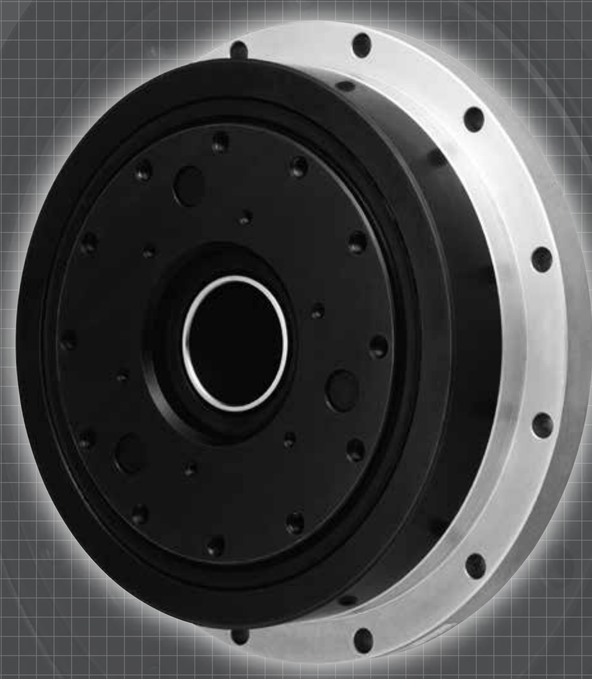
HarmonicPlanetary®

HPF Hollow Shaft Gear Unit



Size
2 Sizes

25, 32

Peak torque
Size 25: 100Nm, Size 32: 220Nm

Reduction ratio
11:1

Low backlash
Standard: <3 arc-min Low Backlash for Life
Innovative ring gear automatically adjusts for backlash, ensuring consistent, low backlash for the life of the gearhead. The ring gear design automatically provides the optimum backlash in the planetary gear train and maintains the same low backlash for the life of the gearhead.

Inside diameter of the hollow shaft
Size 25: Ø25mm Size 32: Ø30mm

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

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

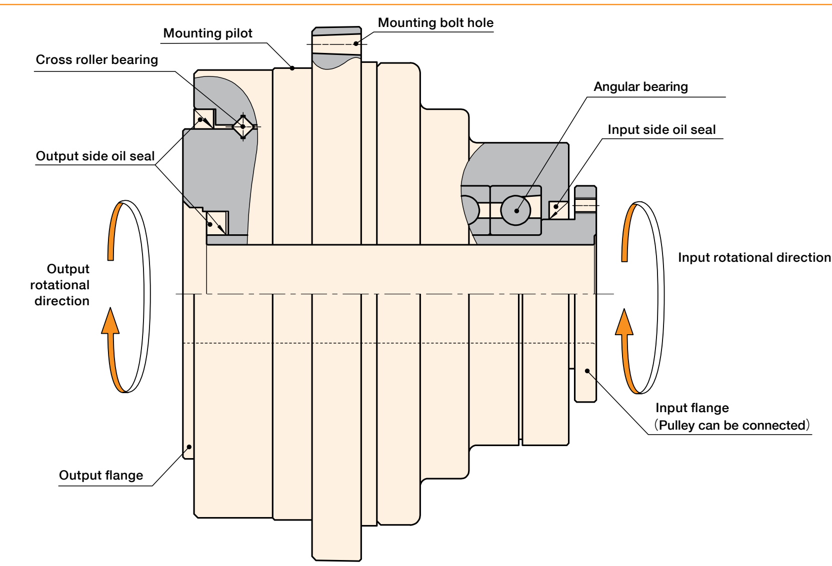
CONTENTS

HPF - 25 A - 11 - F0 U1 - SP1

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

Gearhead Construction

Figure 094-1



Rating Table

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

Table 095-1

Size	Ratio	Rated Torque at 2000 rpm *1	Rated Torque at 3000 rpm *2	Limit for Repeated Peak Torque *3	Limit for Momentary Torque *4	Max. Average Input Speed *5	Max. Input Speed *6	Input Moment of Inertia	Mass
		Nm	Nm	Nm	Nm	rpm	rpm	$\times10^{-4}$kgm²	kg
25	11	48	21	100	170	3000	5600	1.63	3.8
32	11	100	44	220	450	3000	4800	3.84	7.2

