10	21	40	54	73	110	151
160	—	—	6.6	12	26	45	64	85	130	180

SHF series

Table 087-5
Unit: Nm

Ratio \ Size	14	17	20	25	32	40	45	50	58
30	2.3	3.5	6.1	11	23	—	—	—	—
50	2.2	3.4	4.4	8.2	17	30	42	56	84
80	2.7	3.7	4.6	8.6	18	32	45	60	90
100	2.8	4	5.2	9.5	21	35	49	67	100
120	—	4.5	5.6	10	21	40	54	73	110
160	—	—	6.6	12	26	45	64	85	130

Component Set SHG/SHF

Ratcheting torque

See "Engineering data" for a description of terms.

SHG series

Table 088-1
Unit: Nm

Ratio \ Size	14	17	20	25	32	40	45	50	58	65
50	110	190	280	580	1200	2300	3500	—	—	—
80	140	260	450	880	1800	3600	5000	7000	10000	14000
100	100	200	330	650	1300	2700	4000	5300	8300	12000
120	—	150	310	610	1200	2400	3600	4900	7500	10000
160	—	—	280	580	1200	2300	3300	4600	7200	10000

SHF series

Table 088-2
Unit: Nm

Ratio \ Size	14	17	20	25	32	40	45	50	58
30	59	100	170	340	720	—	—	—	—
50	88	150	220	450	980	1800	2700	3700	5800
80	110	200	350	680	1400	2800	3900	5400	8200
100	84	160	260	500	1000	2100	3100	4100	6400
120	—	120	240	470	980	1900	2800	3800	5800
160	—	—	220	450	980	1800	2600	3600	5600

Buckling torque

See "Engineering data" for a description of terms.

SHG series

Table 088-3
Unit: Nm

Size	14	17	20	25	32	40	45	50	58	65
All ratios	180	350	590	1100	2400	4400	6300	8600	13400	18800

SHF series

Table 088-4
Unit: Nm

Size	14	17	20	25	32	40	45	50	58
All ratios	140	270	440	890	1750	3750	5400	7500	11800

No-load running torque

No-load running torque is the torque which is required to rotate the input side (high speed side), when there is no load on the output side (low speed side).
*Contact us for detailed values

Measurement condition

Table 088-5

Reduction ratio			
Lubricant	Grease lubrication	Name	Harmonic Grease SK-1A
			Harmonic Grease SK-2
		Quantity	Recommended quantity (See page 92)
Torque value is measured after 2 hours at 2000rpm input.			

* Contact us for oil lubrication.

■ Compensation Value in Each Ratio

No-load running torque of the gear varies with ratio.
The graphs indicate a value for ratio 100.
For other gear ratios, add the compensation values from the table on the right.

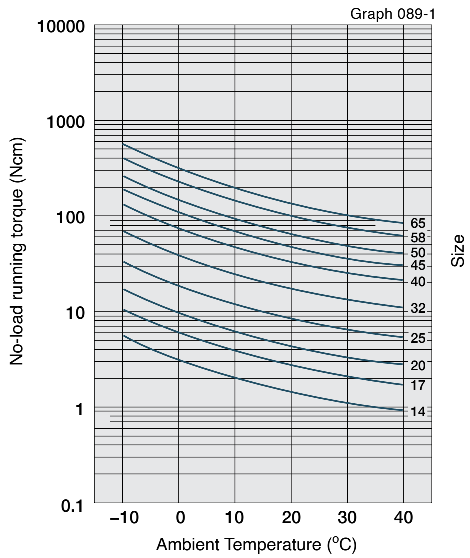
Table 089-1

No-load running torque compensation values. Unit: Ncm

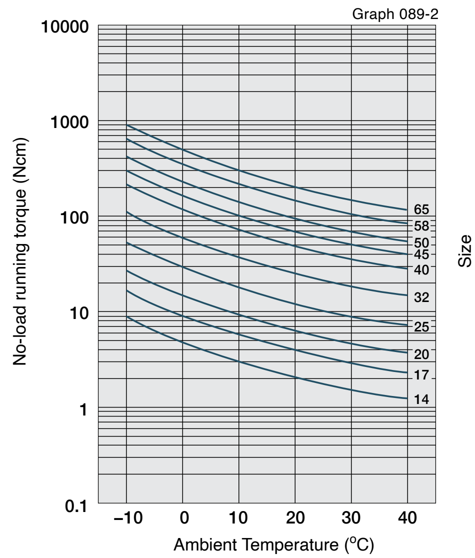
Size \ Ratio	30	50	80	120	160
14	+1.2	+0.5	+0.1	—	—
17	+2.1	+0.9	+0.1	-0.1	—
20	+3.1	+1.4	+0.2	-0.2	-0.4
25	+5.7	+2.5	+0.4	-0.3	-0.7
32	+11.7	+5.2	+0.8	-0.6	-1.4
40	—	+9.2	+1.4	-1.0	-2.5
45	—	+12.7	+2.0	-1.4	-3.5
50	—	+17.0	+2.6	-1.9	-4.6
58	—	+25.8	+4.0	-2.9	-7.0
65	—	—	+5.4	-4.0	-9.7

■ No-load running torque for a reduction ratio of 100

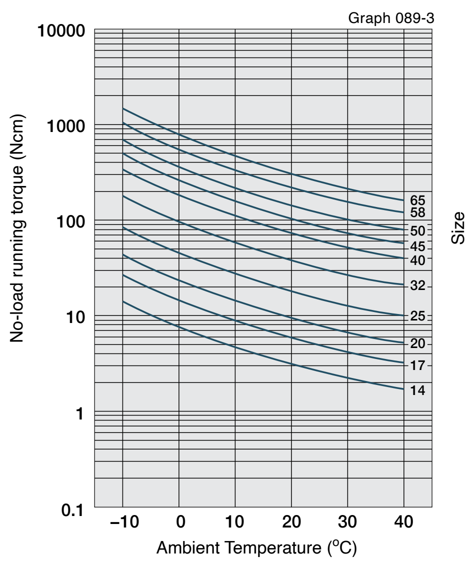
Input speed: 500rpm



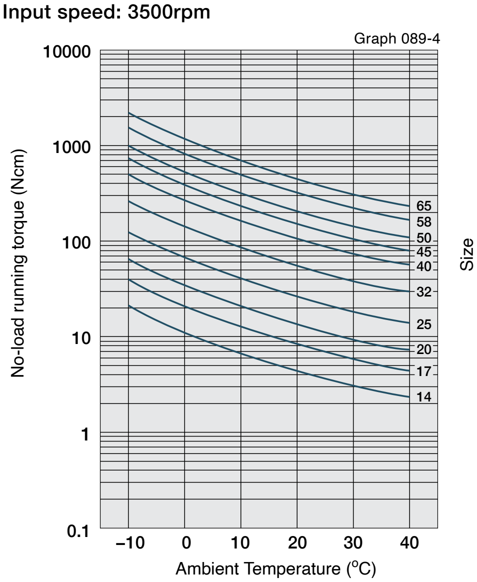
Input speed: 1000rpm



Input speed: 2000rpm



Input speed: 3500rpm



*The values in this graph are average values ($\overline{X}$). σ≈20%

Efficiency

The efficiency varies depending on the following conditions.

- Reduction ratio
- Input rotational speed
- Load torque
- Temperature
- Lubrication (Type and quantity)

Measurement condition Table 090-1

Installation	Based on recommended tolerance.		
Load torque	The rated torque shown in the rating table (see page 82 and 83)		
Lubricant	Grease lubrication	Name	Harmonic Grease SK-1A
			Harmonic Grease SK-2
		Quantity	Recommended quantity (see page 92)

* Contact us for oil lubrication.

■ Efficiency compensation coefficient

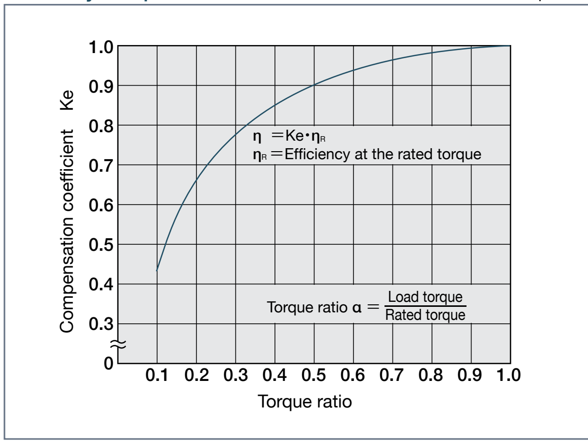
If the load torque is lower than the rated torque, the efficiency value lowers. Calculate the compensation coefficient Ke from Graph 090-1 to calculate the efficiency using the following example.

Calculation Example

Efficiency η (%) under the following condition is calculated from the example of SHF-20-80-2A-GR.
Input rotational speed: 1000 rpm
Load torque: 19.6 Nm
Lubrication: Grease lubrication (Harmonic Grease SK-1A)
Lubricant temperature: 20ºC
Since the rated torque of size 20 with a reduction ratio of 80 is 34 Nm (ratings: Page 83), the torque ratio α is 0.58.
(α=19.6/34=0.58)

- The efficiency compensation coefficient is Ke=0.93 from Graph 090-1.
- Efficiency η at load torque 19.6 Nm: η=Ke•ηR=0.93 x 82=76%

Efficiency compensation coefficient Graph 090-1

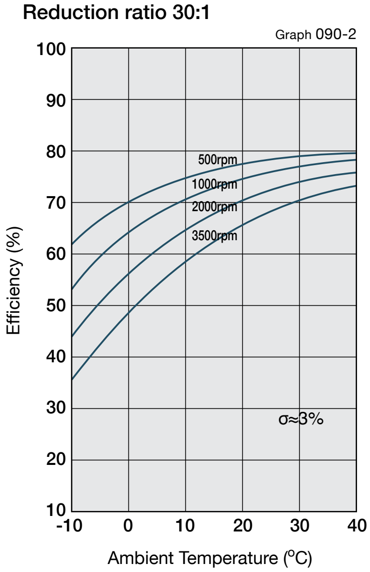


* Efficiency compensation coefficient Ke=1 holds when the load torque is greater than the rated torque.

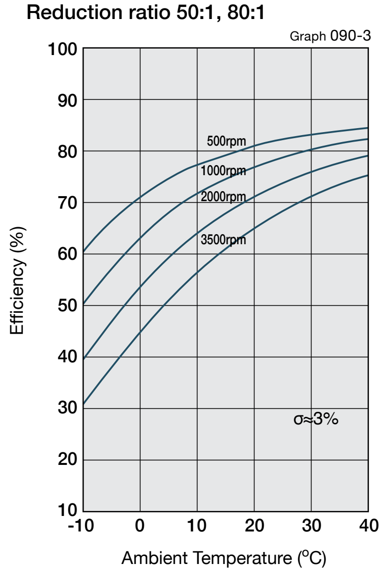
■ Efficiency at rated torque

Size 14

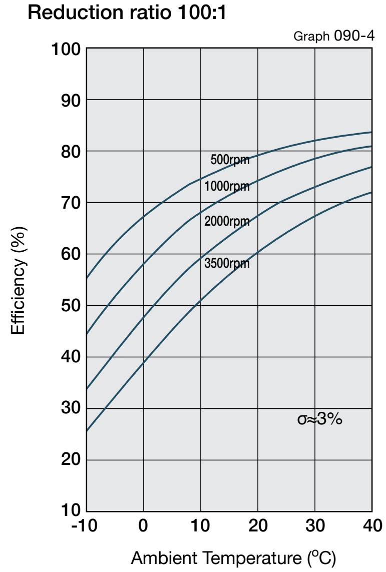
Reduction ratio 30:1



Reduction ratio 50:1, 80:1



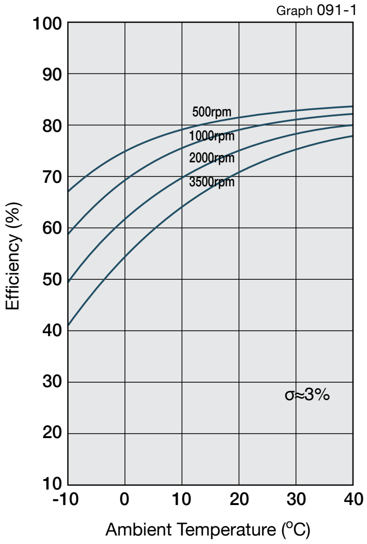
Reduction ratio 100:1



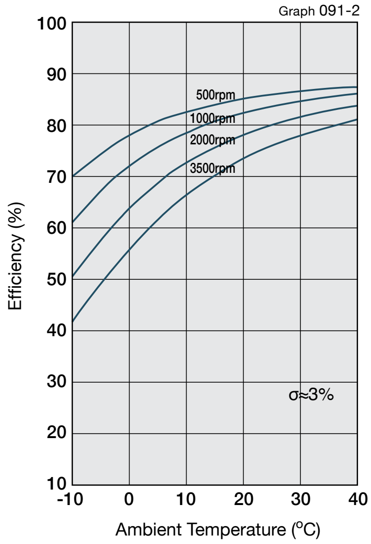
■ Efficiency at rated torque

Size 17 to 65

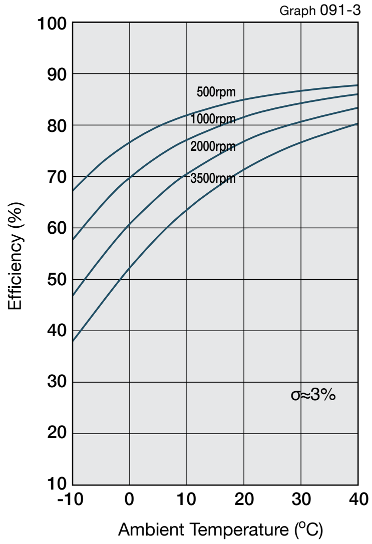
Reduction ratio 30:1



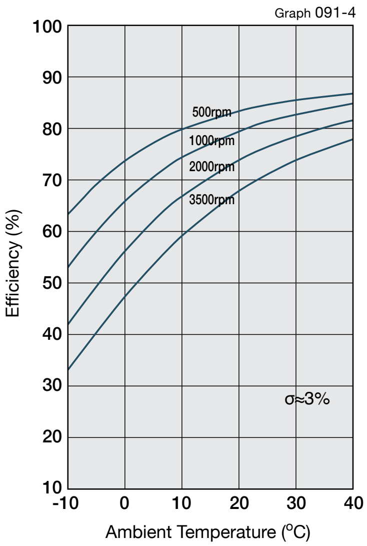
Reduction ratio 50:1



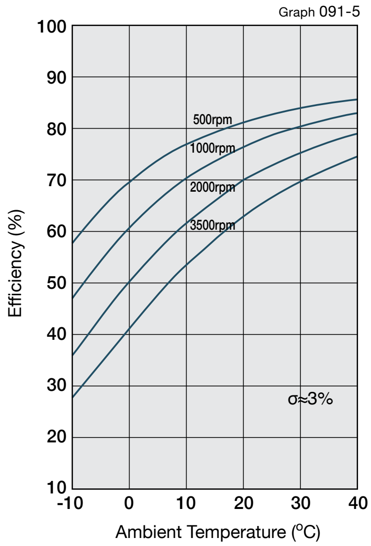
Reduction ratio 80:1, 100:1



Reduction ratio 120:1



Reduction ratio 160:1



Design Guide

Lubrication

■ Grease lubrication*

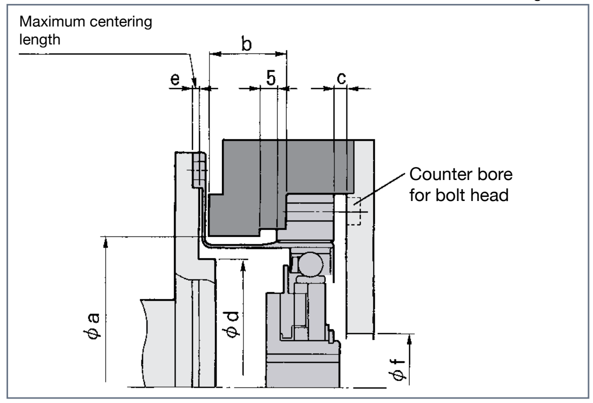
See "Engineering data" on Page 16 for details of the lubricant.

Recommended housing dimensions

See table below for recommended housing dimensions. These dimensions must be maintained to prevent damage to the gear and to maintain a proper grease cavity.

Recommended housing dimensions

Fig. 092-1



Recommended housing dimensions

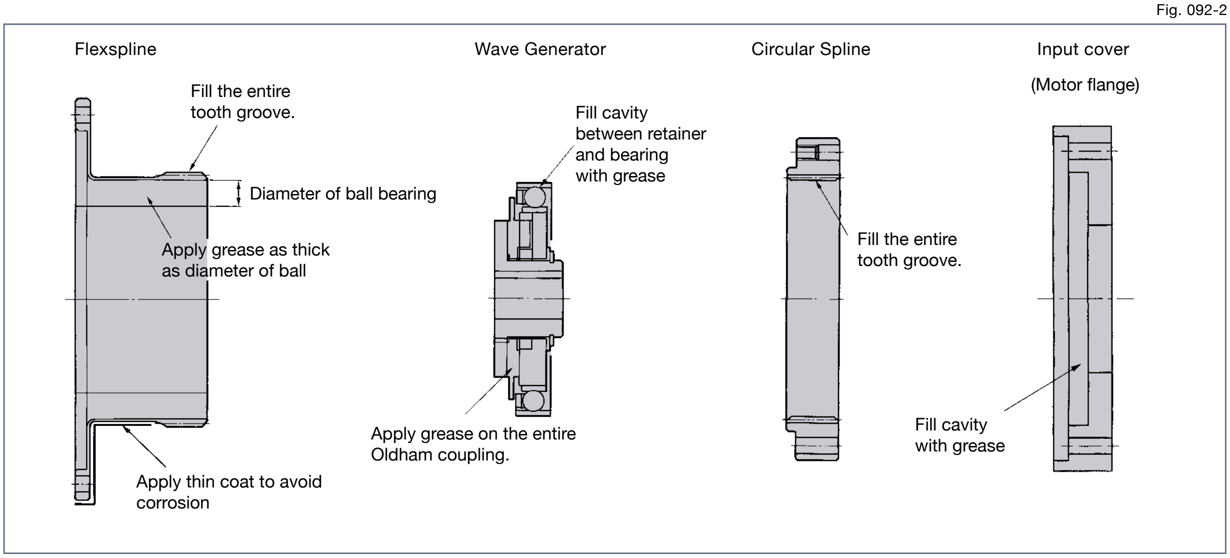
Table 092-1
Unit: mm

Symbol \ Size	14	17	20	25	32	40	45	50*	58*	65*
φa	38	45	53	66	86	106	119	133	154	172
b	14.6	16.4	17.8	19.8	23.2	28.6	31.9	34.2	40.1	43
c	1 (3)	1 (3)	1.5 (4.5)	1.5 (4.5)	1.5 (4.5)	2 (6)	2 (6)	2 (6)	2.5 (7.5)	2.5 (7.5)
φd	31	38	45	56	73	90	101	113	131	150
e	1.7	2.1	2.0	2.0	2.0	2.0	2.3	2.5	2.9	3.5
φf $^{+0.5}_{0}$	16	26	30	37	37	45	45	45	56	62

(Note) The value in parenthesis is the value when the wave generator is facing upward (see Figure 094-2 on Page 94).
* Oil lubrication is required for component-sets size 50 or larger with a reduction ratio of 50:1.

Application guide

Fig. 092-2

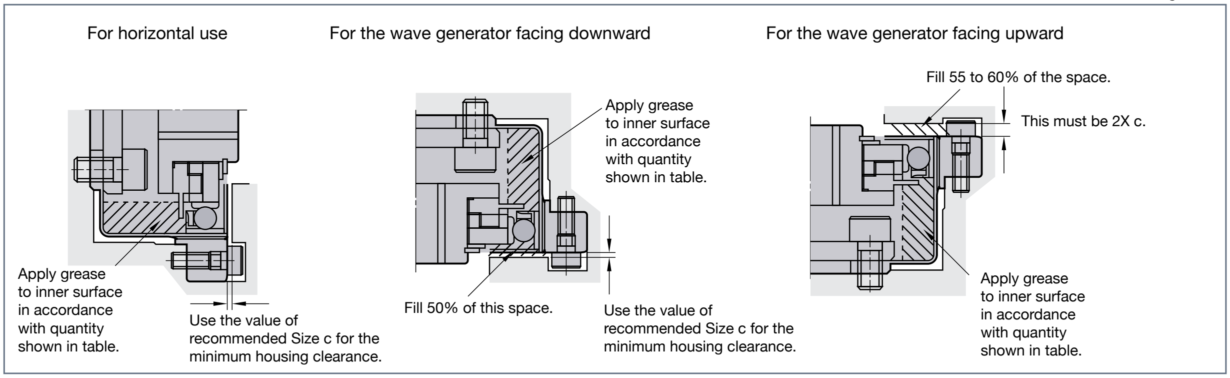


Application guide by usage

When the wave generator is facing upward or downward, refer to the next page for application guide.

Application guide by usage

Fig. 093-1



Application quantity

Table 093-1
Unit: g

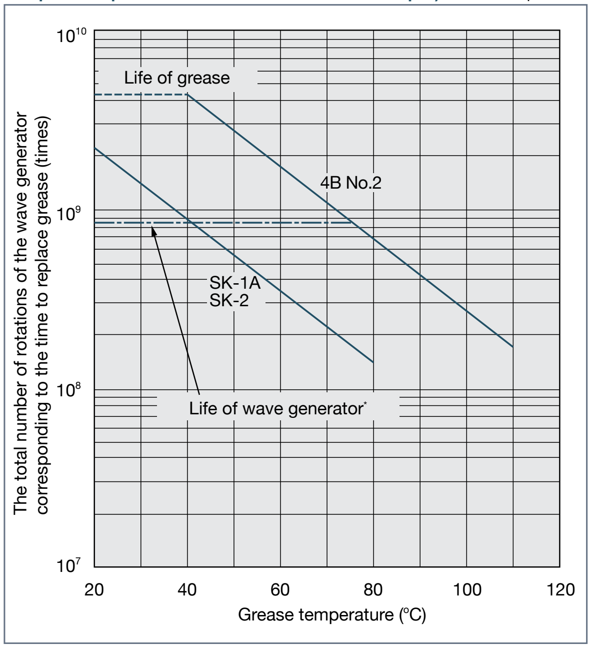
Usage \ Size		14	17	20	25	32	40	45	50	58	65
Horizontal use		5.8	11	18	32	64	120	185	235	385	495
Vertical use	Output shaft facing upward	7.5	13	19	37	74	130	200	255	400	530
	Output shaft facing downward	8.9	15	22	42	84	150	230	290	480	630

When to replace grease

The wear characteristics of the gear are strongly influenced by the condition of the grease lubrication. The condition of the grease is affected by the ambient temperature. The graph shows the maximum number of input rotations for various temperatures. This graph applies to applications where the average load torque does not exceed the rated torque.
In cases where the rated torque is exceeded, calculate the grease change interval using the equation shown below.

When to replace grease: L_{GTn} (when the average load torque is equal to or less than the rated torque)

Graph 093-1



* Life of wave generator is based on L10 life of the bearing.

Formula when load torque exceeds rated torque

Formula 093-1

$$L_{GT} = L_{GTn} \times \left(\frac{T_r}{T_{av}}\right)^3$$

Symbols for Formula

Table 093-2

L_{GT}	Replacement timing if average load torque exceeds rated torque	Number of input revolutions	———
L_{GTn}	Replacement timing if average load torque is equal to or less than rated torque (or use formulas, i.e. Tav ≤ Tr)	Number of input revolutions	See the right-hand figure.
Tr	Rated torque	Nm	See the "Rating table" on page 82 and 83.
T_{av}	Average load torque	Nm	Calculation formula: See Page 14.

■ Other precautions

1. Avoid using it with other grease. The gear should be in an individual case when installed.

2. If you use the gear with the wave generator facing upward (see Figure 050-2 on Page 50) at low-speed rotation (input rotational speed: 1000 rpm or less) and in one direction, please contact us as it may cause lubrication problems.

3. Oil lubrication is required for component-sets size 50 or larger with a reduction ratio of 50:1. Use grease lubrication within half the rated torque.

Component Set SHG/SHF

■ Oil lubrication

See "Engineering data" on Page 18 for details of the lubricant.

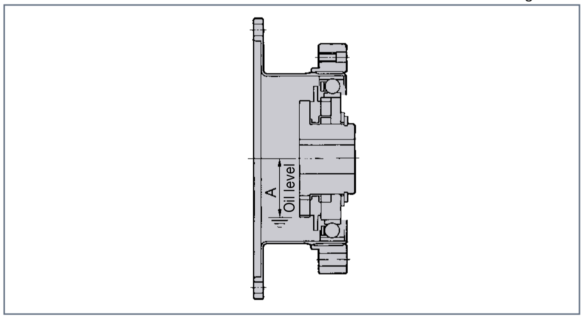
Usage and oil level

For horizontal installation

Oil level should be maintained at the level “A” as shown.

Oil level for horizontal use

Fig. 094-1



Oil level for horizontal use

Table 094-1
Unit: mm

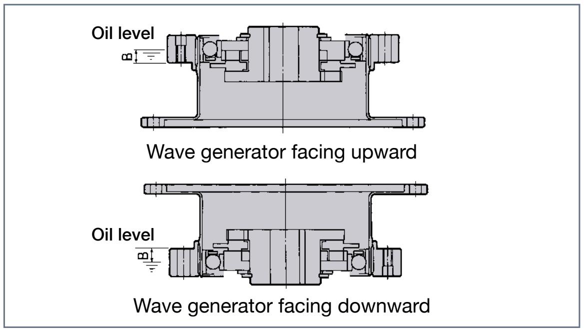
Size	14	17	20	25	32	40	45	50	58	65
A	10	12	14	17	24	31	35	38	44	50

For vertical installation

Fill the center of the ball of the wave generator facing upward or downward with oil (Size B of Figure 094-2). An oil groove should be added to the flexspline. Inform us when you place an order.

Oil level for vertical use

Fig. 094-2



Oil level for vertical use

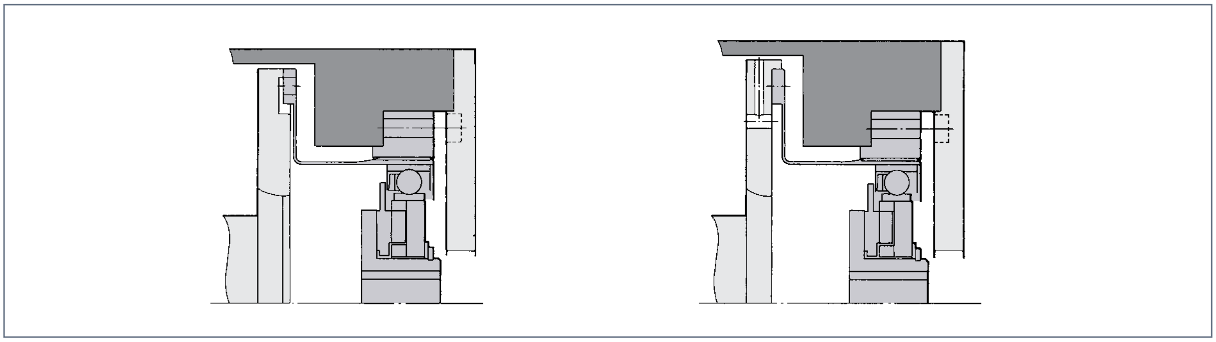
Table 094-2
Unit: mm

Size	14	17	20	25	32	40	45	50	58	65
B	2.5	3	3	5	7	9	10	12	13	15

Example of Oil Channeling to the Flexspline Interface

When using oil as lubrication, the flange connected to the Flexspline must have a passage for oil to flow through. This allows for proper oil circulation.

Fig. 094-3



Oil quantity

Table 095-1
Unit: ℓ

Size	14	17	20	25	32	40	45	50	58	65
Amount	0.01	0.02	0.03	0.07	0.13	0.25	0.32	0.4	0.7	1.0

When to replace oil

First time ·····························100 hours after starting operation
Second time or later ···········Every 1000 operation hours or every 6 months
Note that you should replace oil earlier than specified if the operating conditions are demanding.

Other precautions

Avoid mixing different kinds of oil. The gear should be in an individual case when installed.

Component Set SHG/SHF

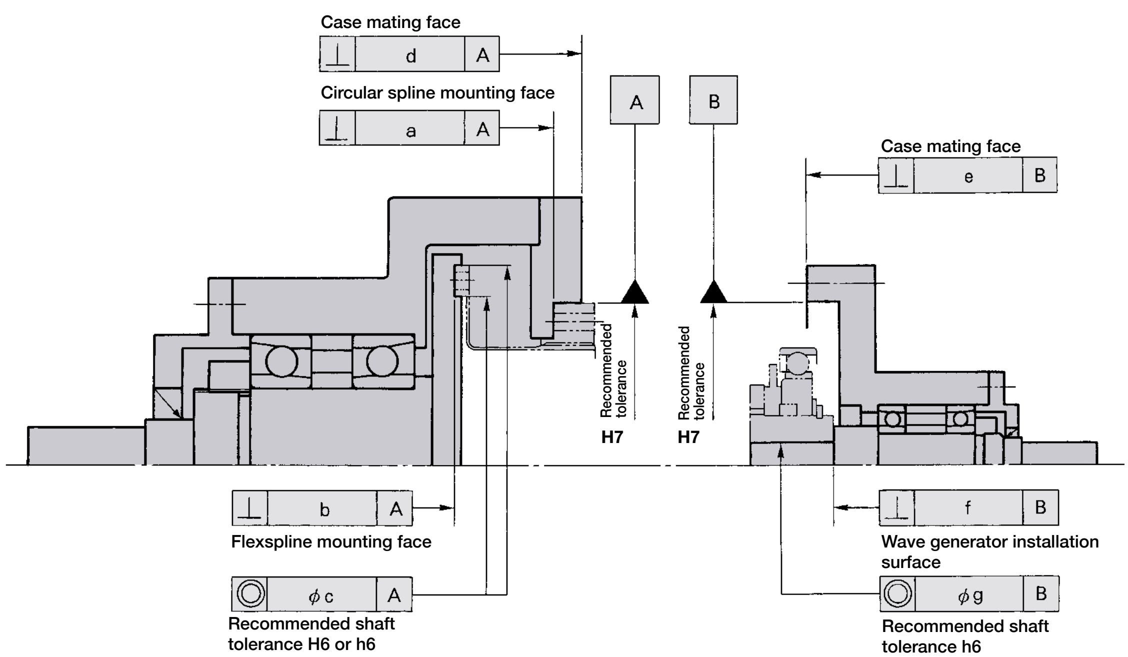
Recommended tolerances for assembly

For peak performance of the gear, it is essential that the following tolerances be observed when assembly is complete.
Pay careful attention to the following points and maintain the recommended assembly tolerances to avoid grease leakage.

- Warping and deformation on the mounting surface
- Contamination due to foreign matter
- Burrs, raised surfaces and location around the tap area of the mounting holes
- Insufficient chamfering on the mounting pilot joint
- Insufficient radii on the mounting pilot joint

Recommended Tolerances for Assembly

Fig. 096-1



Recommended Tolerances for Assembly

Table 096-1
Unit: mm

Symbol \ Size	14	17	20	25	32	40	45	50	58	65
a	0.011	0.012	0.013	0.014	0.016	0.016	0.017	0.018	0.020	0.023
b	0.016	0.021	0.027	0.035	0.042	0.048	0.053	0.057	0.062	0.067
ϕc	0.015	0.018	0.019	0.022	0.022	0.024	0.027	0.030	0.032	0.035
d	0.011	0.015	0.017	0.024	0.026	0.026	0.027	0.028	0.031	0.034
e	0.011	0.015	0.017	0.024	0.026	0.026	0.027	0.028	0.031	0.034
f	0.017 (0.008)	0.020 (0.010)	0.024 (0.012)	0.024 (0.012)	0.024 (0.012)	0.032 (0.012)	0.032 (0.013)	0.032 (0.015)	0.032 (0.015)	0.032 (0.015)
ϕg	0.030 (0.016)	0.034 (0.018)	0.044 (0.019)	0.047 (0.022)	0.050 (0.022)	0.063 (0.024)	0.065 (0.027)	0.066 (0.030)	0.068 (0.033)	0.070 (0.035)

(Note) The value in the parentheses indicates a solid wave generator (without Oldham's coupling structure).

Sealing

Sealing is needed to maintain the high durability of the gear and prevent grease leakage.
Rotating parts should have an oil seal (with spring), surface should be smooth (no scratches).
Mating flanges should have an O Ring, seal adhesive.
Screws should have a thread lock (LOCTITE® 242 recommended) or seal adhesive.

(Note) If you use Harmonic Grease® 4BNo.2, strict sealing is required.

Installation of three basic elements

■ Installation of the wave generator

1. Maximum hole diameter size

Hole diameter of the wave generator hub with Oldham coupling

Table 097-1
Unit: mm

Item \ Size	14	17	20	25	32	40	45	50	58	65
Stand. dimension (H7)	6	8	9	11	14	14	19	19	22	24
Minimum size (ϕ)	3	4	5	6	6	10	10	10	13	16
Maximum size (ϕ)	8	10	13	15	15	20	20	20	25	30

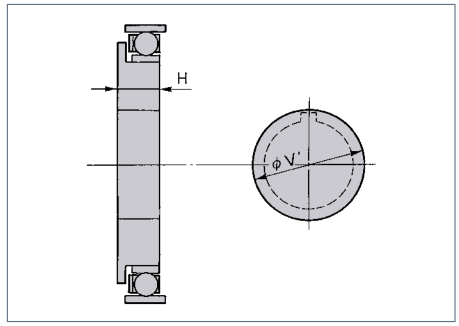
The standard hole dimension of the Wave Generator for each size is shown. The dimension can be changed within a range up to the maximum hole dimension shown in table 097-2. We recommend the dimension of keyway based on JIS standard. It is necessary that the dimension of keyways should sustain the transmission torque.

* Please note: Tapered holes are also available.

In cases where a larger hole is required, use the Wave Generator without the Oldham coupling. The maximum diameter of the hole should be considered to prevent deformation of the Wave Generator plug by load torque.
The dimensions shown in table 097-2 include the keyway.

Hole diameter of the wave generator with Oldham coupling

Fig. 097-1



Maximum hole diameter without Oldham coupling

Table 097-2
Unit: mm

Item \ Size	14	17	20	25	32	40	45	50	58	65
Max. hole ϕV'	17	20	23	28	36	42	47	52	60	67
Min. plug thickness $H^{0}_{-0.1}$	7.2	7.6	11.3	11.3	13.7	15.9	17.8	19	21.4	13.5

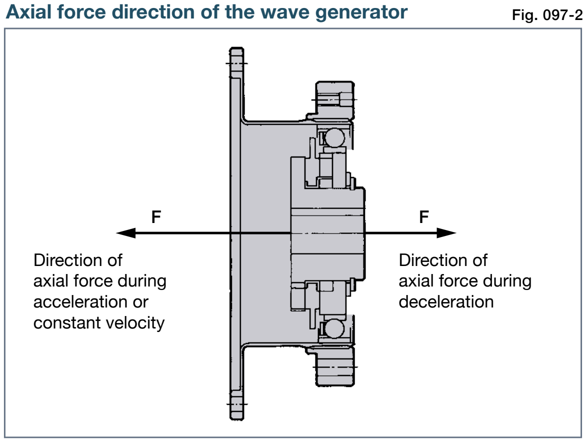
2. Axial force of the wave generator

When a SHF/SHG gear is used to accelerate a load, the deflection of the Flexspline leads to an axial force acting on the Wave Generator. This axial force, which acts in the direction of the closed end of the Flexspline, must be supported by the bearings of the input shaft (motor shaft). When a SHF/SHG gear is used to decelerate a load, an axial force acts to push the Wave Generator out of the Flexspline cup. Maximum axial force of the Wave Generator can be calculated by the equation shown below.
The axial force may vary depending on its operating condition. The value of axial force tends to be a larger number when using high torque, extreme low speed and constant operation. The force is calculated (approximately) by the equation. In all cases, the Wave Generator must be axially (in both directions), as well as torsionally, fixed to the input shaft.

(Note) Please contact us for further information on attaching the Wave Generator to the input (motor) shaft with bolts.

Axial force direction of the wave generator

Fig. 097-2



Formula for Axial Force

Table 097-3

Ratio	Calculation formula
30	$F=2\times\frac{T}{D}\ 0.07\times\tan 32°$
50	$F=2\times\frac{T}{D}\ 0.07\times\tan 30°$
80 or more	$F=2\times\frac{T}{D}\ 0.07\times\tan 20°$

Symbols for Formula

Table 097-4

F	Axial force	N	See Fig. 097-2.
D	(Size) × 0.00254	m	
T	Output torque	Nm	

Calculation Example

Formula 097-1

Model name : SHF series
Size : 32
Ratio : i=50:1
Output torque : 382 Nm (max. allowable momentary torque)

$$F=2\times\frac{382}{(32\times 0.00254)}\times 0.07\times\tan 30°$$

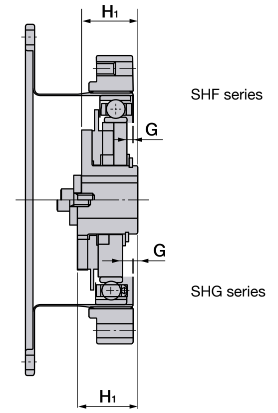
F=380N

3. Shapes and dimensions of the wave generator

The shapes and dimensions of the wave generator of the SHF series are different from those of the SHG series. Exercise extreme care in design and installation. It should also be noted that the mounting bolts of the flexspline must not interfere with the wave generator.
Table 098-1 and Figure 098-1 show a comparison of the shapes and sizes of the wave generator.

Comparison of shapes and sizes of the wave generator

Fig. 098-1



Comparison of Dimension of Wave Generator

Table 098-1
Unit: mm

Symbol \ Size		14	17	20	25	32	40	45	50	58	65
G	SHG Series	1.4	1.6	1.5	3.5	4.2	5.6	6.3	7	8.2	9.5
	SHF Series	0.4	0.3	0.1	2.1	2.5	3.3	3.7	4.2	4.8	—
H_1	SHG Series	$18.5^{0}_{-0.1}$	$20.7^{0}_{-0.1}$	$21.5^{0}_{-0.1}$	$21.6^{0}_{-0.1}$	$23.6^{0}_{-0.1}$	$29.7^{0}_{-0.1}$	$30.5^{0}_{-0.1}$	$34.8^{0}_{-0.1}$	$38.3^{0}_{-0.1}$	$44.6^{0}_{-0.1}$
	SHF Series	$17.6^{0}_{-0.1}$	$19.5^{0}_{-0.1}$	$20.1^{0}_{-0.1}$	$20.2^{0}_{-0.1}$	$22^{0}_{-0.1}$	$27.5^{0}_{-0.1}$	$27.9^{0}_{-0.1}$	$32^{0}_{-0.1}$	$34.9^{0}_{-0.1}$	—

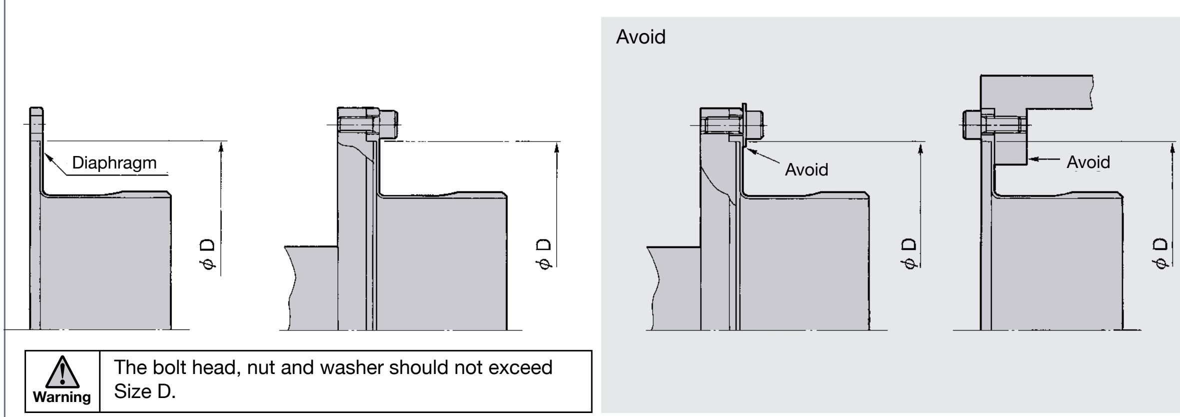
■ Installation of the flexspline

1. Recommended size of the mounting diameter

The mounting diameter should have sufficient allowance (Size D shown in Fig. 098-2) to avoid interference with the diaphragm of the flexspline.
Observe this carefully as the diaphragm may be damaged if the diameter is too small.

Recommended size of the mounting diameter

Fig. 098-2



Size of the mounting diameter

Table 098-2
Unit: Ncm

Symbol \ Size	14	17	20	25	32	40	45	50	58	65
ϕD	48	60	70	88	114	140	158	175	203	232

2. Tightening bolts of the flexspline

Bolts are tightened for installing the flexspline.
As the transmission torque on the tightening area changes significantly according to the conditions described as follows, design and part control corresponding to the load condition should be conducted.
In addition, SHG series has larger torque capacity compared with SHF series. Tighten the bolts according to each series.

- Strength of the selected bolt
- Tightening of bolts and the tightening torque
- Surface condition of bolts and tapped holes
- Friction coefficient of the contact surface

SHG series: Flexspline bolts

Table 099-1

Item \ Size		14	17	20	25	32	40	45	50	58	65
Number of bolts		8	12	12	12	12	12	18	12	16	16
Bolt size		M3	M3	M3	M4	M5	M6	M6	M8	M8	M10
Pitch Circle	mm	54	66	76	96	124	152	180	200	226	258
Clamp torque	Nm	2.4	2.4	2.4	5.4	10.8	18.4	18.4	44	44	74
Torque transmission capacity (bolt only)	Nm	108	198	228	486	1000	1740	3098	4163	6272	9546

SHF series: Flexspline bolts

Table 099-2

Item \ Size		14	17	20	25	32	40	45	50	58
Number of bolts		8	12	12	12	12	12	18	12	16
Bolt size		M3	M3	M3	M4	M5	M6	M6	M8	M8
Pitch Circle	mm	54	66	76	96	124	152	170	190	218
Clamp torque	Nm	2.0	2.0	2.0	4.5	9.0	15.3	15.3	37	37
Torque transmission capacity (bolt only)	Nm	88	157	186	402	843	1450	2430	3312	5076

(Table 099-1, 099-2/Notes)
1. The material of the thread must withstand the clamp torque.
2. Recommended bolt: JIS B 1176 socket head cap screw / Strength range: JIS B 1051 over 12.9.
3. Torque coefficient: K=0.2
4. Clamp coefficient: A=1.4
5. Tightening friction coefficient μ=0.15

■ Installation of the circular spline

Perform design and part control corresponding to the load condition for installation of the circular spline in the same way as the flexspline. Transmission torques by the recommended bolts and tightening torque are shown as follows. When the transmission torque is lower than the load torque, the additional use of pins and bolts should be reviewed. Perform installation to meet the requirements of each series.

SHG series: Installation with bolts

Table 100-1

Item \ Size		14	17	20	25	32	40	45	50	58	65
Number of bolts		8	16	16	16	16	16	16	16	16	16
Bolt size		M3	M3	M3	M4	M5	M6	M8	M8	M10	M10
Pitch Circle	mm	44	54	62	75	100	120	140	150	175	195
Clamp torque	Nm	2.0	2.0	2.0	4.5	9.0	15.3	37	37	74	74
Torque transmission capacity (bolt only)	Nm	72	175	196	419	901	1530	3238	3469	6475	7215

SHF series: Installation with bolts

Table 100-2

Item \ Size		14	17	20	25	32	40	45	50	58
Number of bolts		6	12	12	12	12	12	12	12	12
Bolt size		M3	M3	M3	M4	M5	M6	M8	M8	M10
Pitch Circle	mm	44	54	62	75	100	120	140	150	175
Clamp torque	Nm	2.0	2.0	2.0	4.5	9.0	15.3	37	37	74
Torque transmission capacity (bolt only)	Nm	54	131	147	314	676	1150	2440	2620	4820

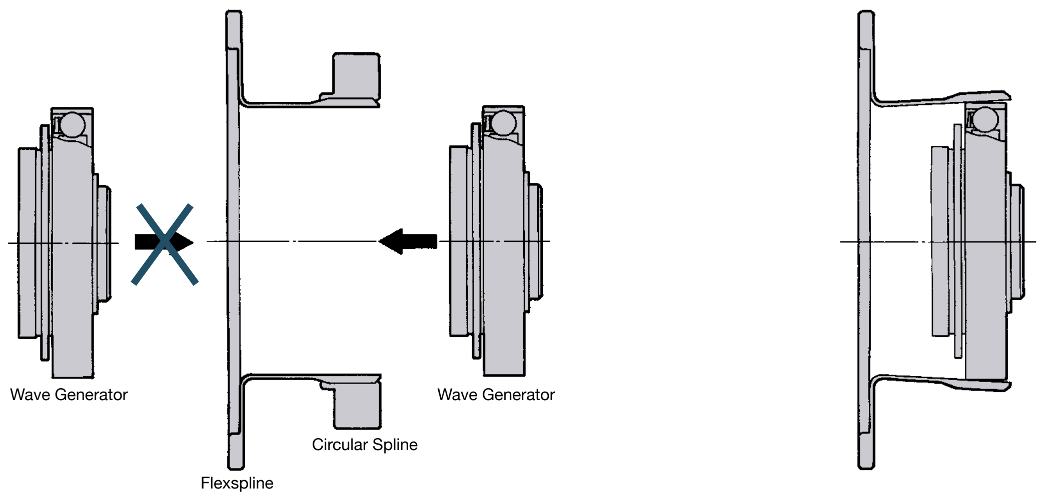
(Table 100-1, 100-2/Notes)
1. The material of the thread must withstand the clamp torque.
2. Recommended bolt: JIS B 1176 socket head cap screw / Strength range: JIS B 1051 over 12.9.
3. Torque coefficient: K=0.2
4. Clamp coefficient: A=1.4
5. Tightening friction coefficient μ=0.15

■ Assembly order of the three basic elements

The wave generator is installed after the flexspline and circular spline. If the wave generator is not inserted into the flexspline last, gear teeth scuffing damage or improper eccentric gear mesh may result. Installation resulting in an eccentric tooth mesh (Dedoidal) will cause noise and vibration, and can lead to early failure of the gear. For proper function, the teeth of the flexspline and Circular Spline mesh symmetrically.

Assembly order for basic three elements

Fig. 101-1



When the flexspline and wave generator are assembled, the open end of the flexspline will expand at the major axis.

Engineering Data
Component Sets
Gear Units
Phase Adjusters
Gearheads & Actuators

■ Precautions on assembly

It is extremely important to assemble the gear accurately and in proper sequence. For each of the three components, utilize the following precautions.

Wave generator

1. Avoid applying undue axial force to the wave generator during installation. Rotating the wave generator bearing while inserting it is recommended and will ease the process.
2. If the wave generator does not have an Oldham coupling, extra care must be given to ensure that concentricity and inclination are within the specified limits (see page 96).

Circular spline

The circular spline must not be deformed in any way during the assembly. It is particularly important that the mounting surfaces are prepared correctly.

1. Mounting surfaces need to have adequate flatness, smoothness, and no distortion.
2. Especially in the area of the screw holes, burrs or foreign matter should not be present.
3. Adequate relief in the housing corners is needed to prevent interference with the corner of the circular spline.
4. The circular spline should be rotatable within the housing. Be sure there is not interference and that it does not catch on anything.
5. Bolts should not rotate freely when tightening and should not have any irregularity due to the bolt hole being misaligned or oblique.
6. Do not tighten the bolts with the specified torque all at once. Tighten the bolts temporarily with about half the specified torque, and then tighten them with the specified torque. Tighten them in an even, crisscross pattern.
7. Avoid pinning the circular spline if possible as it can reduce the rotational precision and smoothness of operation.

Flexspline

1. Mounting surfaces need to have adequate flatness, smoothness, and no distortion.
2. Especially in the area of the screw holes, burrs or foreign matter should not be present.
3. Adequate clearance with the housing is needed to ensure no interference especially with the major axis of flexspline
4. Bolts should rotate freely when installing through the mounting holes of the flexspline and should not have any irregularity due to the shaft bolt holes being misaligned or oblique.
5. Do not tighten the bolts with the specified torque all at once. Tighten the bolts temporarily with about half the specified torque, and then tighten them to the specified torque. Tighten them in an even, crisscross pattern.
6. The flexspline and circular spline are concentric after assembly. After installing the wave generator bearing, if it rotates in unbalanced way, check the mounting for dedoidal or non-concentric installation.
7. Care should be taken not to damage the flexspline diaphragm or gear teeth during assembly.

   Avoid hitting the tips of the flexpline teeth and circular spline teeth. Avoid installing the circular spline from the open side of the flexspline after the wave generator has been installed.

Rust prevention

Although Harmonic Drive® gears come with some corrosion protection, the gear can rust if exposed to the environment. The gear external surfaces typically have only a temporary corrosion inhibitor and some oil applied. If an anti-rust product is needed, please contact us to review the options.

FB Series

Component Set FB

Features

FB series component type

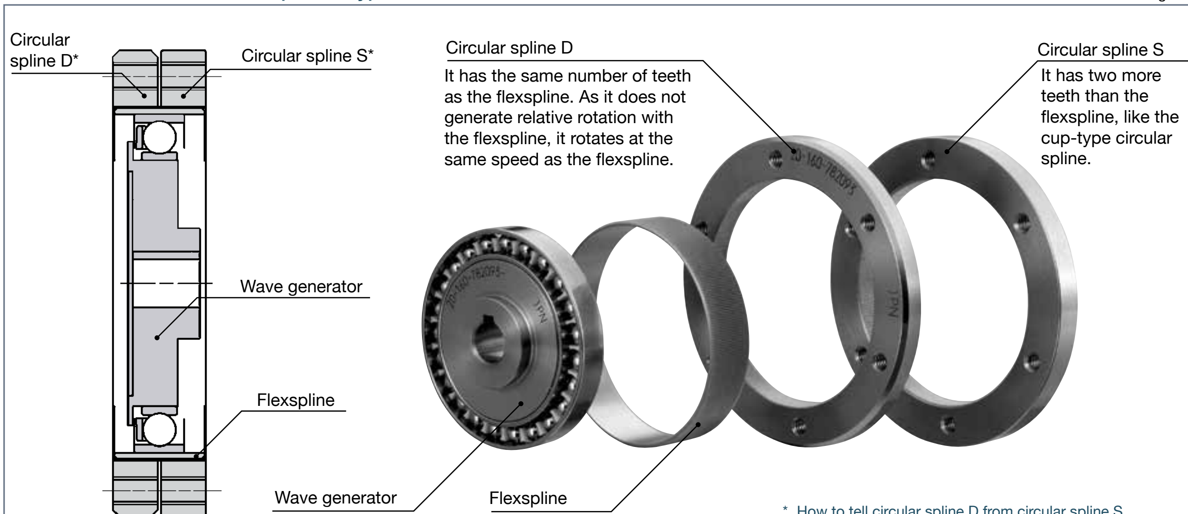
FB is a cup type component set, without the bottom of the cup. This series is also referred to as "pancake style".
It consists of four parts and operates using the same principle as the cup type of the CSG/CSF series.
The flexspline is shaped like the flexspline of the cup type with a cut bottom and is structured to have an additional circular spline with the same number of teeth as the flexspline.

Features

- Flat and thin shape
- Compact and simple design
- High positional and rotational accuracies
- Coaxial input and output

Structure of the FB series component type

Fig. 104-1



* How to tell circular spline D from circular spline S
The peripheral chamfering of circular spline D is larger than that of circular spline S.

Ordering Code

FB - 20 - 80 - 2 - GR

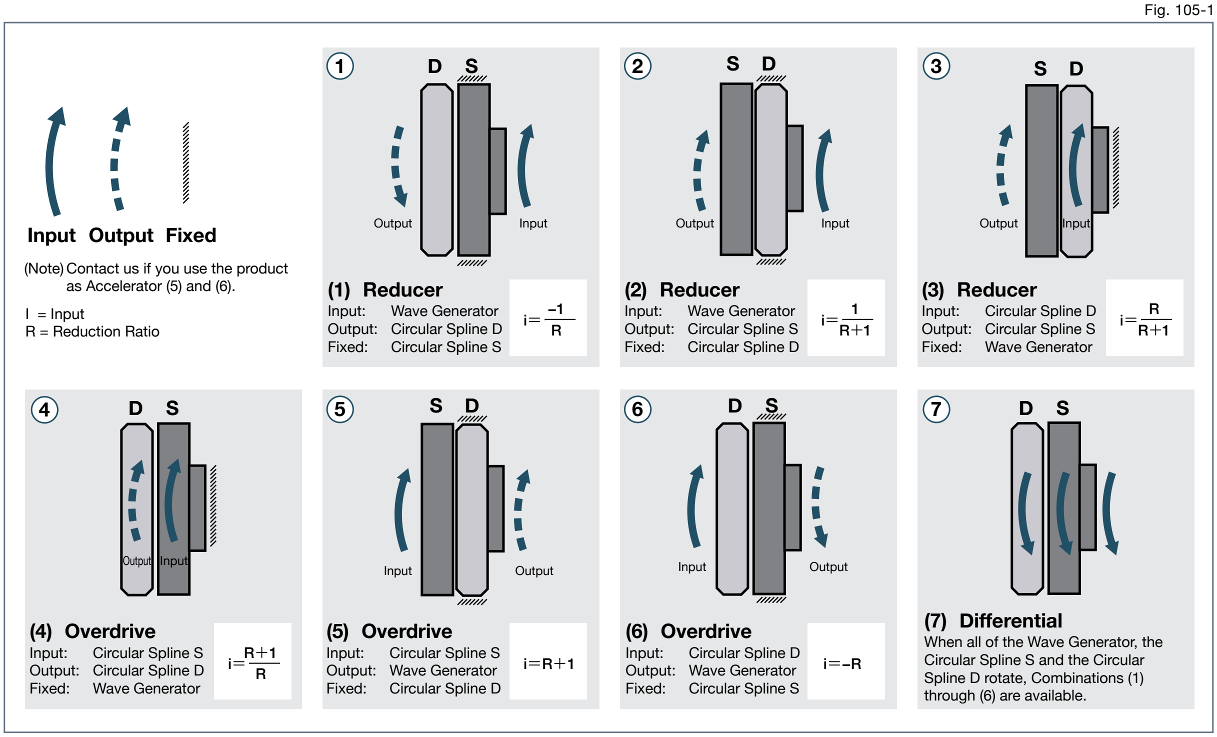
Table 105-1

Series	Size	Ratio*										Model	
FB	14	50	—	88	100	110	—	—	—	—	—	2= Component type	R = Size 14 GR = Size 20-50
	20	50	—	80	100	—	—	128	—	—	160		
	25	50	—	80	100	—	120	—	—	—	160		
	32	50	78	—	100	—	—	—	131	157	—		
	40	50	—	80	100	—	—	128	—	—	160		
	50	—	—	80	100	—	120	—	—	—	160		

* The reduction ratio value is based on the following configuration:
Input: wave generator, fixed: circular spline S, output: circular spline D

Rotational direction and reduction ratio

Fig. 105-1



Technical Data

Rating table

Table 106-1

Size	Ratio	Rated torque at 2000rpm		Repeated Peak Torque		Max. Average Load Torque		Max. Momentary Torque		Rated input rotational speed	Max. Input Speed (rpm)		Limit for Average Input Speed (rpm)		Moment of Inertia	
		Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm	rpm	Oil lubricant	Grease lubricant	Oil lubricant	Grease lubricant	I $\times 10^{-4}$ kgm²	J $\times 10^{-5}$ kgfms²
14	50	2.6	0.27	3.2	0.33	3.2	0.33	6.9	0.7	2000	6000	3600	4000	2500	0.033	0.034
	88	4.9	0.5	7.8	0.8	7.8	0.8	15.7	1.6※							
	100	5.9	0.6	9.8	1.0	9.8	1.0	15.7	1.6※							
	110	5.9	0.6	9.8	1.0	9.8	1.0	15.7	1.6※							
20	50	14	1.4	18	1.8	18	1.8	34	3.5	2000	6000	3600	3600	2500	0.135	0.138
	80	17	1.7	21	2.1	21	2.1	35	3.6							
	100	22	2.2	26	2.7	25	2.5	47	4.8							
	128	24	2.4	33	3.4	25	2.5	58	5.9							
	160	24	2.4	38	3.9	25	2.5	59	6.0※							
25	50	23	2.3	30	3.1	30	3.1	54	5.5	2000	5000	3600	3000	2500	0.36	0.37
	80	31	3.2	39	4.0	39	4.0	70	7.1							
	100	39	4.0	52	5.3	52	5.3	91	9.3							
	120	39	4.0	61	6.2	61	6.2	94	9.6※							
	160	39	4.0	76	7.8	61	6.2	86	8.8※							
32	50	44	4.5	60	6.1	60	6.1	108	11	2000	4500	3600	2500	2300	1.29	1.32
	78	63	6.4	75	7.7	75	7.7	127	13							
	100	82	8.4	98	10	98	10	176	18							
	131	82	8.4	137	14	118	12	235	24※							
	157	82	8.4	157	16	118	12	235	24※							
40	50	88	9	118	12	118	12	216	22	2000	4000	3300	2000	2000	3.38	3.45
	80	118	12	147	15	147	15	265	27							
	100	157	16	186	19	186	19	343	35							
	128	167	17	235	24	235	24	372	38※							
	160	167	17	284	29	274	28	353	38※							
50	80	216	22	265	27	265	27	480	49	1700	3500	3000	1700	1700	9.9	10
	100	284	29	253	36	353	36	627	64							
	120	304	31	421	43	421	43	706	72※							
	160	304	31	510	52	490	50	666	68※							

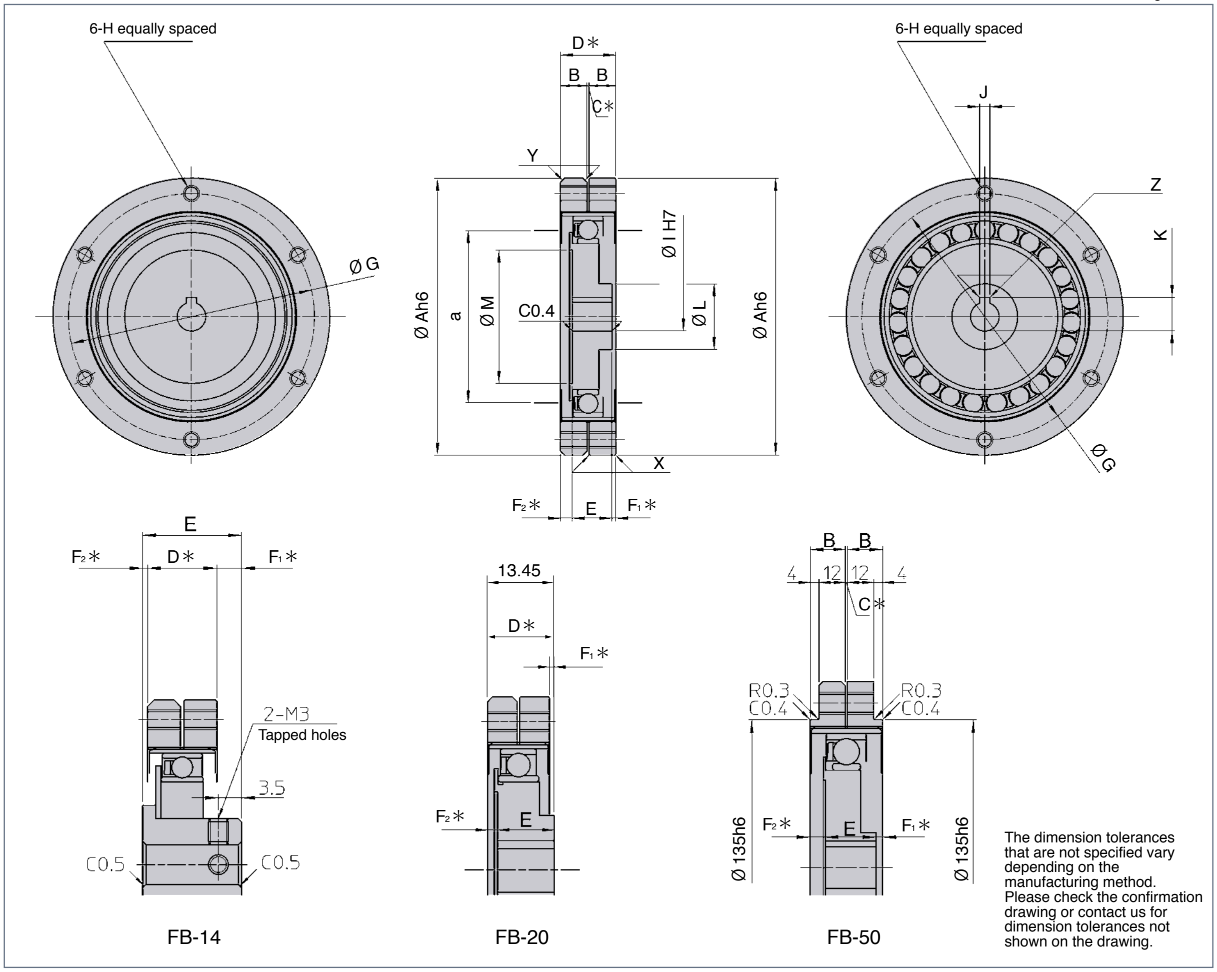
* Torque value limited by ratcheting.

1. Moment of inertia: $I = \frac{1}{4} GD^2$

2. See "Engineering data" on Page 012 for details of the terms.

Outline dimensions

Fig. 107-1



Dimensions

Table 107-1

Unit: mm

Symbol \ Size		14	20	25	32	40	50
ØA (h6)		50	70	85	110	135	170
B		5	6	8	10	13	16
C*		0.5	0.5	0.5	0.5	1.0	1.0
D*		10.5	12.5	16.5	20.5	27	33
E $^{0}_{-0.1}$		15.0	11.4	12.8	15.6	19.4	23.2
F_1*		3.75	0.95	0.35	0.95	1.8	2.9
F_2*		0.75	2.05	3.35	3.95	5.8	6.9
ØG		44	60	75	100	120	150
H		M3	M4	M5	M6	M8	M10
ØI (H7)	Standard	6	9	14	14	14	19
	Max. size	8	12	15	15	20	20
J (Js9)		—	3	5	5	5	6
K $^{+0.1}_{0}$		—	10.4	16.3	16.3	16.3	21.8
ØL		14	20	26	26	32	32
ØM		—	31.5	41	52	65	80
X		C0.2	C0.2	C0.2	C0.2	C0.4	C0.4
Y		C1.0	C1.0	C1.5	C1.5	C2.0	C2.0
Z		—	R0.08～0.16	R0.16～0.25	R0.16～0.25	R0.16～0.25	R0.16～0.25
a		29	42	53	69	84	105
Mass (kgf)		0.1	0.3	0.5	1.0	1.8	2.9

(Note) For Circular spline D, the peripheral chamfering is Y.

*The C, D and F_1 and F_2 values indicate relative position of individual gearing components (wave generator, flexspline, circular spline). Please strictly adhere to these values when designing your housing and mating parts.

● Four parts (wave generator, flexspline, circular spline D, circular spline S) are not assembled when delivered.

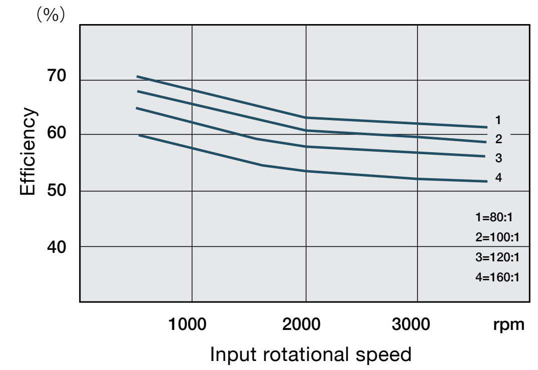
Component Set FB

Efficiency

The efficiency varies depending on the following conditions.
- Reduction ratio
- Input rotational speed
- Load torque
- Temperature
- Lubrication (type and quantity)
- It looks like Graph 108-1 when the product is operated at 100% of the rated load at 40ºC.

(Note) The efficiency is increased by about 10% for the grease lubrication.

Graph 108-1



No-load running torque, starting torque, backdriving torque

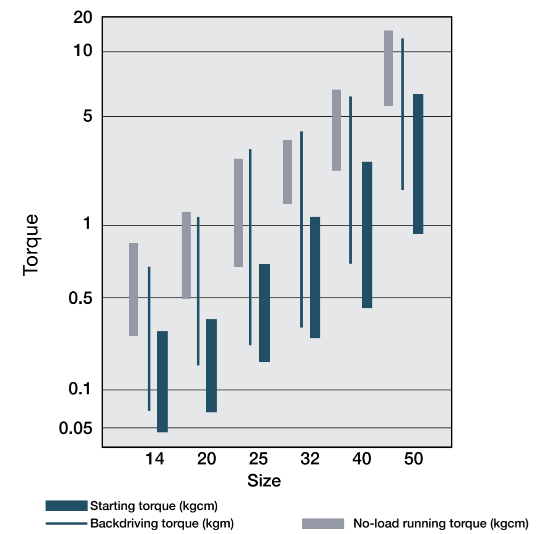
Values are based on actual tests with the component sets assembled in housings, and takes into consideration friction resistance of oils seals, and churning of oil.

1. No-load running torque····· No-load running torque is the torque which is required to rotate the input side (high speed side), when there is no load on the output side (low speed side). The value in the graph indicates the condition when the input rotational speed is 1500 rpm and the oil temperature is about 40ºC.

2. Starting torque··················· This is the static torque required to start the high-speed shaft in a no-load condition.

3. Backdriving torque ··········· This is the static torque required to start the low-speed shaft in a no-load condition.

Graph 108-2



Lost motion and the spring constant

The lost motion and the spring constant of the pancake gear is measured by fixing the wave generator and one circular spline while a torque is applied to the other circular spline.
See Page 120 for a definition of lost motion and the spring constant.

Table 108-1

Size	Lost motion		Spring constant	
	± Load (kgm)	Lost motion (arc min)	Load (kgm)	Spring constant (kgfm/arc min)
14	0.04	3.0	0.8	0.05
20	0.12	3.0	2.5	0.35
25	0.23	3.0	4.0	0.50
32	0.46	3.0	10	1.2
40	0.92	3.0	16	2.1
50	1.73	3.0	30	4.4

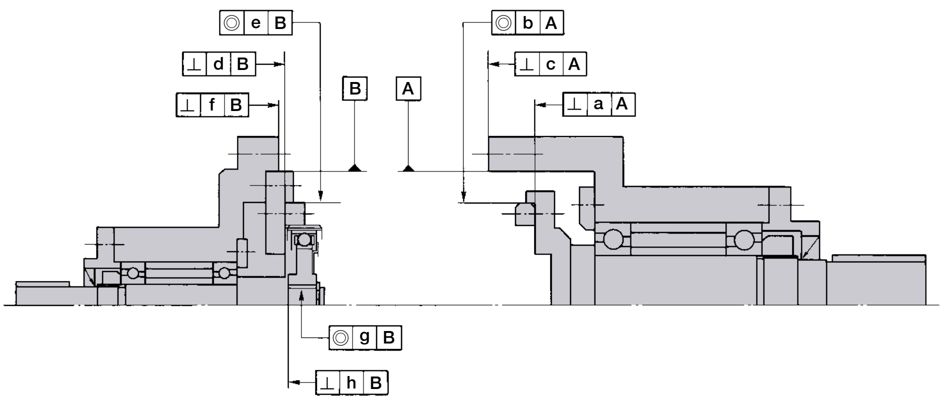
Design Guide

Recommended tolerances for assembly

Maintain the recommended tolerances shown in Figure 109-1 and Table 109-1 for optimal performance.

Recommended tolerances for assembly

Fig. 109-1



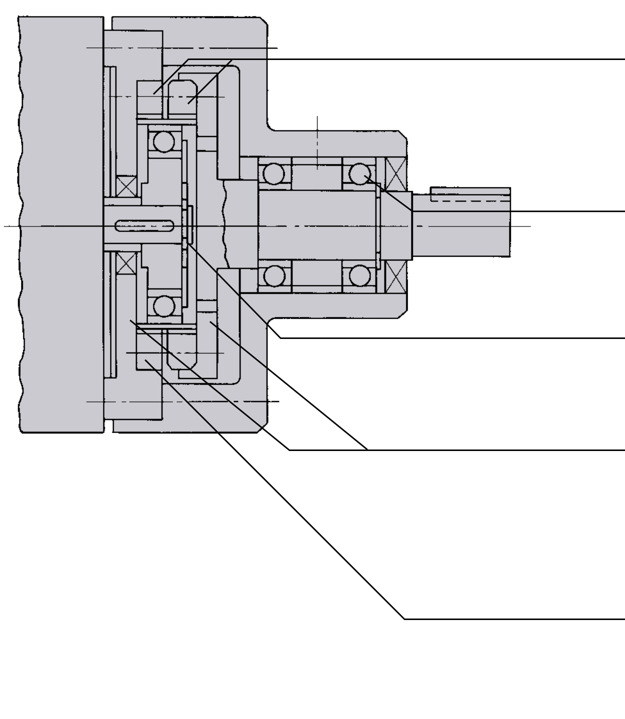
Recommended tolerances for assembly

Table 109-1
Unit: mm

Symbol \ Size	14	20	25	32	40	50
a	0.013	0.017	0.024	0.026	0.026	0.028
b	0.015	0.016	0.016	0.017	0.019	0.024
c	0.016	0.020	0.029	0.031	0.031	0.034
d	0.013	0.017	0.024	0.026	0.026	0.028
e	0.015	0.016	0.016	0.017	0.019	0.024
f	0.016	0.020	0.029	0.031	0.031	0.034
g	0.011	0.013	0.016	0.016	0.017	0.021
h	0.007	0.010	0.012	0.012	0.012	0.015

Precautions on installation

Fig. 109-2



Installation dimension precision

The concentricity and verticality against the input shaft hole of both the circular spline and the wave generator should be as follows.
Concentricity: 0.03mm (T, I, R)
Verticality: 0.05/100

Roller bearing

The input shaft and the output shaft should be supported by two points with an appropriate roller bearing distance and structure to bear all the radial load and axial load applied to the shaft.

Shaft direction stop

As a slight axial load is generated on the wave generator, movement in the shaft direction must be stopped.

Shaft direction stop of the flexspline

As the flexspline is disposed to move to the circular spline S side or D side during operation, a stopper should be set to prevent the flexspline from leaning.
Recommended material and hardness for a stopper S45C, H_B=260 to 290 (HRC 26.4 to 29.8)

Fixing the circular spline (for oil lubrication)

Fix circular spline S. As circular spline D does not have relative rotation for the flexspline, it should be noted that the flexspline does not rotate and may not be fully lubricated if the circular spline is fixed.

Lubrication

There are two types of lubrication; oil lubrication and grease lubrication. Although oil lubrication is common, grease lubrication is applicable to intermittent operation.

■ Oil lubrication

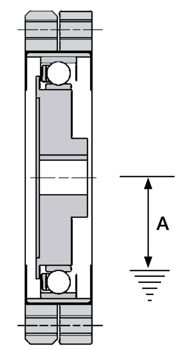
1. Types of lubricant

See Page 18 for details of the lubricant.

2. Oil quantity

Oil level should be maintained at the level “A” as shown. Figure 110-1.

Fig. 110-1



Oil level position

Table 110-1
Unit: mm

Size	14	20	25	32	40	50
A	7	12	15	19	24	29

3. When to replace oil

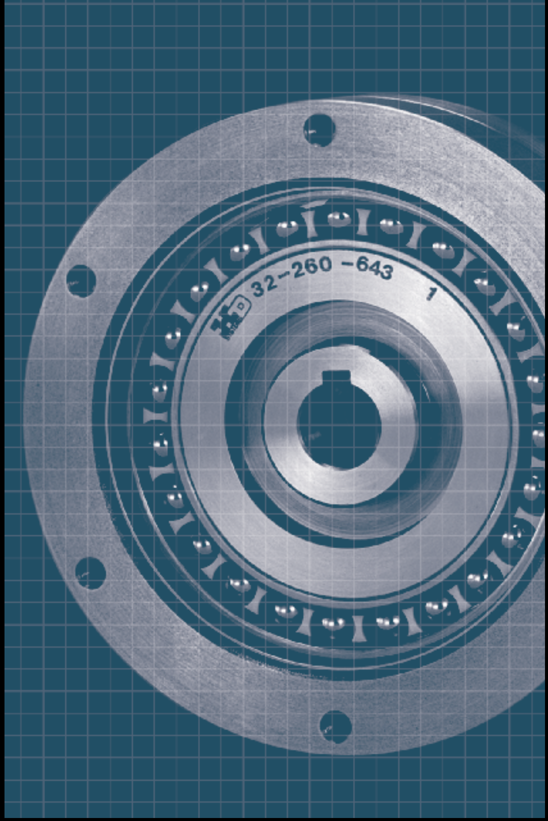
First time ………………… 100 hours after starting operation
Second time and after ···· Every 1000 operation hours or every 6 months. Note that you should replace the oil earlier than specified if the operating condition is demanding.

■ Grease lubrication

Different from oil lubrication, as a cooling effect is not expected from grease lubrication, it is only available for short operation.

- Operating condition: ED%·· 10% or less, continuous operation for 10 minutes or less, the maximum permissible input rotational speed in Table 106-1 or less
- Recommended grease:····· Harmonic Grease SK-1A for sizes 20 to 100
  Harmonic Grease SK-2 for size 14

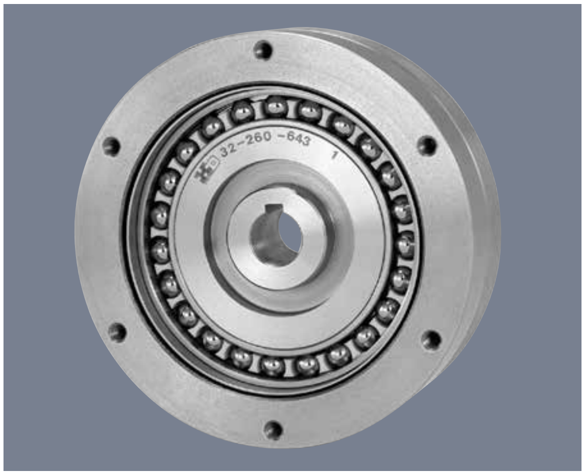
(Note) If you use the product over ED% or the maximum permissible rotational speed, the grease will deteriorate, will not work as a lubricating mechanism and will result in early failure of the gear. Extreme care should be taken.



FR Series

Component Set FR

Features



FR series component type

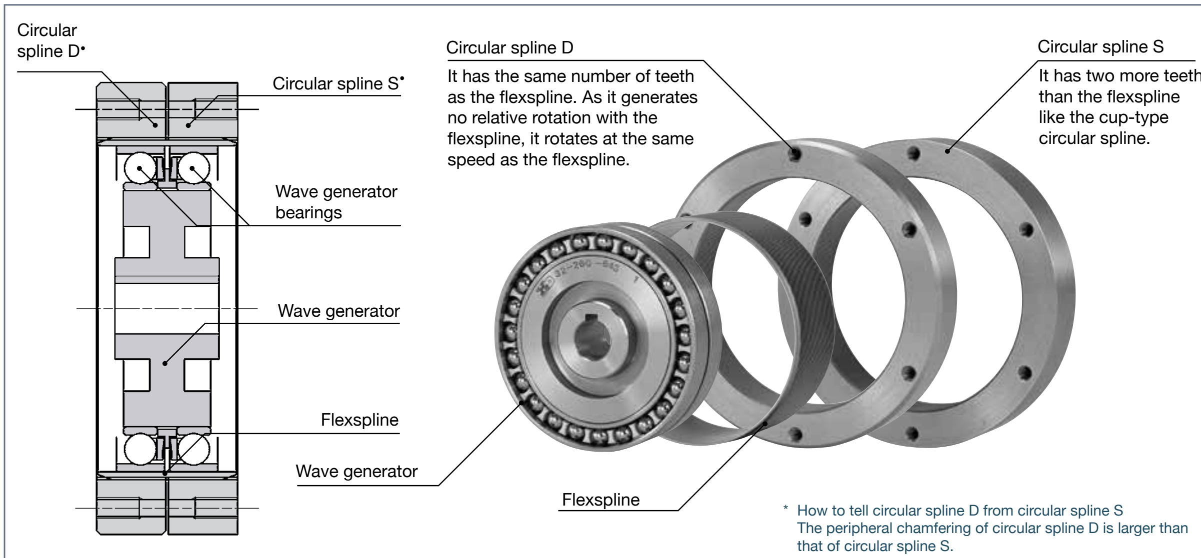
FR is a heavy duty pancake gear that uses a double wave generator bearing. It consists of four parts like the FB series and operates using the same principle as the cup type.
It is basically structured in the same way as the FB series and supports high torque capacity by arranging the wave generator bearings in two lines and widening the tooth width of the circular spline and the flexspline.

Features

- Flat and thin shape
- High torque capacity
- Compact and simple design
- High positional and rotational accuracies
- Coaxial input and output

Structure of the FR series component type

Fig. 112-1



* How to tell circular spline D from circular spline S
The peripheral chamfering of circular spline D is larger than that of circular spline S.

Ordering Code

FR - 20 - 80 - 2 - GR

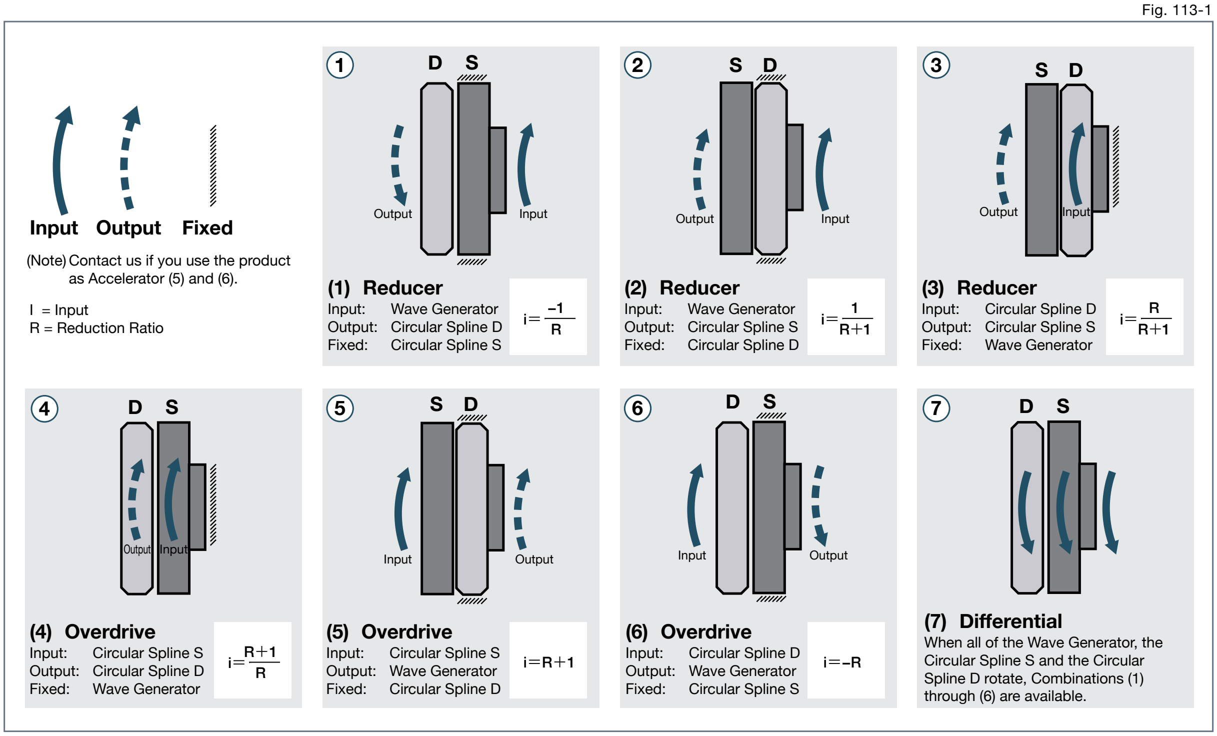
Table 113-1

Series	Size	Ratio*																			Model	
FR	14	50	—	88	—	100	110	—	—	—	—	—	—	—	—	—	—	—	—	—	2= Component type	R = Size 14 GR = Size 20-50
	20	50	—	80	—	100	—	—	128	—	—	—	160	—	—	—	—	—	—	—		
	25	50	—	80	—	100	—	120	—	—	—	—	160	—	200	—	—	—	—	—		
	32	50	78	—	—	100	—	—	—	131	157	—	—	—	200	—	—	—	260	—		
	40	50	—	80	—	100	—	—	128	—	—	—	160	—	200	—	—	258	—	—		
	50	—	—	80	—	100	—	120	—	—	—	—	160	—	200	—	242	—	—	—		
	65	—	78	—	—	—	104	—	—	—	132	158	—	—	—	208	—	—	260	—		
	80	—	—	80	96	—	—	—	128	—	—	—	160	194	—	—	—	258	—	320		
	100	—	—	80	—	100	—	120	—	—	—	—	160	—	200	—	242	—	—	320		

* The reduction ratio value is based on the following configuration:
Input: wave generator, fixed: circular spline, output: flexspline

Rotational direction and reduction ratio

Fig. 113-1



(Note) Contact us if you use the product as Accelerator (5) and (6).

I = Input
R = Reduction Ratio

(1) Reducer
Input: Wave Generator
Output: Circular Spline D
Fixed: Circular Spline S
$i = \frac{-1}{R}$

(2) Reducer
Input: Wave Generator
Output: Circular Spline S
Fixed: Circular Spline D
$i = \frac{1}{R+1}$

(3) Reducer
Input: Circular Spline D
Output: Circular Spline S
Fixed: Wave Generator
$i = \frac{R}{R+1}$

(4) Overdrive
Input: Circular Spline S
Output: Circular Spline D
Fixed: Wave Generator
$i = \frac{R+1}{R}$

(5) Overdrive
Input: Circular Spline S
Output: Wave Generator
Fixed: Circular Spline D
$i = R+1$

(6) Overdrive
Input: Circular Spline D
Output: Wave Generator
Fixed: Circular Spline S
$i = -R$

(7) Differential
When all of the Wave Generator, the Circular Spline S and the Circular Spline D rotate, Combinations (1) through (6) are available.

Engineering Data
Component Sets
Gear Units
Phase Adjusters
Gearheads & Actuators

Technical Data

Rating table

Table 114-1

Size	Ratio	Rated torque at 2000rpm		Repeated Peak Torque		Max. Average Load Torque		Max. Momentary Torque		Rated input rotational speed	Max. Input Speed, rpm		Limit for Average Input Speed, rpm		Moment of Inertia	
		Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm	rpm	Oil lubricant	Grease lubricant	Oil lubricant	Grease lubricant	I $\times10^{-4}kgm^2$	J $\times10^{-5}kgfms^2$
14	50	4.4	0.45	5.4	0.55	5.4	0.55	13.7	1.4	2000	6000	3600	4000	2500	0.060	0.061
	88	5.9	0.6	9.8	1.0	9.8	1.0	19.6*	2.0*							
	100	7.8	0.8	13.7	1.4	9.8	1.0	19.6*	2.0*							
	110	7.8	0.8	13.7	1.4	9.8	1.0	19.6*	2.0*							
20	50	25	2.5	34	3.5	34	3.5	69	7.0	2000	6000	3600	3600	2500	0.32	0.33
	80	34	3.5	41	4.2	41	4.2	72	7.3							
	100	40	4.1	53	5.4	49	5.0	94	9.6							
	128	40	4.1	67	6.8	49	5.0	102*	10.4*							
	160	40	4.1	77	7.9	49	5.0	86*	8.8*							
25	50	39	4.0	55	5.6	55	5.6	108	11.0	2000	5000	3600	3000	2500	0.7	0.71
	80	56	5.7	69	7.0	69	7.0	122	12.4							
	100	67	6.8	91	9.3	91	9.3	160	16.3							
	120	67	6.8	108	11.0	108	11.0	190	19.4							
	160	67	6.8	135	13.8	108	11.0	172*	17.6*							
	200	67	6.8	147	15.0	108	11.0	172*	17.6*							
32	50	76	7.8	108	11	108	11	216	22	2000	4500	3600	2500	2300	2.6	2.61
	78	108	11	137	14	137	14	245	25							
	100	137	14	176	18	176	18	323	33							
	131	137	14	255	26	216	22	451	46							
	157	137	14	294	30	216	22	500*	51*							
	200	137	14	314	32	216	22	372*	38*							
	260	137	14	314	32	216	22	372*	38*							
40	50	137	14	196	20	196	20	353	36	2000	4000	3300	2000	2000	6.8	6.9
	80	196	20	245	25	245	25	431	44							
	100	255	26	314	32	314	32	549	56							
	128	294	30	392	40	392	40	686	70							
	160	294	30	461	47	451	46	813	83							
	200	294	30	529	54	451	46	745	76*							
	258	294	30	627	64	451	46	745	76*							
50	80	363	37	441	45	441	45	784	80	1700	3500	3000	1700	1700	21	21
	100	470	48	578	59	578	59	1019	104							
	120	559	57	696	71	696	71	1225	125							
	160	559	57	833	85	833	85	1470	150							
	200	559	57	960	98	843	86	1411*	144*							
	242	559	57	1176	120	843	86	1411*	144*							
65	78	745	76	921	94	921	94	1617	165	1400	3000	2200	1400	1400	76	78
	104	1070	109	1340	137	1340	137	2360	241							
	132	1070	109	1650	168	1570	160	2890	295							
	158	1070	109	1970	201	1570	160	3450*	352*							
	208	1070	109	2180	222	1570	160	2590*	264*							
	260	1070	109	2200	224	1570	160	2590*	264*							
80	80	1320	135	1640	167	1640	167	2870	293	1200	2500	2000	1200	1200	213	217
	96	1660	169	2050	209	2050	209	3590	366							
	128	2300	235	2820	288	2830	289	4960	506							
	160	2350	240	3380	345	3130	319	5940	606							
	194	2350	240	4300	439	3130	319	6900*	704*							
	258	2350	240	4350	444	3130	319	5170*	528*							
	320	2350	240	4350	444	3130	319	5170*	528*							
100	80	2330	238	2870	293	2870	293	5040	514	1000	2000	1700	1000	1000	635	648
	100	3200	327	3940	402	3940	402	6920	706							
	120	3890	397	4780	488	4780	488	8400	857							
	160	4470	456	6230	636	5720	584	10950	1117							
	200	4470	456	7090	723	5720	584	12440	1269							
	242	4470	456	7960	812	5720	584	9410*	960*							
	320	4470	456	7960	812	5720	584	9410*	960*							

* Torque value limited by ratcheting.

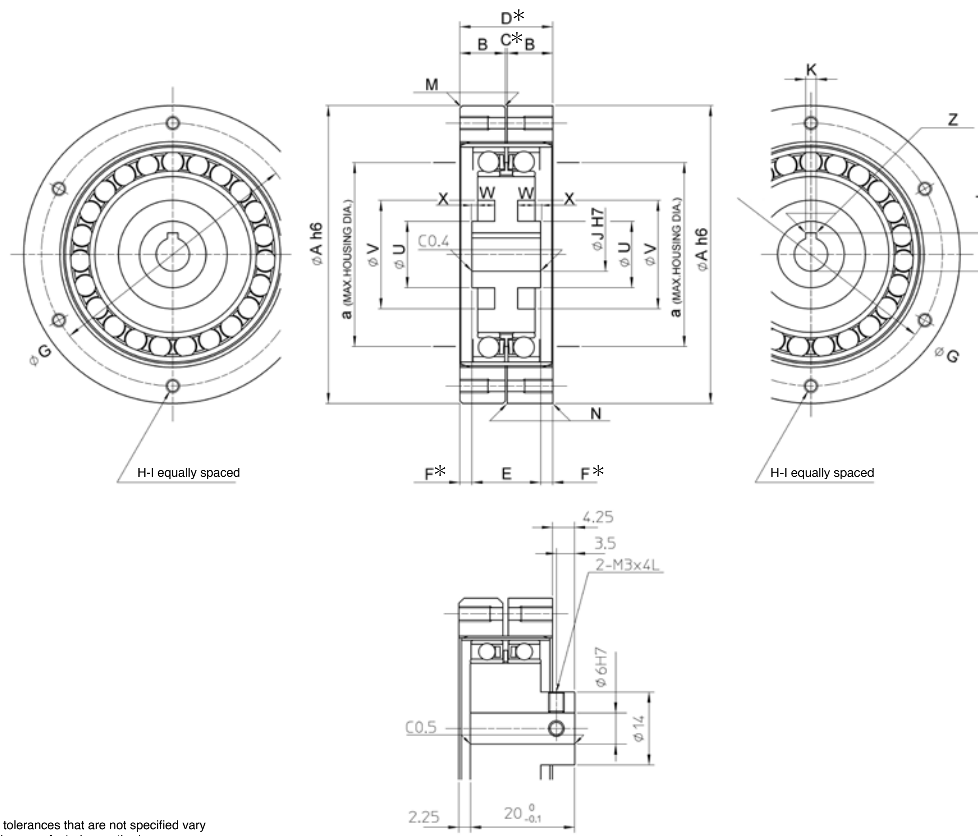
1. Moment of inertia: $I=\frac{1}{4}GD^2$

2. See Rating Table Definitions on Page 12 for details of the terms.

Load inertia = J

Outline dimensions

Fig. 115-1



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.

FR-14

Dimensions

Table 115-1
Unit: mm

Symbol \ Size		14	20	25	32	40	50	65	80	100
ØA (h6)		50	70	85	110	135	170	215	265	330
B		8.5	12	14	18	21	26	35	41	50
C*		1	1	1	1	1	1	1	1	1
D*		18	25	29	37	43	53	71	83	101
E $^{0}_{-0.1}$		—	17.3	20	25.9	31.5	39.1	50.5	62	77.2
F*		—	3.85	4.5	5.55	5.75	6.95	10.25	10.5	11.9
ØG		44	60	75	100	120	150	195	240	290
H		6	6	6	6	6	6	6	8	8
I		M3×6	M3×6	M4×8	M5×10	M6×12	M8×16	M10×20	M10×20	M12×24
ØJ (H7)	Standard	6	9	11	14	14	19	24	28	28
	Max. size	8	11	11	17	20	26	26	32	33
K (J_{s9})		—	3	4	5	5	6	8	8	8
L $^{+0.1}_{0}$		—	10.4	12.8	16.3	16.3	21.8	27.3	31.3	31.3
M		c1	c1	c1.5	c1.5	c1.5	c1.5	c1.5	c2	c2
N		c0.2	c0.2	c0.2	c0.2	c0.4	c0.4	c0.4	c0.4	c0.4
a		29	42	53	69	84	105	138	169	211
ØU		—	—	22	28	32	38	44	52	58
ØV		—	—	32	42	52	62	86	100	128
W		—	—	4.8	6.1	7.6	9.8	12.6	16	19.7
X		—	—	1.6	1.9	2.5	3.2	4.4	5.1	6.3
Z		—	R0.08 to 0.16	R0.08 to 0.16	R0.08 to 0.25	R0.08 to 0.25	R0.08 to 0.25	R0.08 to 0.25	R0.08 to 0.25	R0.08 to 0.25
Mass	kgf	0.2	0.5	0.8	1.7	3.0	6.0	12.0	22.3	42.6

(Note) For Circular spline D, the peripheral chamfering is M.

*The C, D and F values indicate relative position of individual gearing components (wave generator, flexspline, circular spline). Please strictly adhere to these values when designing your housing and mating parts.

● Four parts (wave generator, flexspline, circular spline D, circular spline S) are not assembled when delivered.

Efficiency

The efficiency varies depending on the following conditions.

- Reduction ratio
- Input rotational speed
- Load torque
- Temperature
- Lubrication (Type and quantity)

Measurement condition

Table 116-1

Installation	Based on recommended tolerance.		
Load torque	The rated torque shown in the rating table (see page 114)		
Lubricant	Grease	Name	Harmonic Grease SK-1A
			Harmonic Grease SK-2
	Oil		Industrial gear oil class-2
	Quantity		Recommended quantity (see page 122)

* Contact us for oil lubrication.

Efficiency compensation coefficient

If the load torque is lower than the rated torque, the efficiency will be lower. Calculate the compensation coefficient Ke from Graph 116-1 to calculate the efficiency using the following example.

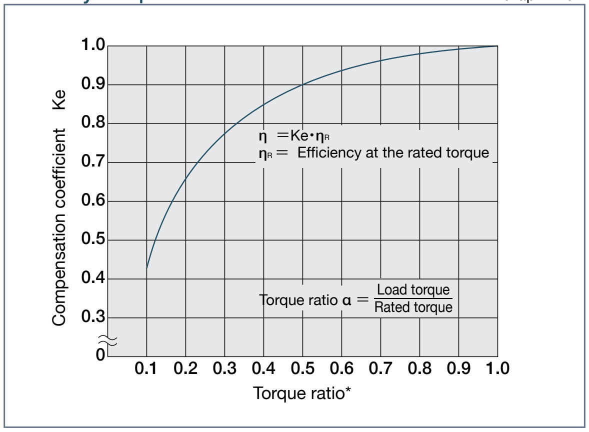
Calculation Example

Efficiency η (%) under the following condition is calculated from the example of FR-20-80-2GR.
Input rotational speed: 1000 rpm
Load torque: 19.6 Nm
Lubrication: Grease lubrication (Harmonic Grease SK-1A)
Lubricant temperature: 20°C
Since the rated torque of size 20 with a reduction ratio of 80 is 34 Nm (Ratings: Page 114), the torque ratio α is 0.58.
(α=19.6/34=0.58)

- The efficiency compensation coefficient is Ke=0.86 from Graph 116-1.
- Efficiency η at load torque 19.6 Nm: η=Ke•ηR=0.86 x 65=56%

Efficiency compensation coefficient

Graph 116-1

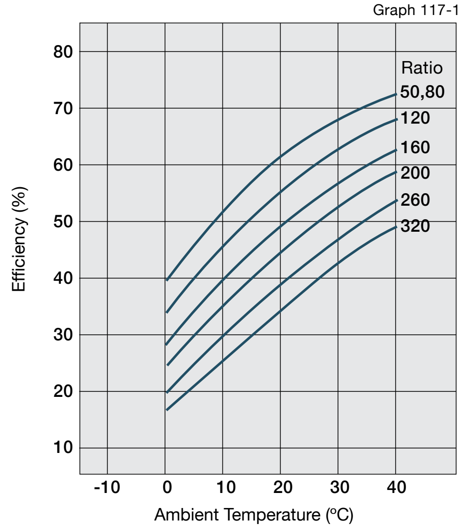


* Efficiency compensation coefficient Ke=1 holds when the load torque is greater than the rated torque.

■ Efficiency at rated torque (oil lubrication)

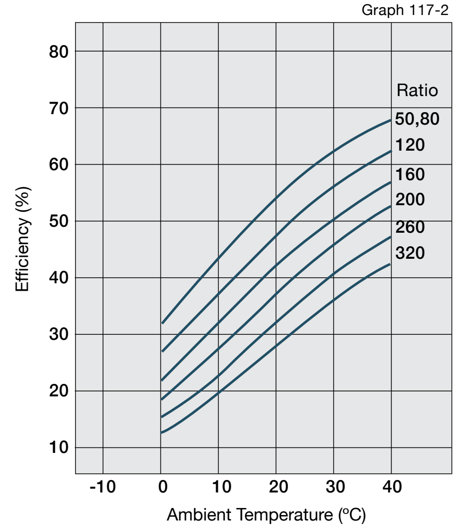
Input speed: 500rpm

Graph 117-1



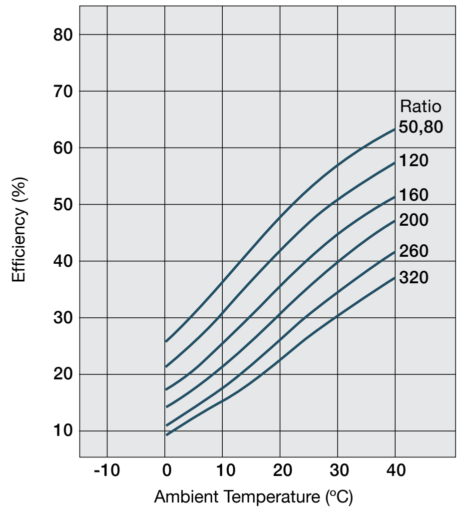
Input speed: 1000rpm

Graph 117-2



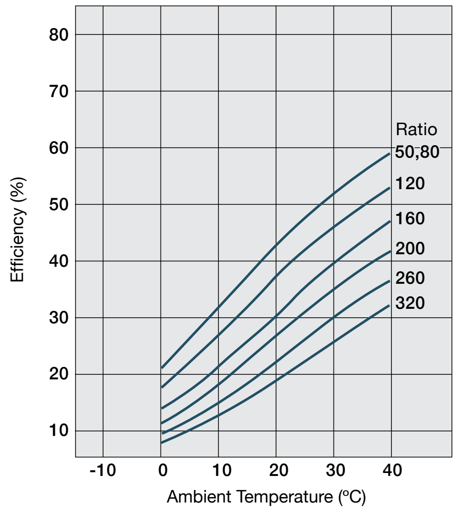
Input speed: 2000rpm

Graph 117-3



Input speed: 3500rpm

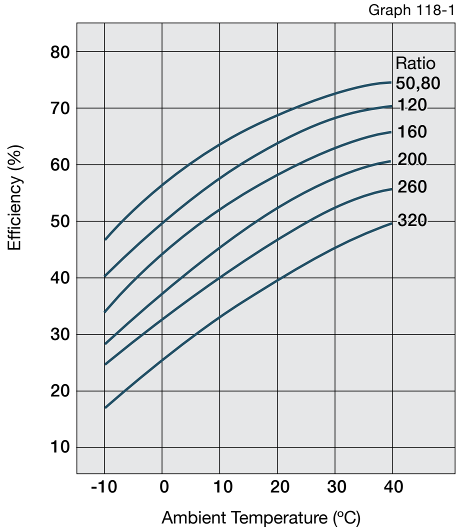
Graph 117-4



■ Efficiency at rated torque (grease lubrication)

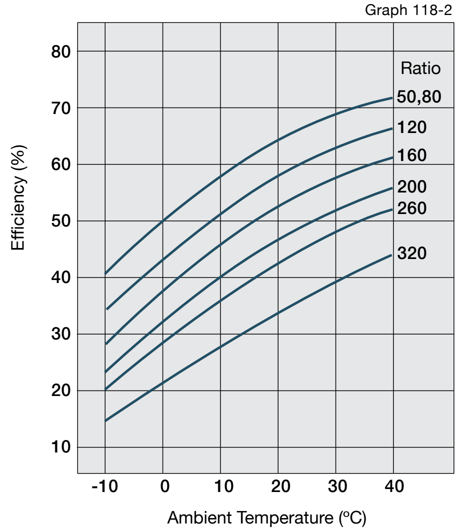
Input speed: 500rpm

Graph 118-1



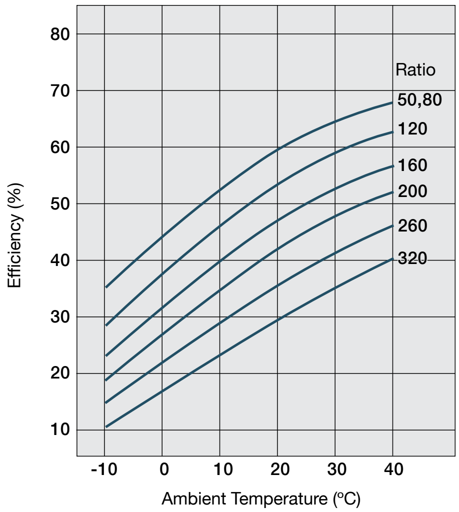
Input speed: 1000rpm

Graph 118-2



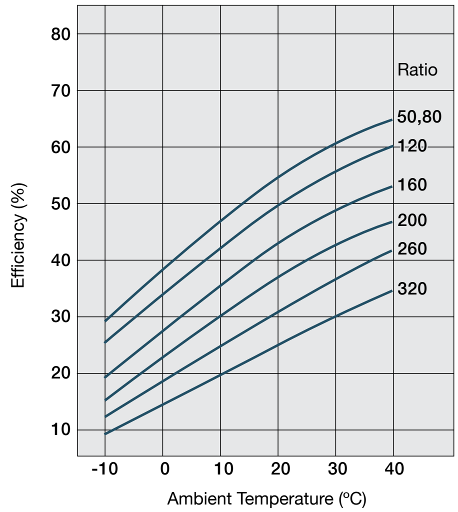
Input speed: 2000rpm

Graph 118-3



Input speed: 3500rpm

Graph 118-4



No-load running torque, starting torque, backdriving torque

Values indicated are from actual tests with the component sets assembled in their housings, and inclusive of friction resistance of oils seals, and churning of oil.

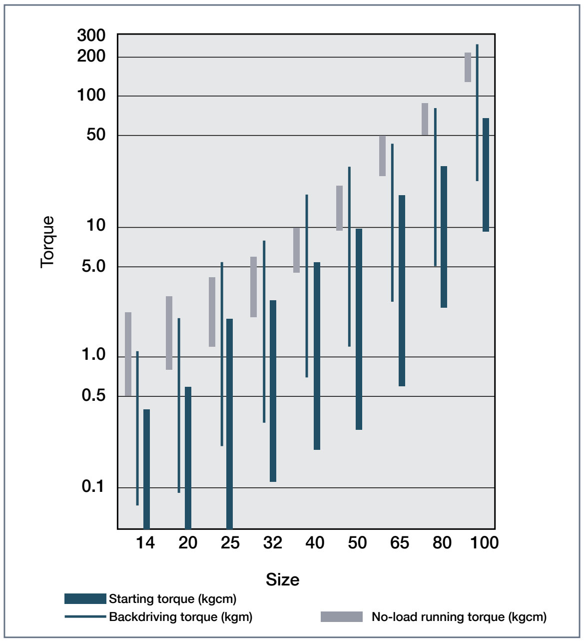
(1) No-load running torque····· No-load running torque is the torque which is required to rotate the input side (high speed side), when there is no load on the output side (low speed side). The value in the graph indicates the condition when the input rotational speed is 1500 rpm and the oil temperature is about 40ºC.

