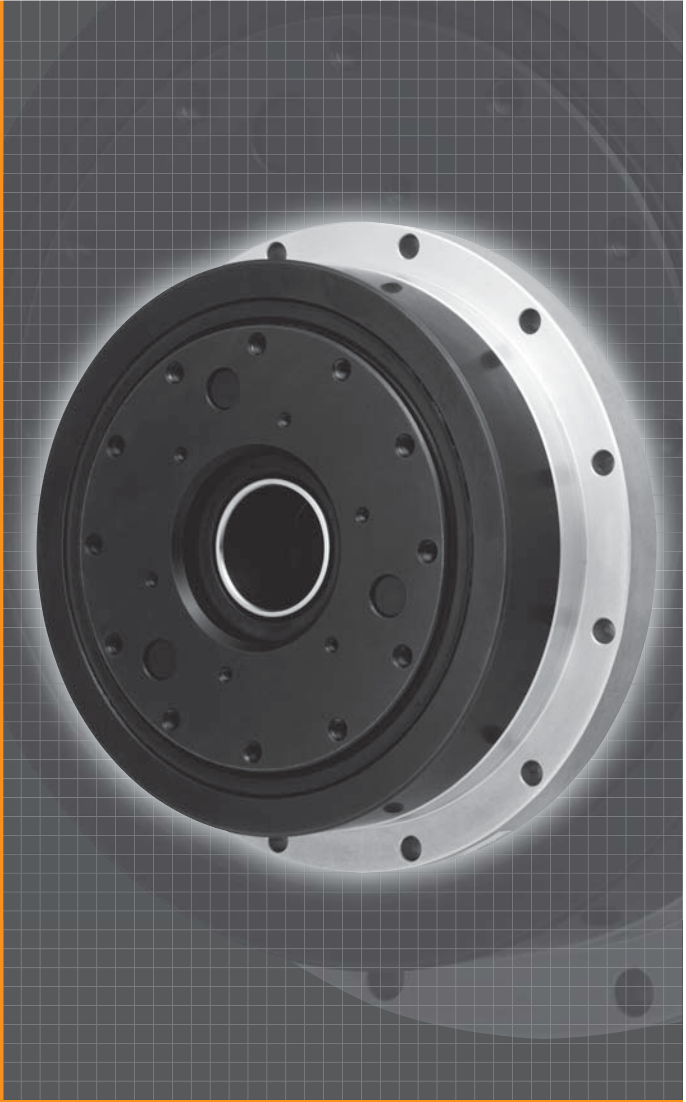
HarmonicPlanetary®

HPF Hollow Shaft Unit Type



Size

Model: 25, 32

2 Types

Peak torque

Model: 25 = 100 Nm
Model: 32 = 220 Nm

Reduction ratio

1／11

Small backlash

Standard: 3 min. or less

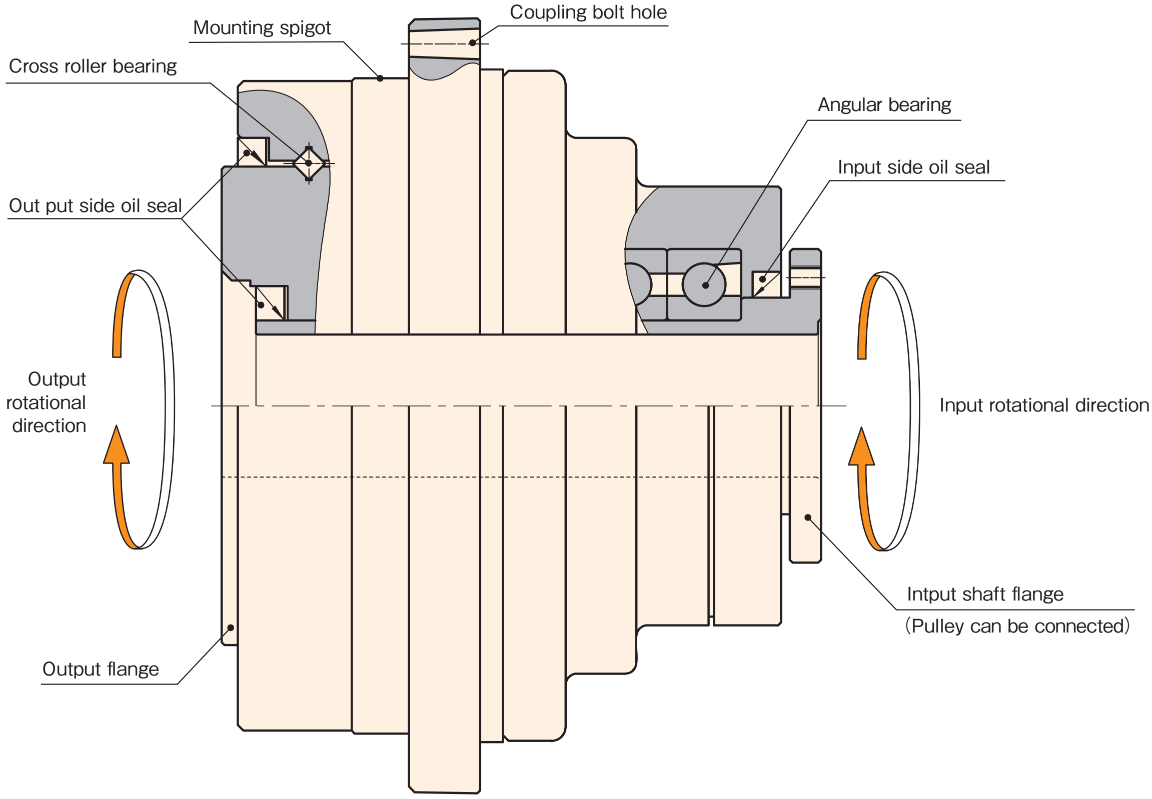
Inside diameter of the hollow shaft

Model: 25 = ϕ25 mm
Model: 32 = ϕ30 mm

The hollow structure unit has been developed based on Harmonic Planetary®. The superior performance and specifications of HPG series has been succeeded. Additionally, a hollow structure has been newly introduced to enjoy the shape advantage. The pass-through hole with the coaxial I/O shaft provides the compactly-designed devices to meet diversified customer needs, such as piping, wiring, and passing-through laser light or combining with a ball screw.

Structural drawing

Figure 071-1



Model Number Selection