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

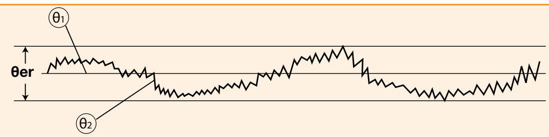
Performance Table

Table 095-2

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

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

Figure 095-1

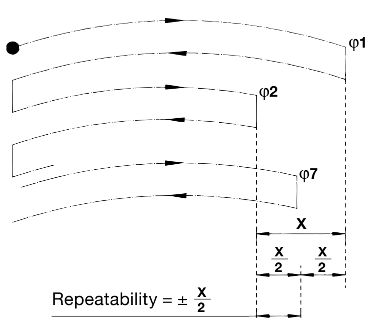


θer : Accuracy
θ1 : Input angle
θ2 : Actual output angle
R : Gear reduction ratio

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

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

Figure 095-2



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

Table 095-3

Load	No load
HPF speed reducer surface temperature	25°C

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

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

Table 095-4

Load	No load
HPF speed reducer surface temperature	25°C

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

Table 095-5

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

Backlash and Torsional Stiffness

Table 096-1

■ HPF Hollow Shaft Unit

Size	Reduction Ratio	Backlash		Torsion angle at TR X 0.15 D		Torsional stiffness A/B	
		arc min	$\times10^{-4}$rad	arc min	$\times10^{-4}$rad	kgfm/arc min	×100Nm/rad
25	11	3.0	8.7	2.0	5.8	1.7	570
32	11	3.0	8.7	1.7	4.9	3.5	1173

Torsional stiffness curve

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

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

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

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

Calculation of total torsion angle

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

Formula 096-1

● Calculation formula

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

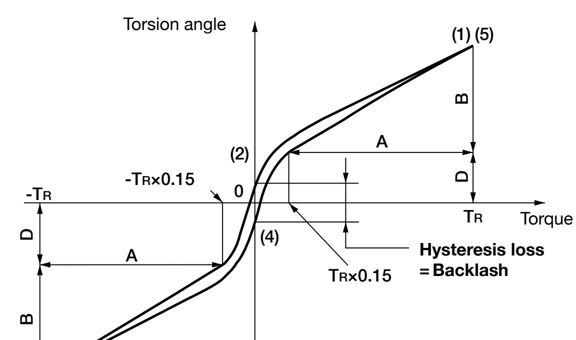
θ	Total torsion angle	——
D	Torsion angle on one side at output torque x 0.15 torque	See Fig. 096-1, Table 096-1
T	Load torque	——
T_L	Output torque x 0.15 torque (=T_RX0.15)	See Fig. 096-1
A/B	Torsional stiffness	See Fig. 096-1, Table 096-1

Backlash (Hysteresis Loss)

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

Figure 096-1

Torque-torsion angle diagram



TR: Rated output torque
A/B: Torsional stiffness
D: Torsion on one side at TRX0.15