(2) Starting torque···················This is the static torque required to start the high-speed shaft in a no-load condition.

(3) Backdriving torque ··········· This is the static torque required to start the low-speed shaft in a no-load condition.

Running torque, starting torque, backdriving torque

Fig. 119-1



Lost motion and the spring constant

Lost motion and the spring constant of the pancake gear is the value when the wave generator or one circular spline is fixed and when a torque is applied to the dynamic spline.

Table 120-1

Size	Lost motion		Spring constant	
	± Load (kgm)	Lost motion (arc min)	Load (kgm)	Spring constant (kgfm/arc min)
14	0.04	max. 3.0	1.26	0.3
20	0.12	3.0	3.69	0.9
25	0.23	3.0	7.20	2.1
32	0.46	3.0	15.78	4.4
40	0.92	3.0	29.50	7.8
50	1.73	3.0	57.60	16
65	3.9	3.0	126.7	27
80	7.4	3.0	236.2	52
100	14.4	3.0	460.8	100

■ Description on lost motion and spring constant

When assembled, rotation of the Wave Generator as a high speed input member imparts a rotating elliptical shape to the Flexspline. This causes progressive engagement of its external teeth with the internal teeth of the Circular Spline. The fixed Circular Spline, having a larger number of teeth than the Flexspline causes the latter to precess at a rate determined by the ratio of tooth difference to the total number of teeth. With the same number of teeth as the Flexspline, The Dynamic Spline rotates with, and at the same speed as, the Flexspline and is the output member of the drive.

(1) Lost motion (L/M)

The lost motion is the total value of rotational angle of low-speed shaft when the high-speed shaft is fixed in rotational direction with the drive installed and when slight load torque (see Table 120-1) is applied to the low-speed shaft the other way round.

(2) Spring constant

By increasing the load torque gradually in the same manner as the lost motion and applying the load the other way round, "load torque - torsional angle" diagram emerges as shown in Fig. 120-2. The average spring constant obtained by this diagram is shown in Table 120-1. (This value is only for the HarmonicDrive® components.)

■ Example of calculation

Use model number FR-40-160-2A-GR to fix the input shaft in rotational direction, and apply the load (30kgfm) rated in the catalog to the output shaft, and then obtain the torsional angle.

$$\text{Torsional angle } \theta = \frac{L \cdot M}{2} + \frac{1}{K}(T - T_{L \cdot M})$$

$$= 1.5 + \frac{1}{7.8}(30 - 0.92)$$

$$= 5.23 \text{arc min}$$

Maximum value "θmax" when rotated the other way round is

$$\theta max = 2 \cdot \theta = 10.46 \text{arc min}$$

Fig. 120-1

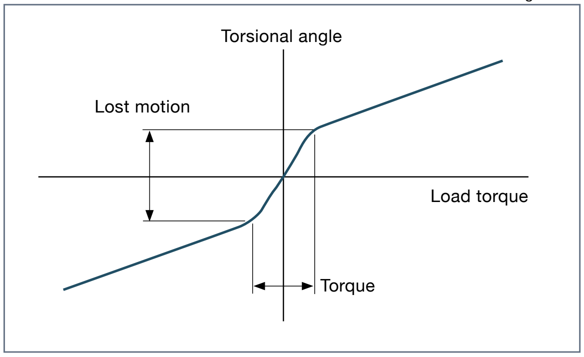


Fig. 120-2

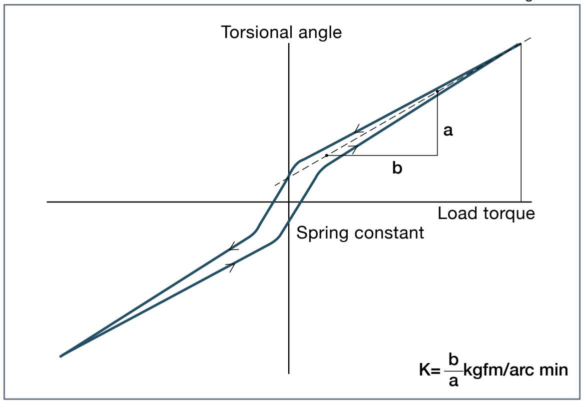
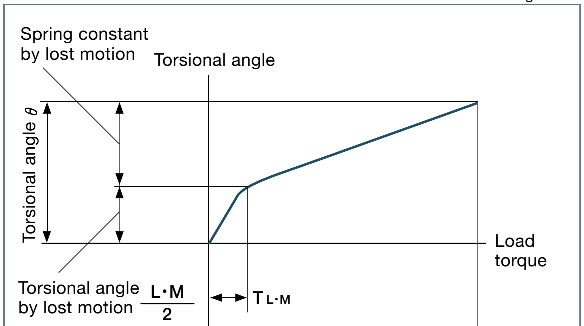


Fig. 120-3



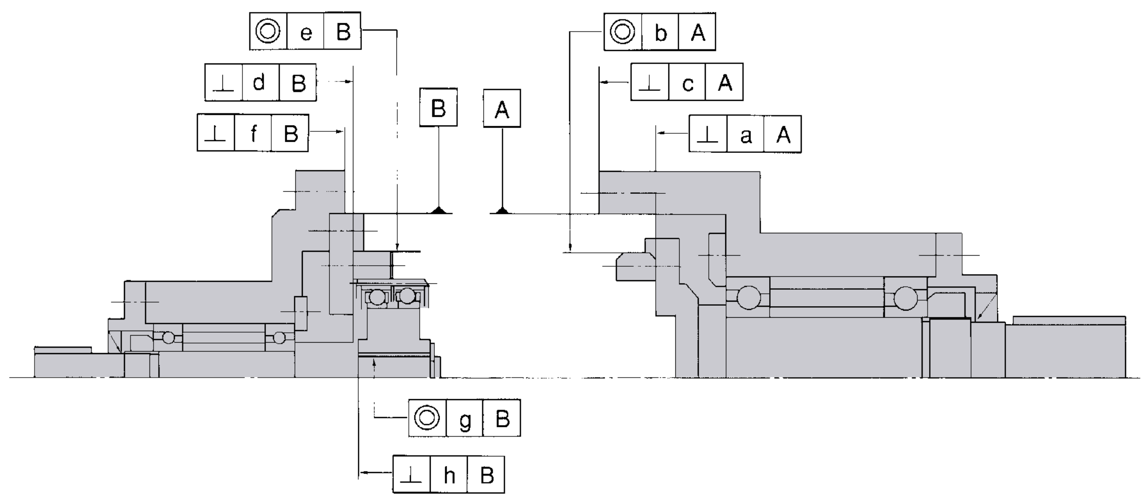
Design Guide

Recommended tolerances for assembly

Maintain the recommended assembly tolerances shown in Figure 121-1 and Table 121-1 for maximum performance of your FR gear.

Recommended tolerances for assembly

Fig. 121-1



Recommended tolerances for assembly

Table 121-1
Unit: mm

Symbol \ Size	14	20	25	32	40	50	65	80	100
a	0.013	0.017	0.024	0.026	0.026	0.028	0.034	0.043	0.057
b	0.015	0.016	0.016	0.017	0.019	0.024	0.027	0.033	0.038
c	0.016	0.020	0.029	0.031	0.031	0.034	0.041	0.052	0.068
d	0.013	0.017	0.024	0.026	0.026	0.028	0.034	0.043	0.057
e	0.015	0.016	0.016	0.017	0.019	0.024	0.027	0.033	0.038
f	0.016	0.020	0.029	0.031	0.031	0.034	0.041	0.052	0.068
g	0.011	0.013	0.016	0.016	0.017	0.021	0.025	0.030	0.035
h	0.007	0.010	0.012	0.012	0.012	0.015	0.015	0.015	0.015

Installation of the circular spline

Conduct design and part control corresponding to the load condition for installation of the circular spline. Transmission torques by the recommended bolts and tightening torques are shown in the following table.

Installation with bolts

Table 121-1

Item \ Size		14	20	25	32	40	50	65	80	100
Number of bolts		6	6	6	6	6	6	6	8	8
Bolt size		M3	M3	M4	M5	M6	M8	M10	M10	M12
Pitch Circle Diameter	mm	44	60	75	100	120	150	195	240	290
Clamp torque	Nm	2.0	2.0	4.5	9.0	15.3	37	74	74	128
	kgfm	0.20	0.20	0.46	0.92	1.56	3.8	7.5	7.5	13.1
Torque transmission	Nm	54	74	159	338	573	1300	2680	4410	7750
	kgfm	5.5	7.5	16	34	58	132	273	450	790

(Table 121-1/Notes)
1. The material of the thread must withstand the clamp torque.
2. Recommended bolt: JIS B 1176 socket head cap screw / Strength range: JIS B 1051 over 12.9.

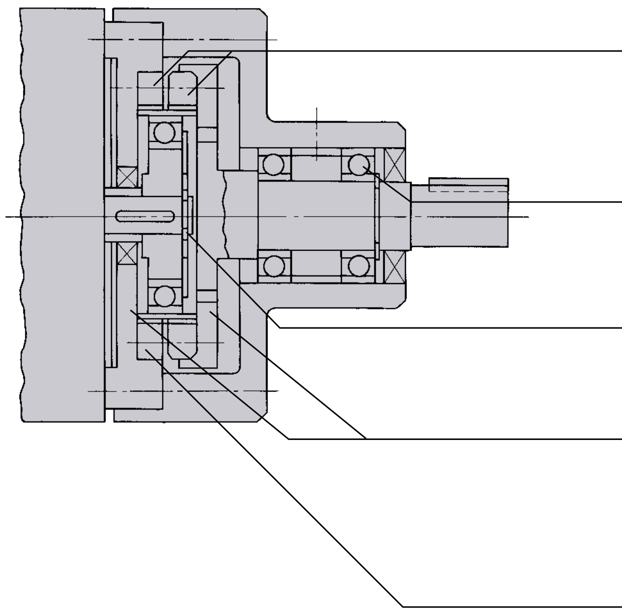
Component Set FR

Precautions on assembly

Maintain the recommended tolerances shown in Figure 122-1 and Table 122-1 for optimal performance.

Precautions on installation

Fig. 122-1



■ Installation dimension precision

The concentricity and verticality against the input shaft hole of both the circular spline and the wave generator should be as follows.
Concentricity: 0.03mm (T, I, R)
Verticality: 0.05/100

■ Roller bearing

The input shaft and the output shaft should be supported by two points with an appropriate roller bearing distance and structure to bear all the radial load and axial load applied to the shaft.

■ Shaft direction stop

As a slight axial load is generated on the wave generator, movement in the shaft direction must be stopped.

■ Shaft direction stop of the flexspline

As the flexspline is disposed to move to the circular spline S side or D side during operation, a stopper should be set to prevent the flexspline from leaning. Recommended material and hardness for a stopper S45C, H_B=260 to 290 (HRC 26.4 to 29.8)

■ Fixing the circular spline (for oil lubrication)

Fix circular spline S. As circular spline D does not have relative rotation for the flexspline, it should be noted that the flexspline does not rotate and may not be fully lubricated if the circular spline is fixed.

Lubrication

There are two types of lubrication; oil lubrication and grease lubrication. Although oil lubrication is common, grease lubrication is applicable to intermittent operation.

■ Oil lubrication

1. Types of Oil

The specified standard lubricant is “Industrial gear oil class-2 (extreme pressure) ISO VG68.” (Page 18).

2. Oil quantity

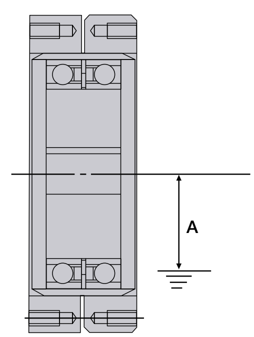
The recommended oil level is shown in Table 122-1.

Oil level

Table 122-1
Unit: mm

Size	14	20	25	32	40	50	65	80	100
A	7	12	15	31	38	44	62	75	94

Fig. 122-2



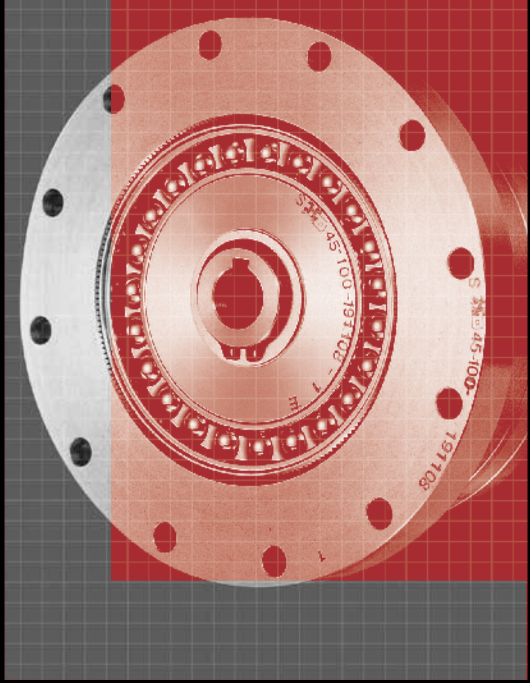
■ Grease lubrication

Different from oil lubrication, as a cooling effect is not expected from grease lubrication, it is only available for short operation.

- Operating condition: ED% ··10% or less, continuous operation for 10 minutes or less, the maximum allowable input rotational speed in Table 114-1 or less
- Recommended grease: ····· Harmonic Grease SK-1A for sizes 20 to 100
  Harmonic Grease SK-2 for size 14

(Note) If you use the product over ED% or the maximum allowable rotational speed, the grease will deteriorate, will not work as a lubricating mechanism and will result in early failure of the gear. Extreme care should be taken.

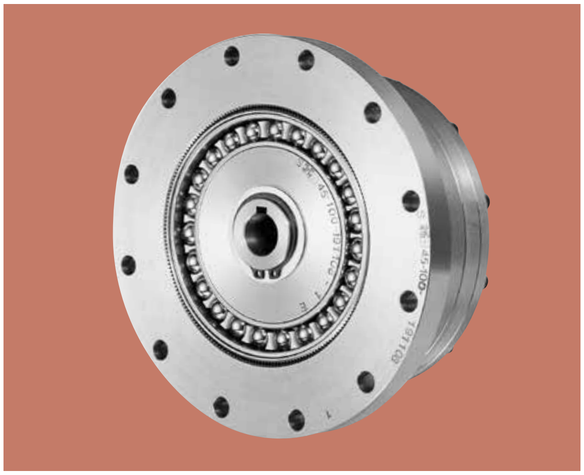
HarmonicDrive®



CSG/CSF Series

Gear Unit CSG/CSF

Features



CSG/CSF Gear Unit

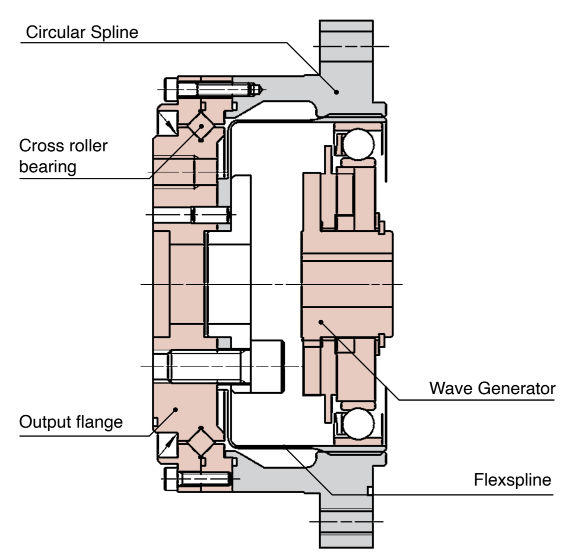
CSF/CSG are housed component gear sets combined with a precision cross roller output bearing & flange. A highly rigid cross roller bearing is built in to directly support (output bearing) the external load. They are a very compact, robust and easy to use gearhead solution. CSF and CSG are also available in lightweight versions.

Features

- Zero backlash
- Compact design
- High-torque capacity
- High stiffness
- High-positional and rotational accuracies

Structure of CSG/CSF series gear unit

Fig. 124-1



CSF v. CSG

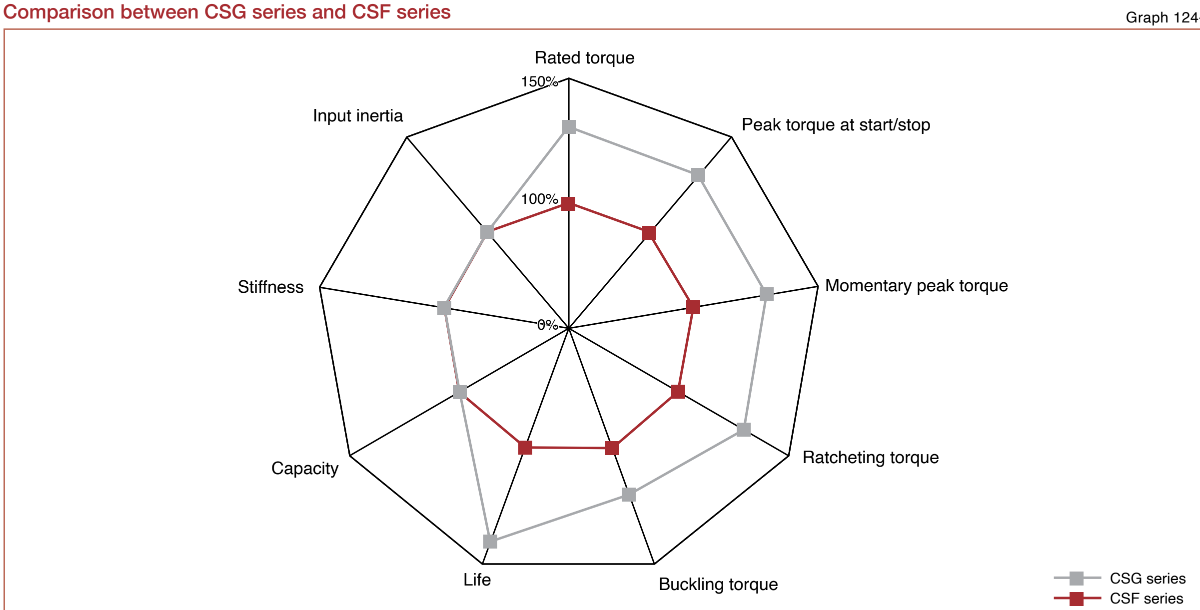
CSG high torque
- 30% Higher torque than CSF series.
- The life has been improved by 43% (10,000 hours) compared to CSF.

CSF: standard torque
- Reduction ratio of 30:1 included for high-speed

CSF/CSG-LW series: Lightweight (sizes 14 to 45)
- 30% average lower weight than Standard Series.
- Same performance as CSF/CSG series.

Comparison between CSG series and CSF series

Graph 124-1



Ordering Code

CSG - 25 - 100 - 2UH - SP

Table 125-1

Series	Size	Ratio*1					Model	Special specification
CSG	14	50	80	100	—	—	2A= Component type 2UH= Unit type 2UJ = Unit type with input shaft*2	LW= Lightweight SP= Special specification code Blank= Standard product
	17	50	80	100	120	—		
	20	50	80	100	120	160		
	25	50	80	100	120	160		
	32	50	80	100	120	160		
	40	50	80	100	120	160		
	45	50	80	100	120	160		
	50	—	80	100	120	160		
	58	—	80	100	120	160		
	65	—	80	100	120	160		

*1 The reduction ratio value is based on the following configuration:
Input: wave generator, fixed: circular spline, output: flexspline
*2 Contact us for details.

CSF - 25 - 100 - 2UH - SP

Table 125-2

Series	Size	Ratio*1						Model	Special specification
CSF	14	30	50	80	100	—	—	2A= Component type 2UH= Unit type 2UJ = Unit type with input shaft*2	LW= Lightweight (sizes 14 to 45) SP= Special specification code Blank= Standard product
	17	30	50	80	100	120	—		
	20	30	50	80	100	120	160		
	25	30	50	80	100	120	160		
	32	30	50	80	100	120	160		
	40	—	50	80	100	120	160		
	45	—	50	80	100	120	160		
	50	—	50	80	100	120	160		
	58	—	50	80	100	120	160		
	65	—	50	80	100	120	160		

*1 The reduction ratio value is based on the following configuration:
Input: wave generator, fixed: circular spline, output: flexspline
*2 Contact us for details.

Technical Data

Rating table

CSG Series

Table 126-1

Size	Ratio	Rated Torque at 2000rpm		Limit for Repeated Peak Torque		Limit for Average Torque		Limit for Momentary Peak Torque		Maximum Input Speed (rpm)		Limit for Average Input Speed (rpm)		Moment of Inertia	
		Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm	Oil lubricant	Grease lubricant	Oil lubricant	Grease lubricant	I $\times 10^{-4}$ kgm^2	J $\times 10^{-5}$ $kgfms^2$
14	50	7.0	0.7	23	2.3	9	0.9	46	4.7	14000	8500	6500	3500	0.033	0.034
	80	10	1.0	30	3.1	14	1.4	58*3	5.9*3						
	100	10	1.0	36	3.7	14	1.4	58*3	5.9*3						
17	50	21	2.1	44	4.5	34	3.4	91	9	10000	7300	6500	3500	0.079	0.081
	80	29	2.9	56	5.7	35	3.6	109*3	11*3						
	100	31	3.2	70	7.2	51	5.2	109*3	11*3						
	120	31	3.2	70	7.2	51	5.2	109*3	11*3						
20	50	33	3.3	73	7.4	44	4.5	127	13	10000	6500	6500	3500	0.193	0.197
	80	44	4.5	96	9.8	61	6.2	165	17						
	100	52	5.3	107	10.9	64	6.5	191	20						
	120	52	5.3	113	11.5	64	6.5	191	20						
	160	52	5.3	120	12.2	64	6.5	191	20						
25	50	51	5.2	127	13	72	7.3	242	25	7500	5600	5600	3500	0.413	0.421
	80	82	8.4	178	18	113	12	332	34						
	100	87	8.9	204	21	140	14	369	38						
	120	87	8.9	217	22	140	14	395*4	40*4						
	160	87	8.9	229	23	140	14	408*4	42*4						
32	50	99	10	281	29	140	14	497	51	7000	4800	4600	3500	1.69	1.72
	80	153	16	395	40	217	22	738	75						
	100	178	18	433	44	281	29	841	86						
	120	178	18	459	47	281	29	892	91						
	160	178	18	484	49	281	29	892	91						
40	50	178	18	523	53	255	26	892	91	5600	4000	3600	3000	4.50	4.59
	80	268	27	675	69	369	38	1270	130						
	100	345	35	738	75	484	49	1400	143						
	120	382	39	802	82	586	60	1510*4	154*4						
	160	382	39	841	86	586	60	1510*4	154*4						
45	50	229	23	650	66	345	35	1235	126	5000	3800	3300	3000	8.68	8.86
	80	407	41	918	94	507	52	1651	168						
	100	459	47	982	100	650	66	2041	208						
	120	523	53	1070	109	806	82	2288	233						
	160	523	53	1147	117	819	84	2483	253						
50	80	484	49	1223	125	675	69	2418	247	4500	3500	3000	2500	12.5	12.8
	100	611	62	1274	130	866	88	2678	273						
	120	688	70	1404	143	1057	108	2678	273						
	160	688	70	1534	156	1096	112	3185	325						
58	80	714	73	1924	196	1001	102	3185	325	4000	3000	2700	2200	27.3	27.9
	100	905	92	2067	211	1378	141	4134	422						
	120	969	99	2236	228	1547	158	4329	441						
	160	969	99	2392	244	1573	160	4459	455						
65	80	969	99	2743	280	1352	138	4836	493	3500	2800	2400	1900	46.8	47.8
	100	1236	126	2990	305	1976	202	6175	630						
	120	1236	126	3263	333	2041	208	6175	630						
	160	1236	126	3419	349	2041	208	6175	630						

(Note) 1. Moment of inertia: $I=\frac{1}{4}GD^2$
2. See "Engineering data" on Page 12 for details of the terms.
3. The value of permissible maximum momentary torque is limited by the transmission torque of the unit (See Table 138-1, 2 on Page 138.).
4. When using LW series, see the transmission torque of the unit (Table 138-3, 4 on Page 138.) for the permissible maximum momentary torque.

Rating table

CSF Series

Table 127-1

Size	Ratio	Rated Torque at 2000rpm		Limit for Repeated Peak Torque		Limit for Average Torque		Limit for Momentary Peak Torque		Maximum Input Speed (rpm)		Limit for Average Input Speed (rpm)		Moment of Inertia	
		Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm	Oil lubricant	Grease lubricant	Oil lubricant	Grease lubricant	I $\times10^{-4}kgm^2$	J $\times10^{-5}kgfms^2$
14	30	4.0	0.41	9.0	0.92	6.8	0.69	17	1.7	14000	8500	6500	3500	0.033	0.034
	50	5.4	0.55	18	1.8	6.9	0.70	35	3.6						
	80	7.8	0.80	23	2.4	11	1.1	47	4.8						
	100	7.8	0.80	28	2.9	11	1.1	54	5.5						
17	30	8.8	0.90	16	1.6	12	1.2	30	3.1	10000	7300	6500	3500	0.079	0.081
	50	16	1.6	34	3.5	26	2.6	70	7.1						
	80	22	2.2	43	4.4	27	2.7	87	8.9						
	100	24	2.4	54	5.5	39	4.0	108	11						
	120	24	2.4	54	5.5	39	4.0	86	8.8						
20	30	15	1.5	27	2.8	20	2.0	50	5.1	10000	6500	6500	3500	0.193	0.197
	50	25	2.5	56	5.7	34	3.5	98	10						
	80	34	3.5	74	7.5	47	4.8	127	13						
	100	40	4.1	82	8.4	49	5.0	147	15						
	120	40	4.1	87	8.9	49	5.0	147	15						
	160	40	4.1	92	9.4	49	5.0	147	15						
25	30	27	2.8	50	5.1	38	3.9	95	9.7	7500	5600	5600	3500	0.413	0.421
	50	39	4.0	98	10	55	5.6	186	19						
	80	63	6.4	137	14	87	8.9	255	26						
	100	67	6.8	157	16	108	11	284	29						
	120	67	6.8	167	17	108	11	304	31						
	160	67	6.8	176	18	108	11	314	32						
32	30	54	5.5	100	10	75	7.7	200	20	7000	4800	4600	3500	1.69	1.72
	50	76	7.8	216	22	108	11	382	39						
	80	118	12	304	31	167	17	568	58						
	100	137	14	333	34	216	22	647	66						
	120	137	14	353	36	216	22	686	70						
	160	137	14	372	38	216	22	686	70						
40	50	137	14	402	41	196	20	686	70	5600	4000	3600	3000	4.50	4.59
	80	206	21	519	53	284	29	980	100						
	100	265	27	568	58	372	38	1080	110						
	120	294	30	617	63	451	46	1180	120						
	160	294	30	647	66	451	46	1180	120						
45	50	176	18	500	51	265	27	950	97	5000	3800	3300	3000	8.68	8.86
	80	313	32	706	72	390	40	1270	130						
	100	353	36	755	77	500	51	1570	160						
	120	402	41	823	84	620	63	1760	180						
	160	402	41	882	90	630	64	1910	195						
50	50	245	25	715	73	350	36	1430	146	4500	3500	3000	2500	12.5	12.8
	80	372	38	941	96	519	53	1860	190						
	100	470	48	980	100	666	68	2060	210						
	120	529	54	1080	110	813	83	2060	210						
	160	529	54	1180	120	843	86	2450	250						
58	50	176	18	1020	104	18	27	1960	200	4000	3000	2700	2200	27.3	27.9
	80	549	56	1480	151	770	79	2450	250						
	100	696	71	1590	162	1060	108	3180	325						
	120	745	76	1720	176	1190	121	3330	340						
	160	745	76	1840	188	1210	123	3430	350						
65	50	245	25	1420	145	360	27	2830	289	3500	2800	2400	1900	46.8	47.8
	80	745	76	2110	215	1040	106	3720	380						
	100	951	97	2300	235	1520	155	4750	485						
	120	951	97	2510	256	1570	160	4750	485						
	160	951	97	2630	268	1570	160	4750	485						

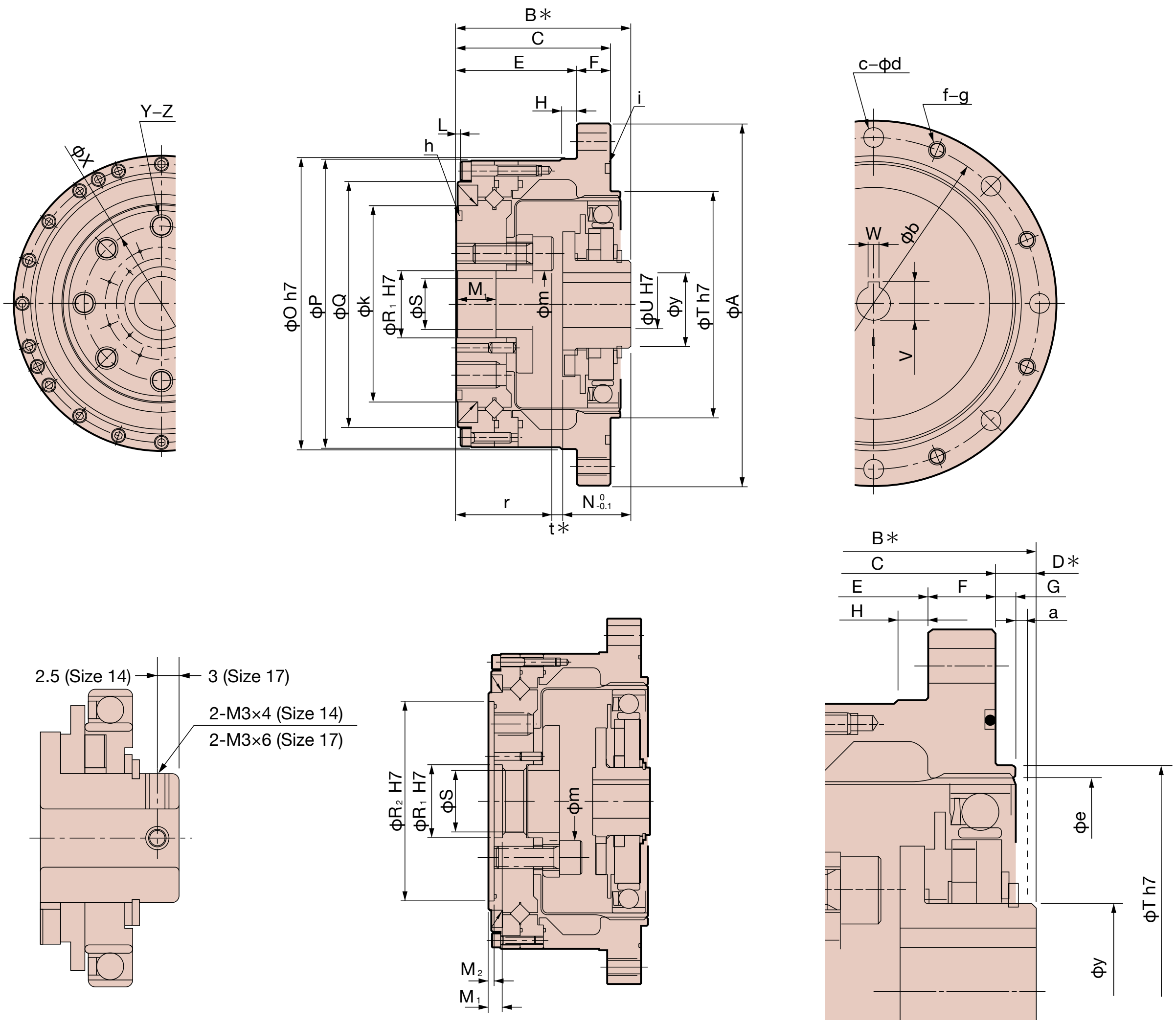
(Note) 1. Moment of inertia: $I=\frac{1}{4}GD^2$
2. See "Engineering data" on Page 12 for details of the terms.

Gear Unit CSG/CSF

Outline Dimensions

You can download the CAD files from our website: harmonicdrive.net

Fig. 128-1



Shape of the wave generator hub for size 14 and 17 (no keyhole)

The shape on the output side of size 65

Enlarged view of the input side

(Note) Note that the length of the path of contact of the bolt will be within the depth of the female screw. If the length exceeds the size indicated by the symbol, Z, it will damage the flexspline.

* The shape of the output flange may vary depending on the size. Contact us for details. * Check the confirmation drawing for details of the sizes.
* See Fig. 040-3 on Page 40 for the shapes of the wave generator. 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.

Dimensions

Table 129-1

Unit: mm

Symbol \ Size		14	17	20	25	32	40	45	50	58	65
φA		73	79	93	107	138	160	180	190	226	260
B*		$41^{0}_{-0.9}$	$45^{0}_{-0.9}$	$45.5^{0}_{-1.0}$	$52^{0}_{-1.0}$	$62^{0}_{-1.1}$	$72.5^{0}_{-1.1}$	$79.5^{0}_{-1.2}$	$90^{0}_{-1.3}$	$104.5^{0}_{-1.3}$	$115^{0}_{-1.3}$
C		34	37	38	46	57	66.5	74	85	97	108.5
D*	CSG Series / CSG-LW Series	$7^{0}_{-0.4}$	$8^{0}_{-0.4}$	$7.5^{0}_{-0.4}$	$6^{0}_{-0.5}$	$5^{0}_{-0.6}$	$6^{0}_{-0.6}$	$5.5^{0}_{-0.6}$	$5^{0}_{-0.6}$	$7.5^{0}_{-0.6}$	$6.5^{0}_{-0.6}$
	CSF Series / CSF-LW Series	$7^{0}_{-0.8}$	$8^{0}_{-0.9}$	$7.5^{0}_{-1.0}$	$6^{0}_{-1.0}$	$5^{0}_{-1.1}$	$6^{0}_{-1.1}$	$5.5^{0}_{-1.2}$	$5^{0}_{-1.3}$	$7.5^{0}_{-1.3}$	$6.5^{0}_{-1.3}$
E		27	29	28	36	45	50.5	58	69	77	84.5
F		7	8	10	10	12	16	16	16	20	24
G		2	2	3	3	3	4	4	4	5	5
H	CSG Series	3.5	4	5	5	5	5	6	6	6	6
	CSG-LW Series	4	4	5	5	5	5	6	6	6	6
	CSF Series	3.5	4	5	5	5	5	6	6	6	6
	CSF-LW Series	4	4	5	5	5	5	6	6	6	6
L	CSG Series	0.5	0.5	0.5	0.5	1	1.5	1	1	1.5	1.5
	CSG-LW Series	1.1	1.1	1.1	1.1	1.2	1.6	1.6	1	1.5	1.5
	CSF Series	0.5	1.1	1.1	1.1	1.2	1.6	1.6	1	1.5	1.5
	CSF-LW Series	1.1	1.1	1.1	1.1	1.2	1.6	1.6	1	1.5	1.5
M1		9.4	9.5	9	2	15	5	6	8	10	10
M2		-	-	-	-	-	-	-	-	-	4
$N^{0}_{-0.1}$	CSG Series / CSG-LW Series	18.5	20.7	21.5	21.6	23.6	29.7	30.5	34.8	38.3	44.6
	CSF Series / CSF-LW Series	17.6	19.5	20.1	20.2	22	27.5	27.9	32	34.9	40.9
φO h7		56	63	72	86	113	127	148	158	186	212
φP	CSG Series	56	62	70	85	112	123	147	157	185	210
	CSG-LW Series	54.6	61.6	69.6	85	110	124.5	143	155	183.4	208.4
	CSF Series	55	62	70	85	112	123	147	157	185	210
	CSF-LW Series	54.6	61.6	69.6	85	110	124.5	143	155	183.4	208.4
φQ	CSG Series	42.5	49.5	58	73	96	109	127	137	161	186
	CSG-LW Series	40.5	47.5	55.5	71	91.1	103	123	130	155	180
	CSF Series	42.5	49.5	58	73	96	109	127	137	161	186
	CSF-LW Series	40.5	47.5	55.5	71	91.1	103	123	130	155	180
φR1 H7		11	10	14	20	26	32	32	40	46	52
φR2 H7		-	-	-	-	-	-	-	-	-	142
φS		8	7	10	15	20	24	25	32	38	44
φT h7		38	48	56	67(68)	90	110	124	135	156	177
φU	Standard (H7)	6	8	12	14	14	14	19	19	22	24
	Max. size	8	10	13	15	15	20	20	20	25	30
V		-	-	$13.8^{+0.1}_{0}$	$16.3^{+0.1}_{0}$	$16.3^{+0.1}_{0}$	$16.3^{+0.1}_{0}$	$21.8^{+0.1}_{0}$	$21.8^{+0.1}_{0}$	$24.8^{+0.1}_{0}$	$27.3^{+0.2}_{0}$
W Js9		-	-	4	5	5	5	6	6	6	8
φX		23	27	32	42	55	68	82	84	100	110
Y		6	6	8	8	8	8	8	8	8	8
Z		M4×8	M5×10	M6×9	M8×12	M10×15	M10×15	M12×18	M14×21	M16×24	M16×24
a		1	1	1.5	1.5	1.5	2	2	2	2.5	2.5
φb		65	71	82	96	125	144	164	174	206	236
c	CSG Series	8	8	8	10	12	10	12	14	12	8
	CSG-LW Series	6	8	8	10	12	10	16	18	16	12
	CSF Series	6	6	6	8	12	8	12	12	12	8
	CSF-LW Series	6	8	8	10	12	10	16	18	16	12
φd		4.5	4.5	5.5	5.5	6.6	9	9	9	11	14
φe		38	45	53	66	86	106	119	133	154	172
f	CSG Series	8	8	8	10	12	10	12	14	12	8
	CSG-LW Series	6	8	8	10	12	10	16	18	16	12
	CSF Series	6	6	6	8	12	8	12	12	12	8
	CSF-LW Series	6	8	8	10	12	10	16	18	16	12
g		M4	M4	M5	M5	M6	M8	M8	M8	M10	M12
h		29.0×0.50	34.5×0.80	40.64×1.14	53.28×0.99	S71	AS568-042	S100	S105	S125	S135
i		S50	S56	S67	S80	S105	S125	S145	S155	S180	S205
φk		31	38	45	58	78	90	107	112	135	155
φm		10	10.5	15.5	20	27	34	36	39	46	56
r		21.4	23.5	23	29	37	39.5	45.5	53	62.8	66.5
t*	CSG Series / CSG-LW Series	1.1	0.8	1	1.4	1.4	3.3	3.5	2.2	3.4	3.9
	CSF Series / CSF-LW Series	2	2	2.4	2.8	3	5.5	6.1	5	6.8	7.6
φy		14	18	21	26	26	32	32	32	40	48
Mass (kg)	CSG Series	0.52	0.68	0.98	1.5	3.2	5.0	7.0	8.9	14.6	20.9
	CSG-LW Series	0.32	0.46	0.64	1.1	2.2	3.5	5.1	7	11.3	16.2
	CSF Series	0.52	0.68	0.98	1.5	3.2	5.0	7.0	8.9	14.6	20.9
	CSF-LW Series	0.32	0.46	0.64	1.1	2.2	3.5	5.1	7	11.3	16.2

(note1) the dimension in parenthesis is for reduction ratio 30.

- *The B, D, and t values indicate relative position of individual gearing components (wave generator, flexspline, circular spline). Please strictly adhere to these values when designing your housing and mating parts.
- Wave generator is removed when the product is delivered.
- CSF & CSG-LW available in sizes 14 to 45.
- Due to deformation of the Flexspline during operation, it is necessary to provide a minimum housing clearance, dimensions a, φe.

Positioning accuracy

See "Engineering data" for a description of terms.

Table 130-1

Unit: X10^{-4}rad (arc•min)

Ratio	Specification \ Size	14	17	20	25	32	40 to 65
30	Standard product	5.8	4.4	4.4	4.4	4.4	—
		(2)	(1.5)	(1.5)	(1.5)	(1.5)	—
	Special product	—	—	2.9	2.9	2.9	—
		—	—	(1)	(1)	(1)	—
50 or more	Standard product	4.4	4.4	2.9	2.9	2.9	2.9
		(1.5)	(1.5)	(1)	(1)	(1)	(1)
	Special product	2.9	2.9	1.5	1.5	1.5	1.5
		(1)	(1)	(0.5)	(0.5)	(0.5)	(0.5)

Hysteresis loss

See "Engineering data" for a description of terms.

Table 130-2

Ratio	Size	14	17	20	25	32	40 or more
30	×10^{-4}rad	8.7	8.7	8.7	8.7	8.7	—
	arc min	3.0	3.0	3.0	3.0	3.0	—
50	×10^{-4}rad	5.8	5.8	5.8	5.8	5.8	5.8
	arc min	2.0	2.0	2.0	2.0	2.0	2.0
80 or more	×10^{-4}rad	2.9	2.9	2.9	2.9	2.9	2.9
	arc min	1.0	1.0	1.0	1.0	1.0	1.0

Max. backlash quantity

See "Engineering data" for a description of terms.

Table 130-3

Ratio	Size	14	17	20	25	32	40	45	50	58	65
30	×10^{-5}rad	29.1	16.0	13.6	13.6	11.2	—	—	—	—	—
	arc sec	60	33	28	28	23	—	—	—	—	—
50	×10^{-5}rad	17.5	9.7	8.2	8.2	6.8	6.8	5.8	5.8	4.8	4.8
	arc sec	36	20	17	17	14	14	12	12	10	10
80	×10^{-5}rad	11.2	6.3	5.3	5.3	4.4	4.4	3.9	3.9	2.9	2.9
	arc sec	23	13	11	11	9	9	8	8	6	6
100	×10^{-5}rad	8.7	4.8	4.4	4.4	3.4	3.4	2.9	2.9	2.4	2.4
	arc sec	18	10	9	9	7	7	6	6	5	5
120	×10^{-5}rad	—	3.9	3.9	3.9	2.9	2.9	2.4	2.4	1.9	1.9
	arc sec	—	8	8	8	6	6	5	5	4	4
160	×10^{-5}rad	—	—	2.9	2.9	2.4	2.4	1.9	1.9	1.5	1.5
	arc sec	—	—	6	6	5	5	4	4	3	3

Torsional stiffness

See "Engineering data" for a description of terms.

Table 130-4

Symbol		Size	14	17	20	25	32	40	45	50	58	65
	T_1	Nm	2.0	3.9	7.0	14	29	54	76	108	168	235
		kgfm	0.20	0.40	0.70	1.4	3.0	5.5	7.8	11	17	24
	T_2	Nm	6.9	12	25	48	108	196	275	382	598	843
		kgfm	0.7	1.2	2.5	4.9	11	20	28	39	61	86
Reduction ratio 30	K_1	×10^{4}Nm/rad	0.19	0.34	0.57	1.0	2.4	—	—	—	—	—
		kgfm/arc min	0.056	0.10	0.17	0.30	0.70	—	—	—	—	—
	K_2	×10^{4}Nm/rad	0.24	0.44	0.71	1.3	3.0	—	—	—	—	—
		kgfm/arc min	0.07	0.13	0.21	0.40	0.89	—	—	—	—	—
	K_3	×10^{4}Nm/rad	0.34	0.67	1.1	2.1	4.9	—	—	—	—	—
		kgfm/arc min	0.10	0.20	0.32	0.62	1.5	—	—	—	—	—
	θ_1	×10^{-4}rad	10.5	11.5	12.3	14	12.1	—	—	—	—	—
		arc min	3.6	4.0	4.1	4.7	4.3	—	—	—	—	—
	θ_2	×10^{-4}rad	31	30	38	40	38	—	—	—	—	—
		arc min	10.7	10.2	12.7	13.4	13.3	—	—	—	—	—
Reduction ratio 50	K_1	×10^{4}Nm/rad	0.34	0.81	1.3	2.5	5.4	10	15	20	31	44
		kgfm/arc min	0.1	0.24	0.38	0.74	1.6	3.0	4.3	5.9	9.3	13
	K_2	×10^{4}Nm/rad	0.47	1.1	1.8	3.4	7.8	14	20	28	44	61
		kgfm/arc min	0.14	0.32	0.52	1.0	2.3	4.2	6.0	8.2	13	18
	K_3	×10^{4}Nm/rad	0.57	1.3	2.3	4.4	9.8	18	26	34	54	78
		kgfm/arc min	0.17	0.4	0.67	1.3	2.9	5.3	7.6	10	16	23
	θ_1	×10^{-4}rad	5.8	4.9	5.2	5.5	5.5	5.2	5.2	5.5	5.2	5.2
		arc min	2.0	1.7	1.8	1.9	1.9	1.8	1.8	1.9	1.8	1.8
	θ_2	×10^{-4}rad	16	12	15.4	15.7	15.7	15.4	15.1	15.4	15.1	15.1
		arc min	5.6	4.2	5.3	5.4	5.4	5.3	5.2	5.3	5.2	5.2

* The values in this table are reference values. The minimum value is approximately 80% of the displayed value.

Table 131-1

Symbol \ Size			14	17	20	25	32	40	45	50	58	65
	T_1	Nm	2.0	3.9	7.0	14	29	54	76	108	168	235
		kgfm	0.20	0.40	0.70	1.4	3.0	5.5	7.8	11	17	24
	T_2	Nm	6.9	12	25	48	108	196	275	382	598	843
		kgfm	0.7	1.2	2.5	4.9	11	20	28	39	61	86
Reduction ratio 80 or more	K_1	$\times 10^4$Nm/rad	0.47	1	1.6	3.1	6.7	13	18	25	40	54
		kgfm/arc min	0.14	0.3	0.47	0.92	2.0	3.8	5.4	7.4	12	16
	K_2	$\times 10^4$Nm/rad	0.61	1.4	2.5	5.0	11	20	29	40	61	88
		kgfm/arc min	0.18	0.4	0.75	1.5	3.2	6.0	8.5	12	18	26
	K_3	$\times 10^4$Nm/rad	0.71	1.6	2.9	5.7	12	23	33	44	71	98
		kgfm/arc min	0.21	0.46	0.85	1.7	3.7	6.8	9.7	13	21	29
	θ_1	$\times 10^{-4}$rad	4.1	3.9	4.4	4.4	4.4	4.1	4.1	4.4	4.1	4.4
		arc min	1.4	1.3	1.5	1.5	1.5	1.4	1.4	1.5	1.4	1.5
	θ_2	$\times 10^{-4}$rad	12	9.7	11.3	11.1	11.6	11.1	11.1	11.1	11.1	11.3
		arc min	4.2	3.3	3.9	3.8	4.0	3.8	3.8	3.8	3.8	3.9

* The values in this table are reference values. The minimum value is approximately 80% of the displayed value.

Starting torque

See "Engineering data" for a description of terms. As the values in the table below vary depending on the use conditions, use them as reference values.

CSG Series

Table 131-2
Unit: Ncm

Ratio \ Size	14	17	20	25	32	40	45	50	58	65
50	4.5	6.7	8.6	17	34	61	85	—	—	—
80	3.1	4.4	5.4	10	21	39	54	73	108	154
100	2.8	3.7	4.7	8.8	20	34	47	64	97	132
120	—	3.4	4.2	8.0	17	31	43	57	88	121
160	—	—	3.6	6.9	15	26	36	50	75	102

CSF Series

Table 131-3
Unit: Ncm

Ratio \ Size	14	17	20	25	32	40	45	50	58	65
30	6.4	9.3	15	25	54	—	—	—	—	—
50	4.1	6.1	7.8	15	31	55	77	110	160	220
80	2.8	4	4.9	9.2	19	35	49	66	98	140
100	2.5	3.4	4.3	8	18	31	43	58	88	120
120	—	3.1	3.8	7.3	15	28	39	52	80	110
160	—	—	3.3	6.3	14	24	33	45	68	93

Backdriving torque

See "Engineering data" for a description of terms. As the values in the table below vary depending on the use conditions, use them as reference values.

CSG Series

Table 131-4
Unit: Nm

Ratio \ Size	14	17	20	25	32	40	45	50	58	65
50	1.8	3.3	5.2	9.9	20	36	52	—	—	—
80	1.8	3.3	5.3	10	21	36	53	69	106	154
100	2	3.6	5.6	11	22	40	56	75	121	165
120	—	3.9	6.1	12	24	43	61	80	121	176
160	—	—	7	14	29	51	70	94	143	198

CSF Series

Table 131-5
Unit: Nm

Ratio \ Size	14	17	20	25	32	40	45	50	58	65
30	2.4	3.8	6.2	11	23	—	—	—	—	—
50	1.6	3	4.7	9	18	33	47	62	95	130
80	1.6	3	4.8	9.1	19	33	48	63	96	140
100	1.8	3.3	5.1	9.8	20	36	51	68	110	150
120	—	3.5	5.5	11	22	39	55	73	110	160
160	—	—	6.4	13	26	46	64	85	130	180

Ratcheting torque

See "Engineering data" for a description of terms.

CSG Series

Table 132-1
Unit: Nm

Ratio \ Size	14	17	20	25	32	40	45	50	58	65
50	110	190	280	580	1200	2300	3500	—	—	—
80	140	260	450	880	1800	3600	5000	7000	10000	14000
100	100	200	330	650	1300	2700	4000	5300	8300	12000
120	—	150	310	610	1200	2400	3600	4900	7500	10000
160	—	—	280	580	1200	2300	3300	4600	7200	10000

CSF Series

Table 132-2
Unit: Nm

Ratio \ Size	14	17	20	25	32	40	45	50	58	65
30	59	100	170	340	720	—	—	—	—	—
50	88	150	220	450	980	1800	2700	3700	5800	7800
80	110	200	350	680	1400	2800	3900	5400	8200	11000
100	84	160	260	500	1000	2100	3100	4100	6400	9400
120	—	120	240	470	980	1900	2800	3800	5800	8300
160	—	—	220	450	980	1800	2600	3600	5600	8000

Buckling torque

See "Engineering data" for a description of terms.

CSG Series

Table 132-3
Unit: Nm

Size	14	17	20	25	32	40	45	50	58	65
All ratios	260	500	800	1700	3500	6700	8900	12200	19000	26600

CSF Series

Table 132-4
Unit: Nm

Size	14	17	20	25	32	40	45	50	58	65
All ratios	190	330	560	1000	2200	4300	5800	8000	12000	17000

No-load running torque

No load running torque indicates the torque which is needed to rotate input of the gear, "Wave Generator", with no load on the output side (low speed side).

Measurement condition

Table 132-5

Ratio			
Lubricant	Grease lubrication	Name	Harmonic Grease SK-1A
			Harmonic Grease SK-2
		Quantity	Recommended quantity
Torque value is measured after 2 hours at 2000rpm input.			

* Contact us for oil lubrication.

Compensation Value in Each Ratio

No-load running torque of the gear varies with ratio.
The graphs indicate a value for ratio 100.
For other gear ratios, add the compensation values from table on the right.

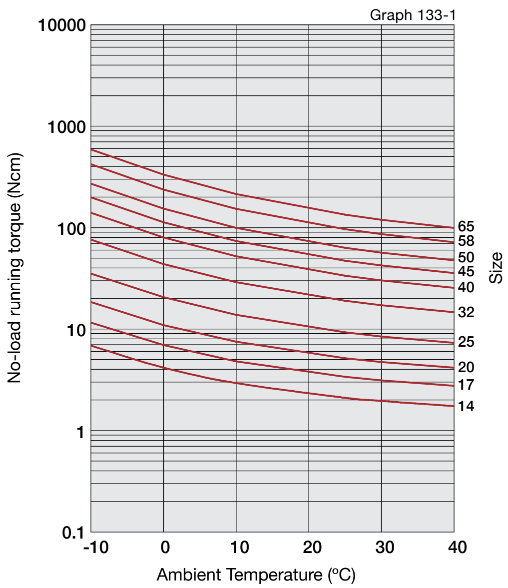
Compensation value for no-load running torque

Table 132-6
Unit: Ncm

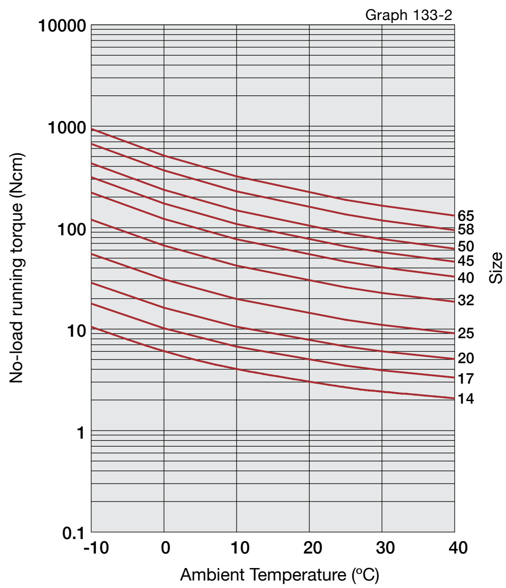
Size \ Ratio	30	50	80	120	160
14	2.5	1.1	0.2	—	—
17	3.8	1.6	0.3	-0.2	—
20	5.4	2.3	0.5	-0.3	-0.8
25	8.8	3.8	0.7	-0.5	-1.2
32	16	7.1	1.3	-0.9	-2.2
40	—	12	2.1	-1.5	-3.5
45	—	16	2.9	-2.1	-4.9
50	—	21	3.7	-2.6	-6.2
58	—	30	5.3	-3.8	-8.9
65	—	41	7.2	-5.1	-12

■ No-load running torque for a reduction ratio of 100:1

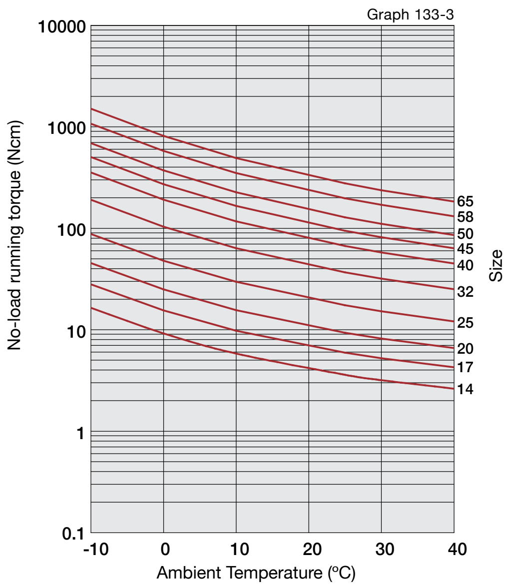
Input speed: 500rpm



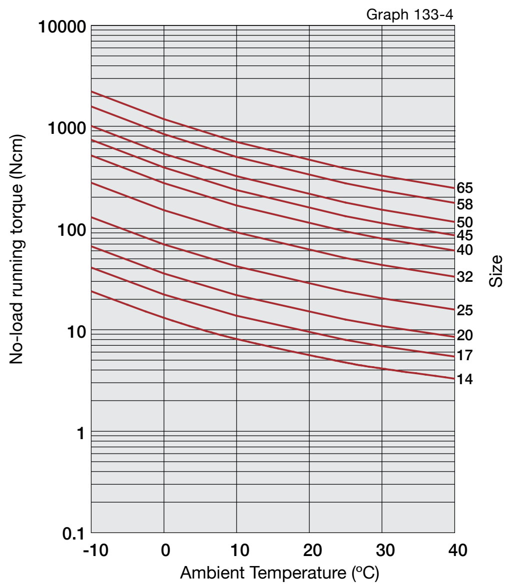
Input speed: 1000rpm



Input speed: 2000rpm



Input speed: 3500rpm



*The values in this graph are average values ($\overline{X}$). σ≈20%

Efficiency

The efficiency varies depending on the following conditions.

- Reduction ratio
- Input rotational speed
- Load torque
- Temperature
- Lubrication (Type and quantity)

Measurement condition Table 134-1

Installation	Based on recommended tolerance.		
Load torque	The rated torque shown in the rating table (see page 126 and 127)		
Lubricant	Grease lubrication	Name	Harmonic Grease SK-1A
			Harmonic Grease SK-2
		Quantity	Recommended quantity

Efficiency compensation coefficient

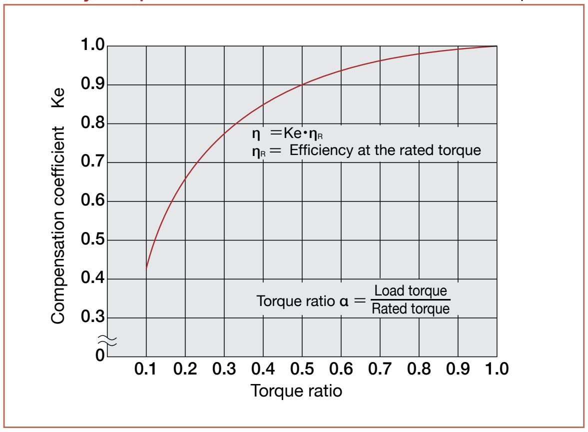
If the load torque is lower than the rated torque, the efficiency will be lower. Calculate the compensation coefficient Ke from Graph 134-1 to calculate the efficiency using the following example.

Calculation Example

Efficiency η (%) under the following condition is calculated from the example of CSF-20-80-2A-GR.
Input rotational speed: 1000 rpm
Load torque: 19.6 Nm
Lubrication: Grease lubrication (Harmonic Grease SK-1A)
Lubricant temperature: 20ºC
Since the rated torque of size 20 with a reduction ratio of 80 is 34 Nm (Ratings: Page 127), the torque ratio α is 0.58.
(α=19.6/34=0.58)

- The efficiency compensation coefficient is Ke=0.93 from Graph 134-1.
- Efficiency η at load torque 19.6 Nm: η=Ke•ηR=0.93 x 78=73%

Efficiency compensation coefficient Graph 134-1

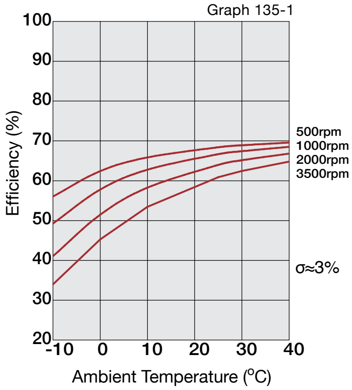


* Efficiency compensation coefficient Ke=1 holds when the load torque is greater than the rated torque.

■ Efficiency at rated torque (Size 14)

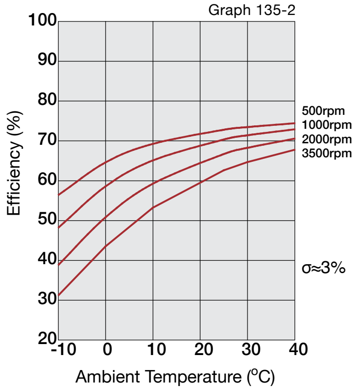
Ratio 30

Graph 135-1



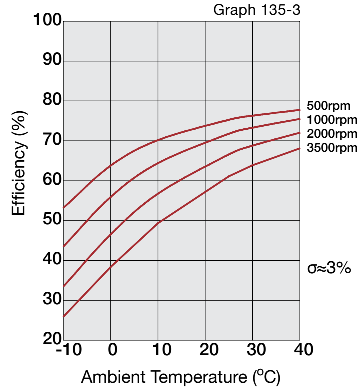
Ratio 50, 80

Graph 135-2



Ratio 100

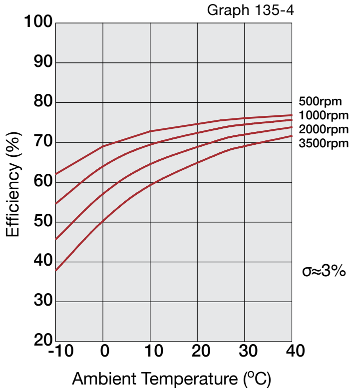
Graph 135-3



■ Efficiency at rated torque (Sizes 17 to 65)

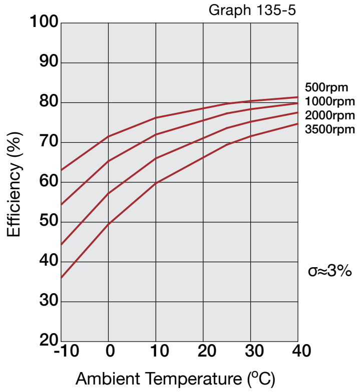
Ratio 30

Graph 135-4



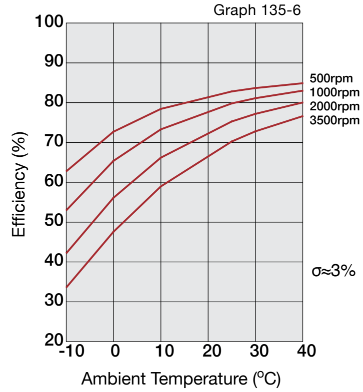
Ratio 50

Graph 135-5



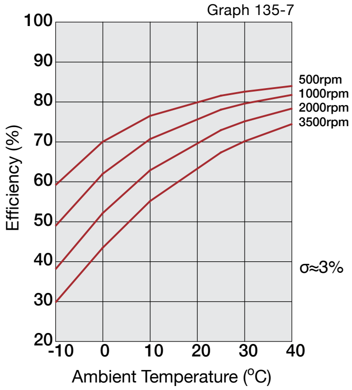
Ratio 80, 100

Graph 135-6



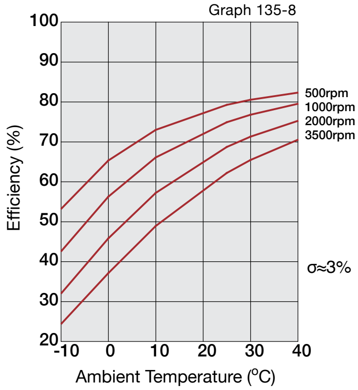
Ratio 120

Graph 135-7



Ratio 160

Graph 135-8



Checking Output Bearing

A precision cross roller bearing is built in the unit type to directly support the external load (output flange).
Check the maximum moment load, life of the bearing and static safety coefficient to fully bring out the performance of the unit type.
See Pages 30 to 34 of "Engineering data" for each calculation formula.

■ Checking procedure

(1) Checking the maximum moment load (M_{max})

Calculate maximum moment load (M_{max}). → Maximum moment load (M_{max}) ≦ allowable moment (Mc)

(2) Checking the life

Calculate the radial load (Fr_{av}) and the average axial load (Fa_{av}). → Calculate the radial load coefficient (x) and the axial load coefficient (y). → Calculate the lifetime

(3) Checking the static safety coefficient

Calculate the static equivalent radial load coefficient (Po). → Check the static safety coefficient. (fs)

■ Output bearing specifications

The specifications of the cross roller are shown in Table 136-1.

Specifications CSG Series/CSF Series

Table 136-1

Size	Pitch circle dia. of a roller dp	Offset R	Basic rated load: Basic dynamic rated load C		Basic rated load: Basic static rated load Co		Allowable moment load Mc		Moment stiffness	
	m	m	$\times10^2$N	kgf	$\times10^2$N	kgf	Nm	kgfm	$\times10^4$ Nm/rad	kgfm/arc min
14	0.035	0.0095	47	480	60.7	620	41	4.2	4.38	1.3
17	0.0425	0.0095	52.9	540	75.5	770	64	6.5	7.75	2.3
20	0.050	0.0095	57.8	590	90.0	920	91	9.3	12.8	3.8
25	0.062	0.0115	96.0	980	151	1540	156	16	24.2	7.2
32	0.080	0.013	150	1530	250	2550	313	32	53.9	16
40	0.096	0.0145	213	2170	365	3720	450	46	91.0	27
45	0.111	0.0155	230	2350	426	4340	686	70	141	42
50	0.119	0.018	348	3550	602	6140	759	77	171	51
58	0.141	0.0205	518	5290	904	9230	1180	120	283	84
65	0.160	0.0225	556	5670	1030	10500	1860	190	404	120

Specifications CSG-LW/CSF-LW Series

Table 136-2

Size	Pitch circle dia. of a roller dp	Offset R	Basic rated load: Basic dynamic rated load C		Basic rated load: Basic static rated load Co		Allowable moment load Mc		Moment stiffness	
	m	m	$\times10^2$N	kgf	$\times10^2$N	kgf	Nm	kgfm	$\times10^4$ Nm/rad	kgfm/arc min
14	0.035	0.0093	47	480	60.7	620	33.6	3.4	3.6	1.1
17	0.043	0.0091	52.9	540	75.5	770	52.5	5.3	6.4	1.9
20	0.050	0.0098	57.8	590	90	920	74.6	7.6	10.5	3.1
25	0.064	0.0118	96	980	151	1540	127.9	13.1	19.8	5.9
32	0.083	0.0133	150	1530	250	2550	256.7	26.2	44.2	13.1
40	0.096	0.0148	213	2170	365	3720	369	37.7	74.6	22.1
45	0.111	0.0158	230	2350	426	4340	562.5	57.4	115.6	34.4
50	0.119	0.0180	348	3550	602	6140	622	63.5	140	48.5
58	0.141	0.0205	518	5290	904	9230	838	85.4	201	59.6
65	0.160	0.0185	556	5670	1030	10500	1525	156	331	108

* The basic dynamic rated load is the static radial load needed to result in a basic dynamic rated life of one million rotations.
* The basic static rated load is the static load that produces a contact stress of 4 kN/mm2 in the center of the contact area between the rolling element receiving the maximum load.
* The moment stiffness value is an average.
* Allowable moment load is the maximum moment load that may be applied to the output shaft. Please adhere to these values for optimum performance. Moment stiffness is a reference value. The minimum value is approximately 80% of the displayed value.
* Allowable axial or radial load is the value that satisfies the reducer life when either a radial load or an axial load is applied to the main shaft. (When radial load is Lr+R=0mm, and axial load is La=0mm)

Design Guide

Output Bearing and Housing Tolerances

Fig. 137-1

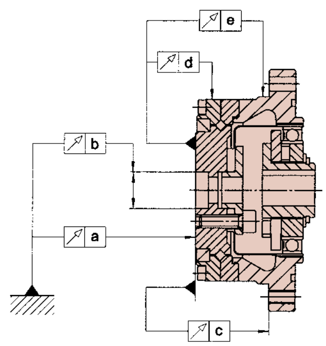


Table 137-1
Unit: mm

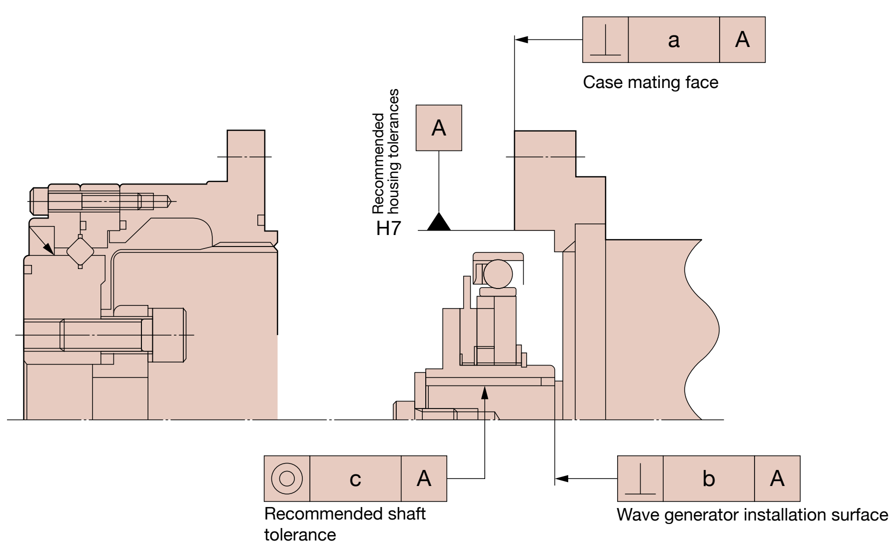
Symbol \ Size	14	17	20	25	32	40	45	50	58	65
a	0.010	0.010	0.010	0.015	0.015	0.015	0.018	0.018	0.018	0.018
b	0.010	0.012	0.012	0.013	0.013	0.015	0.015	0.015	0.017	0.017
c	0.024	0.026	0.038	0.045	0.056	0.060	0.068	0.069	0.076	0.085
d	0.010	0.010	0.010	0.010	0.010	0.015	0.015	0.015	0.015	0.015
e	0.038	0.038	0.047	0.049	0.054	0.060	0.065	0.067	0.070	0.075

Installation Accuracy

For peak performance of your gear, maintain the recommended tolerances shown in Figure 137-1 and Table 137-1.

Recommended tolerances for assembly

Fig. 137-2



Recommended Tolerances for Assembly

Table 137-2
Unit: mm

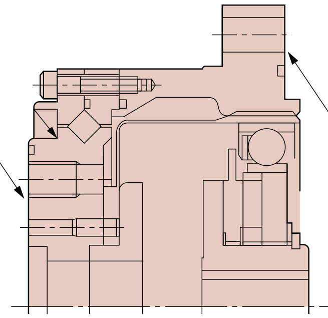
Symbol \ Size	14	17	20	25	32	40	45	50	58	65
a	0.011	0.015	0.017	0.024	0.026	0.026	0.027	0.028	0.031	0.034
b	0.017	0.020	0.020	0.024	0.024	0.032	0.032	0.032	0.032	0.032
	(0.008)	(0.010)	(0.010)	(0.012)	(0.012)	(0.012)	(0.013)	(0.015)	(0.015)	(0.015)
c	0.030	0.034	0.044	0.047	0.050	0.063	0.065	0.066	0.068	0.070
	(0.016)	(0.018)	(0.019)	(0.022)	(0.022)	(0.024)	(0.027)	(0.030)	(0.033)	(0.035)

* The value in the parentheses indicates that input (wave generator) is a solid wave generator.

Gear Unit CSG/CSF

Installation and transmission torque

Fig. 138-1



CSG series: Installation of output flange side and transmission torque

Table 138-1

Item \ Size		14	17	20	25	32	40	45	50	58	65
Number of bolts		6	6	8	8	8	8	8	8	8	8
Bolt size		M4	M5	M6	M8	M10	M10	M12	M14	M16	M16
Pitch circle	mm	23	27	32	42	55	68	82	84	100	110
Clamp torque	Nm	5.4	10.8	18.4	45	89	89	154	246	383	383
Torque transmission capacity (bolt only)	Nm	58	109	245	580	1220	1510	2624	3690	5981	6579

CSG series: Installation of case side and transmission torque

Table 138-2

Item \ Size		14	17	20	25	32	40	45	50	58	65
Number of bolts		8	8	8	10	12	10	12	14	12	8
Bolt size		M4	M4	M5	M5	M6	M8	M8	M8	M10	M12
Pitch circle	mm	65	71	82	96	125	144	164	174	206	236
Clamp torque	Nm	4.5	4.5	9.0	9.0	15.3	37	37	37	74	128
Torque transmission capacity (bolt only)	Nm	182	196	365	538	1200	2100	2844	3251	5717	6293

(Table 138-1, 138-2/Notes)
1. The material of the thread must withstand the clamp torque.
2. Recommended bolt: JIS B 1176 socket head cap screw / Strength range: JIS B 1051 over 12.9.
3. Torque coefficient: K=0.2
4. Clamp coefficient: A=1.4
5. Tightening friction coefficient μ=0.15

CSG-LW series (Lightweight): Bolt connection to output flange and resulting transmission torque

Table 138-3

Item \ Size		14	17	20	25	32	40	45	50	58	65
Number of bolts		6	6	8	8	8	8	8	8	8	8
Bolt size		M4	M5	M6	M8	M10	M10	M12	M14	M16	M16
Pitch circle	mm	23	27	32	42	55	68	82	84	100	110
Clamp torque	Nm	5.4	10.8	18.4	45	89	89	154	246	383	383
Torque transmission capacity (bolt only)	Nm	58	109	245	580	1220	1510	2624	3690	5981	6579

CSG-LW series (Lightweight): Bolt connection to case side and resulting transmission torque

Table 138-4

Item \ Size		14	17	20	25	32	40	45	50	58	65
Number of bolts		6	8	8	10	12	10	16	18	16	12
Bolt size		M4	M4	M5	M5	M6	M8	M8	M8	M10	M12
Pitch circle	mm	65	71	82	96	125	144	164	174	206	236
Clamp torque	Nm	3.2	3.2	6.4	6.4	10.8	26.5	26.5	26.5	51.9	90
Torque transmission capacity (bolt only)	Nm	98	143	261	382	842	1488	2712	3237	5350	6649

(Table 138-3, 138-4/Notes)
1. The material of the thread must withstand the clamp torque.
2. Recommended bolt: JIS B 1176 socket head cap screw / Strength range: JIS B 1051 over 12.9.
3. Torque coefficient: K=0.2
4. Clamp coefficient: A=1.4
5. Tightening friction coefficient μ=0.15
6. Since the material of the flange on the case side of CSG-LW is AL (aluminum), be sure to set the bolt tightening torque to the value in Table 138-4. If the tightening toque exceeds the value listed in Table 138-4, the correct transmission torque may not be obtained and looseness may be caused.

CSF series: Bolt connection to output flange and resulting transmission torque

Table 139-1

Item \ Size		14	17	20	25	32	40	45	50	58	65
Number of bolts		6	6	8	8	8	8	8	8	8	8
Bolt size		M4	M5	M6	M8	M10	M10	M12	M14	M16	M16
Pitch circle	mm	23	27	32	42	55	68	82	84	100	110
Clamp torque	Nm	4.5	9	15.3	37	74	74	128	205	319	319
Torque transmission capacity (bolt only)	Nm	49	91	204	486	1108	1258	2200	3070	4980	5480

CSF series: Bolt connection to case side and resulting transmission torque

Table 139-2

Item \ Size		14	17	20	25	32	40	45	50	58	65
Number of bolts		6	6	6	8	12	8	12	12	12	8
Bolt size		M4	M4	M5	M5	M6	M8	M8	M8	M10	M12
Pitch circle	mm	65	71	82	96	125	144	164	174	206	236
Clamp torque	Nm	4.5	4.5	9.0	9.0	15.3	37	37	37	74	128
Torque transmission capacity (bolt only)	Nm	137	147	274	431	1200	1680	2860	3040	5670	6310

(Table 139-1, 139-2/Notes)
1. The material of the thread must withstand the clamp torque.
2. Recommended bolt: JIS B 1176 socket head cap screw / Strength range: JIS B 1051 over 12.9.
3. Torque coefficient: K=0.2
4. Clamp coefficient: A=1.4
5. Tightening friction coefficient μ=0.15

CSF-LW series: Bolt connection to output flange and resulting transmission torque

Table 139-3

Item \ Size		14	17	20	25	32	40	45	50	58	65
Number of bolts		6	6	8	8	8	8	8	8	8	8
Bolt size		M4	M5	M6	M8	M10	M10	M12	M14	M16	M16
Pitch circle	mm	23	27	32	42	55	68	82	84	100	110
Clamp torque	Nm	4.5	9.0	15.3	37	74	74	128	205	128	128
Torque transmission capacity (bolt only)	Nm	49	91	204	486	1019	1258	2200	3070	4980	5480

CSF-LW series: Bolt connection to case side and resulting transmission torque

Table 139-4

Item \ Size		14	17	20	25	32	40	45	50	58	65
Number of bolts		6	8	8	10	12	10	16	18	16	12
Bolt size		M4	M4	M5	M5	M6	M8	M8	M8	M10	M12
Pitch circle	mm	65	71	82	96	125	144	164	174	206	236
Clamp torque	Nm	3.2	3.2	6.4	6.4	10.8	26.5	26.5	26.5	51.9	90
Torque transmission capacity (bolt only)	Nm	9.8	143	261	382	842	1488	2712	3237	5350	6649

(Table 139-3, 139-4/Notes)
1. The material of the thread must withstand the clamp torque.
2. Recommended bolt: JIS B 1176 socket head cap screw / Strength range: JIS B 1051 over 12.9.
3. Torque coefficient: K=0.2
4. Clamp coefficient: A=1.4
5. Tightening friction coefficient **μ**=0.15
6. Since the material of the flange on the case side of CSF-LW is AL (aluminum), be sure to set the bolt tightening torque to the value in Table 139-4.
   If the tightening toque exceeds the value listed in Table 139-4, the correct transmission torque may not be obtained and looseness may be caused.

■ Precautions on installing the load to the output flange (Sizes 14 to 25)

As the distance (see the size symbol "L" in Figure 128-1 on Page 128) between the oil seal on the output flange periphery and the edge of the output flange (rotor) is short for the gear units sizes 14, 17, 20 and 25, the load may interfere with the oil seal. Produce a design so that the load cannot be applied to the oil seal.

Installation of a motor

Motor mounting flange

A motor mounting flange is required for installing a motor. The recommended size and precision of the basic part of the motor mounting flange is shown in Table 140-1.

Fig. 140-1

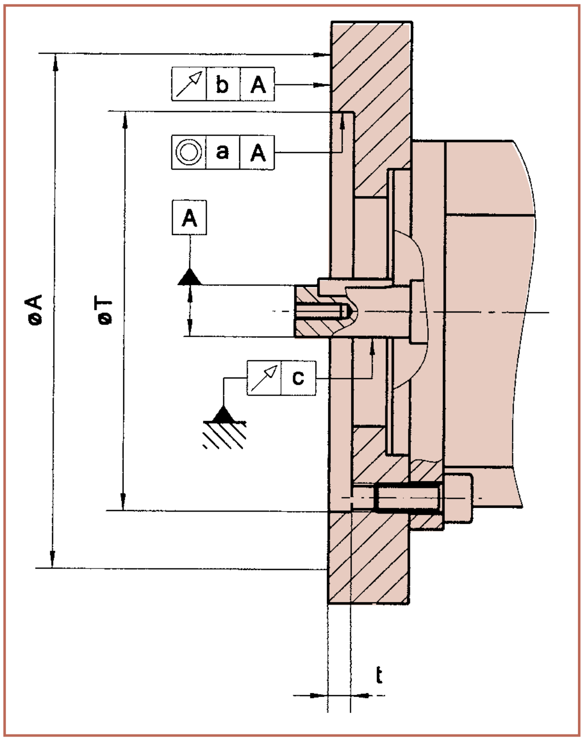


Table 140-1
Unit: mm

Symbol \ Size	14	17	20	25	32	40	45	50	58	65
a	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05
b	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05
c	0.015	0.015	0.018	0.018	0.018	0.018	0.021	0.021	0.021	0.021
ϕA	73	79	93	107	138	160	180	190	226	260
t	3	3	4.5	4.5	4.5	6	6	6	7.5	7.5
ϕT	38H7	48H7	56H7	67H7	90H7	110H7	124H7	135H7	156H7	177H7

Installation of three parts of basic elements

Installation of the wave generator

Maximum hole diameter size

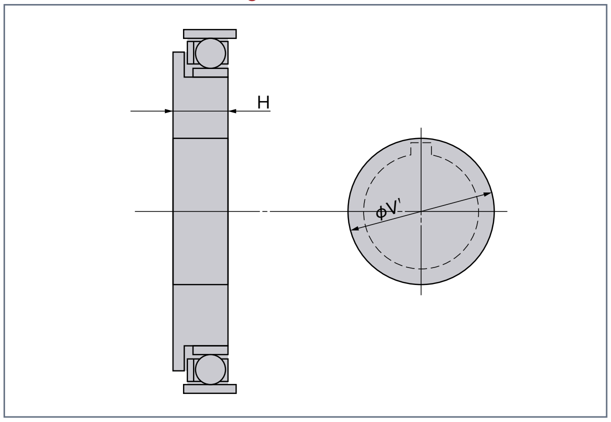
The standard hole diameter of the wave generator is as shown in the dimensional outline drawing and may be changed in the range up to the maximum dimension shown in the table. The JIS standard is recommended for the key groove size. The valid length of the key shall be the value fully durable for the transmission torque.

* The shape can be changed to special forms for taper holes and so on.

Oldham's coupling mechanism may be eliminated to make a hole diameter larger than the maximum size. The maximum hole diameter can be up to the value shown in the table below taking deformation of the wave generator plug by load torque into consideration.
(This is the value including the dimension of the key groove depth.)

Hole diameter of the wave generator

Fig.140-1



Hole diameter of the wave generator hub

Table140-1
Unit: mm

Size \ Model	14	17	20	25	32	40	45	50	58	65
Stand. dimension (H7)	6	8	12	14	14	14	19	19	22	24
Prepared hole size	3	4	5	6	6	10	10	10	13	16
Maximum size	8	10	13	15	15	20	20	20	25	30

Plug maximum diameter and minimum thickness of installing the wave generator plug directly on the input shaft

Table140-2
Unit: mm

Size \ Model	14	17	20	25	32	40	45	50	58	65
Max. hole φV'	17	20	23	28	36	42	47	52	60	67
Min. plug thickness H $^{0}_{-0.1}$	7.2	7.6	11.3	11.3	13.7	15.9	17.8	19	21.4	23.5

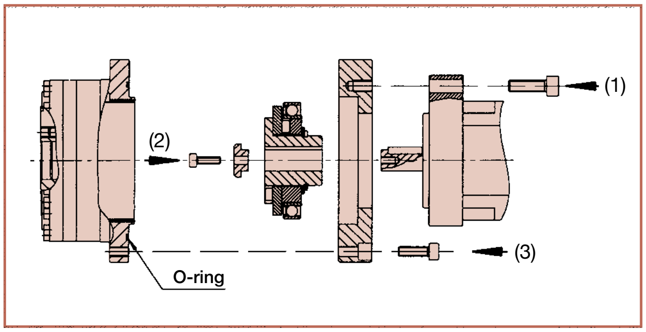
■ Installation procedure

As shown in Figures 141-1 and 141-2, there are two basic procedures to install a motor. Select the installation procedure by the diameter of the pilot hole on the motor mounting surface. Table 141-1 shows the selection standard by the diameter of the pilot hole on the motor mounting surface.

Table 141-1
Unit: mm

Size	14	17	20	25	32	40	45	50	58	65	Reference drawing for installation
The dia. of the pilot hole on the motor mounting surface	<35.5	<43.5	<50.0	<62.5	<81.5	<100.0	<113.5	<124.5	<147	<167	Installation procedure-1 (Fig. 141-1)
	≧35.5	≧43.5	≧50.0	≧62.5	≧81.5	≧100.0	≧113.5	≧124.5	≧147	≧167	Installation procedure-2 (Fig. 141-2)

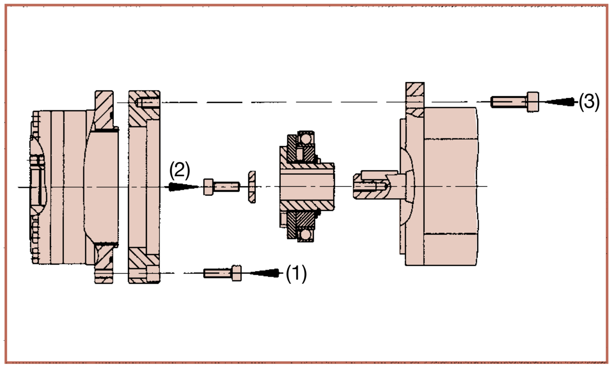
Fig. 141-1



Installation procedure-1

(1) Install the mounting flange on the motor mounting surface.
(2) Install a wave generator on the motor output shaft.
(3) Install the main unit.

Fig. 141-2



Installation procedure-2

(1) Install the mounting flange on the main unit.
(2) Install a wave generator on the motor output shaft.
(3) Install the mounting flange (main unit) on the motor mounting surface.

■ Precautions on assembly

It is extremely important to assemble the gear accurately, in proper sequence. Perform assembly based on the following precautions.

Precautions regarding the wave generator

1. Avoid applying undue axial force to the wave generator during installation. Rotating the wave generator bearing while inserting it is recommended and will ease the process.
2. If the wave generator does not have an Oldham coupling, extra care must be given to ensure that concentricity and inclination are within the specified limits (see "Installation accuracy" of each series on Page 137).

Other precautions

1. Is the flatness of the mounting surface poor or distorted?
2. Is any embossment of the screw hole area, burr or trapped foreign matter found?
3. Have chamfering and relief working of the corner been performed to prevent interference with the area of installation of the unit?

Rust-prevention

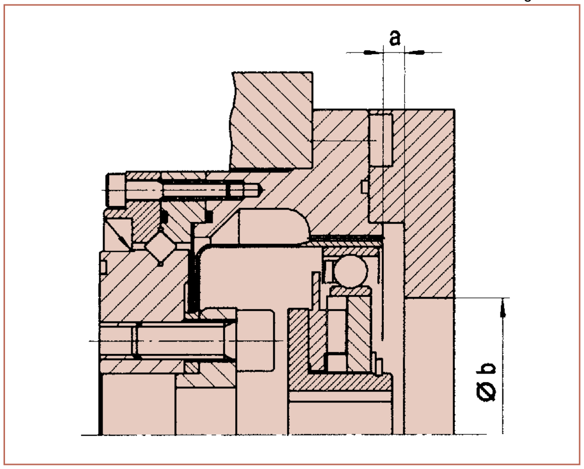
Although Harmonic Drive® gears come with some corrosion protection, the gear can rust if exposed to the environment. The gear external surfaces typically have only a temporary corrosion inhibitor and some oil applied. If an anti-rust product is needed, please contact us to review the options.

Lubrication

Grease lubrication is standard for the CSF/CSG gear units. Harmonic Grease SK-2 is for sizes 14 and 17, and Harmonic Grease SK-1A is for sizes 20 to 65 (Harmonic Grease 4B No.2 for the cross roller bearing). Harmonic Grease 4B No.2 is also available for long-life and for use in a wide temperature range. (see "Engineering data" for the specifications of the grease).

See table below for recommended housing dimensions. These dimensions must be maintained to prevent damage to the gear and to maintain a proper grease cavity.

Fig. 142-1



Recommended housing dimensions

Table 142-1
Unit: mm

Symbol \ Size	14	17	20	25	32	40	45	50	58	65
a*	1	1	1.5	1.5	1.5	2	2	2	2.5	2.5
a**	3	3	4.5	4.5	4.5	6	6	6	7.5	7.5
ϕb	16	26	30	37	37	45	45	45	56	62

* Horizontal and vertical: when the wave generator is below
** Vertical: when the wave generator is above

■ Other precautions

Fill the gap between the wave generator and the input cover (motor flange) with grease to use the wave generator facing upward or downward (see Figure 048-3 on Page 48).

Sealing

Sealing is needed to maintain the high durability of the gear and prevent grease leakage

- Rotating Parts .... Oil seal (with a spring). Surface should be smooth (no scratches)
- Mating flange .... O-ring and seal adhesive. Take care regarding distortion on the plane and how the O-ring is engaged.
- Screw hole area .... Screws should have a thread lock (LOCTITE 242 is recommended) or seal adhesive.

(Note) If you use Harmonic Grease 4BNo.2, strict sealing is required.

Sealing area and the recommended sealing method for the unit type

Table 142-2

Area requiring sealing		Recommended sealing method
Output side	Pass-through hole in the center of the output flange and the output flange mating face	Use O-ring (supplied with product)
	Spanner screw area	Screw lock agent with sealing effect (LOCTITE® 242 is recommended)
Input side	Flange mating face	Use O-ring (supplied with product)
	Motor output shaft	Please select a motor which has an oil seal on the output shaft.

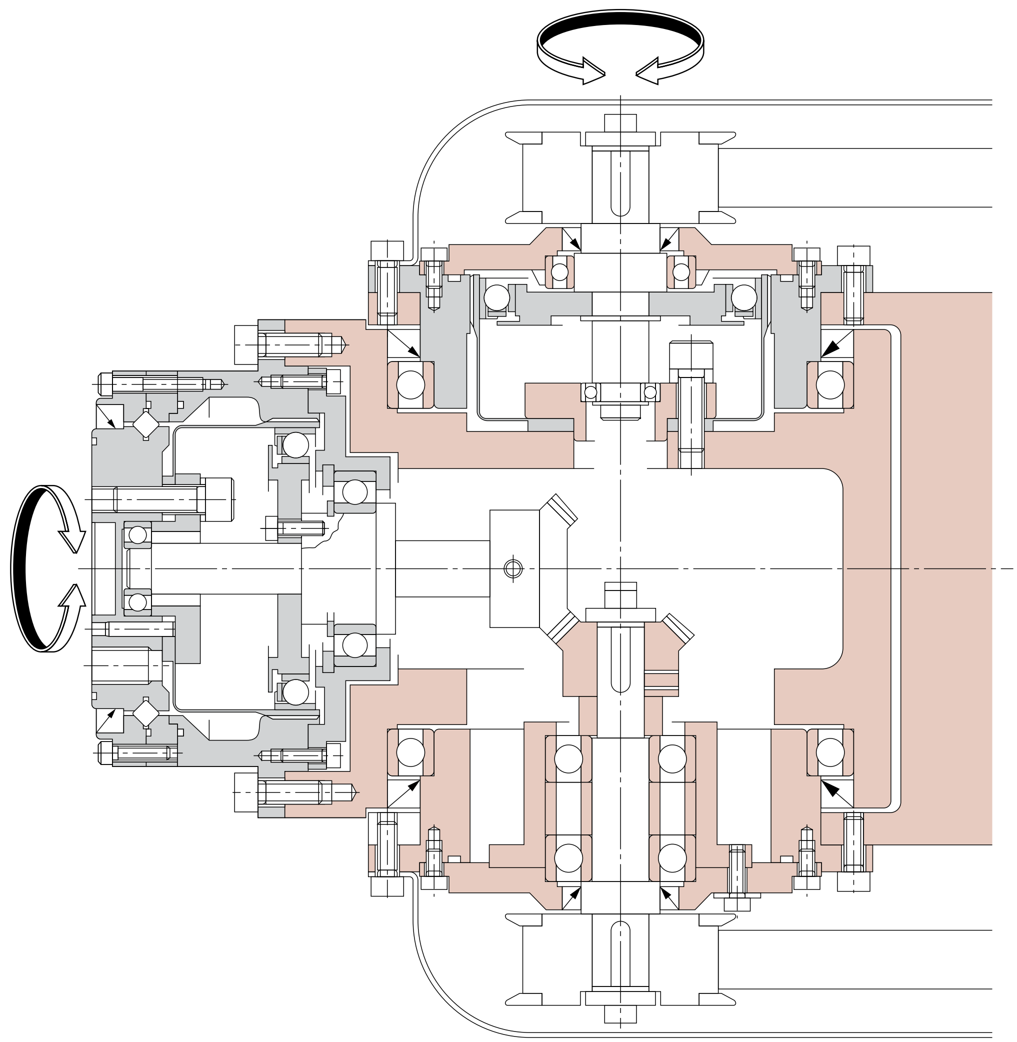
Rust prevention

Although Harmonic Drive® gears come with some corrosion protection, the gear can rust if exposed to the environment. The gear external surfaces typically have only a temporary corrosion inhibitor and some oil applied. If an anti-rust product is needed, please contact us to review the options.

Application

Multi-joint Robot

Fig. 143-1

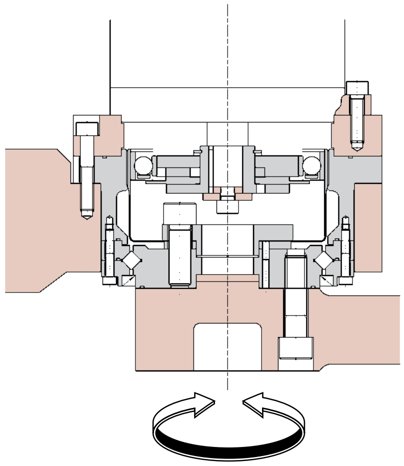


*For this installation example, sealing is required to prevent grease leakage.

Gear Unit CSG/CSF

Horizontal Multi Arm Robot

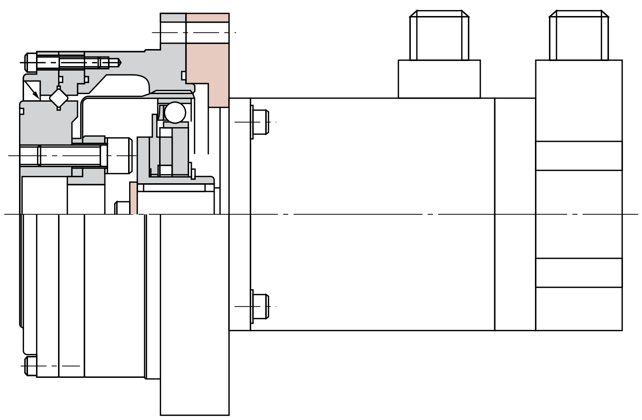
Fig. 144-1



* For usage as this installation example, sealing is required to prevent grease leakage.

Direct Connection to a Servomotor

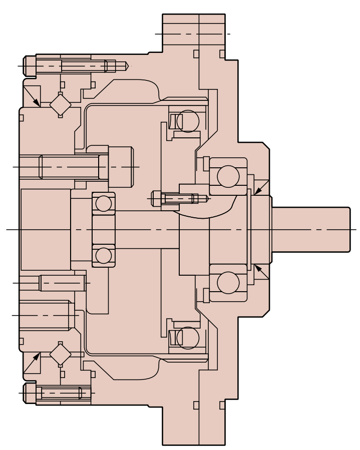
Fig. 144-2



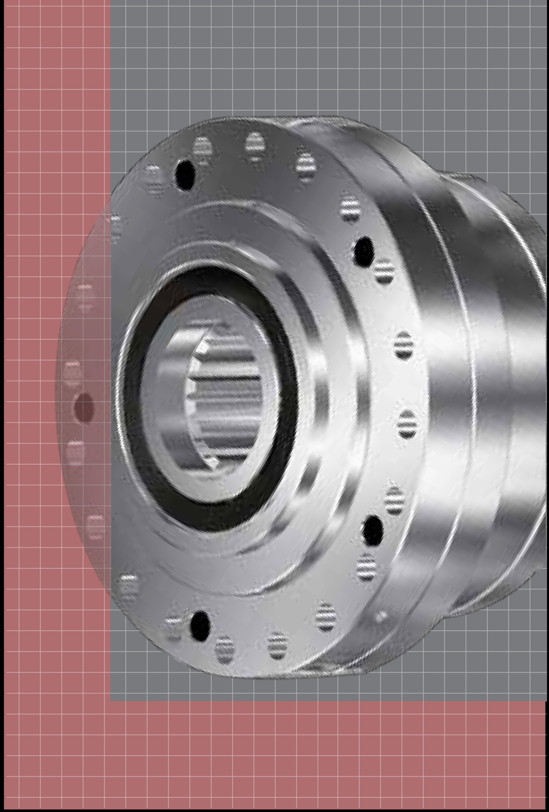
Optional Input Shaft

Fig. 144-3

CSF/CSG-2UJ with optional input shaft



* Contact us for details



CSG-2UK Series

Gear Unit CSG-2UK

Features

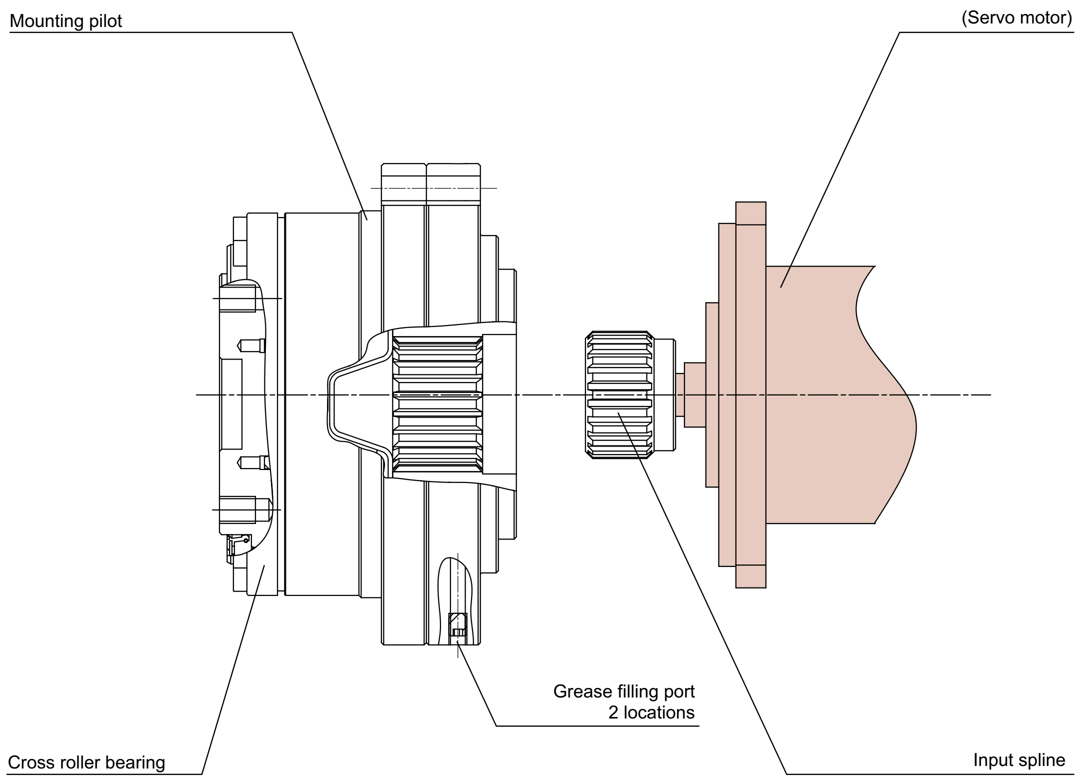
CSG-2UK is a high torque fully sealed, high accuracy gear reducer ideally suited for machine tool applications.

Features

- Compatible with Fanuc motors
- High torque capacity
- High torsional stiffness
- High positional accuracy

Structural drawing

Figure 146-1



* This is a fully enclosed unit with oil seals at the input and output shafts.

Engineering Data
Component Sets
Gear Units
Phase Adjusters
Gearheads & Actuators

Ordering Code

CSG - 25 - 100 - 2UK - A01 - SP

Table 147-1

Series	Size	Ratio*			Model	Spline outer diameter	Form symbol	Special specification
CSG	25	50	100	160	2UK=Sealed unit	A: approx. 29mm, B: approx. 44mm, C: approx. 54mm	01 to 05	Blank=Standard product SP = Special specification code
	32	50	100	160				
	40	50	100	160				
	50	50	100	160				

* The reduction ratio value is based on the following configuration:
Input: wave generator, fixed: circular spline, output: flexspline

Rating table

Table 147-2

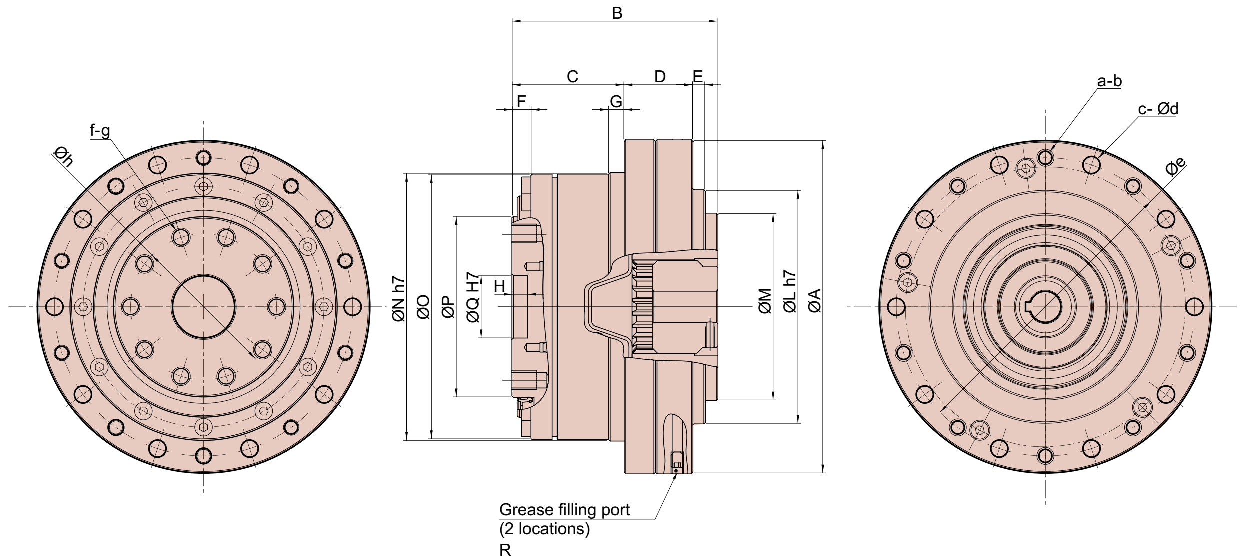
Size	Ratio	Rated Torque at Input Speed 2000 rpm		Limit for Repeated Peak Torque		Limit for Average Torque		Limit for Momentary Peak Torque		Maximum Input Speed rpm	Limit for Average Input Speed rpm	Moment of inertia (including input spline)	
		Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm	Grease lubricant	Grease lubricant	I $\times10^{-4}kgm^2$	J $\times10^{-5}kgfms^2$
25	50	51	5.2	127	13	72	7.3	242	25	5600	3500	0.65	0.66
	80	82	8.4	178	18	113	12	332	34				
	100	87	8.9	204	21	140	14	369	38				
	120	87	8.9	217	22	140	14	382	39				
	160	87	8.9	229	23	140	14	382	39				
32	50	99	10	281	29	140	14	497	51	4800	3500	1.4	1.4
	80	153	16	395	40	217	22	738	75				
	100	178	18	433	44	281	29	841	86				
	120	178	18	459	47	281	29	842	86				
	160	178	18	484	49	281	29	842	86				
40	50	178	18	523	53	255	26	892	91	4000	3000	3.55	3.6
	80	268	27	675	69	369	38	1270	130				
	100	345	35	738	75	484	49	1400	143				
	120	382	39	802	82	586	60	1488	152				
	160	382	39	841	86	586	60	1488	152				
45	50	229	23	650	66	345	35	1235	126	3800	3000	8/78	8.9
	80	407	41	918	94	507	52	1651	168				
	100	459	47	982	100	650	66	2041	208				
	120	523	53	1070	109	806	82	2288	233				
	160	523	53	1147	117	819	84	2483	253				
58	80	714	73	1924	196	1001	102	3185	325	3000	2200	19.9	20.3
	100	905	92	2067	211	1378	141	4134	422				
	120	969	99	2236	228	1547	158	4329	441				
	160	969	99	2392	244	1573	160	4459	455				
65	80	969	99	2743	280	1352	138	4836	493	2800	1900	43.8	44.7
	100	1236	126	2990	305	1976	202	6175	630				
	120	1236	126	3263	333	2041	208	6175	630				
	160	1236	126	3419	349	2041	208	6175	630				

(Note) 1. Moment of inertia: $I = {}^{1}/_{4}\ GD^2$
2. See "Engineering data" on Page 12 for details of the terms.

Gear Unit CSG-2UK

Outline Dimensions

Figure 148-1



Dimensions

Table 148-1

Symbol \ Size	25	32	40	45	58	65
ØA	107	138	160	180	226	260
B	66	75	85	102	120	129
C	36	45	50.5	58	77	84.5
D	22	24	30	32	37	38.5
E	4	4	4.5	7	6	6
F	6.1	6	7.1	7.6	8.5	9
H	5	5	5	6	10	6
ØLh7	75	100	120	135	170	198
ØM	60	60	-	108	-	-
ØNh7	86	113	127	148	186	212
ØO	85	112	126	147	185	210
ØP	58	78	90	107	135	155
ØQH7	20	26	32	32	46	52
R	M4 P=0.7	M5 P=0.8	M5 P=0.8	M6 P=1	M6 P=1	M6 P=1
a	10	12	10	12	12	8
b	M5	M6	M8	M8	M10	M12
c	10	12	10	12	12	8
Ød	5.5	6.6	9	9	11	14
Øe	96	125	144	164	206	236
f	10	10	12	12	8	12
g	M6	M8	M8	M10	M16	M14
Øh	47	62	72	84	104	120
Mass (kg)	2.2	4.5	6.5	9.7	18.5	26.3

Input spline external dimensions

Figure 149-1

• Input spline for keyed shaft

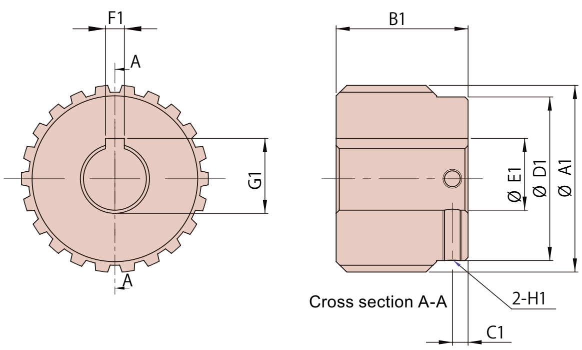
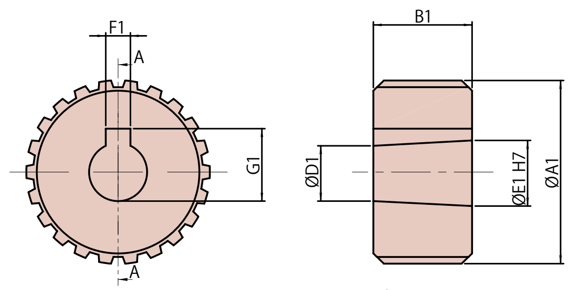


Figure 149-2

• Input spline for keyed tapered shaft



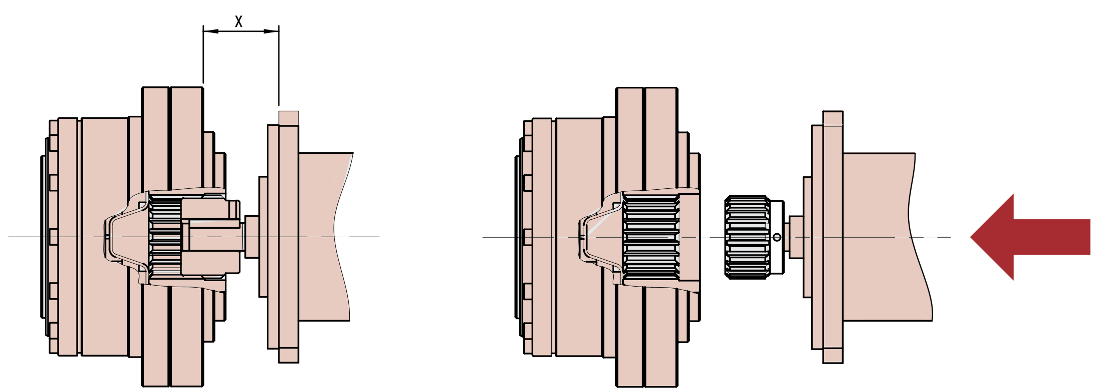
Dimensions

Unit: mm Table 149-1

Symbol	A01	A02	A03	A04	A05	B01	B02	B03	C01	C02	C03	C04	C05
Shaft shape	Straight Ø14	Straight Ø10	Taper Ø11	Taper Ø14	Taper Ø16	Straight Ø24	Taper Ø16	Straight Ø19	Straight Ø35	Taper Ø16	StraightØ19	Straight Ø24	Taper Ø32
Size	25 / 32	25 / 32	25 / 32	25 / 32	32	40	40	40	45 / 58 / 65	45 / 58 / 65	45 / 58 / 65	45 / 58 / 65	45 / 58 / 65
ØA1	29.75	29.75	29.75	29.75	29.75	44.667	44.667	44.667	54.5	54.5	54.5	54.5	54.5
B1	21	21	16	19	29	37	29	37	62	29	37	37	50
C1	2.5	2.5	-	-	-	5.8	-	5.8	12.5	-	5.8	5.8	-
ØD1	26	26	9.4	12.1	13.1	39.4	13.1	40	48	13.1	48	48	26
ØE1	$14^{+0.034}_{+0.016}$	$10^{+0.015}_{0}$	$11^{+0.018}_{0}$	$14^{+0.018}_{0}$	$16^{+0.018}_{0}$	$24^{+0.021}_{0}$	$16^{+0.018}_{0}$	$19^{+0.021}_{0}$	$35^{+0.035}_{+0.010}$	$16^{+0.018}_{0}$	$19^{+0.021}_{0}$	$24^{+0.021}_{0}$	$31^{+0.025}_{0}$
F1	5 ±0.015	3 ±0.013	4 ±0.015	4 ±0.015	5 ±0.015	8 ±0.018	5 ±0.015	6 ±0.015	10 ±0.018	5 ±0.015	6 ±0.015	8 ±0.018	7 ±0.018
G1	$16.3^{+0.1}_{0}$	$11.4^{+0.1}_{0}$	$12.5^{+0.1}_{0}$	$15.8^{+0.1}_{0}$	$17.6^{+0.1}_{0}$	$27.3^{+0.2}_{0}$	$17.6^{+0.1}_{0}$	$21.8^{+0.1}_{0}$	$38.3^{+0.2}_{0}$	$17.6^{+0.1}_{0}$	$21.8^{+0.1}_{0}$	$27.3^{+0.2}_{0}$	$33.8^{+0.1}_{0}$
H1	M3	M3	-	-	-	M5	-	M5	M5	-	M5	M5	-

Input flange axial direction range dimensions

Figure 149-3



X : Input flange width range

Dimensions

Unit: mm Table 149-2

Symbol	A01		A02		A03		A04		A05	B01	B02	B03	C01			C02			C03			C04			C05		
Shaft Shape	Straight Ø14		Straight Ø10		Taper Ø11		Taper Ø14		Taper Ø16	Straight Ø24	Taper Ø16	Straight Ø19	Straight Ø35			Taper Ø16			Straight Ø19			Straight Ø24			Taper Ø32		
Size	25	32	25	32	25	32	25	32	32	40	40	40	45	58	65	45	58	65	45	58	65	45	58	65	45	58	65
Xmin	13	11	13	11	13	11	14	11	21	22	14.5	22.5	48.8	31.6	27.8	16	11	-	24	-	-	12	9	-	63.8	43.8	38.8
Xmax	17.1	14	21.1	18	16.1	13	23.5	16	28	33.8	25.8	34.8	56.8	56.2	56.2	22	21.4	-	31	-	-	18.1	29.4	-	63.8	62.4	74

Positioning accuracy

See "Engineering data" for a description of terms.

Table 150-1
Unit: X10^{-4}rad (arc・min)

Ratio	Specification \ Size	25	32	40 to 65
50 or more	Standard product	2.9 (1)	2.9 (1)	2.9 (1)
	Special product	1.5 (0.5)	1.5 (0.5)	1.5 (0.5)

Hysteresis loss

See "Engineering data" for a description of terms.

Table 150-2

Ratio \ Size		25	32	40 or more
50	×10^{-4}rad	5.8	5.8	5.8
	arc min	2.0	2.0	2.0
80 or more	×10^{-4}rad	2.9	2.9	2.9
	arc min	1.0	1.0	1.0

Max. backlash quantity

See "Engineering data" for a description of terms.

Table 150-3

Ratio \ Size		25	32	40	45	50	58	65
50	×10^{-5}rad	8.2	6.8	6.8	5.8	5.8	.8	4.8
	arc sec	17	14	14	12	12	10	10
80	×10^{-5}rad	5.3	4.4	4.4	3.9	3.9	2.9	2.9
	arc sec	11	9	9	8	8	6	6
100	×10^{-5}rad	4.4	3.4	3.4	2.9	2.9	2.4	2.4
	arc sec	9	7	7	6	6	5	5
120	×10^{-5}rad	3.9	2.9	2.9	2.4	2.4	1.9	1.9
	arc sec	8	6	6	5	5	4	4
160	×10^{-5}rad	2.9	2.4	2.4	1.9	1.9	1.5	1.5
	arc sec	6	5	5	4	4	3	3

Torsional stiffness

See "Engineering data" for a description of terms.

Table 150-4

Symbol \ Size			25	32	40	45	50	58	65
	T_1	Nm	14	29	54	76	108	168	235
		kgfm	1.4	3.0	5.5	7.8	11	17	24
	T_2	Nm	48	108	196	275	382	598	843
		kgfm	4.9	11	20	28	39	61	86
Reduction ratio 50	K_1	×10^4Nm/rad	2.5	5.4	10	15	20	31	44
		kgfm/arc min	0.74	1.6	3.0	4.3	5.9	9.3	13
	K_2	×10^4Nm/rad	3.4	7.8	14	20	28	44	61
		kgfm/arc min	1.0	2.3	4.2	6.0	8.2	13	18
	K_3	×10^4Nm/rad	4.4	9.8	18	26	34	54	78
		kgfm/arc min	1.3	2.9	5.3	7.6	10	16	23
	θ	×10^{-4}rad	5.5	5.5	5.2	5.2	5.5	5.2	5.2
		arc min	1.9	1.9	1.8	1.8	1.9	1.8	1.8
	θ	×10^{-4}rad	15.7	15.7	15.4	15.1	15.4	15.1	15.1
		arc min	5.4	5.4	5.3	5.2	5.3	5.2	5.2

* The values in this table are reference values. The minimum value is approximately 80% of the displayed value.

Table 151-1

Symbol \ Size			25	32	40	45	50	58	65
	T_1	Nm	14	29	54	76	108	168	235
		kgfm	1.4	3.0	5.5	7.8	11	17	24
	T_2	Nm	48	108	196	275	382	598	843
		kgfm	4.9	11	20	28	39	61	86
Reduction ratio 80 or more	K_1	$\times 10^4$Nm/rad	3.1	6.7	13	18	25	40	54
		kgfm/arc min	0.92	2.0	3.8	5.4	7.4	12	16
	K_2	$\times 10^4$Nm/rad	5.0	11	20	29	40	61	88
		kgfm/arc min	1.5	3.2	6.0	8.5	12	18	26
	K_3	$\times 10^4$Nm/rad	5.7	12	23	33	44	71	98
		kgfm/arc min	1.7	3.7	6.8	9.7	13	21	29
	θ_1	$\times 10^{-4}$rad	4.4	4.4	4.1	4.1	4.4	4.1	4.4
		arc min	1.5	1.5	1.4	1.4	1.5	1.4	1.5
	θ_2	$\times 10^{-4}$rad	11.1	11.6	11.1	11.1	11.1	11.1	11.3
		arc min	3.8	4.0	3.8	3.8	3.8	3.8	3.9

* The values in this table are reference values. The minimum value is approximately 80% of the displayed value.

Starting torque

See "Engineering data" for a description of terms. As the values in the table below vary depending on the use conditions, use them as reference values.

■ CSG Series

Table 151-2
Unit: Ncm

Ratio \ Size	25	32	40	45	50	58	65
50	17	34	61	85	—	—	—
80	10	21	39	54	73	108	154
100	8.8	20	34	47	64	97	132
120	8.0	17	31	43	57	88	121
160	6.9	15	26	36	50	75	102

■ CSF Series

Table 151-3
Unit: Ncm

Ratio \ Size	25	32	40	45	50	58	65
30	25	54	—	—	—	—	—
50	15	31	55	77	110	160	220
80	9.2	19	35	49	66	98	140
100	8	18	31	43	58	88	120
120	7.3	15	28	39	52	80	110
160	6.3	14	24	33	45	68	93

Backdriving torque

See "Engineering data" for a description of terms. As the values in the table below vary depending on the use conditions, use them as reference values.

■ CSG Series

Table 151-4
Unit: Nm

Ratio \ Size	25	32	40	45	50	58	65
50	9.9	20	36	52	—	—	—
80	10	21	36	53	69	106	154
100	11	22	40	56	75	121	165
120	12	24	43	61	80	121	176
160	14	29	51	70	94	143	198

■ CSF Series

Table 151-5
Unit: Nm

Ratio \ Size	25	32	40	45	50	58	65
30	11	23	—	—	—	—	—
50	9	18	33	47	62	95	130
80	9.1	19	33	48	63	96	140
100	9.8	20	36	51	68	110	150
120	11	22	39	55	73	110	160
160	13	26	46	64	85	130	180

No-load running torque

No-load running torque is the torque which is required to rotate the input side (high speed side), when there is no load on the output side (low speed side).

Measurement condition

Table 152-1

Ratio 100			
Lubricant	Grease lubricant	Name	Harmonic Grease®4B No.2
		Quantity	Recommended quantity
The torque value is measured after two or more hours run-in at 2000rpm input.			

Temperature range of the operating environment

Table 152-3

Grease	Harmonic Grease® 4BNo2 -10 °C to +70 °C

Compensation value for each ratio

The no load running torque for HarmonicDrive® CSG varies depending on the gear ratio. The following graph shows the value for ratio 100. Other gear ratios must be calculated by adding the compensation value indicated in Table 152-2.

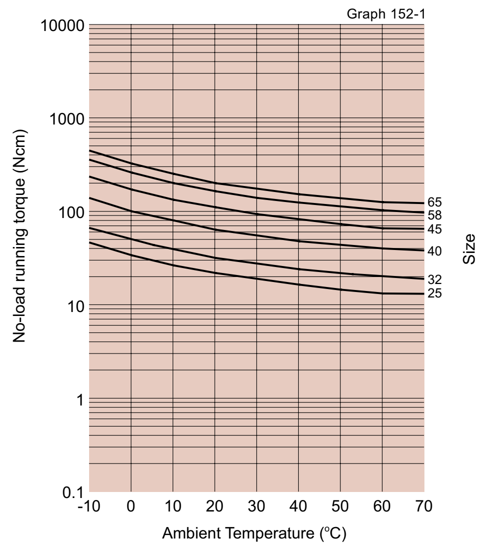
No load running torque compensation value

Table 152-2

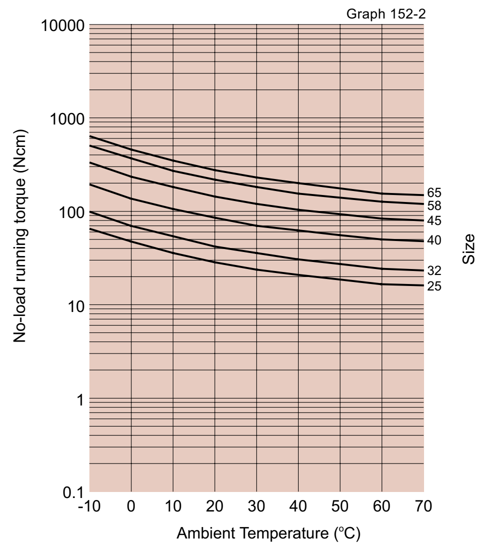
Size \ Ratio	50	80	120	160
25	3.8	0.7	-0.5	-1.2
32	7.1	1.3	-0.9	-2.2
40	12	2.1	-1.5	-3.5
45	16	2.9	-2.1	-4.9
58	—	5.3	-3.8	-8.9
65	—	7.2	-5.1	-12

No-load running torque at ratio 100:1

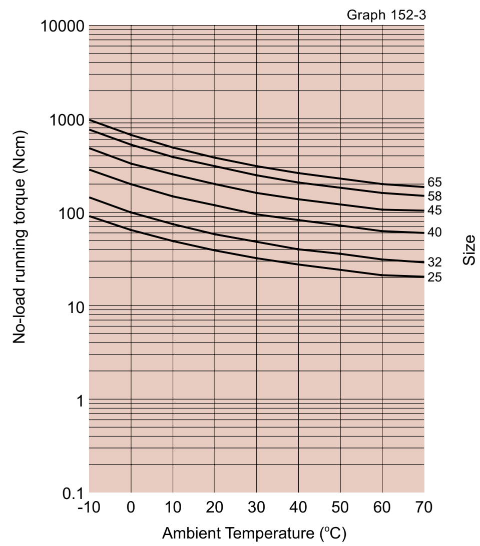
Input speed: 500rpm



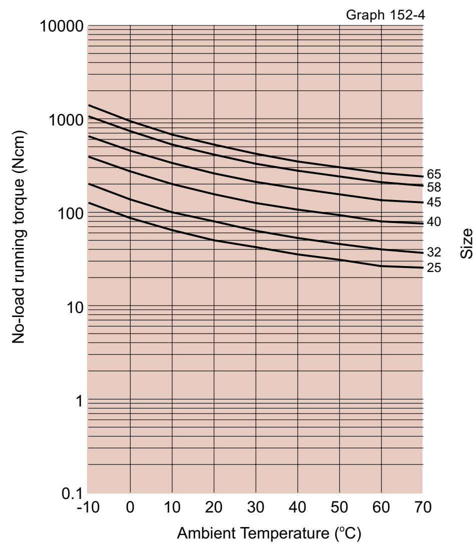
Input speed: 1000rpm



Input speed: 2000rpm



Input speed: 3500rpm



* Average value is $\overline{X}$ in this graph. $\sigma \approx 20\%$

Efficiency

The efficiency varies depending on the following conditions:

- Ratio
- Input speed
- Load torque
- Temperature
- Lubrication (type and quantity)

* Consult us if using oil lubricant.

Measurement condition

Table 153-1

Installation	Recommended tolerance		
Load torque	Rated torque indicated in the rated table		
Lubricant	Grease lubricant	Title	Harmonic Grease®4B No.2
		Quantity	Recommended quantity

Efficiency compensation coefficient and efficiency compensation amount

Efficiency compensation coefficient by load torque and efficiency compensation amount by size is calculated by using the following formula

Calculation formula

Efficiency $\eta = Ke \times (\eta_R + \eta e)$

Symbols

Table 153-2

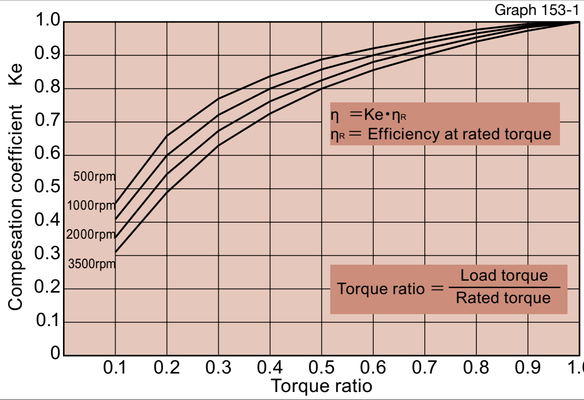
η	Efficiency	—
Ke	Efficiency compensation coefficient	Graph 153-1
η_R	Efficiency at rated torque	Graphs 153-2 to 153-4
ηe	Efficiency compensation amount	Table 153-3

Efficiency compensation coefficient by load torque

The value of efficiency drops when load torque is lower than rated torque.
Calculate the value of efficiency by calculating compensation coefficient Ke with the reference to the efficiency compensation calculation formula.

Efficiency compensation coefficient

Graph 153-1



*When load torque is larger than rated torque, efficiency compensation coefficient Ke = 1.

Efficiency compensation amount by size

CSG-2UK employs support bearing and oil seal on the input side. The influence from those parts vary depending on the size. Compensation amount ηe at rated torque by size must be calculated from Table 153-3.

Table for the efficiency compensation amount by size

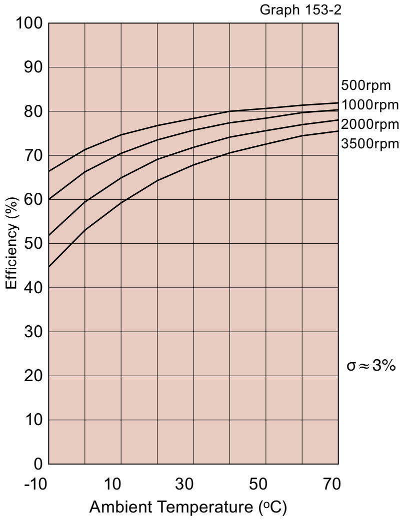
Table 153-3

Size \ Ratio	50	80	100	120	160
25	-2.0	-1.1	-4.7	-6.8	-5.8
32	1.4	2.6	0.5	-1.1	0.8
40	0.0	0.0	0.0	0.0	0.0
45	-3.7	-1.7	-4.0	-3.8	-2.5
58	—	0.6	0.2	-0.3	1.7
65	—	1.7	1.4	-0.1	1.9

Efficiency at rated torque

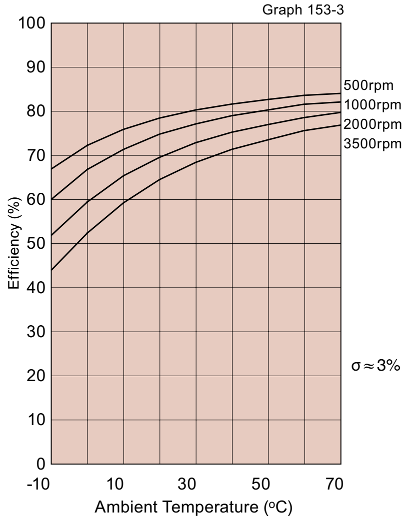
Ratio 50

Graph 153-2



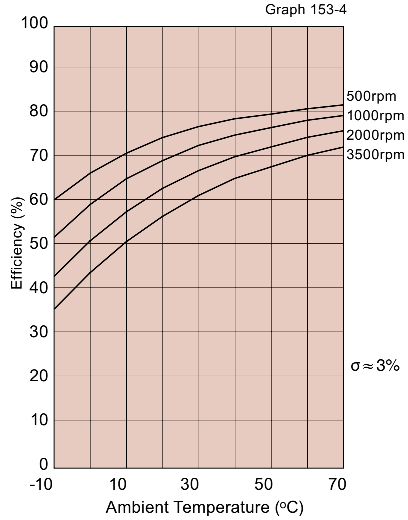
Ratio 80, 100, 120

Graph 153-3



Ratio 160

Graph 153-4



Gear Unit CSG-2UK

Output bearing specifications

Table 154-1

Size	Pitch Circle	Offset	Basic Dynamic Rated Load C		Basic Static Rated Load Co		Allowable Moment Load Mc		Moment Stiffness	
	m	m	$\times 10^2$ N	kgf	$\times 10^2$ N	kgf	Nm	kgfm	$\times 10^4$ Nm/rad	kgfm/arc-min
25	0.064	0.0118	96	980	151	1540	128	13.1	19.8	5.9
32	0.083	0.0133	150	1530	250	2550	257	26.2	44.2	13.1
40	0.096	0.0148	213	2170	365	3720	369	37.7	74.6	22.1
45	0.111	0.0158	230	2350	426	4340	563	57.4	116	34.4
58	0.141	0.0205	518	5290	904	9230	838	85.4	201	59.6
65	0.160	0.0185	556	5670	1030	10500	1525	156	331	108

Installation and transmission torque

Bolt connection to output flange (CRB) and resulting transmission torque

Table 154-2

Size		25	32	40	45	58	65
Number of Bolts		10	10	12	12	8	12
Size of Bolts		M6	M8	M8	M10	M16	M14
P.C.D.	mm	47	62	72	84	104	120
Bolt Tightening Torque	Nm	18.4	45	45	88	382	246
Transmission Torque	Nm	448	1090	1519	2778	6211	7900

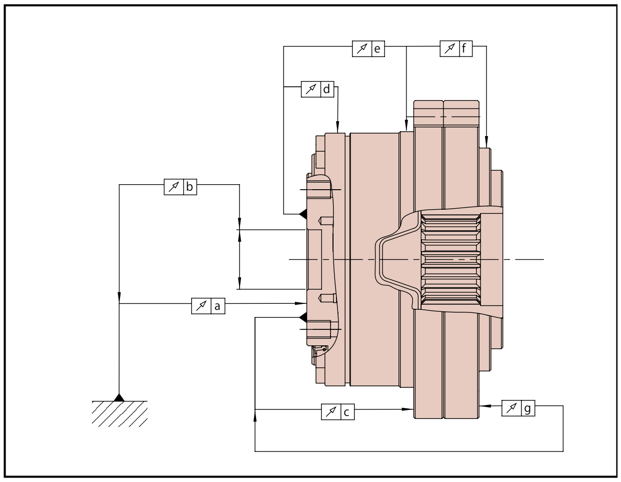
Bolt connection to input side flange and resulting transmission torque

Table 154-3

Size		25	32	40	45	58	65
Number of Bolts		10	12	10	12	12	8
Size of Bolts		M5	M6	M8	M8	M10	M12
P.C.D.	mm	96	125	144	164	206	236
Bolt Tightening Torque	Nm	9	15.3	37.2	37.2	73.5	128
Transmission Torque	Nm	541	1194	2095	2863	5678	6312

Output bearing and housing tolerances

Figure 155-1



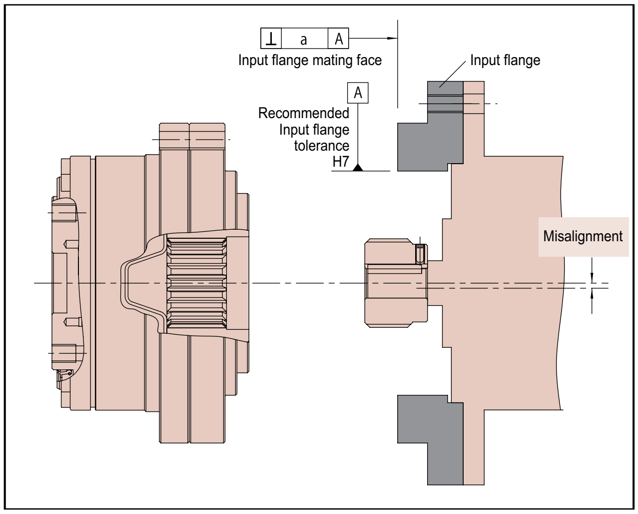
Unit: mm
Table 155-1

Symbol \ Size	25	32	40	45	58	65
a	0.015	0.015	0.015	0.018	0.018	0.018
b	0.013	0.013	0.015	0.015	0.017	0.017
c	0.045	0.056	0.060	0.068	0.076	0.085
d	0.010	0.010	0.015	0.015	0.015	0.015
e	0.049	0.049	0.060	0.065	0.070	0.075
f	0.157	0.172	0.185	0.200	0.212	0.218
g	0.051	0.061	0.058	0.063	0.075	0.096

Installation accuracy

Be sure to retain the recommended input flange tolerance indicated in Figure 155-2 and Table 155-2 for best performance results.

Figure 155-2



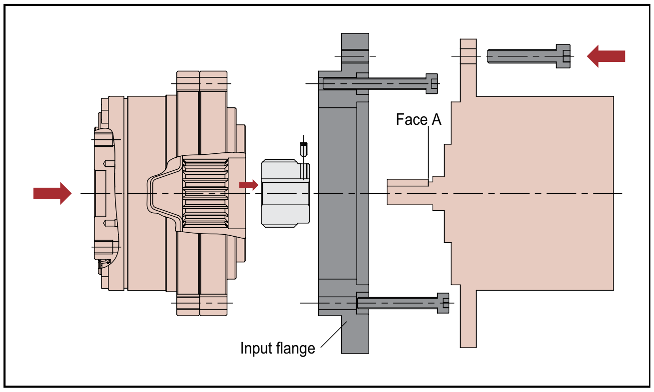
Unit: mm
Table 155-2

Symbol \ Size	25	32	40	45	58	65
a	0.024	0.026	0.026	0.027	0.031	0.034
Misalignment	0.014	0.014	0.020	0.019	0.019	0.019

Example of motor installation

Motor straight shaft

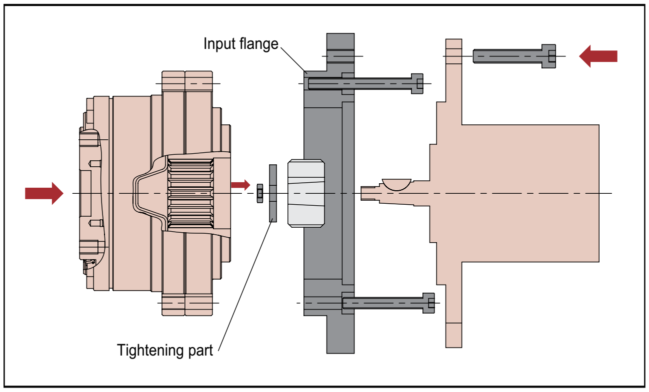
Figure 155-3



Recommended assembly procedure:
(1) Insert the spline into the keyed motor shaft and tighten set screw.
(2) Install the input flange to the gear unit and tighten the bolts.
(3) Insert motor assembly into the unit ensuring to align the input spline. Tighten the bolts.

Motor straight shaft

Figure 155-4



* Input flange and clamp plates are not provided with the motor, they should be manufactured by the customer.

Lubrication

The lubricant is Harmonic Grease®4B No.2. Lubricant has been already applied on the unit side of spline.

Figure 156-1

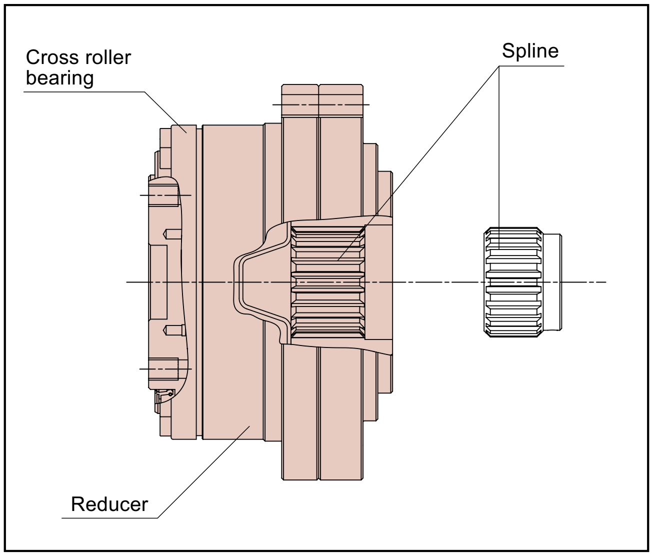


Table 156-1

Gear	Harmonic Grease®4B No.2
Cross roller bearing	Harmonic Grease®4B No.2
Spline	MOLUB-ALLOY 777

Continuous operation rating

Temperature rises inside CSG-2UK due to the of oil seal and bearing that are used in the input shaft (on the high-speed rotation side). In the case of continuous operation, operate CSG-2UK within the operating time indicated in Table 156-3.

The continuous operating time in Table 156-3 is determined based on the time when the temperature inside the unit rises to 80 °C and the temperature at the oil seal area rises to 100°C under the conditions in Table 156-2.

For continuous operation, the Max. Operating Times specified in Table 156-3 should not be exceeded.

Please contact us if the operating conditions vary from table 156-2.

If this occurs,the following should be considered:

- Lubricant may need to be replaced earlier than usual
- Measures for unit radiation
- Measures for leakage of lubrication agent due to the rise of unit inner pressure
- Measures for the oil seal area deterioration due to heat

Note: For sizes 25 and 32, the unit inner temperature should not exceed 80 °C .

Installation condition

Table 156-2

Ambient temperature	25 °C
Inputs speed	2000 rpm
Radiation plate	None (single unit radiation only)

Continuous operating time

Table 156-3

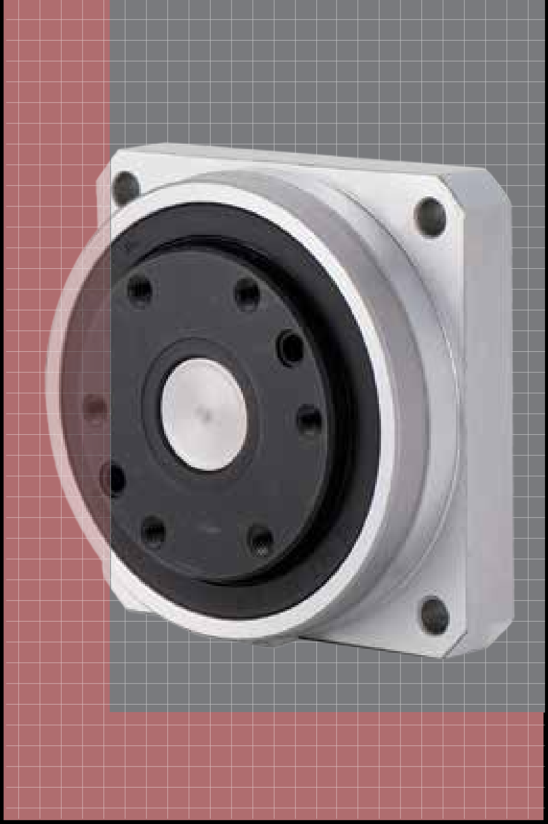
	Operating time at no load (minutes)
25	— (Note)
32	— (Note)
40	35
45	50
58	50
65	50

Caution

Avoid radial load on the input side.

Rust-prevention

Although Harmonic Drive® gears come with some corrosion protection, the gear can rust if exposed to the environment. The gear external surfaces typically have only a temporary corrosion inhibitor and some oil applied. If an anti-rust product is needed, please contact us to review the options.



CSF-2UP mini Series

Gear Unit CSF-2UP

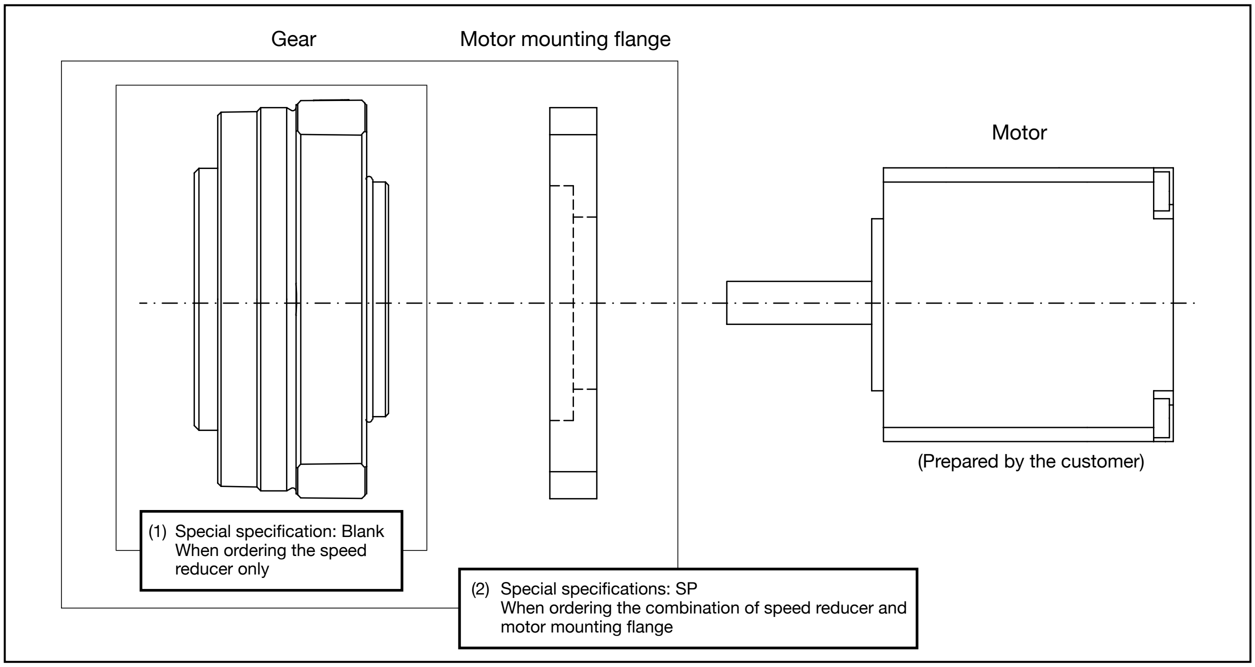
Features

The CSF-2UP gear units are the newest models in the CSF mini-series lineup. These new gear units have an ultra-flat configuration with high-moment stiffness. Harmonic Drive® gear units are zero-backlash gears with a precision output bearing with an integrated housing. The new models are lightweight and extremely flat. Cross roller bearing used at the output flange enables the CSF-2UP gearheads to offer high-moment stiffness. The CSF-2UP mini gearheads are ideally suited for small robots or equipment requiring an ultra-compact solution.

Features

- Zero backlash
- High-positioning accuracy
- Compact and lightweight
- High-torque capacity
- High-radial, axial, and moment load capacity
- Cross roller bearing
- Ratios: 30:1 to 100:1

Figure 158-1



* The motor mounting flange is designed and sold as an option. Please let us know the required dimension shown in Figure 168-1 on page 168 if you need the flange designed.
* Installation of the motor mounting flange and motor must be performed by the customer. For proper installation, refer to pages 165 through 168.
* The special specification: SP may include other special specifications.

Ordering Code

CSF - 14 - 100 - 2UP - SP

Table158-1

Series	Size	Reduction ratio			Model	Special specifications
CSF series	8	30	50	100	2UP (High-moment stiffness)	Blank = standard product SP = Special specification code (Including the motor mounting flange option)
	11	30	50	100		
	14	30	50	100		

Rating table

Table159-1

Size	Ratio	Rated torque at input speed 2000 rpm	Limit for repeated peak torque	Limit for average torque	Limit for momentary peak torque	Maximum input speed	Limit for average input speed	Moment of inertia (1/4GD^2)
		Nm	Nm	Nm	Nm	rpm	rpm	kgcm^2
8	30	0.9	1.8	1.4	3.3	8500	3500	4.0×10^{-3}
	50	1.8	3.3	2.3	6.6			
	100	2.4	4.8	3.3	9.0			
11	30	2.2	4.5	3.4	8.5	8500	3500	1.5×10^{-2}
	50	3.5	8.3	5.5	17			
	100	5.0	11	8.9	25			
14	30	4.0	9.0	6.8	17	8500	3500	4.0×10^{-2}
	50	5.4	18	6.9	35			
	100	7.8	28	11	54			

Positional accuracy

See "Engineering data" for a description of terms.

Table 159-2

Ratio	Specification \ Size	8	11	14
30	$\times 10^{-3}$rad	0.58	0.58	0.58
	arc min	2.00	2.00	2.00
50 or more	$\times 10^{-3}$rad	0.58	0.44	0.44
	arc min	2.00	1.50	1.50

Hysteresis loss

See "Engineering data" for a description of terms.

Table 159-3

Ratio \ Size		8	11	14
30	$\times 10^{-4}$rad	8.7	8.7	8.7
	arc min	3.0	3.0	3.0
50	$\times 10^{-4}$rad	5.8	5.8	5.8
	arc min	2.0	2.0	2.0
100	$\times 10^{-4}$rad	5.8	5.8	2.9
	arc min	2.0	2.0	1.0

Starting torque

See "Engineering data" for a description of terms. Please use as reference values; the values vary based on use conditions.

Unit: Ncm Table 159-4

Ratio \ Size	8	11	14
30	1.5	3.4	4.6
50	0.92	2.0	3.5
100	0.65	1.5	2.2

Backdriving torque

See "Engineering data" for a description of terms. Please use as reference values; the values vary based on use conditions.

Unit: Nm Table 159-5

Ratio \ Size	8	11	14
30	0.70	1.7	2.4
50	0.55	1.2	1.6
100	0.75	1.5	1.8

Ratcheting torque

See "Engineering data" for a description of terms.

Unit: Nm Table 159-6

Ratio \ Size	8	11	14
30	11	29	59
50	12	34	88
100	14	43	84

Buckling torque

See "Engineering data" for a description of terms.

Unit: Nm Table 159-7

Size	8	11	14
All ratios	35	90	190

Cross Roller Bearing Specifications

A precise cross roller bearing is built in the CSF-2UP for the purpose of directly supporting external load (on the output side).
In order to fully achieve the performance of the unit, check the maximum moment load, cross roller bearing life, and static safety coefficient.

■ Checking procedure

(1) Checking the maximum moment load (M max)

Calculate the maximum moment load (M max). → Maximum moment load (M max) ≤ allowable moment (Mc)

(2) Checking the life

Calculate the average radial load (*Frav*) and the average axial load (*Faav*). → Calculate the radial load coefficient (X) and an axial load coefficient (Y). → Calculate the life and check it

(3) Checking the static safety coefficient

Calculate the static equivalent radial load coefficient (Po). → Check the static safety coefficient (fs).

■ Output bearing specifications

Table 160-1

Size	Pitch circle	Offset	Basic rated load		Allowable moment load Mc*3	Moment stiffness Km*4
	dp	R	Basic dynamic rated load C*1	Basic static rated load Co*2		
	mm	mm	$\times 10^2$ N	$\times 10^2$ N	Nm	Nm/rad
8	35	12.9	58	80	15	2.0×10^4
11	42.5	14	65	99	40	4.0×10^4
14	54	14	74	128	75	8.0×10^4

*1 The basic dynamic load rating is referred to as a constant static radial load so that the basic dynamic load rating of the bearing is to be a million rotations.
*2 The basic static load rating is referred to as a static load that provides a constant level contact stress (4kN/mm^2) at the center of the contact side between the rolling element that bears the maximum load and the orbit.
*3 The allowable moment load is referred to as the maximum moment load that can be applied to the output bearing while the basic performance can be retained within the range of the maximum moment load that can be operable.
*4 The values of the moment stiffness are the reference values. The minimum value is approximately 80% of the display value.

Lubrication

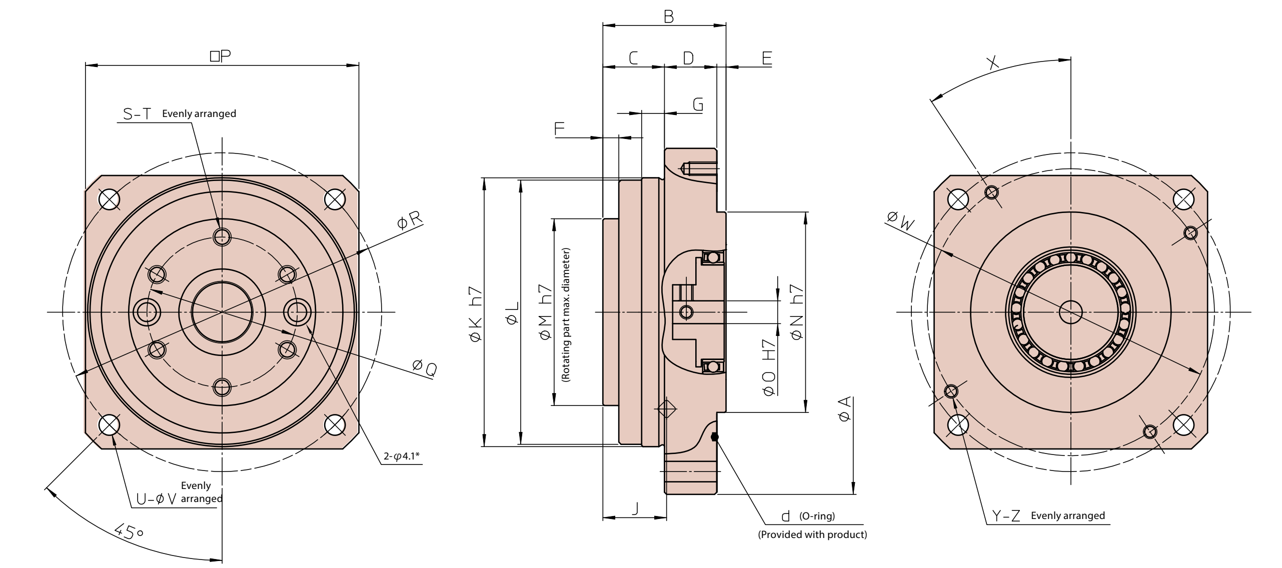
Grease is the standard lubrication for CSF-2UP mini series. There is no need to add or apply grease upon installation since the products are shipped with the grease applied.

Table 160-2

Lubricated area	Gear	Cross roller bearing
Lubrication	Harmonic Grease® SK-2	
Manufacturer	Harmonic Drive Systems Inc.	
Base oil	Refined oil	
Base Viscosity (25°C)	265 to 295	
Thickening agent	Lithium soap base	
Drop point	198°C	
Appearance	Green color	

Outline Dimensions

Figure 161-1



* May be deformed or scratched as they are used during assembly at our factory. The accuracies of positional tolerance and other properties are not guaranteed.

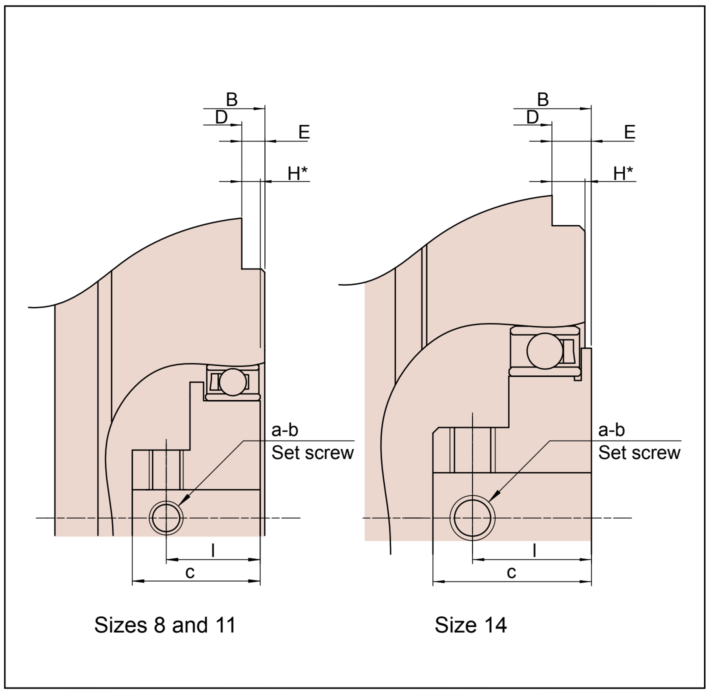
■ Dimensions

Unit: mm Table 161-1

Symbol \ Size	8	11	14
øA	66	80	100
B	24.8	27	33.5
C	13	13.5	18.5
D	9	11.5	12
E	2.8	2	3
F	3	3.5	3.5
G	5	5	8
H*	$1.1^{0}_{-0.3}$	$1.6^{0}_{-0.7}$	$3.5^{0}_{-0.8}$
I	7.2	8.3	10.5
J	12.9	14	14
øK	49	59	74
øL	48	58	73
øM	33.5	41	52.5
øN	30	44	52
øO	5	5	8
□P	50±1	60±1	75±1
øQ	25.5	33	44
øR	58	70	88
S	6	6	6
T	M3 × 5	M4 × 5	M5 × 7
U	4	4	4
øV	3.5	4.5	5.5
øW	52	63	70.71
X	35°	33.5°	55°
Y	4	4	4
Z	M3 × 5	M3 × 6	M4 × 8
Mass (g)	200	330	620

■ Wave generator mounting diagram

Figure 161-2



* Dimension H is the mounting position in the shaft direction and tolerance of the three parts (wave generator, flexspline, circular spline). Strictly observe these dimensions as they affect the performance and strength.

Table 161-2

Symbol \ Size	8	11	14
a	2	2	2
b	M3×4	M3×4	M4×4
c	10.2	11.3	14
d	ø29.8×0.8	ø54.0×1.2	ø58.4×1.3

Wave Generator Hole Diameter Dimension

The hole diameter dimension (as shown in Table 161-1 on page 161, øO) can be changed in accordance with the shaft diameter of the mounting motor within the range shown in the table below:

Table 162-1

Symbol \ Size	8	11	14
øO H7	2 to 8	3 to 8	4 to 10

* The special specification is applied to the entire unit when a hole diameter is changed. For information on the dimensions, please contact our sales representatives.
* The wave generator of a standard product is a solid wave generator. The Oldham type (self-aligning mechanism) is included in the special specification.

Torsional stiffness

See "Engineering data" for a description of terms.

Table 162-2

Symbol			Size 8	11	14
	T_1	Nm	0.29	0.80	2.0
		kgfm	0.030	0.082	0.20
	T_2	Nm	0.75	2.0	6.9
		kgfm	0.077	0.20	0.70
Ratio 30	K_1	$\times 10^4$ Nm/rad	0.034	0.084	0.188
		kgfm/arc min	0.010	0.025	0.056
	K_2	$\times 10^4$ Nm/rad	0.044	0.124	0.235
		kgfm/arc min	0.013	0.037	0.070
	K_3	$\times 10^4$ Nm/rad	0.054	0.158	0.335
		kgfm/arc min	0.016	0.047	0.100
	θ_1	$\times 10^{-4}$ rad	8.6	9.5	11
		arc min	3.0	3.3	3.6
	θ_2	$\times 10^{-4}$ rad	19	19	31
		arc min	6.6	6.6	11
Ratio 50	K_1	$\times 10^4$ Nm/rad	0.044	0.221	0.335
		kgfm/arc min	0.013	0.066	0.100
	K_2	$\times 10^4$ Nm/rad	0.067	0.300	0.468
		kgfm/arc min	0.020	0.089	0.140
	K_3	$\times 10^4$ Nm/rad	0.084	0.320	0.568
		kgfm/arc min	0.025	0.095	0.170
	θ	$\times 10^{-4}$ rad	6.6	3.6	6.0
		arc min	2.3	1.2	2.0
	θ	$\times 10^{-4}$ rad	14	7.6	16
		arc min	4.7	2.6	5.6
Ratio 100	K_1	$\times 10^4$ Nm/rad	0.090	0.267	0.468
		kgfm/arc min	0.027	0.079	0.140
	K_2	$\times 10^4$ Nm/rad	0.104	0.333	0.601
		kgfm/arc min	0.031	0.099	0.179
	K_3	$\times 10^4$ Nm/rad	0.120	0.432	0.700
		kgfm/arc min	0.036	0.128	0.209
	θ	$\times 10^{-4}$ rad	3.2	3.0	4.3
		arc min	1.1	1.0	1.5
	θ	$\times 10^{-4}$ rad	7.7	6.6	12
		arc min	2.6	2.3	4.2

* The values in this table are reference values. The minimum value is approximately 80% of the displayed value.

Mechanical Accuracy

By using high-accuracy and high-stiffness cross roller bearings, the CSF-2UP mini series, achieves high accuracy. The mechanical accuracy on the output side is shown below.

Figure 163-1

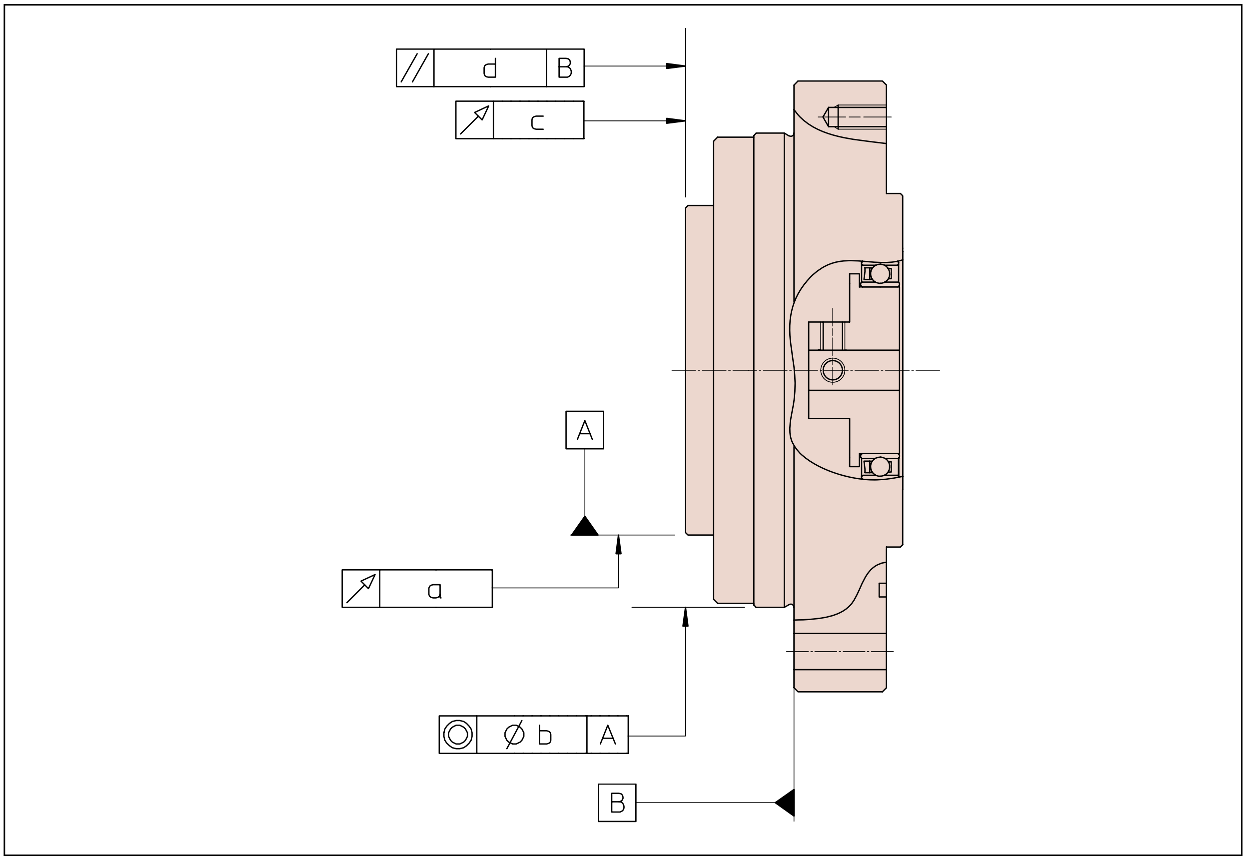


Table 163-2

Symbol	Feature	Size		
		8	11	14
a	Output shaft axial runout	0.010		
b	Concentricity of the mounting pilot	0.040		
c	Output flange surface runout	0.010		
d	Parallelism between the mounting face and the output flange face	0.040		

(Note) Values are based on the Total Indicator Reading (T.I.R.).

Efficiency

The efficiency varies depending on the following conditions.
- Reduction ratio
- Load torque
- Input rotating speed
- Temperature
- Lubrication (Type and quantity)

Measurement condition

Table 164-1

Load torque	Rated torque indicated in the rating table		
Lubricant	Grease lubrication	Name	Harmonic Grease® SK-2
		Quantity	Recommended quantity

■ Efficiency compensation coefficient

The value of efficiency drops when load torque is lower than rated torque. Calculate the compensation coefficient Ke from graph 6-1 and calculate the value of efficiency with the reference to the efficiency compensation calculation formula.

Example: Calculate efficiency η (%) for the CSF-8-100-2UP under the following conditions:
Input rotational speed 1000 rpm
Load torque: 2.0 Nm
Lubrication method: Grease lubricant
Lubricant temperature: 20°C

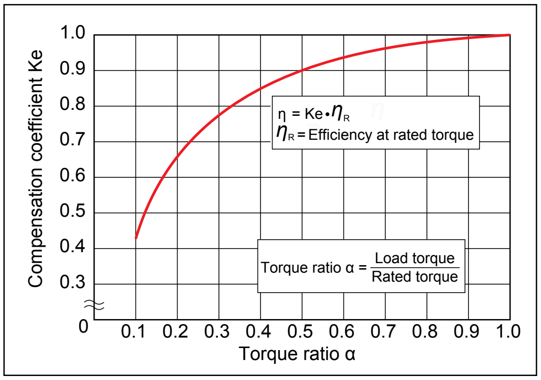
Torque ratio α is 0.83 since the rated torque for size 8 and reduction ratio 100 is 2.4 Nm. (α = 2.0 / 2.4 ≈ 0.83)

The efficiency compensation coefficient is calculated according to graph 6-1: Ke = 0.99
Efficiency η when load torque is 2.0 Nm is calculated: $\eta = Ke \cdot \eta_R = 0.99 \times 77\% = 76\%$

* When load torque is larger than rated torque, efficiency compensation coefficient Ke = 1.

Efficiency compensation coefficient

Graph 164-1

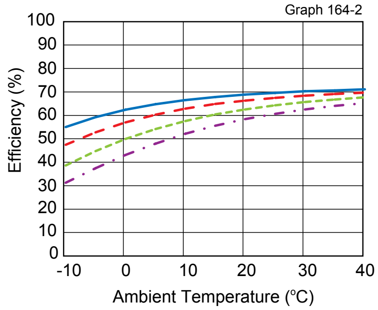


■ Efficiency at rated torque

Size: 8

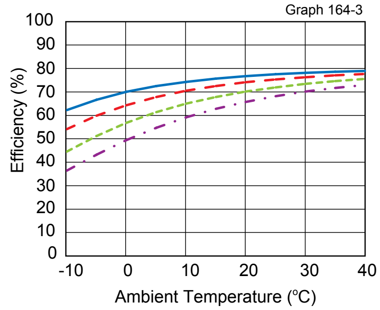
Ratio 30

Graph 164-2



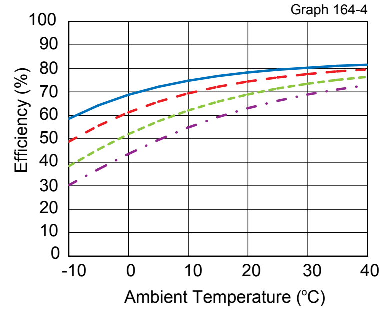
Ratio 50

Graph 164-3



Ratio 100

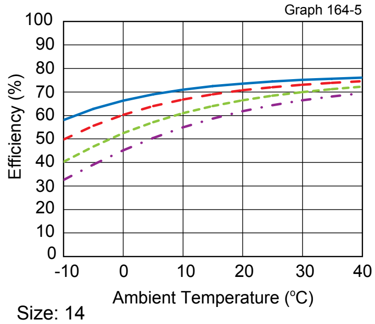
Graph 164-4



Size: 11

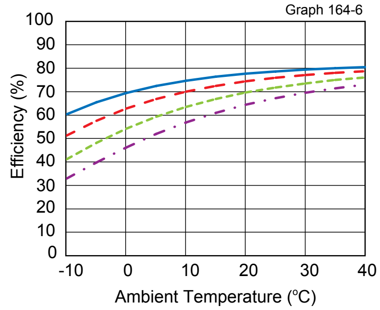
Ratio 30

Graph 164-5



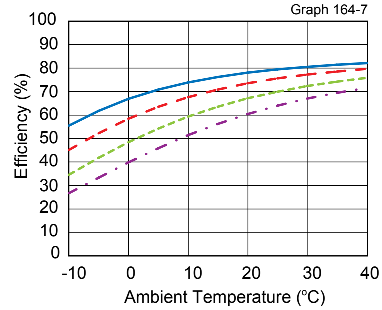
Ratio 50

Graph 164-6



Ratio 100

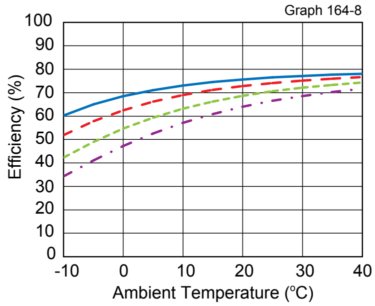
Graph 164-7



Size: 14

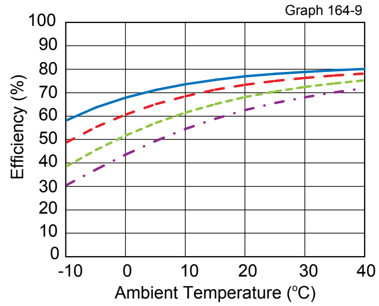
Ratio 30

Graph 164-8



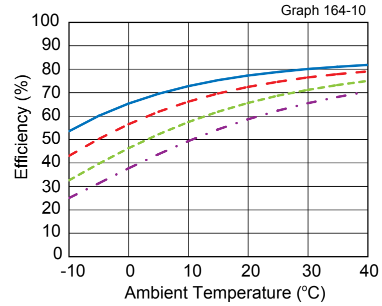
Ratio 50

Graph 164-9



Ratio 100

Graph 164-10



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

No-load running torque

No-load running torque is the torque which is required to rotate the input side (high speed side), when there is no load on the output side (low speed side).

* For details about the values, please contact us.

Measurement condition

Table 165-1

Ratio 100:1			
Lubricant	Grease lubricant	Name	Harmonic Grease® SK-2
Torque value is measured after 2 hours at 2000rpm input.			

■ Compensation Value in Each Ratio

The no-load running torque of the gear varies with ratio. Graphs 165-1 through 165-4 show the value of reduction ratio 100. Other reduction ratios must be calculated by adding the compensation value indicated in Table 165-2

No-load running torque compensation value

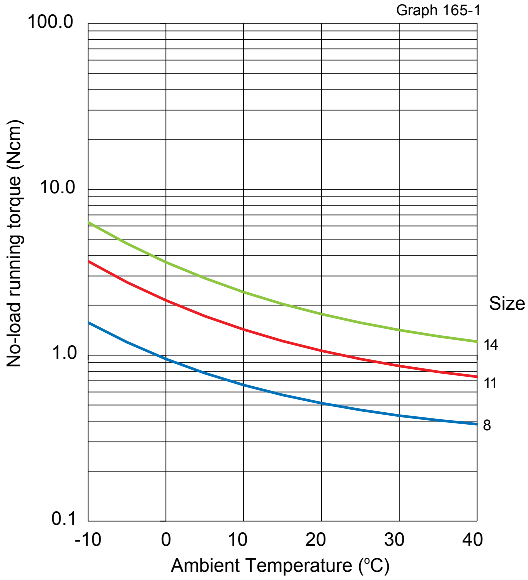
Unit: mm Table 165-2

Size \ Ratio	30	50
8	0.49	0.22
11	0.81	0.36
14	1.25	0.55

■ No load running torque for reduction ratio 100

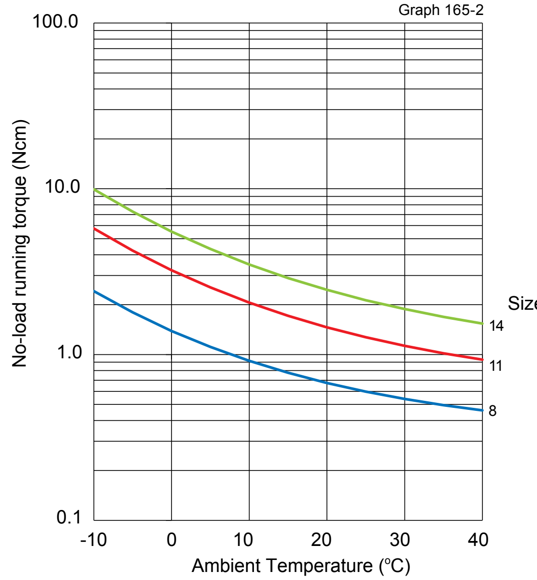
Input rotational speed 500rpm

Graph 165-1



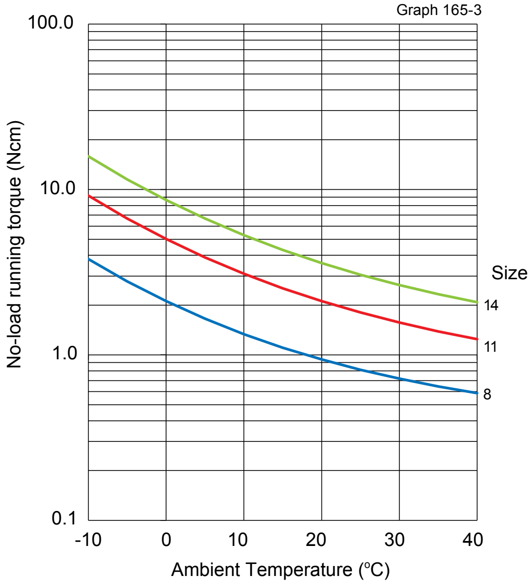
Input rotational speed 1000rpm

Graph 165-2



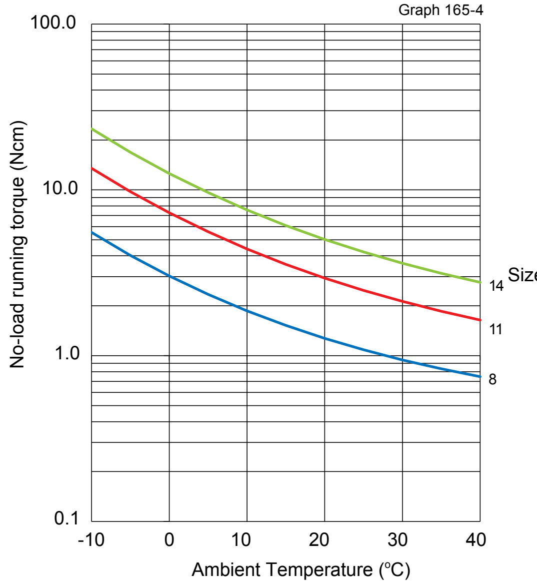
Input rotational speed 2000rpm

Graph 165-3



Input rotational speed 3500rpm

Graph 165-4

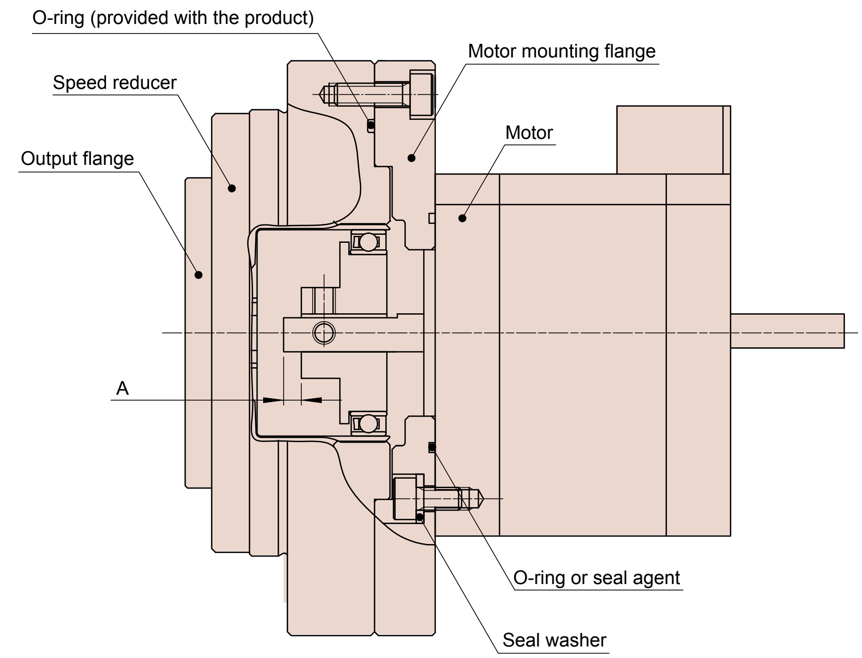


*Average value is $\overline{X}$ in this graph.

Example of Mounting

Example of motor mounting is shown below:

Figure 166-1



■ Sealing

The sealing structure as shown is required for mounting the motor for the purpose of grease leakage prevention and of maintaining the high-durability of the HarmonicDrive® gear.

Table 166-1

Area requiring sealing		Recommended sealing method
Motor mounting flange	On the gear side (On the reducer side)	Using O-ring (provided with our product)
	On the motor side	O-ring, seal agent, seal washer, and others (Take care regarding the distortion on the plane and how the O-ring is engaged)
Motor output shaft		Please select a motor output shaft with oil seal attached. If the oil seal is not provided, employ a design where the oil seal is attached to the motor mounting flange.
Screw hole area		Use the screw lock agent with sealing effect (LOCTITE® 242 is recommended), or use the sealing tape.

* There is no need to apply a seal agent on the output flange because it includes a seal.

■ Precautions when installing the motor

Be sure that the motor shaft does not protrude from the wave generator more that permitted in Table 166-2 below. (Refer also to Figure 166-1)

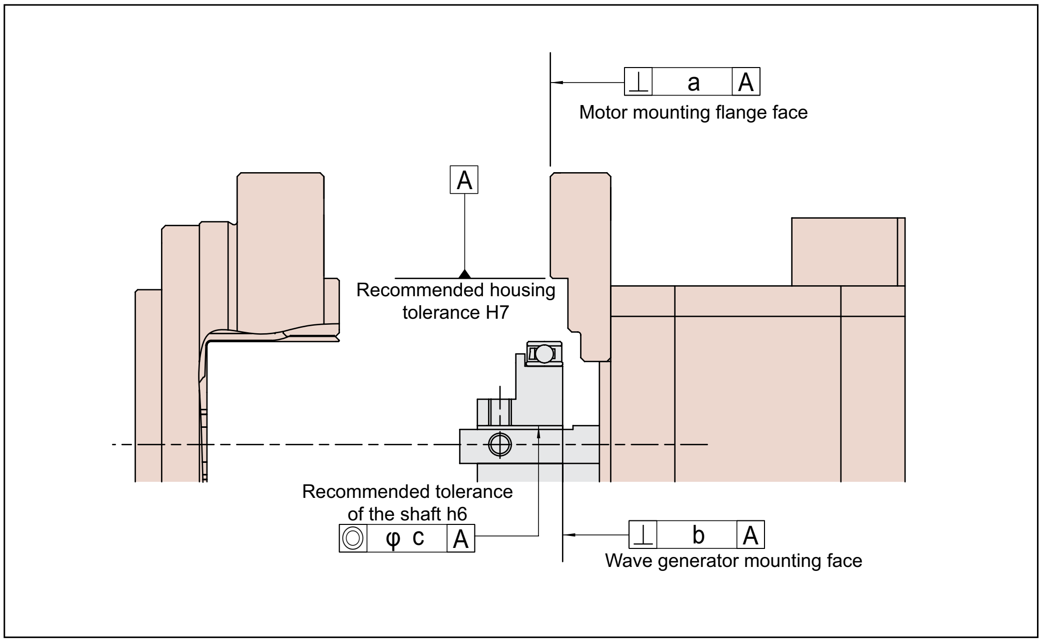
Unit: mm Table 166-2

Dimension \ Size	8	11	14
A	2.5	4.5	6

Installation accuracy

In order to fully achieve the excellent performance of the CSF-2UP, maintain the recommended installation tolerances shown below:

Figure 167-1

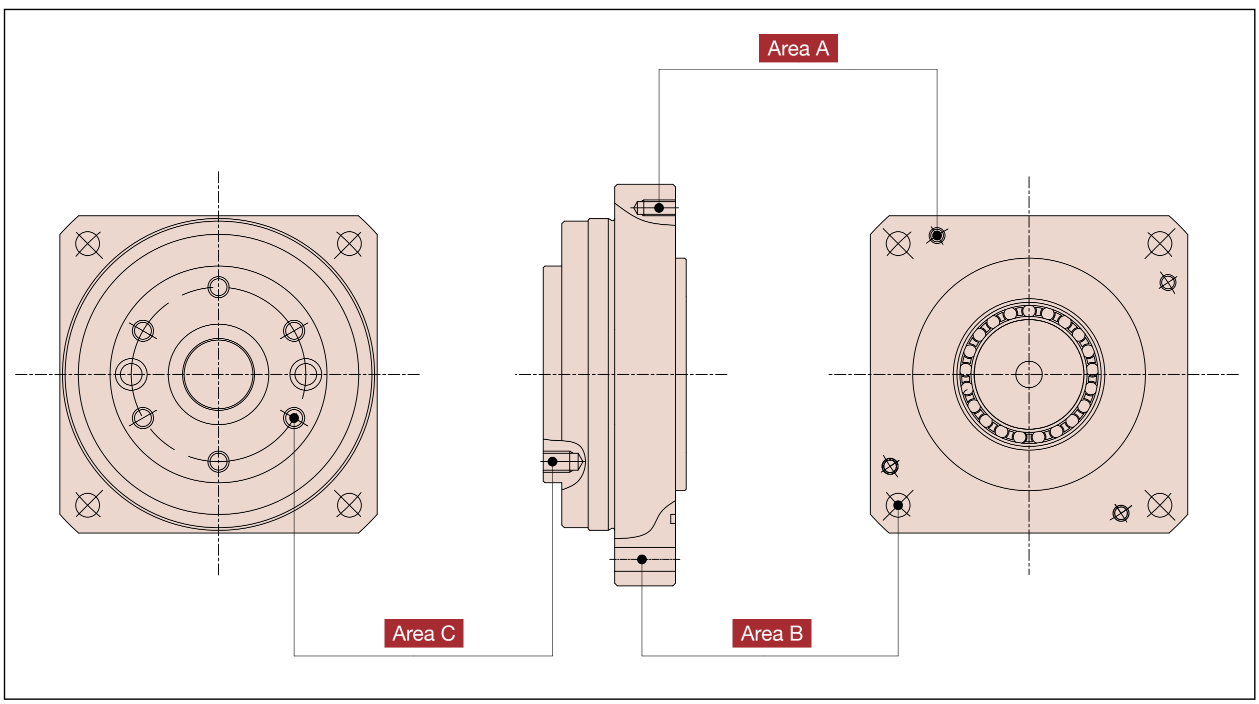


Unit: mm Table 167-1

Tolerance \ Size		8	11	14
a	Adapter surface	0.010	0.011	0.011
b	Wave generator installation surface	0.006	0.007	0.008
c	Concentricity of the input shaft	0.006	0.007	0.016

Installation and transmission torque

Figure 167-2



Gear Unit CSF-2UP

■ Mounting on the flange A

When the CSF-2UP mini series is installed on the motor, check the flatness of the mounting face and assure that holes are free from burrs, then fasten the reducer to the mounting flange using bolts.

Table 168-1

Item \ Size		8	11	14
Number of bolts		4	4	4
Bolt size		M3	M3	M4
Mounting P.C.D.	mm	52	63	70.7
Tightening torque*	Nm	0.85	0.85	2.0
Minimum screw length	mm	3.6	3.6	4.8
Transmission torque*	Nm	18	22	44

* Recommended bolt: JIS B 1176 hexagon socket head bolt, tensile strength rank: JIS B 1051 12.9 or higher

■ Installation into the equipment B

When the CSF-2UP mini series is installed into the equipment, check the flatness of the mounting face and assure that holes are free from burrs, then fasten the reducer to the equipment using bolts.

Table 168-2

Item \ Size		8	11	14
Number of bolts		4	4	4
Bolt size		M3	M4	M5
Mounting P.C.D.	mm	58	70	88
Tightening torque*	Nm	1.2	2.7	5.4
Minimum screw length	mm	3.6	4.8	6.0
Transmission torque*	Nm	29.0	59.1	119

* When the part of the mounting destination is made of steel
* Recommended bolt: JIS B 1176 hexagon socket head bolt, tensile strength rank: JIS B 1051 12.9 or higher
* Use a washer so that the bolt seating surface does not directly touch the aluminum

■ Mounting load into the output C

Mount the load to the output side of the CSF-2UP mini series by taking into consideration the cross roller bearing specifications.

Table 168-3

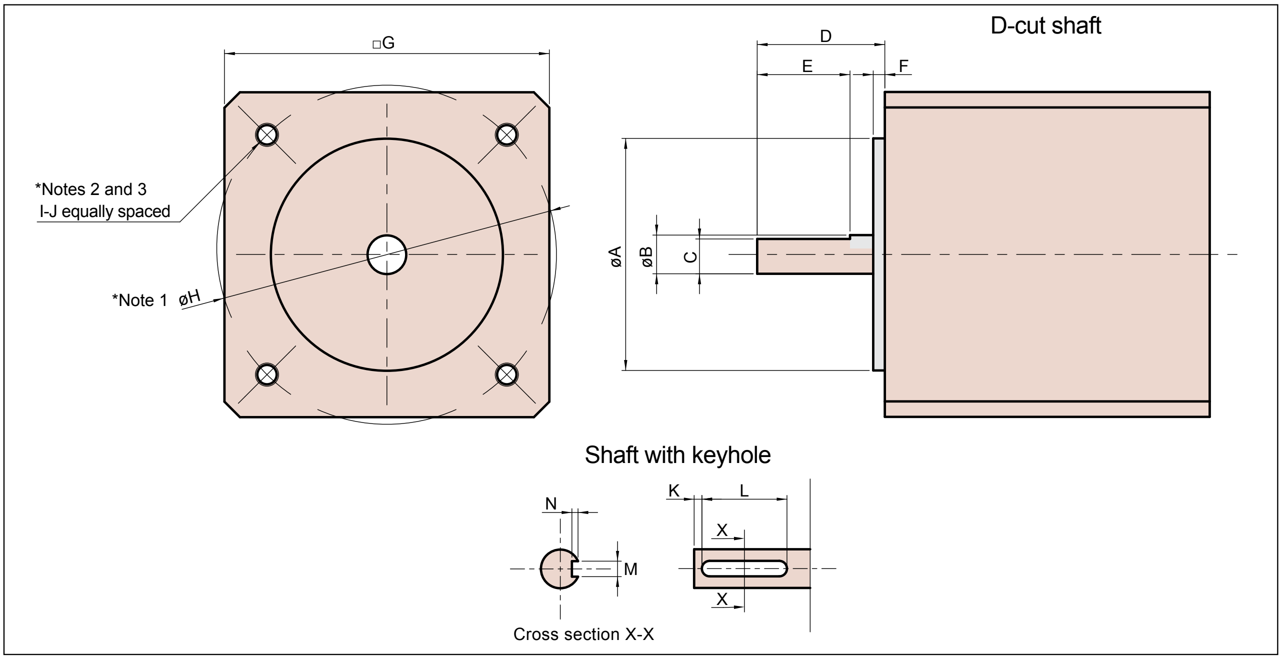
Item \ Size		8	11	14
Number of bolts		6	6	6
Bolt size		M3	M4	M5
Mounting P.C.D.	mm	25.5	33.0	44.0
Tightening torque*	Nm	2.0	4.5	9.0
Minimum screw length	mm	3.6	4.8	6.0
Transmission torque*	Nm	31.9	69.6	184

There is no need to apply a sealing compound to the output flange because it includes a seal.
* Recommended bolt: JIS B 1176 hexagon socket head bolt, tensile strength rank: JIS B 1051 12.9 or higher

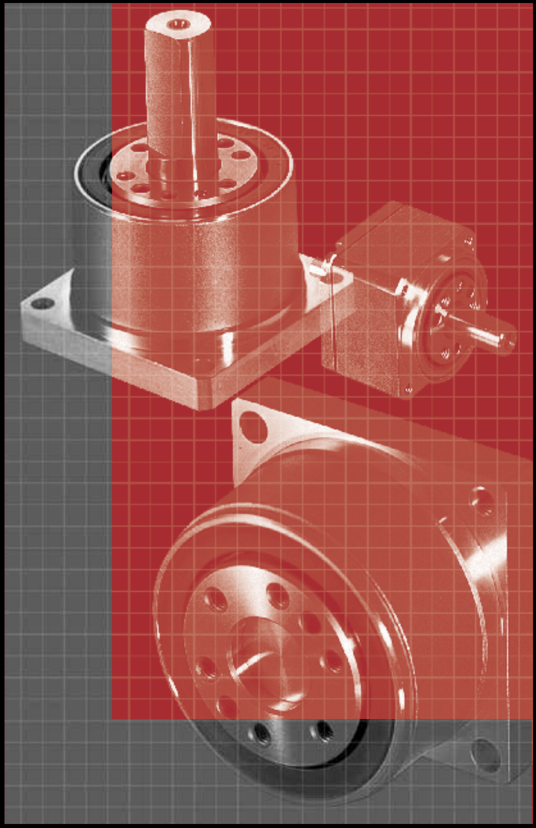
Motor mounting flange

Optional motor mounting flange is available from Harmonic Drive. If interested in ordering through Harmonic Drive, please let us know dimensions A through J (when the keyhole is attached: A through N) described in Figure 168-1 when ordering.

Figure 168-1



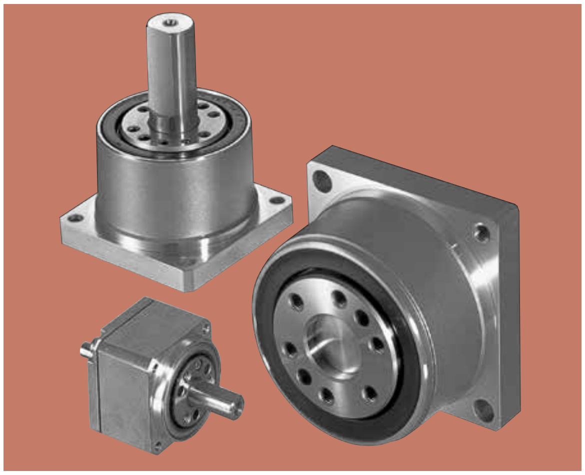
* Note 1. H: Mounting hole pitch diameter or pitch angular dimension
* Note 2. I: Total number of mounting holes
* Note 3. J: Tap hole nominal diameter and hole depth or through hole diameter
* Note 4. If using an O-ring between the motor and motor mounting flange, provide the O-ring dimensions.



CSF-mini Series

Gear Unit CSF-mini

Features



CSF-mini series

CSF mini gearheads provide excellent positioning accuracy in a super-compact package.
Compact 4-point contact bearing on the output side to support external loads. Available in four sizes and four ratios, the CSF mini gearheads feature shaft or flange outputs.

Features

- Zero backlash
- Compact and lightweight
- High-torque capacity
- High-torsional stiffness
- Excellent positional accuracy
- Coaxial input and output

Ordering Code

The HarmonicDrive® CSF-mini series consists of a wide variety of products including four sizes and six models.

CSF - 14 - 100 - 2XH - F - SP

Table 170-1

Series	Size	Ratio*1				Model	Special specification
CSF	5	30	50	—	100	1U= Input shaft, shaft output 1U-F= Input shaft, flange output 1U-CC= Square flange type, shaft output 1U-CC-F= Square flange type, flange output 2XH-J= Square flange type, shaft output 2XH-F= Square flange type, flange output	SP= Special specification code Blank = Standard product
	8	30	50	—	100		
	11	30	50	—	100		
	14	30	50	80	100		

*1 The reduction ratio value is based on the following configuration:
Input: wave generator, fixed: circular spline, output: flexspline

Technical Data

Rating table

Table 170-2

Size	Ratio	Rated Torque at input speed 2000rpm	Limit for Repeated Peak Torque	Limit for Average Torque	Limit for Momentary Peak Torque	Maximum Input Speed	Limit for Average Input Speed	Moment of Inertia ($^1/_4GD^2$)
		Nm	Nm	Nm	Nm	rpm	rpm	kgcm²
5	30	0.25	0.5	0.38	0.9	10000	6500	2.5×10^{-4} 2.5×10^{-4}
	50	0.4	0.9	0.53	1.8			
	100	0.6	1.4	0.94	2.7			
8	30	0.9	1.8	1.4	3.3	8500	3500	3.2×10^{-3} 3.0×10^{-3}
	50	1.8	3.3	2.3	6.6			
	100	2.4	4.8	3.3	9.0			
11	30	2.2	4.5	3.4	8.5	8500	3500	1.4×10^{-2} 1.2×10^{-2}
	50	3.5	8.3	5.5	17			
	100	5.0	11	8.9	25			
14	30	4.0	9.0	6.8	17	8500	3500	3.4×10^{-2} 3.3×10^{-2}
	50	5.4	18	6.9	35			
	80	7.8	23	11	47			
	100	7.8	28	11	54			

* The upper value of moment of inertia is for 1U, whereas, the lower value of it is for 2 XH.

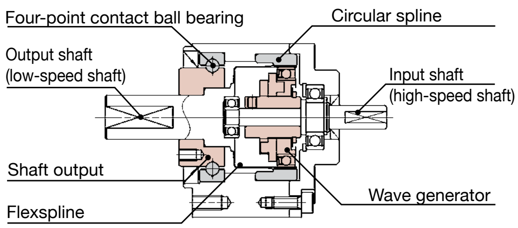
Structure

Fig. 171-1

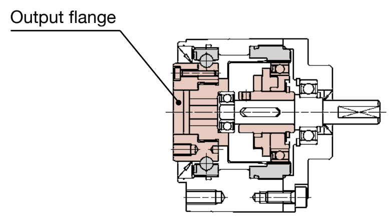
Input shaft version

This unit can be driven by a belt, coupling or a gear mounted on the input shaft. Available with shaft output or flange output.

Shaft output: 1U



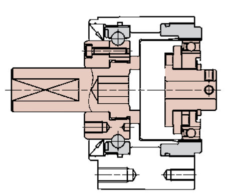
Flange output: 1U-F



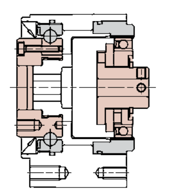
Motor mounting type

This gearhead is designed to be mounted to a motor, with the use of an adapter plate.

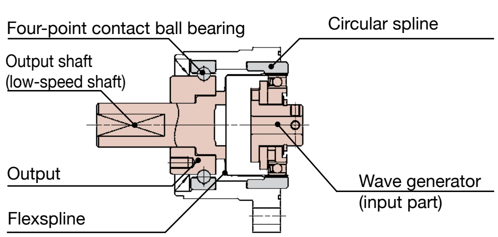
1U shaft output: 1U-CC



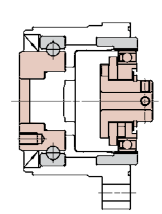
1U flange output: 1U-CC-F



Square flange version: 2XH-J



Flange output: 2XH-F



* The rotational direction of the output shaft is opposite to that of the input shaft (wave generator) when the housing is fixed.

Gear Unit CSF mini

Positional accuracy

See "Engineering data" for a description of terms.

Table 172-1

Ratio	Size / Specification	5	8	11	14
30	$\times 10^{-3}$rad	1.20	0.58	0.58	0.58
	arc min	4.00	2.00	2.00	2.00
50 or more	$\times 10^{-3}$rad	0.87	0.58	0.44	0.44
	arc min	3.00	2.00	1.50	1.50

Hysteresis

See "Engineering data" for a description of terms.

Table 172-2

Ratio	Size	5	8	11	14
30	$\times 10^{-4}$rad	8.7	8.7	8.7	8.7
	arc min	3.0	3.0	3.0	3.0
50	$\times 10^{-4}$rad	8.7	5.8	5.8	5.8
	arc min	3.0	2.0	2.0	2.0
80 or more	$\times 10^{-4}$rad	8.7	5.8	5.8	2.9
	arc min	3.0	2.0	2.0	1.0

Max. backlash

See "Engineering data" for a description of terms.

Table 172-3

Ratio	Size	8	11	14
30	$\times 10^{-5}$rad	28.6	23.8	29.1
	arc sec	59	49	60
50	$\times 10^{-5}$rad	17	14.1	17.5
	arc sec	35	24	36
80	$\times 10^{-5}$rad	—	—	11.2
	arc sec	—	—	23
100	$\times 10^{-5}$rad	8.7	7.3	8.7
	arc sec	18	15	18

Starting torque

See "Engineering data" for a description of terms. Please use as reference values; the values vary based on use conditions.

Table 172-4
Unit: Ncm

Ratio \ Size	5	8	11	14
30	0.53	1.3	3.4	6.4
50	0.40	0.80	2.0	4.1
80	—	—	—	2.8
100	0.30	0.59	1.5	2.5

Backdriving torque

See "Engineering data" for a description of terms. Please use as reference values; the values vary based on use conditions.

Table 172-5
Unit: Nm

Ratio \ Size	5	8	11	14
30	0.29	0.70	1.7	2.4
50	0.21	0.55	1.2	1.6
80	—	—	—	1.6
100	0.27	0.75	1.5	1.8

Ratcheting torque

See "Engineering data" for a description of terms.

Table 172-6
Unit: Nm

Ratio \ Size	5	8	11	14
30	2.7	11	29	59
50	3.2	12	34	88
80	–	–	–	110
100	3.5	14	43	84

Buckling torque

See "Engineering data" for a description of terms.

Table 172-7
Unit: Nm

Size	5	8	11	14
All ratios	9.8	35	90	190

Checking output bearing

A precision 4-point contact ball bearing is built into the CSF-mini series to directly support the external load.
Check the maximum moment load, life of the 4-point contact ball bearing and static safety coefficient to fully maximize the performance of the CSF-mini series.
See page 30 to 34 of "Engineering data" for each calculation formula.

■ Checking procedure

(1) Checking the maximum moment load (M_{max})

Calculate the maximum moment load (M_{max}). → Maximum moment load (M_{max}) ≦ allowable moment (Mc)

(2) Checking the life

Calculate the radial load (Fr_{av}) and the average axial load (Fa_{av}). → Calculate the radial load coefficient (x) and the axial load coefficient (y). → Calculate the lifetime

(3) Checking the static safety coefficient

Calculate the static equivalent radial load coefficient (Po). → Check the static safety coefficient. (fs)

■ Output bearing specifications

Specifications

Table 173-1

Size	Pitch circle dp	Offset R	Basic rated load: Basic dynamic rated load	Basic rated load: Basic static rated load	Allowable moment load	Moment rigidity	Allowable radial load *	Allowable axial load
	mm	mm	$\times 10^2$N	$\times 10^2$N	Nm	Nm/rad	N	N
5	13.5	4.85	9.14	7.63	0.89	7.41×10^2	90	270
8	20.5	7.3	21.6	19.0	3.46	2.76×10^3	200	630
11	27.5	9	38.9	35.4	6.6	7.41×10^3	300	1150
14	35	11.4	61.2	58.5	13.2	1.34×10^4	550	1800

* Allowable radial load is the value on the center of output shaft side of both shaft type (1U) and that of gearhead shaft output type (2XH-J).
* The value of the moment stiffness is the average value.

Lubrication

The standard CSF-mini gearheads are shipped already lubricated with grease. The table shows the grease that is used in the gear reducer and in the output bearing.

Table 173-2

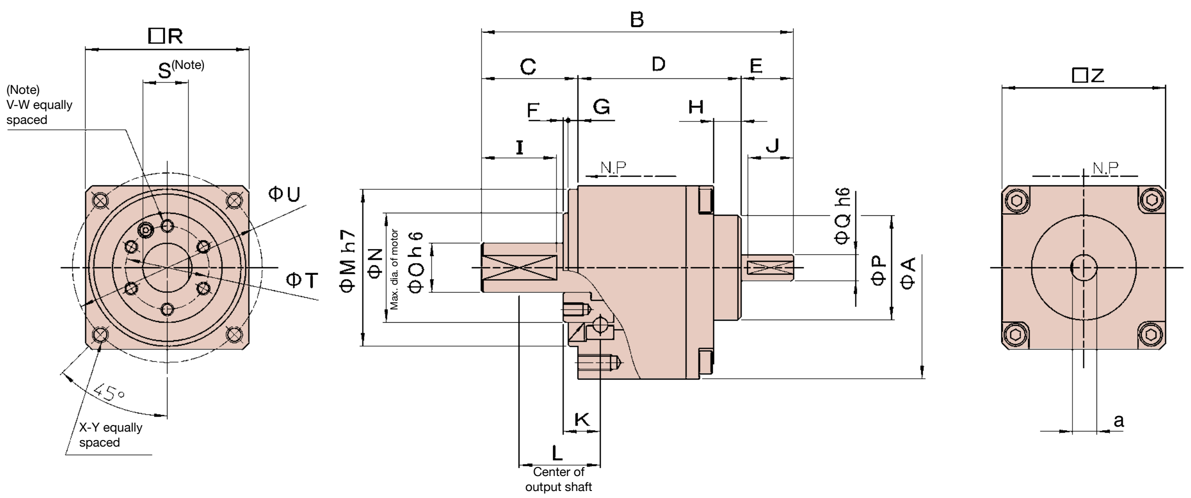
Lubricated area	Gear	Output bearing
Lubricant	Harmonic Grease SK-2	Multemp HL-D
Manufacturer	Harmonic Drive Systems	Kyodo Yushi
Base oil	Refined oil	Composite hydrocarbon oil
Base Viscosity cSt (25°C)	295	280
Thickening agent	Lithium soap	Lithium soap
Drop point	198°C	210°C
Appearance	Green	White

Outline Dimensions

Shaft output: outline dimension of 1U

You can download the CAD files from our website: harmonicdrive.net

Fig. 174-1



* Refer to the confirmation drawing for detailed dimensions

(Note) There is no positional relationship between the flat on the output shaft and the V-W tapped holes.
The allowance varies depending on the part manufacturing method (cast or machined products).
Contact us if the allowance is not described in the dimensions and is required.

Dimensions

Table 174-1

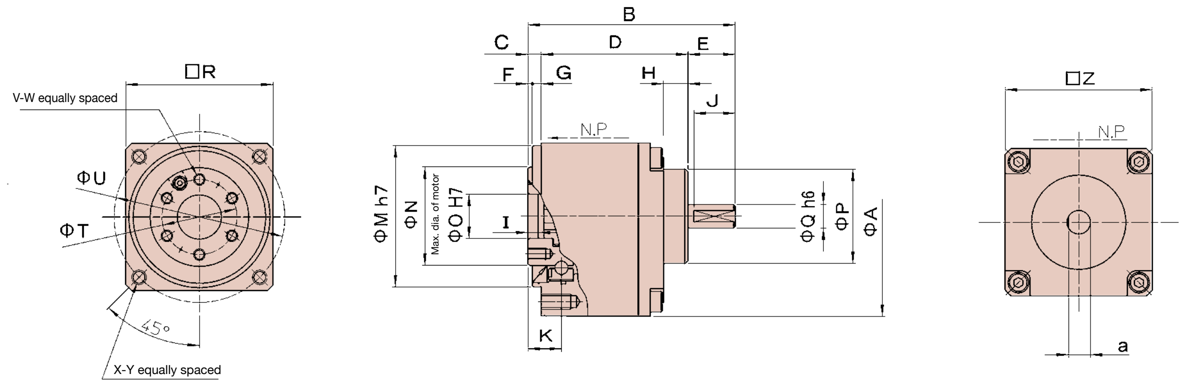
Unit: mm

Symbol \ Size	5	8	11	14
ϕA	26.5	40	54	68
B	37	65.5	82.5	95.4
C	13	23	29.5	29.5
D	16	29.5	37	49.9
E	8	13	16	16
F	0.5	0.5	0.5	1.5
G	2.5	2.5	3	3
H	0.8	2.6	3.9	8.4
I	9	18	21.5	23
J	7	11	14	14
K	4.85	7.3	9	11.4
L	9.85	17.3	22	23.9
ϕM h7	19.5	29	39	48
ϕN	13	20	26.5	33.5
ϕO h6	5	9	12	15
ϕP	9	16	24	32
ϕQ h6	3	5	6	8
□R	20.4±0.42	30.7±0.46	40.9±0.50	51.1±0.50
S	4.6	8	10.5	14
ϕT	9.8	15.5	20.5	25.5
ϕU	23	35	46	58
V	3	4	6	6
W	M2×3	M3×4	M3×5	M4×6
X	4	4	4	4
Y	M2×3	M3×6	M4×8	M5×10
□Z	20±0.42	30±0.46	40±0.50	50±0.50
a	2.6	4.5	5.5	7.5
Mass (g)	35	130	240	440

Outline Dimensions

Flange output: outline dimension of 1U-F

You can download the CAD files from our website: harmonicdrive.net



* Refer to the confirmation drawing for detailed dimensions

(Note) There is no positional relationship between the flat on the output shaft and the V-W tapped holes.
The allowance varies depending on the part manufacturing method (cast or machined products).
Contact us if the allowance is not described in the dimensions and is required.

Dimensions

Table 175-1
Unit: mm

Symbol \ Size	5	8	11	14
ϕA	26.5	40	54	68
B	27	45.5	56.5	70.4
C	3	3	3.5	4.5
D	16	29.5	37	49.9
E	8	13	16	16
F	0.5	0.5	0.5	1.5
G	2.5	2.5	3	3
H	0.8	2.6	3.9	8.4
I	1.7	2.2	2.5	3.5
J	7	11	14	14
K	4.85	7.3	9	11.4
ϕM h7	19.5	29	39	48
ϕN	13	20	26.5	33.5
ϕO H7	5	9	12	15
ϕP	9	16	24	32
ΦQ h6	3	5	6	8
□R	20.4±0.42	30.7±0.46	40.9±0.5	51.1±0.5
ϕT	9.8	15.5	20.5	25.5
ϕU	23	35	46	58
V	3	4	6	6
W	M2×3	M3×4	M3×5	M4×6
X	4	4	4	4
Y	M2×3	M3×6	M4×8	M5×10
□Z	20.4±0.42	30±0.46	40±0.5	50±0.5
a	2.6	4.5	5.5	7.5
Mass (g)	34	120	220	405

Gear Unit CSF-1U

Torsional stiffness

See "Engineering data" for a description of terms.

Table 176-1

Symbol		Unit	5 1U	5 1U-F	8 1U	8 1U-F	11 1U	11 1U-F	14 1U	14 1U-F
	T_1	Nm	0.075		0.29		0.80		2.0	
	T_1	kgfm	0.0077		0.030		0.082		0.20	
	T_2	Nm	0.22		0.75		2.0		6.9	
	T_2	kgfm	0.022		0.077		0.20		0.70	
Ratio 30	K_1	$\times 10^4$Nm/rad	0.009	0.010	0.031	0.034	0.077	0.084	0.172	0.188
	K_1	kgfm/arc min	0.003	0.003	0.009	0.010	0.023	0.025	0.051	0.056
	K_2	$\times 10^4$Nm/rad	0.011	0.013	0.039	0.044	0.109	0.124	0.210	0.235
	K_2	kgfm/arc min	0.003	0.004	0.012	0.013	0.032	0.037	0.063	0.070
	K_3	$\times 10^4$Nm/rad	0.012	0.016	0.046	0.054	0.134	0.158	0.286	0.335
	K_3	kgfm/arc min	0.004	0.005	0.014	0.016	0.040	0.047	0.085	0.100
	θ_1	$\times 10^{-4}$rad	8.7	7.5	9.5	8.6	10	9.5	12	11
	θ_1	arc min	3.0	2.6	3.2	3.0	3.6	3.3	4.0	3.6
	θ_2	$\times 10^{-4}$rad	22	19	21	19	21	19	35	31
	θ_2	arc min	7.5	6.4	7.3	6.6	7.4	6.6	12	11
Ratio 50	K_1	$\times 10^4$Nm/rad	0.011	0.013	0.039	0.044	0.177	0.221	0.286	0.335
	K_1	kgfm/arc min	0.003	0.004	0.012	0.013	0.053	0.066	0.085	0.100
	K_2	$\times 10^4$Nm/rad	0.014	0.018	0.056	0.067	0.225	0.300	0.378	0.468
	K_2	kgfm/arc min	0.004	0.005	0.017	0.020	0.067	0.089	0.113	0.140
	K_3	$\times 10^4$Nm/rad	0.017	0.025	0.067	0.084	0.236	0.320	0.440	0.568
	K_3	kgfm/arc min	0.005	0.007	0.020	0.025	0.070	0.095	0.131	0.170
	θ	$\times 10^{-4}$rad	6.9	5.6	7.5	6.6	4.5	3.6	7.0	6.0
	θ	arc min	2.4	2.0	2.6	2.3	1.6	1.2	2.4	2.0
	θ	$\times 10^{-4}$rad	18	14	16	14	9.9	7.6	20	16
	θ	arc min	6.0	4.8	5.4	4.7	3.4	2.6	6.8	5.6
Ratio 80 or more	K_1	$\times 10^4$Nm/rad	0.015	0.020	0.072	0.090	0.206	0.267	0.378	0.468
	K_1	kgfm/arc min	0.004	0.006	0.021	0.027	0.061	0.079	0.113	0.140
	K_2	$\times 10^4$Nm/rad	0.018	0.027	0.080	0.104	0.243	0.333	0.460	0.601
	K_2	kgfm/arc min	0.005	0.008	0.024	0.031	0.072	0.099	0.137	0.179
	K_3	$\times 10^4$Nm/rad	0.020	0.030	0.089	0.120	0.291	0.432	0.516	0.700
	K_3	kgfm/arc min	0.006	0.009	0.027	0.036	0.086	0.128	0.154	0.209
	θ	$\times 10^{-4}$rad	5.0	3.7	4.1	3.2	3.9	3.0	5.3	4.3
	θ	arc min	1.7	1.3	1.4	1.1	1.3	1.0	1.8	1.5
	θ	$\times 10^{-4}$rad	13	9.2	9.8	7.7	8.8	6.6	16	12
	θ	arc min	4.4	3.1	3.4	2.6	3.0	2.3	5.4	4.2

* The values in this table are reference values. The minimum value is approximately 80% of the displayed value.

Mechanical precision

The CSF-mini series gearheads have 4-point contact bearings on the output side to support external loads. The mechanical precision of the output shaft and output flange is shown below.

The output shaft of the input shaft version

Fig. 176-1

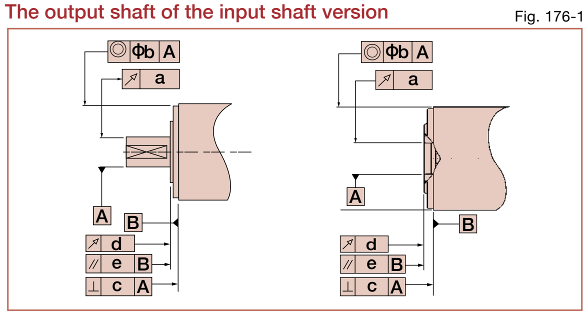


Table 176-2

* T.I.R. Unit: mm

Symbol	Precision item		5 1U	5 1U-F	8 1U	8 1U-F	11 1U	11 1U-F	14 1U	14 1U-F
a	1U	Runout on the edge of the output flange	0.030	—	0.030	—	0.030	—	0.030	—
a	1U-F	Runout on the inner diameter of the output flange	—	0.005	—	0.005	—	0.005	—	0.005
b	Concentricity		0.040		0.040		0.055		0.055	
c	Perpendicularity		0.020		0.020		0.025		0.025	
d	Runout		0.005		0.005		0.005		0.005	
e	Parallelism		0.015		0.020		0.030		0.030	

* T.I.R.: This indicates the total reading of the dial gauge when the measuring part is rotated once.

Efficiency

The efficiency varies depending on the following conditions.