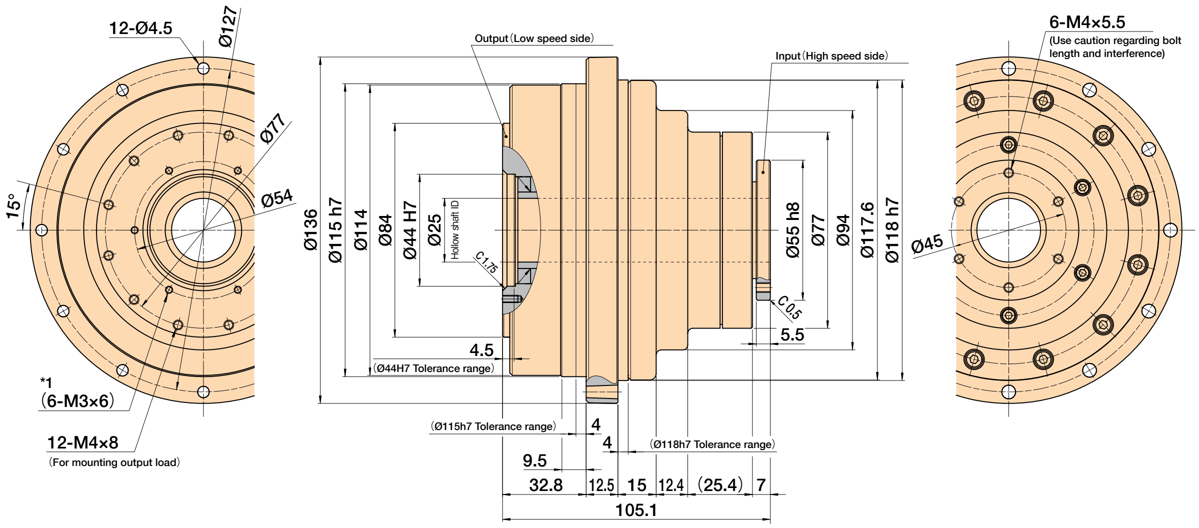
Outline Dimensions

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

HPF-25 Outline Dimensions

Figure 097-1

(Unit: mm)

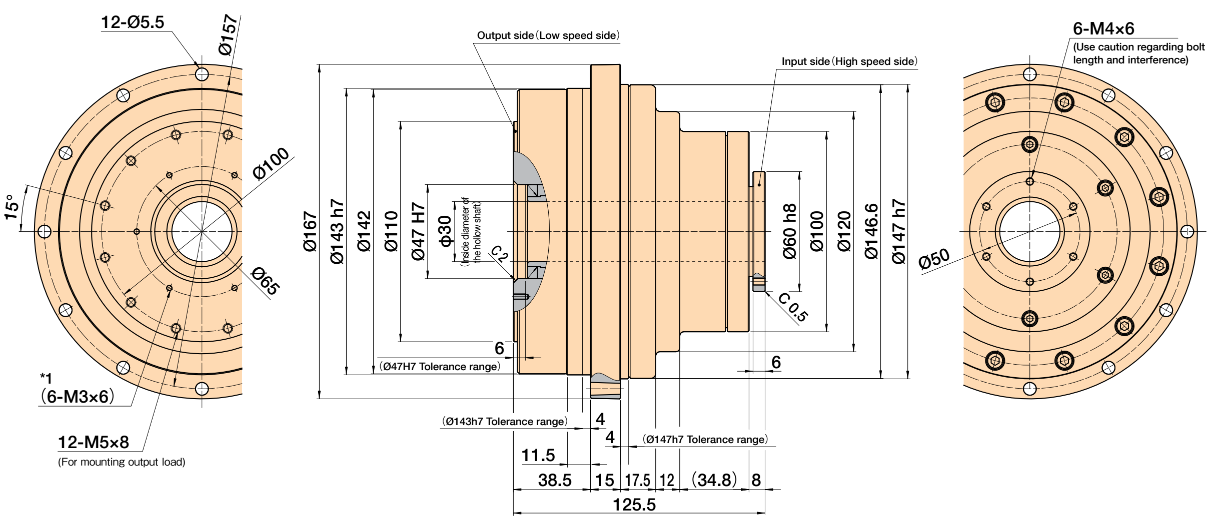


(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above.
*1: The inside diameter of the hollow shaft rotates with the input shaft (high speed). Use these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

HPF-32 Outline Dimensions

Figure 097-2

(Unit: mm)



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

Product Sizing & Selection

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

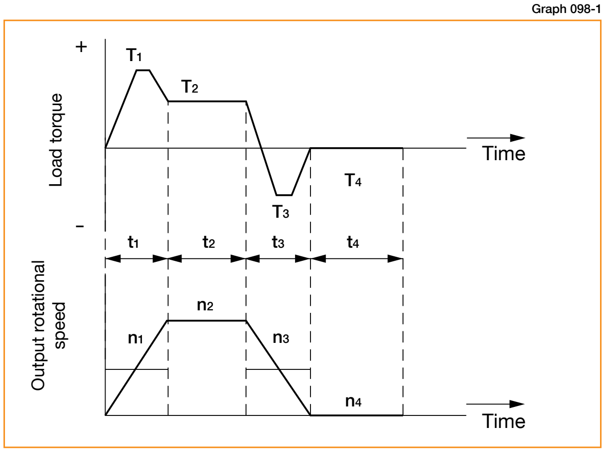
In general, a servo system rarely operates at a continuous load and speed. The input speed, load torque change and a comparatively large torque is applied during start and stop. Unexpected impact torques may also be applied.