- Reduction ratio
- Input rotational speed
- Load torque
- Temperature
- Lubrication (type and quantity)

Measurement condition

Table 177-1

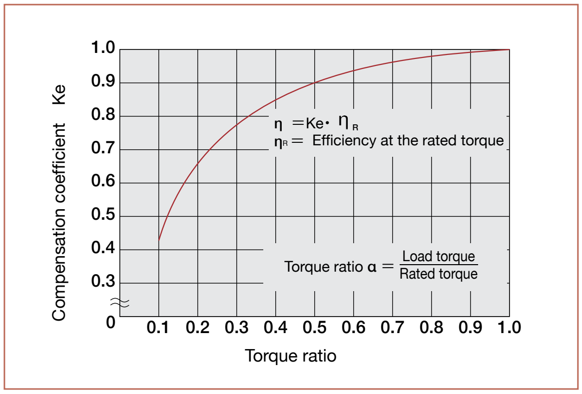
Load torque	Rated torque in rating table (see Page 170)		
Lubricant	Grease lubrication	Name	Harmonic Grease SK-2
		Quality	Recommended quantity

Efficiency compensation coefficient

When the load torque is lower than the rated torque, the efficiency value decreases. Calculate compensation coefficient Ke from Graph 177-1.

Efficiency compensation coefficient

Graph 177-1



Efficiency η (%) under the following condition is obtained from the example of CSF-8-100-1U.
Input rotational speed: 1000 rpm
Load torque: 2.0 Nm
Lubrication method: Grease lubrication
Lubricant temperature: 20°C

Since the rated torque of size 8 with a reduction ratio of 100 is 2.4 Nm (Ratings: Page 170), the torque ratio α is 0.83. (α=2.0/2.4≈0.83)

- The efficiency compensation coefficient is Ke=0.99 from Graph 177-1.
- Efficiency η at load torque 2.0 Nm: $\eta = Ke \cdot \eta_R = 0.99 \times 77\% = 76\%$

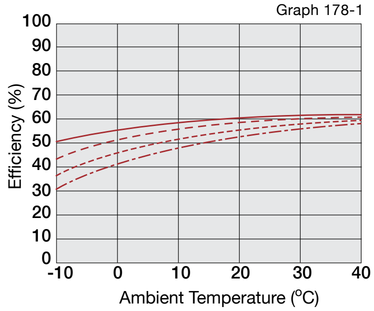
* When the load torque is higher than the rated torque, efficiency compensation value Ke is 1.

■ Efficiency at rated torque

Size 5

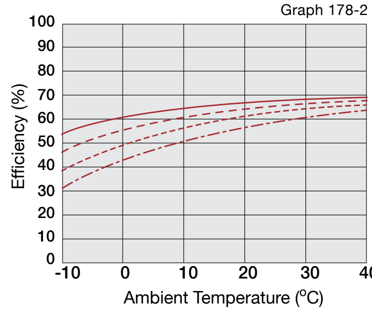
Ratio 30

Graph 178-1



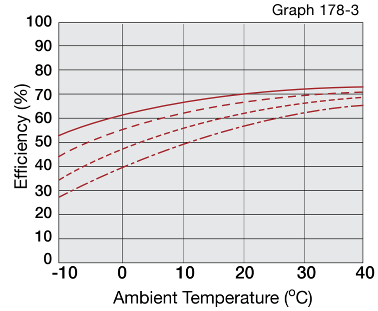
Ratio 50

Graph 178-2



Ratio 100

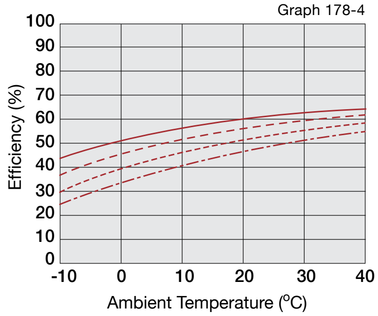
Graph 178-3



Size 8

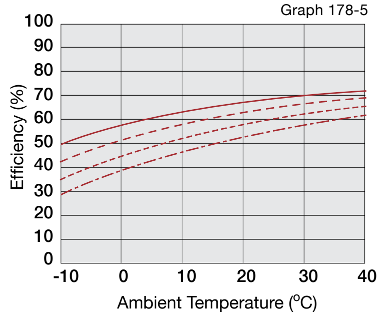
Ratio 30

Graph 178-4



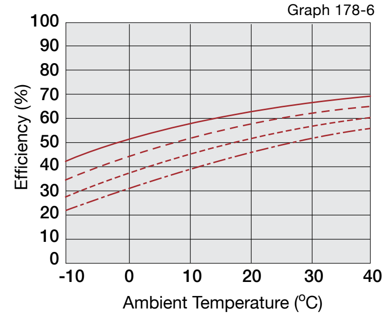
Ratio 50

Graph 178-5



Ratio 100

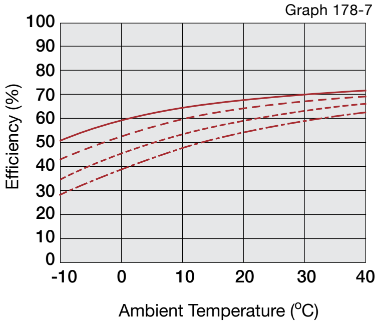
Graph 178-6



Size 11

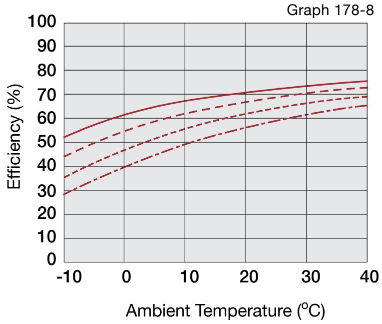
Ratio 30

Graph 178-7



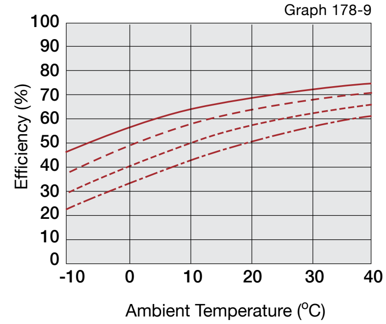
Ratio 50

Graph 178-8



Ratio 100

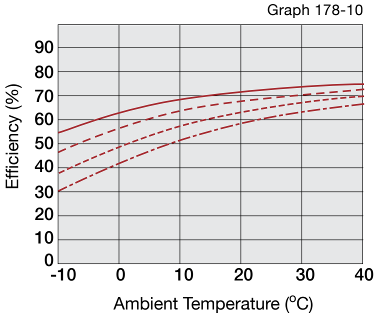
Graph 178-9



Size 14

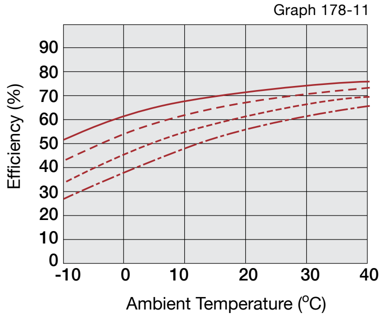
Ratio 30

Graph 178-10



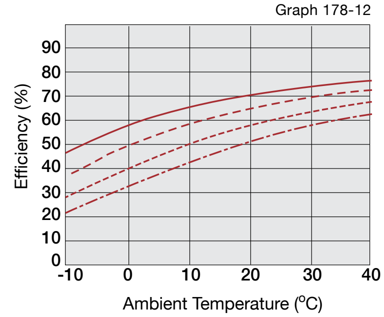
Ratio 50

Graph 178-11



Ratio 80 and 100

Graph 178-12



Input rotational speed: ——— 500rpm, – – – – 1000rpm, - - - - 2000rpm, –·–·– 3500rpm

No-load running torque

No-load running torque is the torque which is required to rotate the input side (high speed side), when there is no load on the output side (low speed side).

Measurement Condition Table 179-1

Ratio			
Lubrication type	Grease lubrication	Name	Harmonic Grease SK-2
Torque value is measured after 2 hours at 2000rpm input.			

■ Compensation Value in Each Ratio

No-load running torque of the gear varies with ratio. Graphs 179-1 to 179-4 show the values for a reduction ratio of 100. For other gear ratios, add the compensation values in the right-hand table (Table 179-2).

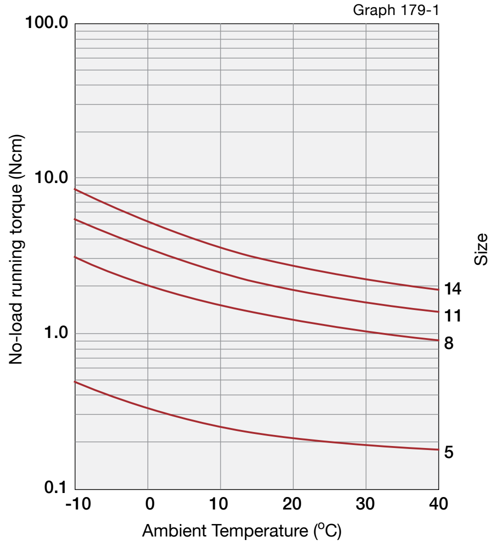
No-Load Torque Running Torque Compensation Value Table 179-2 Unit: Ncm

Size \ Ratio	30	50	80
5	0.26	0.11	—
8	0.44	0.19	—
11	0.81	0.36	—
14	1.33	0.58	0.1

■ No-load running torque for a reduction ratio of 100

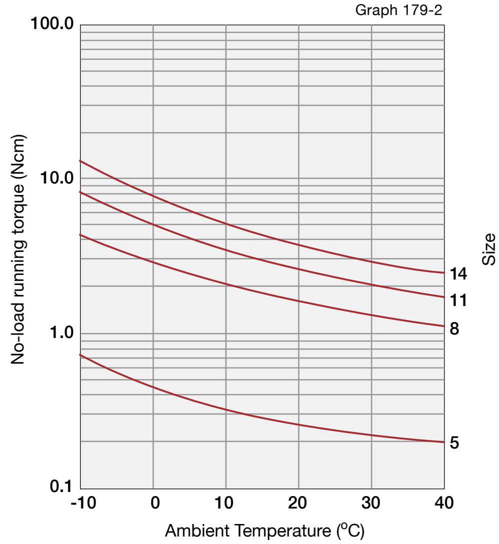
Input speed: 500rpm

Graph 179-1



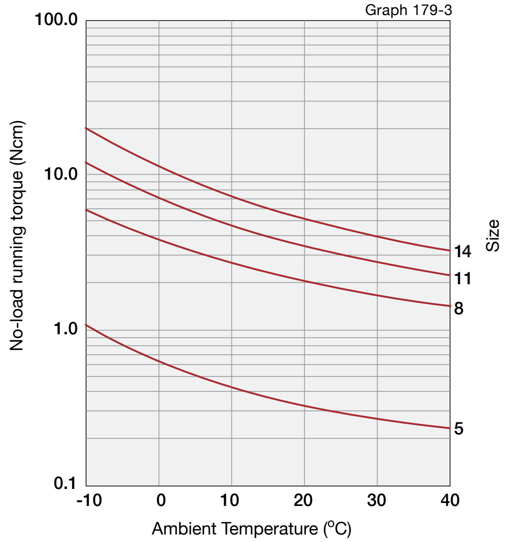
Input speed: 1000rpm

Graph 179-2



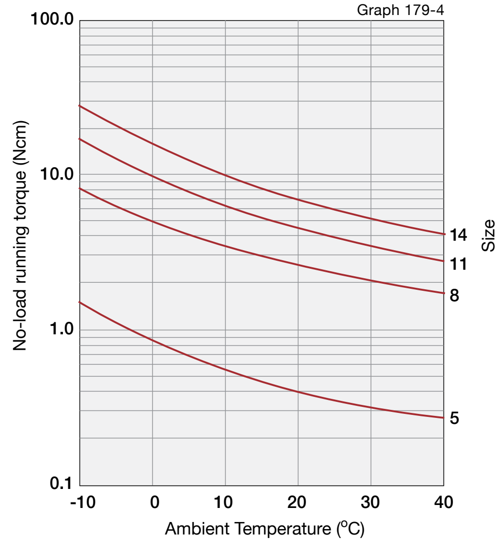
Input speed: 2000rpm

Graph 179-3



Input speed: 3500rpm

Graph 179-4



*The values in this graph are average values ($\bar{X}$).

Gear Unit CSF-1U

Performance data for the input bearing

■ Performance data for the input bearing

The input shaft type is supported by two deep groove single row ball bearings. Please check the loading on the input shaft to make sure that it is acceptable. Figure 180-1, Table 244-1, Graph 180-1 show the points of application of forces, which determine the maximum allowable radial and axial loads as indicated.
The values in Graph 180-1 are valid for an average input speed of 2000 rpm and a mean bearing life of L10=7000h.

Example: When an 8-N axial load (Fa) is applied to the size 14 input shaft, the value of the maximum allowable radial load (Fr) is 20 N.

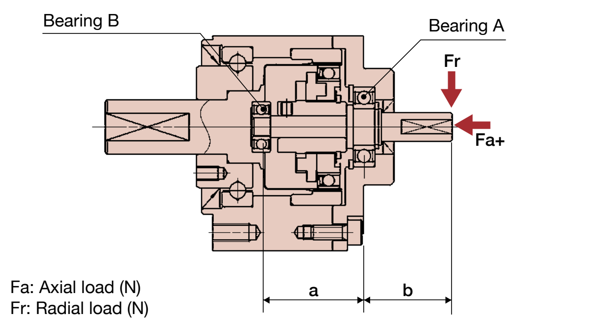
Specification for Input Bearing

Table 180-1

Size	Bearing A			Bearing B			Distance between bearings a	Overhang length of the input shaft b	Maximum radial load
	Model	Basic dynamic rated load	Basic static rated load	Model	Basic dynamic rated load	Basic static rated load			
		Cr (N)	Cor (N)		Cr (N)	Cor (N)	a (mm)	b (mm)	Fr (N)
5	SSLF-630DD	196	59	L-520WO2	176	54	10.8	9.25	8
8	MR126	715	292	MR83	560	170	16.65	18	10
11	689	1330	665	624	1300	485	20.6	21.9	20
14	6900ZZ	2700	1270	605ZZ	1330	505	28.25	24.25	30

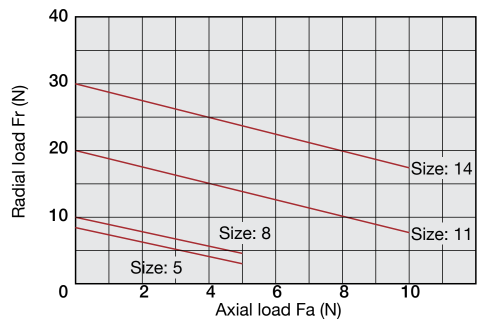
Supporting point of the roller bearing

Fig. 180-1



Relation between the radial load and the axial load

Graph 180-1



Installation and transmission torque

■ Installation on the equipment

Check the mating surface for flatness and any burrs prior to mounting the CSF-mini product. Use the proper screws and tightening torque as specified in Table 180-2.

Tightening torque of the bolt* of the mounting flange (A in Figure 181-1)

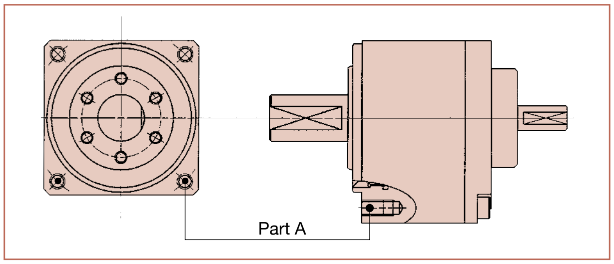
Table 180-2

Item \ Size		5	8	11	14
Number of bolts		4	4	4	4
Bolt size		M2	M3	M4	M5
Pitch circle	mm	23	35	46	58
Clamp torque	Nm	0.25	0.85	2.0	3.96
Screw	mm	2.4	3.6	4.8	6.0
Transmission torque	Nm	3.5	12	29	57

* Recommended bolt: JIS B 1176 hexagonal bolt,strength: JIS B 1051 12.9 or higher.

Mounting flange

Fig. 181-1



■ Installation of the load on the output part

Install the load on the output part taking the specifications of the output bearing (see Page 173) into consideration.

Tightening torque of the bolt* of the mounting flange (B in Figure 181-2)

Table 181-1

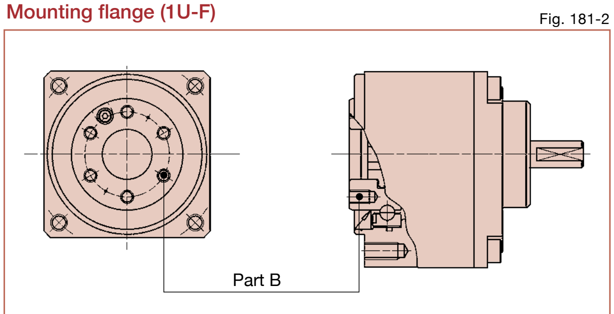
Item \ Size		5	8	11	14
Number of bolts		3	4	6	6
Bolt size		M2	M3	M3	M4
Pitch circle	mm	9.8	15.5	20.5	25.5
Clamp torque	Nm	0.54	2.0	2.0	4.6
Transmission torque	Nm	2	13	26	55

As measures have been taken against oil leakage of the output flange, no sealing agent needs to be applied.

* Recommended bolt: JIS B 1176 hexagonal bolt, strength: JIS B 1051 12.9 or higher.

Mounting flange (1U-F)

Fig. 181-2



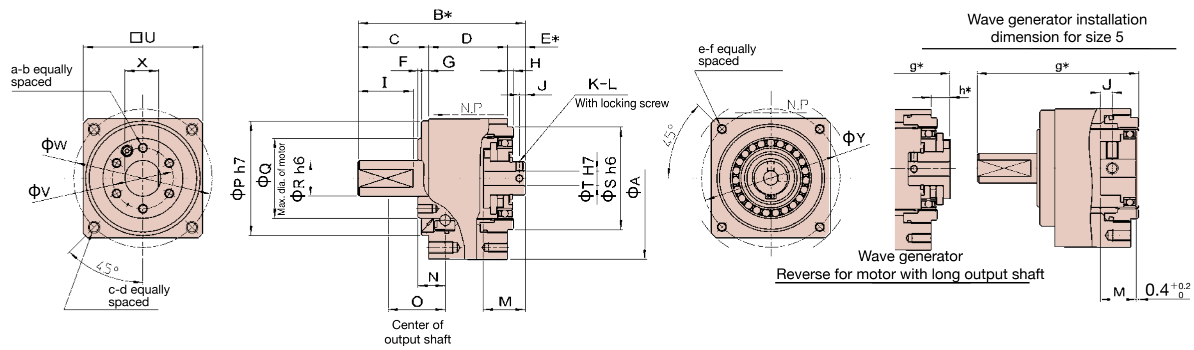
Do not allow the output shaft to receive a shock when you install a pulley and pinion. It can deteriorate the precision of the reducer and cause failure.

Outline Dimensions

Shaft output: outline dimensions 1U-CC

You can download the CAD files from our website: harmonicdrive.net

Fig. 182-1



* Please refer to the confirmation drawing for detailed dimensions. 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.* See Fig. 040-3 on Page 040 for the shapes of the wave generator.

Dimensions

Table 182-1

Unit : mm

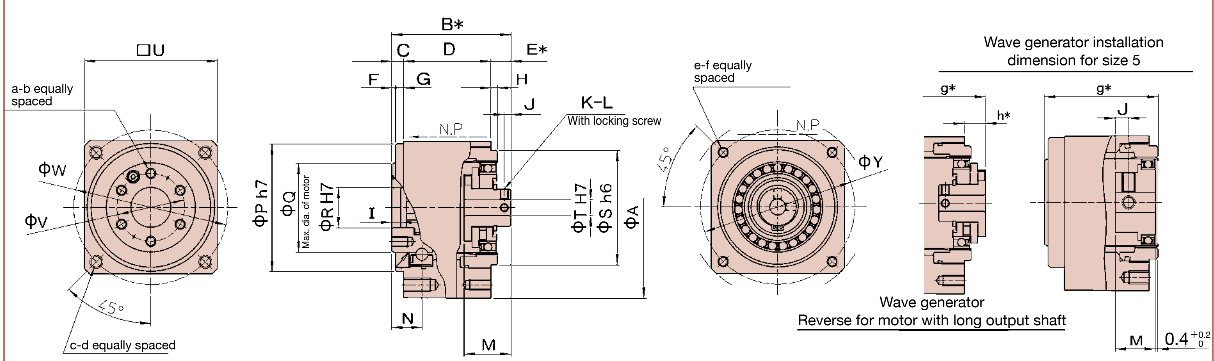
Symbol \ Size	5	8	11	14
ϕA	26.5	40	54	68
B*	30.5	51	64.3	70
C	13	23	29.5	29.5
D	12.7	21.5	26.5	33
E*	4.8 $^{0}_{-0.2}$	6.5 $^{0}_{-0.3}$	8.3 $^{0}_{-0.7}$	7.5 $^{0}_{-0.8}$
F	0.5	0.5	0.5	1.5
G	2.5	2.5	3	3
H	1.3	1.5	2	2.5
I	9	18	21.5	23
J	2	2	3	2.5
K	2	2	2	2
L	M2×3	M2×3	M3×4	M3×4
M	6	12	16	17.6
N	4.85	7.3	9	11.4
O	9.85	17.3	22	23.9
ϕP h7	19.5	29	39	48
ϕQ	13	20	26.5	33.5
ϕR h6	5	9	12	15
ϕS h6	17	26	35	43
ϕT H7	3	3	5	6
□U	20.4±0.42	30.7±0.46	40.9±0.5	51.1±0.5
ϕV	9.8	15.5	20.5	25.5
ϕW	23	35	46	58
X	4.6	8	10.5	14
ϕY	22.5	34	46	58
a	3	4	6	6
b	M2×3	M3×4	M3×5	M4×6
c	4	4	4	4
d	M2×3	M3×6	M4×8	M5×10
e	4	4	4	4
f	M2×3	M2.5×5	M3×6	M4×8
g*	27	48.7	62.1	70.4
h*	—	4.2 $^{0}_{-0.3}$	6.1 $^{0}_{-0.7}$	7.9 $^{0}_{-0.8}$
Mass (g)	27	111	176	335

- *The B, E, g and h dimensions indicated by an asterisk are the mounting positions in the shaft direction and allowance of the three parts (wave generator, flexspline, circular spline). Strictly observe these dimensions as they affect the performance and strength.
- Wave generator is removed when the product is delivered.

Flange output: outline dimensions 1U-CC-F

You can download the CAD files from our website: harmonicdrive.net

Fig. 183-1



* Please refer to the confirmation drawing for detailed dimensions. 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.* See Fig. 040-3 on Page 040 for the shapes of the wave generator.

Dimensions

Table 183-1

Unit : mm

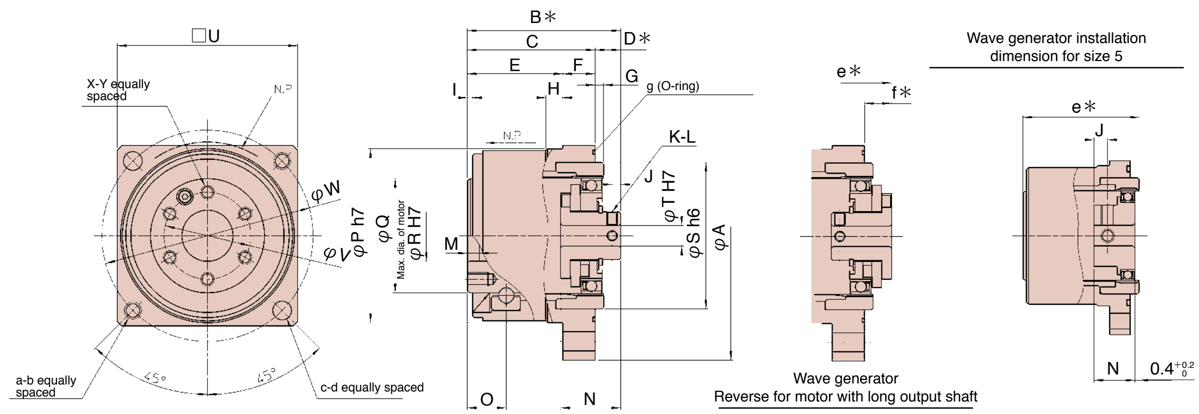
Symbol \ Size	5	8	11	14
ΦA	26.5	40	54	68
B*	20.5	31	38.3	45
C	3	3	3.5	4.5
D	12.7	21.5	26.5	33
E*	$4.8^{0}_{-0.2}$	$6.5^{0}_{-0.3}$	$8.3^{0}_{-0.7}$	$7.5^{0}_{-0.8}$
F	0.5	0.5	0.5	1.5
G	2.5	2.5	3	3
H	1.3	1.5	2	2.5
I	1.7	2.2	2.5	3.5
J	2	2	3	2.5
K	2	2	2	2
L	M2×3	M2×3	M3×4	M3×4
M	6	12	16	17.6
N	4.85	7.3	9	11.4
ΦP h7	19.5	29	39	48
ΦQ	13	20	26.5	33.5
ΦR H7	5	9	12	15
ΦS h6	17	26	35	43
ΦT H7	3	3	5	6
□U	20.4±0.42	30.7±0.46	40.9±0.5	51.1±0.5
ΦV	9.8	15.5	20.5	25.5
ΦW	23	35	46	58
ΦY	22.5	34	46	58
a	3	4	6	6
b	M2×3	M3×4	M3×5	M4×6
c	4	4	4	4
d	M2×3	M3×6	M4×8	M5×10
e	4	4	4	4
f	M2×3	M2.5×5	M3×6	M4×8
g*	17	28.7	36.1	45.4
h*	—	$4.2^{0}_{-0.3}$	$6.1^{0}_{-0.7}$	$7.9^{0}_{-0.8}$
Mass (g)	25	100	150	295

- *The B, E, g and h dimensions indicated by an asterisk are the mounting positions in the shaft direction and allowance of the three parts (wave generator, flexspline, circular spline). Strictly observe these dimensions as they affect the performance and strength.
- Wave generator is removed when the product is delivered.

Flange output: outline dimensions 2XH-F

You can download the CAD files from our website: harmonicdrive.net

Fig. 184-1



* Please refer to the confirmation drawing for detailed dimensions. 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.* See Fig. 040-3 on Page 040 for the shapes of the wave generator.

Dimensions

Table 184-1

Unit : mm

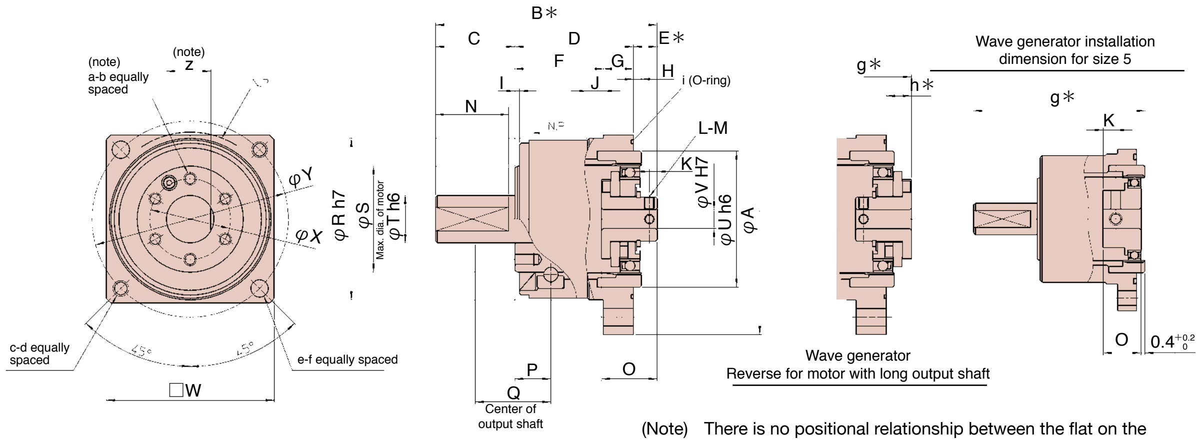
Symbol \ Size	5	8	11	14
ϕA	29	43.5	58	73
B*	20.5	31	38.3	45
C	15.7	24.5	30	37.5
D*	$4.8^{0}_{-0.2}$	$6.5^{0}_{-0.3}$	$8.3^{0}_{-0.7}$	$7.5^{0}_{-0.8}$
E	12.7	19	23.5	28
F	3	5.5	6.5	9.5
G	1.3	1.5	2	2.5
H	2	3	3	5
I	0.5	0.5	0.5	1.5
J	2	2	3	2.5
K	2	2	2	2
L	M2×3	M2×3	M3×4	M3×4
M	1.7	2.2	2.5	3.5
N	6	12	16	17.6
O	4.85	7.3	9	11.4
ϕP h7	20.5	31	40.5	51
ϕQ	13	20	26.5	33.5
ϕR H7	5	9	12	15
ϕS h6	17	26	35	43
ϕT H7	3	3	5	6
□U	22±0.42	32±0.46	43±0.50	53±0.50
ϕV	9.8	15.5	20.5	25.5
ϕW	25	37.5	50	62
X	3	4	6	6
Y	M2×3	M3X4	M3×5	M4×6
a	2	2	2	2
b	M2	M3	M4	M5
c	2	2	2	2
ϕd	2.3	3.4	4.5	5.5
e*	17	28.7	36.1	45.4
f*	—	$4.2^{0}_{-0.3}$	$6.1^{0}_{-0.7}$	$7.9^{0}_{-0.8}$
g (accessory)	18.90×0.70	28.20×1.00	38.00×1.50	48.00×1.00
Mass (g)	25	100	150	295

- *The B, D, e and f dimensions indicated by an asterisk are the mounting positions in the shaft direction and allowance of the three parts (wave generator, flexspline, circular spline). Strictly observe these dimensions as they affect the performance and strength.
- Wave generator is removed when the product is delivered.

Shaft output: outline dimensions 2XH-J

You can download the CAD files from our website: harmonicdrive.net

Fig. 185-1



(Note) There is no positional relationship between the flat on the output shaft and the a-b tapped holes.

* Please refer to the confirmation drawing for detailed dimensions. 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.* See Fig. 040-3 on Page 040 for the shapes of the wave generator.

Dimensions

Table 185-1

Unit : mm

Symbol \ Size	5	8	11	14
φA	29	43.5	58	73
B*	30.5	51	64.3	70
C	10	20	26	25
D	15.7	24.5	30	37.5
E*	$4.8^{0}_{-0.2}$	$6.5^{0}_{-0.3}$	$8.3^{0}_{-0.7}$	$7.5^{0}_{-0.8}$
F	12.7	19	23.5	28
G	3	5.5	6.5	9.5
H	1.3	1.5	2	2.5
I	0.5	0.5	0.5	1.5
J	2	3	3	5
K	2	2	3	2.5
L	2	2	2	2
M	M2×3	M2×3	M3×4	M3×4
N	9	18	21.5	23
O	6	12	16	17.6
P	4.85	7.3	9	11.4
Q	9.85	17.3	22	23.9
φR h7	20.5	31	40.5	51
φS	13	20	26.5	33.5
φT h6	5	9	12	15
φU h6	17	26	35	43
φV H7	3	3	5	6
□W	22±0.42	32±0.46	43±0.50	53±0.50
φX	9.8	15.5	20.5	25.5
φY	25	37.5	50	62
Z	4.6	8	10.5	14
a	3	4	6	6
b	M2×3	M3×4	M3×5	M4×6
c	2	2	2	2
d	M2	M3	M4	M5
e	2	2	2	2
φf	2.3	3.4	4.5	5.5
g*	27	48.7	62.1	70.4
h*	—	$4.2^{0}_{-0.3}$	$6.1^{0}_{-0.7}$	$7.9^{0}_{-0.8}$
i (accessory)	18.90×0.70	28.20×1.00	38.00×1.50	48.00×1.00
Mass (g)	27	111	176	335

- *The B, E, g and h dimensions indicated by an asterisk are the mounting positions in the shaft direction and allowance of the three parts (wave generator, flexspline, circular spline). Strictly observe these dimensions as they affect the performance and strength.
- Wave generator is removed when the product is delivered.

Hole diameter of the wave generator

The standard hole dimension of the Wave Generator for each size is shown. The dimension can be changed within a range up to the maximum hole dimension shown in the following table to match the shaft diameter of the mounting motor.

Table 186-1

Unit: mm

Symbol \ Size	5	8	11	14
2XH-F: φT H7 2XH-J: φV H7 1U-CC-F: φT H7 1U-CC: φT H7	1.5 to 6	2 to 4 (2 to 8)	3 to 7 (3 to 8)	4 to 8 (4 to 10)

Note 1: The standard Wave Generator has an Oldham coupling to compensate for any misalignment. The parenthesized value indicates the value for an input without an Oldham coupling (known as a solid wave generator). The size 5 is standard with a solid wave generator.
Note 2: The size of the set screw may be changed due to the hole diameter.
Note 3: A keyway may be incorporated, depending on the hole diameter.
Note 4: Special specifications apply to all changes of the hole diameter size. Contact our office for details of the sizes.

Torsional stiffness

See "Engineering data" for a description of terms.

Table 186-2

Symbol \ Size			5		8		11		14	
			2XH-J/1U-CC	2XH-F/1U-CC-F	2XH-J/1U-CC	2XH-F/1U-CC-F	2XH-J/1U-CC	2XH-F/1U-CC-F	2XH-J/1U-CC	2XH-F/1U-CC-F
	T_1	Nm	0.075		0.29		0.80		2.0	
	T_1	kgfm	0.0077		0.030		0.082		0.20	
	T_2	Nm	0.22		0.75		2.0		6.9	
	T_2	kgfm	0.022		0.077		0.20		0.70	
Ratio 30	K_1	×10⁴Nm/rad	0.009	0.010	0.031	0.034	0.077	0.084	0.172	0.188
		kgfm/arc min	0.003	0.003	0.009	0.010	0.023	0.025	0.051	0.056
	K_2	$\times 10^4$Nm/rad	0.011	0.013	0.039	0.044	0.109	0.124	0.210	0.235
		kgfm/arc min	0.003	0.004	0.012	0.013	0.032	0.037	0.063	0.070
	K_3	$\times 10^4$Nm/rad	0.012	0.016	0.046	0.054	0.134	0.158	0.286	0.335
		kgfm/arc min	0.004	0.005	0.014	0.016	0.040	0.047	0.085	0.100
	θ_1	$\times 10^{-4}$rad	8.7	7.5	9.5	8.6	10	9.5	12	11
		arc min	3.0	2.6	3.2	3.0	3.6	3.3	4.0	3.6
	θ_2	$\times 10^{-4}$rad	22	19	21	19	21	19	35	31
		arc min	7.5	6.4	7.3	6.6	7.4	6.6	12	11
Ratio 50	K_1	$\times 10^4$Nm/rad	0.011	0.013	0.039	0.044	0.177	0.221	0.286	0.335
		kgfm/arc min	0.003	0.004	0.012	0.013	0.053	0.066	0.085	0.100
	K_2	$\times 10^4$Nm/rad	0.014	0.018	0.056	0.067	0.225	0.300	0.378	0.468
		kgfm/arc min	0.004	0.005	0.017	0.020	0.067	0.089	0.113	0.140
	K_3	$\times 10^4$Nm/rad	0.017	0.025	0.067	0.084	0.236	0.320	0.440	0.568
		kgfm/arc min	0.005	0.007	0.020	0.025	0.070	0.095	0.131	0.170
	θ_1	$\times 10^{-4}$rad	6.9	5.6	7.5	6.6	4.5	3.6	7.0	6.0
		arc min	2.4	2.0	2.6	2.3	1.6	1.2	2.4	2.0
	θ_2	$\times 10^{-4}$rad	18	14	16	14	9.9	7.6	20	16
		arc min	6.0	4.8	5.4	4.7	3.4	2.6	6.8	5.6
Ratio 80 or more	K_1	$\times 10^4$Nm/rad	0.015	0.020	0.072	0.090	0.206	0.267	0.378	0.468
		kgfm/arc min	0.004	0.006	0.021	0.027	0.061	0.079	0.113	0.140
	K_2	$\times 10^4$Nm/rad	0.018	0.027	0.080	0.104	0.243	0.333	0.460	0.601
		kgfm/arc min	0.005	0.008	0.024	0.031	0.072	0.099	0.137	0.179
	K_3	$\times 10^4$Nm/rad	0.020	0.030	0.089	0.120	0.291	0.432	0.516	0.700
		kgfm/arc min	0.006	0.009	0.027	0.036	0.086	0.128	0.154	0.209
	θ_1	$\times 10^{-4}$rad	5.0	3.7	4.1	3.2	3.9	3.0	5.3	4.3
		arc min	1.7	1.3	1.4	1.1	1.3	1.0	1.8	1.5
	θ_2	$\times 10^{-4}$rad	13	9.2	9.8	7.7	8.8	6.6	16	12
		arc min	4.4	3.1	3.4	2.6	3.0	2.3	5.4	4.2

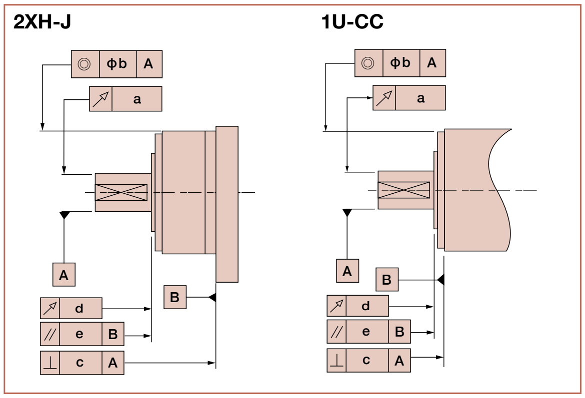
* The values in this table are reference values. The minimum value is approximately 80% of the displayed value.

Output bearing and housing tolerances

The CSF-mini series gearheads have 4-point contact bearings on the output side to support external loads. The mechanical precision of the output shaft and output flange is shown below.

Shaft output

Fig. 187-1



Flange output

Fig. 187-2

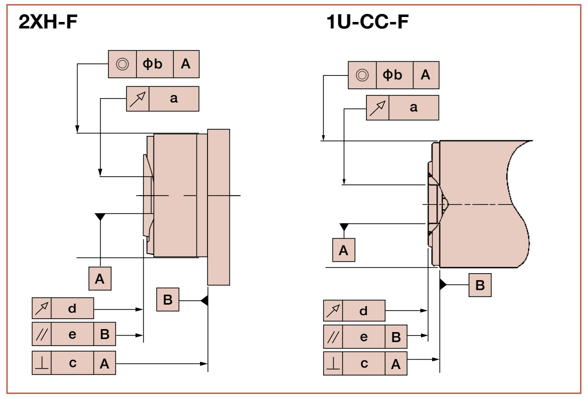


Table 187-1

* T.I.R. Unit: mm

Symbol	Size / Precision item	5		8		11		14	
		2XH-J/1U-CC	2XH-F/1U-CC-F	2XH-J/1U-CC	2XH-F/1U-CC-F	2XH-J/1U-CC	2XH-F/1U-CC-F	2XH-J/1U-CC	2XH-F/1U-CC-F
a	Runout of the output shaft	0.030	—	0.030	—	0.030	—	0.030	—
	Runout of the pilot hole in the output flange	—	0.005	—	0.005	—	0.005	—	0.005
b	Concentricity of the mounting pilot	0.040		0.040		0.055		0.055	
c	Perpendicularity of the mounting face	0.020		0.020		0.025		0.025	
d	Runout on the output flange face	0.005		0.005		0.005		0.005	
e	Parallelism of the mounting face and the output flange face	0.015		0.020		0.030		0.030	

* T.I.R.: This indicates the total reading of the dial gauge when the measuring part is rotated once.

Efficiency

The efficiency varies depending on the following conditions.

- Reduction ratio
- Input rotational speed
- Load torque
- Temperature
- Lubrication (Type and quantity)

Measurement condition

Table 187-2

Load torque	Rated torque in rating table (see Page 170)		
Lubricant	Grease lubrication	Name	Harmonic Grease SK-2
		Quantity	Recommended quantity

■ Efficiency compensation coefficient

If the load torque is lower than the rated torque, the efficiency value lowers. Calculate compensation coefficient Ke from Graph 187-1 to calculate the efficiency using the following example.

Calculation Example

Efficiency η (%) under the following condition is calculated from the example of CSF-8-100-2XH.
Input rotational speed: 1000 rpm
Load torque: 2.0 Nm
Lubrication method: Grease lubrication
Lubricant temperature: 20°C

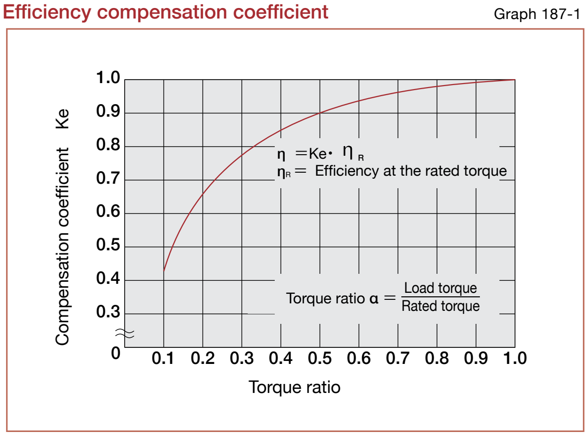
Since the rated torque of size 8 with a reduction ratio of 100 is 2.4 Nm (Ratings: Page 170), the torque ratio α is 0.83. (α=2.0/2.4≈0.83)

- The efficiency compensation coefficient is Ke=0.99 from Graph 187-1.
- Efficiency η at load torque 2.0 Nm: $\eta = Ke \cdot \eta_R = 0.99 \times 77\% = 76\%$

* Efficiency compensation coefficient Ke=1 holds when the load torque is greater than the rated torque.

Efficiency compensation coefficient

Graph 187-1

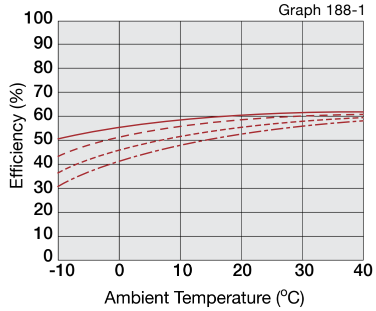


■ Efficiency at rated torque

Size 5

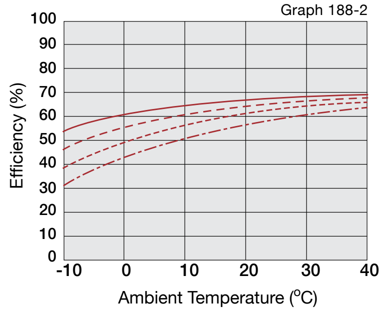
Ratio 30

Graph 188-1



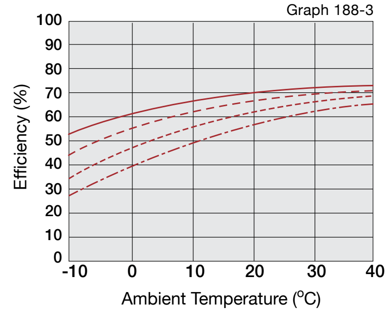
Ratio 50

Graph 188-2



Ratio 100

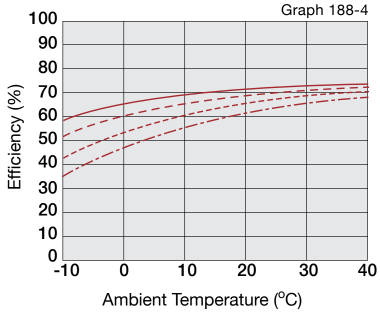
Graph 188-3



Size 8

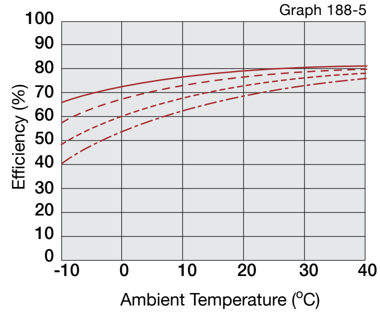
Ratio 30

Graph 188-4



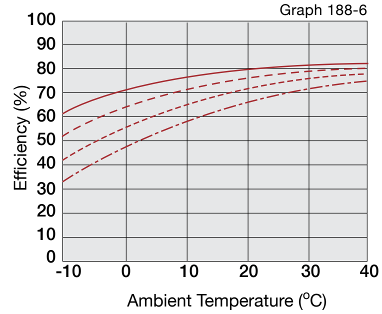
Ratio 50

Graph 188-5



Ratio 100

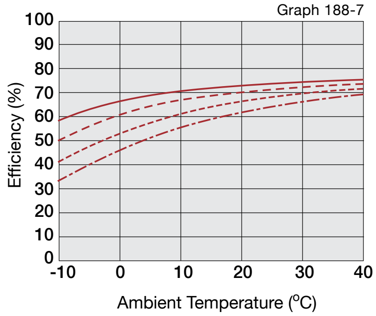
Graph 188-6



Size 11

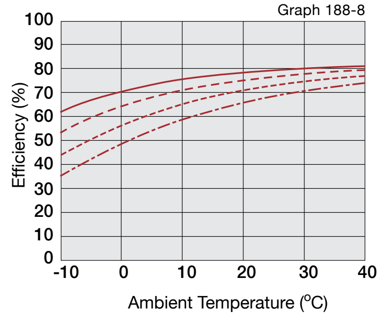
Ratio 30

Graph 188-7



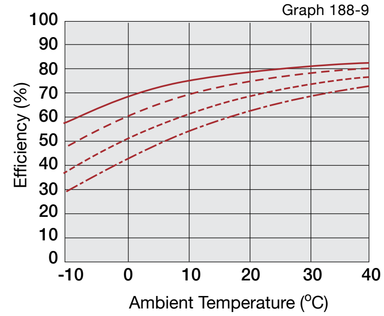
Ratio 50

Graph 188-8



Ratio 100

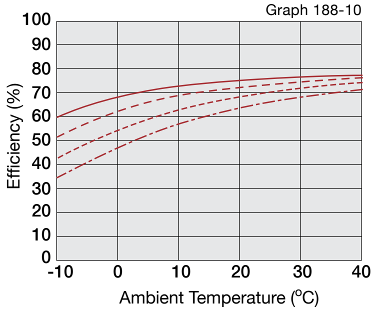
Graph 188-9



Size 14

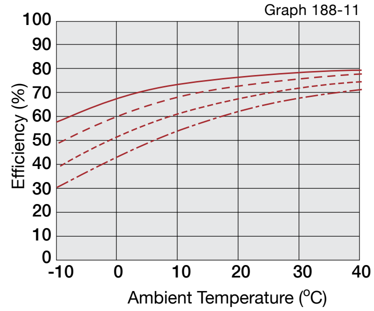
Ratio 30

Graph 188-10



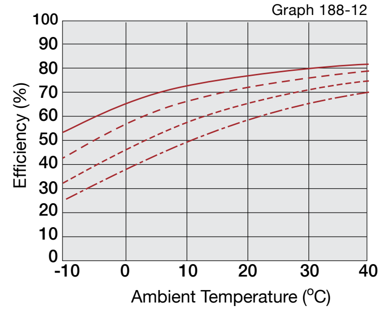
Ratio 50

Graph 188-11



Ratio 80 and 100

Graph 188-12



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

No-load running torque

No-load running torque is the torque which is required to rotate the input side (high speed side), when there is no load on the output side (low speed side).

Measurement condition

Table 189-1

Ratio			
Lubricant	Grease lubrication	Name	Harmonic Grease SK-2
Torque value is measured after 2 hours at 2000rpm input.			

■ Compensation Value in Each Ratio

No-load running torque of the gear varies with ratio. The graphs indicate a value for ratio 100. For other gear ratios, add the compensation values from table on the right.

No-Load Torque Running Torque Compensation Value

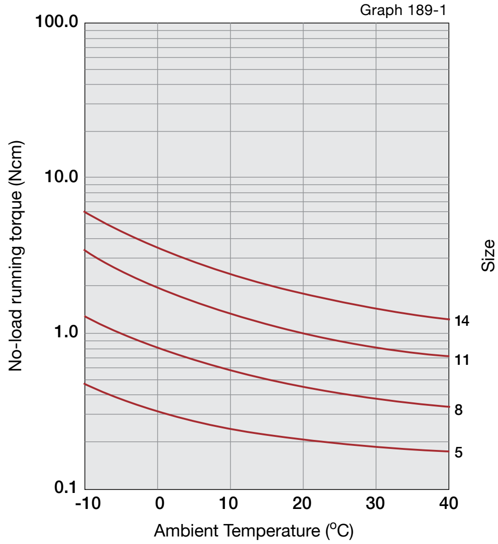
Table 189-2
Unit: Ncm

Size \ Ratio	30	50	80
5	0.26	0.11	–
8	0.44	0.19	–
11	0.81	0.36	–
14	1.33	0.58	0.1

■ No-load running torque for a reduction ratio of 100

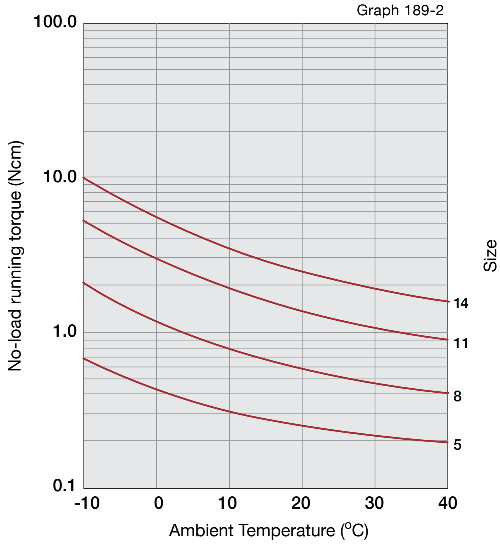
Input speed: 500rpm

Graph 189-1



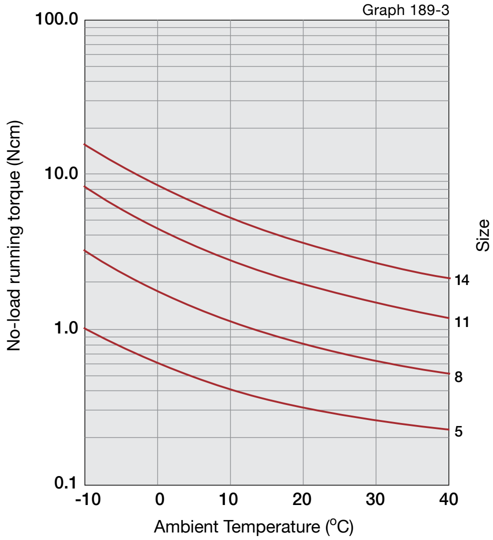
Input speed: 1000rpm

Graph 189-2



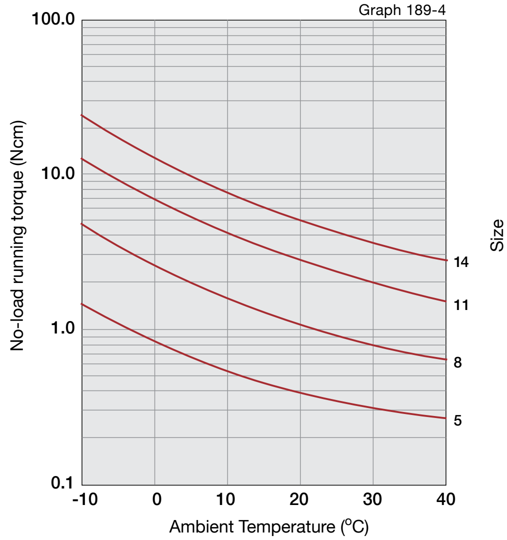
Input speed: 2000rpm

Graph 189-3



Input speed: 3500rpm

Graph 189-4



*The values in this graph are average values ($\bar{X}$).

Example of installation

The following examples show a CSF-2XH miniature gearhead mounted to a motor.

Fig. 190-1

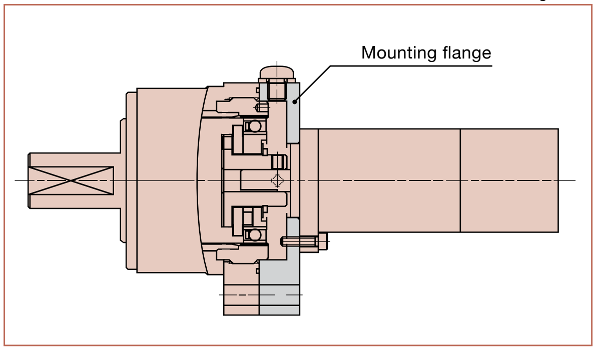
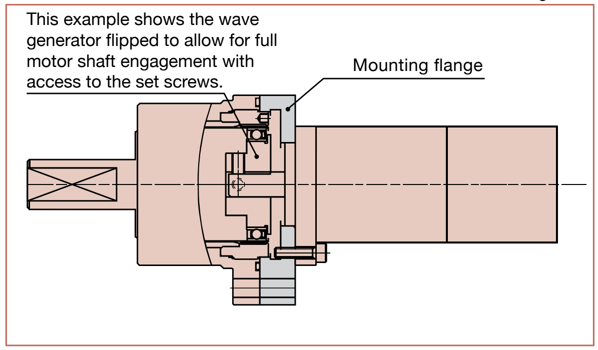


Fig. 190-2



■ Motor matching table

The table below provides a rough guide for matching a gearhead to a motor, based on the motor wattage. Note that the motor shaft diameter may not always match the diameter of the gearhead's standard input hub. The input hub can be supplied with a non-standard diameter, see Page 185.

Table 190-1

Size \ Motor capacity	3W·5W	10W	20W	30W
5	○			
8		○		
11			○	○
14				○

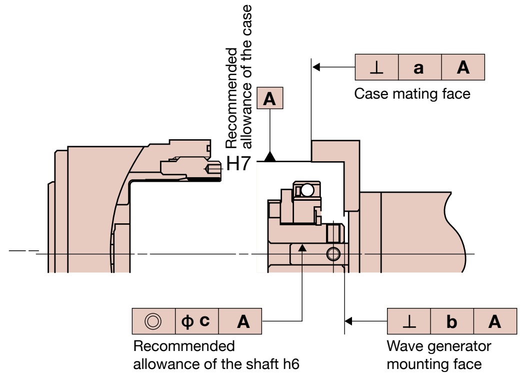
(Note) The shaft diameter of some motors may not fit the hole diameter of the standard wave generator. In this case, the hole diameter should be changed (hole diameter size: see Page 185). Changes to the hole diameter should be performed using special specifications.

Recommended tolerances for assembly

Maintain the recommended tolerances shown in Figure 191-1 and Table 191-1 for maximum performance of CSF mini gearheads.

Recommended assembly tolerances

Fig. 191-1



Recommended assembly tolerances

Table 191-1
Unit: mm

Symbol	Precision item \ Size	5	8	11	14
a	Perpendicularity of mounting flange	0.008	0.010	0.011	0.011
b	Perpendicularity of the input hub	0.005	0.012	0.012	0.017
			(0.006)	(0.007)	(0.008)
c	Concentricity of the input shaft	0.005	0.015	0.015	0.030
			(0.006)	(0.007)	(0.016)

* The standard Wave Generator has an Oldham coupling to compensate for any misalignment. The parenthesized value indicates the value for an input without an Oldham coupling (known as a solid wave generator). The size 5 is standard with a solid wave generator.

Installation and transmission torque

■ Installation

Check the mating surface for flatness and for burrs prior to mounting the CSF-mini product. Use the proper screws and the tightening torque as specified in Table 192-1 and 192-2.

Bolt tightening torque* of the mounting flange (A in Figure 193-1) /2XH type

Table 192-1

Item \ Size		5	8	11	14
Number of bolts		2	2	2	2
Bolt size		M2	M3	M4	M5
Pitch circle	mm	25	37.5	50	62
Clamp torque	Nm	0.25	0.85	2.0	4.0
Screws	mm	2.4	3.6	4.8	6.0
Transmission torque	Nm	2	7	16	31

* Recommended bolt: JIS B 1176 hexagonal bolt, strength: JIS B 1051 12.9 or higher
* Use a washer so that the bolt seating surface does not directly touch the aluminum.

Bolt tightening torque* of the mounting flange (A and C part in Figure 193-2) /1U-CC type

Table 192-2

Item \ Size		5		8		11		14	
		Part A	Part C	Part A	Part C	Part A	Part C	Part A	Part C
Number of bolts		4	4	4	4	4	4	4	4
Bolt size		M2	M2	M3	M2.5	M4	M3	M5	M4
Pitch circle	mm	23	22.5	35	34	46	46	58	58
Clamp torque	Nm	0.25	0.25	0.85	0.55	2.0	0.85	4.0	2.0
Screws	mm	3	3	6	5	8	6	10	8
Transmission torque	Nm	3.5	—	12	—	29	—	57	—

* Recommended bolt: JIS B 1176 hexagonal bolt, strength: JIS B 1051 12.9 or higher

■ Installation of the load on the output part

Install the load on the output part of the CSF-mini series taking the specifications of the output bearing (see Page 173) into consideration.

Bolt tightening torque* of the mounting flange (B in Figure 193-1 and Figure 193-2) (flange output type)

Table 193-1

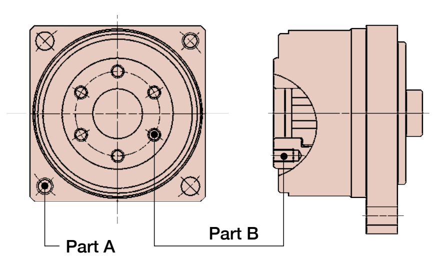
Item \ Size		5	8	11	14
Number of bolts		3	4	6	6
Bolt size		M2	M3	M3	M4
Pitch circle	mm	9.8	15.5	20.5	25.5
Clamp torque	Nm	0.54	2.	2.0	4.6
Transmission torque	Nm	2	13	26	55

Output Flange is treated to prevent for grease leakage, re-sealing is not necessary.

* Recommended bolt: JIS B 1176 hexagonal bolt, strength: JIS B 1051 12.9 or higher

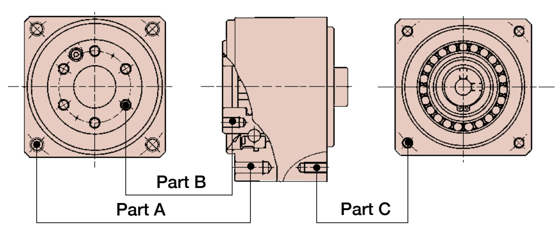
Mounting flange (2XH-F)

Fig. 193-1



Mounting flange (1U-CC-F)

Fig. 193-2



Avoid impact to the output flange during assembly. It may result in damage to the gearhead.

Sealing

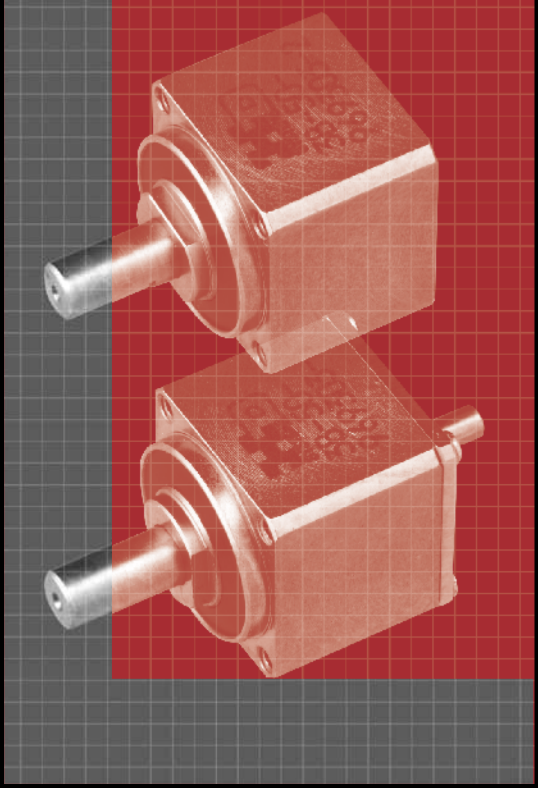
Sealing is required to prevent grease leakage

- Mating flange .... Use the O-Ring supplied with the gearhead, as well as a seal adhesive, such as gasket eliminator. Make sure the O-Ring is seated properly.
- Screw hole area .... Apply LOCTITE® 242 to the screw threads.

Area requiring sealing and recommended sealing methods

Table 194-1

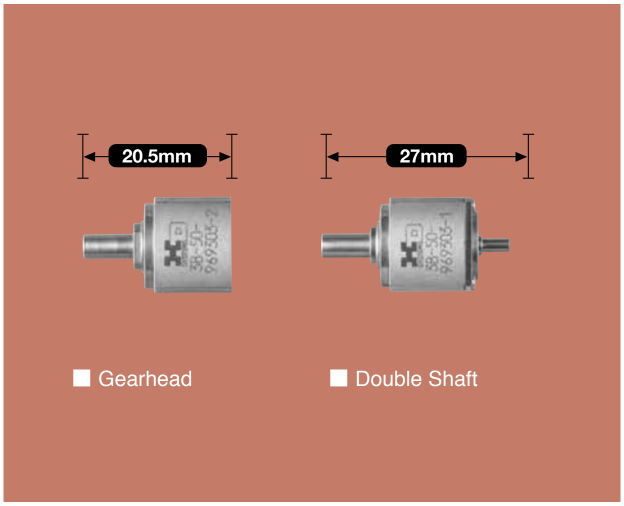
Area requiring sealing		Recommended sealing method
Input side	Mating flange	Use O-ring (supplied with the product)
	Motor output shaft	Please select a motor which has an oil seal on the output shaft.



CSF Supermini Series

Gear Unit CSF supermini

Features



* Exact sized photograph

CSF supermini series

The CSF supermini series gear units are our smallest gearheads available today. Equipped with our proprietary 4-point contact bearing, these mini gearheads are available in two varieties. The CSF-1U-CC is designed to mount directly onto a servo motor, and the CSF-1U offers both an input shaft and output shaft. Choose the version that works best for your application. Both are available in 3 ratios: 30:1, 50:1 and 100:1.

Features

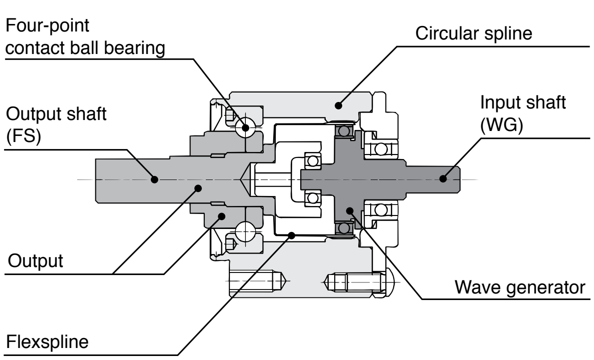
- Zero backlash
- High-positioning accuracy
- Compact and lightweight
- High-torque capacity
- High-radial, axial, and moment load capacity
- 4 point contact bearing
- Ratios: 30:1 to 100:1

CSF supermini series

Fig. 196-1

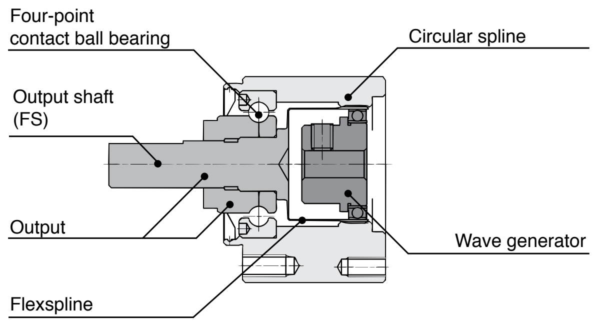
Double Shaft Gearhead (1U)

This gearhead is easy to use and has both an input and an output shaft. It also allows for pulleys to be used for the input and output to the gearhead.



Gearhead (1U-CC)

This is a gearhead designed to be combined with a high-performance compact servo motor.



* The rotational direction of the output shaft is opposite to that of the input shaft (wave generator) when the circular spline is fixed.

Engineering Data
Component Sets
Gear Units
Phase Adjusters
Gearheads & Actuators

Ordering Code

CSF - 3 B - 50 - 1U - CC - SP

Table 197-1

Series	Size	Version symbol	Ratio*1			Model	Special specification
CSF	3	B	30	50	100	1U = Double Shaft Gearhead 1U-CC = Gearhead	SP= Special specification code Blank= Standard product

*1 The reduction ratio value is based on the following configuration:
Input: wave generator, fixed: circular spline, output: output shaft

Technical Data

Rating table

Table 197-2

Size	Ratio	Rated torque at input 2000rpm		Limit for Repeated Peak Torque		Limit for Average Torque		Limit for Momentary Peak Torque		Maximum Input Speed (rpm)	Limit for Average Input Speed (rpm)	Moment of Inertia ($^1/_4GD^2$)*1
		Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm	rpm	rpm	kgcm²
3	30	0.06	0.006	0.13	0.013	0.10	0.010	0.22	0.022	10000	6500	1U: 5.3×10^{-7} 1U-CC: 7.0×10^{-7}
	50	0.11	0.011	0.21	0.021	0.13	0.013	0.41	0.040			
	100	0.15	0.015	0.30	0.029	0.23	0.023	0.57	0.056			

*1 The higher value for moment of inertia is for 1U, the lower value is for 1U-CC.

Positional accuracy

See "Engineering data" for a description of terms.

Table 198-1

Ratio	Specification \ Size	3
Total reduction ratio	$\times10^{-3}$rad	2.9
	arc min	10

Hysteresis loss

See "Engineering data" for a description of terms.

Table 198-2

Ratio \ Size		3
30	$\times10^{-4}$rad	13
	arc min	4.5
50	$\times10^{-4}$rad	12
	arc min	4
100	$\times10^{-4}$rad	12
	arc min	4

Starting torque

See "Engineering data" for a description of terms. Please use as reference values; the values vary based on use conditions.

Table 198-3
Unit: Ncm

Ratio \ Size	3	
	1U	1U-CC
30	0.34	0.32
50	0.30	0.28
100	0.26	0.24

Backdriving torque

See "Engineering data" for a description of terms. Please use as reference values; the values vary based on use conditions.

Table 198-4
Unit: Nm

Ratio \ Size	3	
	1U	1U-CC
30	0.14	0.12
50	0.14	0.11
100	0.16	0.13

Ratcheting torque

See "Engineering data" for a description of terms.

Table 198-5
Unit: Nm

Ratio \ Size	3
30	0.88
50	0.83
100	0.74

Buckling torque

See "Engineering data" for a description of terms.

Table 198-6
Unit: Nm

Size	3
All ratios	3.7

Checking output bearing

A precision 4-point contact ball bearing is built in the CSF supermini series to directly support the external load (output flange).
Check the maximum moment load, life of the 4-point contact ball bearing and static safety coefficient to insure long life.
See page 030 to 034 of "Engineering data" for each calculation formula.

■ Checking procedure

(1) Checking the maximum moment load (M_{max})

Calculate the maximum moment load (M_{max}). → Maximum moment load (M_{max}) ≦ allowable moment (Mc)

(2) Checking the life

Calculate the radial load (F_{rav}) and the average axial load (F_{aav}). → Calculate the radial load coefficient (x) and the axial load coefficient (y). → Calculate the lifetime

(3) Checking the static safety coefficient

Calculate the static equivalent radial load coefficient (Po). → Check the static safety coefficient. (fs)

■ Output bearing specifications

Specifications

Table 199-1

Size	Pitch circle	Offset	Basic rated load		Allowable moment load	Moment stiffness	Allowable radial load *	Allowable axial load
	dp	R	Basic dynamic rated load	Basic static rated load				
	mm	mm	$\times10^2$N	$\times10^2$N	Nm	Nm/rad	N	N
3	7.7	4.1	6.65	4.24	0.27	0.9×10^2	36	130

* Allowable radial load is the value on the center of output shaft side of both shaft type (1U) and that of gear head shaft output type (1U-CC).
* The value of the moment stiffness is the average value.

Lubrication

The CSF-supermini gearheads are shipped already lubricated with grease. The table shows the grease that is used in the gearhead.

Table 199-2

Lubricated area	Reducer
Lubricant	Harmonic Grease SK-2
Manufacturer	Harmonic Drive Systems
Base oil	Refined oil
Base Viscosity (25°C)	265 to 295
Thickening agent	Lithium soap
Drop point	198°C
Appearance	Green

Engineering Data
Component Sets
Gear Units
Phase Adjusters
Gearheads & Actuators

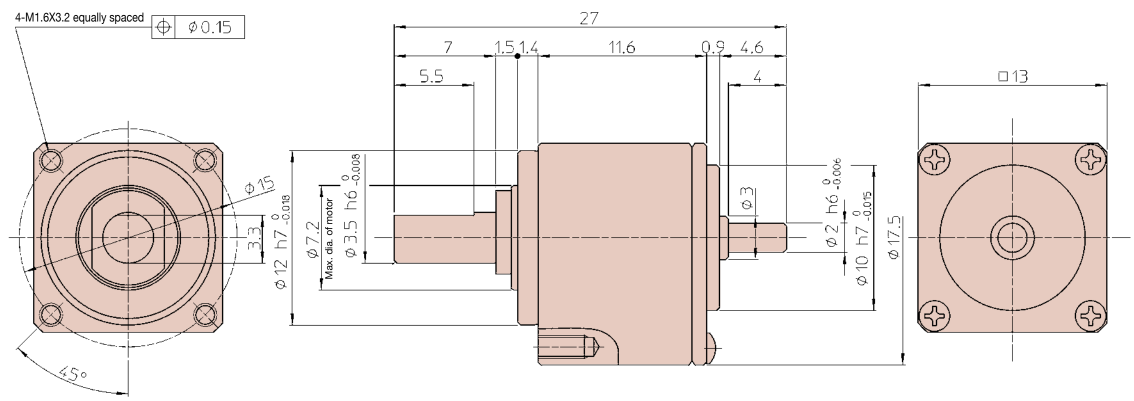
Outline Dimensions

Outline dimensions 1U

You can download the CAD files from our website: harmonicdrive.net

Fig. 200-1
Unit: mm

Mass: 13.7g



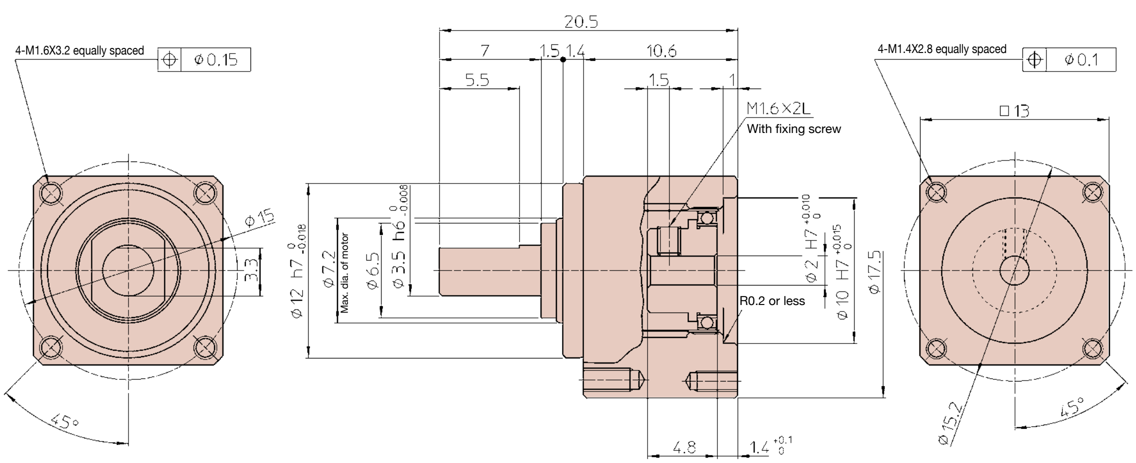
* Please refer to the confirmation drawing for detailed dimensions.

Outline dimensions 1U-CC

You can download the CAD files from our website: harmonicdrive.net

Fig. 200-2
Unit: mm

Mass: 11.4g



* Please refer to the confirmation drawing for detailed dimensions.

Torsional stiffness

See "Engineering data" for a description of terms.

Table 201-1

Symbol		Size	3
	T_1	Nm	0.16
		kgfm	0.0016
	T_2	Nm	0.05
		kgfm	0.005
Reduction ratio 30	K_1	Nm/rad	27
		$\times 10^{-4}$kgfm/arc min	8
	K_2	Nm/rad	40
		$\times 10^{-4}$kgfm/arc min	12
	K_3	Nm/rad	51
		$\times 10^{-4}$kgfm/arc min	15
	θ	$\times 10^{-4}$rad	5.9
		arc min	2.0
	θ	$\times 10^{-4}$rad	12.5
		arc min	4.2
Reduction ratio 50	K_1	Nm/rad	30
		$\times 10^{-4}$kgfm/arc min	9
	K_2	Nm/rad	47
		$\times 10^{-4}$kgfm/arc min	14
	K_3	Nm/rad	57
		$\times 10^{-4}$kgfm/arc min	17
	θ_1	$\times 10^{-4}$rad	5.3
		arc min	1.8
	θ_2	$\times 10^{-4}$rad	10.6
		arc min	3.6
Reduction ratio 100	K_1	Nm/rad	34
		$\times 10^{-4}$kgfm/arc min	10
	K_2	Nm/rad	54
		$\times 10^{-4}$kgfm/arc min	16
	K_3	Nm/rad	67
		$\times 10^{-4}$kgfm/arc min	20
	θ	$\times 10^{-4}$rad	4.7
		arc min	1.6
	θ	$\times 10^{-4}$rad	9.3
		arc min	3.1

* The values in this table are reference values. The minimum value is approximately 80% of the displayed value.

Output bearing and housing tolerances

The CSF supermini gearheads have a precision 4-point contact bearing on the output side to support external loads. The mechanical precision of the output shaft and the gearhead are as shown below.

Fig. 201-1

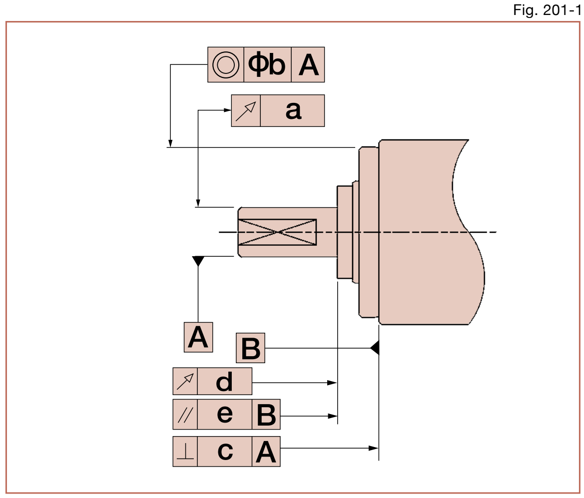


Table 201-2

* T.I.R. Unit: mm

Symbol	Precision item / Size	3
a	Runout of the output shaft	0.030
b	Concentricity of the mounting pilot	0.020
c	Perpendicularity of the mounting face	0.020
d	Runout on the output flange face	0.005
e	Parallelism of the mounting face and the output flange face	0.015

* T.I.R.: This indicates the total reading of the dial gauge when the measuring part is rotated once.

Efficiency

The efficiency varies depending on the following conditions.

- Reduction ratio
- Input rotational speed
- Load torque
- Temperature
- Lubrication (Type and quantity)

Measurement condition Table 202-1

Load torque	Rated torque in rating table (see Page 197)		
Lubricant	Grease lubrication	Name	Harmonic Grease SK-2
		Quantity	Recommended quantity

■ Efficiency correction coefficient

If the load torque is lower than the rated torque, the efficiency value lowers. Calculate compensation coefficient Ke from Graph 202-1 to calculate the efficiency using the following example.

Calculation Example

Efficiency η (%) under the following condition is calculated from the example of CSF-8-100-1U.

Input rotational speed: 1000 rpm   Lubrication method: Grease

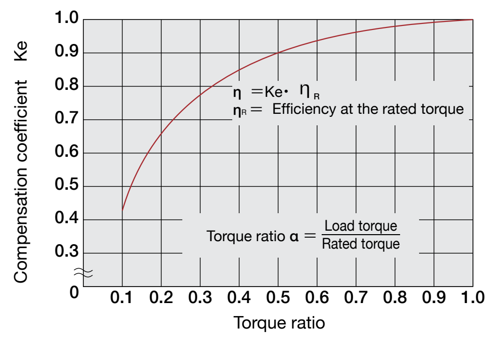
Load torque: 2.0 Nm   Lubricant temperature: 20°C

Since the rated torque of size 8 with a reduction ratio of 100 is 2.4 Nm (Ratings: Page 197), the torque ratio α is 0.83. (α=2.0/2.4≈0.83)

- The efficiency compensation coefficient is Ke=0.93 from Graph 202-1.
- Efficiency η at load torque 2.0 Nm: η=Ke•ηR=0.99 x 77=76%

* Efficiency compensation coefficient Ke=1 holds when the load torque is greater than the rated torque.

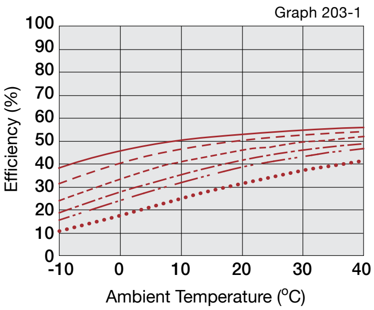
Efficiency Compensation coefficient Graph 202-1



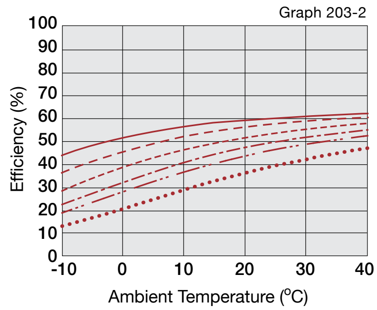
Efficiency at rated torque

Size 3: (1U)

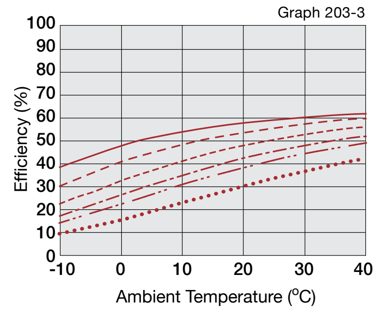
Ratio 30



Ratio 50

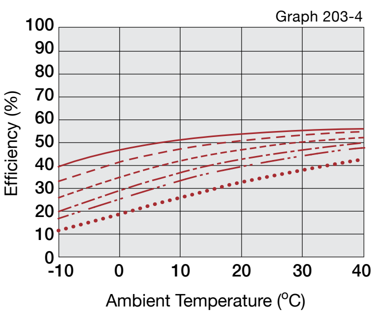


Ratio 100

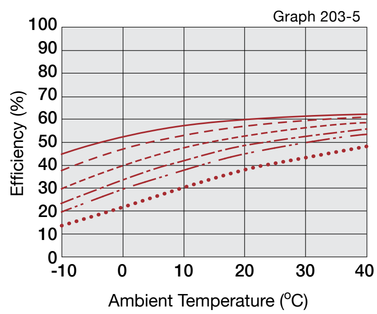


Size 3: (1U-CC)

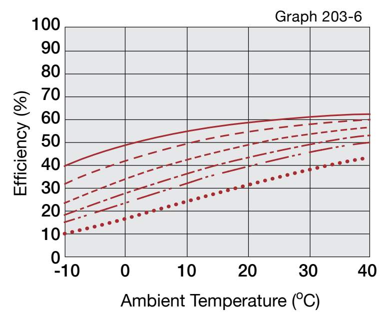
Ratio 30



Ratio 50



Ratio 100



Input rotational speed

500rpm (solid line), 1000rpm, 2000rpm, 3500rpm, 5000rpm, 10000rpm (dotted line)

No-load running torque

No-load running torque is the torque which is required to rotate the input side (high speed side), when there is no load on the output side (low speed side).

Measurement condition

Table 204-1

CSF-3-100-1U-CC (Gearhead)			
Ratio 100:1			
Lubricant	Grease lubrication	Name	Harmonic Grease SK-2
Torque value is measured after 2 hours at 2000rpm input.			

■ Compensation value in each ratio

No-load running torque of the gear varies with ratio.
The graphs indicate a value for ratio 100.
For other gear ratios, add the compensation values from table on the right.

No-load running torque compensation values.

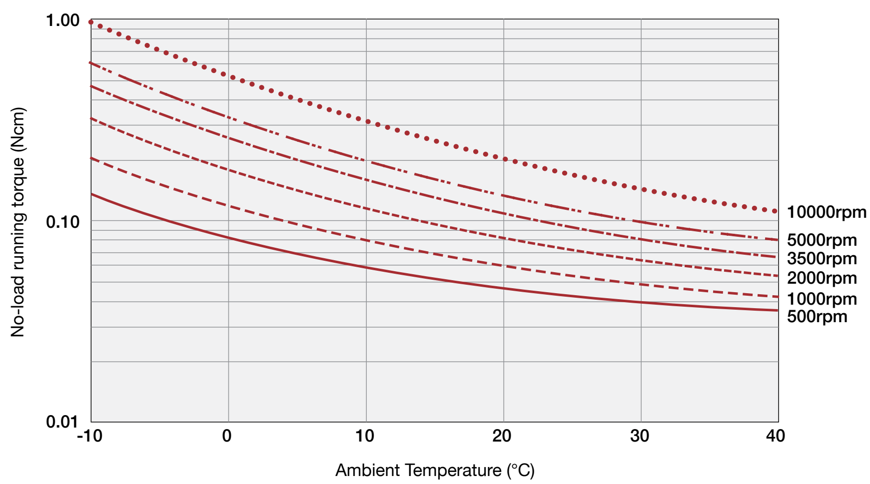
Table 204-2

Unit: Ncm

Model \ Ratio	30	50	100
CSF-1U	0.026	0.023	0.006
CSF-1U-CC	0.020	0.017	—

■ No-load running torque for Gearhead (1U-CC, 100:1)

Graph 204-1



*The values in this graph are average values (X̄).

Allowable load on the input shaft (1U)

The Input Shaft is supported by two deep groove single row ball bearings.
Please check the loading on the input shaft to make sure that it is acceptable.

The following figure shows the supporting point of the bearing. See the following table for the size of (a) and (b). The following graph shows the relation between the maximum allowable radial load and the axial load of size 3.
The values in the following graph are those assuming that the average input rotational speed is 2,000 rpm and the basic rated life, L10, is 7,000 hours

Example: When a 3-N axial load (Fa) is applied to the input shaft, the value of the maximum allowable radial load (Fr) is 3.75 N.

*For structural reasons, the input shaft moves in the axial direction when the external force is applied.

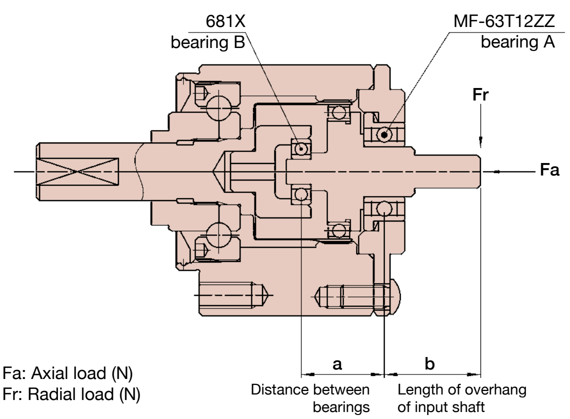
Bearing specifications

Table 205-1

Size	Bearing A			Bearing B			Distance between bearings a	Overhang length of the input shaft b	Maximum radial load
	Model	Basic dynamic rated load	Basic static rated load	Model	Basic dynamic rated load	Basic static rated load			
		Cr (N)	Cor (N)		Cr (N)	Cor (N)	a (mm)	b (mm)	Fr (N)
3	MF-63T12ZZ	242	94	681X	102	29	5.05	5.85	6

Supporting point of the roller bearing

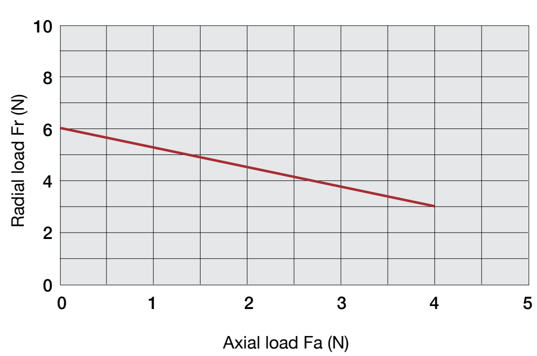
Fig. 205-1



Fa: Axial load (N)
Fr: Radial load (N)

Relation between the radial load and the axial load

Graph 205-1



Installation and transmission torque

■ Installation

Ensure that surface used for installation is flat and does not have any burrs. Please fasten bolt with the proper torque for each size as indicated.

Tightening torque of the bolt* of the mounting flange (A in Figure 206-1)

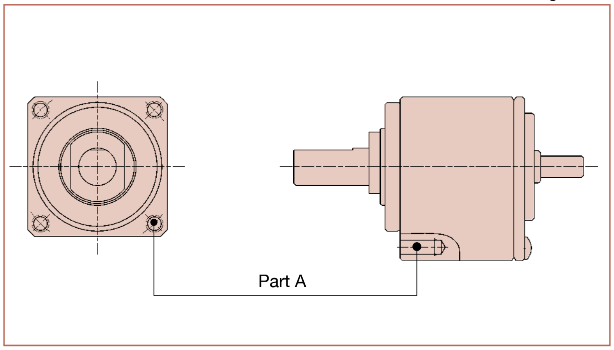
Table 206-1

Item \ Size		3
Number of bolts		4
Bolt size		M1.6
Pitch Circle	mm	15
Tightening torque	Nm	0.26
Screw	mm	1.9
Transmission torque	Nm	3.0

* Recommended bolt: JIS B 1176 hexagonal bolt, strength: JIS B 1051 12.9 or higher.

Mounting flange

Fig. 206-1



■ Installation of the output shaft

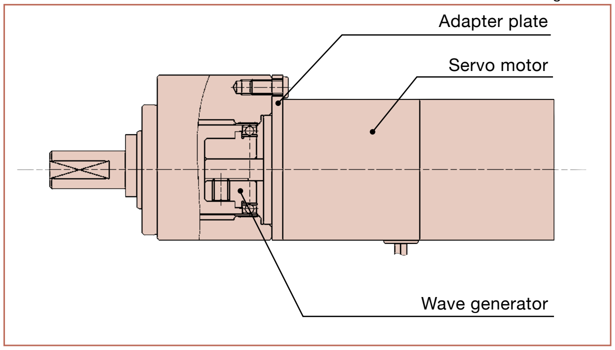
Do not allow the output shaft to receive a shock when you install a pulley and pinion. It can deteriorate the precision of the reducer and cause failure.

Installation Example

Installation Example

The following shows an example of the representative installation of gearhead (1U-CC).

Fig. 207-1

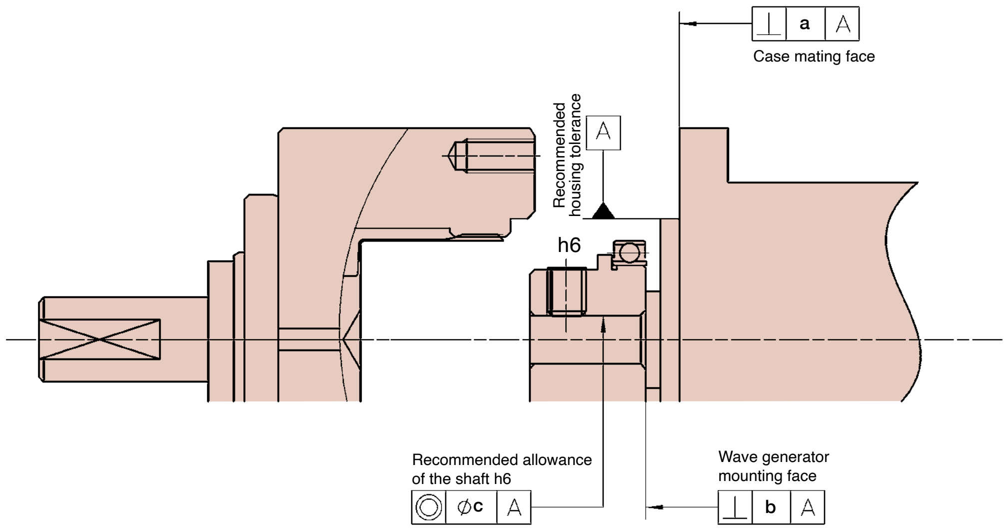


Installation accuracy

For peak performance of the gear, maintain the recommended assembly tolerances shown in Figure 208-1 and Table 208-1.

Recommended Tolerances for Assembly

Fig. 208-1



Recommended tolerances

Table 208-1

Unit: mm

Symbol	Precision item \ Size	3
a	Perpendicularity of the case mating face	0.006
b	Perpendicularity of the wave generator	0.004
c	Concentricity of the input shaft	0.004

CSD Series

Gear Unit CSD

Features

CSD Gear Units

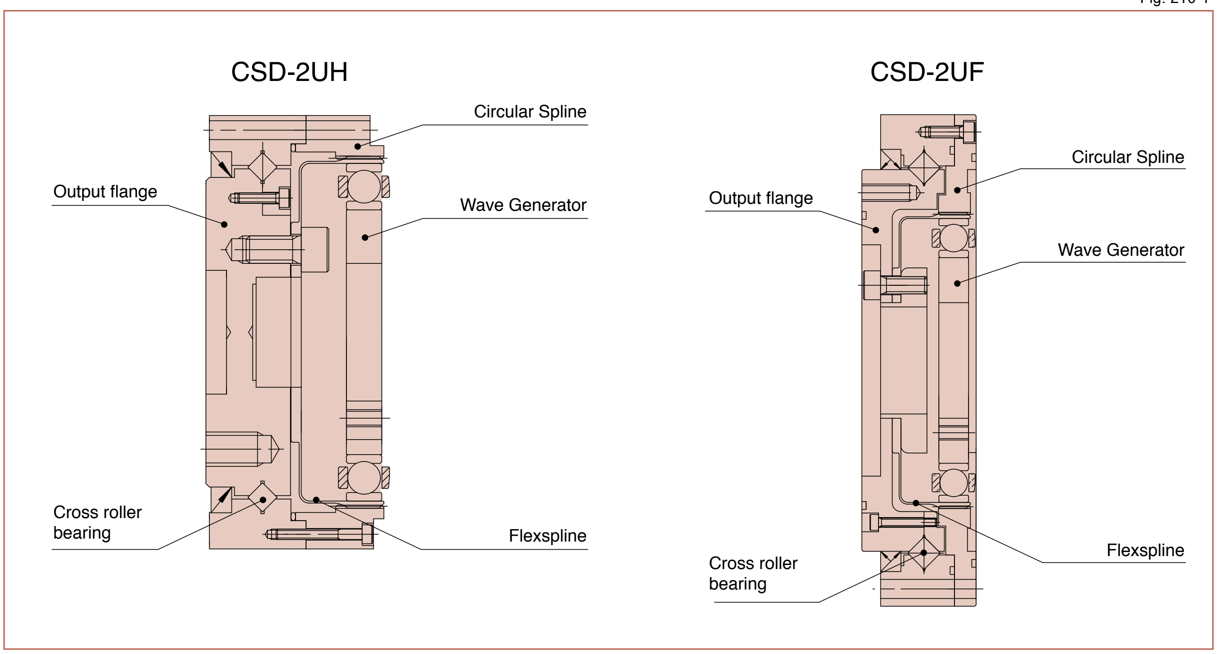
Available in two form factors, the CSD series gear units offer zero backlash while remaining lightweight and compact. These units are ideal for humanoid robots, aerospace, semiconductor equipment and many other critical applications. Ratios available are from 50:1 to 100:1.

Features

- Zero backlash
- Compact design
- Hollow shaft (2UF only)
- High-load capacity
- Lightweight

Structure of CSD Gear Unit

Fig. 210-1



Ordering Code

CSD - 20 - 100 - 2UH - SP

Table 210-1

Series	Size	Ratio*			Model	Special specification
CSD	14	50	80	100	2UH= Unit type (Size 14 to 50) 2UF= Hollow shaft (Size 14 to 40)	Blank= Standard product SP = Special specification code
	17	50	80	100		
	20	50	80	100		
	25	50	80	100		
	32	50	80	100		
	40	50	80	100		
	50	50	80	100		

* The reduction ratio value is based on the following configuration:
Input: wave generator, fixed: circular spline, output: flexspline

Engineering Data
Component Sets
Gear Units
Phase Adjusters
Gearheads & Actuators

CSD-2UH Gear Unit

Size	Gear ratio	Rated torque at input speed 2000rpm		Limit for repeated peak torque		Limit for average torque		Limit for momentary peak torque		Maximum input speed (rpm)	Limit for average input speed (rpm)	Moment of inertia	
		Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm	Grease	Grease	$I \times 10^{-4} kgm^2$	$J \times 10^{-5} kgfms^2$
14	50	3.7	0.38	12	1.2	4.8	0.49	24	2.4	8500	3500	0.021	0.021
	80	5.4	0.55	16	1.6	7.7	0.79	35	3.6				
	100	5.4	0.55	19	1.9	7.7	0.79	35	3.6				
17	50	11	1.1	23	2.3	18	1.8	48	4.9	7300	3500	0.054	0.055
	80	15	1.5	29	3.0	19	1.9	61	6.2				
	100	16	1.6	37	3.8	27	2.8	71	7.2				
20	50	17	1.7	39	4.0	24	2.4	69	7.0	6500	3500	0.090	0.092
	80	24	2.4	51	5.2	33	3.4	89	9.1				
	100	28	2.9	57	5.8	34	3.5	95	9.7				
25	50	27	2.8	69	7.0	38	3.9	127	13	5600	3500	0.282	0.288
	80	44	4.5	96	9.8	60	6.1	179	18				
	100	47	4.8	110	11	75	7.6	184	19				
32	50	53	5.4	151	15	75	7.6	268	27	4800	3500	1.09	1.11
	80	83	8.5	213	22	117	12	398	41				
	100	96	9.8	233	24	151	15	420	43				
40	50	96	9.8	281	29	137	14	480	49	4000	3000	2.85	2.91
	80	144	15	364	37	198	20	686	70				
	100	185	19	398	41	260	27	700	71				
50	50	172	18	500	51	247	25	1000	102	3500	2500	8.61	8.78
	80	260	27	659	67	363	37	1300	133				
	100	329	34	686	70	466	48	1440	147				

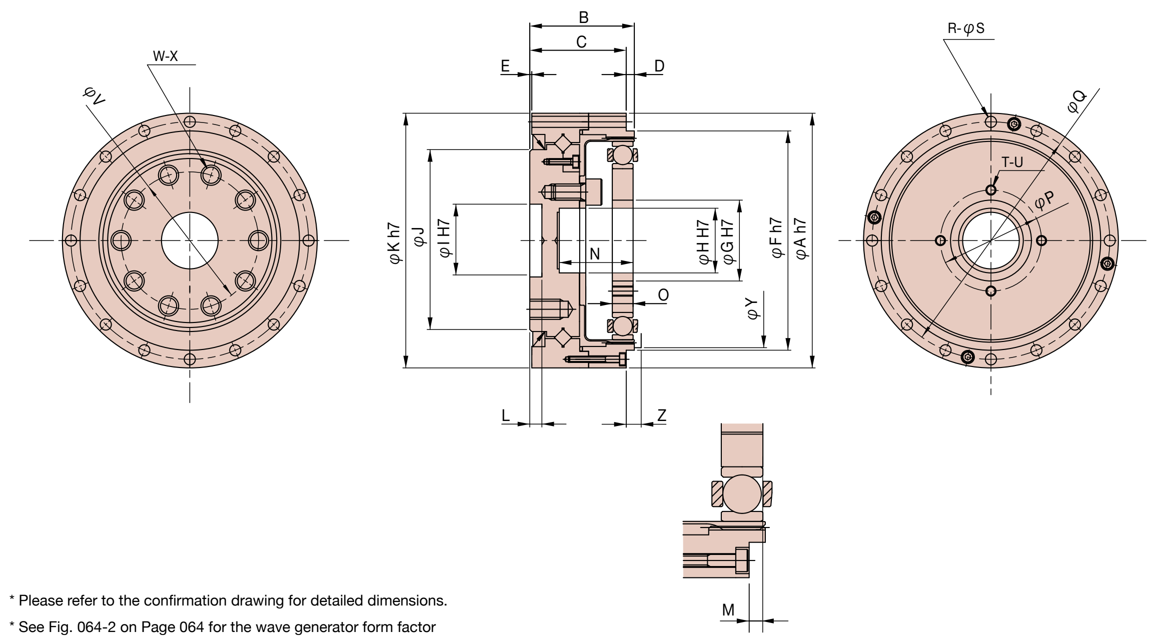
CSD-2UF Hollow Shaft Gear Unit

Size	Gear ratio	Rated torque at input speed 2000rpm		Limit for repeated peak torque		Limit for average torque		Limit for momentary peak torque		Maximum input speed (rpm)	Limit for average input speed (rpm)	Moment of inertia	
		Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm	Grease	Grease	$I \times 10^{-4} kgm^2$	$J \times 10^{-5} kgfms^2$
14	50	3.7	0.38	12	1.2	4.8	0.49	24	2.4	8500	3500	0.021	0.021
	80	5.4	0.55	16	1.6	7.7	0.79	35	3.6				
	100	5.4	0.55	19	1.9	7.7	0.79	35	3.6				
17	50	11	1.1	23	2.3	18	1.8	48	4.9	7300	3500	0.054	0.055
	80	15	1.5	29	3.0	19	1.9	61	6.2				
	100	16	1.6	37	3.8	27	2.8	71	7.2				
20	50	17	1.7	39	4.0	24	2.4	69	7.0	6500	3500	0.090	0.092
	80	24	2.4	51	5.2	33	3.4	89	9.1				
	100	28	2.9	57	5.8	34	3.5	95	9.7				
25	50	27	2.8	69	7.0	38	3.9	127	13	5600	3500	0.282	0.288
	80	44	4.5	96	9.8	60	6.1	179	18				
	100	47	4.8	110	11	75	7.6	184	19				
32	50	53	5.4	151	15	75	7.6	268	27	4800	3500	1.09	1.11
	80	83	8.5	213	22	117	12	398	41				
	100	96	9.8	233	24	151	15	420	43				
40	50	96	9.8	281	29	137	14	480	49	4000	3000	2.85	2.91
	80	144	15	364	37	198	20	686	70				
	100	185	19	398	41	260	27	700	71				

(Note) Moment of inertia: $I = \frac{1}{4} GD^2$

Outline dimensions CSD-2UH

Fig. 212-1



* Please refer to the confirmation drawing for detailed dimensions.

* See Fig. 064-2 on Page 064 for the wave generator form factor

Dimensions CSD-2UH

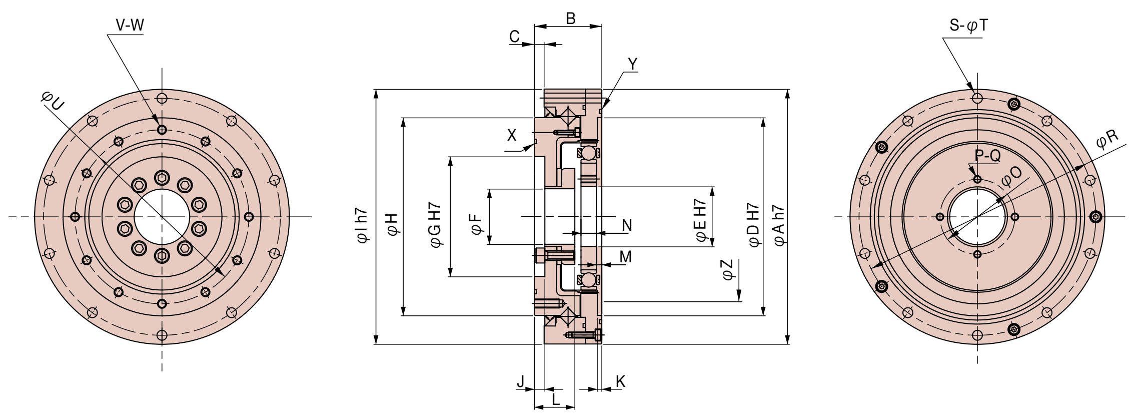
Table 212-1

Unit : mm

Symbol \ Size	14	17	20	25	32	40	50
ϕA h7	55	62	70	85	112	126	157
B	25	26.5	29.7	37.1	43	51.7	62.5
C	23	24.5	27.7	34.1	40	47.7	58.5
D	2	2	2	3	3	4	4
E	0.5	0.5	0.5	0.5	1	1	1
ϕF h7	42.5	49.5	58	73	96	108.5	136
ϕG H7	11	15	20	24	32	40	50
ϕH H7	11	11	16	20	30	32	44
ϕI H7	12	14	18	24	32	36	48
ϕJ	31	38	45	58	78	90	112
ϕK h7	55	62	70	85	112	126	157
L	5	5	5	5.5	5.5	6	7
M	$1.7^{+0.2}_{0}$	$1.7^{+0.2}_{0}$	$1.7^{+0.2}_{0}$	$2.6^{+0.2}_{0}$	$2.5^{+0.2}_{0}$	$3.4^{+0.2}_{0}$	$3.2^{+0.2}_{0}$
N	14.8	16.3	18.8	23.7	30.6	36.5	44.3
O	$4^{0}_{-0.1}$	$5^{0}_{-0.1}$	$5.2^{0}_{-0.1}$	$6.3^{0}_{-0.1}$	$8.6^{0}_{-0.1}$	$10.3^{0}_{-0.1}$	$12.7^{0}_{-0.1}$
ϕP (PCD)	17	21	26	30	40	50	60
ϕQ (PCD)	49	56	64	79	104	117.5	147
R	6	10	12	18	18	18	22
ϕS	3.4	3.4	3.4	3.4	4.5	5.5	6.6
T	4	4	4	4	4	4	4
U	M3	M3	M3	M3	M4	M5	M6
ϕV (PCD)	25	27	34	42	57	72	88
W	10	8	8	8	10	10	10
X	M3×7	M5×8	M6×9	M8×12	M8×12	M10×15	M12×18
ϕY	38	45	53	66	86	106	133
Z	3	3	3.5	4.5	5	6.5	7.5
Mass (kg)	0.35	0.46	0.65	1.2	2.4	3.6	6.9

Outline dimensions CSD-2UF

Fig. 213-1



* Please refer to the confirmation drawing for detailed dimensions.