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

Checking the load torque pattern

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

Graph 098-1



Obtain the value of each load torque pattern.

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

<Normal operation pattern>

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

<Maximum rotational speed>

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

<Impact torque>

When impact torque is applied T_s

<Required life>

L_{10} = L (hours)

Flowchart for selecting a size

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

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

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

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

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

↓

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

↓ OK

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

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

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

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

↓

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

↓ OK

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

↓ OK

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

↓ OK

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

↓ OK

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

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

→ NG

↓ OK

The model number is confirmed.

NG: Refer to the Caution note below. / Review the operation conditions, size and reduction ratio.

Caution

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

Example of model number Selection

Value of each load torque pattern.

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

<Normal operation pattern>

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

<Maximum rotational speed>

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

<Impact torque>

When impact torque is applied T_s = 120 Nm

<Required life>

L_{10} = 30,000 (hours)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

— NG / OK

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

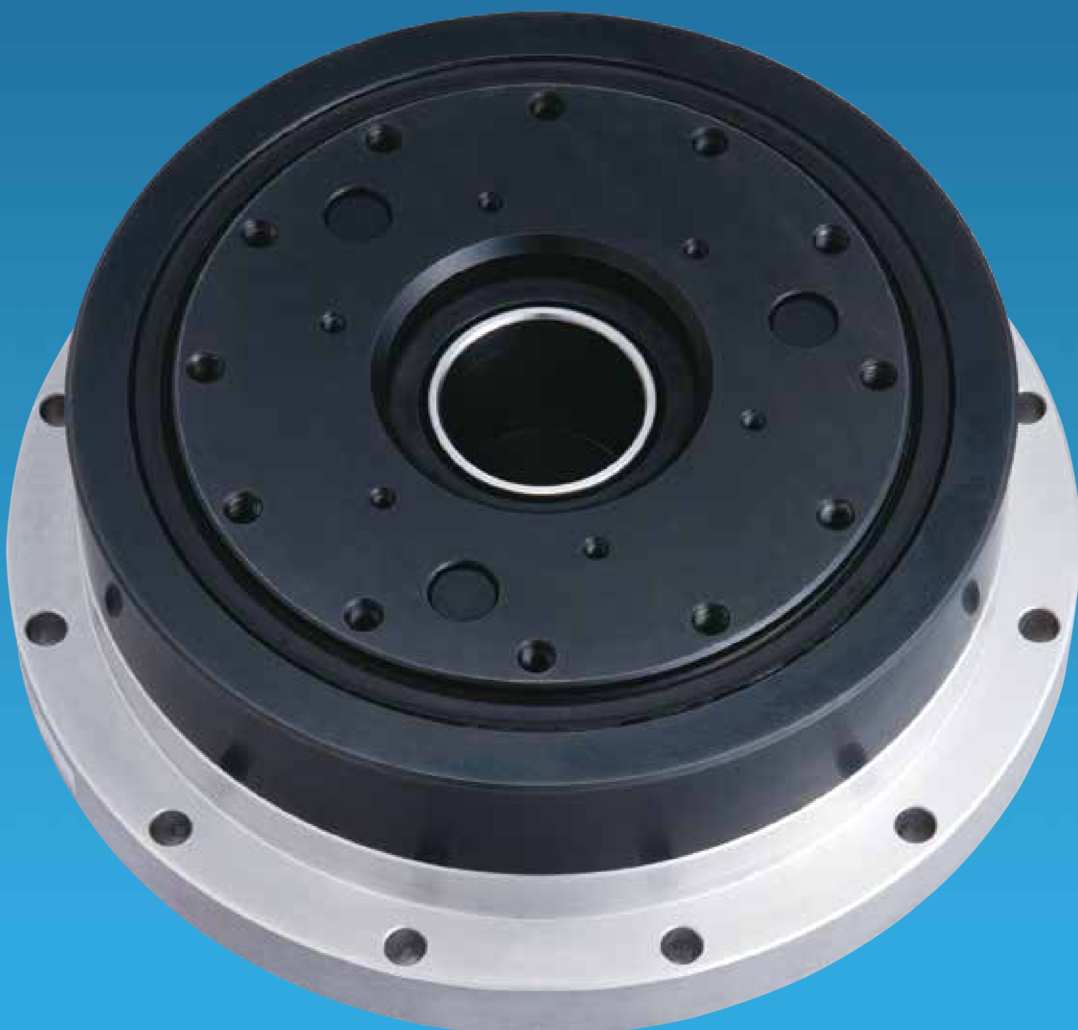
Refer to the Caution note at the bottom of page 98.