* See Fig. 064-2 on Page 064 for the wave generator form factor

Dimensions CSD-2UF

Table 213-1

Unit : mm

Symbol \ Size	14	17	20	25	32	40
ϕA h7	70	80	90	110	142	170
B	22	22.7	26.8	31.5	37	45
C	0.5	0.5	2.3	2.1	2.8	6.5
ϕD H7	48	56	64	80	106	132
ϕE H7	11	15	20	24	32	40
ϕF	9	9	18	22	29	37
ϕG H7	30	34	40	52	70	80
ϕH	49	59	69	84	110	132
ϕI h7	70	80	90	110	142	170
J	4.9	5.4	4.8	5.5	6	7
K	2.5	2.5	2.5	3	3	3
L	12.9	13.4	16.8	19.5	22	27
M	$2.8^{+0.2}_{0}$	$2.8^{+0.2}_{0}$	$2.8^{+0.2}_{0}$	$3.4^{+0.2}_{0}$	$3.5^{+0.2}_{0}$	$3.6^{+0.2}_{0}$
N	$4^{0}_{-0.1}$	$5^{0}_{-0.1}$	$5.2^{0}_{-0.1}$	$6.3^{0}_{-0.1}$	$8.6^{0}_{-0.1}$	$10.3^{0}_{-0.1}$
ϕO (PCD)	17	21	26	30	40	50
P	4	4	4	4	4	4
Q	M3	M3	M3	M3	M4	M5
ϕR (PCD)	64	74	84	102	132	158
S	6	8	8	10	10	10
ϕT	3.4	3.4	3.4	4.5	5.5	6.6
ϕU (PCD)	42	50	60	73	96	116
V	8	10	8	8	8	12
W	M3×5	M3×6	M4×8	M5×8	M6×10	M6×10
X	34.5×0.80	38.0×1.20	S48	S60	S80	S100
Y	49.0×1.50	59.4×1.20	S70	S85	S115	S140
ϕZ	38	45	53	66	86	106
Mass (kg)	0.50	0.66	0.94	1.7	3.3	5.7

Gear Unit CSD

Positional accuracy

See "Engineering data" for a description of terms.

Table 214-1

Size		14	17	20	25	32	40	50
Positional Accuracy	$\times10^{-4}$ rad	4.4	4.4	2.9	2.9	2.9	2.9	2.9
	arc min	1.5	1.5	1.0	1.0	1.0	1.0	1.0

Hysteresis loss

See "Engineering data" for a description of terms.

Table 214-2

Ratio	Unit \ Size	14	17	20	25	32	40	50
50	$\times10^{-4}$ rad	7.3	4.4	5.8	5.8	5.8	5.8	5.8
	arc min	2.5	1.5	2.0	2.0	2.0	2.0	2.0
80 or more	$\times10^{-4}$ rad	5.8	2.9	2.9	2.9	2.9	2.9	2.9
	arc min	2.0	1.0	1.0	1.0	1.0	1.0	1.0

Torsional stiffness

See "Engineering data" for a description of terms.

Table 214-3

Item		Unit \ Size	14	17	20	25	32	40	50
	T_1	Nm	2.0	3.9	7.0	14	29	54	108
		kgfm	0.2	0.4	0.7	1.4	3.0	5.5	11
	T_2	Nm	6.9	12	25	48	108	196	382
		kgfm	0.7	1.2	2.5	4.9	11	20	39
Reduction ratio 50	K_1	$\times10^4$ Nm/rad	0.29	0.67	1.1	2.0	4.7	8.8	17
		kgfm/arc min	0.085	0.2	0.32	0.6	1.4	2.6	5.0
	K_2	$\times10^4$ Nm/rad	0.37	0.88	1.3	2.7	6.1	11	21
		kgfm/arc min	0.11	0.26	0.4	0.8	1.8	3.4	6.3
	K_3	$\times10^4$ Nm/rad	0.47	1.2	2.0	3.7	8.4	15	30
		kgfm/arc min	0.14	0.34	0.6	1.1	2.5	4.5	9.0
	θ_1	$\times10^{-4}$ rad	6.9	5.8	6.4	7.0	6.2	6.1	6.4
		arc min	2.4	2.0	2.2	2.4	2.1	2.1	2.2
	θ_2	$\times10^{-4}$ rad	19	14	19	18	18	18	18
		arc min	6.4	4.6	6.6	6.1	6.1	5.9	6.2
Reduction ratio 80 or more	K_1	$\times10^4$ Nm/rad	0.4	0.84	1.3	2.7	6.1	11	21
		kgfm/arc min	0.12	0.25	0.4	0.8	1.8	3.2	6.3
	K_2	$\times10^4$ Nm/rad	0.44	0.94	1.7	3.7	7.8	14	29
		kgfm/arc min	0.13	0.28	0.5	1.1	2.3	4.2	8.5
	K_3	$\times10^4$ Nm/rad	0.61	1.3	2.5	4.7	11	20	37
		kgfm/arc min	0.18	0.39	0.75	1.4	3.3	5.8	11
	θ_1	$\times10^{-4}$ rad	5.0	4.6	5.4	5.2	4.8	4.9	5.1
		arc min	1.7	1.6	1.8	1.8	1.7	1.7	1.7
	θ_2	$\times10^{-4}$ rad	16	13	15	13	14	14	13
		arc min	5.4	4.3	5.0	4.5	4.8	4.8	4.6

* The values in this table are reference values. The minimum value is approximately 80% of the displayed value.

Starting torque

See "Engineering data" for a description of terms. The values in the table below vary depending on the use conditions, use them as reference values.

■ CSD-2UH

Table 214-4
Unit: Ncm

Ratio \ Size	14	17	20	25	32	40	50
50	4.4	6.7	8.9	16	32	55	102
80	3.2	4.4	5.7	10	22	36	68
100	2.8	3.8	5.1	9.1	20	32	60

■ CSD-2UF

Table 214-5
Unit: Ncm

Ratio \ Size	14	17	20	25	32	40
50	5.3	7.5	9.7	17	34	58
80	3.8	4.9	6.2	11	23	37
100	3.2	4.2	5.5	9.6	21	33

Backdriving torque

See "Engineering data" for a description of terms. The values in the table below vary depending on the use conditions, use them as reference values.

CSD-2UH

Table 215-1
Unit: Nm

Ratio \ Size	14	17	20	25	32	40	50
50	2.9	4.3	5.2	9.5	19	33	61
80	2.9	4.1	5.7	10	21	35	66
100	3.5	4.6	6.0	11	23	38	71

CSD-2UF

Table 215-2
Unit: Nm

Ratio \ Size	14	17	20	25	32	40
50	3.3	4.7	5.6	10	20	34
80	3.3	4.5	6.1	10	22	36
100	3.9	5.0	6.4	11	24	39

Ratcheting torque

See "Engineering data" for a description of terms.

Table 215-3
Unit: Nm

Ratio \ Size	14	17	20	25	32	40	50
50	60	105	150	315	685	1260	2590
80	75	140	245	475	980	1960	3780
100	55	110	180	350	700	1470	2870

Buckling torque

See "Engineering data" for a description of terms.

Table 215-4
Unit: Nm

Size	14	17	20	25	32	40	50
All ratios	190	330	560	1000	2200	4300	8000

No-load running torque

No-load running torque is the torque which is required to rotate the input side (high speed side), when there is no load on the output side (low speed side).

Measurement condition

Table 216-1

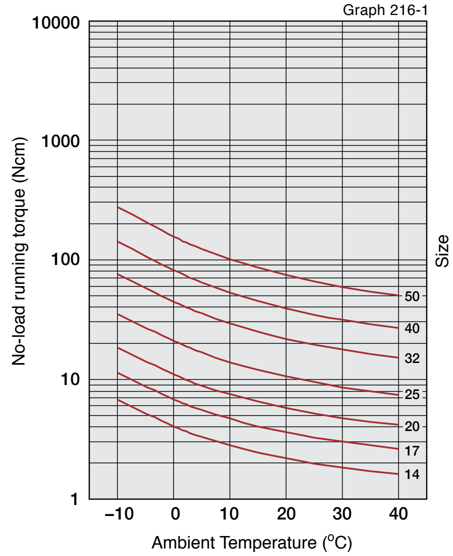
Ratio 100			
Lubricant	Grease lubrication	Name	Harmonic Grease SK-1A (size 20 or larger)
			Harmonic Grease SK-2 (size 14, 17)
		Quantity	Recommended quantity
Torque value is measured after 2 hours at 2000rpm input.			

■ No-load running torque for a reduction ratio of 100:1

■ CSD-2UH

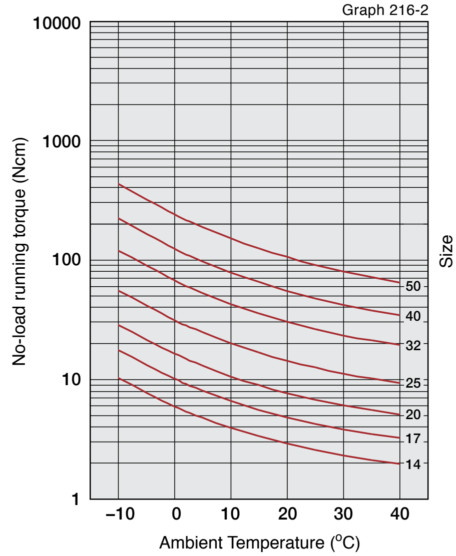
Input speed: 500rpm

Graph 216-1



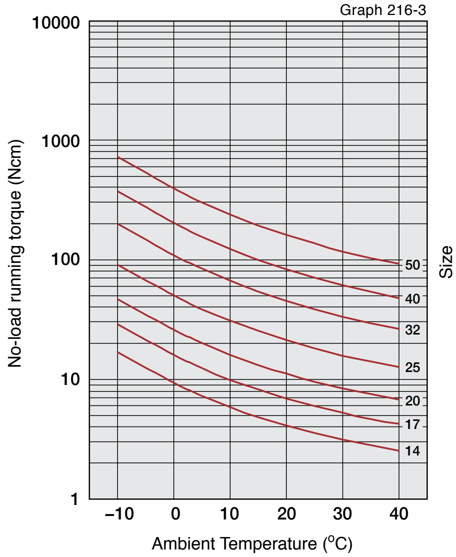
Input speed: 1000rpm

Graph 216-2



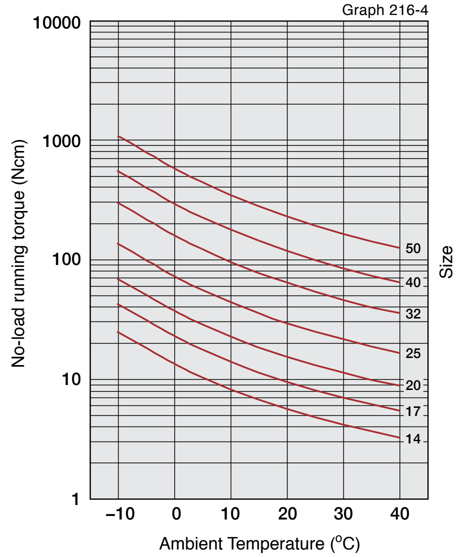
Input speed: 2000rpm

Graph 216-3



Input speed: 3500rpm

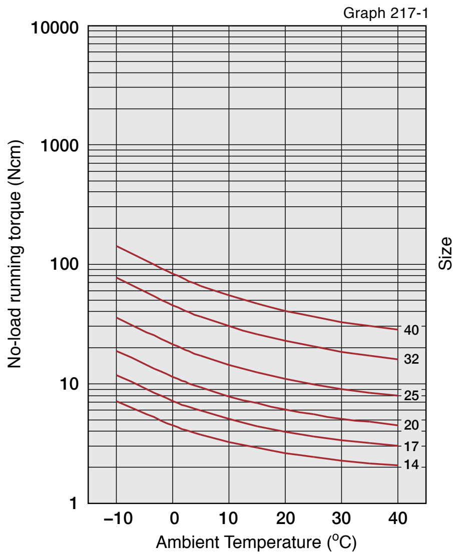
Graph 216-4



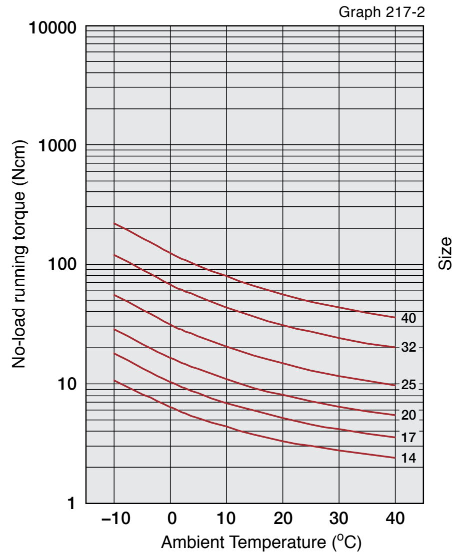
*The values in this graph are average values ($\overline{X}$). σ≈20%

■ CSD-2UF

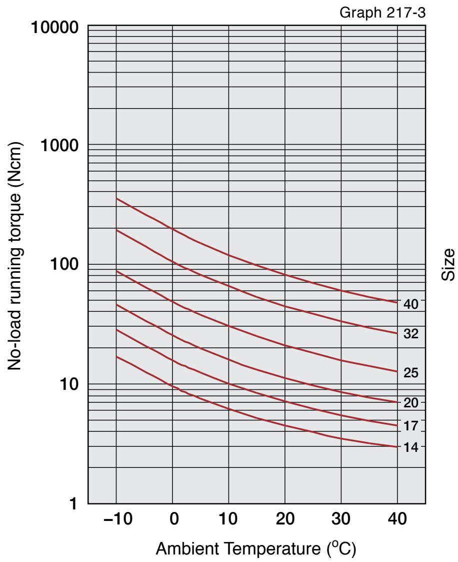
Input speed: 500rpm



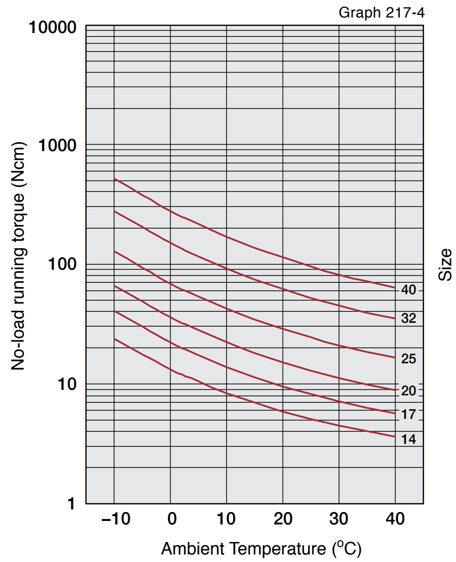
Input speed: 1000rpm



Input speed: 2000rpm



Input speed: 3500rpm



*The values in this graph are average values ($\overline{X}$). σ≈20%

■ Compensation value in each ratio

No-load running torque of the gear varies with ratio.
The graphs indicate a value for ratio 100.
For other gear ratios, add the compensation values from table on the right.

Table 217-1

No-load running torque compensation values

Unit: Ncm

Size \ Ratio	2UH		2UF	
	50	80	50	80
14	+0.93	+0.2	+1.4	+.03
17	+1.5	+0.3	+1.8	+0.4
20	+2.3	+0.4	+2.6	+0.5
25	+3.8	+0.7	+4.3	+0.8
32	+7.3	+1.3	+8.2	+1.5
40	+12	+2.1	+14	+2.5
50	+22	+3.8	–	–

■ Efficiency compensation amount by size

With the CSD-2UH, CSD-2UF, input-side support bearings and oil seal are attached. The effect of these varies depending on the model number.

Use Table 218-1, 2 to determine the compensation amount (η e) for efficiency at rated torque for each size.

Efficiency compensation amount by size

CSD-2UH

Table 218-1, Unit: %

Size \ Reduction ratio	50	80	100
14	0.0	3.1	0.0
17	3.0	2.3	0.4
20	2.4	2.3	1.8
25	-0.3	1.8	-0.1
32	-1.4	-0.1	-0.8
40	-1.4	-0.9	0.0
50	-2.4	-1.9	-1.2

CSD-2UF

Table 218-2, Unit: %

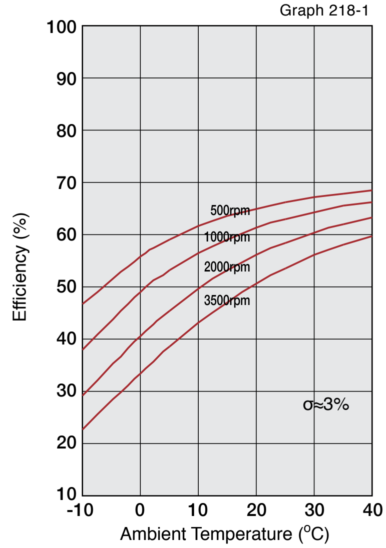
Size \ Reduction ratio	50	80	100
14	0.0	2.9	0.0
17	1.9	1.6	-0.2
20	1.8	1.9	1.5
25	-0.1	1.6	-0.3
32	-1.9	-0.3	-0.9
40	-1.7	-1.0	-0.1

■ Efficiency at rated torque

■ CSD-2UH

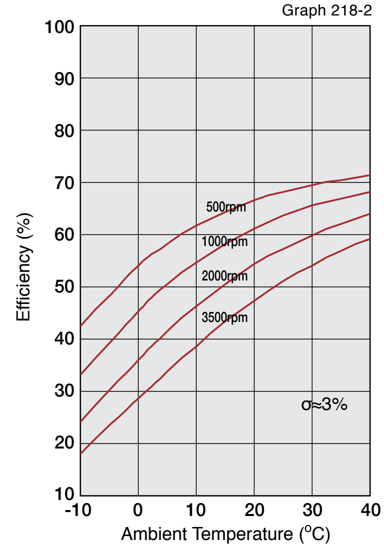
Size 14/ Ratio 50

Graph 218-1



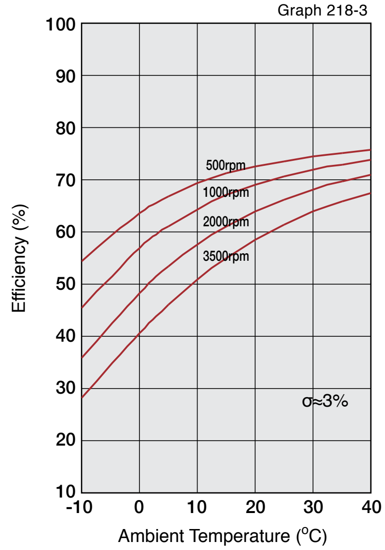
Size 14/ Ratio 80, 100

Graph 218-2



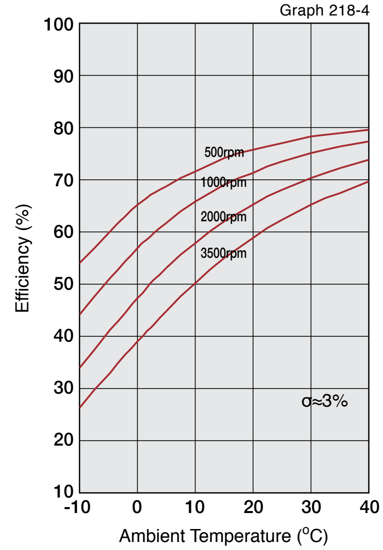
Size 17 to 50/ Ratio 50

Graph 218-3



Size 17 to 50/ Ratio 80, 100

Graph 218-4



*The values in this graph are average values ($\overline{X}$). σ≈20%

Efficiency characteristics

The efficiency varies depending on the following conditions:
- Reduction ratio
- Input rotational speed
- Load torque
- Temperature
- Lubrication (Type of lubricant and the quantity)

Measuring condition

Built-in	Measurement by building the recommended built-in precision into the product		
Load torque	The rated torque shown in the ratings (see the Page 211)		
* When load torque is smaller than rated torque, the efficiency value gets low. See “Efficiency compensation coefficient”			
Lubrication	Grease lubrication	Name	Harmonic Grease® SK-1A (sizes 20 or larger)
			Harmonic Grease® SK-2 (sizes 14, 17)
		Application quantity	Appropriate application quantity

■ Efficiency compensation coefficient

Efficiency compensation calculation formula

Calculate the efficiency by the "Efficiency compensation coefficient by load torque" and the "Efficiency compensation amount by the size" from the following formula:

Calculation Formula

Efficiency $\eta = Ke \times (\eta_R + \eta e)$

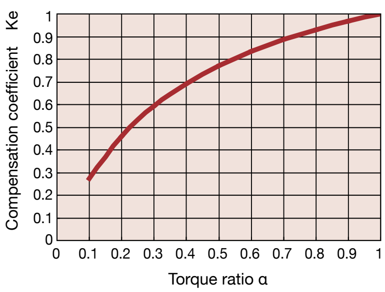
Symbols of the calculation formula

η	Efficiency	
Ke	Efficiency compensation coefficient	Graph 218-1, 2
η_R	Efficiency at rated torque	Graphs 218-1 to 218-4
ηe	Efficiency compensation amount	Table 218-1, 2

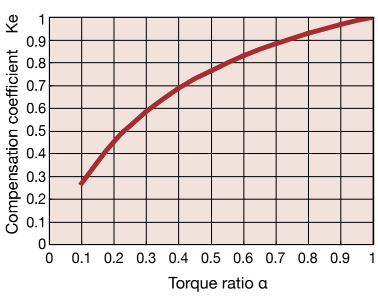
■ Efficiency compensation coefficient due to load torque

When load torque is lower than rated torque, efficiency drops. Determine the compensation coefficient Ke in the graphs below, and then refer to the efficiency compensation calculation formula to determine efficiency.

CSD-2UH



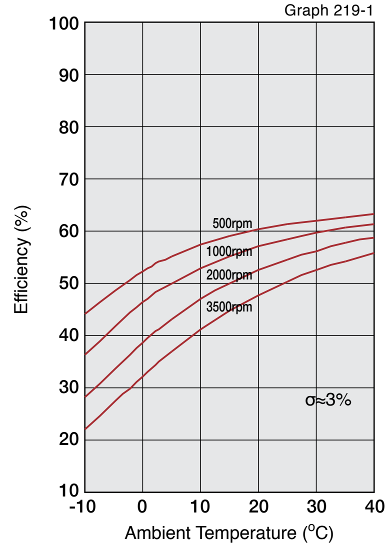
CSD-2UF



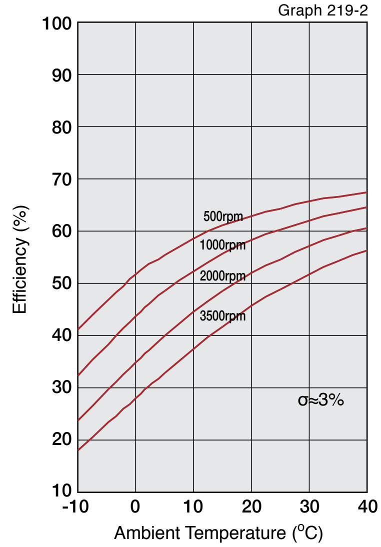
Note: When the load torque is greater than the rated torque the efficiency compensation coefficient Ke = 1.

■ CSD-2UF

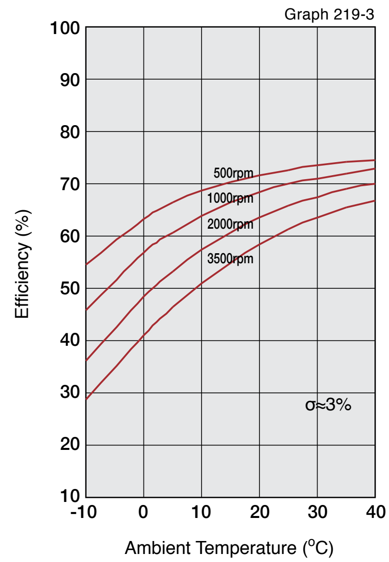
Size 14/ Ratio 50



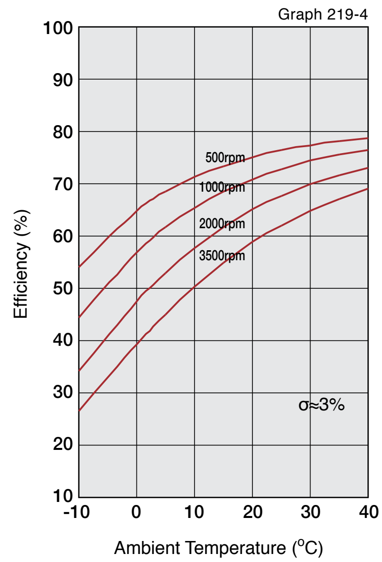
Size 14/ Ratio 80, 100



Size 17 to 40/ Ratio 50



Size 17 to 40/ Ratio 80, 100



*The values in this graph are average values ($\overline{X}$). σ≈20%

Gear Unit CSD

Checking output bearing

A precision cross roller bearing is built in the gear unit to directly support the external load (output flange).
Check the maximum moment load, life of the bearing and static safety coefficient to fully bring out the performance of the unit type.
See Page 030 to 034 of "Engineering data" for each calculation formula.

■ Checking procedure

(1) Checking the maximum moment load (Mmax)

Calculate the maximum moment load (M*max*). → Maximum moment load (M*max*) ≦ allowable moment (Mc)

(2) Checking the life

Calculate the radial load (Fr*av*) and the average axial load (Fa*av*). → Calculate the radial load coefficient (x) and the axial load coefficient (y). → Calculate the lifetime

(3) Checking the static safety coefficient

Calculate the static equivalent radial load coefficient (Po). → Check the static safety coefficient. (fs)

■ Output bearing specifications

The specifications of the cross roller bearing are shown in Table 220-1 and -2.

■ CSD-2UH

Table 220-1

Size	Pitch circle dia. of a roller dp	Offset R	Basic rated load: Basic dynamic rated load C		Basic rated load: Basic static rated load Co		Allowable moment load Mc		Moment stiffness Km		Allowable axial load Fa	Allowable radial load Fr
	m	m	×10²N	kgf	×10²N	kgf	Nm	kgfm	×10⁴ Nm/rad	kgfm/arc-min	×10²N	×10²N
14	0.035	0.0095	47	480	60.7	620	41	4.2	4.38	1.3	10.1	6.74
17	0.0425	0.0099	52.9	540	75.5	770	64	6.5	7.75	2.3	11.3	7.58
20	0.050	0.0102	57.8	590	90	920	91	9.3	12.8	3.8	12.4	8.28
25	0.062	0.0130	96.0	980	151	1540	156	16	24.2	7.2	20.5	13.8
32	0.080	0.0144	150	1530	250	2550	313	32	53.9	16	32.1	2.15
40	0.096	0.0151	213	2170	365	3720	450	46	91	27	45.6	3.05
50	0.119	0.0192	348	3550	602	6140	759	77	171	51	74.4	4.99

■ CSD-2UF

Table 220-2

Size	Pitch circle dia. of a roller dp	Offset R	Basic rated load: Basic dynamic rated load C		Basic rated load: Basic static rated load Co		Allowable moment load Mc		Moment stiffness Km		Allowable axial load Fa	Allowable radial load Fr
	m	m	×10²N	kgf	×10²N	kgf	Nm	kgfm	×10⁴ Nm/rad	kgfm/arc-min	×10²N	×10²N
14	0.050	0.0118	57.8	590	90	920	91	9.3	12.8	3.8	12.4	8.28
17	0.060	0.0123	104	1060	163	1670	124	12.6	15.4	4.6	22.2	14.9
20	0.070	0.0128	146	1490	220	2250	187	19.1	25.2	7.5	31.2	20.9
25	0.085	0.0134	218	2230	358	3660	258	26.3	39.2	11.6	46.6	31.2
32	0.111	0.0168	382	3900	654	6680	580	59.1	100	29.6	81.7	54.7
40	0.133	0.0215	433	4410	816	8330	849	86.6	179	53.2	92.6	62.0

(Note)
* The basic dynamic rated load is the static radial load needed to result in a basic dynamic rated life of one million rotations.
* The basic static rated load is the static load that produces a contact stress of 4 kN/mm2 in the center of the contact area between the rolling element receiving the maximum load.
* The moment stiffness value is an average.
* Allowable moment load is the maximum moment load that may be applied to the output shaft. Please adhere to these values for optimum performance. Moment stiffness is a reference value. The minimum value is approximately 80% of the displayed value.
* Allowable axial or radial load is the value that satisfies the reducer life when either a radial load or an axial load is applied to the main shaft. (When radial load is Lr+R=0mm, and axial load is La=0mm)

Output bearing and housing tolerances

Input: Wave generator
Output: Circular spline
Fixed: Flexspline

CSD-2UH

Fig. 221-1

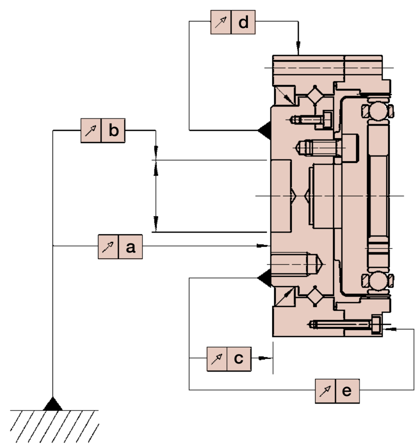


Table 221-1
Unit: mm

Symbol \ Size	14	17	20	25	32	40	50
a	0.010	0.010	0.010	0.015	0.015	0.015	0.018
b	0.010	0.012	0.012	0.013	0.013	0.015	0.015
c	0.007	0.007	0.007	0.007	0.007	0.007	0.007
d	0.010	0.010	0.010	0.010	0.010	0.015	0.015
e	0.025	0.025	0.025	0.035	0.037	0.037	0.040

CSD-2UF

Fig. 221-2

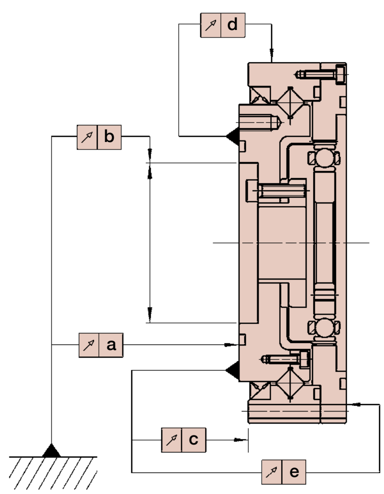


Table 221-2
Unit: mm

Symbol \ Size	14	17	20	25	32	40
a	0.010	0.010	0.010	0.015	0.015	0.015
b	0.010	0.010	0.010	0.010	0.013	0.013
c	0.010	0.010	0.010	0.010	0.013	0.013
d	0.010	0.010	0.010	0.010	0.013	0.013
e	0.031	0.031	0.031	0.041	0.047	0.047

Gear Unit CSD

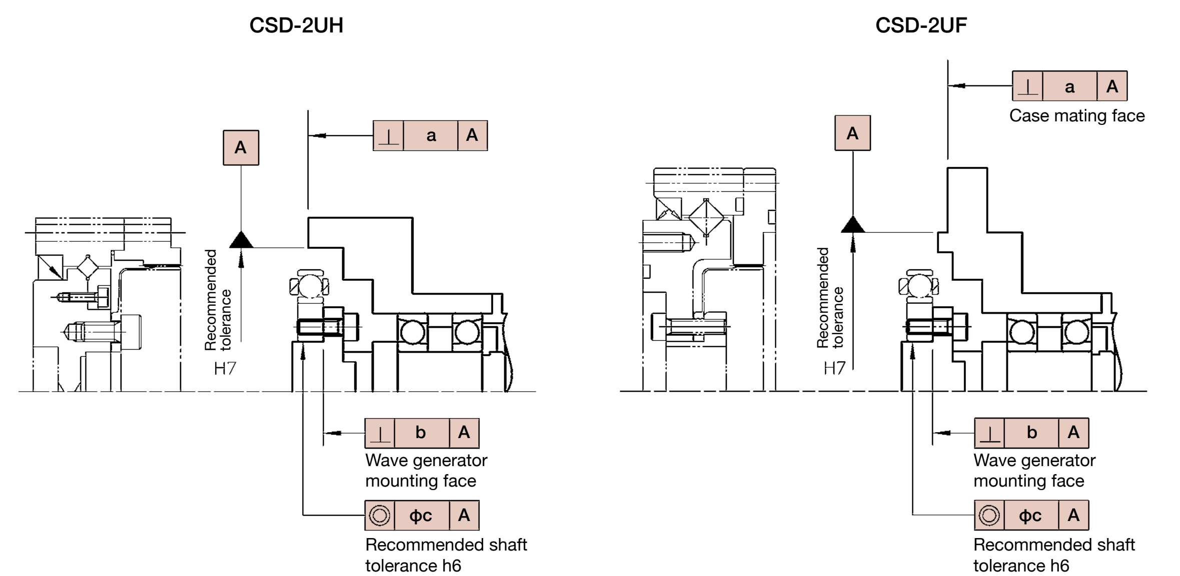
Recommended tolerances for assembly

For peak performance of the gear, it is essential that the following tolerances be observed when assembly is complete.
Pay careful attention to the following points and maintain the recommended assembly tolerances to avoid grease leakage.

- Warping and deformation on the mounting surface
- Contamination due to foreign matter
- Burrs, raised surfaces and location around the tap area of the mounting holes
- Insufficient chamfering on the mounting pilot joint
- Insufficient radii on the mounting pilot joint

Recommended Tolerances for Assembly

Fig. 222-1



Tolerances for Assembly CSD-2UH

Table 222-1
Unit: mm

Symbol \ Size	14	17	20	25	32	40	50
a	0.011	0.015	0.017	0.024	0.026	0.026	0.028
b	0.008	0.010	0.012	0.012	0.012	0.012	0.015
ϕc	0.016	0.018	0.019	0.022	0.022	0.024	0.030

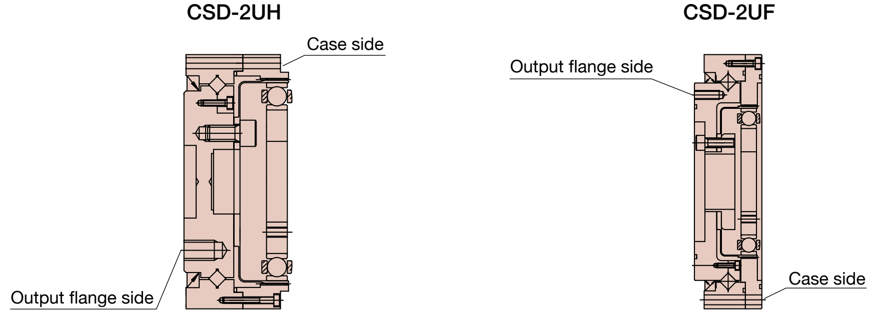
Tolerances for Assembly CSD-2UF

Table 222-2
Unit: mm

Symbol \ Size	14	17	20	25	32	40
a	0.011	0.015	0.017	0.024	0.026	0.026
b	0.008	0.010	0.012	0.012	0.012	0.012
ϕc	0.016	0.018	0.019	0.022	0.022	0.024

Installation and transmission torque

Fig. 223-1



■ Installation on output flange side and resulting transmission torque

■ CSD-2UH

Table 223-1

Item \ Size		14	17	20	25	32	40	50
Number of bolts		10	8	8	8	10	10	10
Bolt size		M3	M5	M6	M8	M8	M10	M12
Pitch circle	mm	25	27	34	42	57	72	88
Bolt tightening torque	Nm	2.4	10.8	18.4	44	44	74	128
Torque transmission capacity (bolt only)	Nm	50	122	217	486	824	1665	2933

■ CSD-2UF

Table 223-2

Item \ Size		14	17	20	25	32	40
Number of bolts		8	10	8	8	8	12
Bolt size		M3	M3	M4	M5	M6	M6
Pitch circle	mm	42	50	60	73	96	116
Bolt tightening torque	Nm	2.4	2.4	5.4	10.8	18.4	18.4
Torque transmission capacity (bolt only)	Nm	70	104	167	329	765	1109

■ Bolt connection to case side and resulting transmission torque

■ CSD-2UH

Table 223-3

Item \ Size		14	17	20	25	32	40	50
Number of bolts		6	10	12	18	18	18	22
Bolt size		M3	M3	M3	M3	M4	M5	M6
Pitch circle	mm	49	56	64	79	104	117.5	147
Bolt tightening torque	Nm	2.4	2.4	2.4	2.4	5.4	10.8	18.4
Torque transmission capacity (bolt only)	Nm	43	82	112	207	461	833	1804

■ CSD-2UF

Table 223-4

Item \ Size		14	17	20	25	32	40
Number of bolts		6	8	8	10	10	10
Bolt size		M3	M3	M3	M4	M5	M6
Pitch circle	mm	64	74	84	102	132	158
Bolt tightening torque	Nm	2.4	2.4	2.4	5.4	10.8	18.4
Torque transmission capacity (bolt only)	Nm	80	123	140	359	743	1259

(Table 223-1 **to** 223-4/Notes)
1. The material of the thread must withstand the clamp torque.
2. Recommended bolt: JIS B 1176 socket head cap screw / Strength range : JIS B 1051 over 12.9
3. Torque coefficient: K=0.2
4. Clamp coefficient: A=1.4
5. Tightening friction coefficient μ=0.15

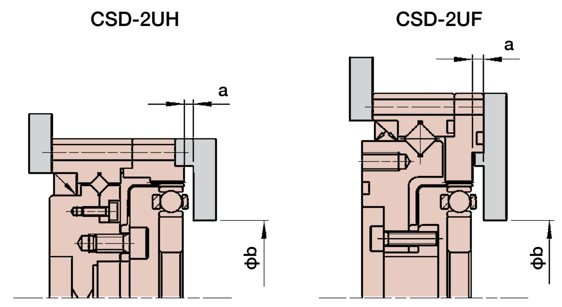
Gear Unit CSD

Lubrication

Grease lubrication is standard for the CSD-2UH and CSD-2UF. There is no need to add or apply grease upon installation since the products are shipped with the grease applied.

See table below for recommended housing dimensions. These dimensions must be maintained to prevent damage to the gear and to maintain a proper grease cavity.

Fig. 224-1



■ Recommended housing dimensions

Table 224-1
Unit: mm

Symbol \ Size	14	17	20	25	32	40	50
a*	1	1	1.5	1.5	2	2.5	3.5
a**	3	3	4.5	4.5	6	7.5	10.5
$\phi b^{+0.5}_{0}$	16	26	30	37	37	45	45

*For the wave generator facing downward
**For the wave generator facing upward
When you use the wave generator facing upward or downward (see page 048), fill the space between the wave generator and input cover (gap with the motor flange) with grease.

■ Compatible grease by size

Compatible grease varies depending on the size and reduction ratio. See the following compatibility table. We recommend SK-1A and SK-2 for general use.
See "Engineering data" on Page 016 for details for grease.

Compatible grease

Table 224-2

Size	14	17	20	25	32	40	50
SK-1A	—	—	○	○	○	○	○
SK-2	○	○	△	△	△	△	△
4BNo.2	□	□	□	□	□	□	□

○ mark: Standard grease
△ mark: Semi-standard grease
□ mark: Recommended grease for long life and high load

Sealing

The following sealing mechanism is required to prevent grease leakage and maintain the high durability of the gear.

- Rotating Parts .... Oil seal (with a spring). Surface should be smooth (no scratches)
- Mating flange .... O-ring and seal adhesive. Take care regarding distortion on the plane and how the O-ring is engaged.
- Screw hole area .... Screws should have a thread lock (Loctite 242 is recommended) or seal adhesive.

(Note) If you use Harmonic Grease® 4BNo.2 lubrication, strict sealing is required.

Sealing area and the recommended sealing method for the unit type

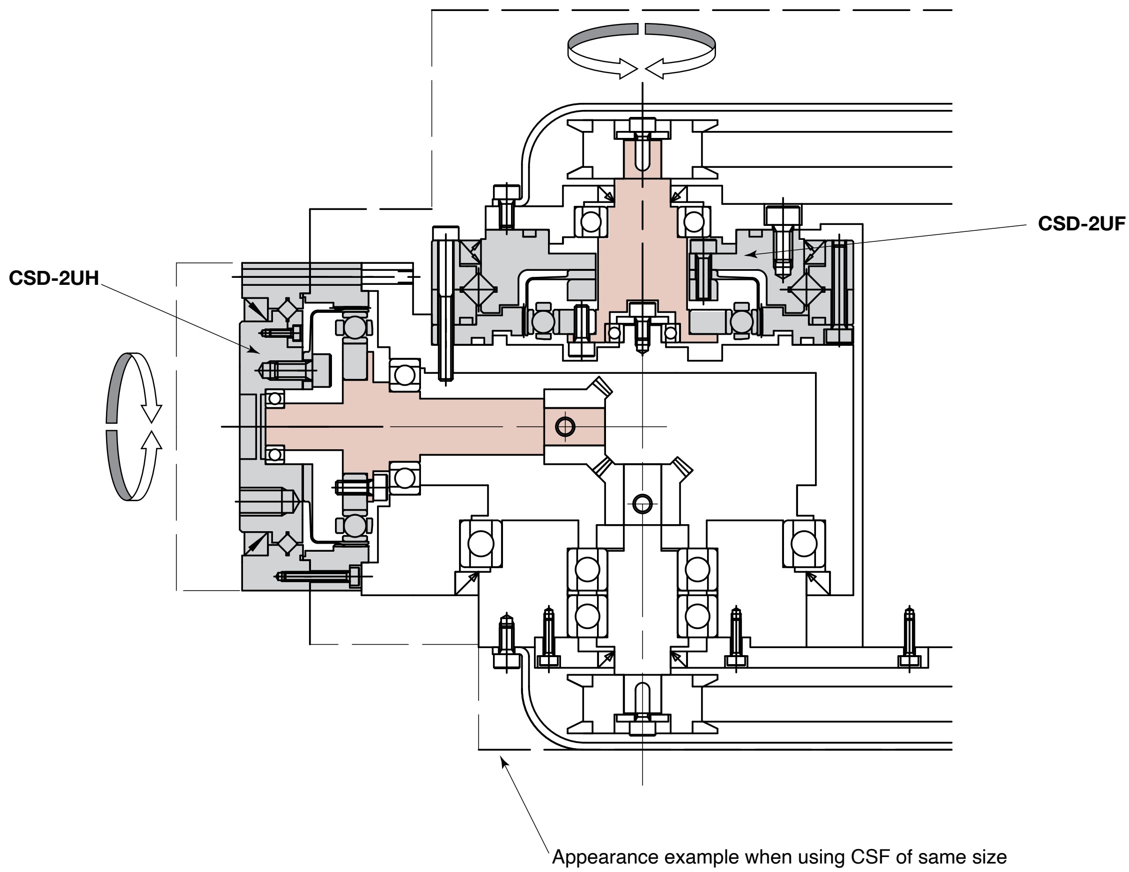
Table 224-3

Area requiring sealing		Recommended sealing method
Output side	Pass-through hole in the center of the output flange and the output flange mating face	Use O-ring (supplied with the product)
	Mounting screw area	Screw lock agent with sealing effect (Loctite 242 is recommended)
Input side	Flange mating face	Use O-ring (supplied with the product)
	Motor output shaft	Please select a motor which has an oil seal on the output shaft.

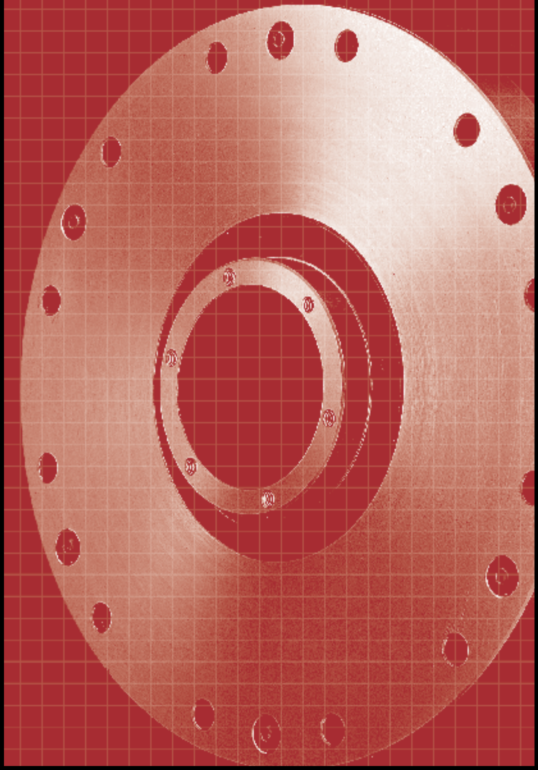
Application

Bending and twisting drive of the wrist for a vertical multijoint robot

Fig. 225-1



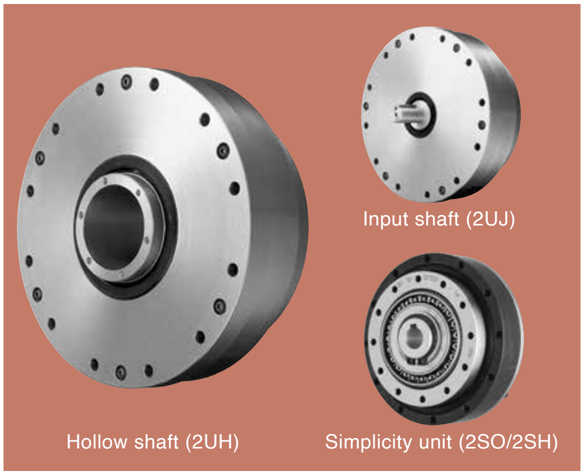
MEMO



SHG/SHF Series

Gear Unit SHG/SHF

Features



SHG/SHF series gear units

The SHG/SHF series gear unit is an easy-to-use gearhead solution. An accurate, highly rigid cross roller bearing is built in to directly support the external load.

Features

- Zero backlash
- Large bore with hollow through hole (2UH)
- Input shaft option available (2UJ)
- Flat shape, compact and simple design
- High-torque capacity
- High stiffness
- High-positional and rotational accuracies
- Coaxial input and output

Configurations

The SHG/SHF gearheads are available in 4 variations allowing the customer to choose the best configuration for their application.

- Large-diameter hollow shaft: (2UH)
- Input shaft (2UJ)
- Easier to use: Simplicity unit (2SO)
  Hollow shaft simplicity unit (2SH)

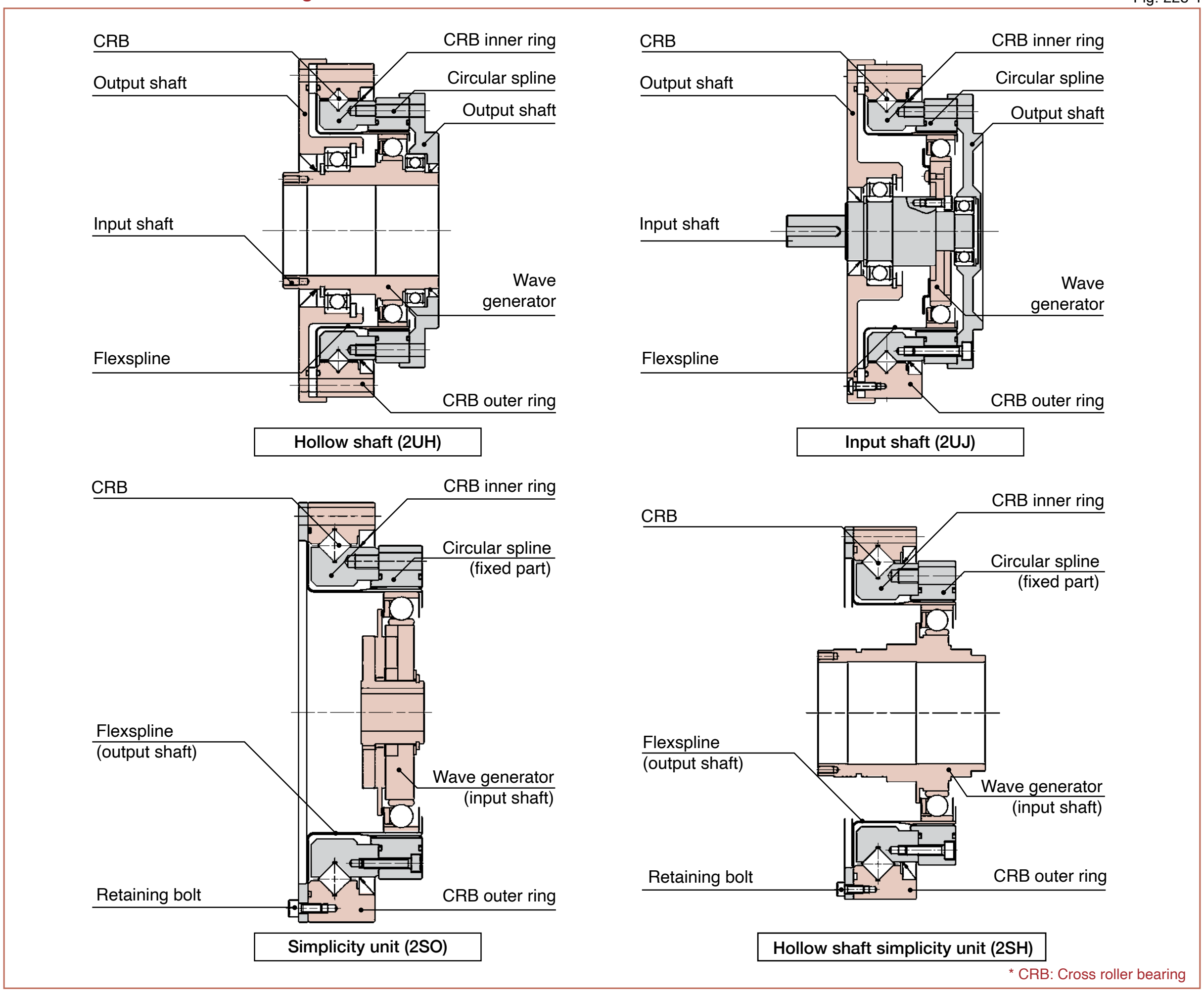
Series

SHG: high torque
- Torque capacity has been improved by 30% compared to the SHF series.
- The life has been improved by 43% (10,000 hours) compared to the SHF series.

SHF: standard torque
- Reduction ratio of 30:1 added for high speed.
- Lightweight versions available, up to 20% lighter than standard models.

Structure of the SHG/SHF series gear unit

Fig. 228-1

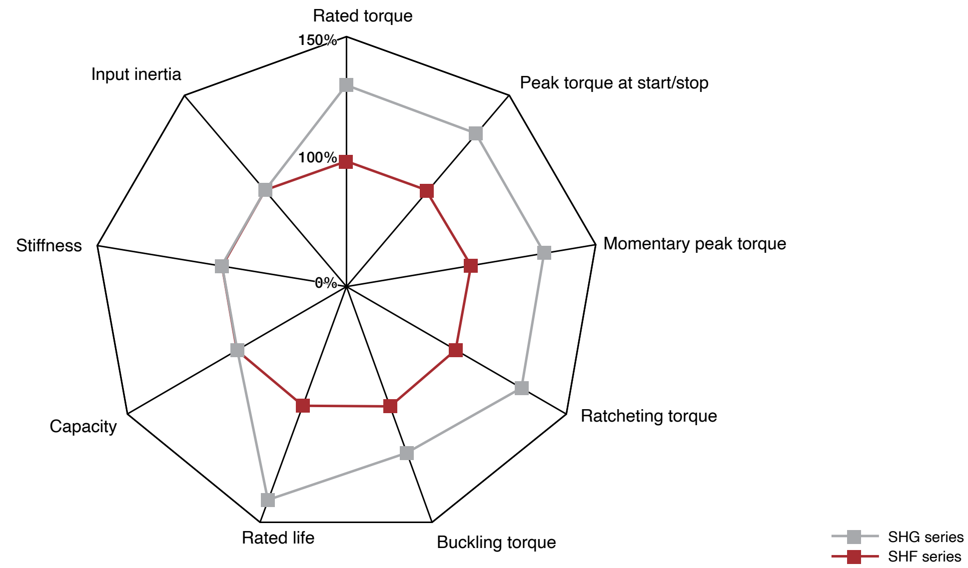


* CRB: Cross roller bearing

Engineering Data
Component Sets
Gear Units
Phase Adjusters
Gearheads & Actuators

Comparison between SHG/SHF series and CSF series

Graph 229-1



Ordering Code

SHG - 25 - 100 - 2UH - SP

Table 229-1

Series	Size	Ratio[*1]					Model	Special specification
SHG	14	50	80	100	—	—	2A-GR = Component set (2A-R for sizes 14, 17) 2UH = Hollow shaft 2UJ = Input shaft 2SO = Simplicity unit (Std. structure) 2SH = Simplicity unit (Hollow shaft)	LW = Lightweight SP = Special specification code Blank = Standard product
	17	50	80	100	120	—		
	20	50	80	100	120	160		
	25	50	80	100	120	160		
	32	50	80	100	120	160		
	40	50	80	100	120	160		
	45	50	80	100	120	160		
	50	—	80	100	120	160		
	58	—	80	100	120	160		
	65	—	80	100	120	160		

*1: The reduction ratio value is based on the following configuration: Input: wave generator, fixed: circular spline, output: flexspline

SHF - 25 - 100 - 2UH - SP

Table 229-2

Series	Size	Ratio[*1]						Model	Special specification
SHF	11[*2]	—	50	—	100	—	—	2A-GR = Component set (2A-R for sizes 14, 17) 2UH = Hollow shaft 2UJ = Input shaft 2SO = Simplicity unit (Std. structure) 2SH = Simplicity unit (Hollow shaft)	LW = Lightweight SP = Special specification code Blank = Standard product
	14	30	50	80	100	—	—		
	17	30	50	80	100	120	—		
	20	30	50	80	100	120	160		
	25	30	50	80	100	120	160		
	32	30	50	80	100	120	160		
	40	—	50	80	100	120	160		
	45	—	50	80	100	120	160		
	50	—	50	80	100	120	160		
	58	—	50	80	100	120	160		

*1: The reduction ratio value is based on the following configuration: Input: wave generator, fixed: circular spline, output: flexspline
*2: Size 11 is only available in SHF-2UH

Technical Data

Rating table

SHG series

Table 230-1

Size	Ratio	Rated torque at 2000rpm		Limit for repeated peak torque		Limit for average torque		Limit for momentary peak torque		Maximum input speed (rpm)	Limit for average input speed (rpm)
		Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm	Grease lubricant	Grease lubricant
14	50	7.0	0.7	23	2.3	9	0.9	46	4.7	8500	3500
	80	10	1.0	30	3.1	14	1.4	61	6.2		
	100	10	1.0	36	3.7	14	1.4	70	7.2		
17	50	21	2.1	44	4.5	34	3.4	91	9	7300	3500
	80	29	2.9	56	5.7	35	3.6	113	12		
	100	31	3.2	70	7.2	51	5.2	143	15		
	120	31	3.2	70	7.2	51	5.2	112	11		
20	50	33	3.3	73	7.4	44	4.5	127	13	6500	3500
	80	44	4.5	96	9.8	61	6.2	165	17		
	100	52	5.3	107	10.9	64	6.5	191	20		
	120	52	5.3	113	11.5	64	6.5	191	20		
	160	52	5.3	120	12.2	64	6.5	191	20		
25	50	51	5.2	127	13	72	7.3	242	25	5600	3500
	80	82	8.4	178	18	113	12	332	34		
	100	87	8.9	204	21	140	14	369	38		
	120	87	8.9	217	22	140	14	395	40		
	160	87	8.9	229	23	140	14	408	42		
32	50	99	10	281	29	140	14	497	51	4800	3500
	80	153	16	395	40	217	22	738	75		
	100	178	18	433	44	281	29	841	86		
	120	178	18	459	47	281	29	892	91		
	160	178	18	484	49	281	29	892	91		
40	50	178	18	523	53	255	26	892	91	4000	3000
	80	268	27	675	69	369	38	1270	130		
	100	345	35	738	75	484	49	1400	143		
	120	382	39	802	82	586	60	1530	156		
	160	382	39	841	86	586	60	1530	156		
45	50	229	23	650	66	345	35	1235	126	3800	3000
	80	407	41	918	94	507	52	1651	168		
	100	459	47	982	100	650	66	2041	208		
	120	523	53	1070	109	806	82	2288	233		
	160	523	53	1147	117	819	84	2483	253		
50	80	484	49	1223	125	675	69	2418	247	3500	2500
	100	611	62	1274	130	866	88	2678	273		
	120	688	70	1404	143	1057	108	2678	273		
	160	688	70	1534	156	1096	112	3185	325		
58	80	714	73	1924	196	1001	102	3185	325	3000	2200
	100	905	92	2067	211	1378	141	4134	422		
	120	969	99	2236	228	1547	158	4329	441		
	160	969	99	2392	244	1573	160	4459	455		
65	80	969	99	2743	280	1352	138	4836	493	2800	1900
	100	1236	126	2990	305	1976	202	6175	630		
	120	1236	126	3263	333	2041	208	6175	630		
	160	1236	126	3419	349	2041	208	6175	630		

(Note) 1. Moment of inertia: $I=\frac{1}{4}GD^2$

2. See Rating Table Definitions on Page 12 for details of the terms.

Rating table

■ SHF series

Table 231-1

Size	Ratio	Rated torque at 2000rpm		Limit for repeated peak torque		Limit for average torque		Limit for momentary peak torque		Maximum input speed (rpm)	Limit for average input speed (rpm)
		Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm	Grease lubricant	Grease lubricant
11	50	3.5	0.36	8.3	0.85	5.5	0.56	17	1.73	8500	3500
	100	5	0.51	11	1.12	8.9	0.91	25	2.55		
14	30	4.0	0.41	9.0	0.92	6.8	0.69	17	1.7	8500	3500
	50	5.4	0.55	18	1.8	6.9	0.70	35	3.6		
	80	7.8	0.80	23	2.4	11	1.1	47	4.8		
	100	7.8	0.80	28	2.9	11	1.1	54	5.5		
17	30	8.8	0.90	16	1.6	12	1.2	30	3.1	7300	3500
	50	16	1.6	34	3.5	26	2.6	70	7.1		
	80	22	2.2	43	4.4	27	2.7	87	8.9		
	100	24	2.4	54	5.5	39	4.0	110	11		
	120	24	2.4	54	5.5	39	4.0	86	8.8		
20	30	15	1.5	27	2.8	20	2.0	50	5.1	6500	3500
	50	25	2.5	56	5.7	34	3.5	98	10		
	80	34	3.5	74	7.5	47	4.8	127	13		
	100	40	4.1	82	8.4	49	5.0	147	15		
	120	40	4.1	87	8.9	49	5.0	147	15		
	160	40	4.1	92	9.4	49	5.0	147	15		
25	30	27	2.8	50	5.1	38	3.9	95	9.7	5600	3500
	50	39	4.0	98	10	55	5.6	186	19		
	80	63	6.4	137	14	87	8.9	255	26		
	100	67	6.8	157	16	108	11	284	29		
	120	67	6.8	167	17	108	11	304	31		
	160	67	6.8	176	18	108	11	314	32		
32	30	54	5.5	100	10	75	7.7	200	20	4800	3500
	50	76	7.8	216	22	108	11	382	39		
	80	118	12	304	31	167	17	568	58		
	100	137	14	333	34	216	22	647	66		
	120	137	14	353	36	216	22	686	70		
	160	137	14	372	38	216	22	686	70		
40	50	137	14	402	41	196	20	686	70	4000	3000
	80	206	21	519	53	284	29	980	100		
	100	265	27	568	58	372	38	1080	110		
	120	294	30	617	63	451	46	1180	120		
	160	294	30	647	66	451	46	1180	120		
45	50	176	18	500	51	265	27	950	97	3800	3000
	80	313	32	706	72	390	40	1270	130		
	100	353	36	755	77	500	51	1570	160		
	120	402	41	823	84	620	63	1760	180		
	160	402	41	882	90	630	64	1910	195		
50	50	122	12	715	73	175	18	1430	146	3500	2500
	80	372	38	941	96	519	53	1860	190		
	100	470	48	980	100	666	68	2060	210		
	120	529	54	1080	110	813	83	2060	210		
	160	529	54	1180	120	843	86	2450	250		
58	50	176	18	1020	104	260	27	1960	200	3000	2200
	80	549	56	1480	151	770	79	2450	250		
	100	696	71	1590	162	1060	108	3180	325		
	120	745	76	1720	176	1190	121	3330	340		
	160	745	76	1840	188	1210	123	3430	350		

(Note) 1. Moment of inertia: $I=\frac{1}{4}GD^2$

3. See Rating Table Definitions on Page 12 for details of the terms.

4. Size 11 is only available in 2UH.

Engineering Data
Component Sets
Gear Units
Phase Adjusters
Gearheads & Actuators

Positional accuracy

See "Engineering data" for a description of terms.

Table 232-1

Ratio	Specification \ Size		11	14	17	20	25	32	40 or more
30	Standard product	$\times 10^{-4}$rad	—	5.8	4.4	4.4	4.4	4.4	—
		arc min	—	2	1.5	1.5	1.5	1.5	—
	Special product	$\times 10^{-4}$rad	—	—	—	2.9	2.9	2.9	—
		arc min	—	—	—	1	1	1	—
50 or more	Standard product	$\times 10^{-4}$rad	5.8 (4.4)	4.4	4.4	2.9	2.9	2.9	2.9
		arc min	2 (1.5)	1.5	1.5	1	1	1	1
	Special product	$\times 10^{-4}$rad	—	2.9	2.9	1.5	1.5	1.5	1.5
		arc min	—	1	1	0.5	0.5	0.5	0.5

Note 1: * The parenthesized value of size 11 indicates the value for reduction ratio 100.

Hysteresis loss

See "Engineering data" for a description of terms.

Table 232-2

Ratio	Unit \ Size	11	14	17	20	25	32	40 or more
30	$\times 10^{-4}$rad	—	8.7	8.7	8.7	8.7	8.7	—
	arc min	—	3.0	3.0	3.0	3.0	3.0	—
50	$\times 10^{-4}$rad	5.8	5.8	5.8	5.8	5.8	5.8	5.8
	arc min	2.0	2.0	2.0	2.0	2.0	2.0	2.0
80 or more	$\times 10^{-4}$rad	5.8	2.9	2.9	2.9	2.9	2.9	2.9
	arc min	2.0	1.0	1.0	1.0	1.0	1.0	1.0

Backlash

See "Engineering data" for a description of terms.

Table 232-3

Ratio	Size	11	14	17	20	25	32	40	45	50	58	65
30	$\times 10^{-5}$rad	—	29.1	16.0	13.6	13.6	11.2	—	—	—	—	—
	arc sec	—	60	33	28	28	23	—	—	—	—	—
50	$\times 10^{-5}$rad	Note 1	17.5	9.7	8.2	8.2	6.8	6.8	5.8	5.8	4.8	—
	arc sec	Note 1	36	20	17	17	14	14	12	12	10	—
80	$\times 10^{-5}$rad	—	11.2	6.3	5.3	5.3	4.4	4.4	3.9	3.9	2.9	2.9
	arc sec	—	23	13	11	11	9	9	8	8	6	6
100	$\times 10^{-5}$rad	Note 1	8.7	4.8	4.4	4.4	3.4	3.4	2.9	2.9	2.4	2.4
	arc sec	Note 1	18	10	9	9	7	7	6	6	5	5
120	$\times 10^{-5}$rad	—	—	3.9	3.9	3.9	2.9	2.9	2.4	2.4	1.9	1.9
	arc sec	—	—	8	8	8	6	6	5	5	4	4
160	$\times 10^{-5}$rad	—	—	—	2.9	2.9	2.4	2.4	1.9	1.9	1.5	1.5
	arc sec	—	—	—	6	6	5	5	4	4	3	3

Note 1: For size 11, the wave generator is a solid wave generator. See "Engineering data" for details.

Torsional stiffness

See "Engineering data" for a description of terms.

Table 232-4

Symbol		Size	11	14	17	20	25	32	40	45	50	58	65
T_1		Nm	0.8	2.0	3.9	7.0	14	29	54	76	108	168	235
		kgfm	0.082	0.2	0.4	0.7	1.4	3.0	5.5	7.8	11	17	24
T_2		Nm	2.0	6.9	12	25	48	108	196	275	382	598	843
		kgfm	0.2	0.7	1.2	2.5	4.9	11	20	28	39	61	86
Reduction ratio 30	K_1	$\times 10^4$Nm/rad	—	0.19	0.34	0.57	1.0	2.4	—	—	—	—	—
		kgfm/arc min	—	0.056	0.10	0.17	0.30	0.70	—	—	—	—	—
	K_2	$\times 10^4$Nm/rad	—	0.24	0.44	0.71	1.3	3.0	—	—	—	—	—
		kgfm/arc min	—	0.07	0.13	0.21	0.40	0.89	—	—	—	—	—
	K_3	$\times 10^4$Nm/rad	—	0.34	0.67	1.1	2.1	4.9	—	—	—	—	—
		kgfm/arc min	—	0.10	0.20	0.32	0.62	1.5	—	—	—	—	—
	θ_1	$\times 10^{-4}$rad	—	10.5	11.5	12.3	14	12.1	—	—	—	—	—
		arc min	—	3.6	4.0	4.1	4.7	4.3	—	—	—	—	—
	θ_2	$\times 10^{-4}$rad	—	31	30	38	40	38	—	—	—	—	—
		arc min	—	10.7	10.2	12.7	13.4	13.3	—	—	—	—	—
Reduction ratio 50	K_1	$\times 10^4$Nm/rad	0.22	0.34	0.81	1.3	2.5	5.4	10	15	20	31	—
		kgfm/arc min	0.066	0.1	0.24	0.38	0.74	1.6	3.0	4.3	5.9	9.3	—
	K_2	$\times 10^4$Nm/rad	0.3	0.47	1.1	1.8	3.4	7.8	14	20	28	44	—
		kgfm/arc min	0.09	0.14	0.32	0.52	1.0	2.3	4.2	6.0	8.2	13	—
	K_3	$\times 10^4$Nm/rad	0.32	0.57	1.3	2.3	4.4	9.8	18	26	34	54	—
		kgfm/arc min	0.096	0.17	0.4	0.67	1.3	2.9	5.3	7.6	10	16	—
	θ_1	$\times 10^{-4}$rad	3.6	5.8	4.9	5.2	5.5	5.5	5.2	5.2	5.5	5.2	—
		arc min	1.2	2.0	1.7	1.8	1.9	1.9	1.8	1.8	1.9	1.8	—
	θ_2	$\times 10^{-4}$rad	8.0	16	12	15.4	15.7	15.7	15.4	15.1	15.4	15.1	—
		arc min	2.6	5.6	4.2	5.3	5.4	5.4	5.3	5.2	5.3	5.2	—

* The values in this table are reference values. The minimum value is approximately 80% of the displayed value.

Table 233-1

Symbol			11	14	17	20	25	32	40	45	50	58	65
T_1		Nm	0.8	2.0	3.9	7.0	14	29	54	76	108	168	235
		kgfm	0.82	0.2	0.4	0.7	1.4	3.0	5.5	7.8	11	17	24
T_2		Nm	2	6.9	12	25	48	108	196	275	382	598	843
		kgfm	0.2	0.7	1.2	2.5	4.9	11	20	28	39	61	86
Reduction ratio 80 or more	K_1	$\times10^4$Nm/rad	0.27	0.47	1	1.6	3.1	6.7	13	18	25	40	54
		kgfm/arc min	0.08	0.14	0.3	0.47	0.92	2.0	3.8	5.4	7.4	12	16
	K_2	$\times10^4$Nm/rad	0.34	0.61	1.4	2.5	5.0	11	20	29	40	61	88
		kgfm/arc min	0.1	0.18	0.4	0.75	1.5	3.2	6.0	8.5	12	18	26
	K_3	$\times10^4$Nm/rad	0.44	0.71	1.6	2.9	5.7	12	23	33	44	71	98
		kgfm/arc min	0.13	0.21	0.46	0.85	1.7	3.7	6.8	9.7	13	21	29
	θ_1	$\times10^{-4}$rad	3	4.1	3.9	4.4	4.4	4.4	4.1	4.1	4.4	4.1	4.4
		arc min	1	1.4	1.3	1.5	1.5	1.5	1.4	1.4	1.5	1.4	1.5
	θ_2	$\times10^{-4}$rad	6	12	9.7	11.3	11.1	11.6	11.1	11.1	11.1	11.1	11.3
		arc min	2.2	4.2	3.3	3.9	3.8	4.0	3.8	3.8	3.8	3.8	3.9

* The values in this table are reference values. The minimum value is approximately 80% of the displayed value.

Ratcheting torque

See "Engineering data" for a description of terms.

SHG series

Table 233-2
Unit: Nm

Ratio \ Size	14	17	20	25	32	40	45	50	58	65
50	110	190	280	580	1200	2300	3500	—	—	—
80	140	260	450	880	1800	3600	5000	7000	10000	14000
100	100	200	330	650	1300	2700	4000	5300	8300	12000
120	—	150	310	610	1200	2400	3600	4900	7500	10000
160	—	—	280	580	1200	2300	3300	4600	7200	10000

SHF series

Table 233-3
Unit: Nm

Ratio \ Size	11	14	17	20	25	32	40	45	50	58
30	—	59	100	170	340	720	—	—	—	—
50	34	88	150	220	450	980	1800	2700	3700	5800
80	—	110	200	350	680	1400	2800	3900	5400	8200
100	43	84	160	260	500	1000	2100	3100	4100	6400
120	—	—	120	240	470	980	1900	2800	3800	5800
160	—	—	—	220	450	980	1800	2600	3600	5600

Buckling torque

See "Engineering data" for a description of terms.

SHG series

Table 233-4
Unit: Nm

Size	14	17	20	25	32	40	45	50	58	65
All ratios	180	350	590	1100	2400	4400	6300	8600	13400	18800

SHF series

Table 233-5
Unit: Nm

Size	11	14	17	20	25	32	40	45	50	58
All ratios	90	140	270	440	890	1750	3750	5400	7500	11800

Checking output bearing

A precision cross roller bearing is built in the unit type to directly support the external load (output flange).
Please calculate maximum moment load, life of cross roller bearing, and static safety factor to fully maximize the performance of housed unit (gearhead).

See Pages 030 to 034 of "Engineering data" for each calculation formula.

■ Checking procedure

(1) Checking the maximum moment load (M_{max})

Calculate the maximum moment load (M_{max}). → Maximum moment load (M_{max}) ≦ allowable moment (Mc)

(2) Checking the life

Calculate the radial load (F_{rav}) and the average axial load (F_{aav}). → Calculate the radial load coefficient (x) and the axial load coefficient (y). → Calculate the lifetime

(3) Checking the static safety coefficient

Calculate the static equivalent radial load coefficient (Po). → Check the static safety coefficient. (fs)

■ Output bearing specifications

The specifications of the cross roller are shown in Table 234-1.

Specifications

Table 234-1

Size	Pitch circle	Offset	Basic rated load				Allowable moment load Mc		Moment stiffness Km	
	dp	R	Basic dynamic rated load C		Basic static rated load Co					
	m	m	$\times10^2$N	kgf	$\times10^2$N	kgf	Nm	kgfm	$\times10^4$ Nm/rad	kgfm/arc min
11	0.043	0.018	52.9	540	75.5	770	74	7.6	6.5	1.8
14	0.050	0.0217	58	590	86	880	74	7.6	8.5	2.5
17	0.060	0.0239	104	1060	163	1670	124	12.6	15.4	4.6
20	0.070	0.0255	146	1490	220	2250	187	19.1	25.2	7.5
25	0.085	0.0296	218	2230	358	3660	258	26.3	39.2	11.6
32	0.111	0.0364	382	3900	654	6680	580	59.1	100	29.6
40	0.133	0.044	433	4410	816	8330	849	86.6	179	53.2
45	0.154	0.0475	776	7920	1350	13800	1127	115	257	76.3
50	0.170	0.0525	816	8330	1490	15300	1487	152	351	104
58	0.195	0.0622	874	8920	1710	17500	2180	222	531	158
65	0.218	0.072	1300	13300	2230	22700	2740	280	741	220

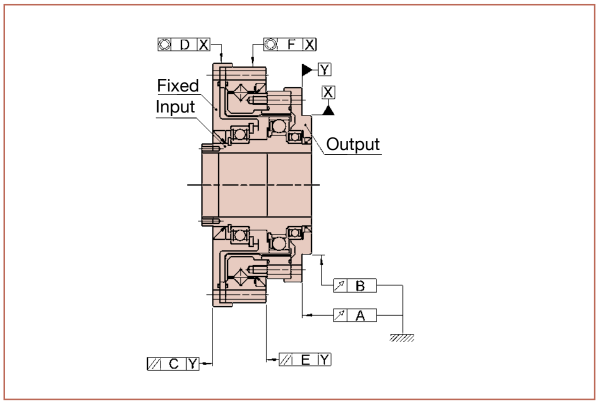
* The basic dynamic rated load is the static radial load needed to result in a basic dynamic rated life of one million rotations.
* The basic static rated load is the static load that produces a contact stress of 4 kN/mm2 in the center of the contact area between the rolling element receiving the maximum load.
* The moment stiffness value is an average.
* Allowable moment load is the maximum moment load that may be applied to the output shaft. Please adhere to these values for optimum performance. Moment stiffness is a reference value. The minimum value is approximately 80% of the displayed value.
* Allowable axial or radial load is the value that satisfies the reducer life when either a radial load or an axial load is applied to the main shaft. (When radial load is Lr+R=0mm, and axial load is La=0mm)

Output bearing and housing tolerances

■ Flexspline fixed

Input: Wave generator
Output: Circular spline
Fixed: Flexspline

Hollow Shaft (2UH) Fig. 235-1



Input shaft (2UJ) Fig. 235-2

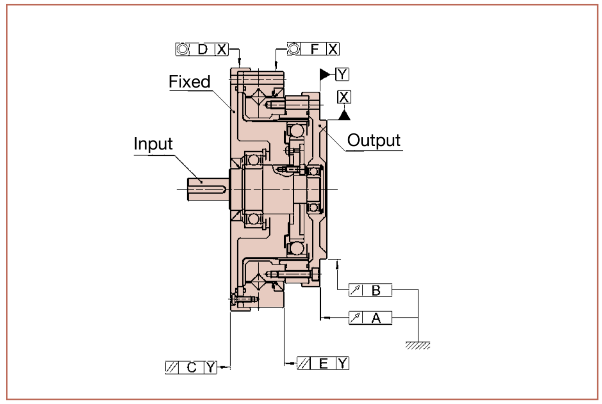


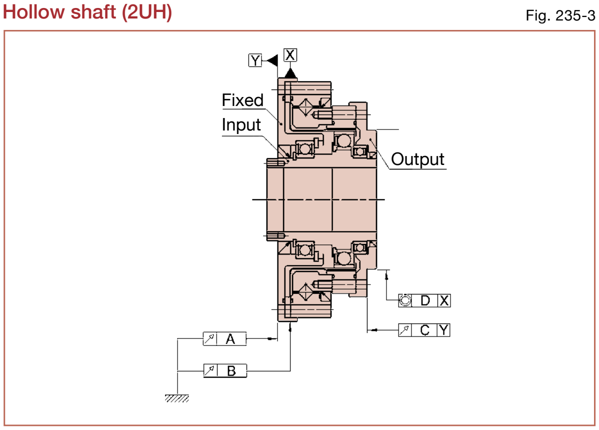
Table 235-1
Unit: mm

Symbol \ Size	11	14	17	20	25	32	40	45	50	58	65
A	0.033	0.033	0.038	0.040	0.046	0.054	0.057	0.057	0.063	0.063	0.067
B	0.035	0.035	0.035	0.039	0.041	0.047	0.050	0.053	0.060	0.063	0.063
C	0.053	0.064	0.071	0.079	0.085	0.104	0.111	0.118	0.121	0.121	0.131
D	0.053	0.053	0.050	0.059	0.061	0.072	0.075	0.078	0.085	0.088	0.089
E	0.039	0.040	0.045	0.051	0.057	0.065	0.071	0.072	0.076	0.076	0.082
F	0.038	0.038	0.038	0.047	0.049	0.054	0.060	0.065	0.067	0.070	0.072

■ Circular spline fixed

Input: Wave generator
Output: Flexspline
Fixed: Circular spline

Hollow shaft (2UH) Fig. 235-3



Input shaft (2UJ) Fig. 235-4

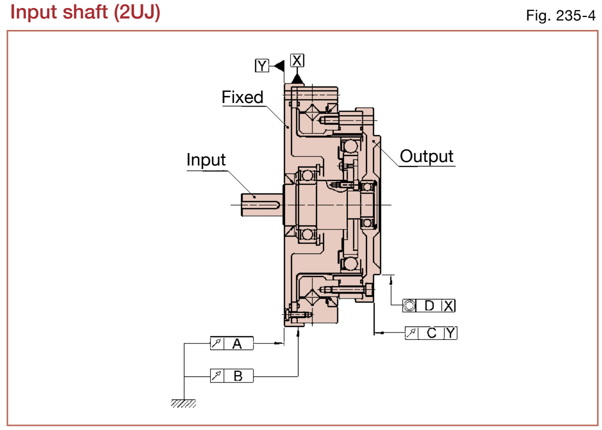


Table 235-2
Unit: mm

Symbol \ Size	11	14	17	20	25	32	40	45	50	58	65
A	0.027	0.037	0.039	0.046	0.047	0.059	0.060	0.070	0.070	0.070	0.076
B	0.031	0.031	0.031	0.038	0.038	0.045	0.048	0.050	0.050	0.050	0.054
C	0.053	0.064	0.071	0.079	0.085	0.104	0.111	0.118	0.121	0.121	0.131
D	0.053	0.053	0.053	0.059	0.061	0.072	0.075	0.078	0.085	0.088	0.089

Rotational direction and reduction ratio

The rotational direction and the reduction ratio vary depending on the flange to be fixed for the unit type.

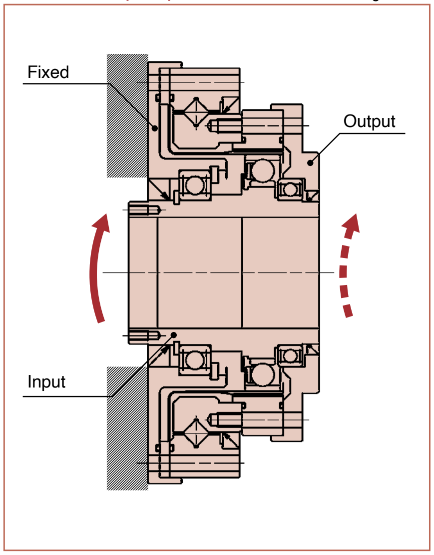
■ Flexspline fixed

Input: Wave generator
Output: Circular spline
Fixed: Flexspline

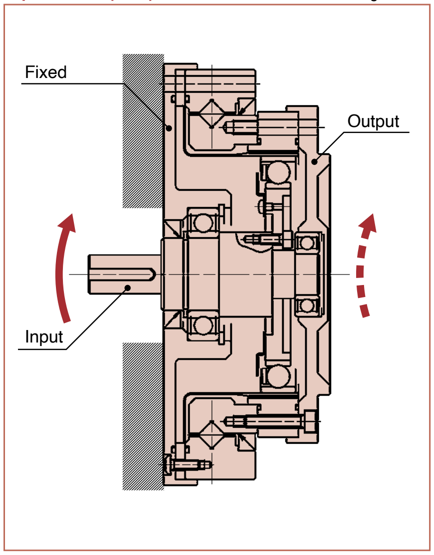
Output rotational direction:
Same rotational direction as the input

Reduction ratio (i): $i = \frac{1}{R+1}$

Hollow shaft (2UH) Fig. 236-1



Input shaft (2UJ) Fig. 236-2



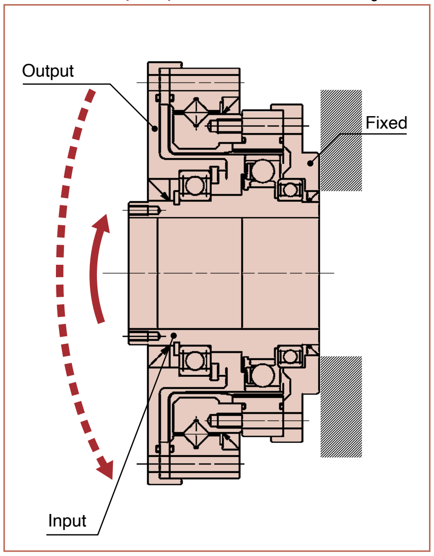
■ Circular spline fixed

Input: Wave generator
Output: Flexspline
Fixed: Circular spline

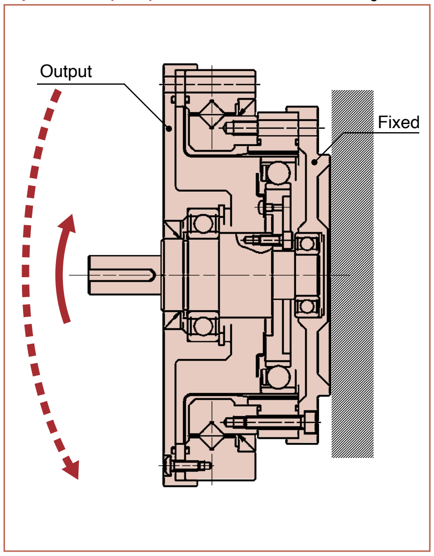
Output rotational direction:
Opposite rotational direction to the input

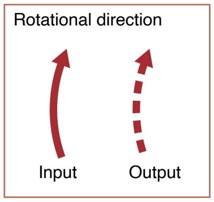
Reduction ratio (i): $i = \frac{-1}{R}$

Hollow shaft (2UH) Fig. 236-3



Input shaft (2UJ) Fig. 236-4





Design Guide

Lubrication

The standard lubricant for Harmonic Drive® gear units is Harmonic Grease SK-1A and SK-2 (Harmonic Grease 4B No.2 for the cross roller bearing). Harmonic Grease 4B No.2 is also available for long-life. The specifications of the grease are described on Page 016.

■ Sealing mechanism

- ● Rotating and sliding area ················ Oil seal (with a spring). Take care regarding flaws on the shaft.
- ● Flange mating face and mating ······ O-ring and seal adhesive. Take care regarding the distortion on the plane and how the O-ring is engaged.
- ● Screw hole area ···························· Use a screw lock agent (LOCTITE 242 is recommended) or seal tape.

(Note) If you use Harmonic Grease 4BNo.2, strict sealing is required.

Rust prevention

Although Harmonic Drive® gears come with some corrosion protection, the gear can rust if exposed to the environment. The gear external surfaces typically have only a temporary corrosion inhibitor and some oil applied. If an anti-rust product is needed, please contact us to review the options.

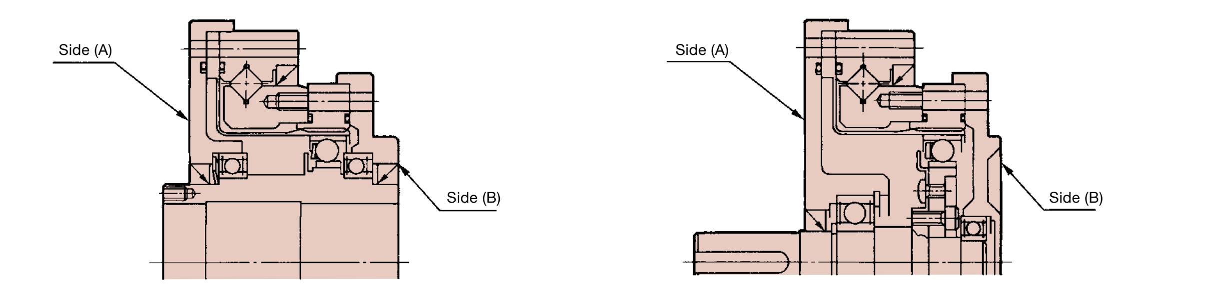
Installation accuracy

For peak performance of the gear, it is essential that the following tolerances be observed when assembly is complete.
Pay careful attention to the following points and maintain the recommended assembly tolerances.
In addition, perform the appropriate installation according to each series, because the torque capacity of SHG series is larger than SHF series.

- Warping and deformation on the mounting surface
- Contamination due to foreign matter
- Burrs, raised surfaces and location around the tap area of the mounting holes
- Insufficient chamfering on the mounting pilot joint
- Insufficient radii on the mounting pilot joint

Installation and transmission torque

Fig. 238-1



SHG series: (A) Side-installation and Torque Transmission Capacity

Table 238-1

Item \ Size		14	17	20	25	32	40	45	50	58	65
Number of bolts		8	12	12	12	12	12	18	12	16	16
Bolt size		M3	M3	M3	M4	M5	M6	M6	M8	M8	M10
Pitch circle	mm	64	74	84	102	132	158	180	200	226	258
Clamp torque	Nm	2.4	2.4	2.4	5.4	10.8	18.4	18.4	44	44	74
Transmission torque	Nm	128	222	252	516	1069	1813	3098	4163	6272	9546

SHF series: (A) Side-installation and Torque Transmission Capacity

Table 238-2

Item \ Size		11	14	17	20	25	32	40	45	50	58
Number of bolts		4	8	12	12	12	12	12	18	12	16
Bolt size		M3	M3	M3	M3	M4	M5	M6	M6	M8	M8
Pitch circle	mm	56.4	64	74	84	102	132	158	180	200	226
Clamp torque	Nm	2.0	2.0	2.0	2.0	4.5	9.0	15.3	15.3	37	37
Transmission torque	Nm	47	108	186	206	431	892	1509	2578	3489	5236

(Table 238-1, 238-2/Notes)
1. The material of the thread must withstand the clamp torque.
2. Recommended bolt: JIS B 1176 socket head cap screw / Strength Range: JIS B 1051 12.9 or more
3. Torque coefficient: K=0.2
4. Clamp coefficient: A=1.4
5. Friction coefficient on the surface contacted: μ=0.15
6. Use washers for SHG/SHF-LW.

SHG series: (B) Side-installation and Torque Transmission Capacity

Table 239-1

Item \ Size		14	17	20	25	32	40	45	50	58	65
Number of bolts		8	16	16	16	16	16	12	16	12	16
Bolt size		M3	M3	M3	M4	M5	M6	M8	M8	M10	M10
Pitch circle	mm	44	54	62	77	100	122	140	154	178	195
Clamp torque	Nm	2.4	2.4	2.4	5.4	10.8	18.36	44	44	89	89
Transmission torque	Nm	88	216	248	520	1080	1867	2914	4274	5927	8658

SHF series: (B) Side-installation and Torque Transmission Capacity

Table 239-2

Item \ Size		11	14	17	20	25	32	40	45	50	58
Number of bolts		6	8	16	16	16	16	16	12	16	12
Bolt size		M3	M3	M3	M3	M4	M5	M6	M8	M8	M10
Pitch circle	mm	37	44	54	62	77	100	122	140	154	178
Clamp torque	Nm	2	2.0	2.0	2.0	4.5	9.0	15.3	37	37	74
Transmission torque	Nm	46	72	176	206	431	902	1558	2440	3587	4910

(Table 239-1, 239-2/Notes)

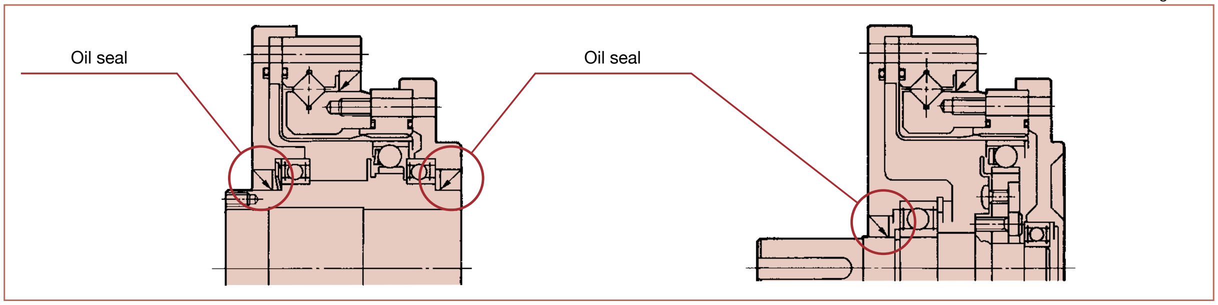
1. The material of the thread must withstand the clamp torque.
2. Recommended bolt: JIS B 1176 hexagonal bolt / Strength: JIS B 1051 12.9 or more
3. Torque coefficient: K=0.2
4. Clamp coefficient A=1.4
5. Friction coefficient on the surface contacted: μ=0.15

Installation Recommendations

Installation on the periphery of the oil seal

Install an oil seal on the mounting face so that they have a space of at least 1 mm between them to avoid interference with each other.

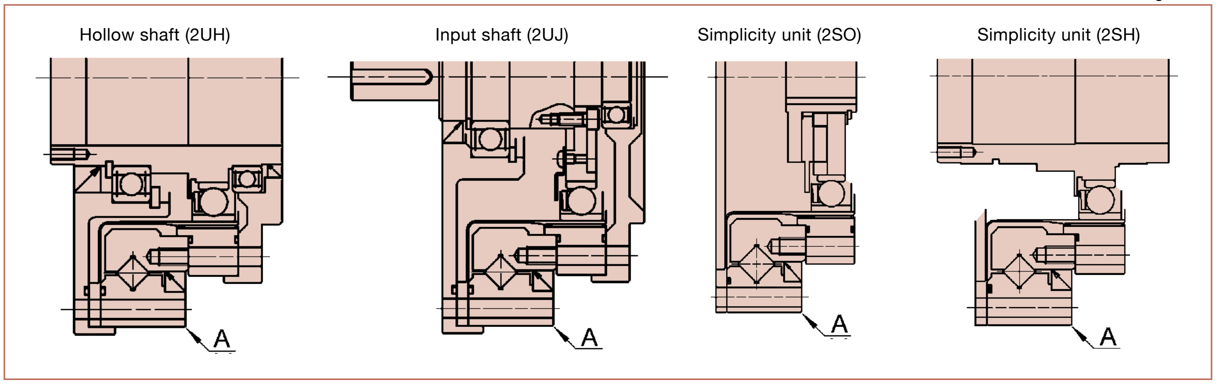
Fig. 240-1



Manufacturing for Mating Part and Housing

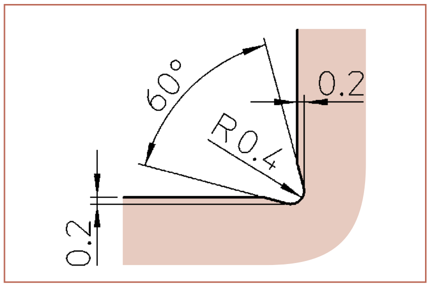
When the housing interferes with corner “A”, an undercut in the housing is recommended as shown below.

Fig. 240-2



Recommended Housing Undercut

Fig. 240-3
Unit: mm

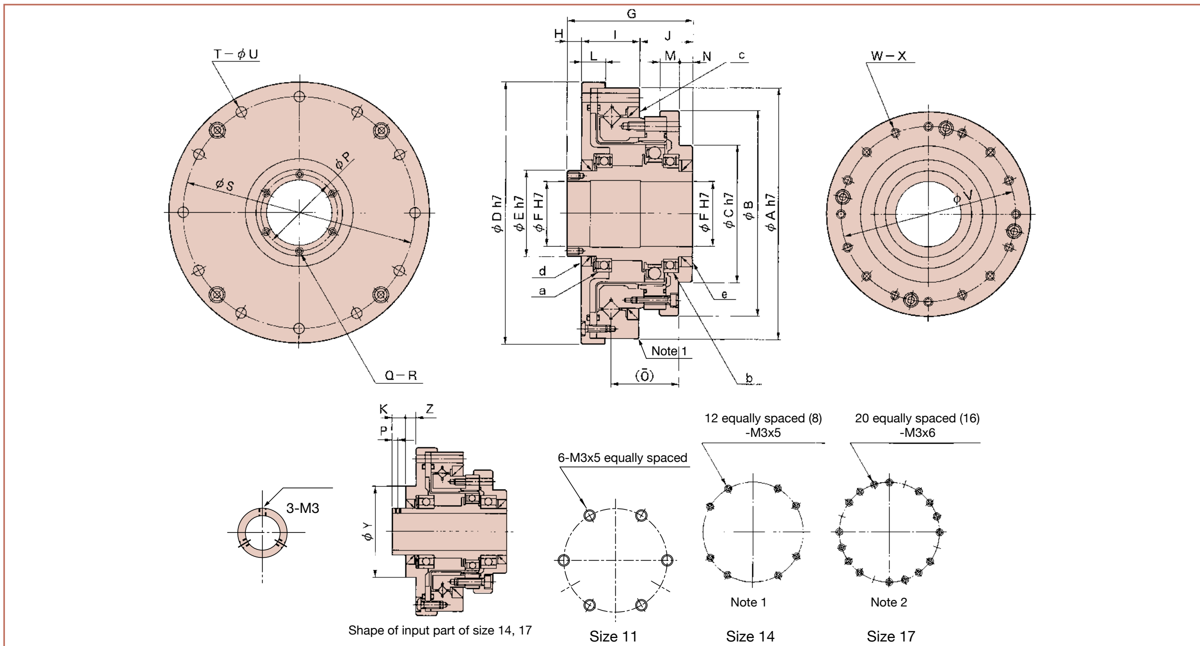


Outline Dimensions (2UH)

Outline dimensions (2UH)

You can download the CAD files from our website: harmonicdrive.net

Fig. 241-1



Note 1: See recommended housing undercut on previous page. 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.

* Please refer to the confirmation drawing for detailed dimensions.

Dimensions (2UH)

Table 241-1

Unit: mm

Symbol	Size	11	14	17	20	25	32	40	45	50	58	65
φA h7		62	70	80	90	110	142	170	190	214	240	276
φB	SHG/SHF Series	45.3	54	64	75	90	115	140	160	175	201	221
	SHG/SHF-LW Series	—	52	62	73	88	115	140	160	168	195	213
φC h7		30.5	36	45	50	60	85	100	120	130	150	160
φD h7		64	74	84	95	115	147	175	195	220	246	284
φE h7		18	20	25	30	38	45	59	64	74	84	96
φF H7		14	14	19	21	29	36	46	52	60	70	80
G		48	52.5	56.5	51.5	55.5	65.5	79	85	93	106	128
H		14	12	12	5	6	7	8	8	9	10	14
I		19	20.5	23	25	26	32	38	42	45	52	56.5
J		15	20	21.5	21.5	23.5	26.5	33	35	39	44	57.5
K		6.5	6.5	6.5	—	—	—	—	—	—	—	—
L		8	9	10	10.5	10.5	12	14	15	16	17	18
M	SHG/SHF Series	6.5	8	8.5	9	8.5	9.5	13	12	12	15	19.5
	SHG/SHF-LW Series	—	11.5	12	13.5	15.5	20.5	25	27	30	35	42.5
N		6.5	7.5	8.5	7	6	5	7	7	7	7	12
O		17.5	21.7	23.9	25.5	29.6	36.4	44	47.5	52.5	62.2	72
φP (P)		—	(2.5)	(2.5)	25.5	33.5	40.5	52	58	67	77	88
Q		—	3	3	6	6	6	6	6	6	8	6
R		—	M3	M3	M3×6	M3×6	M3×6	M4×8	M4×8	M4×8	M4×8	M5×10
φS		56.4	64	74	84	102	132	158	180	200	226	258
T		4	8	12	12	12	12	12	18	12	16	16
φU		3.5	3.5	3.5	3.5	4.5	5.5	6.6	6.6	9	9	11
φV		37	44	54	62	77	100	122	140	154	178	195
W		6	12 E. A. 8	20 E. A. 16	16	16	16	16	12	16	12	16
X	SHG/SHF Series	M3X5	M3×5	M3×6	M3×6	M4×7	M5×8	M6×10	M8×10	M8×11	M10×15	M10×15
		φ3.4X4	φ3.5×11.5	φ3.5×12	φ3.5×13.5	φ4.5×15.5	φ5.5×20.5	φ6.6×25	φ9×28	φ9×30	φ11×35	φ11×42.5
	SHG/SHF-LW Series	—	M3×5	M3×6	M3×6	M4×7	M5×8	M6×10	M8×10	M8×11	M10×15	M10×15
		—	φ3.5×11.5	φ3.5×12	φ3.5×13.5	φ4.5×15.5	φ5.5×20.5	φ6.6×25	φ9×27	φ9×30	φ11×35	φ11×42.5
φY		36	36	45	—	—	—	—	—	—	—	—
Z		7.5	5.5	5.5	—	—	—	—	—	—	—	—
a		6804 ZZ	6804 ZZ	6805 ZZ	6806 ZZ	6808 ZZ	6909 ZZ	6912 ZZ	6913 ZZ	6915 ZZ	6917 ZZ	6920 ZZ
b	SHG/SHF Series	6704 ZZ	6804 ZZ	6805 ZZ	6806 ZZ	6808 ZZ	6809 ZZ	6812 ZZ	6813 ZZ	6815 ZZ	6817 ZZ	6820 ZZ
	SHG/SHF-LW Series	—	6804 ZZ	6805 ZZ	6806 ZZ	6808 ZZ	6809 ZZ	6812 ZZ	6813 ZZ	6815 ZZ	6817 ZZ	6820 ZZ
c		D41.950.95	D49585	D59685	D69785	D84945	D1101226	D1321467	D1521707	D1681868	D1932129	D21623811
d	SHG/SHF Series	S18274	S20304.5	S25356	S30405	S38475	S45607	S60789	S658510	S759510	S8511012	S10012513
	SHG/SHF-LW Series	—	S20304.5	S25356	S30405	S38475	S45607	S60789	S658510	S759510	S8511012	S10012513
e	SHG/SHF Series	S18274	S20304.5	S25356	S30405	S38475	S45555	S59685	S59685	S69785	S84945	S961128
	SHG/SHF-LW Series	—	S20304.5	S25356	S30405	S38475	S45555	S59685	S59685	S69785	S84945	S961128

Gear Unit SHG/SHF

Mass (2UH)

Table 242-1
Unit: kg

Symbol \ Size	11	14	17	20	25	32	40	45	50	58	65
2UH	0.53	0.71	1.00	1.38	2.1	4.5	7.7	10.0	14.5	20.0	28.5
2UH-LW (Lightweight)	—	0.55	0.8	1.1	1.6	3.6	6.2	8	11.8	16.4	23.3

Moment of Inertia (2UH)

Table 242-2

Symbol \ Size			11	14	17	20	25	32	40	45	50	58	65
Moment of inertia	I	$\times10^{-4}$kgm^2	0.080	0.091	0.193	0.404	1.070	2.85	9.28	13.8	25.2	49.5	94.1
	J	$\times10^{-5}$kgfms^2	0.082	0.093	0.197	0.412	1.090	2.91	9.47	14.1	25.7	50.5	96.0

Starting torque (2UH)

See "Engineering data" for a description of terms. Please use as reference values; the values vary based on use conditions.

Table 242-3
Unit: Ncm

Ratio \ Size	11	14	17	20	25	32	40	45	50	58	65
30	—	11	30	43	64	112	—	—	—	—	—
50	7.1	8.8	27	36	56	85	136	165	216	297	—
80	—	7.5	25	33	50	74	117	138	179	244	314
100	5.9	6.9	24	32	49	72	112	131	171	231	297
120	—	—	24	31	48	68	110	126	165	223	287
160	—	—	—	31	47	67	105	122	156	213	276

Backdriving torque (2UH)

See "Engineering data" for a description of terms. Please use as reference values; the values vary based on use conditions.

Table 242-4
Unit: Nm

Ratio \ Size	11	14	17	20	25	32	40	45	50	58	65
30	—	5.4	17	23	35	57	—	—	—	—	—
50	4.6	5.3	16	22	34	51	82	99	129	178	—
80	—	7.2	24	31	48	70	112	133	172	234	301
100	7.6	8.2	29	38	59	86	134	158	205	278	356
120	—	—	34	45	69	97	158	182	237	322	413
160	—	—	—	59	90	128	201	233	299	408	530

No-load running torque

No-load running torque is the torque which is required to rotate the input side (high speed side), when there is no load on the output side (low speed side).

Measurement condition

Table 242-5

Ratio			
Lubricant	Grease lubrication	Name	Harmonic Grease SK-1A
			Harmonic Grease SK-2
		Quantity	Recommended quantity
Torque value is measured after 2 hours at 2000rpm input.			

■ Compensation Value in Each Ratio

No-load running torque of the gear varies with ratio.
The graphs indicate a value for ratio 100.
For other gear ratios, add the compensation values from table on the right. (Table 242-6).