Review the operation conditions, size and reduction ratio.

HarmonicPlanetary®

Planetary Gear Units

HPF Series - Hollow Shaft



Output Bearing Specifications and Checking Procedure

A precision cross roller bearing supports the external load (output flange).
Check the maximum load, moment load, life of the bearing and static safety coefficient to maximize performance.

Checking procedure

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

Obtain the maximum load moment load (M_{max}). → Maximum load moment load (M_{max}) ≦ Permissible moment (Mc)

(2) Checking the life

Obtain the average radial load (Fr_{av}) and the average axial load (Fa_{av}). → Obtain the radial load coefficient (X) and the axial load coefficient (Y). → Calculate the life and check it.

(3) Checking the static safety coefficient

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

Specification of output bearing

HPF Series Table 130-2 indicates the specifications for cross roller bearing.

Table 130-2

Size	Pitch circle	Offset amount	Basic load rating				Allowable moment load Mc*3		Moment stiffness Km*4		Allowable radial load*5	Allowable axial load*5
	dp	R	Basic dynamic load rating C*1		Basic static load rating Co*2				$\times 10^4$ Nm/rad	kgfm/arc min		
	m	m	N	kgf	N	kgf	Nm	kgfm			N	N
25	0.085	0.0153	11400	1163	20300	2071	410	41.8	37.9	11.3	1330	1990
32	0.1115	0.015	22500	2296	39900	4071	932	95	86.1	25.7	2640	3940

*1 The basic dynamic load rating means a certain static radial load so that the basic dynamic rated life of the roller bearing is a million rotations.
*2 The basic static load rating means a static load that gives a certain level of contact stress ($4kN/mm^2$) in the center of the contact area between rolling element receiving the maximum load and orbit.
*3 The allowable moment load is a maximum moment load applied to the bearing. Within the allowable range, basic performance is maintained and the bearing is operable. Check the bearing life based on the calculations shown on the next page.
*4 The value of the moment stiffness is the average value.
*5 The allowable radial load and allowable axial load are the values that satisfy the life of a speed reducer when a pure radial load or an axial load applies to the main bearing. (Lr + R = 0 mm for radial load and La = 0 mm for axial load) If a compound load applies, refer to the calculations shown on the next page.

How to calculate the maximum load moment load

HPGP HPG CSG-GH CSF-GH HPF

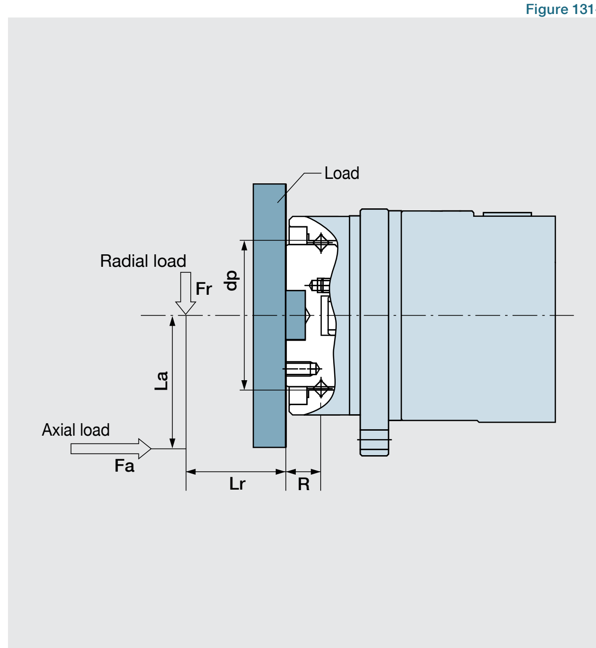
Maximum load moment load (M_{max}) is obtained as follows.
Make sure that $M_{max} \leqq Mc$.

Formula 131-1

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

Fr_{max}	Max. radial load	N (kgf)	See Fig. 131-1.
Fa_{max}	Max. axial load	N (kgf)	See Fig. 131-1.
Lr, La	—	m	See Fig. 131-1.
R	Offset amount	m	See Fig. 131-1. See "Specification of main bearing" of each series

Figure 131-1



How to calculate the radial load coefficient and the axial load coefficient

HPGP HPG CSG-GH CSF-GH HPF

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

Formula 131-2

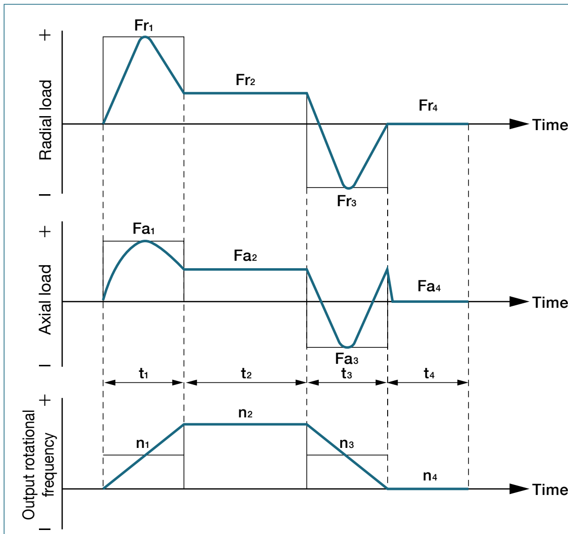
Formula	X	Y
$\dfrac{Fa_{av}}{Fr_{av}+2(Fr_{av}(Lr+R)+Fa_{av}\cdot La)/dp} \leqq 1.5$	1	0.45
$\dfrac{Fa_{av}}{Fr_{av}+2(Fr_{av}(Lr+R)+Fa_{av}\cdot La)/dp} > 1.5$	0.67	0.67

Fr_{av}	Average radial load	N (kgf)	See "How to obtain the average load."
Fa_{av}	Average axial load	N (kgf)	See "How to obtain the average load."
Lr, La	—	m	See Fig. 131-1.
R	Offset amount	m	See Fig. 131-1. See "Output Shaft Bearing Specifications" of each series.
dp	Circlar pitch of roller	m	See Fig. 131-1. See "Output Shaft Bearing Specifications" of each series.

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

HPGP HPG CSG-GH CSF-GH HPF

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



How to obtain the average radial load (Fr_{av}) — Formula 131-3

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

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

How to obtain the average axial load (Fa_{av}) — Formula 131-4

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

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

How to obtain the average output rotational frequency (N_{av}) — Formula 131-5

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

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

Calculate the life of the cross roller bearing using Formula 132-1. You can obtain the dynamic equivalent radial load (Pc) using Formula 132-2.

Formula 132-1

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

L_{10}	Life	hour	—
N_{av}	Ave. output speed	rpm	See "How to calculate the ave. load."
C	Basic dynamic rated load	N (kgf)	See "Output Bearing Specs."
Pc	Dynamic equi. radial load	N (kgf)	See Formula 132-2.
fw	Load coefficient	—	See Table 132-1.

Formula 132-2

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

Fr_{av}	Average radial load	N (kgf)	See "How to calculate the ave. load."
Fa_{av}	Average axial load	N (kgf)	See "How to calculate the ave. load."
dp	Circlar pitch of roller	m	See "Output Bearing Specs."
X	Radial load coefficient	-	See "How to calculate the radial load coefficient and the axial load coefficient."
Y	Axial load coefficient	-	See "How to calculate the radial load coefficient and the axial load coefficient."
Lr, La	—	m	See Figure 131-1. See "External load influence diagram."
R	Offset amount	m	See Figure 131-1. See "External load influence diagram" and "Output Bearing Specs" of each series.

Load coefficient

Table 132-1

Load status	fw
During smooth operation without impact or vibration	1 to 1.2
During normal operation	1.2 to 1.5
During operation with impact or vibration	1.5 to 3

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

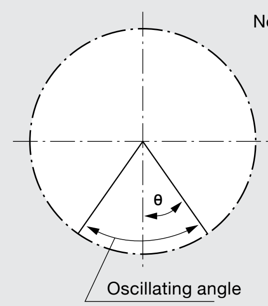
Calculate the life of the cross roller bearing during oscillating movement by Formula 132-3.