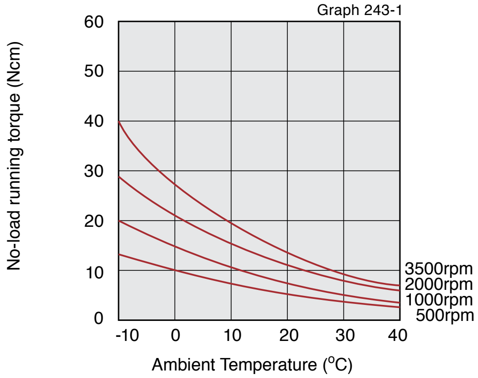
No-Load Torque Compensation

Table 242-6
Unit: Ncm

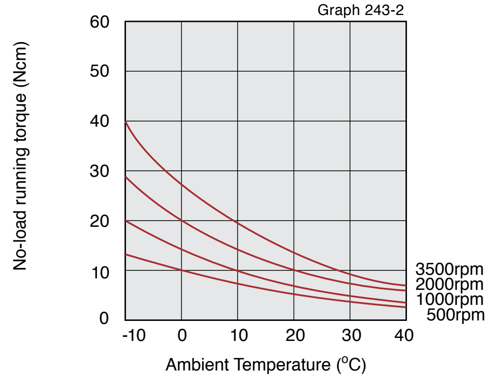
Size \ Ratio	30	50	80	120	160
11	—	+0.5	—	—	—
14	+2.6	+1.1	+0.2	—	—
17	+4.1	+1.8	+0.4	-0.2	—
20	+5.9	+2.6	+0.5	-0.4	-0.8
25	+9.6	+4.2	+0.8	-0.6	-1.3
32	+18.3	+8.0	+1.5	-1.1	-2.5
40	—	+13.3	+2.4	-1.7	-4.0
45	—	+18.2	+3.3	-2.4	-5.5
50	—	+23.9	+4.3	-3.1	-7.2
58	—	+34.6	+6.2	-4.4	-10.3
65	—	—	+8.1	-5.8	-13.7

■ No-load running torque (2UH)

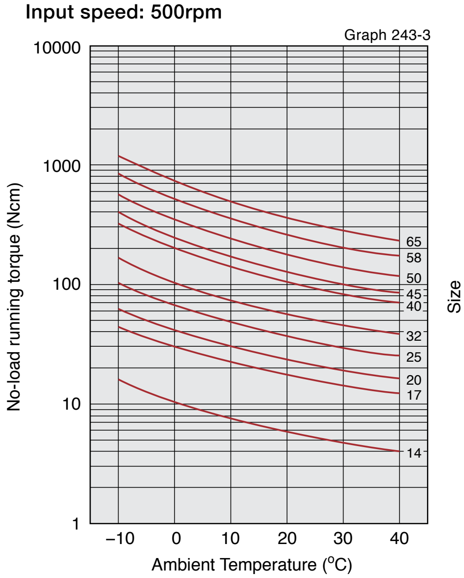
SHF-11 Ratio: 50



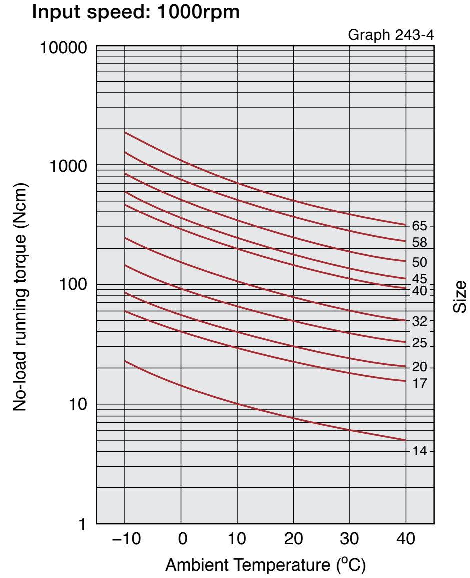
SHF-11 Ratio: 100



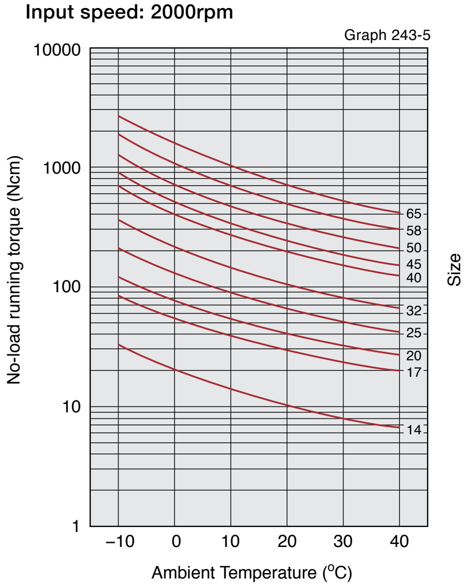
SHG/SHF-14 to 65 Ratio: 100
Input speed: 500rpm



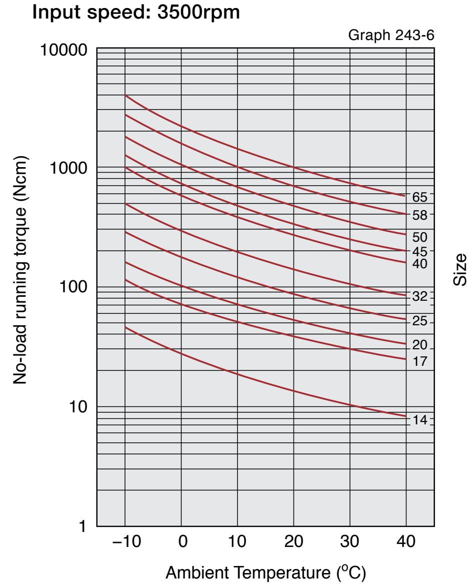
SHG/SHF-14 to 65 Ratio: 100
Input speed: 1000rpm



SHG/SHF-14 to 65 Ratio: 100
Input speed: 2000rpm



SHG/SHF-14 to 65 Ratio: 100
Input speed: 3500rpm



*The values in this graph are average values ($\bar{X}$). σ≈20%

Efficiency (2UH)

The efficiency varies depending on the following conditions.

- Reduction ratio
- Input rotational speed
- Load torque
- Temperature
- Lubrication (Type and quantity)

Measurement condition

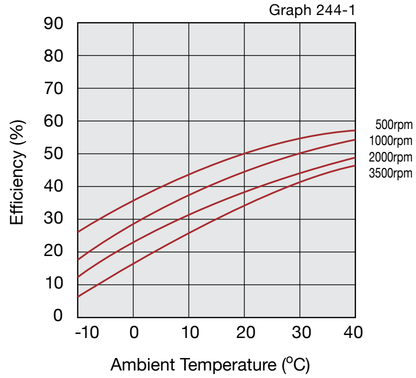
Table 244-1

Installation	Based on recommended tolerance		
Load torque	The rated torque shown in the rating table (see page 230 and 231)		
Lubricant	Grease lubrication	Name	Harmonic Grease SK-1A
			Harmonic Grease SK-2
		Quantity	Recommended quantity

Efficiency at rated torque

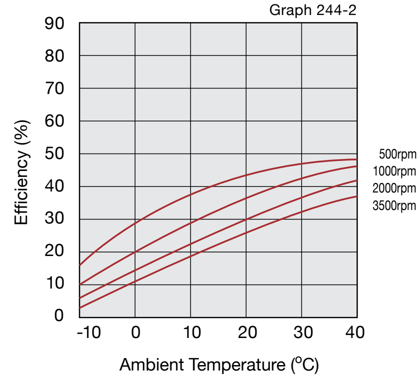
SHF-11 Ratio 50

Graph 244-1



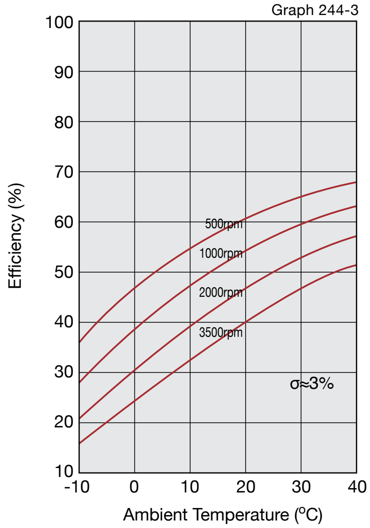
SHF-11 Ratio 100

Graph 244-2



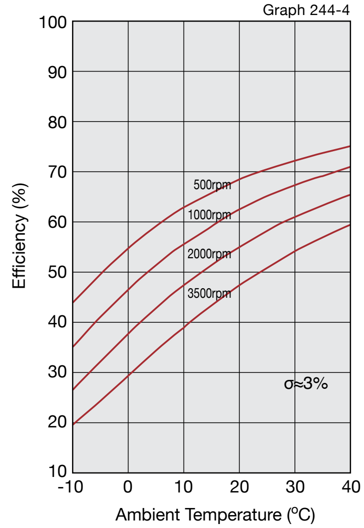
SHG/SHF-14 to 65 Ratio 30

Graph 244-3



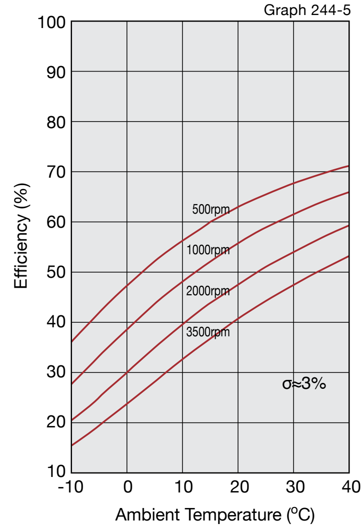
SHG/SHF-14 to 65 Ratio 50, 80, 100, 120

Graph 244-4



SHG/SHF-14 to 65 Ratio 160

Graph 244-5



*The values in this graph are average values ($\bar{X}$). σ≈20%

Efficiency compensation coefficient and compensation amount

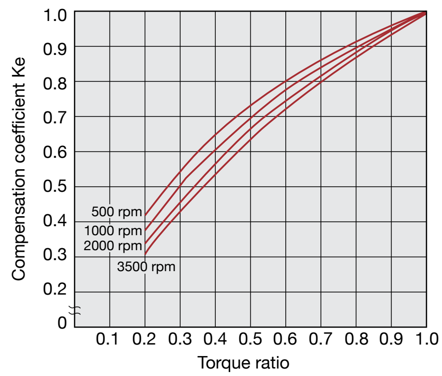
Efficiency compensation coefficient by load torque

When the load torque is lower than the rated torque, the efficiency value decreases. Calculate the compensation coefficient Ke from Graphs 245-1 and 245-2.

* When the load torque is higher than the rated torque, efficiency compensation value Ke is 1.

Efficiency compensation 2UH

Graph 245-1

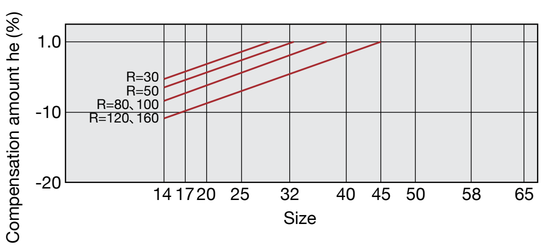


Efficiency compensation amount by size

The unit type is equipped with a supporting bearing and oil seal on the input side. The degree of impact varies depending on the size. Calculate the compensation amount for efficiency at the rated torque using the size from Graph 245-2.

Efficiency compensation 2UH

Graph 245-2



Efficiency compensation calculation formula

Calculate the efficiency by the "Efficiency compensation coefficient by load torque" and the "Efficiency compensation amount by the size" from the following formula.

Calculation formula

Formula 245-1

$$\text{Efficiency } \eta = Ke \times (\eta_R + \eta e)$$

Symbols of the calculation formula

Table 245-1

η	Efficiency	――――――
Ke	Efficiency compensation coefficient	See Graph 245-1.
ηR	Efficiency at the rated torque	See Graph 244-1 through 244-5.
ηe	Efficiency compensation amount	See Graph 245-2.

Continuous Operating Time (2UH)

The internal temperature rises due to the effect of the oil seal and the supporting bearing used for the input shaft (high-speed rotation side) for SHF-2UH. Observe the operating time shown in Table 246-2 for continuous operation.
The operating time shown in Table 246-2 is calculated based on the time required for the temperature inside the unit to rise to 80ºC and for the oil seal temperature to rise to 100ºC. Take care not to exceed the temperature given above in conducting continuous operation. The following review will be necessary if the temperature exceeds the value given above. Contact us in such an event.

- Change of timing to replace lubricant
- Change of lubricant
- Measures against lubricant leakage accompanied by the pressure rise inside the unit
- Measures against deterioration due to heat on the oil seal area

Setting condition

Table 246-1

Operating temp.	25ºC (ambient)
Input rotational speed	2,000 rpm
Installation of the unit	Fix the flexspline. Output on the circular spline.

Continuous operating time

Table246-2

Size \ Operating time	Continuous operating time at no-load operation (min)	Continuous operating time at the rated load (min)
11	90	60
14	90	60
17	90	60
20	90	60
25	60	45
32	45	35
40	40	30
45	35	25
50	30	20
58	20	15
65	15	10

* Contact us as the continuous operating time may vary significantly depending on the operating condition.

Performance Data for the Input Bearing for Hollow Shaft (2UH)

The Hollow Shaft incorporated in the SHF-2UH unit is supported by two deep groove single row ball bearings. For peak performance of the SHF-2UH it is essential that the following specifications for input bearing be observed. the input part to fully bring out the performance of the unit type. Figure 247-1 shows shows the points of application of forces. See Table 247-1 for the size of (a) and (b). Graphs 247-1 and 247-2 show the relation between the maximum allowable radial and axial loads.
The values in Graph 247-1 and 247-2 are those assuming that the average input rotational speed is 2,000 rpm and the basic rated life, L10, is 7,000 hours.

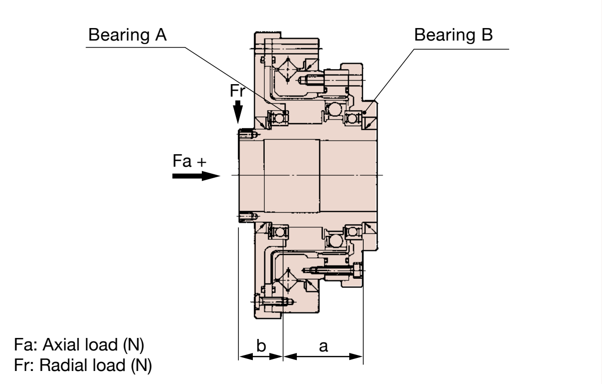
Example: If the hollow shaft of a SHF-40-2UH unit is subjected to an axial load of 500 N. The maximum allowable radial force will be 400 N.

Input bearing specifications

Table 247-1

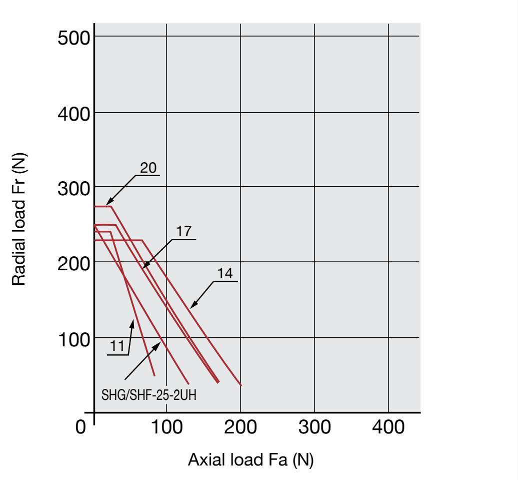
Size	Bearing A			Bearing B			a	b	Maximum radial load
	Model	Basic dynamic rated load	Basic static rated load	Model	Basic dynamic rated load	Basic static rated load			
		Cr (N)	Cor (N)		Cr (N)	Cor (N)	(mm)	(mm)	Fr (N)
11	6804ZZ	4000	2470	6704ZZ	1400	720	25.7	15.5	—
14	6804ZZ	4000	2470	6804ZZ	4000	2470	27	16.5	230
17	6805ZZ	4300	2950	6805ZZ	4300	2950	29	17.5	250
20	6806ZZ	4500	3450	6806ZZ	4500	3450	27	15.5	275
25	6808ZZ	4900	4350	6808ZZ	4900	4350	29.5	16.5	250
32	6909ZZ	14100	10900	6809ZZ	5350	5250	33	23	770
40	6912ZZ	14300	16400	6812ZZ	11500	10900	39.5	27.5	1060
45	6913ZZ	17400	16100	6813ZZ	11900	12100	44	28.5	900
50	6915ZZ	24400	22600	6815ZZ	12500	13900	49	31.5	1370
58	6917ZZ	32000	29600	6817ZZ	18700	20000	56.2	36.5	1720
65	6920ZZ	42500	36500	6820ZZ	19600	21200	67	44.5	2300

Fig 247-1



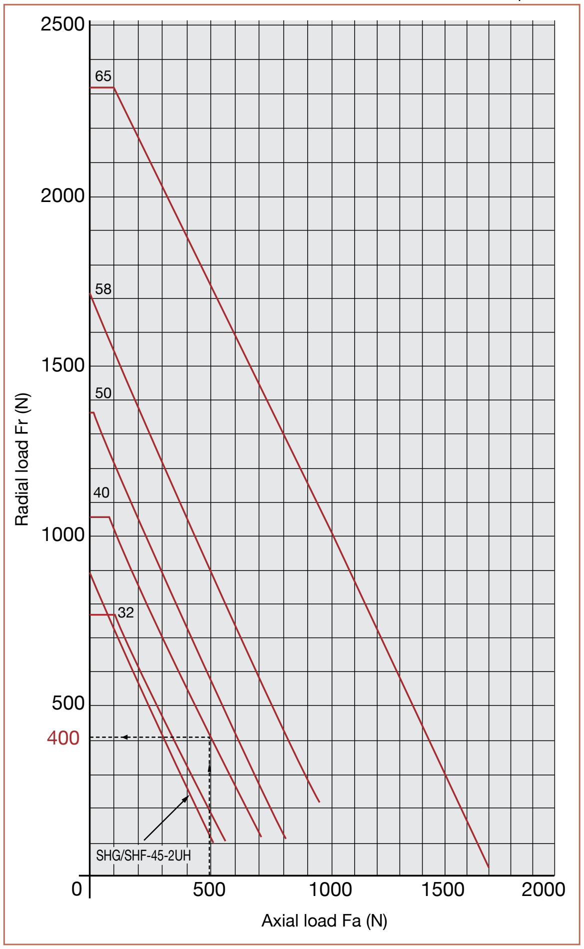
Size 11 to 25

Graph 247-1



Size 32 to 65

Graph 247-2

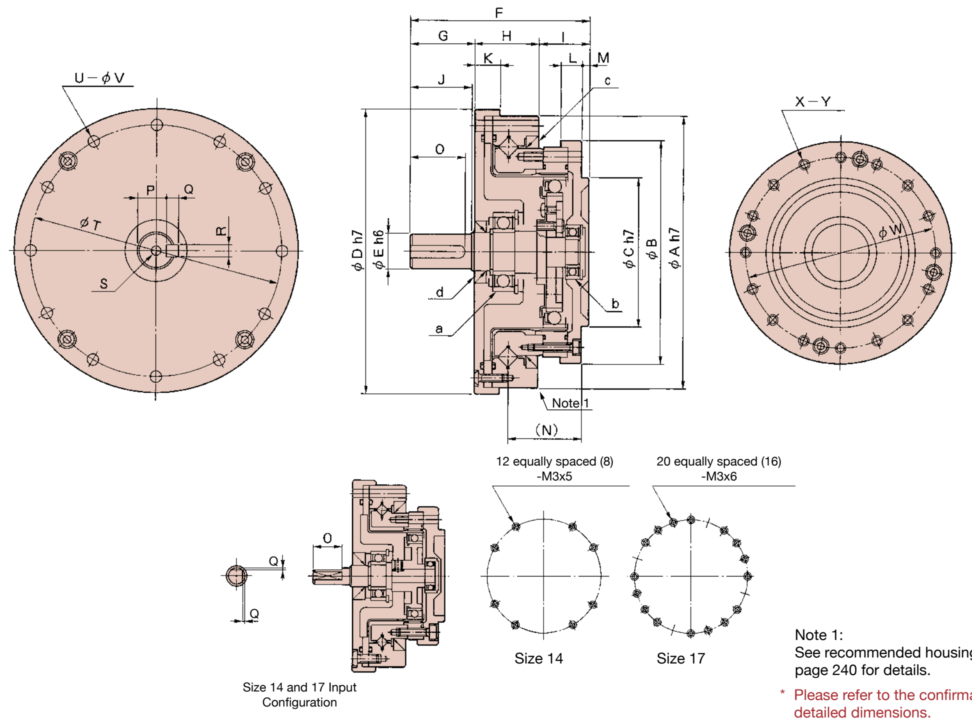


Outline Dimensions (2UJ)

Outline Dimensions (2UJ)

You can download the CAD files from our website: harmonicdrive.net

Fig. 248-1



Note 1:
See recommended housing undercut on page 240 for details.

* Please refer to the confirmation drawing for detailed dimensions.

Dimensions (2UJ)

Table 248-1

Unit: mm

Symbol \ Size	14	17	20	25	32	40	45	50	58	65
ϕA h7	70	80	90	110	142	170	190	214	240	276
ϕB	54	64	75	90	115	140	160	175	201	221
ϕC h7	36	45	50	60	85	100	120	130	150	160
ϕD h7	74	84	95	115	147	175	195	220	246	284
ϕE h6	6	8	10	14	14	16	19	22	22	25
F	50.5	56	63.5	72.5	84.5	100	108	121	133	156
G	15	17	21	26	26	31	31	37	37	42
H	20.5	23	25	26	32	38	42	45	52	56.5
I	15	16	17.5	20.5	26.5	31	35	39	44	57.5
J	14	16	20	25	25	30	30	35	35	40
K	9	10	10.5	10.5	12	14	15	16	17	18
L	8	8.5	9	8.5	9.5	13	12	12	15	19.5
M	2.5	3	3	3	5	5	7	7	7	12
N	21.7	23.9	25.5	29.6	36.4	44	47.5	52.5	62.2	72
O	11	12	16.5	22.5	22.5	27.5	28	33	33	39
P	—	—	$8.2^{0}_{-0.1}$	$11^{0}_{-0.1}$	$11^{0}_{-0.1}$	$13^{0}_{-0.1}$	$15.5^{0}_{-0.1}$	$18.5^{0}_{-0.1}$	$18.5^{0}_{-0.1}$	$21^{0}_{-0.1}$
Q	0.5	0.5	$3^{0}_{-0.025}$	$5^{0}_{-0.030}$	$5^{0}_{-0.030}$	$5^{0}_{-0.030}$	$6^{0}_{-0.030}$	$6^{0}_{-0.030}$	$6^{0}_{-0.030}$	$7^{0}_{-0.036}$
R	—	—	$3^{0}_{-0.025}$	$5^{0}_{-0.030}$	$5^{0}_{-0.030}$	$5^{0}_{-0.030}$	$6^{0}_{-0.030}$	$6^{0}_{-0.030}$	$6^{0}_{-0.030}$	$8^{0}_{-0.036}$
S	—	—	M3×6	M5×10	M5×10	M5×10	M6×12	M6×12	M6×12	M8×16
ϕT	64	74	84	102	132	158	180	200	226	258
U	8	12	12	12	12	12	18	12	16	16
ϕV	3.5	3.5	3.5	4.5	5.5	6.6	6.6	9	9	11
ϕW	44	54	62	77	100	122	140	154	178	195
X	12 E. A. 8	20 E. A. 16	16	16	16	16	12	16	12	16
Y	M3×5 ϕ3.5×11.5	M3×6 ϕ3.5×12	M3×6 ϕ3.5×13.5	M4×7 ϕ4.5×15.5	M5×8 ϕ5.5×20.5	M6×10 ϕ6.6×25	M8×10 ϕ9×28	M8×11 ϕ9×30	M10×15 ϕ11×35	M10×15 ϕ11×42.5
a	698 ZZ	6900 ZZ	6902 ZZ	6002 ZZ	6004 ZZ	6006 ZZ	6206 ZZ	6207 ZZ	6208 ZZ	6209 ZZ
b	695 ZZ	697 ZZ	698 ZZ	6900 ZZ	6902 ZZ	6003 ZZ	6004 ZZ	6005 ZZ	6006 ZZ	6007 ZZ
c	D49585	D59685	D69785	D84945	D1101226	D1321467	D1521707	D1681868	D1932129	D21623811
d	G8184	D10205	D15255	D15255	D20355	D30457	D30457	D35557	D40607	D45607

Mass (2UJ)

Table 249-1
Unit: kg

Symbol \ Size	14	17	20	25	32	40	45	50	58	65
Mass (kg)	0.66	0.94	1.38	2.1	4.4	7.3	9.8	13.9	19.4	26.5

Moment of Inertia (2UJ)

Table 249-2

Symbol \ Size			14	17	20	25	32	40	45	50	58	65
Moment of inertia	I	$\times 10^{-4}$kgm^2	0.025	0.059	0.137	0.320	1.20	3.41	5.80	9.95	20.5	35.5
	J	$\times 10^{-5}$kgfms^2	0.026	0.060	0.140	0.327	1.22	3.48	5.92	10.2	20.9	36.2

Starting torque (2UJ)

See "Engineering data" for a description of terms. Please use as reference values; the values vary based on use conditions.

Table 249-3
Unit: Ncm

Ratio \ Size	14	17	20	25	32	40	45	50	58	65
30	6.8	11	19	26	63	—	—	—	—	—
50	5.7	9.7	14	22	41	72	94	125	178	—
80	4.4	7.2	11	15	29	52	68	88	125	163
100	3.7	6.5	9.9	14	27	47	60	80	113	147
120	—	6.2	9.3	13	24	44	55	74	105	137
160	—	—	8.6	12	23	39	50	66	94	122

Backdriving torque (2UJ)

See "Engineering data" for a description of terms. Please use as reference values; the values vary based on use conditions.

Table 249-4
Unit: Nm

Ratio \ Size	14	17	20	25	32	40	45	50	58	65
30	3.5	5.9	10	16	31	—	—	—	—	—
50	3.4	5.8	8.4	13	25	43	56	75	107	—
80	4.2	6.9	10	15	28	50	65	85	120	154
100	4.5	7.8	12	17	33	56	72	96	135	176
120	—	8.9	13	19	34	63	79	106	151	198
160	—	—	17	23	43	75	96	126	181	235

No-load running torque (2UJ)

No-load running torque is the torque which is required to rotate the input side (high speed side), when there is no load on the output side (low speed side).

Measurement condition Table 250-1

Ratio 100			
Lubricant	Grease lubrication	Name	Harmonic Grease SK-1A
			Harmonic Grease SK-2
		Quantity	Recommended quantity
Torque value is measured after 2 hours at 2000rpm input.			

■ Compensation Value in Each Ratio

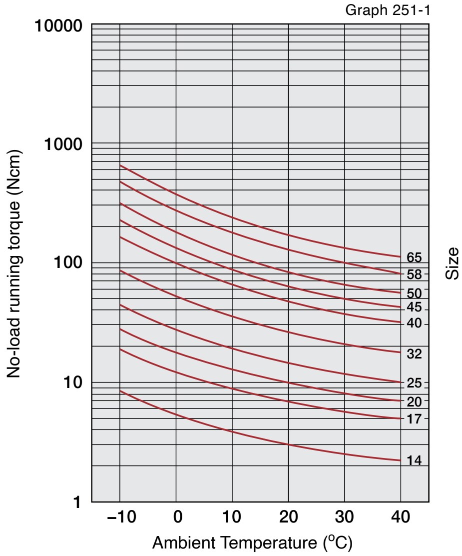
No-load running torque of the gear varies with ratio. Graphs 251-1 to 251-4 show the values for a reduction ratio of 100. For other gear ratios, add the compensation values in the right-hand table (Table 250-2).

No-Load Torque Running Torque Compensation Value Table 250-2 Unit: Ncm

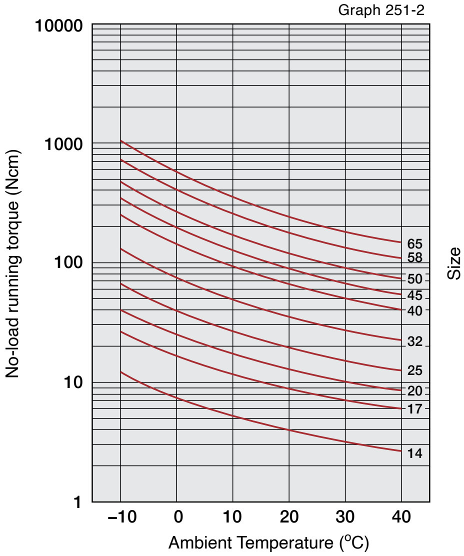
Size \ Ratio	30	50	80	120	160
14	+2.6	+1.1	+0.2	—	—
17	+4.1	+1.8	+0.4	-0.2	—
20	+5.9	+2.6	+0.5	-0.4	-0.8
25	+9.6	+4.2	+0.8	-0.6	-1.3
32	+18.3	+8.0	+1.5	-1.1	-2.5
40	—	+13.3	+2.4	-1.7	-4.0
45	—	+18.2	+3.3	-2.4	-5.5
50	—	+23.9	+4.3	-3.1	-7.2
58	—	+34.6	+6.2	-4.4	-10.3
65	—	—	+8.1	-5.8	-13.7

■ **No-load running torque for a reduction ratio of 100:1 (2UJ)**

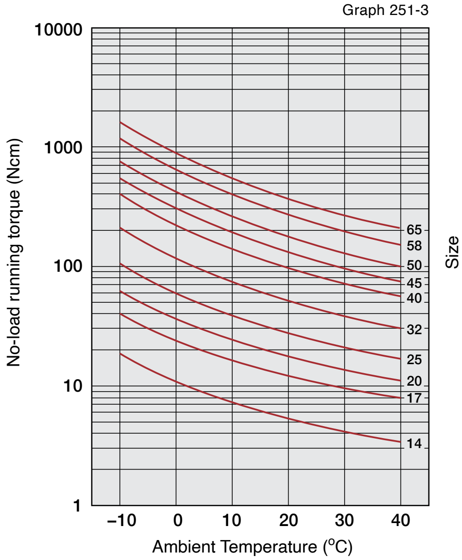
Input speed: 500rpm



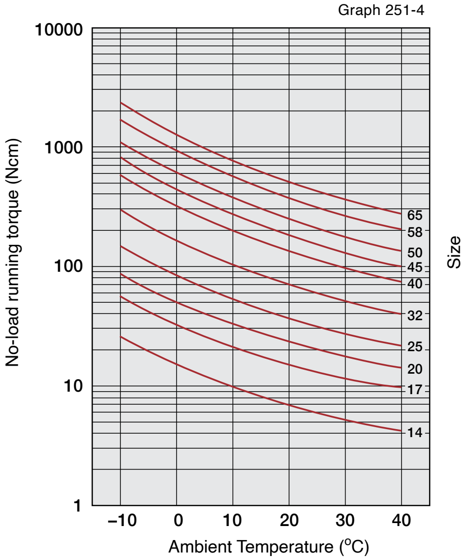
Input speed: 1000rpm



Input speed: 2000rpm



Input speed: 3500rpm



*The values in this graph are average values (X). σ≈20%

Efficiency (2UJ)

The efficiency varies depending on the following conditions.

- Reduction ratio
- Input rotational speed
- Load torque
- Temperature
- Lubrication (Type and quantity)

Measurement condition

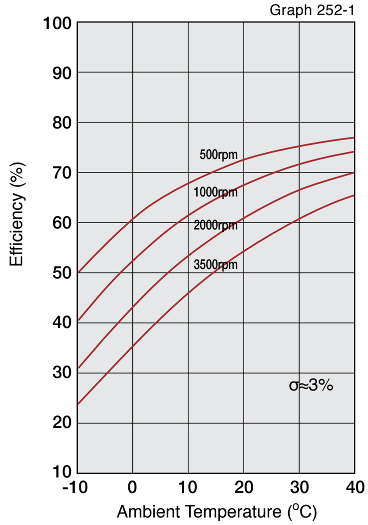
Table 252-1

Installation	Based on recommended tolerance		
Load torque	The rated torque shown in the rating table (see page 230 and 231)		
Lubricant	Grease lubrication	Name	Harmonic Grease SK-1A
			Harmonic Grease SK-2
		Quantity	Recommended quantity

Efficiency at rated torque

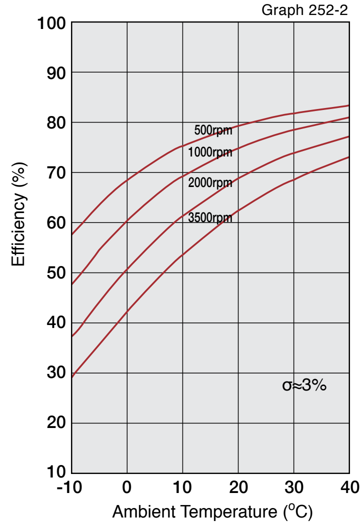
Ratio 30

Graph 252-1



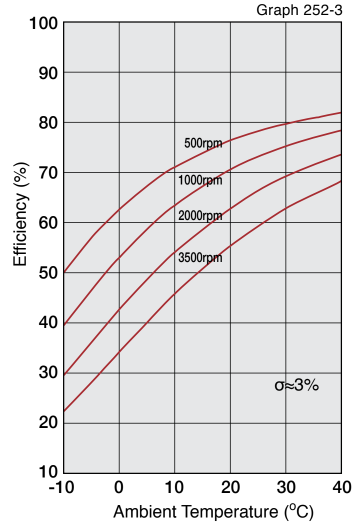
Ratio 50, 80, 100, 120

Graph 252-2



Ratio 160

Graph 252-3



■ Efficiency compensation coefficient and efficiency compensation amount

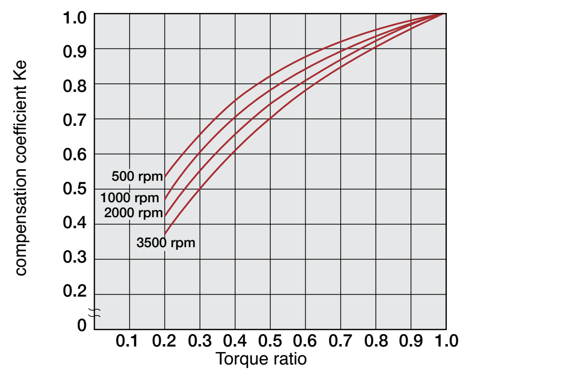
Efficiency compensation coefficient by load torque

When the load torque is lower than the rated torque, the efficiency value decreases. Calculate compensation coefficient Ke from Graph 253-1.

* When the load torque is higher than the rated torque, efficiency compensation value Ke is 1.

Efficiency compensation coefficient of 2UJ (input shaft)

Graph 253-1

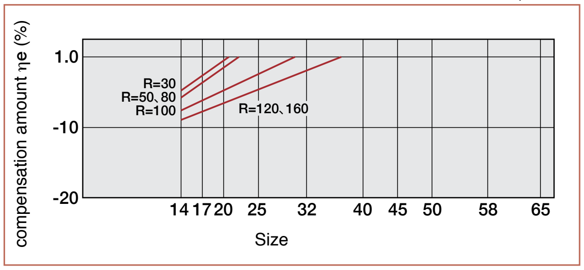


Efficiency compensation amount by the size

The unit type is equipped with a supporting bearing and oil seal on the input side. The degree of impact varies depending on the size. Calculate the compensation amount “ηe” for efficiency at the rated torque using the size from Graph 253-2.

Efficiency compensation of 2UJ (input shaft)

Graph 253-2



Efficiency compensation calculation formula

Calculate the efficiency by the "Efficiency compensation coefficient by load torque" and the "Efficiency compensation amount by the size" from the following formula.

Calculation formula

Formula 253-1

Efficiency $\eta = Ke \times (\eta_R + \eta e)$

Symbols for the calculation formula

Table 253-1

η	Efficiency	––––––
Ke	Efficiency compensation coefficient	See Graph 253-1.
ηR	Efficiency at the rated torque	See Graph 252-1 through 252-3.
ηe	Efficiency compensation amount	See Graph 253-2.

Lubrication

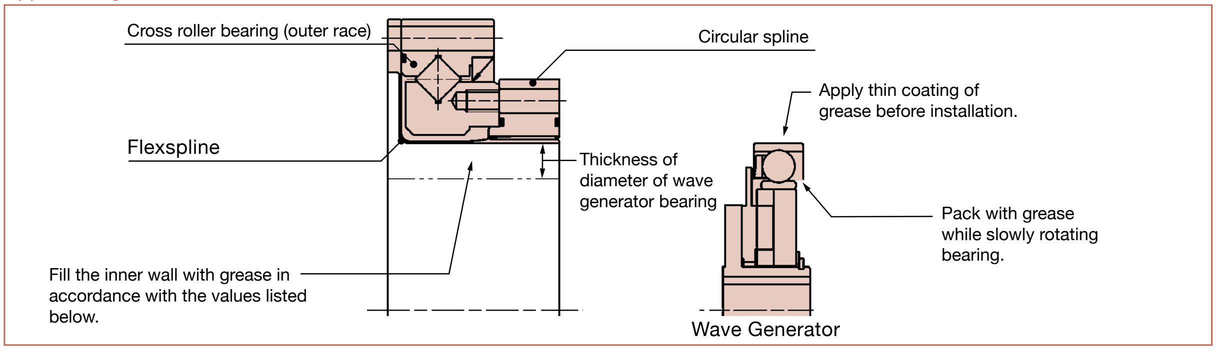
Standard lubrication for SHG/SHF series is grease.
See "Engineering data" on Page 016 for details of the lubricant.

Application guide

As the gear unit is shipped with the outer race of the cross roller bearing and the flexspline temporarily bolted together, grease is not applied other than the gear teeth. Refer to the following application guide for grease application instructions

Application guide

Table 259-1



Application quantity

Table 259-2
Unit: g

Application \ Size		14	17	20	25	32	40	45	50	58	65
Horizontal use		5.8	11	18	32	64	120	185	235	385	495
Vertical use	Output shaft facing up	7.5	13	19	37	74	130	200	255	400	530
	Output shaft facing down	8.9	15	22	42	84	150	230	290	480	630

When to replace grease

The wear characteristics of the gear are strongly influenced by the condition of the grease lubrication. The condition of the grease is affected by the ambient temperature. The graph shows the maximum number of input rotations for various temperatures. This graph applies to applications where the average load torque does not exceed the rated torque.

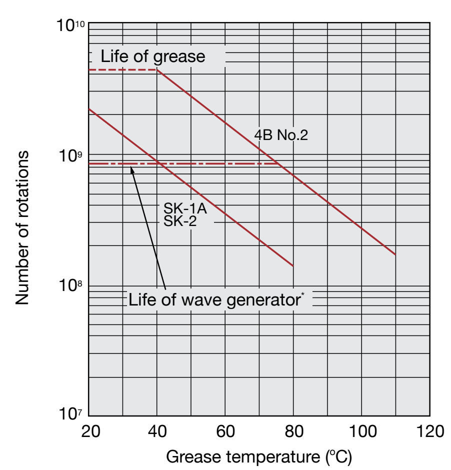
Formula when average load torque exceeds rated torque

Formula 259-1

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

When to replace grease: L_{GTn} (when the average load torque is equal to or less than the rated torque)

Graph 259-2



* Life of wave generator is based on L10 life of the bearing.

Calculation formula

Table 259-3

L_{GT}	Replacement timing if average load torque exceeds rated torque	Number of input revolutions	–––––
L_{GTn}	Replacement timing if average load torque is equal to or less than rated torque (or use formulas, i.e. Tav ≤ Tr)	Number of input revolutions	See Fig. 259-2.
Tr	Rated torque	Nm	See the "Rating table" on page 230 and 231.
Tav	Average load torque	Nm	Calculation formula: See Page 14.

■ Other precautions

1. Avoid using it with other grease. The gear should be in an individual case when installed.
2. If you use the gear with the wave generator facing upward (see Figure 050-2 on Page 50) at low-speed rotation (input rotational speed: 1000 rpm or less) and in one direction, please contact us as it may cause lubrication problems.
3. Fill the gap between the wave generator and the input cover (motor flange) with grease to use the wave generator facing upward or downward (see Figure 094-2 on Page 094).

Performance Data for the Input bearing (2UJ)

The input shaft of the 2UJ is supported by two single-row deep-groove bearings. For peak performance of the SHF-2UJ it is essential that the following Specification for Input Bearing be observed -
Figure 254-1 shows the points of application of forces. See Table 254-1 for the dimensions (a) and (b). Graphs 254-1 and 254-2 show the Maximum Allowable Radial and Axial Loads.
The values in Graph 254-1 and 254-2 are based on an average input speed of 2,000 rpm and a mean bearing life of L10=7,000h.

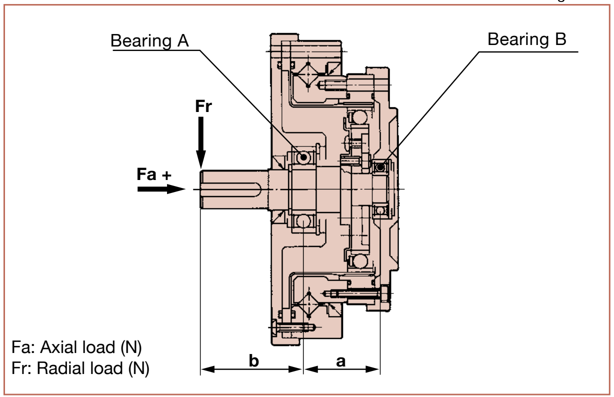
Example: If the input shaft of a SHF-40-2UJ unit is subjected to an axial load (Fa) of 500 N. The maximum allowable radial force will be 400 N.

Input bearing specifications

Table 254-1

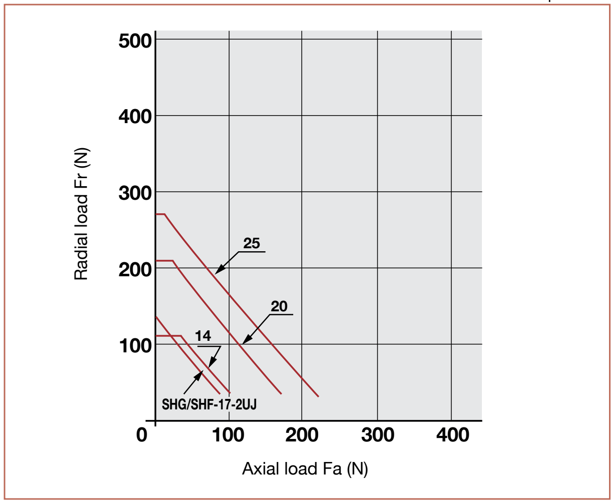
Size	Bearing A			Bearing B			a	b	Maximum radial load
	Model	Basic dynamic rated load	Basic static rated load	Model	Basic dynamic rated load	Basic static rated load			
		Cr (N)	Cor (N)		Cr (N)	Cor (N)	(mm)	(mm)	Fr (N)
14	698ZZ	2240	910	695ZZ	1080	430	20	14	110
17	6900ZZ	2700	1270	697ZZ	1610	710	23.5	21	135
20	6902ZZ	4350	2260	698ZZ	2240	910	26.5	23.3	210
25	6002ZZ	5600	2830	6900ZZ	2700	1270	28	28	270
32	6004ZZ	9400	5000	6902ZZ	4350	2260	36	27	490
40	6006ZZ	13200	8300	6003ZZ	6000	3250	43	32.5	660
45	6206ZZ	19500	11300	6004ZZ	9400	5000	47.5	34.5	1030
50	6207ZZ	25700	15300	6005ZZ	10100	5850	53	39	1330
58	6208ZZ	29100	17800	6006ZZ	13200	8300	62.5	40	1600
65	6209ZZ	32500	20500	6007ZZ	16000	10300	79	63	1650

Fig 255-1



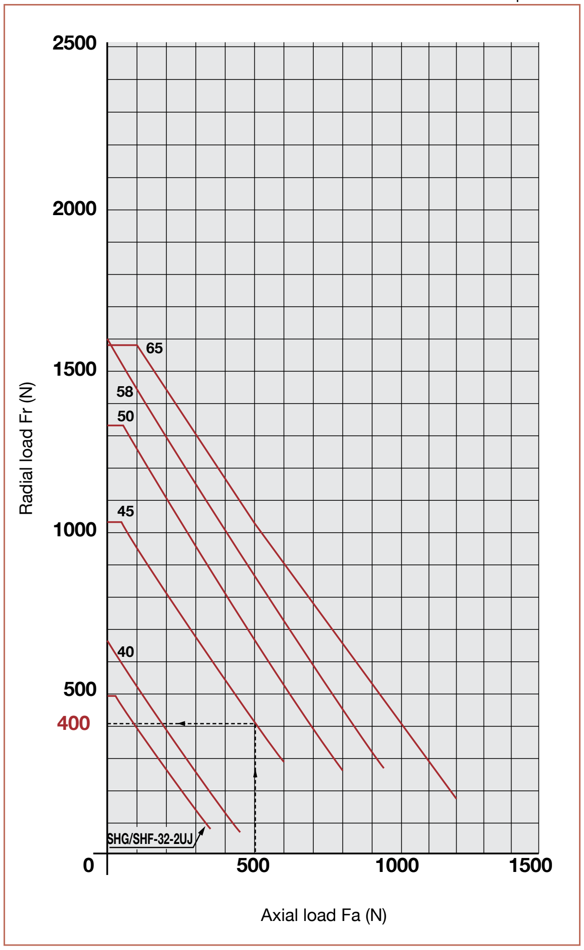
Size 14 to 25

Graph 255-1



Size 32 to 65

Graph 255-2

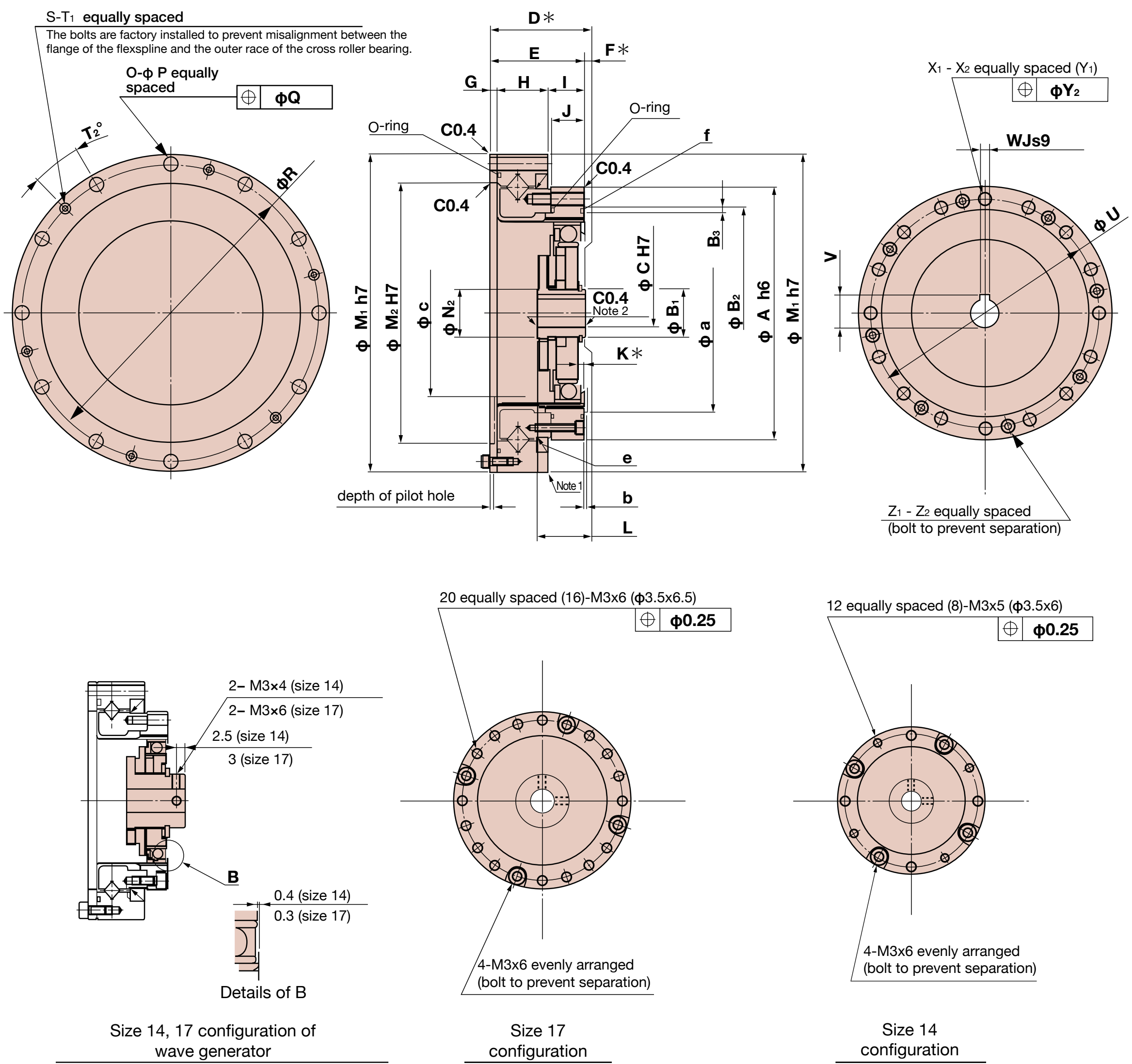


Outline Dimensions

Outline Dimensions (2SO)

You can download the CAD files from our website: harmonicdrive.net

Fig. 255-1



Note 1: See undercutting the housing on Page 240 for details.
Note 2: For size 14, C0.5.

* Refer to the confirmation drawing for detailed dimensions
* See Fig. 228-1 on Page 228 for the configurations of the wave generator.
* The allowance varies depending on the part manufacturing method (cast or machined products). Contact us if the allowance is not described in the dimensions and is required.
* Be careful not to remove the separation prevention bolt.

Dimensions (2SO)

Table 256-1
Unit : mm

Symbol		14	17	20	25	32	40	45	50	58	65
ϕA h6		50	60	70	85	110	135	155	170	195	215
ϕB_1		14	18	21	26	26	32	32	32	40	48
ϕB_2		—	—	—	—	—	—	128	141	163	180.4
ϕB_3		—	—	—	—	—	—	2.7	2.7	2.7	2.7
ϕC	Standard (H7)	6	8	9	11	14	14	19	19	22	24
ϕC	Max. dimen.	8	10	13	15	16	20	20	20	25	30
D∗	SHF Series	$28.5^{0}_{-0.8}$	$32.5^{0}_{-0.9}$	$33.5^{0}_{-1.0}$	$37^{0}_{-1.1}$	$44^{0}_{-1.1}$	$53^{0}_{-1.1}$	$58^{0}_{-1.2}$	$64^{0}_{-1.3}$	$75.5^{0}_{-1.3}$	—
D∗	SHG Series	$28.5^{0}_{-0.4}$	$32.5^{0}_{-0.4}$	$33.5^{0}_{-0.4}$	$37^{0}_{-0.5}$	$44^{0}_{-0.6}$	$53^{0}_{-0.6}$	$58^{0}_{-0.6}$	$64^{0}_{-0.7}$	$75.5^{0}_{-0.7}$	$83^{0}_{-0.7}$
E		23.5	26.5	29	34	42	51	56.5	63	73	81.5
F∗		5	6	4.5	3	2	2	1.5	1	2.5	1.5
G		2.4	3	3	3.3	3.6	4	4.5	5	5.8	6.5
H		14.1	16	17.5	18.7	23.4	29	32	34	40.2	43
I		7	7.5	8.5	12	15	18	20	24	27	32
J		6	6.5	7.5	10	14	17	19	22	25	29
K∗	SHF Series	0.4	0.3	0.1	2.1	2.5	3.3	3.7	4.2	4.8	—
K∗	SHG Series	1.4	1.6	1.5	3.5	4.2	5.6	6.3	7	8.2	9.5
L	SHF Series	$17.6^{0}_{-0.1}$	$19.5^{0}_{-0.1}$	$20.1^{0}_{-0.1}$	$20.2^{0}_{-0.1}$	$22^{0}_{-0.1}$	$27.5^{0}_{-0.1}$	$27.9^{0}_{-0.1}$	$32^{0}_{-0.1}$	$34.9^{0}_{-0.1}$	—
L	SHG Series	$18.5^{0}_{-0.1}$	$20.7^{0}_{-0.1}$	$21.5^{0}_{-0.1}$	$21.6^{0}_{-0.1}$	$23.6^{0}_{-0.1}$	$29.7^{0}_{-0.1}$	$30.5^{0}_{-0.1}$	$34.8^{0}_{-0.1}$	$38.3^{0}_{-0.1}$	$44.6^{0}_{-0.1}$
ϕM_1 h7		70	80	90	110	142	170	190	214	240	276
ϕM_2 H7		48	60	70	88	114	140	158	175	203	232
ϕN_2		—	—	—	—	—	32	—	32	—	48
O		8	12	12	12	12	12	18	12	16	16
ϕP		3.5	3.5	3.5	4.5	5.5	6.6	6.6	9	9	11
ϕQ		0.25	0.25	0.25	0.25	0.25	0.3	0.3	0.5	0.5	0.5
ϕR		64	74	84	102	132	158	180	200	226	258
S		2	4	4	4	4	6	6	6	8	8
T_1		M3×6	M3×6	M3×8	M3×8	M4×8	M4×10	M4×8	M5×12	M5×12	M6×16
T_2 (angle)		22.5°	15°	15°	15°	15°	15°	10°	15°	11.25°	11.25°
ϕU		44	54	62	77	100	122	140	154	178	195
V		—	—	10.4	12.8	16.3	16.3	21.8	21.8	24.8	27.3
W Js9		—	—	3	4	5	5	6	6	6	8
X_1		12 E. A. 8	12E. A. 16	16	16	16	16	12	16	12	16
X_2		M3×5	M3×6	M3×6	M4×7	M5×8	M6×10	M8×10	M8×11	M10×15	M10×15
Y_1		ϕ3.5×6	ϕ3.5×6.5	ϕ3.5×7.5	ϕ4.5×10	ϕ5.5×14	ϕ6.6×17	ϕ9×19	ϕ9×22	ϕ11×25	ϕ11×29
Y_2		0.25	0.25	0.25	0.25	0.25	0.3	0.5	0.5	0.5	0.5
Z_1		4	4	4	4	4	4	4	8	6	8
Z_2		M3×6	M3×6	M3×8	M3×10	M4×16	M5×20	M5×20	M5×25	M6×25	M6×30
Minimum housing clearance	ϕa	38	45	53	66	86	106	119	133	154	172
Minimum housing clearance	b	1	1	1.5	1.5	1.5	2	2	2	2.5	2.5
Minimum housing clearance	ϕc	31	38	45	56	73	90	101	113	131	150
d		1.7	2.1	2	2	2	2	2.3	2.5	2.9	3.5
e		D49585	D59685	D69785	D84945	D1101226	D1321467	D1521707	D1681868	D1932129	D21623811
f		—	—	—	—	—	—	d1 121.5 d2 2.0	S135	d1 157.0 d2 2.0	S175
Mass (kg)		0.41	0.57	0.81	1.31	2.94	5.1	6.5	9.6	13.5	19.5

- The following dimensions can be modified to accommodate customer-specific requirements.

  Wave Generator : C
  Flexspline : O and P
  Circular Spline : X_1 and X_2

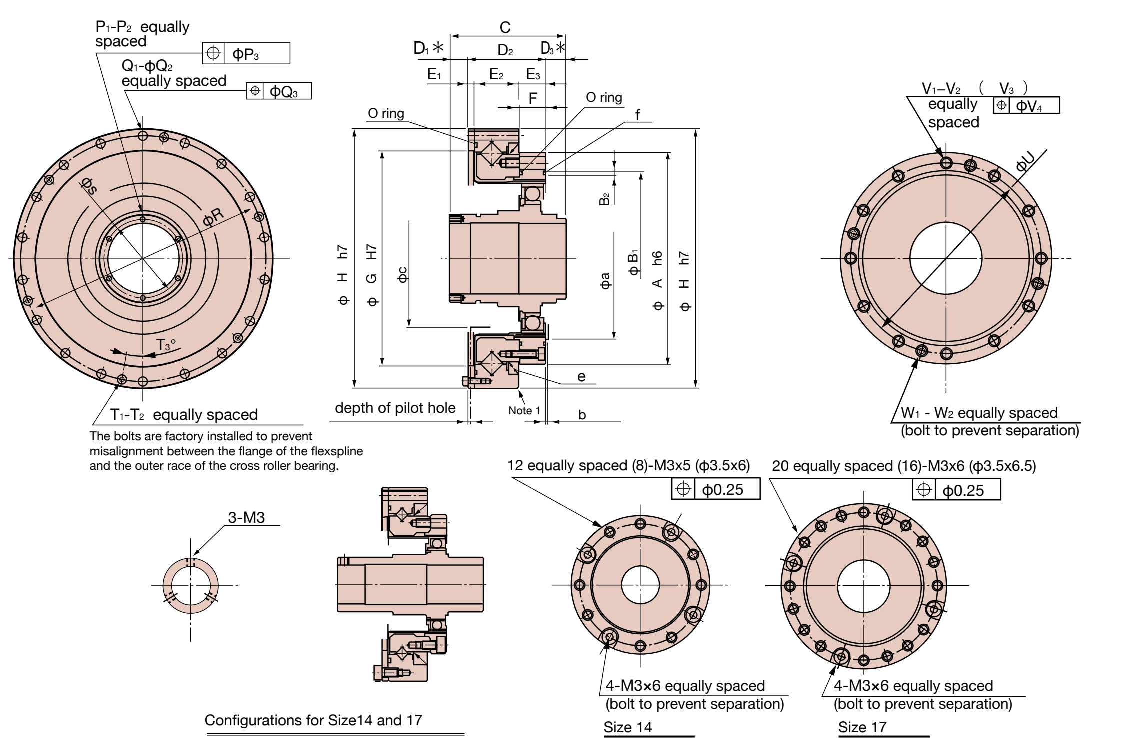
- *The D, F and K values indicate relative position of individual gearing components (wave generator, flexpline, circular spline). Please strictly adhere to these values when designing your housing and mating parts.
- Please note that the circular spline face of sizes 14 through 40 does not incorporate an O-ring groove. Please provide alternate sealing arrangements.
- Due to the deformation of the Flexspline during operation, it is necessary to provide a minimum housing clearance, dimensions ϕa, b, c.

Wave generator is removed when the product is delivered.

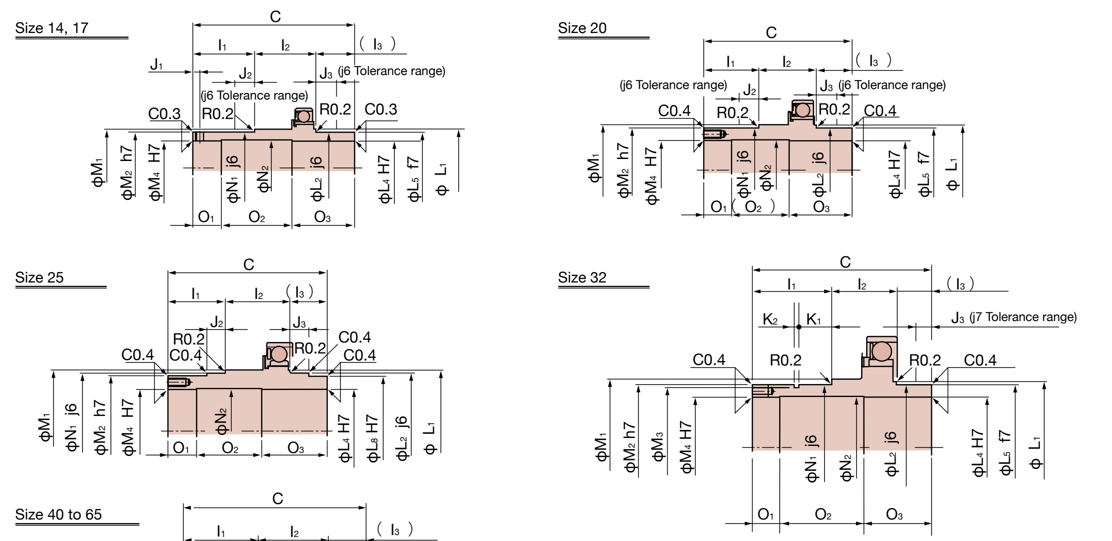
Outline Dimensions (2SH)

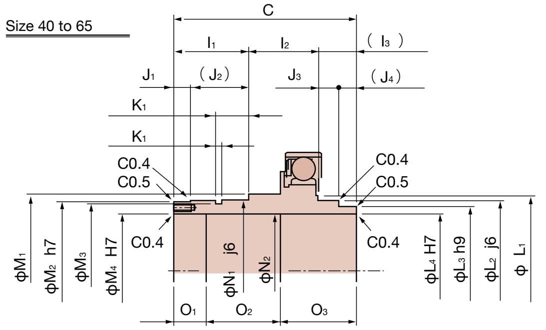
You can download the CAD files from our website: harmonicdrive.net

Fig. 257-1



Configurations Of Wave Generator All Sizes





Note 1:
See undercutting the housing on Page 240 for details.

* Refer to the confirmation drawing for detailed dimensions. Especially be certain to check the delivered specifications since the configuration of the wave generator varies depends on the size. (* Also see Fig. 228-1 on Page 228.)

* The allowance varies depending on the part manufacturing method (cast or machined products). Contact us if the allowance is not described in the dimensions and is required.

* Be careful not to remove the separation prevention bolt.

Dimensions (2SH)

Table 258-1
Unit : mm

	Symbol \ Size	14	17	20	25	32	40	45	50	58	65
	φA h6	50	60	70	85	110	135	155	170	195	215
	φB_1	—	—	—	—	—	—	128	141	163	180.4
	B_2	—	—	—	—	—	—	2.7	2.7	2.7	2.7
	C	$52.5^{0}_{-0.1}$	$56.5^{0}_{-0.1}$	$51.5^{0}_{-0.1}$	$55.5^{0}_{-0.1}$	$65.5^{0}_{-0.1}$	$79^{0}_{-0.1}$	$85^{0}_{-0.1}$	$93^{0}_{-0.1}$	$106^{0}_{-0.1}$	$128^{0}_{-0.1}$
D_1*	SHF	$16^{+0.8}_{0}$	$16^{+0.9}_{0}$	$9.5^{+1.0}_{0}$	$10^{+1.1}_{0}$	$12^{+1.1}_{0}$	$13^{+1.1}_{0}$	$13.5^{+1.2}_{0}$	$15^{+1.3}_{0}$	$16^{+1.3}_{0}$	$21^{+1.3}_{0}$
	SHG	$16^{+0.4}_{0}$	$16^{+0.4}_{0}$	$9.5^{+0.4}_{0}$	$10^{+0.5}_{0}$	$12^{+0.6}_{0}$	$13^{+0.6}_{0}$	$13.5^{+0.6}_{0}$	$15^{+0.7}_{0}$	$16^{+0.7}_{0}$	$21^{+0.7}_{0}$
	D_2	23.5	26.5	29	34	42	51	56.5	63	73	81.5
	D_3*	13	14	13	11.5	11.5	15	15	15	17	25.5
	E_1	2.4	3	3	3.3	3.6	4	4.5	5	5.8	6.5
	E_2	14.1	16	17.5	18.7	23.4	29	32	34	40.2	43
	E_3	7	7.5	8.5	12	15	18	20	24	27	32
	F	6	6.5	7.5	10	14	17	19	22	25	29
	φG H7	48	60	70	88	114	140	158	175	203	232
	φH h7	70	80	90	110	142	170	190	214	240	276
Wave generator dimensions	I_1	$20_{\pm0.1}$	$21.5_{\pm0.1}$	$19_{\pm0.1}$	$20_{\pm0.1}$	$29_{\pm0.1}$	$34_{\pm0.1}$	$35_{\pm0.1}$	$39.5_{\pm0.1}$	$45.3_{\pm0.1}$	$54.5_{\pm0.1}$
	I_2	$20_{\pm0.1}$	$21.5_{\pm0.1}$	$20_{\pm0.1}$	$22.5_{\pm0.1}$	$23.5_{\pm0.1}$	$28_{\pm0.1}$	$32.5_{\pm0.1}$	$36_{\pm0.1}$	$40.7_{\pm0.1}$	—
	I_3	(12.5)	(13.5)	(12.5)	(13)	(13)	(17)	(17.5)	(17.5)	(20)	—
	J_1	2.5	2.5	—	—	—	—	8	9	10	14
	J_2	7	7	7	6.5	—	—	(27)	(30.5)	(35.3)	(40.5)
	J_3	7	7	7	6.5	—	9.5	9.5	9.5	12.5	11.5
	J_4	—	—	—	—	—	(7.5)	(8)	(8)	(7.5)	(11.5)
	K_1	—	—	—	—	13.9	15.1	15.6	18.6	21.1	23.1
	K_2	—	—	—	—	1.9	2.2	2.7	2.7	3.2	3.1
	φL_1	22	27	32	42	47	62	69	79	90	106
	φL_2 j6	20	25	30	40	45	60	65	75	85	100
	φL_3 h9	—	—	—	38	—	59	59	69	84	96
	φL_4 H7	14	19	21	29	36	46	52	60	70	80
	φL_5 f7	20	25	30	—	45	—	—	—	—	—
	φM_1	22	27	32	42	49	65	70	80	91.5	111
	φM_2 h7	20	25	30	38	45	59	64	74	84	96
	φM_3	—	—	—	—	42.5	57	62	72	81.5	96.5
	φM_4 H7	14	19	21	29	36	46	52	60	70	80
	φN_1 j6	20	25	30	40	45	60	65	75	85	100
	φN_2	14.5	19.5	21.5	29.5	36.5	46.5	52.5	60.5	70.5	80.5
	O_1	10	10	10	10	10	12	15	15	15	20
	O_2	22.5	24.5	(19.5)	22.5	(30.5)	(35)	35	41	48	54
	O_3	20	22	22	23	25	32	35	37	43	54
	P_1	3	3	6	6	6	6	6	6	8	6
	P_2	M3	M3	M3×6	M3×6	M3×6	M4×8	M4×8	M4×8	M4×8	M5×10
	φP_3	—	—	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	Q_1	8	12	12	12	12	12	18	12	16	16
	φQ_2	3.5	3.5	3.5	4.5	5.5	6.6	6.6	9	9	11
	φQ_3	0.25	0.25	0.25	0.25	0.25	0.3	0.3	0.5	0.5	0.5
	φR	64	74	84	102	132	158	180	200	226	258
	φS	—	—	25.5	33.5	40.5	52	58	67	77	88
	T_1	2	4	4	4	4	6	6	6	8	8
	T_2	M3×6	M3×6	M3×8	M3×8	M4×8	M4×10	M4×10	M5×12	M5×12	M6×16
	T_3 (angle)	22.5°	15°	15°	15°	15°	15°	10°	15°	11.25°	11.25°
	φU	44	54	62	77	100	122	140	154	178	195
	V_1	12 E.A. 8	20 E. A. 16	16	16	16	16	12	16	12	16
	V_2	M3×5	M3×6	M3×6	M4×7	M5×8	M6×10	M8×10	M8×11	M10×15	M10×15
	V_3	φ3.5×6	φ3.5×6.5	φ3.5×7.5	φ4.5×10	φ5.5×14	φ6.6×17	φ9×19	φ9×22	φ11×25	φ11×29
	V_4	0.25	0.25	0.25	0.25	0.25	0.3	0.5	0.5	0.5	0.5
	W_1	4	4	4	4	4	4	4	8	6	8
	W_2	M3×6	M3×6	M3×8	M3×10	M4×16	M5×20	M5×20	M5×25	M6×25	M6×30
Minimum housing clearance	φa	38	45	53	66	86	106	119	133	154	172
	b	1	1	1.5	1.5	1.5	2	2	2	2.5	2.5
	φc	31	38	45	56	73	90	101	113	131	150
	d	1.7	2.1	2	2	2	2	2.3	2.5	2.9	3.5
	e	D49585	D59685	D69785	D84945	D1101226	D1321467	D1521707	D1681868	D1932129	D21623811
	f	—	—	—	—	—	—	d1 121.5 d2 2.0	S135	d1 157.0 d2 2.0	S175
	Mass (kg)	0.45	0.63	0.89	1.44	3.1	5.4	6.9	10.2	14.1	20.9

- As the flexspline is subject to elastic deformation, the housing clearance should be φa, b, c or more and it should not exceed.
- *The D_1 and D_3 sizes indicated by an asterisk are the mounting positions in the shaft direction and allowance of the three parts (wave generator, flexspline, circular spline). Strictly observe these tolerances.
- The circular spline of sizes 14 to 40 does not have an O-ring groove (symbol: f) for sealing. Account for sealing during design and installation.

Wave generator is removed when the product is delivered.

Installation accuracy

Maintain the recommended tolerances shown in Figure 260-1 and Table 260-1 for peak performance.

Fig. 260-1

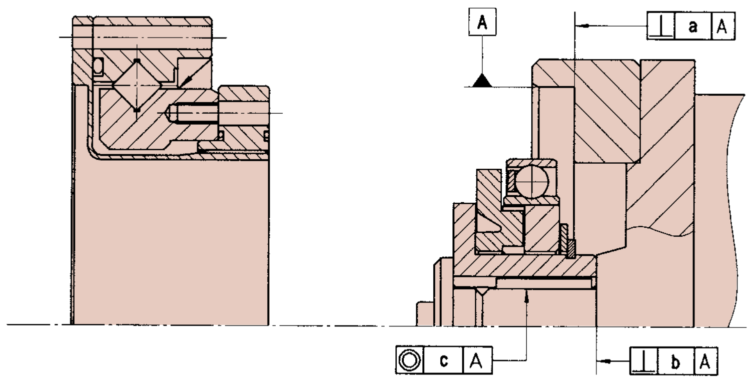


Table 260-1
Unit: mm

Size	14	17	20	25	32	40	45	50	58
a	0.011	0.015	0.017	0.024	0.026	0.026	0.027	0.028	0.031
b	0.017	0.020	0.020	0.024	0.024	0.024	0.032	0.032	0.032
	(0.008)	(0.010)	(0.010)	(0.012)	(0.012)	(0.012)	(0.012)	(0.015)	(0.015)
c	0.030	0.034	0.044	0.047	0.047	0.050	0.063	0.066	0.068
	(0.016)	(0.018)	(0.019)	(0.022)	(0.022)	(0.022)	(0.024)	(0.030)	(0.033)

* The value in the parentheses indicates that Wave Generator does not have an Oldham coupling.

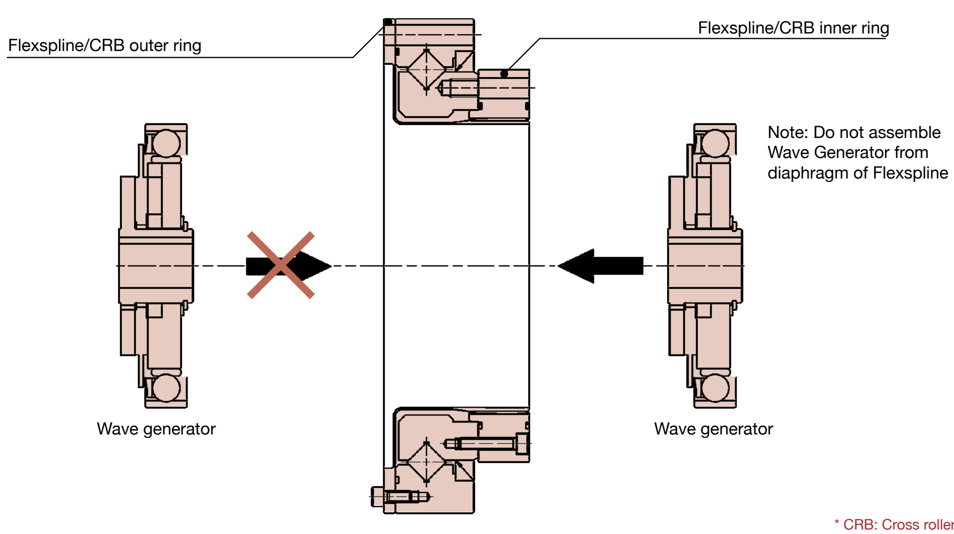
Installation Recommendations

■ Installation sequence

The wave generator is installed after the flexspline and circular spline. If the wave generator is not inserted into the flexspline last, gear teeth scuffing damage or improper eccentric gear mesh may result. Installation resulting in an eccentric tooth mesh (Dedoidal) will cause noise and vibration, and can lead to early failure of the gear. For proper function, the teeth of the flexspline and Circular Spline mesh symmetrically.

Assembly order for basic three elements

Fig. 260-2



* CRB: Cross roller bearing

■ Precautions on assembly

It is extremely important to assemble the gear accurately and in proper sequence. For each of the three components, utilize the following precautions.

Wave generator

1. Avoid applying undue axial force to the wave generator during installation. Rotating the wave generator bearing while inserting it is recommended and will ease the process.
2. Extra care must be given to ensure that concentricity and inclination are within the specified limits (see page 253).
3. Installation bolts on the Wave Generator and Flexspline should not interfere each other.

Circular spline

The circular Spline must not be deformed in any way during the assembly. It is particularly important that the mounting surfaces are prepared correctly.

1. Mounting surfaces need to have adequate flatness, smoothness, and no distortion.
2. Especially in the area of the screw holes, burrs or foreign matter should not be present.
3. Adequate relief in the housing corners is needed to prevent interference with the corner of the circular spline.
4. The circular spline should be rotatable within the housing. Be sure there is not interference and that it does not catch on anything.
5. Bolts should not rotate freely when tightening and should not have any irregularity due to the bolt hole being misaligned or oblique.
6. Do not tighten the bolts with the specified torque all at once. Tighten the bolts temporarily with about half the specified torque, and then tighten them with the specified torque. Tighten them in an even, crisscross pattern.
7. Avoid pinning the circular spline if possible as it can reduce the rotational precision and smoothness of operation.

Flexspline

1. Mounting surfaces need to have adequate flatness, smoothness, and no distortion.
2. Especially in the area of the screw holes, burrs or foreign matter should not be present.
3. Adequate clearance with the housing is needed to ensure no interference especially with the major axis of flexspline
4. Bolts should rotate freely when installing through the mounting holes of the flexspline and should not have any irregularity due to the shaft bolt holes being misaligned or oblique.
5. Do not tighten the bolts with the specified torque all at once. Tighten the bolts temporarily with about half the specified torque, and then tighten them to the specified torque. Tighten them in an even, crisscross pattern.
6. The flexspline and circular spline are concentric after assembly. After installing the wave generator bearing, if it rotates in unbalanced way, check the mounting for dedoidal or non-concentric installation.
7. Care should be taken not to damage the flexspline diaphragm or gear teeth during assembly.

   Avoid hitting the tips of the flexpline teeth and circular spline teeth. Avoid installing the CS from the open side of the flexspline after the wave generator has been installed.

Rust prevention

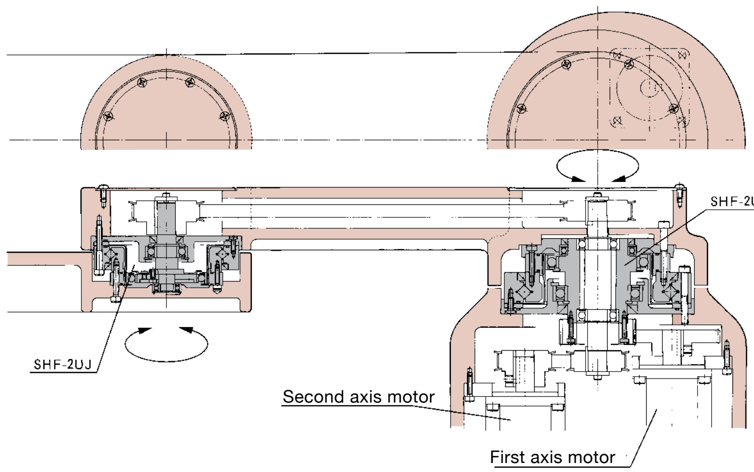
Although Harmonic Drive® gears come with some corrosion protection, the gear can rust if exposed to the environment. The gear external surfaces typically have only a temporary corrosion inhibitor and some oil applied. If an anti-rust product is needed, please contact us to review the options.

Application

Typical example of a Scara-type robot two-axis arrangement using SHF-2UH and SHF-2UJ gear units.

The robot arm is equipped with SHF-2UH and SHF-2UJ Series units. The hollow shaft of the first axis unit is used to pilot the shaft driving the second axis unit. This allows both motors to be mounted in the base of the robot, minimizing the moment of inertia of the arm.

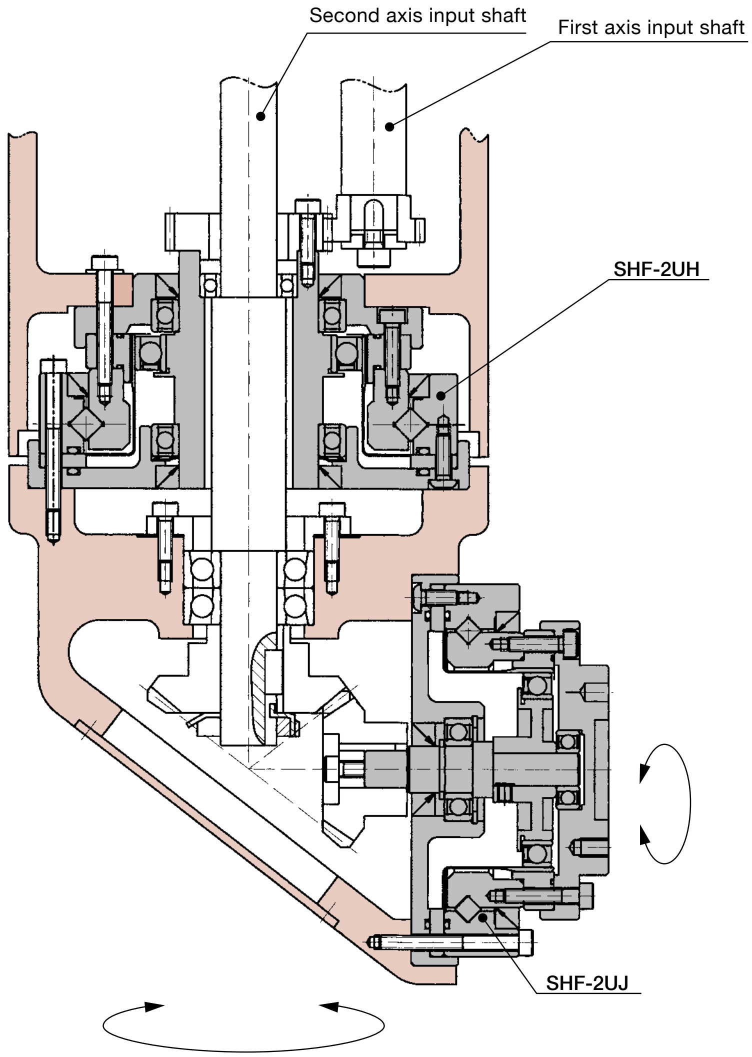
Fig. 262-1



Typical example of a wrist joint arrangement in a gantry-type robot using SHF-2UH and SHF-2UJ gear units.

This robot wrist axis design incorporates both SHF-2UH and SHF-2UJ units.
The second axis is driven through the hollow shaft of the first axis gear. This design has number of advantages, including the compact design and low inertia for the second axis.

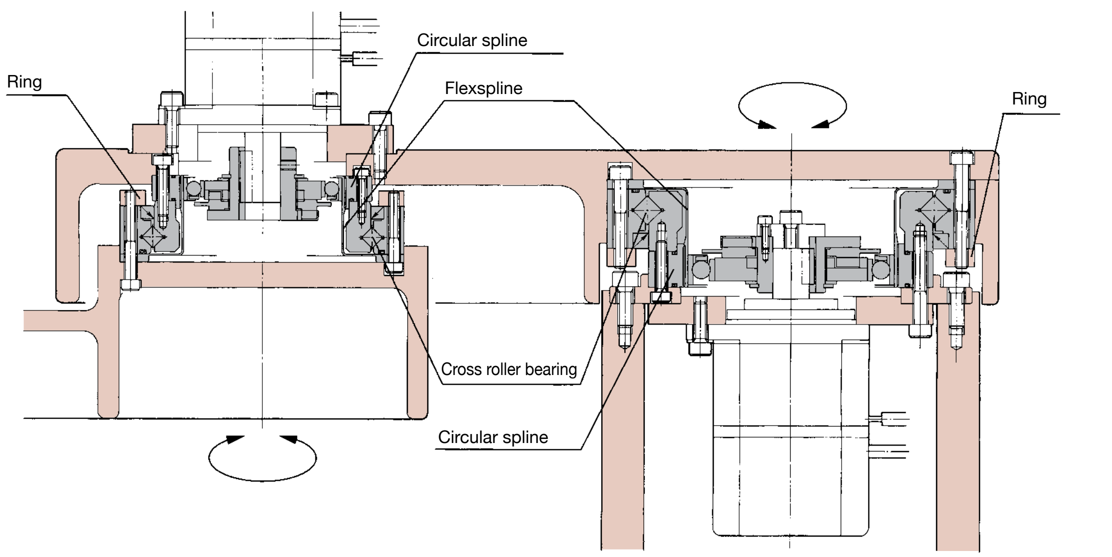
Fig. 263-1



Typical example of a Scara-type robot two-axis arrangement using SHF-2SO simplicity unit.

Specially designed units are used in the robot arm featured below.
The Simplicity units feature SHF-2SO component sets combined with integral cross roller bearing, circular spline and flexspline.
It is important to note that the motor can be assembling from both sides of the unit.

Fig. 264-1

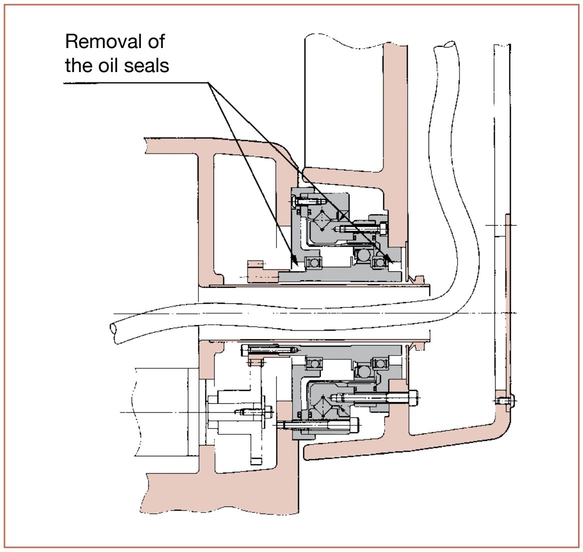


* Sealing is required to prevent grease leakage.

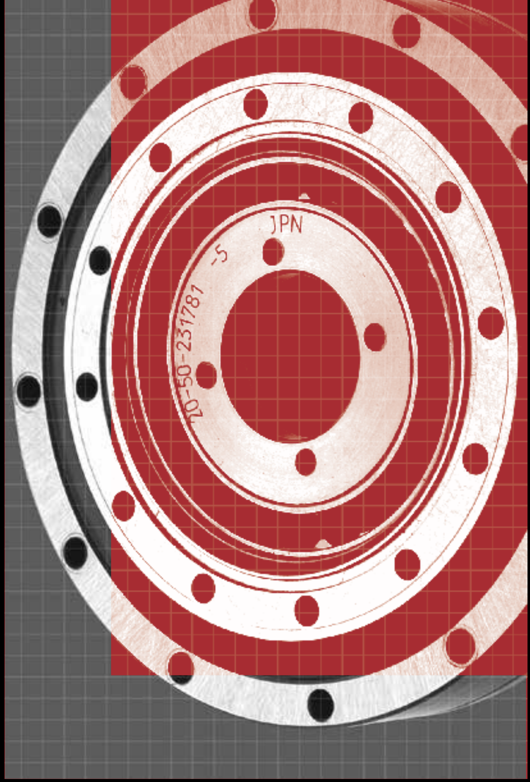
Typical example of the use of SHF-2UH gear unit with rotary shaft seals removed.

Friction generated by the rotary shaft seals on the high-speed side can result in a temperature rise in the SHF-2UH gearhead during operation. This application example shows the SHF-2UH gearhead with its rotary shaft seals removed.
The removal of one or both of these seals should only be carried out if other measures have been undertaken to prevent lubricant leakage or if a leakage can be ruled out due to the installation position.

Fig. 265-1



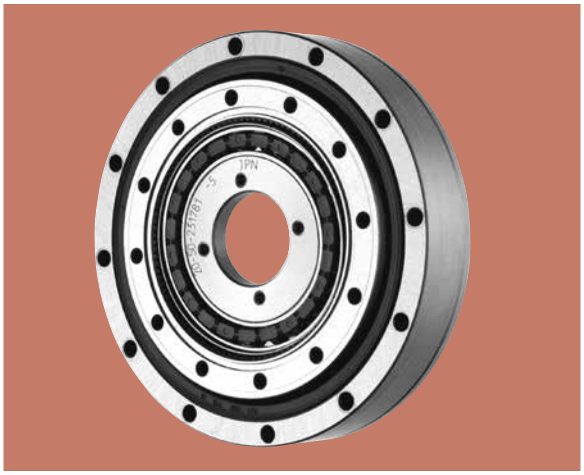
MEMO



SHD Series

Gear Unit SHD

Features



SHD series

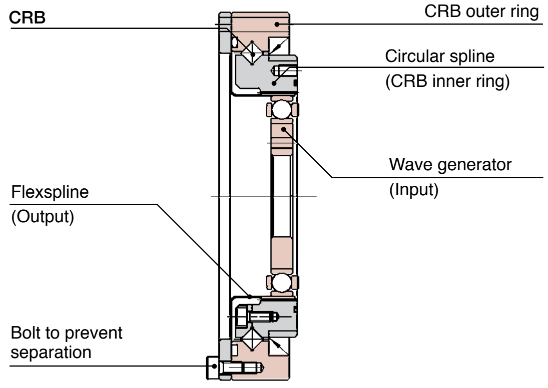
Axially compact, these gear units feature a large hollow input shaft and a robust cross roller bearing so loads can be mounted directly to the unit without the need for additional support bearings

Features of SHD series

- Zero Backlash
- Ultra-flat design - 15% thinner than the SHF Series
- Large Hollow Input Shaft
- Accuracy <1 arc-min (most sizes)
- Rigid cross roller output bearing
- Lightweight - 30% lower weight than Standard SHF Series

Structure of SHD gear unit

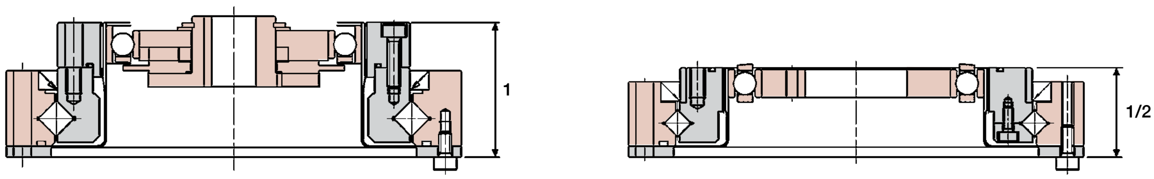
Fig. 268-1



* CRB: Cross roller bearing

Shaft thickness

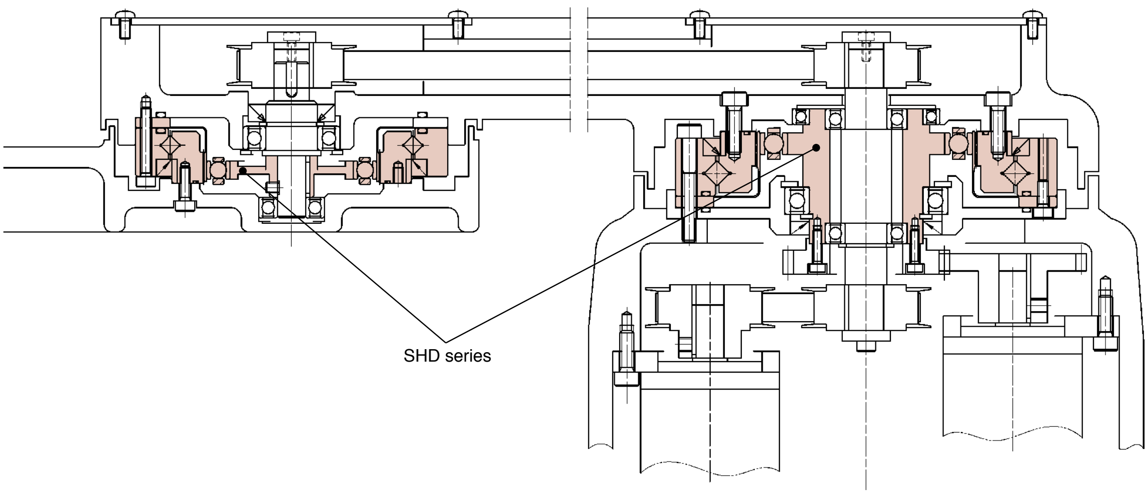
Fig. 268-2



Application example, SHD series

Fig. 269-1

SCARA robot
SHD is ideal when space is limited.



Ordering Code

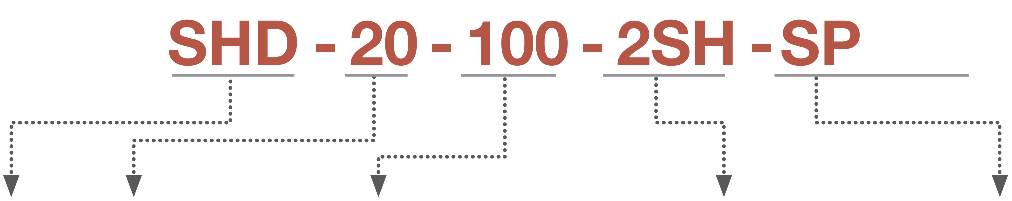


Table 269-1

Series	Size	Ratio[*1]			Model	Special specification
SHD	14	50	80	100	2SH = Simplicity Unit 2UH = Gear Unit	LW = Lightweight SP= Special specification code Blank=Standard product
	17	50	80	100		
	20	50	80	100		
	25	50	80	100		
	32	50	80	100		
	40	50	80	100		

*1 The reduction ratio value is based on the following configuration:
Input: wave generator, fixed: circular spline, output: flexspline

Engineering Data
Component Sets
Gear Units
Phase Adjusters
Gearheads & Actuators

Technical Data

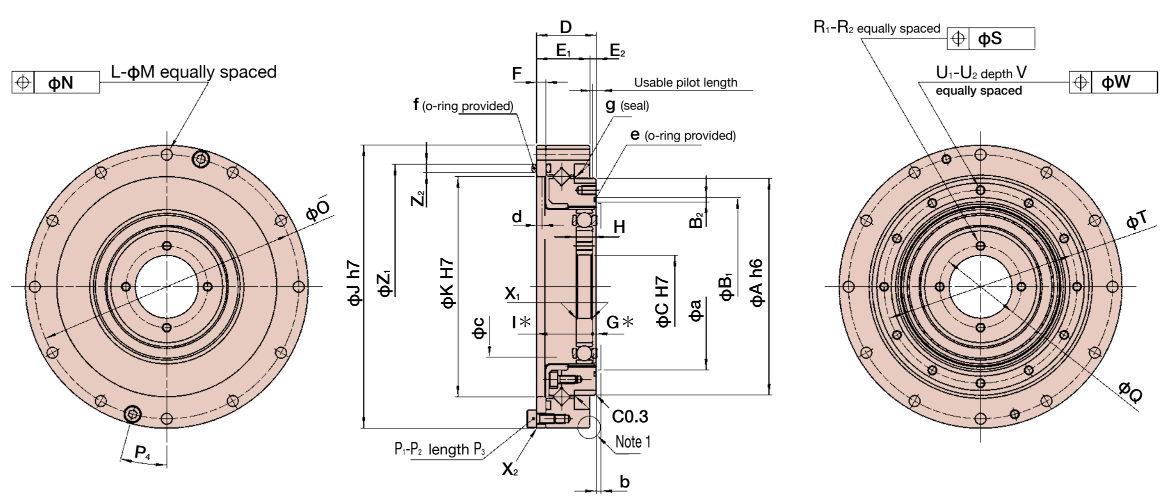
Rating Table

Size	Gear ratio	Rated torque at input speed 2000rpm		Limit for repeated peak torque		Limit for average torque		Limit for momentary peak torque		Maximum input speed (rpm)	Limit for average input speed (rpm)	Moment of inertia (2SH)		Moment of inertia (2UH)	
		Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm	Grease	Grease	$I \times 10^{-4} kgm^2$	$J \times 10^{-5} kgfms^2$	$I \times 10^{-4} kgm^2$	$J \times 10^{-5} kgfms^2$
14	50	3.7	0.38	12	1.2	4.8	0.49	23	2.3	8500	3500	0.021	0.021	0.064	0.065
	80	5.4	0.55	16	1.6	7.7	0.79	35	3.6						
	100	5.4	0.55	19	1.9	7.7	0.79	35	3.6						
17	50	11	1.1	23	2.3	18	1.8	48	4.9	7300	3500	0.054	0.055	0.141	0.144
	80	15	1.5	29	3.0	19	1.9	61	6.2						
	100	16	1.6	37	3.8	27	2.8	71	7.2						
20	50	17	1.7	39	4.0	24	2.4	69	7.0	6500	3500	0.090	0.092	0.271	0.276
	80	24	2.4	51	5.2	33	3.4	89	9.1						
	100	28	2.9	57	5.8	34	3.5	95	9.7						
25	50	27	2.8	69	7.0	38	3.9	127	13	5600	3500	0.282	0.288	0.793	0.809
	80	44	4.5	96	9.8	60	6.1	179	18						
	100	47	4.8	110	11	75	7.6	184	19						
32	50	53	5.4	151	15	75	7.6	268	27	4800	3500	1.09	1.11	2.900	2.957
	80	83	8.5	213	22	117	12	398	41						
	100	96	9.8	233	24	151	15	420	43						
40	50	96	9.8	281	29	137	14	480	49	4000	3000	2.85	2.91	7.432	7.578
	80	144	15	364	37	198	20	686	70						
	100	185	19	398	41	260	27	700	71						

Outline Dimensions SHD-2SH

You can download the CAD files from our website: harmonicdrive.net

Fig. 270-1



Note 1:
See undercutting the housing on Page 240 for details.

* Please refer to the confirmation drawing for detailed dimensions.
* See Fig. 040-3 on Page 040 for the shapes of the wave generator.

Dimensions SHD-2SH

Table 271-1

Unit : mm

Symbol	Size	14	17	20	25	32	40
	φA h6	$49^{0}_{-0.016}$	$59^{0}_{-0.019}$	$69^{0}_{-0.019}$	$84^{0}_{-0.022}$	$110^{0}_{-0.022}$	$132^{0}_{-0.025}$
	φB_1	$39.1^{+0.1}_{0}$	$48^{+0.1}_{0}$	$56.8^{+0.1}_{0}$	$70.5^{+0.1}_{0}$	$92^{+0.1}_{0}$	$112.4^{+0.1}_{0}$
	B_2	$0.8^{+0.15}_{0}$	$1.1^{+0.25}_{0}$	$1.4^{+0.25}_{0}$	$1.7^{+0.25}_{0}$	$2^{+0.25}_{0}$	$2.2^{+0.25}_{0}$
	φC H7	$11^{+0.018}_{0}$	$15^{+0.018}_{0}$	$20^{+0.021}_{0}$	$24^{+0.021}_{0}$	$32^{+0.025}_{0}$	$40^{+0.025}_{0}$
	D	17.5 ±0.1	18.5 ±0.1	19 ±0.1	22 ±0.1	27.9 ±0.1	33 ±0.1
	E_1	15.5	16.5	17	20	23.6	28
	E_2	2	2	2	2	4.3	5
	F	2.4	3	3	3.3	3.6	4
	G*	1.8	1.6	1.2	0.4	0.6	0.8
	H	$4^{0}_{-0.1}$	$5^{0}_{-0.1}$	$5.2^{0}_{-0.1}$	$6.35^{0}_{-0.1}$	$8.6^{0}_{-0.1}$	$10.3^{0}_{-0.1}$
	I*	$15.7^{0}_{-0.2}$	$16.9^{0}_{-0.2}$	$17.8^{0}_{-0.2}$	$21.6^{0}_{-0.2}$	$27.3^{0}_{-0.2}$	$32.2^{0}_{-0.2}$
	φJ h7	$70^{0}_{-0.030}$	$80^{0}_{-0.030}$	$90^{0}_{-0.035}$	$110^{0}_{-0.035}$	$142^{0}_{-0.040}$	$170^{0}_{-0.040}$
	φK H7	$50^{+0.025}_{0}$	$61^{+0.030}_{0}$	$71^{+0.030}_{0}$	$88^{+0.035}_{0}$	$114^{+0.035}_{0}$	$140^{+0.040}_{0}$
	L	8	12	12	12	12	12
	φM	3.5	3.5	3.5	4.5	5.5	6.6
	φN	0.25	0.25	0.25	0.25	0.25	0.3
	φO	64	74	84	102	132	158
	P_1	2	2	2	4	4	4
	P_2	M3	M3	M3	M3	M4	M4
	P_3	6	6	6	8	10	10
	P_4	22.5°	15°	15°	15°	15°	15°
	φQ	17	21	26	30	40	50
	R_1	4	4	4	4	4	4
	R_2	M3	M3	M3	M3	M4	M5
	φS	0.25	0.25	0.25	0.25	0.25	0.25
	φT	43	52	61.4	76	99	120
	U_1	8	12	12	12	12	12
	U_2	M3	M3	M3	M4	M5	M6
	V	4.5	4.5	4.5	6	8	9
	φW	0.25	0.25	0.25	0.25	0.25	0.3
	X_1	C0.4	C0.4	C0.5	C0.5	C0.5	C0.5
	X_2	C0.4	C0.4	C0.5	C0.5	C0.5	C0.5
	Z_1	$57^{+0.1}_{0}$	$68.1^{+0.1}_{0}$	$78^{+0.1}_{0}$	$94.8^{+0.1}_{0}$	$123^{+0.1}_{0}$	$148^{+0.1}_{0}$
	Z_2	$2^{+0.25}_{0}$	$2^{+0.25}_{0}$	$2.7^{+0.25}_{0}$	$2.4^{+0.25}_{0}$	$2.7^{+0.25}_{0}$	$2.7^{+0.25}_{0}$
Minimum housing clearance	φa	36.5	45	53	66	86	106
	b	1	1	1.5	1.5	2	2.5
	φc	31	38	45	56	73	90
	d	1.4	1.8	1.7	1.8	1.8	1.8
	e	d37.1d0.6	d45.4d0.8	d53.28d0.99	d66.5d1.3	d87.5d1.5	d107.5d1.6
	f	d54.38d1.19	d64.0d1.5	d72.0d2.0	d88.62d1.78	d117.0d2.0	d142d2.0
	g	D49585	D59685	D69785	D84945	D1101226	D1321467
	h	1.5	1.5	1.5	1.5	3.3	4
	Mass (kg)	0.33	0.42	0.52	0.91	1.87	3.09

● The following dimensions can be modified to accommodate:

Wave Generator: C
Flexspline: O and P
Circular Spline: X_1 and X_2

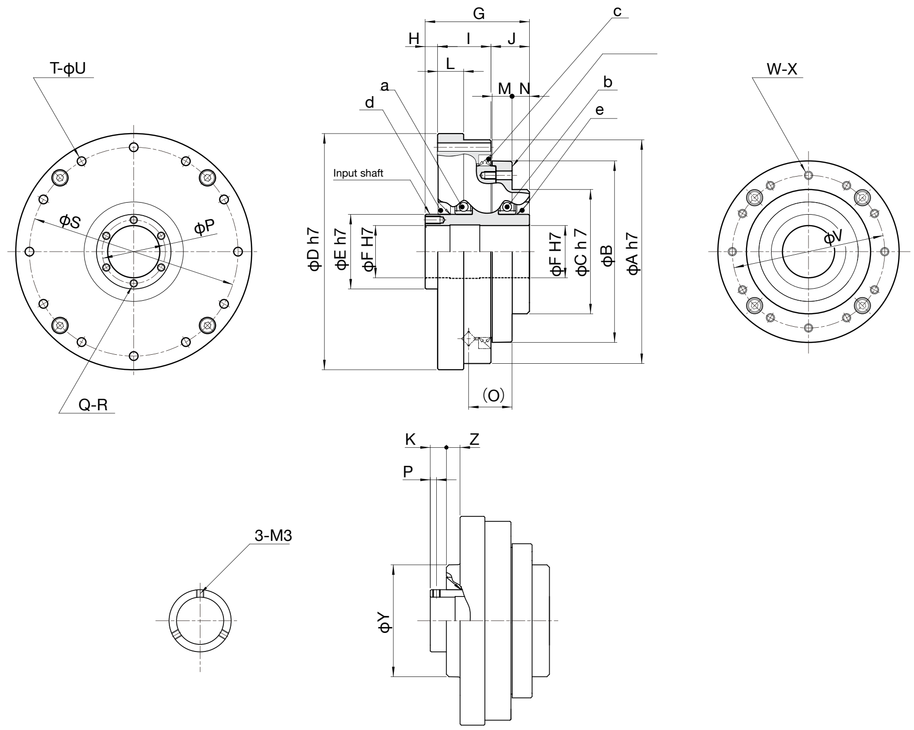
● *The G and I sizes indicated by an asterisk are the mounting positions in the shaft direction and allowance of the three parts (wave generator, flexspline, circular spline). Strictly observe these sizes as they affect the performance and strength.

● As the flexspline is subject to elastic deformation, the inner wall should be φa, b, c or more and it should not exceed **φd** to prevent possible contact with the housing.

Wave generator is removed when the product is delivered.

Outline Dimensions SHD-2UH

Fig. 272-1



Input configuration, size 14 and 17

Dimensions SHD-2UH

Table 272-1

Unit : mm

	Size					
	14	17	20	25	32	40
ϕA h7	70	80	90	110	142	170
ϕB	52	62	73	87	114	137
ϕC h7	36	45	50	60	75	100
ϕD h7	74	84	95	115	147	175
ϕE h7	20	25	30	38	54	64
ϕF H7	14	19	21	29	41	51
G	45.5	48	42	46.5	55	65
H	12	12	5	6	7	8
I	19.5	20.5	21.5	24	28.6	33
J	14	15.5	15.5	16.5	19.4	24
K	6.5	6.5	—	—	—	—
L	9	10	10.5	10.5	12	14
M	7	8	8	10	11	14
N	6.5	7	7	6	7.5	9
O	16.6	18	17.5	20.6	24.9	29.5
ϕP (P)	(2.5)	(2.5)	25.5	33.5	48	57
Q	3	3	6	6	6	6
R	M3	M3	M3×6	M3×6	M3×6	M4×8
ϕS	64	74	84	102	132	158
T	8	12	12	12	12	12
ϕU	3.5	3.5	3.5	4.5	5.5	6.6
ϕV	43	52	61.4	76	99	120
W	8	12	12	12	12	12
X	M3×4.5	M3×4.5	M3×4.5	M4×6	M5×8	M6×9
	ϕ3.5×5.5	ϕ3.5×6.5	ϕ3.5×6.5	ϕ4.5×8.5	ϕ5.5×7.6	ϕ6.6×10
ϕY	36	45	—	—	—	—
Z	5.5	5.5	—	—	—	—
a	6804ZZ	6805ZZ	6806ZZ	6808ZZ	6811ZZ	6813ZZ
b	6804ZZ	6805ZZ	6806ZZ	6808ZZ	6810ZZ	6813ZZ
c	D49585	D59685	D69785	D84945	D1101226	D1321467
d	S20304.5	S25356	S30405	S38475	S54645	S64745
e	S20304.5	S25356	S30405	S38475	S50605	S64745
Mass (kg)	0.49	0.66	0.84	1.4	2.7	4.6

Positional accuracy

See "Engineering data" for a description of terms.

Table 273-1
Unit: X10^{-4}rad (arc•min)

Size		14	17	20	25	32	40
Positional Accuracy	×10^{-4}rad	4.4	4.4	2.9	2.9	2.9	2.9
	arc min	1.5	1.5	1.0	1.0	1.0	1.0

Hysteresis loss

See "Engineering data" for a description of terms.

Table 273-2

Ratio \ Size		14	17	20	25	32	40
50	×10^{-4}rad	7.3	5.8	5.8	5.8	5.8	5.8
	arc min	2.5	2.0	2.0	2.0	2.0	2.0
80 or more	×10^{-4}rad	5.8	2.9	2.9	2.9	2.9	2.9
	arc min	2.0	1.0	1.0	1.0	1.0	1.0

Torsional stiffness

See "Engineering data" for a description of terms.