Formula 132-3

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

Loc	Rated life under oscillating movement	hour	-
n1	No. of reciprocating oscillation per min.	cpm	-
C	Basic dynamic rated load	N (kgf)	See "Output Bearing Specs."
Pc	Dynamic equivalent radial load	N (kgf)	See Formula 132-2.
fw	Load coefficient	—	See Table 132-1.
θ	Oscillating angle /2	Deg.	See Figure 132-1.

Figure 132-1



Note: When the oscillating angle is small (5° or less), it is difficult to generate an oil film on the contact surface of the orbit ring, and the rolling element and fretting may be generated. Contact us if this happens.

Note When it is used for a long time while the rotation speed of the output shaft is in the ultra-low operation range (0.02rpm or less), the lubrication of the bearing becomes insufficient, resulting in deterioration of the bearing or increased load in the driving side. When using it in the ultra-low operation range, contact us.

How to calculate the static safety coefficient HPGP HPG CSG-GH CSF-GH HPF

In general, the basic static rated load (Co) is considered to be the permissible limit of the static equivalent load. However, obtain the limit based on the operating and required conditions. Calculate the static safety coefficient (fs) of the cross roller bearing using Formula 132-4.
General values under the operating condition are shown in Table 132-2. You can calculate the static equivalent radial load (Po) using Formula 132-5.

Formula 132-4

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

Co	Basic static rated load	N (kgf)	See "Output Bearing Specs."
Po	Static equivalent radial load	N (kgf)	See Formula 132-5.

Formula 132-5

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

Fr_{max}	Max. radial load	N (kgf)	See "How to calculate the max. load moment load."
Fa_{max}	Max. axial load	N (kgf)	See "How to calculate the max. load moment load."
M_{max}	Max. load moment load	Nm (kgfm)	See "How to calculate the max. load moment load."
dp	Circlar pitch of roller	m	See "Output Bearing Specs" of each series.

Static safety coefficient

Table 132-2

Load status	fs
When high rotation precision is required	≧3
When impact or vibration is expected	≧2
Under normal operating condition	≧1.5

Input Bearing Specifications and Checking Procedure

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

Checking procedure HPG HPF

(1) Checking maximum load

Calculate:
Maximum load moment load (Mi *max*)
Maximum load axial load (Fai *max*)
Maximum load radial load (Fri *max*)

→

Maximum load moment load (Mi *max*) ≦ Permissible moment load (Mc)
Maximum load axial load (Fai *max*) ≦ Permissible axial load (Fac)
Maximum load radial load (Fri *max*) ≦ Permissible radial load (Frc)

(2) Checking the life

Calculate:
Average moment load (Mi *av*)
Average axial load (Fai *av*)
Average input speed (Ni *av*)

→

Calculate the life and check it.

Specification of input shaft bearing

The specification of the input side main bearing of the input shaft unit is shown below.

Specification of input shaft bearing HPG

Table 133-1

Size	Basic rated load			
	Basic dynamic rated load Cr		Basic static rated load Cor	
	N	kgf	N	kgf
11	2700	275	1270	129
14	5800	590	3150	320
20	9700	990	5600	570
32	22500	2300	14800	1510
50	35500	3600	25100	2560
65	51000	5200	39500	4050

Table 133-2

Size	Allowable moment load Mc		Allowable axial load Fac *1		Allowable radial load Frc *2	
	Nm	kgfm	N	kgf	N	kgf
11	0.16	0.016	245	25	20.6	2.1
14	6.3	0.64	657	67	500	51
20	13.5	1.38	1206	123	902	92
32	44.4	4.53	3285	335	1970	201
50	96.9	9.88	5540	565	3226	329
65	210	21.4	8600	878	5267	537

Specification of input shaft bearing HPF

Table 133-3

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

Table 133-4

Size	Allowable moment load Mc		Allowable axial load Fac *1		Allowable radial load Frc *3	
	Nm	kgfm	N	kgf	N	kgf
25	10	1.02	1538	157	522	53.2
32	19	1.93	3263	333	966	98.5

〔Note: Table 133-2 and 133-4〕
*1 The allowable axial load is the tolerance of an axial load applied to the shaft center.
*2 The allowable radial load of HPG series is the tolerance of a radial load applied to the shaft length center.
*3 The allowable radial load of HPG series is the tolerance of a radial load applied to the point of 20 mm from the shaft edge (input flange edge).