Table 273-3

Symbol \ Size			14	17	20	25	32	40
	T_1	Nm	2.0	3.9	7.0	14	29	54
		kgfm	0.2	0.4	0.7	1.4	3.0	5.5
	T_2	Nm	6.9	12	25	48	108	196
		kgfm	0.7	1.2	2.5	4.9	11	20
Ratio 50	K_1	×10^{4}Nm/rad	0.29	0.67	1.1	2.0	4.7	8.8
		kgfm/arc min	0.085	0.2	0.32	0.6	1.4	2.6
	K_2	×10^{4}Nm/rad	0.37	0.88	1.3	2.7	6.1	11
		kgfm/arc min	0.11	0.26	0.4	0.8	1.8	3.4
	K_3	×10^{4}Nm/rad	0.47	1.2	2.0	3.7	8.4	15
		kgfm/arc min	0.14	0.34	0.6	1.1	2.5	4.5
	θ_1	×10^{-4}rad	6.9	5.8	6.4	7.0	6.2	6.1
		arc min	2.4	2.0	2.2	2.3	2.1	2.1
	θ_2	×10^{-4}rad	19	14	19	18	18	18
		arc min	6.4	4.6	6.3	6.1	6.1	5.9
Ratio 80 or more	K_1	×10^{4}Nm/rad	0.4	0.84	1.3	2.7	6.1	11
		kgfm/arc min	0.12	0.25	0.4	0.8	1.8	3.2
	K_2	×10^{4}Nm/rad	0.44	0.94	1.7	3.7	7.8	14
		kgfm/arc min	0.13	0.28	0.5	1.1	2.3	4.2
	K_3	×10^{4}Nm/rad	0.61	1.3	2.5	4.7	11	20
		kgfm/arc min	0.18	0.39	0.75	1.4	3.3	5.8
	θ_1	×10^{-4}rad	5.0	4.6	5.4	5.2	4.8	4.9
		arc min	1.7	1.6	1.8	1.8	1.7	1.7
	θ_2	×10^{-4}rad	16	13	15	13	14	14
		arc min	5.4	4.3	5.0	4.5	4.8	4.8

* The values in this table are reference values. The minimum value is approximately 80% of the displayed value.

Gear Unit SHD

Simplicity unit (2SH) Starting torque

Table 274-1

See "Engineering data" for a description of terms. The values are reference values. Unit: cNm

Ratio \ Size	14	17	20	25	32	40
50	6.2	19	25	39	60	95
80	5.0	16	23	36	55	83
100	4.8	17	22	34	50	78

Gear unit (2UH) Starting torque

Table 274-2

See "Engineering data" for a description of terms. The values are reference values. Unit: cNm

Ratio \ Size	14	17	20	25	32	40
50	11	39	53	79	114	177
80	9.0	34	44	66	108	175
100	8.7	37	49	73	10	157

Simplicity unit (2SH) Backdriving torque

Table 274-3

See "Engineering data" for a description of terms. The values are reference values. Unit: Nm

Ratio \ Size	14	17	20	25	32	40
50	3.7	11	15	24	36	57
80	4.3	15	21	32	46	72
100	5.8	21	27	41	60	94

Gear unit (2UH) Backdriving torque

Table 274-4

See "Engineering data" for a description of terms. The values are reference values. Unit: Nm

Ratio \ Size	14	17	20	25	32	40
50	6.0	21	29	44	63	98
80	7.1	28	41	60	84	130
100	9.7	41	54	80	111	173

Ratcheting torque

See "Engineering data" for a description of terms.

Table 274-5
Unit: Nm

Ratio \ Size	14	17	20	25	32	40
50	88	150	220	450	980	1800
80	110	200	350	680	1400	2800
100	84	160	260	500	1000	2100

Buckling torque

See "Engineering data" for a description of terms.

Table 274-6
Unit: Nm

Size	14	17	20	25	32	40
All ratios	130	260	470	850	1800	3600

No-load running torque

No-load running torque is the torque which is required to rotate the input side (high speed side), when there is no load on the output side (low speed side).

Measurement condition

Table 275-1

Ratio 100			
Lubricant	Grease lubrication	Name	Harmonic Grease SK-1A (size 20 or more)
			Harmonic Grease SK-2 (size 14, 17)
		Quantity	Recommended quantity (See page 281)
Torque value is measured after 2 hours at 2000rpm input.			

■ Compensation Value in Each Ratio

No-load running torque of the gear varies with ratio. Graphs 276-1 to 276-4 show the values for a reduction ratio of 100. For other gear ratios, add the compensation values in the right-hand table (Table 275-2).

No-Load Torque Running Torque Compensation Value

SHD-2SH

Unit: Ncm Table 275-2

Size \ Ratio	50	80
14	+1.0	+0.2
17	+1.6	+0.3
20	+2.4	+0.5
25	+4.0	+0.8
32	+7.0	+1.4
40	+13	+2.4

SHD-2UH

Unit: Ncm Table 275-3

Size \ Ratio	50	80
14	+1.0	+0.2
17	+1.6	+0.3
20	+2.4	+0.5
25	+4.0	+0.8
32	+7.0	+1.4
40	+13	+2.4

■ Temperature range of the operating environment

Table 275-3

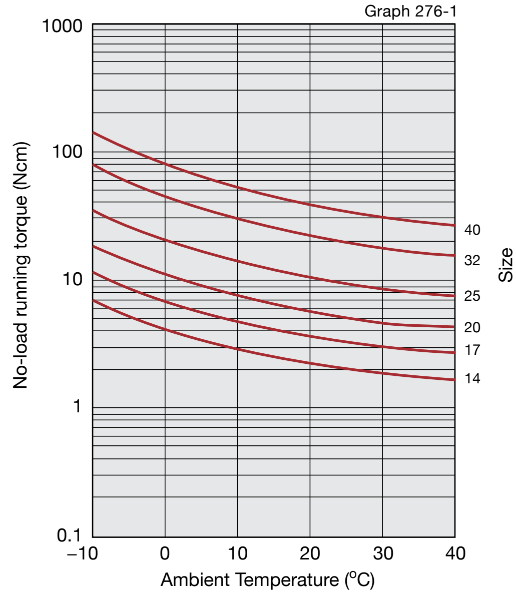
Grease	SK-1A 0ºC to + 40ºC
	SK-2 0ºC to + 40ºC

* Housing temperature should not exceed 80ºC .

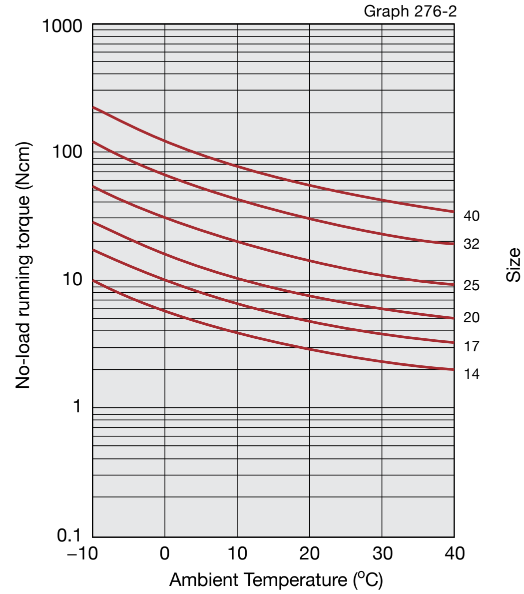
■ No-load running torque for a reduction ratio of 100:1

■ SHD-2SH (Simplicity unit)

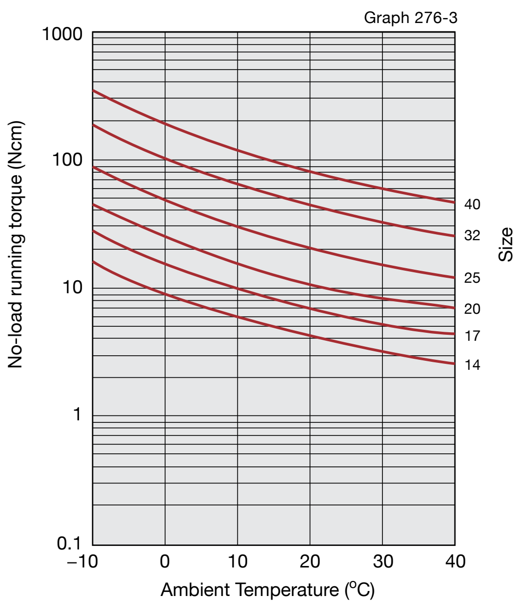
Input speed: 500rpm



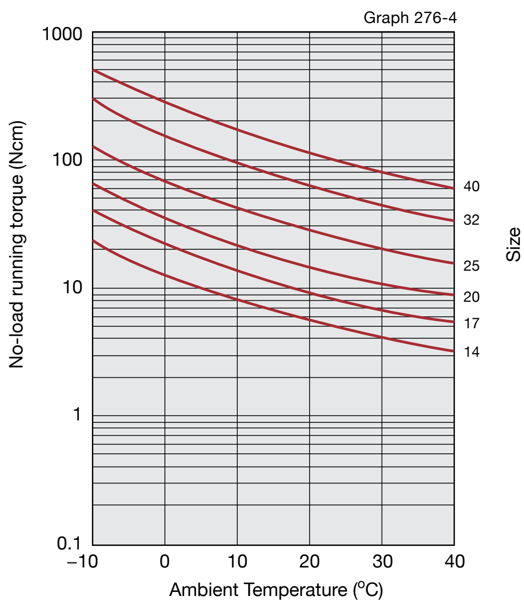
Input speed: 1000rpm



Input speed: 2000rpm



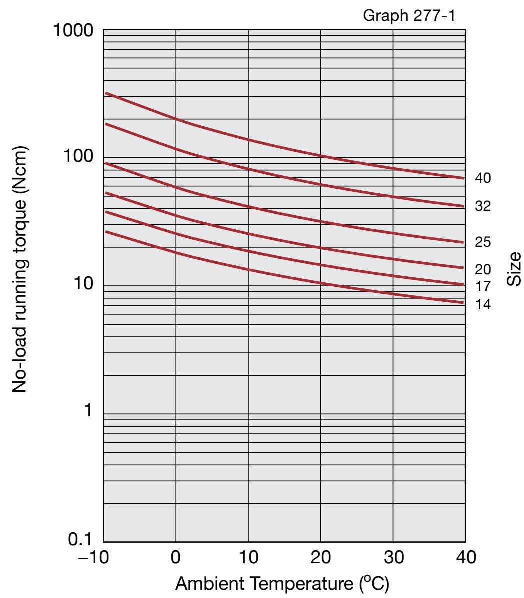
Input speed: 3500rpm



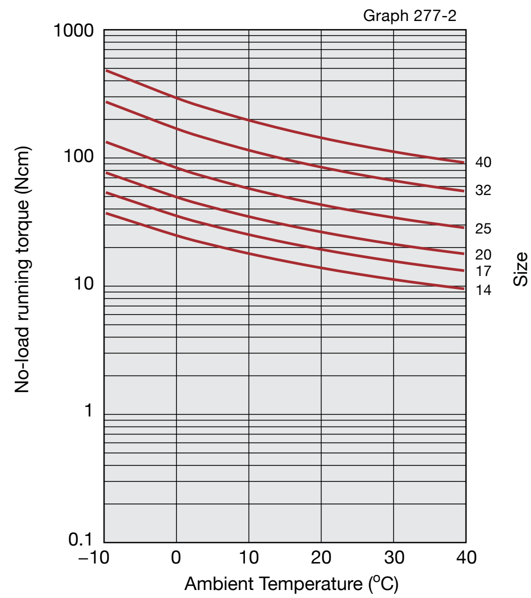
*The values in this graph are average values ($\overline{X}$).

■ SHD-2UH (Gear unit)

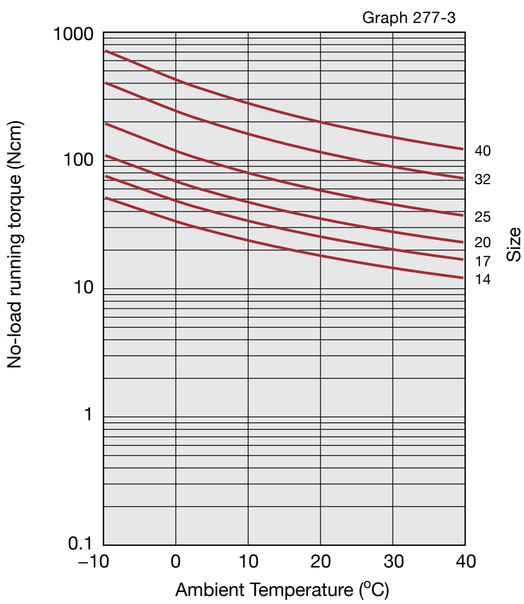
Input speed: 500rpm



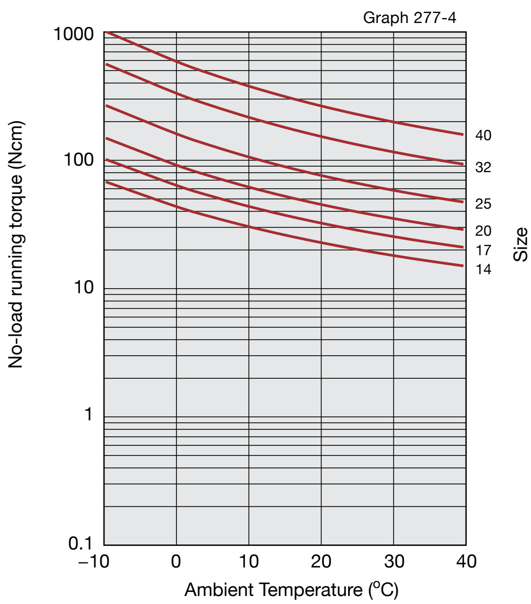
Input speed: 1000rpm



Input speed: 2000rpm



Input speed: 3500rpm



*The values in this graph are average values ($\bar{X}$).

SHD-2SH (Simplicity unit) Efficiency

The efficiency varies depending on the following conditions.

- Reduction ratio
- Input rotational speed
- Load torque
- Temperature
- Lubrication (Type and quantity)

Measurement condition

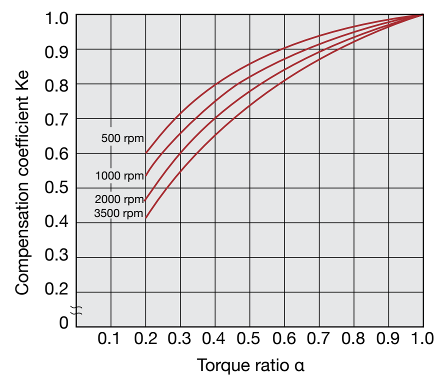
Table 278-1

Installation	Based on recommended tolerance		
Load torque	Rated torque in rating table		
Lubricant	Grease lubrication	Name	Harmonic Grease SK-1A (Size 20 or larger)
			Harmonic Grease SK-2 (Size 14 and 17)
		Quantity	Recommended quantity

■ Efficiency compensation coefficient

When the load torque is lower than the rated torque, the efficiency value decreases. Calculate compensation coefficient Ke from Graph 278-1.

Graph 278-1



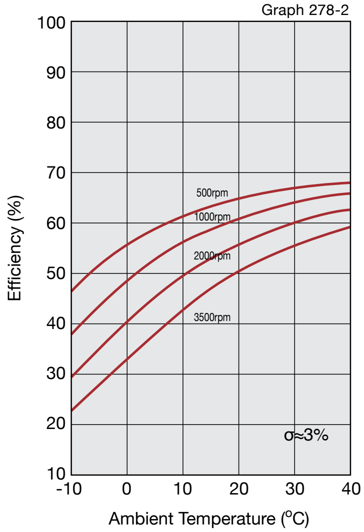
* When the load torque is higher than the rated torque, efficiency compensation value Ke is 1.

■ Efficiency at rated torque

Ratio 50

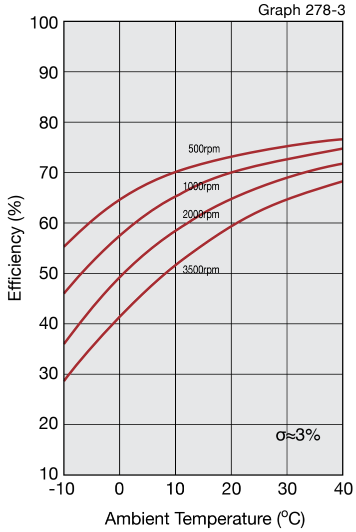
Size 14

Graph 278-2



Size 17, 20, 25, 32, 40

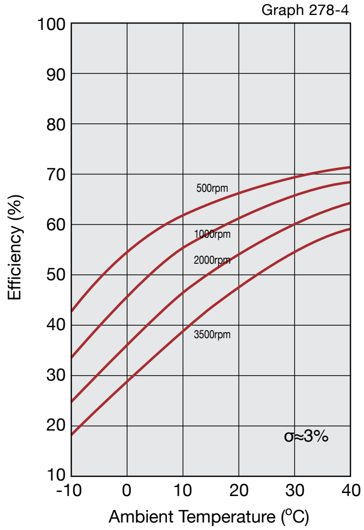
Graph 278-3



Ratio 80, 100

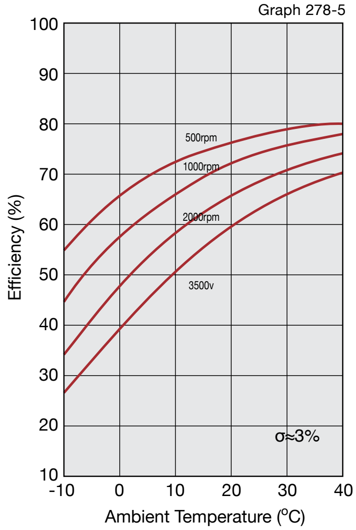
Size 14

Graph 278-4



Size 17, 20, 25, 32, 40

Graph 278-5



SHD-2UH (Gear unit) Efficiency

The efficiency varies depending on the following conditions.

- Reduction ratio
- Input rotational speed
- Load torque
- Temperature
- Lubrication (Type and quantity)

Measurement condition

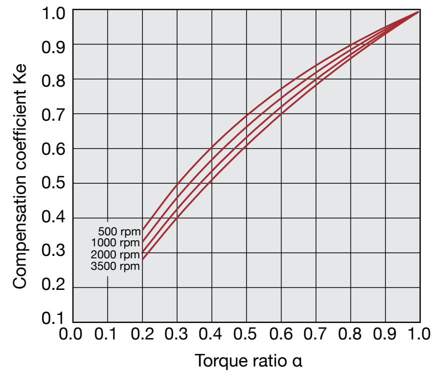
Table 279-1

Installation	Based on recommended tolerance		
Load torque	Rated torque in rating table		
Lubricant	Grease lubrication	Name	Harmonic Grease SK-1A (Size 20 or larger)
			Harmonic Grease SK-2 (Size 14 and 17)
		Quantity	Recommended quantity

Efficiency compensation coefficient

When the load torque is lower than the rated torque, the efficiency value decreases. Calculate compensation coefficient Ke from Graph 279-1.

Graph 279-1

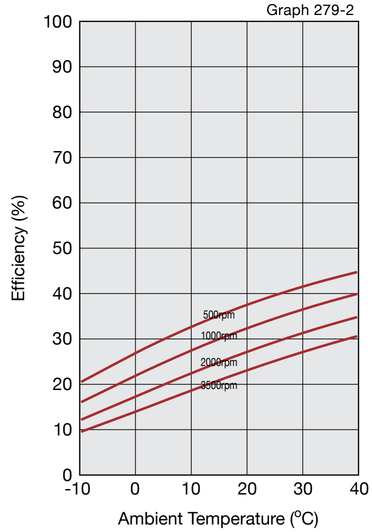


* When the load torque is higher than the rated torque, efficiency compensation value Ke is 1.

Efficiency at rated torque

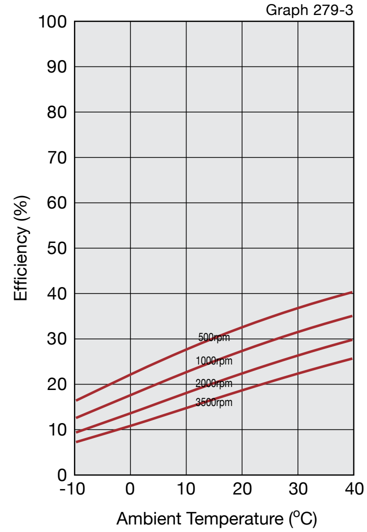
Ratio 50
Size 14

Graph 279-2



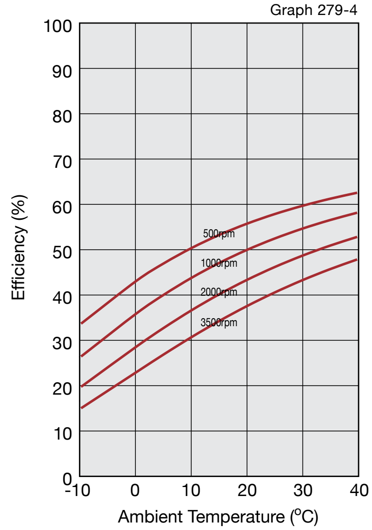
Ratio 80, 100
Size 14

Graph 279-3



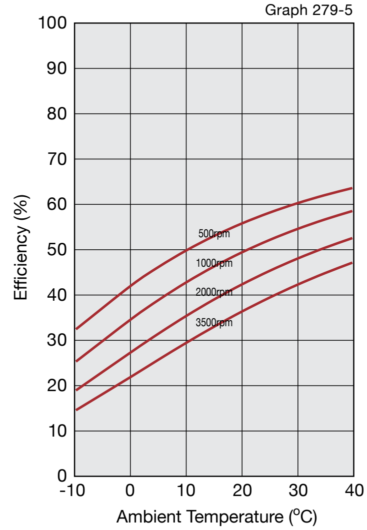
Ratio 50
Size 17, 20, 25, 32, 40

Graph 279-4



Ratio 80, 100
Size 17, 20, 25, 32, 40

Graph 279-5



Checking output bearing

A precision cross roller bearing is built in the unit type to directly support the external load (output flange).
Check the maximum moment load, life of the cross roller bearing and static safety coefficient to fully bring out the performance of the unit type.

See page 030 to 034 of "Engineering data" for each calculation formula.

■ Checking procedure

(1) Checking the maximum moment load (M_{max})

Calculate the maximum moment load (M_{max}). → Maximum moment load (M_{max}) ≦ allowable moment (Mc)

(2) Checking the life

Calculate the average radial load (Fr_{av}) and the average axial load (Fa_{av}) → Calculate the radial load coefficient (x) and the axial load coefficient (y). → Calculate the lifetime

(3) Checking the static safety coefficient

Calculate the static equivalent radial load coefficient (Po). → Check the static safety coefficient. (fs)

■ Output bearing specifications

The specifications of the cross roller are shown in Table 280-1.

Specifications

Table 280-1

Size	Pitch circle dia. of a roller dp	Offset R	Basic rated load				Allowable moment load Mc		Moment stiffness Km	
			Basic dynamic rated load C		Basic static rated load Co					
	m	m	$\times 10^2$N	kgf	$\times 10^2$N	kgf	Nm	kgfm	$\times 10^4$ Nm/rad	kgfm/arc min
14	0.0503	0.0111	29	296	43	438	37	3.8	7.08	2.1
17	0.061	0.0115	52	530	81	826	62	6.3	12.7	3.8
20	0.070	0.011	73	744	110	1122	93	9.5	21	6.2
25	0.086	0.0121	109	1111	179	1825	129	13.2	31	9.2
32	0.112	0.0173	191	1948	327	3334	290	29.6	82.1	24.4
40	0.133	0.0195	216	2203	408	4160	424	43.2	145	43.0

(Note) * The basic dynamic rated load is the static radial load needed to result in a basic dynamic rated life of one million rotations.
* The basic static rated load is the static load that produces a contact stress of 4 kN/mm2 in the center of the contact area between the rolling element receiving the maximum load.
* The moment stiffness value is an average.
* Allowable moment load is the maximum moment load that may be applied to the output shaft. Please adhere to these values for optimum performance. Moment stiffness is a reference value. The minimum value is approximately 80% of the displayed value.
* Allowable axial or radial load is the value that satisfies the reducer life when either a radial load or an axial load is applied to the main shaft. (When radial load is Lr+R=0mm, and axial load is La=0mm)

Simplicity Unit (2SH) Design Guide

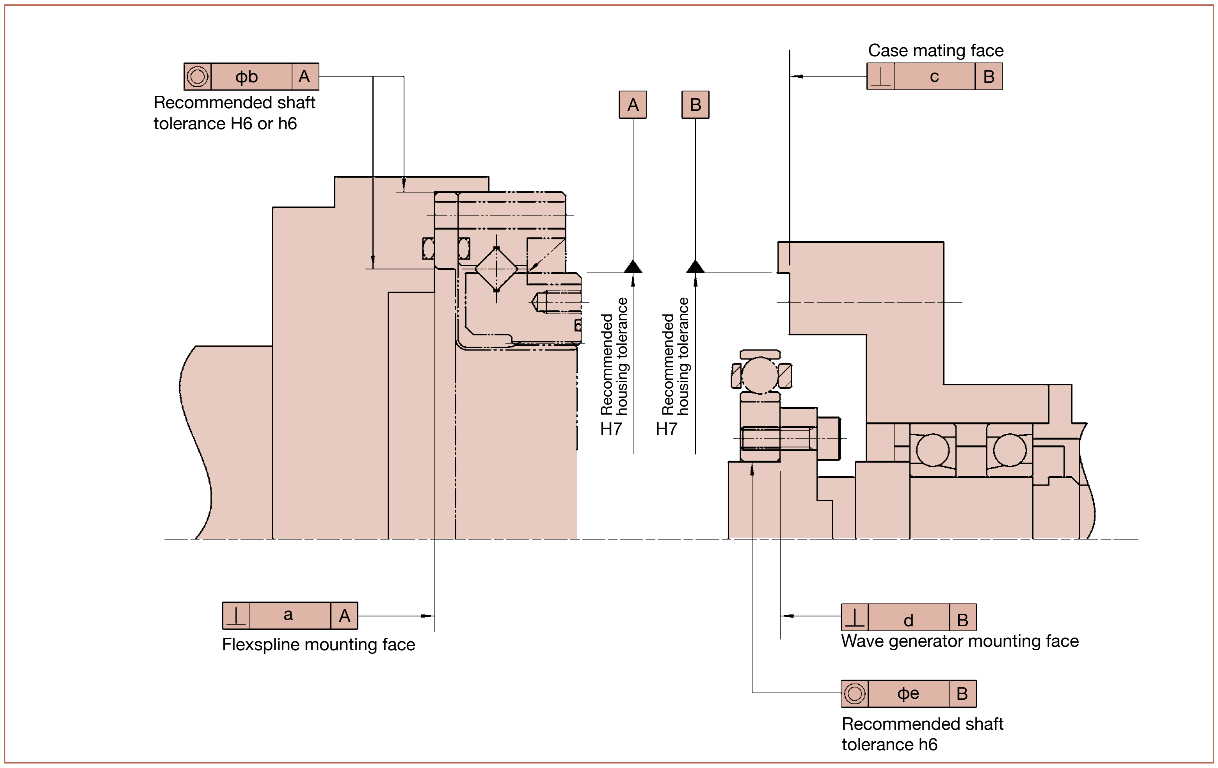
Installation accuracy

For peak performance of the gear, it is essential that the following tolerances be observed when assembly is complete.
Pay careful attention to the following points and maintain the recommended assembly tolerances to avoid grease leakage.

- Warping and deformation on the mounting surface
- Contamination due to foreign matter
- Burrs, raised surfaces and location around the tap area of the mounting holes
- Insufficient chamfering on the mounting pilot joint
- Insufficient radii on the mounting pilot joint

Recommended tolerances for assembly

Fig. 281-1



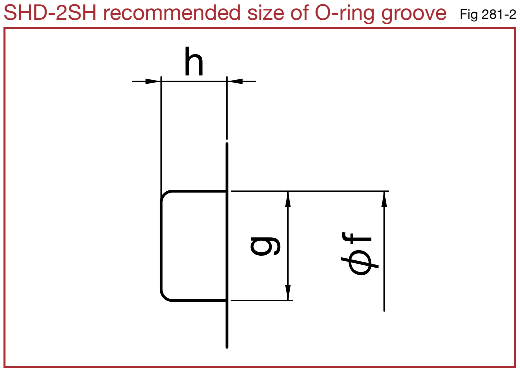
Recommended tolerances for assembly

Table 281-1
Unit：mm

Symbol \ Size	14	17	20	25	32	40
a	0.016	0.021	0.027	0.035	0.042	0.048
ϕb	0.015	0.018	0.019	0.022	0.022	0.024
c	0.011	0.012	0.013	0.014	0.016	0.016
d	0.008	0.010	0.012	0.012	0.012	0.012
ϕe	0.016	0.018	0.019	0.022	0.022	0.024

SHD-2SH recommended size of O-ring groove

Fig 281-2



Recommended size of O-ring groove

Table 281-2
Unit: mm

Size	φf		g		h		O-ring (provided with product)
14	57	+0.1/0	2	+0.25/0	1.1	0/-0.1	54.38 × 1.19
17	68.1	+0.1/0	2	+0.25/0	1.1	0/-0.1	64.0 × 1.5
20	78	+0.1/0	2.7	+0.25/0	1.5	0/-0.1	72.0 × 2.0
25	94.8	+0.1/0	2.4	+0.25/0	1.35	0/-0.1	88.62 × 1.78
32	123	+0.1/0	2.7	+0.25/0	1.5	0/-0.1	117.0 × 2.0
40	148	+0.1/0	2.7	+0.25/0	1.5	0/-0.1	142.0 × 2.0

Unit Type (2UH) Design Guide

Output part and fixed part

The output part of the SHD series varies depending on where it is to be fixed. The reduction ratio and the rotational direction also change. The relation is shown below.

Fig. 282-1

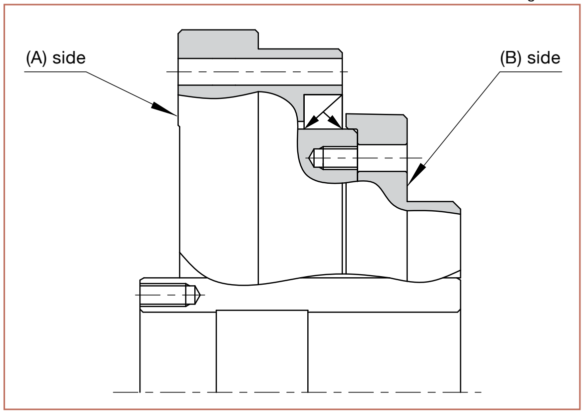


Table 282-1

Fixed part	Output part	Rotational direction and reduction ratio
(A) side	(B) side	(2) on page 011
(B) side	(A) side	(1) on page 011

Installation and transmission torque

Installation and transmission torque on (A) side

Table 282-2

Item \ Size		14	17	20	25	32	40
Number of bolts		8	12	12	12	12	12
Bolt size		M3	M3	M3	M4	M5	M6
Pitch Circle Diameter	mm	64	74	84	102	132	158
Clamp torque	Nm	2.0	2.0	2.0	4.5	9.0	15.3
Transmission torque	Nm	108	186	210	431	892	1509

(Notes)
1. The material of the thread must withstand the clamp torque.
2. Recommended bolt: JIS B 1176 socket head cap screw. Strength range : JIS B 1051 over 12.9.
3. Torque coefficient: K=0.2
4. Tightening coefficient: A=1.4
5. Tightening friction coefficient μ=0.15

Installation and transmission torque on (B) side

Table 282-3

Item \ Size		14	17	20	25	32	40
Number of bolts		8	12	12	12	12	12
Bolt size		M3	M3	M3	M4	M5	M6
Pitch Circle Diameter	mm	43	52	61.4	76	99	120
Effective depth of screw part	mm	4.5	4.5	4.5	6	8	9
Clamp torque	Nm	2.0	2.0	2.0	4.5	9.0	15.3
Transmission torque	Nm	72	130	154	321	668	1148

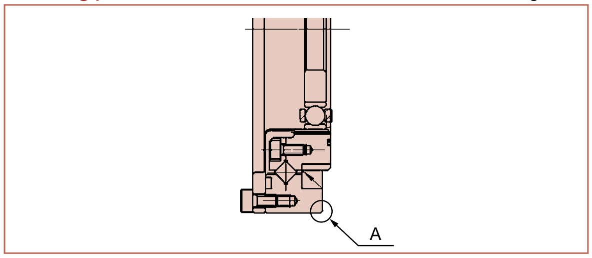
(Notes)
1. The material of the thread must withstand the clamp torque.
2. Recommended bolt: JIS B 1176 socket head cap screw. Strength range : JIS B 1051 over 12.9.
3. Torque coefficient: K=0.2
4. Tightening coefficient: A=1.4
5. Tightening friction coefficient μ=0.15

* Since the flange material on the case side is AL (aluminum), be sure to tighten the bolt to the specified torque as described above.
If the tightening torque exceeds the above value, the correct transmission torque may not be secured or the bolt may be loosened.
Use washers instead of putting the aluminum directly on the bolt-bearing surface when tightening with the bolt from the A side.

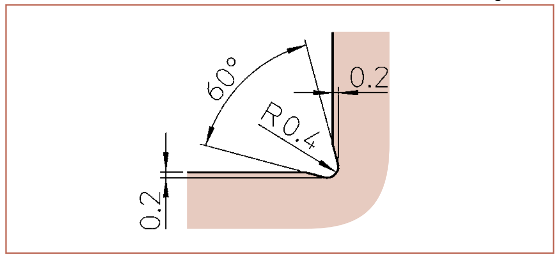
Recessing of the mounting pilot

When the housing interferes with corner “A” shown below, an undercut in the housing is recommended.

Mounting pilot Fig. 283-1



Recommended housing undercut Fig. 283-2

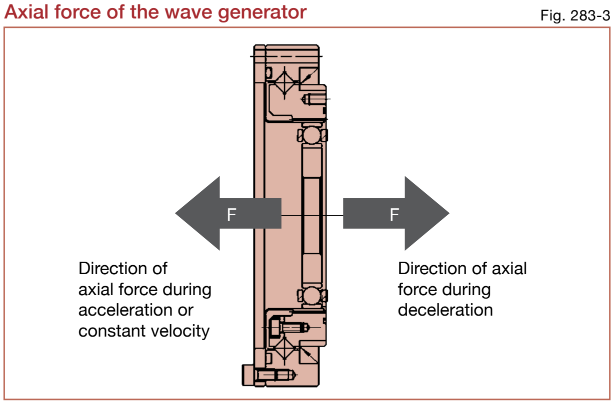


Axial force of the wave generator

When a SHD gear is used to accelerate a load, the deflection of the Flexspline leads to an axial force acting on the Wave Generator. This axial force, which acts in the direction of the back end of the Flexspline, (toward the left in fig. 283-3) must be supported by the bearings of the input shaft (motor shaft).
When an SHD gear is used to decelerate a load, an axial force acts to push the Wave Generator out of the Flexspline (toward the right in fig. 283-3). Maximum axial force of the Wave Generator can be calculated by the equation shown to the right. The axial force may vary depending on its operating condition. The value of axial force tends to be a larger number when using high torque, extreme low speed and constant operation.
The force is calculated (approximately) by the equation. In all cases, the Wave Generator must be axially (in both directions), as well as torsionally, fixed to the input shaft.

(Note) Please contact us for further information on attaching the Wave Generator to the input (motor) shaft.

Axial force of the wave generator Fig. 283-3



Formula for axial force Table 283-2

Ratio	Calculation formula
i =50:1	$F=2\times\frac{T}{D}\times 0.07\times\tan 30°+2\mu PF$
i =100:1 more	$F=2\times\frac{T}{D}\times 0.07\times\tan 20°+2\mu PF$

Axial force by bearing reaction force Table 283-3

Model	Size	2μPF (N)
SHD	14	1.2
	17	3.3
	20	5.6
	25	9.3
	32	16
	40	24

Symbols of the calculation formula Table 283-4

F	Axial force	N	See Fig. 283-3.
D	(Size) × 0.00254	m	
T	Output torque	Nm	
2μPF	Axial force by bearing reaction force	N	See Table 283-3.

Calculation example Formula 283-1

Model : SHD
Size : 32
Ratio : i=50:1
Output torque : 200Nm

$$F=2\times\frac{200}{(32\times 0.00254)}\times 0.07\times\tan 30°+16$$

F=215N

Lubrication

Standard lubrication for SHD series is grease lubrication.
See "Engineering data" on Page 016 for details of the lubricant.

Recommended minimum housing clearance

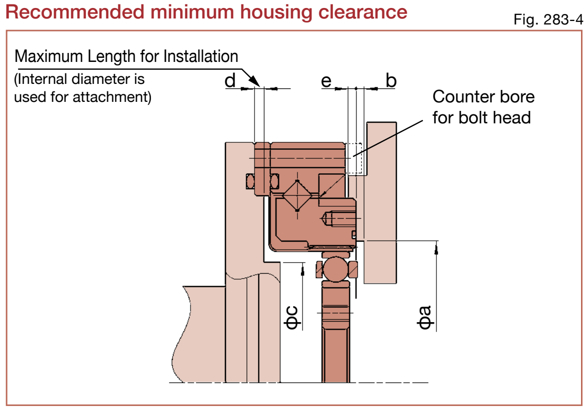
These dimensions must be maintained to prevent damage to the gear and to maintain a proper grease cavity.

Minimum housing clearance Table 283-5 Unit: mm

Symbol \ Size	14	17	20	25	32	40
φa	36.5	45	53	66	86	106
b	1 (3)	1 (3)	1.5 (4.5)	1.5 (4.5)	2 (6)	2.5 (7.5)
φc	31	38	45	56	73	90
d	1.4	1.8	1.7	1.8	1.8	1.8
e	1.5	1.5	1.5	1.5	3.3	4

(Note) The value in parenthesis is the value when the wave generator is facing upward.

Recommended minimum housing clearance Fig. 283-4

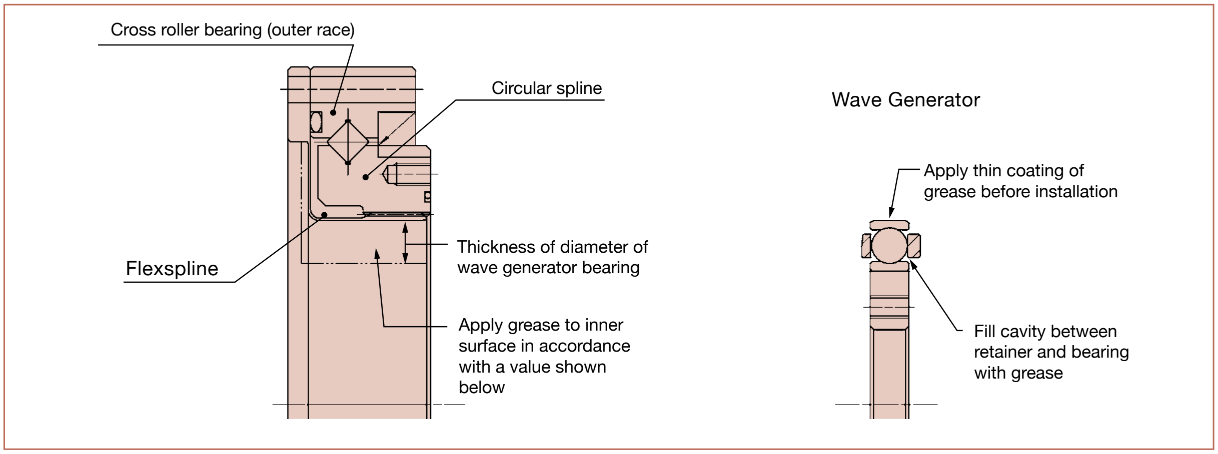


Application guide

As the SHD series is shipped with the outer race of the cross roller bearing and the flexspline temporarily bolted together, grease is applied to the gear teeth, the periphery of the flexspline and the tooth groove of the circular spline. Refer to the following application guide for grease application instructions.

Application guide

Table 284-1



Application quantity

Table 284-1
Unit: g

Size	14	17	20	25	32	40
Application qty	5	9	13	24	51	99

When to replace grease

The wear characteristics of the gear is strongly influenced by the condition of the grease lubrication. The condition of the grease is affected by the ambient temperature. The graph shows the maximum number of input rotations for various temperatures. This graph applies to applications where the average load torque does not exceed the rated torque.

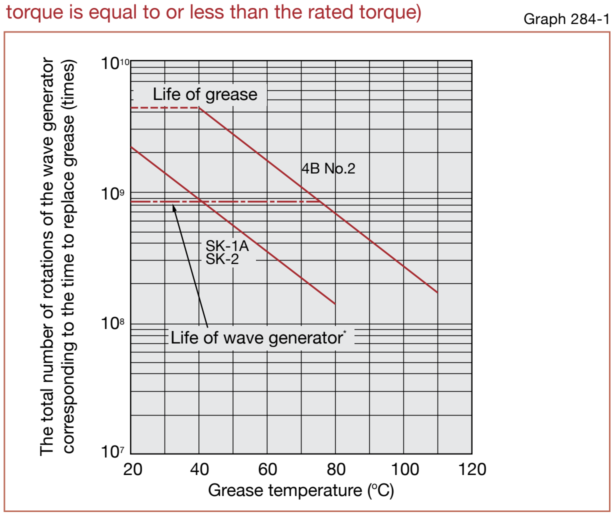
Formula when the average load torque exceeds the rated torque

Formula 284-1

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

When to replace grease: L_{GTn} (when the average load torque is equal to or less than the rated torque)

Graph 284-1



* Life of wave generator is based on L10 life of the bearing.

Symbols for formula

Table 284-2

L_{GT}	Replacement timing if average load torque exceeds rated torque	Number of input revolutions	———
L_{GTn}	Replacement timing if average load torque is equal to or less than rated torque (or use formulas, i.e. Tav ≤ Tr)	Number of input revolutions	See Fig. on the left.
Tr	Rated torque	Nm	See the Rating table on Page 270.
Tav	Average load torque	Nm	Calculation formula: See Page 14.

■ Other precautions

1. Avoid using it with other grease. The gear should be in an individual case when installed.

2. If you use the gear with the wave generator facing upward (see Figure 050-2 on Page 050) at low-speed rotation (input rotational speed: 1000 rpm or less) and in one direction, please contact us as it may cause lubrication problems.

3. Fill the gap between the wave generator and the input cover (motor flange) with grease to use the wave generator facing upward or downward (see Figure 094-2 on Page 094).

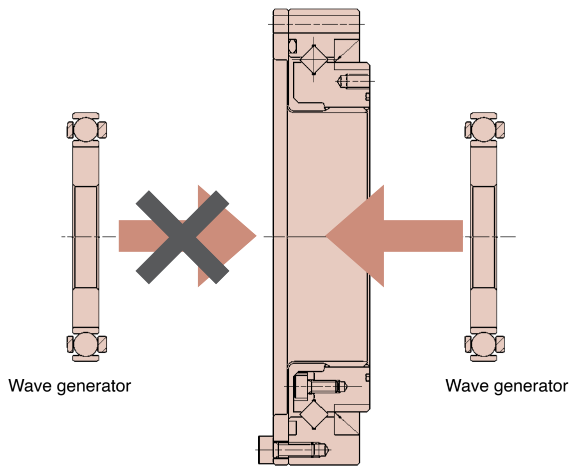
Precautions on installation

■ Assembly order of the three basic elements

The wave generator is installed after the flexspline and circular spline. If the wave generator is not inserted into the flexspline last, gear teeth scuffing damage or improper eccentric gear mesh may result. Installation resulting in an eccentric tooth mesh (Dedoidal) will cause noise and vibration, and can lead to early failure of the gear. For proper function, the teeth of the flexspline and Circular Spline mesh symmetrically.

Assembly order for basic three elements

Fig. 285-1



(Note)
Do not build in the wave generator from the diaphragm side of flexspline.

■ Precautions on assembly

It is extremely important to assemble the gear accurately and in proper sequence. For each of the three components, utilize the following precautions.

Wave generator

1. Avoid applying undue axial force to the wave generator during installation. Rotating the wave generator bearing while inserting it is recommended and will ease the process.
2. Extra care must be given to ensure that concentricity and inclination are within the specified limits (see page 281).
3. Installation bolts on the Wave Generator and Flexspline should not interfere each other.

Circular spline

The circular Spline must not be deformed in any way during the assembly. It is particularly important that the mounting surfaces are prepared correctly.

1. Mounting surfaces need to have adequate flatness, smoothness, and no distortion.
2. Especially in the area of the screw holes, burrs or foreign matter should not be present.
3. Adequate relief in the housing corners is needed to prevent interference with the corner of the circular spline.
4. The circular spline should be rotatable within the housing. Be sure there is not interference and that it does not catch on anything.
5. Bolts should not rotate freely when tightening and should not have any irregularity due to the bolt hole being misaligned or oblique.
6. Do not tighten the bolts with the specified torque all at once. Tighten the bolts temporarily with about half the specified torque, and then tighten them with the specified torque. Tighten them in an even, crisscross pattern.
7. Avoid pinning the circular spline if possible as it can reduce the rotational precision and smoothness of operation.

Flexspline

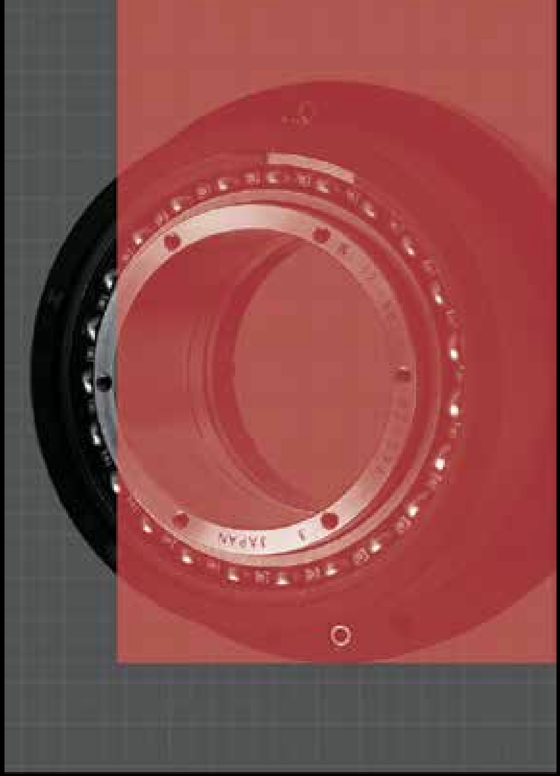
1. Mounting surfaces need to have adequate flatness, smoothness, and no distortion.
2. Especially in the area of the screw holes, burrs or foreign matter should not be present.
3. Adequate clearance with the housing is needed to ensure no interference especially with the major axis of flexspline
4. Bolts should rotate freely when installing through the mounting holes of the flexspline and should not have any irregularity due to the shaft bolt holes being misaligned or oblique.
5. Do not tighten the bolts with the specified torque all at once. Tighten the bolts temporarily with about half the specified torque, and then tighten them to the specified torque. Tighten them in an even, crisscross pattern.
6. The flexspline and circular spline are concentric after assembly. After installing the wave generator bearing, if it rotates in unbalanced way, check the mounting for dedoidal or non-concentric installation.
7. Care should be taken not to damage the flexspline diaphragm or gear teeth during assembly.

   Avoid hitting the tips of the flexspline teeth and circular spline teeth. Avoid installing the CS from the open side of the flexspline after the wave generator has been installed.

Rust prevention

Although Harmonic Drive® gears come with some corrosion protection, the gear can rust if exposed to the environment. The gear external surfaces typically have only a temporary corrosion inhibitor and some oil applied. If an anti-rust product is needed, please contact us to review the options.

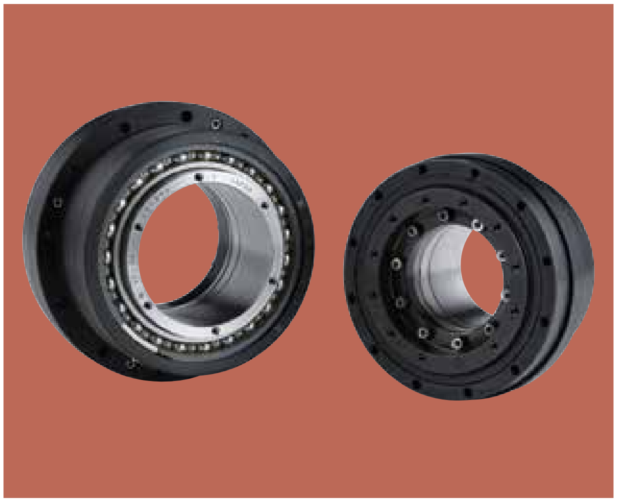
MEMO



FBS-2UH Series

Unit Type FBS-2UH

Features

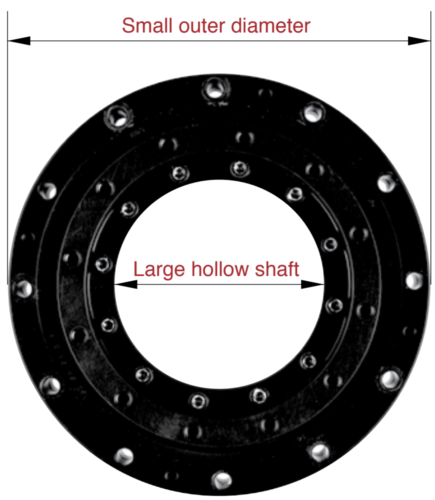


FBS-2UH Extra-Large Hollow Shaft

This Harmonic Drive® gear features a large, hollow shaft with a compact outer diameter. An extra large hollow shaft is ideal for robots and machines requiring complex cabling to pass through the axis of rotation. The new gear design features Harmonic Drive's "S" tooth profile for optimal tooth engagement resulting in high torque, high-torsional stiffness, long life and smooth rotation. The new FBS Series is available in two sizes (25, 32) and three ratios (30:1, 50:1, 100:1).

Features of FBS-2UH Series

- Extra large hollow-shaft diameter is our largest yet for a standard product
- Compact dimensions for use in robotics
- Outer diameter and hollow bore optimized for design flexibility and performance



Ratio of the hollow-shaft diameter to the outer diameter

Table 288-1

Size	Hollow-shaft diameter	Outer diameter	Ratio
25	41.0mm	93mm	44%
32	55.1mm	113mm	49%

Ordering Code

FBS - 25 - 30 - 2UH - SP

Table 288-2

Model name	Size	Reduction ratio			Model	Special Specifications
FBS Series	25	30	50	100	Unit Type	Blank = Standard Product SP = Special Specifications Code
	32	30	50	100		

Technical Data

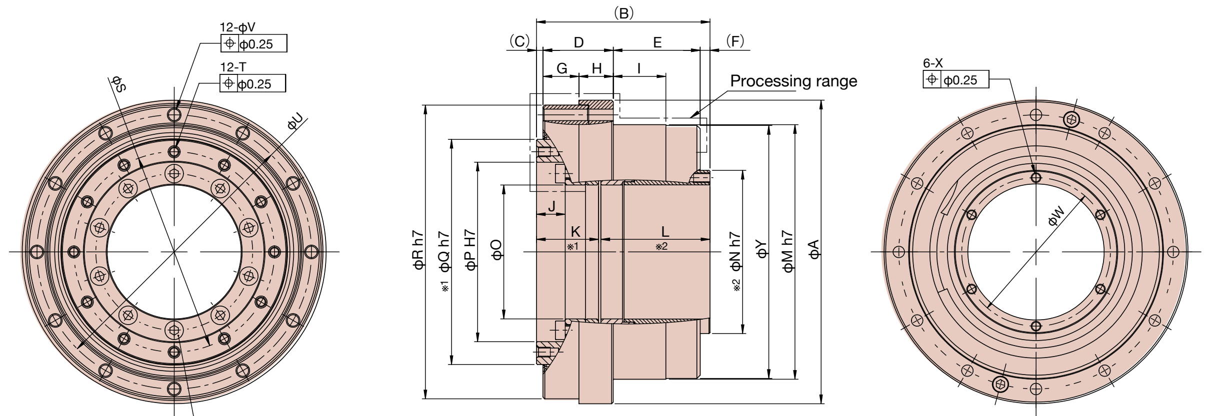
Rating table

Table 289-1

Size	Reduction ratio	Rated torque at input speed 2000rpm		Limit for repeated peak torque		Limit for average load		Limit for momentary peak torque		Maximum input speed	Limit for average input speed	Moment of inertia (1 / 4GD^2)
		N·m	kgf·m	N·m	kgf·m	N·m	kgf·m	N·m	kgf·m	rpm	rpm	kg·cm^2
25	30	15	1.5	25	2.5	24	2.4	50	5.1	3600	2500	1.0
	50	22	2.2	47	4.8	35	3.6	93	9.5			
	100	37	3.8	70	7.1	59	6.0	100	10.2			
32	30	30	3.1	48	4.9	48	4.9	96	9.8		2300	3.3
	50	43	4.4	92	9.4	67	6.8	151	15.4			
	100	56	5.7	106	10.8	89	9.1	151	15.4			

■ Outline dimensions

Fig 289-1



Cross roller bearing inner ring fixing bolt
Size 25
Ratio 30, 50: 10-M3x10 evenly arranged
Ratio 100: 20 equally spaced15-M3x10
Size 32
Ratio 30, 50: 12-M3x14 evenly arranged
Ratio100: 24 equally spaced18-M3x14

※1: Outer diameter of output rotor part (low-speed rotation side)
※2: Outer diameter of input rotor part (high-speed rotation side)

■ Measurement table

Table 289-2
Unit: mm

Symbol \ Size	ϕA	B	C	D	E	F	G	H	I	J	K	L	ϕM h7	ϕN h7	ϕO	ϕP H7	ϕQ h7	ϕR h7	ϕS	T	ϕU	ϕV	ϕW	X	ϕY
25	93	53.1	2	21.5	26.6	3	11.0	10.5	16.1	8.8	19.0	33.4	78	50	41.0	55	69	90	61.4	M3×4.5	84	3.5	45.5	M3×5	77.5
32	113	62.5	2	25.2	32.3	3	13.7	11.5	20.0	7.5	21.7	39.97	96	65	55.1	69	84	110	77.0	M4×6.0	102	4.5	60.0	M3×6	95.5

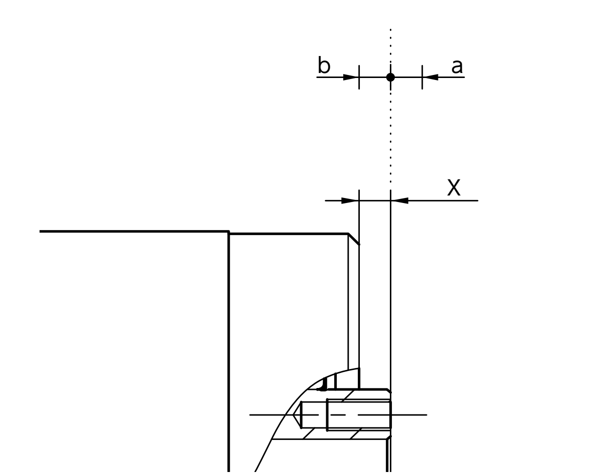
■ Input part (wave generator axial clearance)

The support structure of the input part has internal clearance, and the input part moves depending on the external force or operating conditions. The following table shows the axial clearance.
If positioning in the axial direction is required, the design that can fix the part must be secured.

Table 289-3
Unit: mm

Size	Dimension X	Axial clearance	
		a	b
25	3	0.1 to 0.7	0.0 to 0.6
32	3	0.2 to 0.8	0.1 to 0.7

Fig 289-2



Positional accuracy

See “Engineering data” for a description of terms.

Table 290-1

Reduction ratio	Unit	25	32
30	$\times10^{-4}$rad	8.7	8.7
	arc-min	3	3
50	$\times10^{-4}$rad	5.8	5.8
	arc-min	2	2
100	$\times10^{-4}$rad	5.8	5.8
	arc-min	2	2

Hysteresis loss

See “Engineering data” for a description of terms.

Table 290-2

Reduction ratio	Unit	25	32
30	$\times10^{-4}$rad	8.7	8.7
	arc-min	3	3
50	$\times10^{-4}$rad	5.8	5.8
	arc-min	2	2
100	$\times10^{-4}$rad	2.9	2.9
	arc-min	1	1

Torsional stiffness

See “Engineering data” for a description of terms.

Table 290-3

Symbol		Unit	25	32
T_1		N·m	7.4	16
		kgf·m	0.75	1.6
T_2		N·m	26	55
		kgf·m	2.7	5.6
Reduction ratio 30	K_1	$\times10^4$N·m/rad	1.3	2.1
		kgf·m/arc-min	0.4	0.64
	K_2	$\times10^4$N·m/rad	1.3	2.4
		kgf·m/arc-min	0.4	0.71
	K_3	$\times10^4$N·m/rad	1.6	2.9
		kgf·m/arc-min	0.48	0.87
	θ_1	$\times10^{-4}$rad	5.4	7.4
		arc-min	1.9	2.5
	θ_2	$\times10^{-4}$rad	19	24
		arc-min	6.6	8.2
Reduction ratio 50	K_1	$\times10^4$N·m/rad	1.9	3.5
		kgf·m/arc-min	0.56	1.0
	K_2	$\times10^4$N·m/rad	2.0	3.7
		kgf·m/arc-min	0.6	1.1
	K_3	$\times10^4$N·m/rad	2.3	4.3
		kgf·m/arc-min	0.69	1.3
	θ_1	$\times10^{-4}$rad	3.9	4.5
		arc-min	1.4	1.6
	θ_2	$\times10^{-4}$rad	13	15
		arc-min	4.5	5.2
Reduction ratio 100	K_1	$\times10^4$N·m/rad	3.2	6.5
		kgf·m/arc-min	0.94	1.9
	K_2	$\times10^4$N·m/rad	3.2	6.5
		kgf·m/arc-min	0.94	1.9
	K_3	$\times10^4$N·m/rad	3.2	6.6
		kgf·m/arc-min	0.94	2.0
	θ_1	$\times10^{-4}$rad	2.0	2.2
		arc-min	0.7	0.8
	θ_2	$\times10^{-4}$rad	7.8	8.3
		arc-min	2.7	2.9

* The values in this table are reference values. The lower-limit value is approximately 70% of the displayed value.

Starting torque

See "Engineering data" for a description of terms. As the values in the table below vary depending on the use conditions, use them as reference values.

Table 291-1
Unit: cN·m

Reduction ratio \ Size	25	32
30	25	54
50	15	31
100	11	20

Backdriving torque

See "Engineering data" for a description of terms. As the values in the table below vary depending on the use conditions, use them as reference values.

Table 291-2
Unit: N·m

Reduction ratio \ Size	25	32
30	11	23
50	9	18
100	13	22

Ratcheting torque

See "Engineering data" for a description of terms.

Table 291-3
Unit: N·m

Reduction ratio \ Size	25	32
30	170	270
50	200	410
100	270	510

Buckling torque

See "Engineering data" for a description of terms.

If the torque that exceeds the value listed in the following table is applied to the output part while the input part is fixed, the tightening part of the unit is damaged, and the torque cannot be transmitted.

Table 291-4
Unit: N·m

Reduction ratio \ Size	25	32
30	370	730
50		
100		

No-load running torque

No-load running torque is the torque which is required to rotate the input side (high speed side), when there is no load on the output side (low speed side).

* For detailed values, contact us.

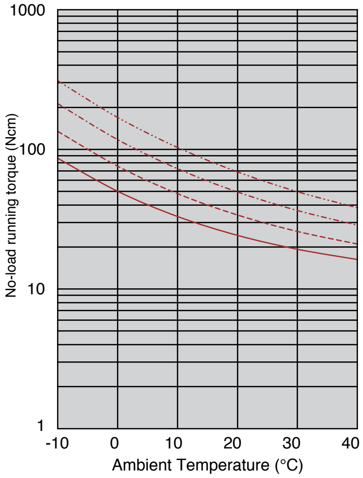
Measuring condition

Table 292-1

	Reducer	Main roller bearing
Lubricant	Harmonic Grease® SK-1A	Harmonic Grease® 4B No.2
Torque value is measured after 2 hours at 2000rpm input.		

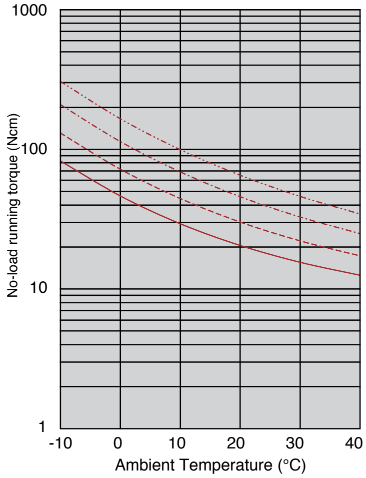
Size: 25
Reduction ratio: 30

Graph 292-1



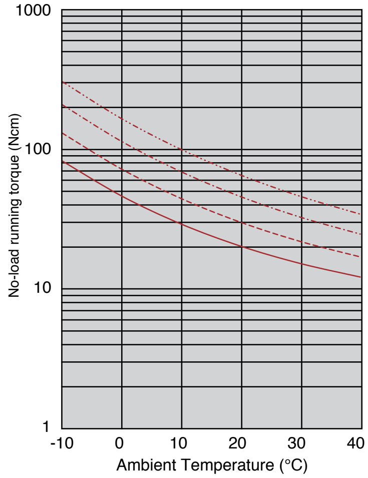
Size: 25
Reduction ratio: 50

Graph 292-2



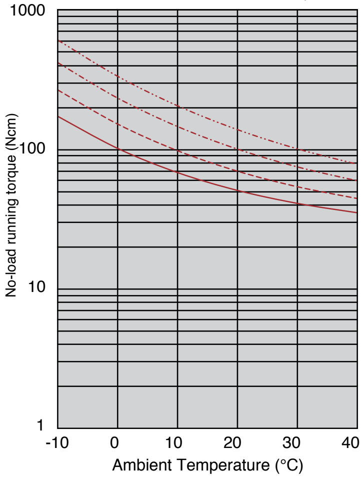
Size: 25
Reduction ratio: 100

Graph 292-3



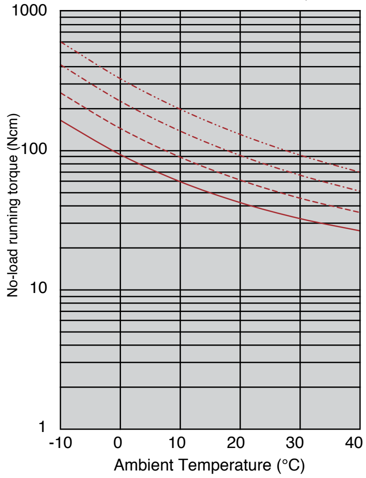
Size: 32
Reduction ratio: 30

Graph 292-4



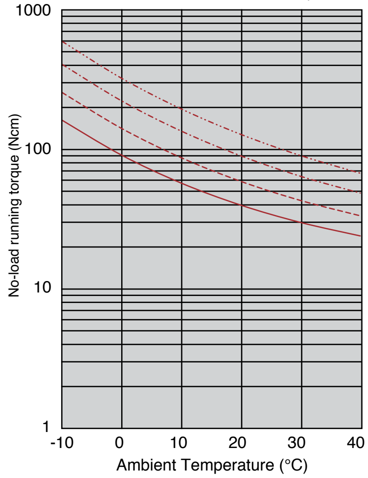
Size: 32
Reduction ratio: 50

Graph 292-5



Size: 32
Reduction ratio: 100

Graph 292-6



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

Note: These graph values are average of $\bar{X}$.

Efficiency

When the load torque is lower than the rated torque, the efficiency value decreases. Calculate the compensation coefficient Ke from Graph 293-1 using the following example.

*1 The efficiency compensation coefficient is the average value when the grease temperature is approximately 30°C.
*2 When the load torque is greater than the rated torque, the efficiency compensation coefficient Ke = 1.

Efficiency correction coefficient: Ke
Efficiency at rated torque: ηR
Efficiency depending on the load torque: η

$\eta = Ke \times \eta R$

$\text{Torque ratio } \alpha = \dfrac{\text{Load torque}}{\text{Rated torque}}$

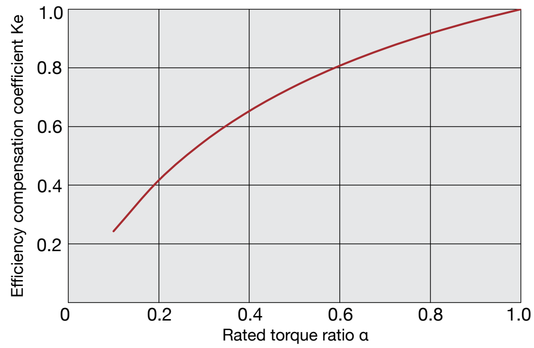
Measuring condition

Table 293-1

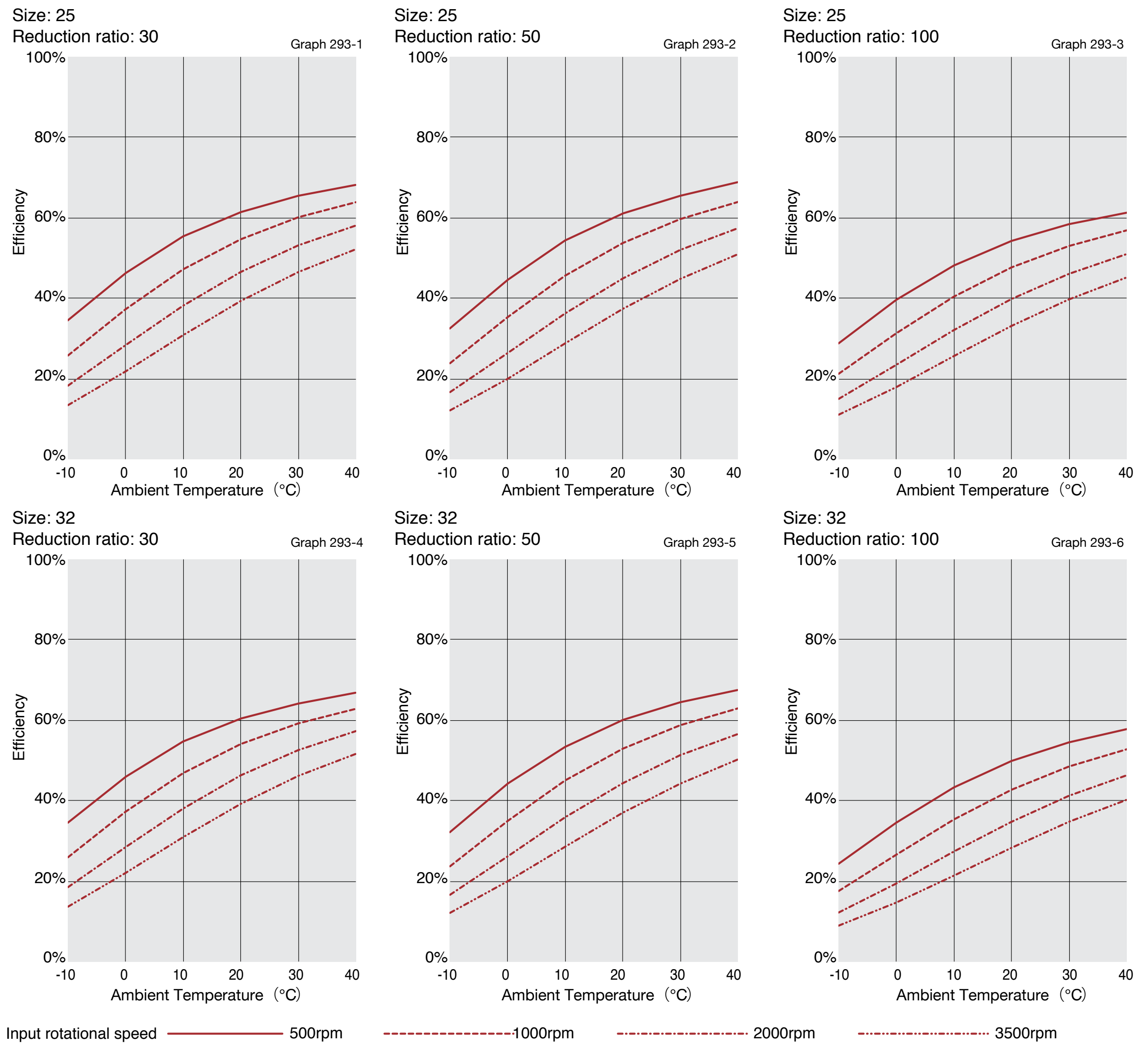
	Reducer	Main roller bearing
Lubricant	Harmonic Grease® SK-1A	Harmonic Grease® 4B No.2
The efficiency value is measured after two or more hours run-in at 2000 rpm input speed.		

Efficiency compensation coefficient

Graph 293-1



Efficiency at rated torque



Note: These graph values are average of $\bar{X}$.

Checking output bearing

A precision cross roller bearing is built in the unit type to directly support the external load (output flange).
Please calculate maximum moment load, life of cross roller bearing, and static safety factor to fully maximize the performance of housed unit (gearhead).

■ Checking procedure

(1) Checking the maximum load moment load (M_{max})

Calculate the maximum moment load (M_{max}). → Maximum moment load (M_{max}) ≦ allowable moment (Mc)

(2) Checking the life

Calculate the average radial load (F_{rav}) and the average axial load (F_{aav}). → Calculate the radial load coefficient (x) and the axial load coefficient (y). → Calculate the lifetime

(3) Checking the static safety coefficient

Calculate the static equivalent radial load coefficient (Po). → Check the static safety coefficient. (fs)

■ Output bearing specifications

Table 294-1

Size	Pitch circle dia. of a roller dp	Offset amount R	Basic rated load: Basic dynamic rated load C		Basic rated load: Basic static rated load Co		Allowable moment load Mc		Moment stiffness Km	
	m	m	$\times 10^2$N	kgf	$\times 10^2$N	kgf	N·m	kgf·m	$\times 10^4$N·m/rad	kgf·m/arc-min
25	0.070	0.0110	73	744	110	1122	93	9.5	21	6.2
32	0.086	0.0121	109	1111	179	1825	129	13.2	31	9.2

Installation accuracy

Fig 294-1

Recommended tolerances for assembly

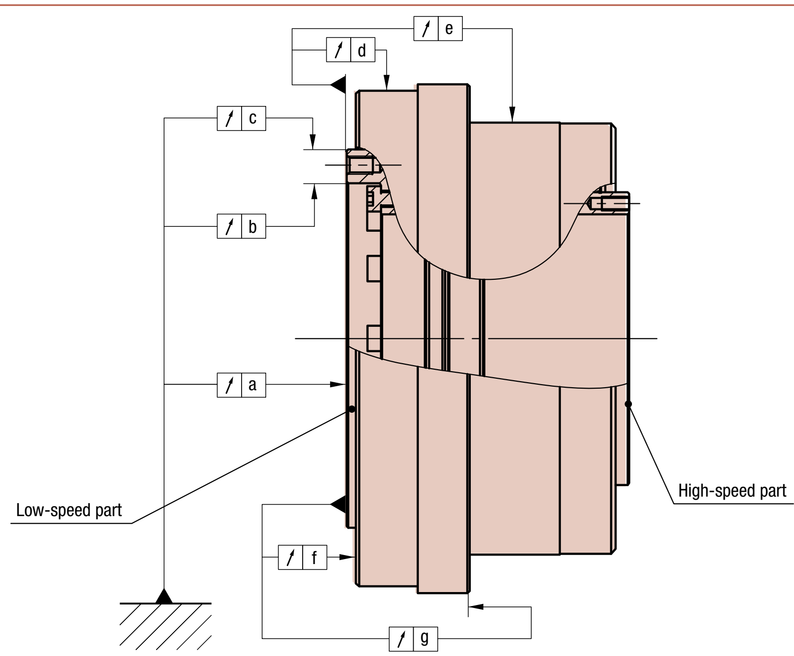


Table 294-2

Recommended tolerances for assembly

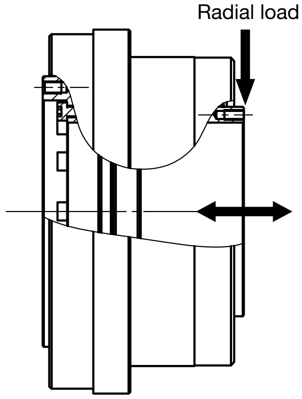
Unit: mm

Symbol \ Size	25	32
a	0.015	0.015
b	0.010	0.010
c	0.010	0.010
d	0.010	0.013
e	0.070	0.073
f	0.010	0.010
g	0.018	0.024

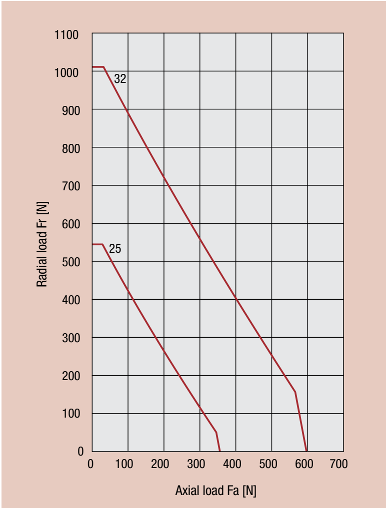
Allowable load on the input shaft

Two bearings support the input part. To fully exert the performance, please check the load to be applied to the input part.
The following graph shows the maximum allowable radial load and thrust load for each size.
Note that the values on the graph are the examples when the average input speed is 2000 rpm and basic rating life L_{10} is 5,000 hours.

Fig 295-1



Graph 295-1



Axial force of the input shaft

Axial force applies to the wave generator during operation due to elastic deformation of the flexspline.
In response to this force, this product may move in the shaft direction since the wave generator support structure has the clearance.
To reduce the movement in the input shaft direction, the design to receive the thrust force must be secured.
The thrust force (maximum value) of the wave generator can be obtained through the following formula.
The severity and direction of the thrust force varies depending on the operating conditions. The axial force tends to increase at the extremely low speed and during the fixed continuous speed while the torque is higher, and is approximately equal to the value obtained by the formula. In both cases, the design to receive the thrust force of the wave generator must be secured.

Fig 295-2

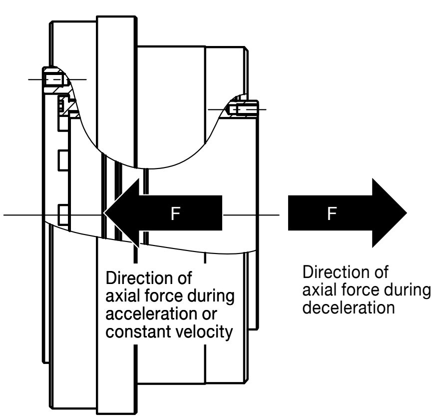


Table 295-1

Reduction ratio	Formula
30	$F=5.2\times \frac{T}{D}\times 0.07\times \tan 32°$
More than 50	$F=5.2\times \frac{T}{D}\times 0.07\times \tan 30°$

F = Axial force (N)
T = Output torque (N·m)
D = (Size) x 0.00254 (m)

Engineering Data
Component Sets
Gear Units
Phase Adjusters
Gearheads & Actuators

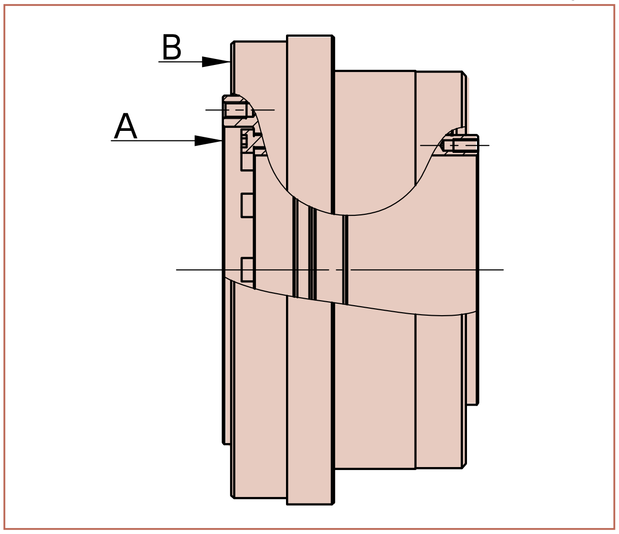
Installation accuracy and transmission torque

■ Installation accuracy

For peak performance of the gear, it is essential that the following tolerances be observed when assembly is complete. Pay careful attention to the following points and maintain the recommended assembly tolerances to avoid grease leakage.

- Warping and deformation on the mounting surface
- Contamination due to foreign matter
- Burrs, raised surfaces and location around the tap area of the mounting holes
- Insufficient chamfering on the mounting pilot joint
- Insufficient radii on the mounting pilot joint

Fig 296-1



Installation and bolt transmission torque on side A

Table 296-1

Item \ Size		25	32
Number of bolts		12	12
Bolt size		M3	M4
Installation of bolts: P.C.D.	mm	61.4	77.0
Bolt tightening torque	N·m	2.0	4.5
	kgf·m	0.20	0.46
Bolt transmission torque	N·m	154	324
	kgf·m	15.7	33.1

1. It is assumed that the material of the female screws can endure the bolt tightening torque.
2. Recommended bolt Bolt name: JIS B 1176 hexagonal bolt
   Intensity type: JIS B 1051 12.9 or more
3. Torque efficiency: K=0.2
4. Tightening efficiency: A=1.4
5. Friction coefficient on the surface contacted: μ=0.15

Installation and bolt transmission torque on side B

Table 296-2

Item \ Size		25	32
Number of bolts		12	12
Bolt size		M3	M4
Installation of bolts: P.C.D.	mm	84	102
Bolt tightening torque	N·m	2.0	4.5
	kgf·m	0.20	0.46
Bolt transmission torque	N·m	210	431
	kgf·m	21	44

1. It is assumed that the material of the female screws can endure the bolt tightening torque.
2. Recommended bolt Bolt name: JIS B 1176 hexagonal bolt
   Intensity type: JIS B 1051 12.9 or more
3. Torque efficiency: K=0.2
4. Tightening efficiency: A=1.4
5. Friction coefficient on the surface contacted: μ=0.15

■ Manufacturing for Mating Part and Housing

When the housing interferes with corner “A”, an undercut in the housing is recommended as shown below.

Fig 296-2

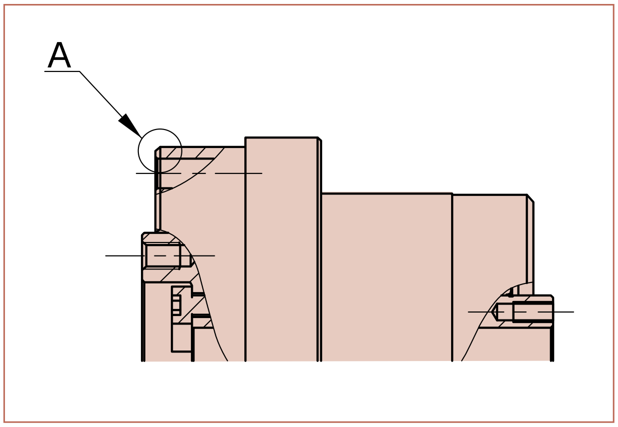
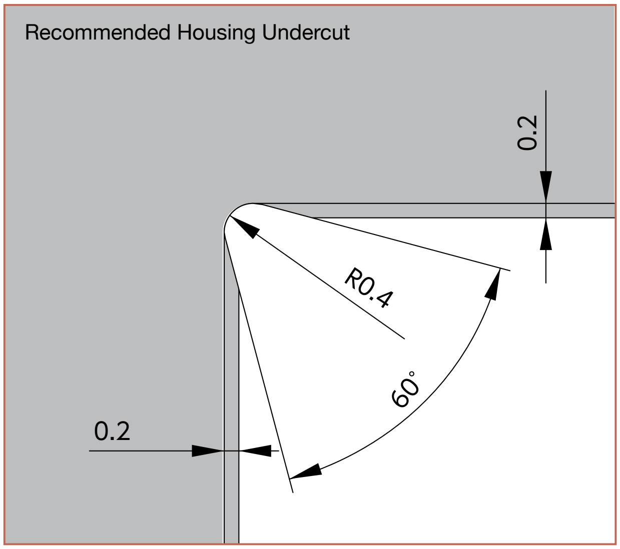


Fig 296-3



Lubrication

For lubrication of FBS-2UH, grease is used. The product is shipped with grease applied. Additional grease or lubricant is not required during assembly. For lubrication, use the following grease.

■ When to replace grease

See "Engineering data" for details.

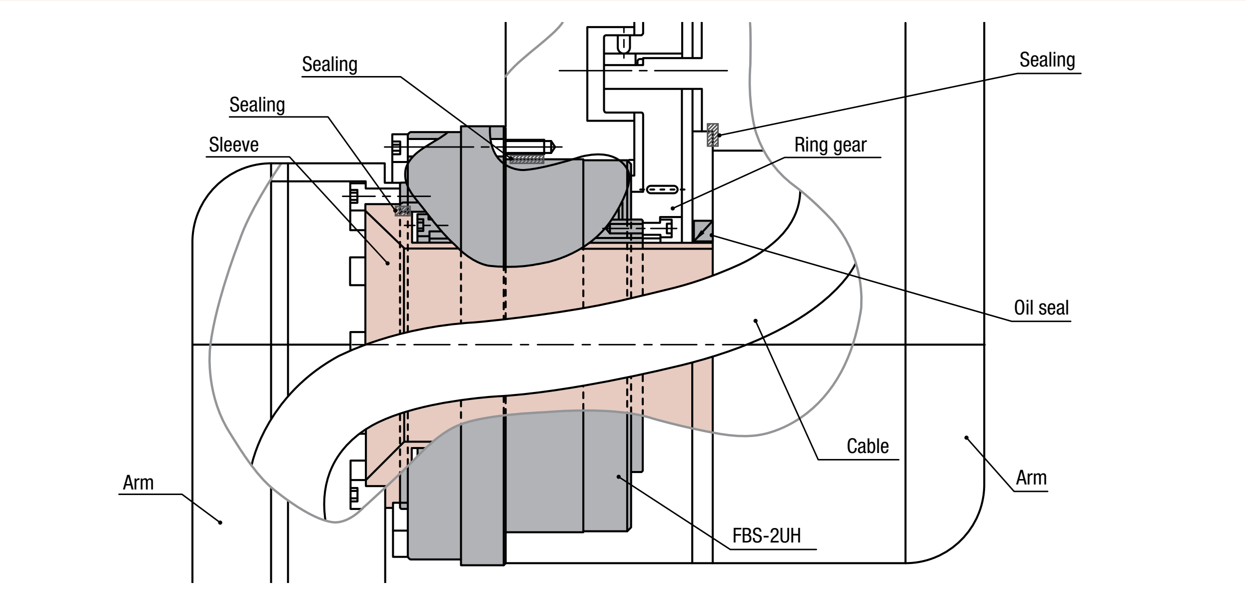
Table 297-1

Lubricated area	Reducer	Main roller bearing
Lubricant name	Harmonic Grease® SK-1A	Harmonic Grease® 4B No.2
Manufacturer	Harmonic Drive Systems Inc.	
Base oil	Refined oil	Composite hydrocarbon oil
Puffing agent	Lithium soap base	Urea
Mixing consistency (25°C)	265 to 295	290 to 320
Drop point	197°C	247°C
Exterior	Yellow	Light yellow

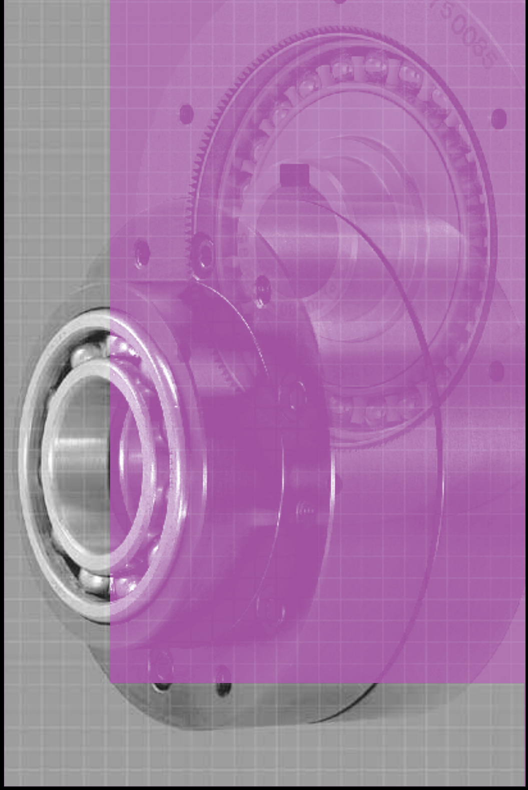
Application

FBS-2UH is not equipped with the sealing mechanism on the input side (high speed side) to prevent larger loss of friction caused by the larger-diameter sealing mechanism.
The following figure shows an example of sealing of the housing and on the output side (low speed side) to reduce loss of friction on the input side (high speed side) and greatly utilize the hollow-shaft shape. Note that the sealing agent or sealing mechanism such as an O-ring is required for each part to prevent grease leakage.

Fig 297-1



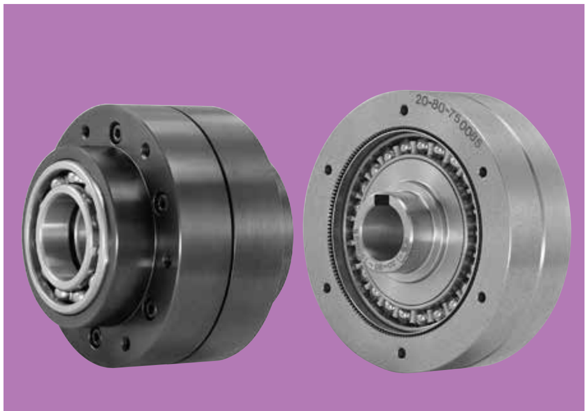
MEMO



FD Series

Differential Gear FD

Features



Unit type　　Component type

Differential gear FD series

The FD series is an extremely compact differential unit that allows you to fine-tune the phase and timing during operation.
Like the pancake component sets, the FD series consist of four parts. FD is available as a gear unit with housing or as a component set without a housing. The housing enables additional gears or pulleys to be directly mounted onto it.

Features of FD series

- Pancake component set
- Ultra compact differential unit
- Backlash is very small and unit requires no assembly adjustment
- Very large reduction ratios between the adjusting shaft and the output, it allows precision position adjustment and requires little torque for adjusting the shaft
- Easily installed into OEM equipment
- Component set consists of only four parts and is mounted coaxially

Structure of the FD series

Fig. 300-1

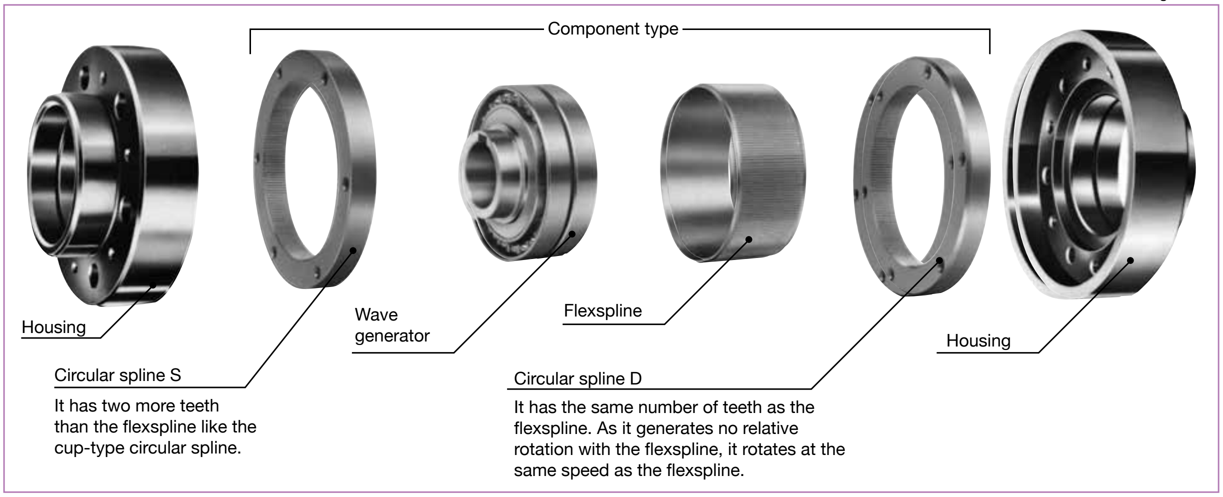
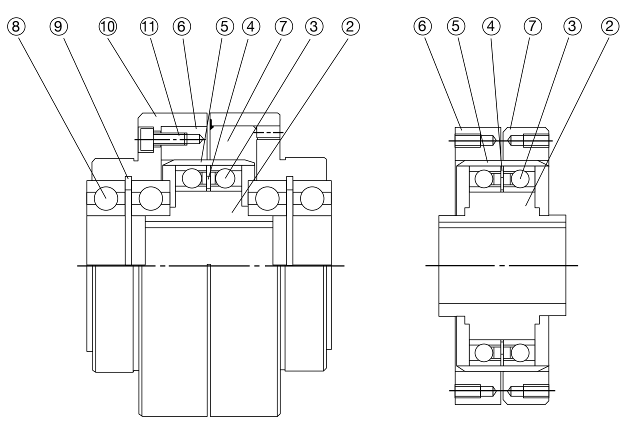


Fig. 300-2



Unit type (FD-0)　　Component type (FD-2)

Part No.	Part name
① ② ③ ④	Wave generator Wave generator plug Wave generator bearing Retainer presser
⑤	Flexspline
⑥	Circular spline S
⑦	Circular spline D
⑧	Ball bearing
⑨	Internal C-type stop ring
⑩	Housing
⑪	Bolt with hexagonal hole

(Note) How to tell circular spline D from circular spline S
The peripheral chamfering of circular spline D is larger than that of circular spline S.

Rotational direction and reduction ratio

The rotational direction is the same as the FB series (Page 105).
This section describes how to use the unit as a differential unit.
(R indicates the reduction ratio value in the ratings table.)

Fig. 301-1

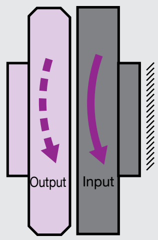
①

Input: Circular spline S
Output: Circular spline D
Fixed: Wave generator
Reduction ratio (i) is:

$$i=\frac{R+1}{R}$$

Hence, input rotation: N_S
output speed: N_{D1}

$$N_{D1}=\frac{R+1}{R}N_S$$



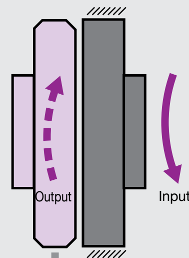
②

Input: Wave generator
Output: Circular spline D
Fixed: Circular spline S
Reduction ratio (i) is:

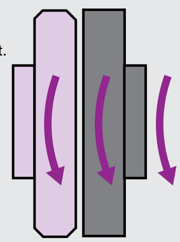
$$i=-\frac{1}{R}$$

Hence, input rotation: N_W
output speed: N_{D2}

$$N_{D2}=-\frac{1}{R}N_W$$



When ① and ② are combined, the rotational speed of circular spline S is represented as shown on the right.



$$N_D=N_{D1}+N_{D2}$$
$$=\frac{R+1}{R}N_S \underset{(+)}{-} \frac{1}{R}N_W$$

(Note) The sign (+) indicates that the wave generator is turned in the opposite direction to the circular spline S.

Fig. 301-2

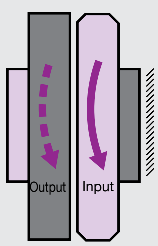
①

Input: Circular spline D
Output: Circular spline S
Fixed: Wave generator
Reduction ratio (i) is:

$$i=\frac{R}{R+1}$$

Hence, input rotation: N_D
output speed: N_{S1}

$$N_{S1}=\frac{R}{R+1}N_D$$



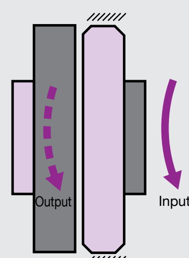
②

Input: Wave generator
Output: Circular spline S
Fixed: Circular spline D
Reduction ratio (i) is:

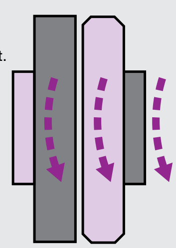
$$i=\frac{1}{R+1}$$

Hence, input rotation: N_W
output speed: N_{S2}

$$N_{S2}=\frac{1}{R+1}N_W$$



When ① and ② are combined, the rotational speed of circular spline D is represented as shown on the right.



$$N_S=N_{S1}+N_{S2}$$
$$=\frac{R}{R+1}N_D \underset{(-)}{+} \frac{1}{R+1}N_W$$

(Note) The sign (-) indicates that the wave generator is turned in the opposite direction to the circular spline D.

Engineering Data

Component Sets

Gear Units

Phase Adjusters

Gearheads & Actuators

Ordering Code

FD - 20 - 80 - 0 - G

Table 302-1

Series	Size	Ratio *1																					Model	
FD	20	—	80	—	—	100	—	—	—	128	—	—	—	—	160	—	—	—	—	—	—	—	0= Unit type 2= Component type	Unit type G= Oil lubrication G-GP= Grease lubrication Component type G= New type
	25	—	80	—	—	100	—	—	120	—	—	—	—	—	160	—	200	—	—	—	—	—		
	32	78	—	—	—	100	—	—	—	—	131	—	157	—	—	—	200	—	—	—	260	—		
	40	—	80	—	—	100	—	—	—	128	—	—	—	—	160	—	200	—	—	258	—	—		
	50	—	80	—	—	100	—	—	120	—	—	—	—	—	160	—	200	—	242	—	—	—		
	65	78	—	—	—	—	104	—	—	—	—	132	—	158	—	—	—	208	—	—	260	—		
	80	—	80	—	96	—	—	—	—	128	—	—	—	—	160	194	—	—	—	258	—	320		
	100	—	80	—	—	100	—	—	120	—	—	—	—	—	160	—	200	—	242	—	—	320		

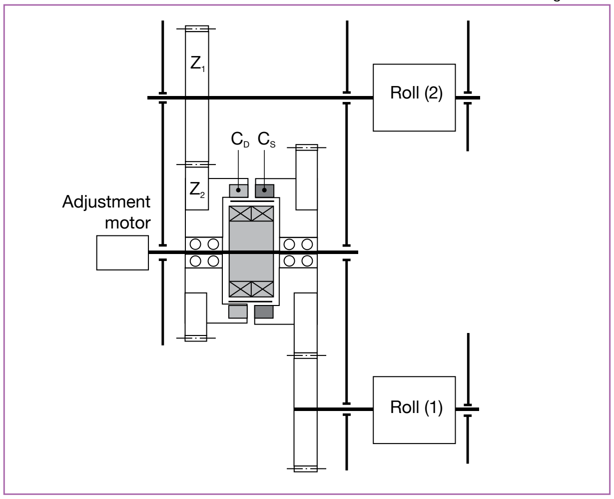
*1 The reduction ratio value is based on the following configuration:
Input: wave generator, fixed: circular spline S, output: circular spline D

How To Use

Usage example

Phase adjustment

Fig. 303-1



Brake a unit to adjust the phase of two rolls, normally an adjusting motor, and rotate it in the system: roll (1) → C_S → C_D → Roll (2). When the phase of Roll (2) against Roll (1) needs to be adjusted, the adjusting motor should be rotated. Stop the motor after adjustment and return Roll (2) to the original rotation.

(Calculation formula)
When the adjusting motor is fixed, the rotational speed of Roll (2) should be N_O. Assuming that the adjusting motor rotates in N_W, rotational speed N of the roll is expressed as follows.

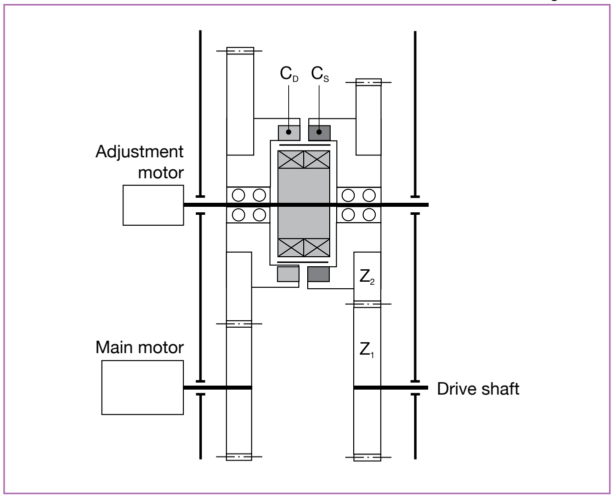
Formula 303-1

$$N = N_O \pm \frac{1}{R}\left(\frac{Z_2}{Z_1}\right) N_W$$

(The sign is minus (–) when the wave generator rotates in the same direction as the circular spline. It is plus (+) when the wave generator rotates in the opposite direction.)

Fine adjustment

Fig. 303-2



This is the method to fine-tune the speed and timing of the drive shaft by the adjusting motor without changing the rotational speed of the main motor.

(Calculation formula)
When the adjusting motor is fixed, the rotational speed of the drive shaft is expressed as follows.

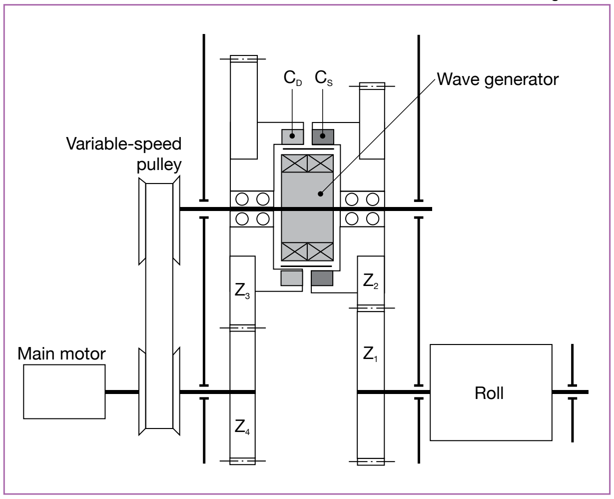
Formula 303-2

$$N = N_O \pm \frac{1}{R+1}\left(\frac{Z_2}{Z_1}\right) N_W$$

(The sign is plus (+) when the wave generator rotates in the same direction as the circular spline. It is minus (–) when the wave generator rotates in the opposite direction.)

Continuous operation adjustment

Fig. 303-3



This is a unit to continuously make a slight change to the rotational speed of the roll. The rotation of the main motor has the following two routes.

(1) Z_4 → $Z_3(C_O)$ → $Z_2(C_S)$ → Z_1 → Roll
(2) Variable-speed pulley → wave generator → C_S (Z_2) → Z_1 → Roll

The speed change of the roll is given by (2).

(Calculation formula)
Assuming that the rotation of the variable-speed pulley is zero, the rotational speed of the roll rotated by the main motor is N_O. When the rotation of the wave generator, namely the variable-speed pulley, changes from N1 to N2, rotational speed N of the roll is expressed as follows.

Formula 303-3

$$N = N_O \pm \frac{1}{R+1}\left(\frac{Z_2}{Z_1}\right)(N_1 \text{ to } N_2)$$

(The sign is plus (+) when the wave generator rotates in the same direction as the circular spline. It is minus (–) when the wave generator rotates in the opposite direction.)

Engineering Data
Component Sets
Gear Units
Phase Adjusters
Gearheads & Actuators

Example of assembly

■ Paper-cutting machine

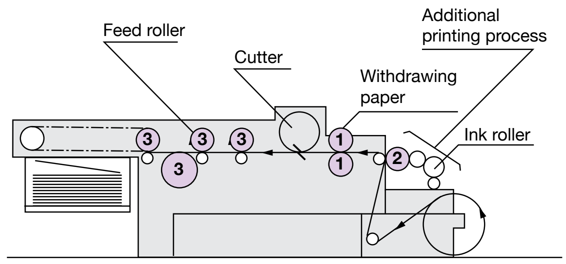
The right-hand figure shows an example of a general application that is used for the mechanism shown below.

Outline of operation

Rollers (1), (2) and (3) are interlocked based on the rotation of the cutter. Roller (2) feeds paper for further printing on the printed paper that is then extracted by Roller (1). Roller (2) adjusts the misaligned printing.
Roller (1) adjusts the printed paper so that it will be cut in the correct position by Roller (2). Roller (3) makes further adjustment following Roller (1).

You can change the phase between the rollers by building a Harmonic differential gear in Units (1), (2) and (3) without stopping the unit.

Fig. 304-1



■ Printer (film material)

The following process is essential for printing on elastic material.

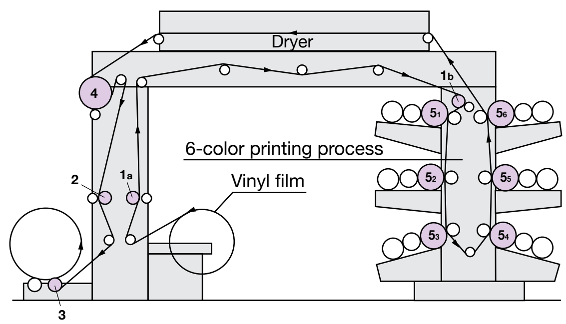
1. A device to adjust printing misalignment by expansion and contraction
2. A device to continue tensioning film to prevent wrinkling

Outline of operation

The film material is withdrawn by (1_a).
(1_b) tensions film between (1_a) and (1_b) to prevent wrinkling.
(2) tensions film between (1_b) and (2) to prevent slackening in the printing process (5). In the printing process (5), all rollers from (5_1) to (5_6) are used for 6-color printing. Adjustment is made to (5_2) based on (5_1), to (5_3) based on (5_2) and so on up to (5_6) by the Harmonic differential gear.

The harmonic differential is built in for all rollers from (1_a) to (5_6).

Fig. 304-2



Difference between the differential gear and the Harmonic differential gear

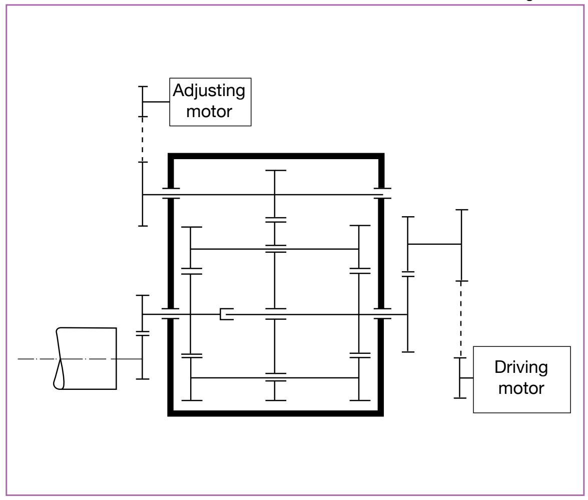
Table 305-1

Differential gear	Harmonic differential gear
As many gears are required in the differential device, the device increases in size, causing problems in design, and is difficult build it in.	As the Harmonic differential gear includes the differential mechanism, it can be designed to be of compact size and is easily built in.
A unit using a plant gear causes a lot of backlash and is disadvantageous in position and timing precision.	As it causes very small backlash, it is advantageous in position and timing precision.
It is not easy to fine tune compared to the Harmonic differential gear.	As it has a large reduction ratio, it can produce very fine tuning.
Noisy gear sound	Very quiet.