Calculating maximum load moment load to input shaft

HPG HPF

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

Formula 134-1

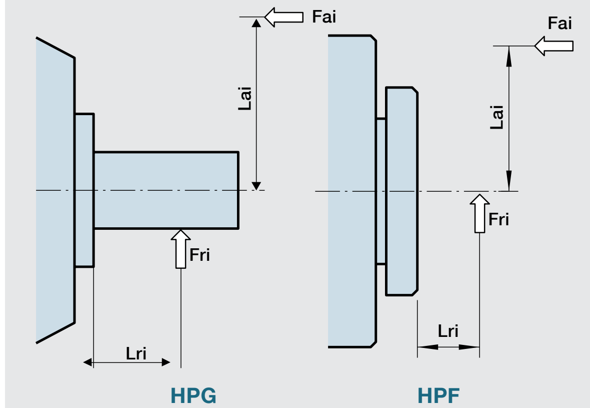
$$Mi_{max} = Fri_{max} \cdot Lri + Fai_{max} \cdot Lai$$

Fri_{max}	Max. radial load	N (kgf)	See Fig. 134-1.
Fai_{max}	Max. axial load	N (kgf)	See Fig. 134-1.
Lri,Lai	————	m	See Fig. 134-1.

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

Figure 134-1

External load influence diagram

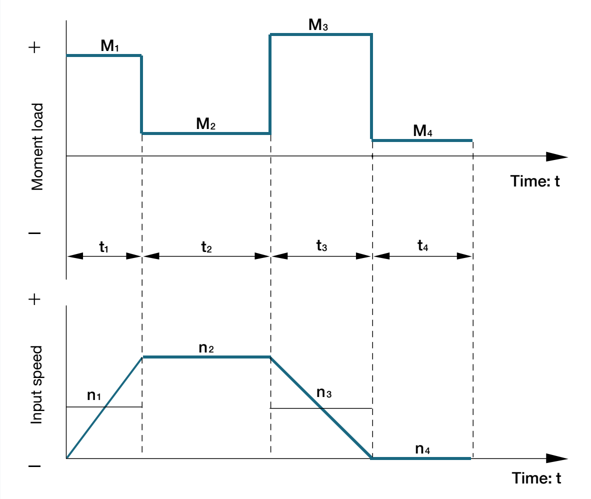


How to calculate average load
(Average moment load, average axial load, average input rotational frequency)

HPG HPF

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

Graph 134-1



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

Formula 134-2

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

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

Formula 134-3

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

How to calculate the average output rotational frequency (Ni_{av})

Formula 134-4

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

Calculating life of input side bearing

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

Formula 134-5

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

L_{10}	Life	Hour	—
Ni_{av}	Average input rotational speed	rpm	See Formula 134-4
Cr	Basic dynamic rated load	N (kgf)	See Table 133-1 and -3
Pci	Dynamic equivalent radial load	N	See Table 134-1 and -2

Dynamic equivalent radial load HPG

Table 134-1

Size	Pci
11	$0.444 \times Mi_{av} + 1.426 \times Fai_{av}$
14	$0.137 \times Mi_{av} + 1.232 \times Fai_{av}$
20	$0.109 \times Mi_{av} + 1.232 \times Fai_{av}$
32	$0.071 \times Mi_{av} + 1.232 \times Fai_{av}$
50	$0.053 \times Mi_{av} + 1.232 \times Fai_{av}$
65	$0.041 \times Mi_{av} + 1.232 \times Fai_{av}$

Dynamic equivalent radial load HPF

Table 134-2

Size	Pci
25	$121 \times Mi_{av} + 2.7 \times Fai_{av}$
32	$106 \times Mi_{av} + 2.7 \times Fai_{av}$

Mi_{av}	Average moment load Nm (kgfm)	See Formula 134-2
Fai_{av}	Average axial load N (kgf)	See Formula 134-3

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