That shown in the right-hand figure is a differential gear used in a printer maker. It is an example of very smart, compact design using the Harmonic differential gear.

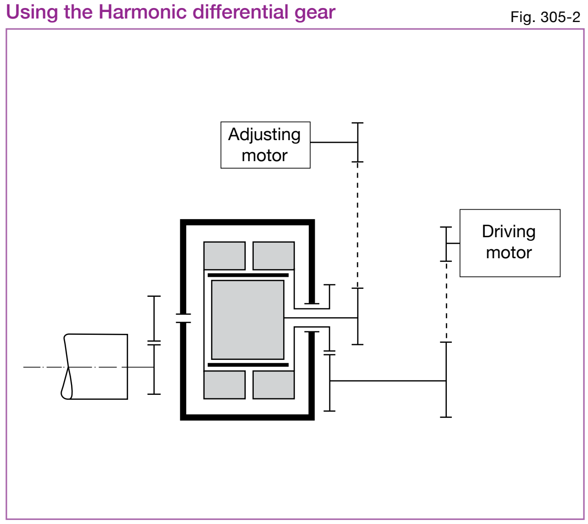
Conventional differential gear

Fig. 305-1



Using the Harmonic differential gear

Fig. 305-2

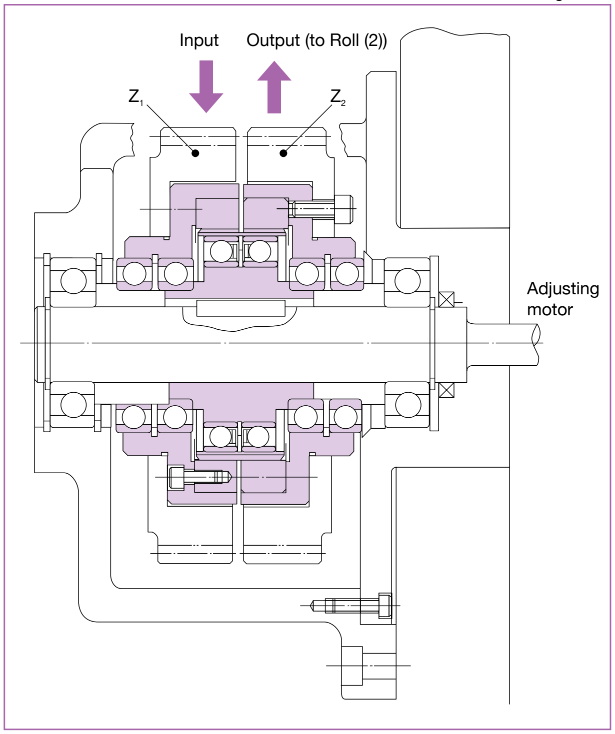


Differential Gear FD

Example of design

■ Multicolor printer Phase adjuster

Fig. 306-1



The figure is an example of a Harmonic differential gear unit (FD-0) built in as a phase adjuster for the roll of a multicolor printer.

The adjusting motor is fixed during normal operation, and the rotation at Z_1 is transmitted to Z_2 almost at a ratio of 1:1. To adjust the phase of only Roll (2), rotate the adjusting motor to generate a small rotational difference. After adjustment, stop the motor to bring Roll (2) back to the original rotational speed.

Gear selection data

The selection data of the number of teeth, Z_1, Z_2, Z_3 and Z_4, of the gear is shown when rotational speed N_1 is equal to N_2, namely $i=\frac{N_2}{N_1}=1$.

$$\frac{N_2}{N_1}=i=\frac{Z_1}{Z_2}\cdot\frac{Z_D}{Z_S}\cdot\frac{Z_3}{Z_4}\ldots\ldots(i)$$

Where,
Zs: the number of teeth of circular spline S
ZD: the number of teeth of circular spline D

Here $i_D=\frac{Z_D}{Z_S}$ $\left(\text{or } \frac{R}{R+1}\right)$ makes

$$i=\frac{Z_1}{Z_2}\cdot\frac{Z_3}{Z_4}\cdot i_D$$

Fig. 306-2

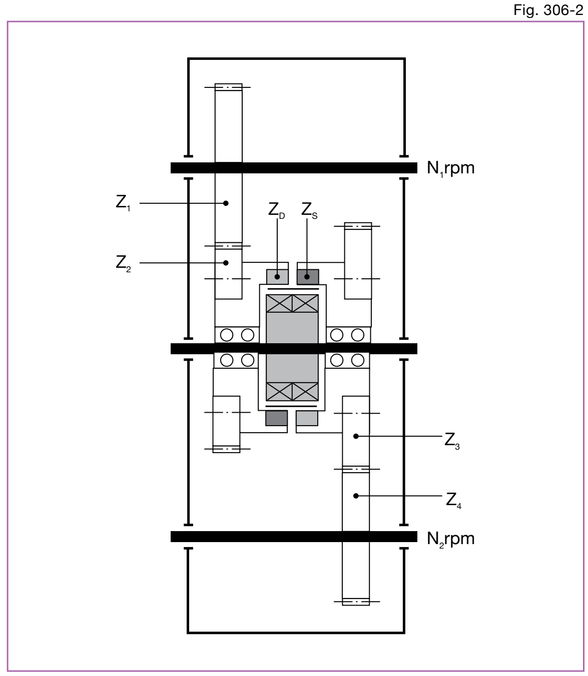


Table 306-1

i_D	$\frac{Z_1}{Z_2}\cdot\frac{Z_3}{Z_4}$					
$\frac{80}{81}$	$\frac{18}{16}\cdot\frac{18}{20}$	$\frac{18}{16}\cdot\frac{27}{30}$	$\frac{15}{16}\cdot\frac{27}{25}$	$\frac{18}{20}\cdot\frac{27}{24}$	$\frac{21}{20}\cdot\frac{27}{28}$	$\frac{27}{26}\cdot\frac{39}{40}$
$\frac{120}{121}$	$\frac{22}{20}\cdot\frac{22}{24}$					
$\frac{128}{129}$	$\frac{15}{16}\cdot\frac{43}{40}$	$\frac{33}{32}\cdot\frac{43}{40}$	$\frac{43}{42}\cdot\frac{63}{64}$			
$\frac{160}{161}$	$\frac{14}{16}\cdot\frac{23}{20}$	$\frac{21}{20}\cdot\frac{23}{24}$	$\frac{23}{22}\cdot\frac{77}{80}$	$\frac{23}{25}\cdot\frac{35}{32}$		

(Note) 1. The number of teeth given above is applicable when Z_D and Z_S are arranged as shown in the figure.
2. The difference in the number of teeth is adjusted to $Z_1 - Z_2 \leqq 3$ and $Z_3 - Z_4 \leqq 3$.
3. It is useful to break down i_D to prime numbers to use a different number of teeth.
It is not possible to break down i_D to prime numbers for R=79, 96, 100, 131, 208 and 258.

Calculation example

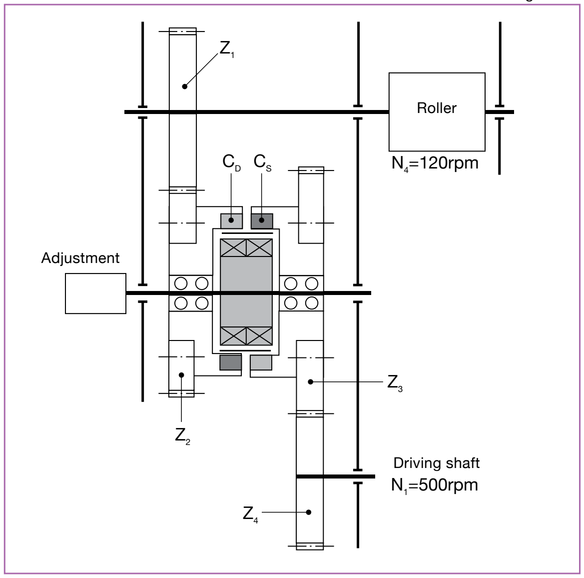
This is to calculate the torque required for the number of teeth of the gear, rotational speed, adjustment quantity and adjustment based on the example shown in the right-hand figure (Fig. 267-1).

[Usage condition]
In Figure 267-1

Speed around the roller	$V = 60\text{m/min}$
Length around the roller	$L_W = 500\text{mm}$
Roller torque	$T_W = 7\text{kg-m}$
Rotational speed of the drive shaft	$N_1 = 500\text{rpm}$
Rotational speed of the roller	$N_4 = \dfrac{V}{L_W} = \dfrac{60}{0.5} = 120\text{rpm}$

Under these conditions, select model number 25 of differential gear with reduction ratio R=80, review whether or not this mode l number is appropriate, as well as the number of teeth and adjustment torque.

Fig. 307-1



■ The number of teeth of each gear (selection of Z1, Z2, Z3 and Z4)

The total reduction ratio is as follows.

From $$i = \frac{N_4}{N_1} = \frac{Z_2}{Z_1} \cdot \frac{C_S}{C_D} \cdot \frac{Z_4}{Z_3}$$

$$\frac{Z_2 \cdot Z_4}{Z_1 \cdot Z_3} = \frac{N_4 \cdot C_D}{N_1 \cdot C_S}$$ is calculated.

Here, $$\frac{N_4}{N_1} = \frac{120}{500} = \frac{2^3 \times 3 \times 5}{2^2 \times 5^3}$$

$$\frac{C_D}{C_S} = \frac{80}{81} = \frac{2^4 \times 5}{3^4}$$

$$\frac{Z_2}{Z_1} \times \frac{Z_4}{Z_3} = \frac{2^3 \times 3 \times 5}{2^2 \times 5^3} \times \frac{2^4 \times 5}{3^4} = \frac{2^5}{3^3 \times 5} = \frac{2^3}{3 \times 5} \times \frac{2^2}{3^2} = \frac{8}{15} \times \frac{4}{9} = \frac{16}{30} \times \frac{16}{36}$$

Hence,
$Z_1 = 30$, $Z_2 = 16$, $Z_3 = 36$, $Z_4 = 16$

■ Calculation of rotational speed

The rotational speed of each gear is shown below.

Z_4: $N_1 = 500\text{rpm}$

Z_3: $N_3 = \dfrac{Z_4}{Z_3} \cdot N_1 = \dfrac{16}{36} \times 500 = 222.2\text{rpm}$

Z_2: $N_2 = \dfrac{C_S}{C_D} \cdot N_3 = \dfrac{81}{80} \times 222.2 = 225\text{rpm}$

Z_1: $N_4 = 120\text{rpm}$

■ Adjustment quantity

The misalignment (adjustment quantity),△θ, at the roller is expressed as follows when the adjusting wave generator rotates once (360º).

$$\triangle\theta = \frac{Z_2}{Z_1} \cdot \frac{1}{R} \cdot \theta = \frac{16}{30} \times \frac{1}{80} \times 360° = 2.4°$$

Therefore, the adjustment quantity is expressed as follows in the circle.

$$\triangle\theta = \frac{2.4°}{360°} \times 500\text{mm} = 3.3\text{mm}$$

■ Adjustment torque required

The torque required for adjustment is expressed as follows.

$$T = T_W \cdot \frac{Z_2}{Z_1} \cdot \frac{1}{R} \cdot \frac{1}{\eta} = 7\text{kg-m} \times \frac{16}{30} \times \frac{1}{80} \times \frac{1}{0.6}$$

$= 0.07\text{kg-m}$

(η: efficiency)

Technical Data

Rating table

The rated torque at each rotational speed is shown below.

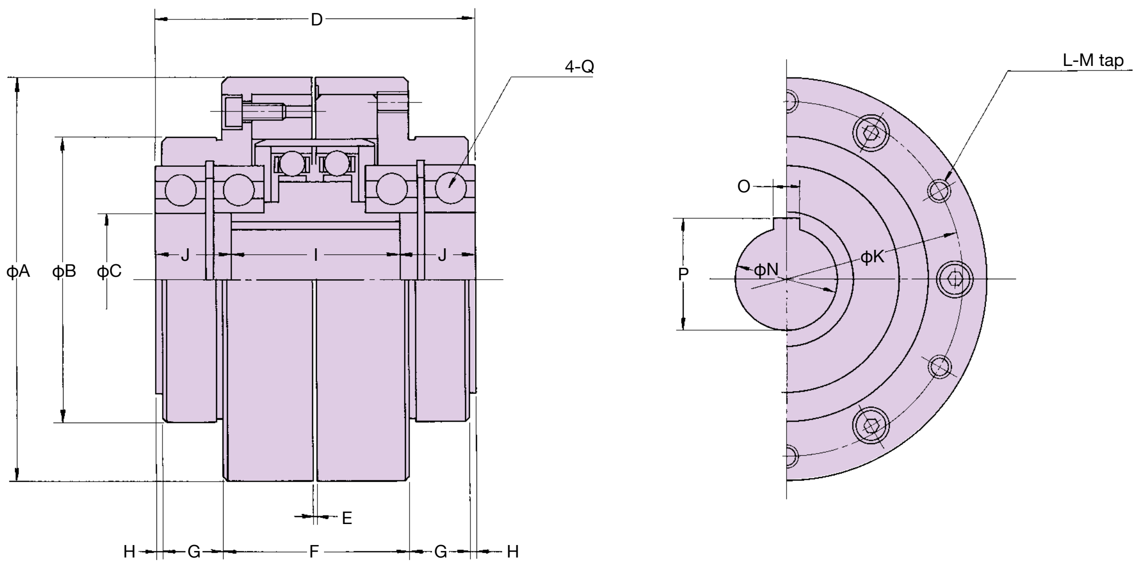
Table 308-1

Rotational speed rpm		3500		2850		1750		1450		1150		960		870		750		600		500	
Size	Ratio	Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm
20	80	29	3.0	30	3.1	30	3.1	30	3.1	30	3.1	30	3.1	30	3.1	30	3.1	30	3.1	30	3.1
	100	30	3.1	31	3.2	36	3.7	36	3.7	36	3.7	36	3.7	36	3.7	36	3.7	36	3.7	36	3.7
	128	31	3.2	34	3.5	42	4.3	43	4.4	43	4.4	43	4.4	43	4.4	43	4.4	43	4.4	43	4.4
	160	32	3.3	35	3.6	42	4.3	45	4.6	48	4.9	49	5.0	49	5.0	49	5.0	49	5.0	49	5.0
25	80	46	4.7	50	5.1	57	5.8	57	5.8	57	5.8	57	5.8	57	5.8	57	5.8	57	5.8	57	5.8
	100	49	5.0	53	5.4	67	6.8	67	6.8	79	8.1	79	8.1	79	8.1	79	8.1	79	8.1	79	8.1
	120	52	5.3	55	5.6	70	7.1	70	7.1	80	8.2	82	8.4	89	9.1	91	9.3	96	9.8	96	9.8
	160	54	5.5	57	5.8	71	7.2	73	7.4	80	8.2	83	8.5	89	9.1	92	9.4	98	10	108	11
	200	55	5.6	59	6.0	71	7.2	74	7.5	80	8.2	84	8.6	89	9.1	92	9.4	98	10	108	11
32	78	98	10	108	11	108	11	108	11	108	11	108	11	108	11	108	11	108	11	108	11
	100	108	11	118	12	137	14	147	15	157	16	157	16	157	16	157	16	157	16	157	16
	131	108	11	118	12	137	14	157	16	167	17	176	18	176	18	196	20	206	21	206	21
	157	108	11	118	12	137	14	157	16	167	17	176	18	176	18	196	20	206	21	216	22
	200	108	11	118	12	137	14	157	16	167	17	176	18	176	18	196	20	206	21	216	22
	260	108	11	118	12	137	14	157	16	167	17	176	18	176	18	196	20	206	21	216	22
40	80	196	20	196	20	196	20	196	20	196	20	196	20	196	20	196	20	196	20	196	20
	100	235	24	245	25	265	27	265	27	265	27	265	27	265	27	265	27	265	27	265	27
	128	235	24	245	25	294	30	314	32	343	35	363	37	372	38	372	38	372	38	372	38
	160	235	24	245	25	294	30	314	32	343	35	363	37	372	38	392	40	421	43	451	46
	200	235	24	245	25	294	30	314	32	343	35	363	37	372	38	392	40	421	43	451	46
	258	235	24	245	25	294	30	314	32	343	35	363	37	372	38	392	40	421	43	451	46
50	80	353	36	353	36	353	36	353	36	353	36	353	36	353	36	353	36	353	36	353	36
	100	441	45	470	48	549	56	559	57	559	57	559	57	559	57	559	57	559	57	559	57
	120	441	45	470	48	549	56	588	60	637	65	666	68	666	68	666	68	666	68	666	68
	160	441	45	470	48	549	56	588	60	637	65	676	69	696	71	745	76	794	81	843	86
	200	441	45	470	48	549	56	588	60	637	65	676	69	696	71	745	76	794	81	843	86
	242	441	45	470	48	549	56	588	60	637	65	676	69	696	71	745	76	794	81	843	86
65	78	—	—	—	—	764	78	764	78	764	78	764	78	764	78	764	78	764	78	764	78
	104	—	—	—	—	1030	105	1100	112	1180	120	1190	121	1190	121	1190	121	1190	121	1190	121
	132	—	—	—	—	1030	105	1100	112	1180	120	1250	128	1290	132	1380	141	1460	149	1570	160
	158	—	—	—	—	1030	105	1100	112	1180	120	1250	128	1290	132	1380	141	1460	149	1570	160
	208	—	—	—	—	1030	105	1100	112	1180	120	1250	128	1290	132	1380	141	1460	149	1570	160
	260	—	—	—	—	1030	105	1100	112	1180	120	1250	128	1290	132	1380	141	1460	149	1570	160
80	80	—	—	—	—	1370	140	1370	140	1370	140	1370	140	1370	140	1370	140	1370	140	1370	140
	96	—	—	—	—	1800	184	1800	184	1800	184	1800	184	1800	184	1800	184	1800	184	1800	184
	128	—	—	—	—	2040	208	2180	222	2340	239	2490	254	2570	262	2710	277	2710	277	2710	277
	160	—	—	—	—	2040	208	2180	222	2340	239	2490	254	2570	262	2740	280	2950	301	3130	319
	194	—	—	—	—	2040	208	2180	222	2340	239	2490	254	2570	262	2740	280	2950	301	3130	319
	258	—	—	—	—	2040	208	2180	222	2340	239	2490	254	2570	262	2740	280	2950	301	3130	319
	320	—	—	—	—	2040	208	2180	222	2340	239	2490	254	2570	262	2740	280	2950	301	3130	319
100	80	—	—	—	—	2470	252	2470	252	2470	252	2470	252	2470	252	2470	252	2470	252	2470	252
	100	—	—	—	—	3720	380	3720	380	3720	380	3720	380	3720	380	3720	380	3720	380	3720	380
	120	—	—	—	—	3720	382	3980	406	4280	437	4560	465	4710	481	4740	484	4740	484	4740	484
	160	—	—	—	—	3720	382	3980	406	4280	437	4560	465	4710	481	5010	511	5390	550	5720	584
	200	—	—	—	—	3720	382	3980	406	4280	437	4560	465	4710	481	5010	511	5390	550	5720	584
	242	—	—	—	—	3720	382	3980	406	4280	437	4560	465	4710	481	5010	511	5390	550	5720	584
	320	—	—	—	—	3720	382	3980	406	4280	437	4560	465	4710	481	5010	511	5390	550	5720	584

(Note) 1. Rotational speed: This indicates the rotational speed of the wave generator if used as a reducer. This indicates the relative rotational speed of the wave generator and the circular spline if used as a differential unit.
2. The torque against a rotational speed of 2,500 rpm or less is equal to the torque for 500 rpm.
3. The allowable momentary torque allows up to 200% of the torque at a rotational speed of 1,450 rpm.

Outline dimensions (FD-0)

Fig. 309-1



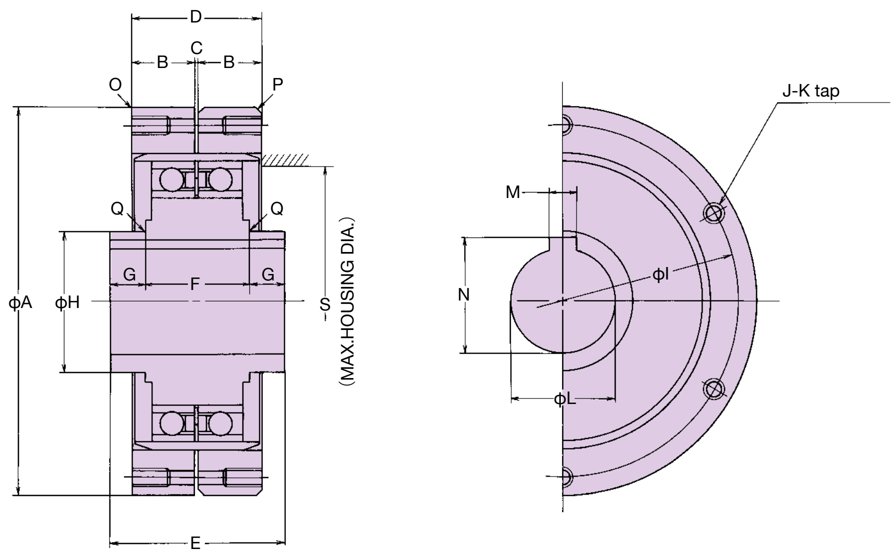
Dimensions (FD-0)

Table 309-1
Unit: mm

Symbol \ Size	20	25	32	40	50	65	80	100
ϕA	85	95	120	145	185	235	290	360
ϕB h7	52	65	85	100	125	140	180	210
ϕC	20	30	40	50	60	70	90	110
D	73	81	95	113	132	147	178	212
E	1	1	1	1	1	1	1	1
F	44	45	55	65	80	117	129	155
G	12.5	16	18	20	22	12	21.5	25.5
H	2	2	2	4	4	3	3	3
I	38	40	50	68	78	87	106	130
J	17.5	20.5	22.5	22.5	27	30	36	41
ϕK	70	80	105	125	155	195	240	290
L	6	6	6	6	6	6	8	8
M	M4X7	M5X8	M6X9	M8X11	M10X13.5	M12X23	M12X23	M14X27
ϕN H7	12	20	30	35	40	50	65	80
O Js9	4	6	8	10	12	14	18	22
P	13.8	22.8	33.3	38.3	43.3	53.8	69.4	85.4
Q	#6004	#6006	#6008	#6010	#6012	#6014	#6018	#6022
Mass (kg)	2.0	2.6	5.0	8.3	17	34	59	118

Outline Dimensions (FD-2)

Fig. 310-1



Dimensions (FD-2)

Table 310-1

Unit: mm

Symbol \ Size	20	25	32	40	50	65	80	100
ϕA_{g7}	70	85	110	135	170	215	265	330
B	12	14	18	21	26	35	41	50
C	1	1	1	1	1	1	1	1
D	25	29	37	43	53	71	83	101
E	38	40	50	68	78	87	106	130
F	21.5	25	30	44	54	59	74	92
G	8.25	7.5	10	12	12	14	16	19
ϕH_{J6}	20	30	40	50	60	70	90	110
φI	60	75	100	120	150	195	240	290
J	6	6	6	6	6	6	8	8
K	M3×6	M4×8	M5×10	M6×12	M8×16	M10×20	M10×20	M12×24
ϕL_{H7}	12	20	30	35	40	50	65	80
M_{Js9}	4	6	8	10	12	14	18	22
N	13.8	22.8	33.3	38.3	43.3	53.8	69	85.4
O_C	0.2	0.2	0.2	0.4	0.4	0.4	0.4	0.4
P_C	1	1.5	1.5	1.5	1.5	1.5	2	2
Q_R	0.5	1	1	1	2	1	1.5	2
S	42	53	69	84	105	138	169	211
Mass (kg)	0.6	1.0	2.0	3.6	7.2	14	26	48

Efficiency

The efficiency of the differential gear unit (FD-0) varies depending on the power transmission route.

(1) The efficiency when the power enters from circular spline S (or D) to transmit the rotation to circular spline D (or S)

For oil lubrication: About 90%
For grease lubrication: About 80%

(2) The efficiency for obtaining the input torque required by the wave generator for phase adjustment and to use it as a reducer is shown in Graph 311-1.

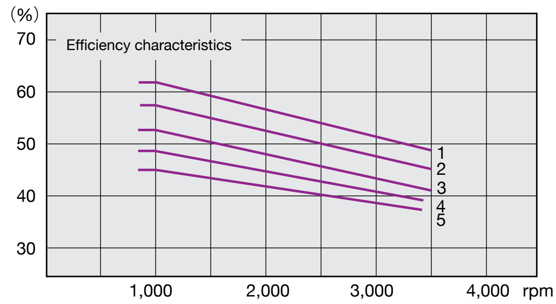
Table 311-1

Load torque	Rated torque in rating table
Lubrication	Oil lubrication (approx. 40°C)

(Note) The efficiency decreases by about 10% for grease lubrication.

Efficiency

Graph 311-1



1=78:1 to 100:1
2=110:1 to 160:1
3=200:1
4=242:1 to 260:1
5=320:1

Moment of inertia

The value of GD^2 of each part is shown in Table 311-2.

Table 311-2
Unit: ($X10^{-4}kgm^2$)

	Size	20	25	32	40	50	65	80	100
I	Wave generator (except the outer race of the wave generator)	1.44	3.63	12.9	37.0	112	366	1020	3050
II	Circular spline S, D Outer ring of the wave generator	13.7	33.8	125	326	1020	3440	9270	27000
III	I + II	15.2	37.5	138	363	1140	3810	10300	30100
IV	Support bearing (4)	2.91	8.98	23.4	451	104	205	646	1590
V	Casing (right and left casing total)	52.6	69.0	204	484	1660	6220	15700	43200

Max. allowable rotational speed

The maximum allowable rotational speed means:

1. The rotational speed of the wave generator when used as a reducer
2. The relative rotational speed of the wave generator and the circular spline when used as a differential unit

(1) For oil lubrication

Table 311-3
Unit: rpm

Size	20	25	32	40	50	65	80	100
Max. allow. rotational speed	6000	5000	4500	4000	3500	3000	2500	2000

(2) For grease lubrication

Table 311-4
Unit: rpm

Size	20	25	32	40	50	65	80	100
Max. allow. rotational speed	3600	3600	3600	3300	3000	2200	2000	1700

Lost motion and spring constant

See Page 120 for a definition of lost motion and the spring constant.
Hysteresis loss and the spring constant of the differential gear is the value when either the wave generator or the circular spline is fixed and a torque is applied to the other circular spline.

Table 312-1

Size	Lost motion (arc min)		Spring constant (kgm/min)	
	± load (kgm)	Standard product (max.)	Load (kgm)	Spring constant
20	0.12	40	3.69	0.9
25	0.23	37	7.20	2.1
32	0.46	35	15.78	4.4
40	0.92	33	29.50	7.8
50	1.73	29	57.60	16
65	3.9	27	126.7	27
80	7.4	26	236.2	52
100	14.4	24	460.8	100

Design Guide

Precaution on handling

The casing and the roller bearing in using a component type (FD-2) as a differential unit should be pursuant to the unit type (FD-0).

Precautions on assembly

The FD gear may generate vibration and abnormal sound due to problems during assembly. Perform assembly based on the FB series precautions (Page 109, Fig. 109-2).

Lubrication

There are two types of lubrication; oil lubrication and grease lubrication. Although oil lubrication is common, grease lubrication is applicable to intermittent operation.

■ Oil lubrication

1. Type of lubricant

See Page 018 for lubrication details.

2. Oil quantity

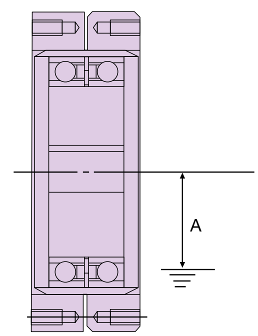
The oil level shall be the position shown in Table 313-1.

Oil position

Table 313-1

Size	20	25	32	40	50	65	80	100
A	12	15	31	38	44	62	75	94

Fig. 313-1



■ Grease lubrication

Different from oil lubrication, as a cooling effect is not expected from grease lubrication, it is only available for short operation.

- Operating condition: ED%·· 10% or less, continuous operation for 10 minutes or less, the maximum allowable input rotational speed in Table 311-4 or less
- Recommended grease:····· Harmonic Grease SK-1A

Note) If you use the product over ED% or the maximum permissible rotational speed, the grease will deteriorate, will not work as a lubricating mechanism and will result in damaging the reducer earlier. Extreme care should be taken.
Please consider the unit type since unit type (FD-0) also comes in grease sealed type (NIPPON KOYU LTD. MP No. 2).

MEMO

FBB Series

Differential Gear FBB

Features

Component type

Differential & Phasing Drive

The FBB was developed as a versatile simple differential drive transmission for direct phasing of rotating elements while they are in motion. Offsetting internal gear ratios deliver a through ratio of 1:1 and trim adjustments can be applied through one or both of two wave generators.

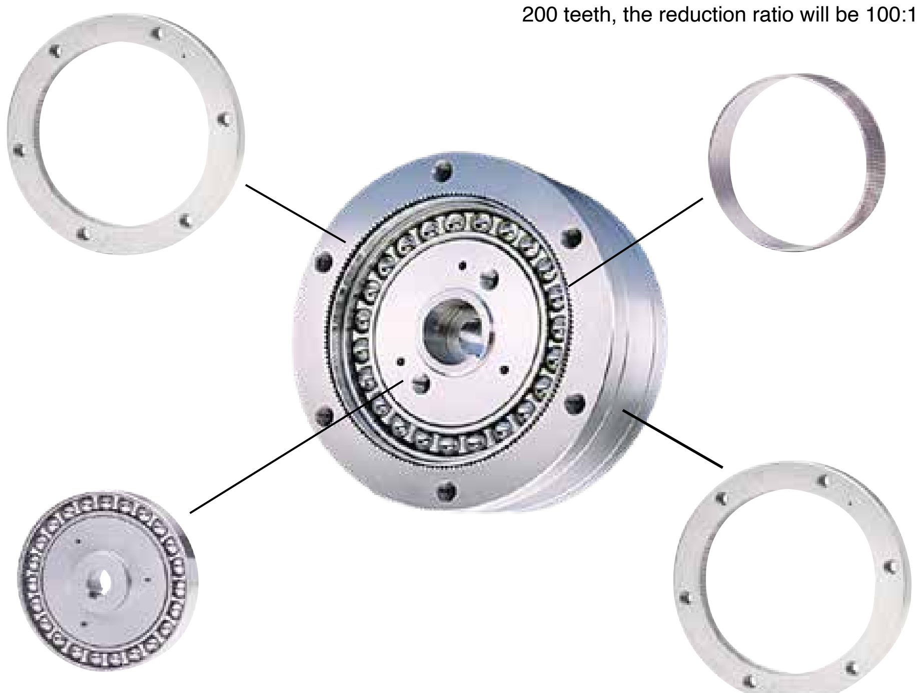
Features

- For dynamic registration of rotating elements
- A 1:1 differential with high-ratio trim adjustment
- Ideal differential for roll registration or angular shaft phasing
- Compact, low-backlash design for end-of-roll mounting

Axially Compact, Single-Stage, High-Ratio Gearing

DYNAMIC CIRCULAR SPLINE:
An internal gear which has the same number of teeth as the Flexspline and which rotates at the same speed and in the same direction as the Flexspline. It usually is the output element to which an output shaft is connected.

FLEXSPLINE:
External spline teeth that progressively engage the internal teeth of the Static Circular Spline and Dynamic Circular Spline at the major axis of its rotating elliptical shape. Speed reduction relative to the Wave Generator is equal to one-half the number of teeth on the Flexspline's outside edge. For example, if the Flexspline has 200 teeth, the reduction ratio will be 100:1.

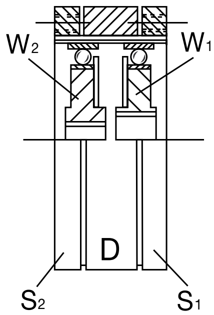


WAVE GENERATOR:
An elliptical bearing and the rotating input element of the transmission. It is connected to a motor or other input shaft and imparts a rotating elliptical shape to the Flexspline.

STATIC CIRCULAR SPLINE:
A fixed nonrotating internal gear which provides mechanical grounding for the transmission. It has two more teeth than the Flexspline to establish a positive transmission reduction ratio equal to one-half the number of Flexspline teeth.

FBB Phasing Differential Gear Sets

Harmonic Drive FBB gear sets allow easy and direct phasing of rotating elements and are ideally suited for web presses and other machines requiring constant monitoring and adjustment while they are in motion.



Drive Power

FBB is essentially two FB pancake gear sets mounted back to back with dynamic splines connected. The FBB provides a 1:1 through ratio from a primary drive source to secondary elements of a machine with optional speed or position adjustment.

Power is applied to S1, the first of three ring gears called circular splines. Torque is transmitted from the first circular spline to the third circular spline S2, through two gear ratios.

The first ratio is a slight speed increase between S1 and the middle circular spline D.

The second ratio is a very slight speed reduction between the D spline and the S2 circular spline.

When the two wave generators W1 and W2 are stationary, the increasing and decreasing ratios offset each other and the S1 and S2 circular splines rotate in the same direction and at the same speed. Power circulates from the S1 input to the S2 output at a 1:1 ratio with an efficiency of approximately 99%.

Trim

With one wave generator W1 rotationally fixed, a second wave generator W2 can be rotated to create, a high ratio advance or retardation (depending on direction) of S2 relative to the S1 circular spline.

Output speed or position can be accurately adjusted with the machine in motion. The output speed of S2 while trim is being applied can be calculated with the following equation:

$$N_{S2} = N_{S1} \pm \left[\frac{N_{W2}}{(R+1)} \right]$$

Where N=speed
R=tabulated ratio

It is possible to attach both wave generators to different drive sources.

For example, W2 could be driven by a servomotor for high-speed automated trim and W1 to a hand crank for low speed manual trim.

Sufficient holding torque must be applied to the trim shaft to prevent rotation. This can be calculated from the following equation:

$$\text{Control Torque} = \frac{\text{System Output Torque (max)}}{\text{Ratio x 0.5}}$$

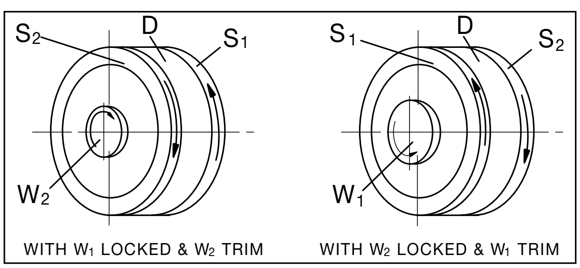
Ratio

Standard ratios are as shown in the rating table page 3, however, other ratios are available on a custom basis (consult our engineering department).

Ratings

Torque ratings are as the equivalent size FB pancake gear set.

Relative Trim Direction



These examples show the displacement of the circular splines S1 and S2 relative to each other when the wave generator is rotated in the direction of the arrow. Actual rotational direction will depend on the direction of the main input drive

Ordering Code

FBB - 20 - 80 - 2 - SP

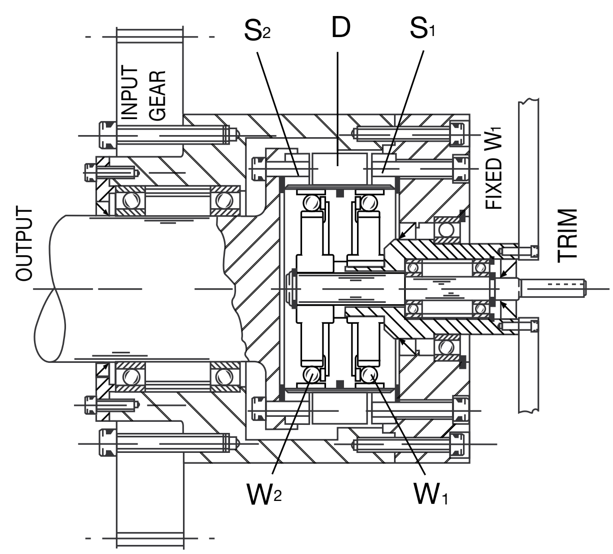
Table 318-1

Series	Size	Ratio *1																					Model	
FBB	20	—	80	—	—	100	—	—	—	128	—	—	—	—	160	—	—	—	—	—	—	—	2= Component type	SP = Special specification code
	25	—	80	—	—	100	—	—	120	—	—	—	—	—	160	—	200	—	—	—	—	—		
	32	78	—	—	—	100	—	—	—	—	131	—	157	—	—	—	200	—	—	—	260	—		
	40	—	80	—	—	100	—	—	—	128	—	—	—	—	160	—	200	—	—	258	—	—		
	50	—	80	—	—	100	—	—	120	—	—	—	—	—	160	—	200	—	242	—	—	—		

*1 The reduction ratio value is based on the following configuration:
Input: wave generator, fixed: circular spline S, output: circular spline D

Assembly

Figure 318-1



FBB differentials are supplied as component sets only and are not self contained power transmissions. Suitable housings with bearing supports, oil reservoirs and seals must be provided.

Circular Splines
Both S1 & S2 circular splines must be supported with a suitable bearing arrangement to maintain specified dimensions and tolerances under all load conditions.

Overhung loads from an external source require a suitable two-bearing or four-point contact bearing support.

Axial restraint in both directions must maintain the gap between each of the three circular splines.

Flexspline
Hardened wear washers are provided to prevent axial displacement of the flexspline. These may be discarded If the customer supplied components in the vicinity of the flexspline are a minimum hardness of Rc45.

Wave Generator
The wave generator bearings should not be used to support a shaft. Axial restraint in both directions should be provided.

Engineering Data
Component Sets
Gear Units
Phase Adjusters
Gearheads & Actuators

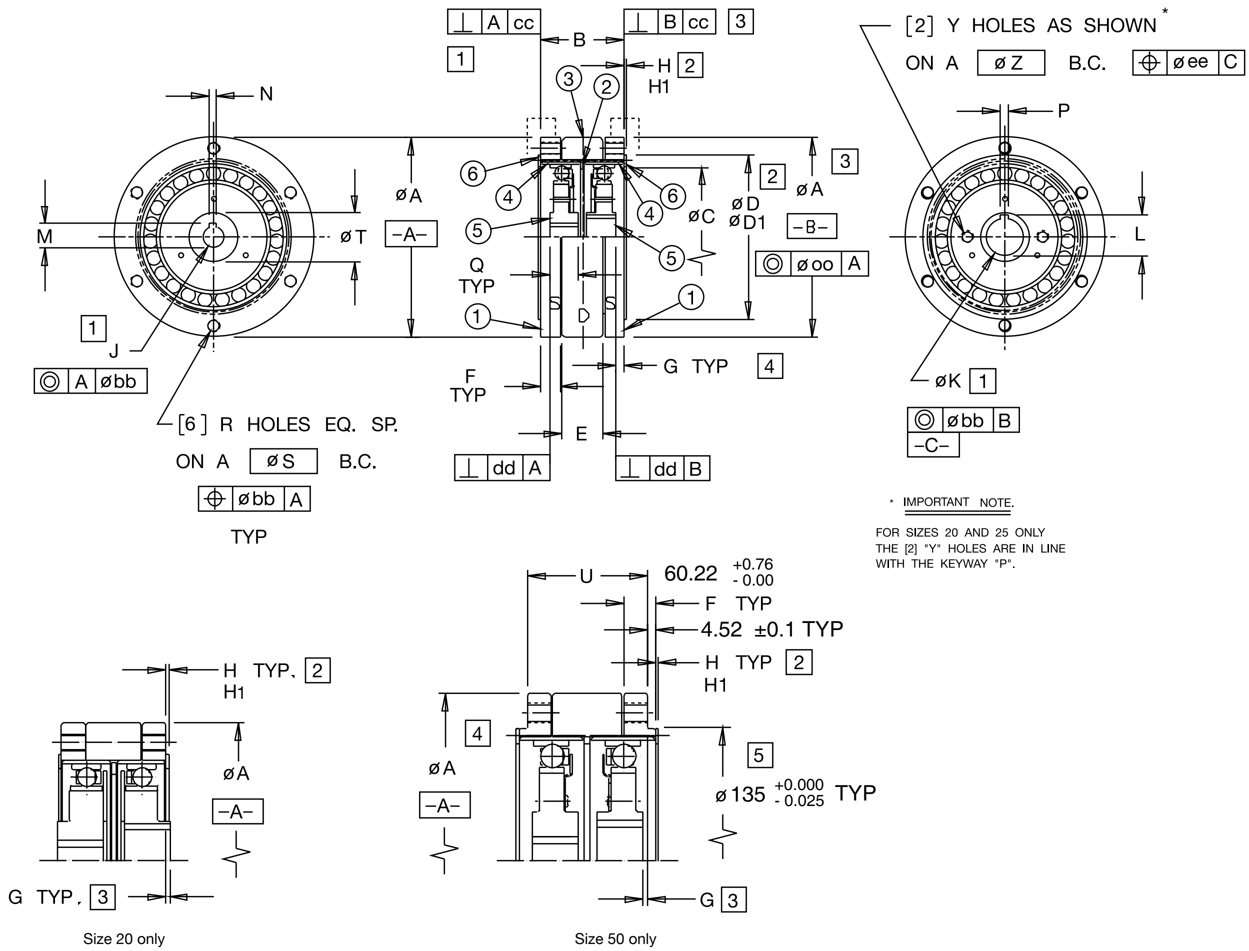
Rating table

Table 319-2

Size	Ratio	Maximum Input Speed rpm		Rated Torque @1750 rpm	Maximum Output Torque	No Load Starting Torque	Input Inertia
		Oil	Grease	Nm	Nm	Ncm	kgcm²
20	80	6000	3500	28	28	3.2	0.14
	100			28	34	3.2	0.14
	120			28	40	3.2	0.14
	160			28	44	3.2	0.14
25	80	5000	3500	46	48	4.2	0.36
	100			46	68	4.2	0.36
	120			46	79	4.2	0.36
	160			46	88	4.2	0.36
32	80	4500	3500	92	107	5.7	1.32
	100			92	136	5.7	1.32
	120			92	158	5.7	1.32
	160			92	175	5.7	1.32
40	80	4000	3000	193	192	19.1	3.42
	100			193	271	19.1	3.42
	120			193	305	19.1	3.42
	160			193	350	19.1	3.42
50	80	3500	2500	359	350	35.3	9.91
	100			359	475	35.3	9.91
	120			359	588	35.3	9.91
	160			359	655	35.3	9.91

Outline Dimensions

Figure 320-1



A. Item ① Static Circular Spline [Marked S]

Item ② Spacer

Item ③ Dynamic Circular Spline [Marked D]

Item ④ Flexspline

Item ⑤ Wave Generator

Item ⑥ Wear washer

B. Dimensions marked [1] established interface and installation requirements and must be maintained under all operating conditions

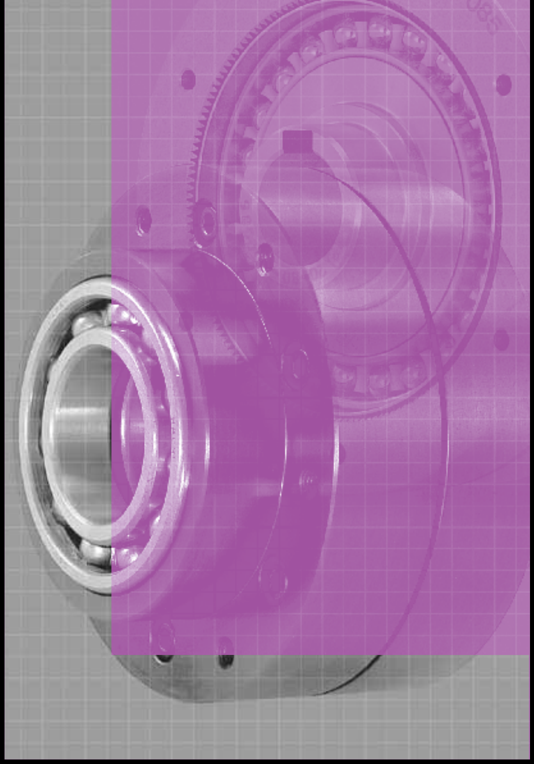
C. Dimensions marked [2] are necessary to locate wear washers item ⑥ in correct position. See assembly notes.

Dimensions

Table 321-1
Unit: mm

Symbol \ Size	20	25	32	40	50
ØA	$70^{-0.018}$	$85^{-0.022}$	$110^{-0.025}$	$134^{-0.025}$	$170^{-0.025}$
B	$26.5^{+0.25}$	$34.8^{\pm0.25}$	$42^{+0.6}$	$56.5^{+0.8}$	–
ØC	$47^{\pm0.51}$	$59^{\pm0.51}$	$77^{\pm0.51}$	$95^{\pm0.51}$	$119^{\pm0.51}$
ØD	$54^{\pm0.51}$	$69.4^{\pm0.51}$	$92^{.1\pm0.51}$	$111.1^{\pm0.51}$	$134.4^{\pm0.51}$
ØD1	$54.7^{+0.51}$	$70.2^{+0.51}$	$92.9^{+0.38}$	$92.9^{+0.38}$	$135.2^{+0.38}$
E	$14^{\pm0.1}$	$18^{\pm0.1}$	$20.9^{\pm0.1}$	$28^{\pm0.1}$	$35^{\pm0.2}$
F	$6^{\pm0.1}$	$8^{\pm02}$	$10^{\pm0.2}$	$13^{\pm0.2}$	$13^{\pm0.2}$
G	$1.8^{\pm.51}$	$3.27^{\pm.51}$	$3.95^{\pm.51}$	$1.95^{\pm.51}$	$1.4^{\pm.51}$
H	$.81^{\pm0.13}$	$.81^{\pm0.13}$	$.81^{\pm0.13}$	$1.57^{\pm0.13}$	$1.57^{\pm0.13}$
H1	$.94^{+0.13}$	$.94^{+0.13}$	$.94^{+0.13}$	$1.69^{+0.13}$	$1.69^{+0.13}$
ØJ	$9^{+0.015}$	$11^{+0.018}$	$14^{\pm0.020}$	$14^{\pm0.020}$	$19^{\pm0.020}$
ØK	$16^{+0.013}$	$19^{+0.013}$	$25^{+0.020}$	$25^{+0.020}$	$35^{+0.023}$
L	$17.4^{\pm0.10}$	$20.8^{+0.10}$	$27.3^{+0.20}$	$27.3^{+0.20}$	$38.3^{+0.20}$
M	$10.4^{+0.10}$	$12.8^{+0.10}$	$16.3^{+0.10}$	$16.3^{+0.10}$	$21.8^{+0.10}$
N	$3^{\pm0.0125}$	$4^{\pm0.013}$	$5^{\pm0.013}$	$5^{\pm0.013}$	$6^{\pm0.013}$
P	$3^{\pm0.0125}$	$4^{\pm0.013}$	$5^{\pm0.013}$	$5^{\pm0.013}$	$10^{\pm0.023}$
Q	11.4	12.8	15.6	19.4	23.2
R	M4 x 0.7	M5 x 0.8	M6 x 1	M8 x 1.25	M10 x 1.5
ØS	60	75	100	120	150
ØT	20	28	36	32	50
Y	M4 x 0.7	M4 x 0.7	M6 x 1.0	M8 x 1.25	M8 x 1.25
ØZ	27	35	44	48	65
aa	0.07	0.076	0.078	0.088	0.098
bb	0.013	0.015	0.015	0.018	0.020
cc	0.018	0.023	0.025	0.025	0.025
dd	0.010	0.013	0.013	0.013	0.015
ee	0.250	0.250	0.250	0.250	0.250
mass (lb/kgf)	1.50/70	2.70/1.23	4.70/2.14	9.00/4.09	15.30/6.9

MEMO



HDI Series

Infinit Indexer®

Features

Differential gear HDI series

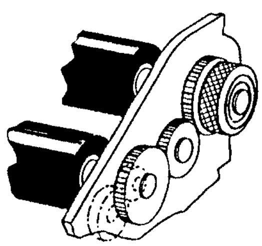
Infinit-Indexer® phase adjusters are available from immediate stock in the standard bore sizes shown with keyways, set screws, and tapped holes for face mounting of either hub. It is possible for the user to modify these configurations by disassembling the unit. The hub material is easily machined low carbon steel. Available sizes are shown in the drawing below. Additional sizes and configurations are available by special order.

Features

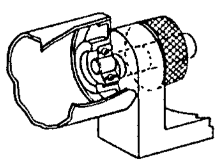
- Fine tune rotational position of shafts and machine parts
- Phase cams
- Adjust roll registration
- Take up backlash in spur and worm gears
- Synchronize indexing devices

Applications

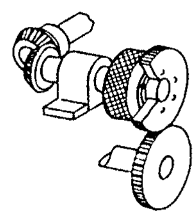
The Infinit-Indexer® phase adjuster provides the designer with a simple component which will solve an almost limitless variety of design problems through precise shaft phase adjustment.



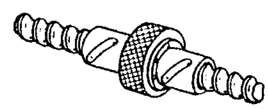
Adjusting Printing Rolls



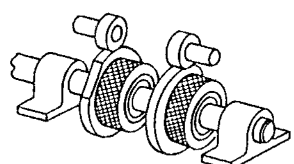
Adjusting an Eccentric



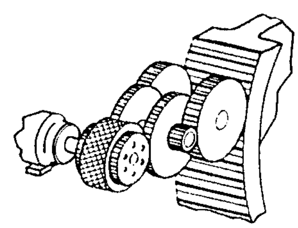
Phasing Gears



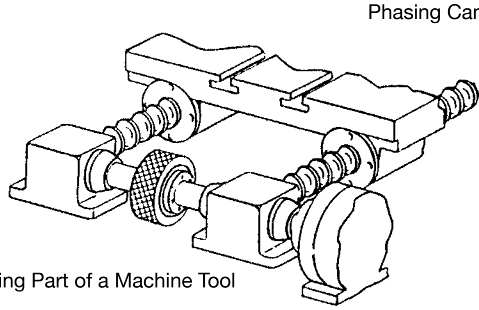
Adjustable Backlash on Ball Nuts



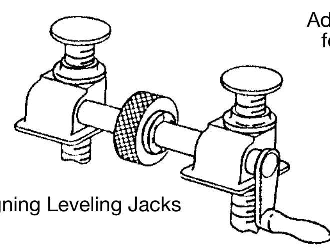
Phasing Cams



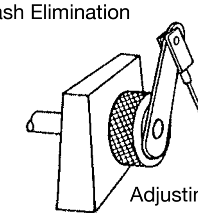
Adjusting a Dual Gear Train for Backlash Elimination



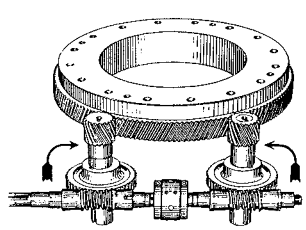
Aligning Part of a Machine Tool



Aligning Leveling Jacks

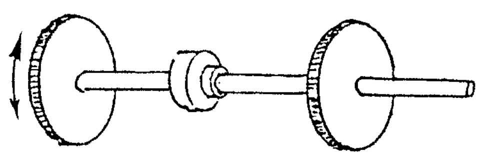


Adjusting Linkage



HDI-25-8SK-8DK

The rotary feed tables are driven by dual pinions which engage the ring gear. This unique design affords the ability to “take up” lost motion in the drive train and to actually preload the mechanism producing the “stiff-ness” necessary for rotary machining.



Aligning Teeth of Gears or Sprockets

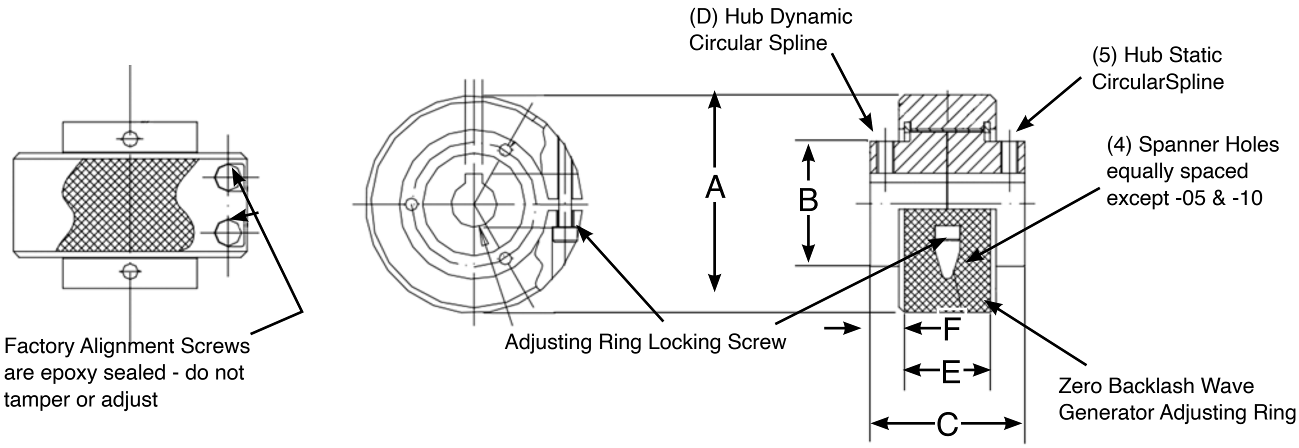
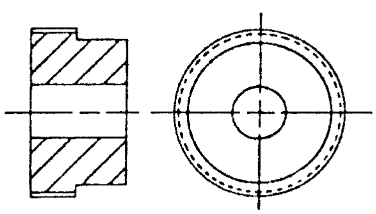


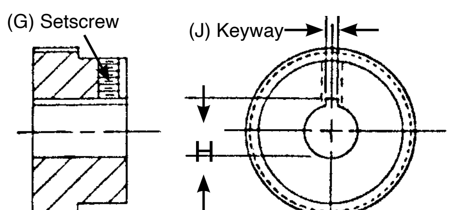
Table 325-1

Basic HDI Size	A	B	C	E	F	*Torque Rating lb.-in.	Approx. Weight lbs.
-05	2.00	0.99	1.43	0.91	.26	500	1.2
-10	2.38	1.38	1.69	1.06	.31	1,000	1.5
-25	3.00	1.75	2.19	1.38	.40	2,500	3.0
-50	3.75	2.17	2.37	1.63	.37	5,000	5.0
-100	4.75	2.94	3.29	2.06	.61	10,000	11.0
-200	6.50	3.75	4.05	2.38	.84	20,000	24.0

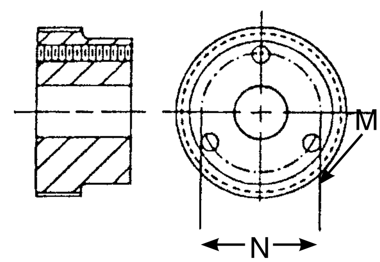
*Torque rating is for continuous one direction of rotation. For reversing torque systems, the tabulated rating is the sum of the CW & CCW torque.



Plain Bore D or S Hub



Keyway-Setscrew DK or SK Hub



Tapped Hole DT or ST Hub

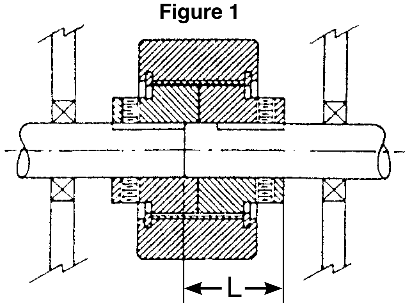
Table 325-2

Basic HDI Size	Bore Size	D Hub	S Hub	D Hub	S Hub	G	H	J	D Hub	S Hub	M* UN-2B	N
-05	.250	2D	2S	2DK	2SK	8-32	—	—	2DT	2ST	6-32	.750
	.375	3D	3S	3DK	3SK	8-32	.409	.062	3DT	3ST	6-32	.750
	.500	4D	4S	4DK	4SK	8-32	.561	.125	4DT	4ST	6-32	.750
-10	.500	4D	4S	4DK	4SK	1/4-20	.585	.187	4DT	4ST	8-32	1.125
	.625	5D	5S	5DK	5SK	1/4-20	.710	.187	5DT	5ST	8-32	1.125
	.750	6D	6S	6DK	6SK	1/4-20	.837	.187	6DT	6ST	8-32	1.125
-25	.750	6D	6S	6DK	6SK	1/4-20	.863	.250	6DT	6ST	10-32	1.500
	.875	7D	7S	7DK	7SK	1/4-20	.988	.250	7DT	7ST	10-32	1.500
	1.000	8D	8S	8DK	8SK	1/4-20	1.114	.250	8DT	8ST	10-32	1.500
-50	1.000	8D	8S	8DK	8SK	1/4-20	1.114	.250	8DT	8ST	1/4-20	1.750
	1.250	10D	10S	10DK	10SK	1/4-20	1.368	.250	10DT	10ST	1/4-20	1.750
-100	1.250	10D	10S	10DK	10SK	3/8-16	1.418	.375	10DT	10ST	5/16-18	2.500
	1.625	13D	13S	13DK	13SK	3/8-16	1.793	.375	13DT	13ST	5/16-18	2.500
	1.750	14D	14S	14DK	14SK	3/8-16	1.918	.375	14DT	14ST	5/16-18	2.500
-200	1.750	14D	14S	14DK	14SK	1/2-13	2.026	.625	14DT	14ST	3/8-16	3.125
	2.000	16D	16S	16DK	16SK	1/2-13	2.276	.625	16DT	16ST	3/8-16	3.125
	2.500	20D	20S	20DK	20SK	1/2-13	2.778	.625	20DT	20ST	3/8-16	3.125

*Six holes equally spaced. True position .015 diameter except sizes -05 and -10 three holes. To order: specify the basic size and desired D and S hub configuration. Example: HDI 10-6D-6SK specifies a size -10 with D hub .750 diameter plain bore and S hub .750 diameter bore with keyway and setscrew.

Installation

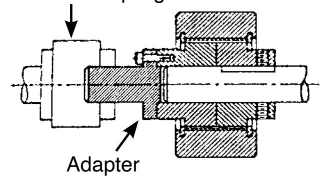
Figure 1



In-Line Shaft

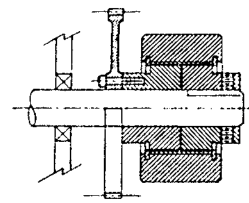
HDI Size	L DIM
-05	.95
-10	1.09
-25	1.34
-50	1.43
-100	1.88
-200	2.25

Figure 2



In-Line Shaft

Figure 3



Concentric Shaft

The Infinit-Indexer® phase adjuster can be installed in a machine system either as an in-line shaft coupling or a concentric shaft coupling.

In-Line Shaft (Fig. 1 & Fig. 2)
In order to properly align shafts concentric to one another, either the driven or driving shaft should pass completely through one hub and engage the other by an amount determined by the (L) dimension. The hubs are symmetrical; therefore, the (L) length applies to a piloting shaft length entering from either hub face.

The coupling is designed to transmit pure torque only. Radial reaction loads generated by gears, sprockets, shaft misalignment, etc., must be isolated from the unit by appropriate shaft bearing supports.

When it is not possible to maintain good shaft concentricity, it is recommended that the Infinit-Indexer be mounted in conjunction with a flexible coupling and adapter as shown in Fig. 2.

Concentric Shaft (Fig. 3)
The shaft should pass completely through the attached sprocket, gear, etc., and the Infinit-Indexer at a uniform diameter with a tight-running fit.

It is recommended that the region of the shaft under the gear, sprocket, etc., and connected hub be lightly lubricated with a multi-purpose grease at assembly.

Adjusting Ring:
One revolution of the knurled outer adjusting ring results in 3.6˚ of shaft phase adjustment. With the (D) hub fixed, rotation of the (S) hub is opposite to the direction of adjustment ring rotation. Conversely, with the (S) hub fixed, rotation at the (D) hub is in the same direction as adjusting ring rotation.

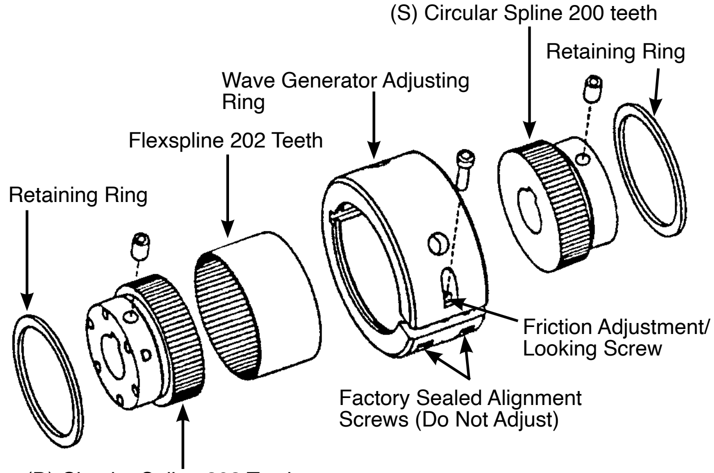
The coupling is essentially self-locking and applications requiring frequent adjustment can be investigated for the possibility of operating without having to seat the locking screw. However, those applications in which the coupling is subjected to typical motor start-up accelerations, sudden stops and/or a vibratory environment will require use of the screw to maintain a phase setting.

The coupling during adjustment is not intended to drive against any significant reaction load that may exist between the connected shafts. However, some adjusting ring torque amplification results to provide a hub drive torque capability within recommended limits noted to below:

Lubrication:
The unit is factory lubricated and will not require further maintenance under normal conditions. Nevertheless, periodic maintenance should be performed when unit is subject to frequent adjustment, dirty or other abnormal conditions, or when unit-adjusting torque becomes higher than normal.

Unit Size	Adjusting Ring Torque (lb. in.) Ref.	Hub Drive Torque (lb. in.)
-05	4	20
-10	8	40
-25	16	80
-50	32	160
-100	76	380
-200	150	750

Spanner wrench holes are provided on the O.D. of the adjusting ring in sizes 50, 100, 200, and 300.

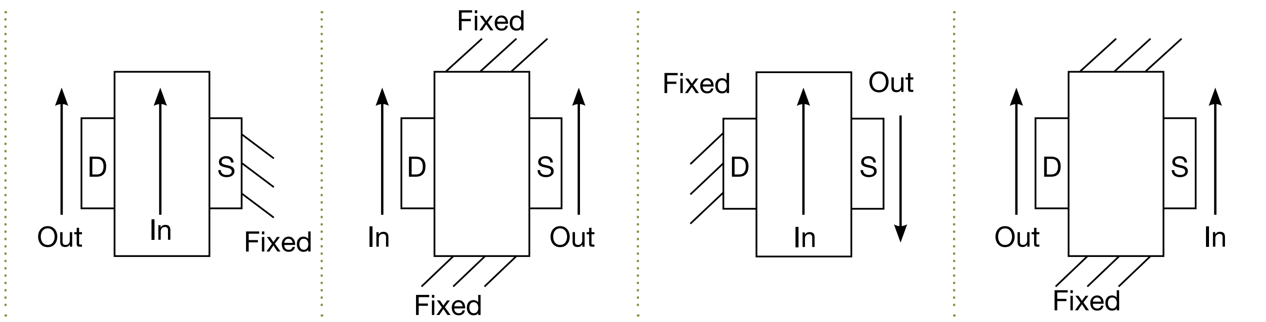


Disassembly:
Loosen friction adjustment/locking screw (it is not necessary to remove screw from unit) and remove one retaining ring. All parts will then slide out in one direction. (Do not tamper with or remove the two factory alignment screws.)

Clean parts and relubricate with multipurpose EP-2 grease.

Reassembly:
Assemble units with one 'D' and one 'S' hub (each is stamped). Unit will not phase adjust with two 'S' splines or two 'D' splines.

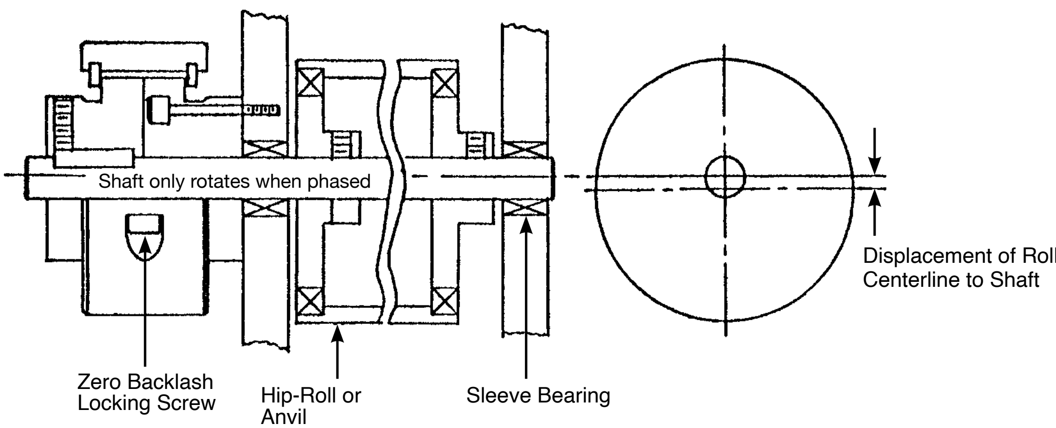
Operation:
Hand rotate the adjusting ring in either direction to produce a 100:1 reduction between the ring and one of the hubs. Adjust the friction adjustment/locking screw to desired resistance. For some applications, one adjustment will be sufficient for both shaft turning and phase adjusting modes. For more sever loading, such as hard stopping or higher torques, the friction adjustment/ locking screw may be used to lock the adjusting ring in place to maintain phase.

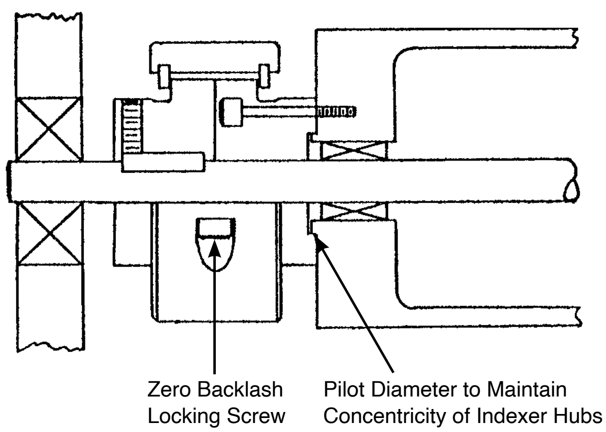


101:1 Reduction | 1:1.01 Increaser | 100:1 Reduction | 1.01:1 Reduction

If any two elements are locked together, the indexer will not phase and the unit will rotate in a 1:1 mode.

Precise manual displacement of roll centerline to adjust nip-roll pressure or depth-of-cut using HDI Infinit-Indexer® phase adjuster

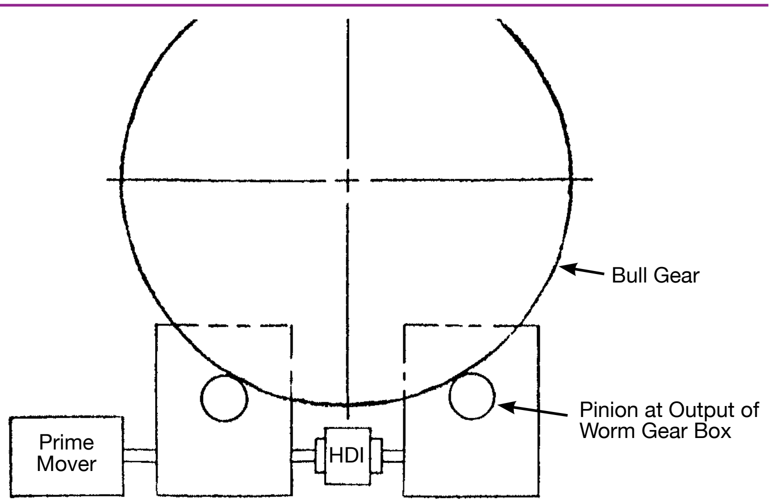




HDI Infinit-Indexer phase adjuster used to manually phase a hollow roll to a solid through-shaft

---

HDI for removal of backlash from a worm gear drive system. Two pinions, each mounted on the output shaft of separate, identical worm gear reducers, mate with a common bull gear. Adjusting the HDI causes one pinion to preload the bull gear against the other pinion. At set-up, the assembler finds the loosest mesh point of the system and adjusts-out the backlash at that point. Any other position of the bull gear will result in a preloaded system.



Infinit Indexer HDI

Special Order

HDI phase adjusters are available in 6 sizes. All sizes are furnished complete with hubs to specific order requirements. Several bore sizes are available with keyways and tapped holes on one or both hubs or in minimum plain bore for alteration by the user.

Special Order by Model Ordering Code:

HDI -10 -6S -6D
1 2 3 4

1.Name of Model : HDI
2.Size : 5, 10, 25, 50, 100, 200
3.Hub Configuration
- Plain Bore Hub : xxS (2S, 3S, 4S...20S)
- Key way-set Screw Hub : xxSK (2SK, 3SK, 4SK...20SK)
- Tapped Holes Hub : xxST (2ST, 3ST, 4ST...20ST)

4.Hub Configuration
- Plain Bore Hub : xxD (2D, 3D, 4D...20D)
- Key way-set Screw Hub : xxDK (2DK, 3DK, 4DK...20DK)
- Tapped Holes Hub : xxDT (2DT, 3DT, 4DT...20DT)

The Stocking Program

The stocking program offers the most cost effective way to purchase HDI phase adjusters. Three sizes of HDIs, (10, 25, and 50) are available from the stocking program.

Each comes with keyways and tapped holes on both hubs and is readily available from stock. Several bore sizes are available from the stocking program:

Stocking Options

Table 328-1

HDI Size	Bore Sizes	Keyway	Tapped Holes	Torque Capacity		Model Ordering Code
10	1/2"	3/16"	3 - #8-32	113 Nm	1000 lb-in	HDI - 010 - 500
	5/8"					HDI - 010 - 625
	3/4"					HDI - 010 - 750
25	3/4"	1/4"	6 - #10-32	283 Nm	2500 lb-in	HDI - 025 - 750
	1"					HDI - 025 -10005
50	1 1/4"	1/4"	6 - ¼-20	565 Nm	5000 lb-in	HDI - 050-12500

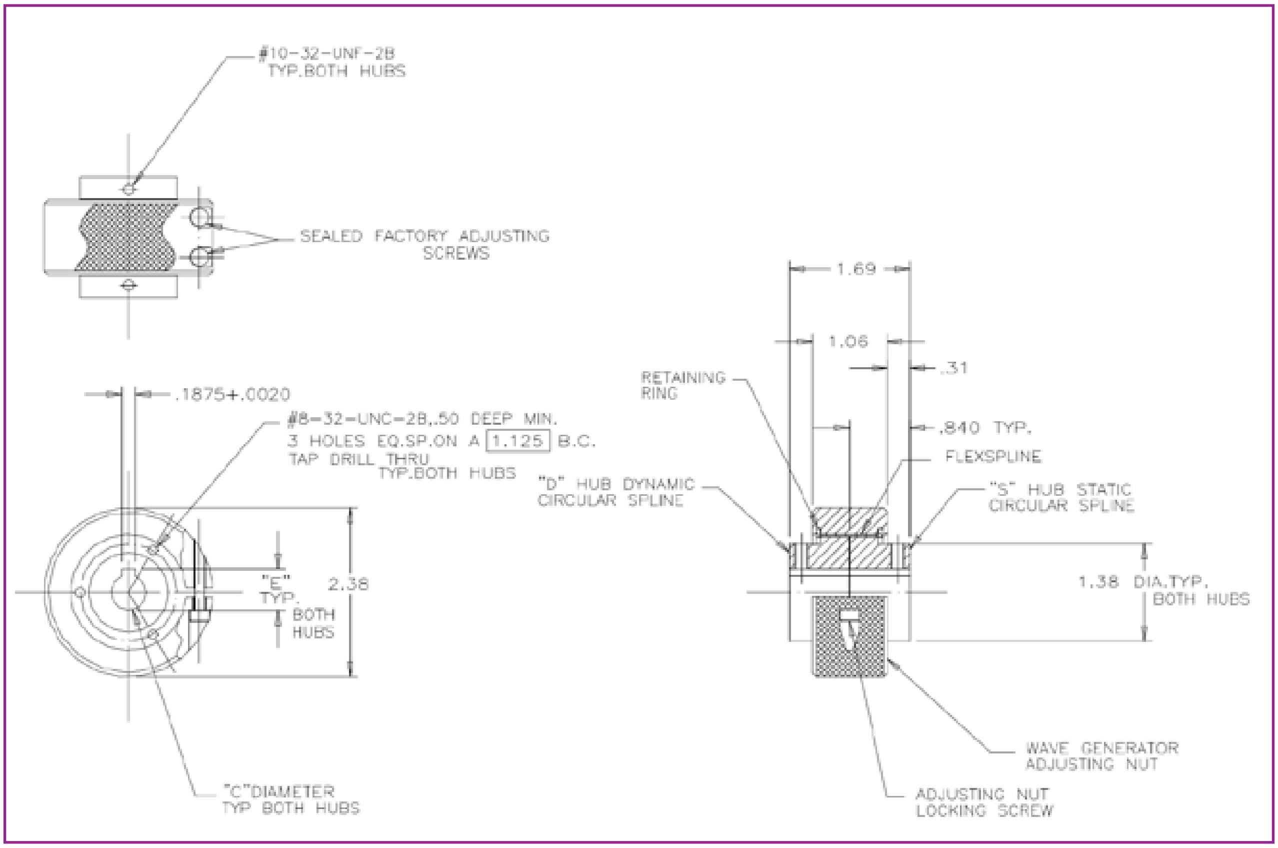
Dimensions-Stocking Program

Table 328-2

Size	10	10	10	25	25	50
BORE	0.5000	0.6250	0.7500	0.7500	1.0000	1.2500
D2	1.38	1.38	1.38	1.75	1.75	2.17
D3	2.38	2.38	2.38	3.00	3.00	3.75
L1	1.69	1.69	1.69	2.19	2.19	2.37
L2	0.31	0.31	0.31	0.40	0.40	0.37
L3	1.06	1.06	1.06	1.38	1.38	1.63
K1	0.1875	0.1875	0.1875	0.2500	0.2500	0.2500
KH1	0.585	0.710	0.831	0.863	1.114	1.368
N1	3	3	3	6	6	6
H1	#8-32	#8-32	#8-32	#10-32	#10-32	1/4-20
PC1	1.125	1.125	1.125	1.500	1.500	1.750

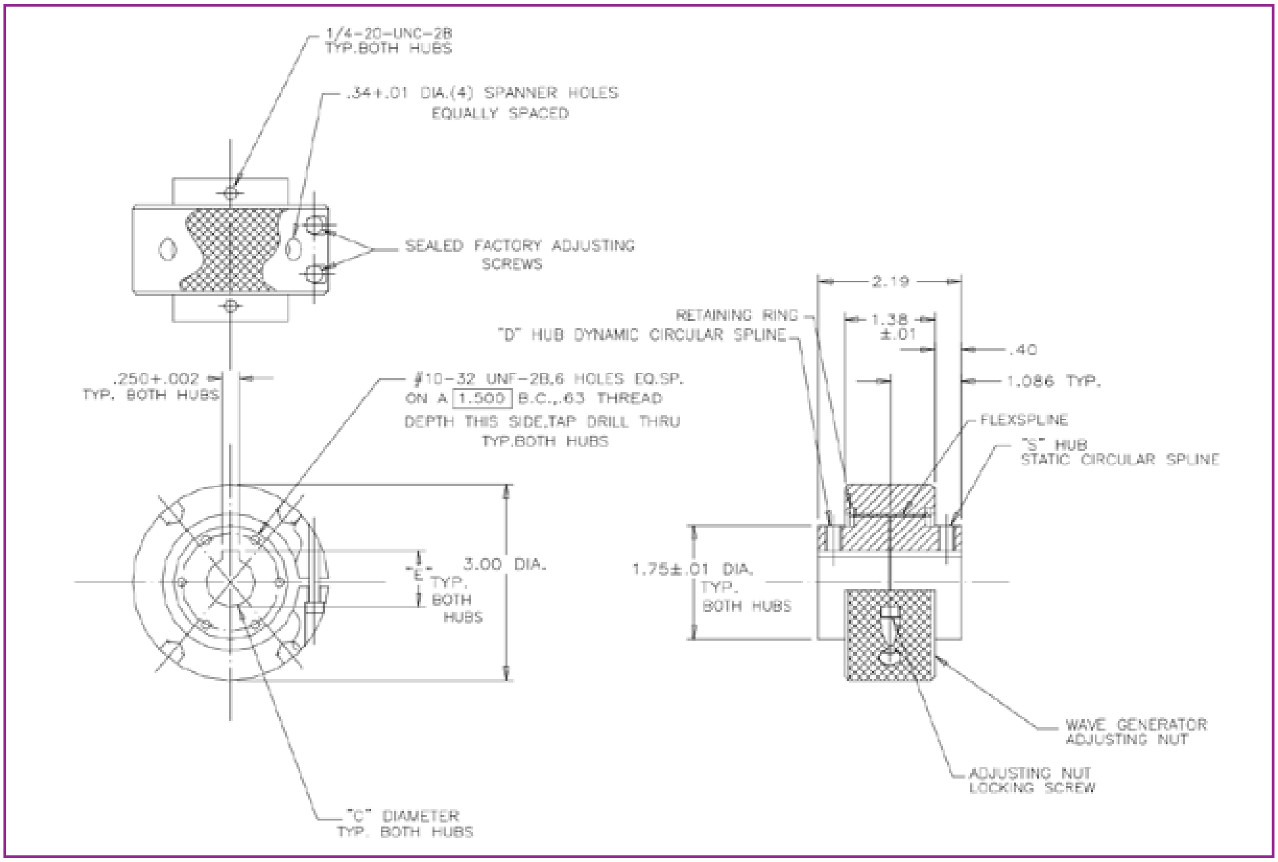
Outline Dimensions

Figure 329-1



Outline Dimensions

Figure 329-2



Engineering Data

Component Sets

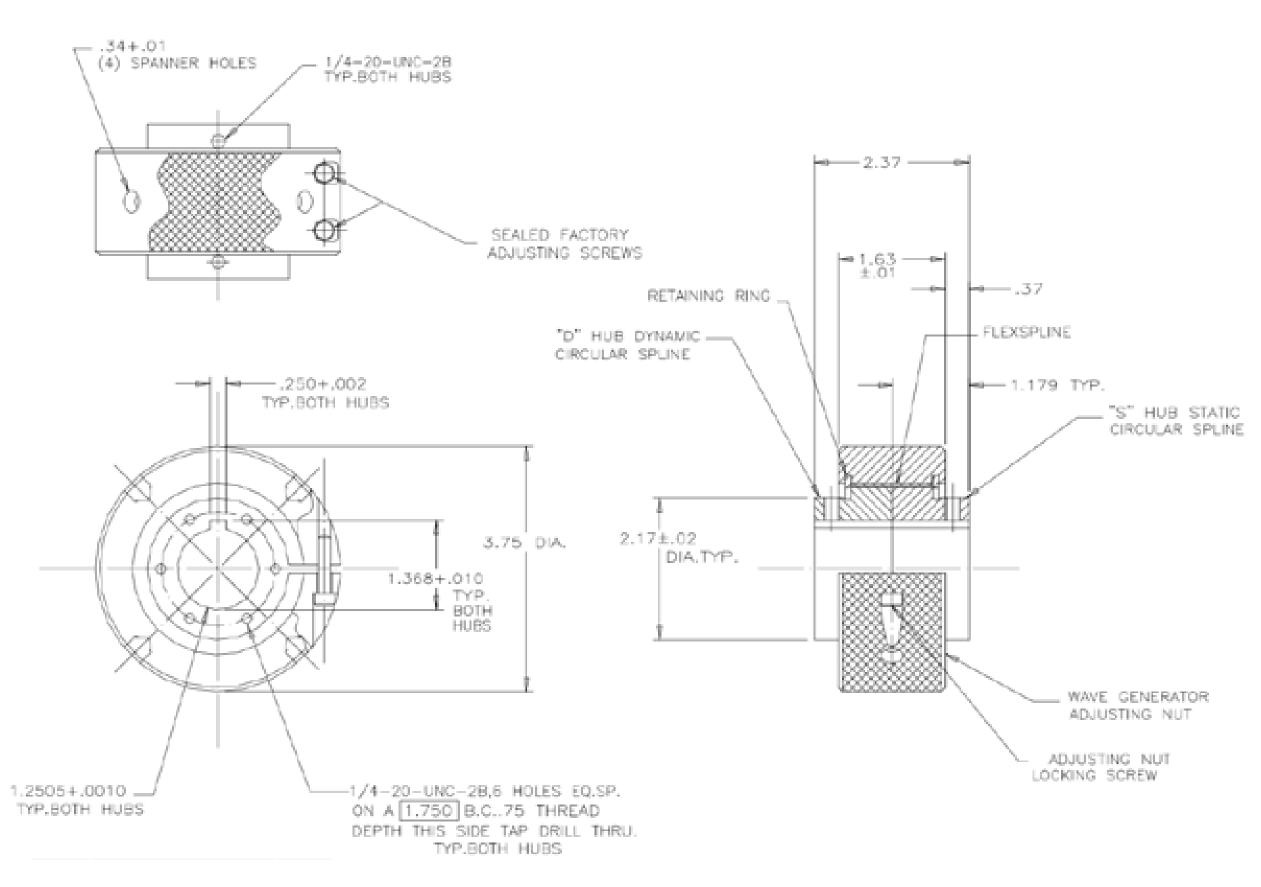
Gear Units

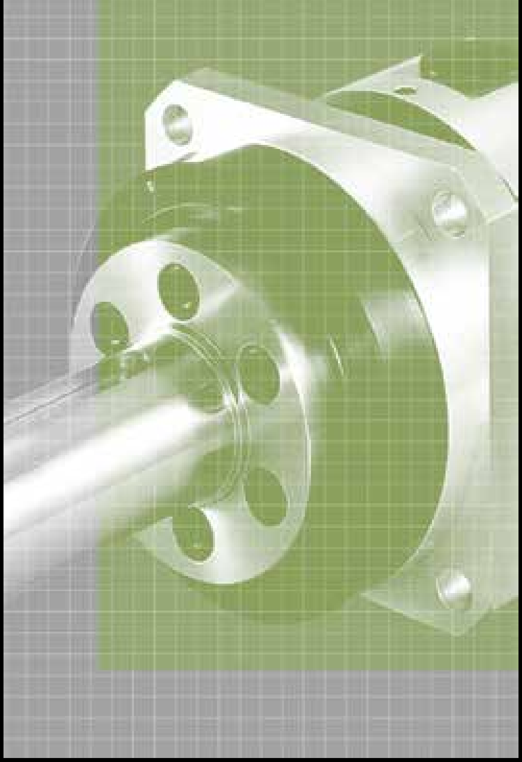
Phase Adjusters

Gearheads & Actuators

Outline Dimensions

Figure 330-1





Gearheads and Actuators

General Overview

Features

Harmonic Planetary® and Harmonic Drive® gearheads are available with a wide range of gear ratios and torque capacities.

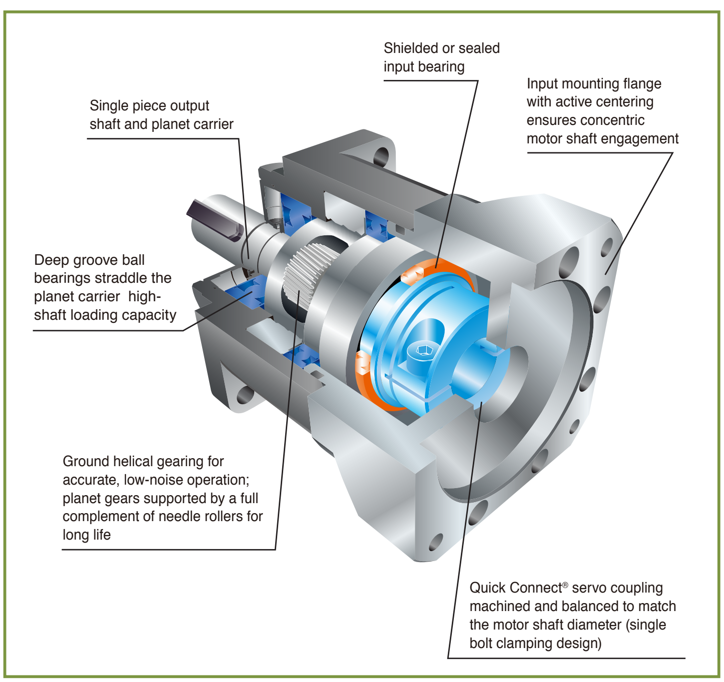
- Harmonic Drive® or Harmonic Planetary® gearheads
- Zero backlash and low backlash versions
- Ratios: 3:1 - 160:1
- Peak Torque: 3.9 N•m - 3940 N•m
- Sizes: 40mm - 230mm
- Output Configurations: Hollow Shaft, Flange, Keyed Shaft, Smooth Shaft
- Quick Connect® mounting system

Harmonic Planetary® (Ratios 3:1 to 50:1)

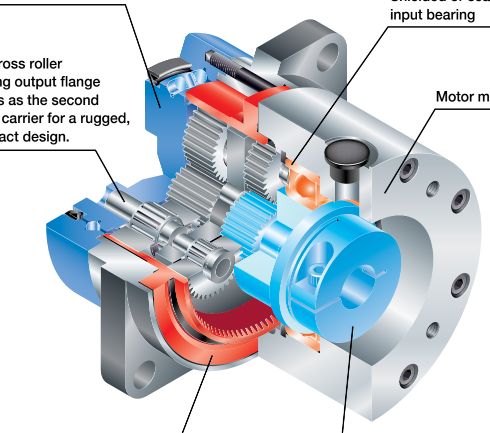
Harmonic Drive LLC offers a range of Harmonic Planetary® gearheads. HPN value series is our newest line of planetary gearheads and offer affordable pricing with short lead times. Plus, they are a drop-in replacement for many popular models. HPG (standard), HPG (helical and HPGP (high torque) gearheads offer precision and low backlash (standard: < 3-arc-min, optional: <1 arc-min). HPG is also available in 3 sizes as a right angle configuration, and is available with a hollow shaft.

Harmonic Drive® (Ratios 50:1 to 160:1)

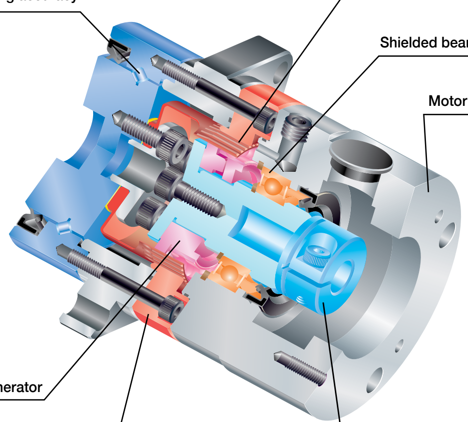
CSF-GH and CSG-GH Quick Connect® gearheads with zero-backlash Harmonic Drive® gearing utilize our proprietary S tooth profile and provide high precision positioning (repeatability ±4 to ±10 arc-sec).



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 servo motor with our Quick Connect® coupling. This value series of planetary gears carry the reputation for quality and reliability for which Harmonic Drive® products are known throughout the world. HPN Harmonic Planetary® gears are available in 5 sizes, with reduction ratios ranging from 3:1 to 50:1. Right Angle and Face-Mount configurations are also available.



HPG and HPGP Quick Connect® gearheads offer high precision and low backlash (standard: < 3-arc-min, optional: <1 arc-min). Harmonic Planetary® HPG gearheads are now available with helical gearing and low reduction ratios. The new models, HPG-XX R, add low-speed ratios from 3:1 through 10:1 including all integer ratios in between. Innovative ring gear ensures consistent, low backlash for the life of the gearhead. Right Angle configuration also available.



CSF-GH and CSG-GH Quick Connect® gearheads with zero backlash Harmonic Drive® gearing are available with high reduction ratios, 50:1 to 160:1. CSF-GH and CSG-GH utilize our proprietary S tooth profile and provide high precision positioning (repeatability ±4 to ±10 arc-sec). The greatest benefit of Harmonic Drive® gearing is the weight and space savings compared to other gearheads because it consists of only three basic parts.

Features

Rotary Actuators

Harmonic Drive® actuators are the easiest solution for your high precision motion control applications. Performance matched precision gearing, motors, and encoders are designed to provide a power dense, cost effective solution. Our actuators are extremely customizable. In fact, most of our customers use a custom actuator.

Harmonic Drive® rotary actuators deliver both high force and outstanding positional accuracy. Harmonic Drive manufactures our own cross roller bearings, as well as all other key components of our actuators including the motor, encoder, and gearing. By having complete control over the design of these critical elements, we have designed the performance matched components needed to develop extremely compact actuators with the highest power density while incorporating unique features such as a hollow shaft. Our designs are ready to be customized to meet your specific requirements.

The availability of these complete servo actuators eliminate the need for machine designers to individually select a motor and gearhead as well as the effort needed to characterize its expected performance. Our highly reliable and performance tested servo actuators and servo drives are the fastest means to get your machine design up and running.

We offer both conventional shaft and hollow shaft rotary actuators in many sizes with gear ratios ranging from 11:1 to 161:1.

FHA-Mini

Small actuators that deliver high torque with exceptional accuracy and repeatability. Peak torque 1.8~28 Nm, max speed 60~200 rpm.

FHA-C

Super-flat hollow shaft actuators with high torque, high positioning accuracy and high torsional stiffness. Peak torque 39~820 Nm, max speed 22~96 rpm.

FHA-C PR

Hollow shaft actuators available in 4 sizes with 3 reduction ratios. FHA-C-PR offers high-precision rotary positioning with improved one-way and bi-directional repeatability.

FHA-C H

Hollow shaft actuators available in 4 sizes with 3 reduction ratios are available with IP65 protection. With IP65, and 480V, the FHA actuator becomes increasingly suitable for machine tool, packaging, and wash-down applications.

New Actuators with Integrated Servo Drive

Actuator with an integrated servo drive utilizing CANopen® communication. Features a single cable connection with only 4 conductors needed: CANH, CANL, +24VDC, 0VDC.

All of our actuators are extremely customizable.

SHA-SG
Hollow shaft actuator with a compact outer diameter and exceptional torque/volume ratio. Peak torque 73~3419 Nm, Max speed 17.4~117.6.

SHA-CG
Hollow shaft actuator with direct drive motor performance with 80-90% less weight. Peak torque 23~3419 Nm, max speed 25~120 rpm.

RSF-Supermini
Small enough to fit inside the finger of a robotic hand, these servo actuators operate with a wide range of drivers. Peak torque .13~1.4 Nm, max speed 100~333 rpm.

RSF-Mini
Available in 3 sizes, these brushless servo actuators deliver exceptional positioning accuracy in a compact package. Peak torque 1.8~28 Nm, max speed 60~200 rpm.

RSF
Available in 4 sizes, these brushless servo actuators deliver exceptional positioning accuracy in a compact package. Peak torque 34~330 Nm, max speed 45~90 rpm.

RKF
High torque AC servo actuator with output flange. Peak torque 56~330 Nm, max speed 45~90 rpm.

RH-Mini
DC servo actuator with incremental encoder. Peak torque .39~20 Nm, max speed 50~180 rpm.

FLA
Ultra-light brushless actuators combine our high-precision/high-performance reducers with a compact, high-output brushless DC motor. Peak torque 1.8~34 Nm, Max speed 50~500 rpm.

Warranty Period and Terms

Products that are described in this catalog are warranted as follows:

■ Warranty period

Under the condition that the products are handled, used and maintained properly in accordance with the technical materials, the manuals, and this catalog, all the products are warranted against defects in workmanship and materials for the shorter period of either one year after delivery or 2,000 hours of operation time.

■ Warranty terms

All the products are warranted against defects in workmanship and materials for the warranted period.
This limited warranty does not apply to any product that has been subject to:

(1) User's misapplication, improper installation, inadequate maintenance, or misuse.
(2) Disassembling, modification or repair by others than Harmonic Drive Systems, Inc.
(3) Imperfection caused by the other than the products.
(4) Natural disasters or others outside of the control of Harmonic Drive Systems, Inc.

Our liability shall be limited exclusively to repairing or replacing the product only found by Harmonic Drive Systems, Inc. to be defective. Harmonic Drive Systems, Inc. shall not be liable for consequential damages of other equipment caused by the defective products, and shall not be liable for the incidental and consequential expenses and the labor costs for detaching and installing to the driven equipment.

■ Disclaimer

All efforts have been made to assure 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.

HarmonicDrive® Reducer for Precision Control

For Safe Use of Harmonic Drive® Component Set and Gear Unit

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.

This product requires approval from Harmonic Drive prior to use in the following applications:

This product cannot be used for the following applications:

* Aircraft equipment
* Automotive equipment
* Game equipment
* Nuclear power equipment
* Space equipment
* Vacuum equipment
* Equipment for transport of humans
* Equipment for use in a special environment
* Equipment that directly works on human bodies
* Equipment and apparatus used in domestic homes

Please consult Harmonic Drive beforehand when intending to use one of its product for the aforementioned applications. A safety mechanism needs to be incorporated if product failure or damage may cause harm to a human, or lead to serious damage.

Design Precaution: Be certain to read the catalog when designing your equipment.

Caution — Use only in a specified environment.
- Please ensure the following environmental conditions are complied with:
  - Ambient temperature 0 to 40°C
  - No splashing of water or oil
  - Do not expose to corrosive or explosive gas
  - No dust such as metal powder

Caution — Install the equipment in a specified manner.
- Carry out assembly precisely in the specified order according to the catalog.
- Observe our recommended tightening methods (such as bolts used).
- Operating the equipment without precise assembly can cause troubles such as generation of vibration, reduction of life, deterioration of precision and breakdown.

Caution — Install the equipment in a specified precision.
- Design and assemble parts to maintain the recommended installation and assembly tolerances in the catalog.
- Failure to keep the precision can cause troubles such as vibration, reduction of life, deterioration of precision and breakdown.

Caution — Use the specified lubricant.
- Using other lubricant than our recommended products can reduce the life. Replace the lubricant in a specified condition.
- Grease is sealed in a unit product. Do not mix other kinds of grease.

Operational Precaution: Be certain to read the catalog before operating the equipment.

Caution — Be careful in handling products and parts.
- Do not impact the parts and units with a hammer, etc. Do not scratch or dent them. Possible damage is assumed.
- If you use the equipment in a damaged condition, the specified performance may not be retained. It can also cause troubles such as breakdown.

Caution — Apply torque within the allowable range.
- Do not apply torque exceeding the instantaneous allowable max. torque. Applying excess torque can cause troubles such as loose tightening bolts, generation of backlash and breakdown.
- Striking an arm directly attached to the output shaft can damage the arm and make the output shaft uncontrollable.

Caution — Do not change a set of parts.
- The product is manufactured with matched serial numbers. The specified performance may not be retained if you have used mixed sets of parts.

Caution — Do not break down unit products.
- Do not break down and reassemble unit products. Original performance may not be reproduced.

Caution
- Rust-proofing was applied before shipping. However, please note that rusting occurs earlier depending on the customers' storage environment.
- Although black oxide finish is applied to some of our products, it dose not guarantee the antirust effect.

Handling lubricant

Warning — Precautions on handling lubricant
- Use protective eyewear when handling. Avoid contact with eyes. May cause inflammation.
- Use gloves and other skin protection when handling. Avoid contact with skin. May cause inflammation.
- Do not swallow. May cause diarrhea and vomiting.
- Keep out of reach of children.

Treatment of waste oil and containers
- Proper disposal is essential. Dispose of waste oil and waste containers properly in accordance with applicable laws and regulations.
- Do not apply pressure on an empty container.
- Do not weld, heat, drill or cut the container. The remainder may ignite with an explosion.

Warning — First-aid
- EYES: Flush with clean water for at least 15 minutes. Consult a physician.
- SKIN: Thoroughly remove with cloth or paper and wash with soap and water.
- INGESTION: Consult a physician immediately. Do not induce vomiting.
- INHALATION: Immediately seek fresh air if adverse effects are observed.

Caution — Storage
- Close the container tightly after use in order to prevent contamination with dust or moisture. Avoid direct exposure to sunlight. Store at room temperature.

When Discarding Actuator and Servo Driver

Caution — Please discard as industrial waste.
- Please discard as industrial waste when discarding.

Major Applications of Our Products


Metal Working Machines

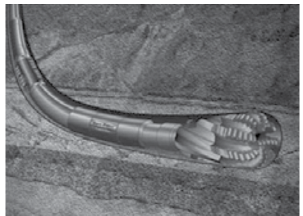

Processing Machine Tools


Measurement, Analytical and Test Systems

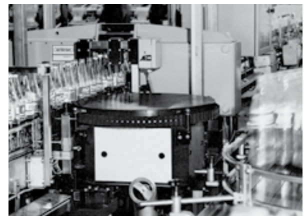

Medical Equipment


Telescopes

Source: National observatory of Inter-University Research Institute Corporation


Energy

Courtesy of Halliburton/Sperry Drilling Services


Crating and Packaging Machines


Communication Equipment


Space Flight Hardware

Rover image created by Dan Maas, copyrighted to Cornell and provided courtesy NASA/ JPL-Caltech.

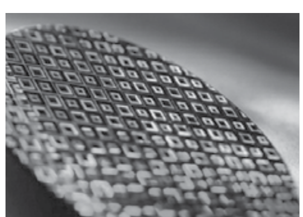

Glass and Ceramic Manufacturing Systems


Robots


Humanoid Robots

Source: Honda Motor Co., Ltd.

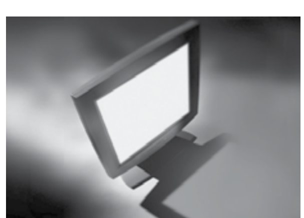

Printing, Bookbinding and Paper Machines

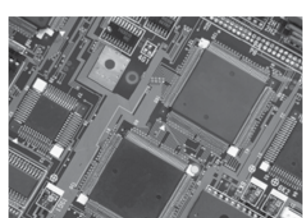

Semiconductor Manufacturing Equip.


Optical Equipment


Machine Tools

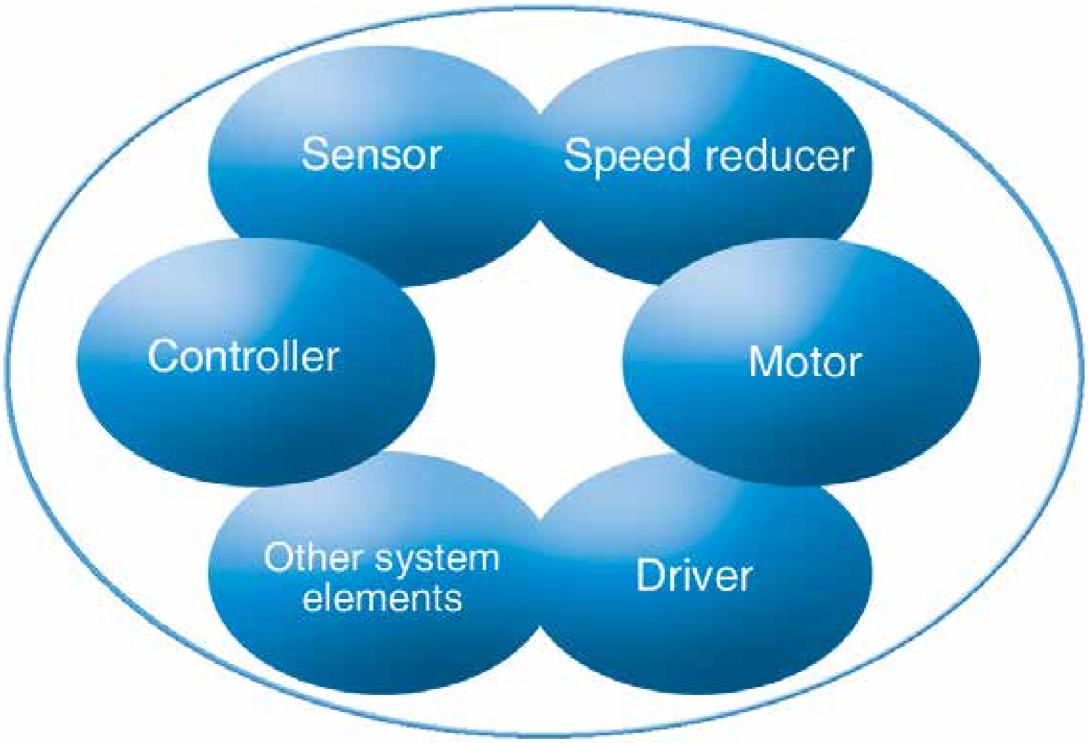

Paper-making Machines


Flat Panel Display Manufacturing Equip.


Printed Circuit Board Manufacturing Machines


Aerospace

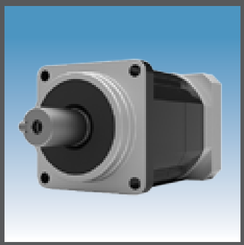
Experts in Precision Motion Control



Other Products

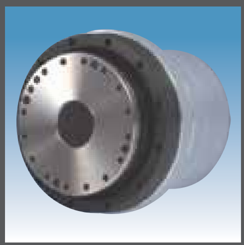
Servo Mount Gearheads

Harmonic Drive® and Harmonic Planetary® Quick Connect® gearheads easily mount to any servomotor to create a high precision actuator.



Hollow Shaft Rotary Actuators

High-torque actuators combine performance matched servomotors with Harmonic Drive® gears to deliver excellent dynamic control characteristics.

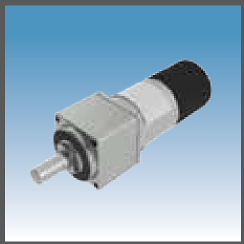


Linear Actuators

Compact linear actuators combine a precision lead screw and HarmonicDrive® gear. Our versatile actuators deliver both ultra precise positioning and high torque.

Mini Actuators

Small enough to fit inside the finger of a robotic hand, these servo actuators operate with a wide range of drivers.



Harmonic Drive LLC

Boston US Headquarters
42 Dunham Ridge
Beverly, MA 01915

New York Sales Office
100 Motor Parkway
Suite 116
Hauppauge, NY 11788

California Sales Office
333 W. San Carlos Street
Suite 1070
San Jose, CA 95110

Chicago Sales Office
137 N. Oak Park Ave.
Suite 410
Oak Park, IL 60301

T: 800.921.3332
T: 978.532.1800
www.HarmonicDrive.net

Group Companies
Harmonic Drive Systems, Inc.
6-25-3 Minami-Ohi, Shinagawa-ku
Tokyo 141-0013, Japan

Harmonic Drive SE
Hoenbergstrasse, 14, D-65555
Limburg/Lahn Germany

HARMONIC DRIVE®

Rev 20230518