Check your operating conditions and select suitable model Nos. based on the flowchart to fully demonstrate the excellent performance of the Harmonic Planetary® HPF series.

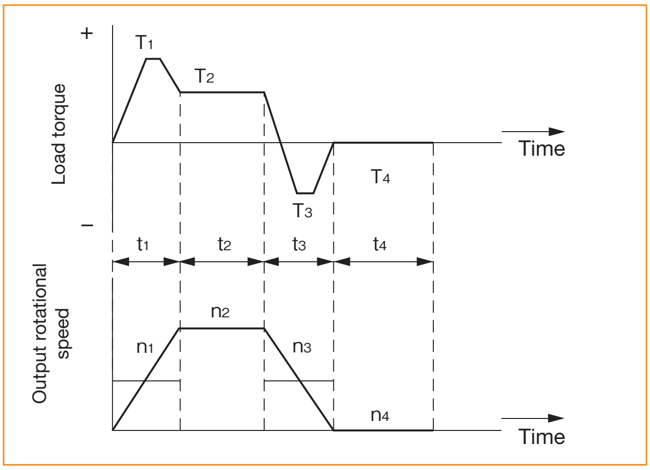
In general, the servo system is rarely in a continuous constant load state. The load torque changes according to the input rotational speed variation and comparatively large torque are applied at start and stop. Unexpected impact torque may be applied.

Check your operating conditions against the following load torque pattern and select suitable model Nos. 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). (See the specification of the input side main bearing and the output side main bearing on pages 104 to 109.)

Checking the load torque pattern

First, you need to look at the picture of the load torque pattern. Check the specifications shown in the figure below.

Graph 072-1



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 (r/min)

<Normal operation pattern>

Starting time	T_1, t_1, n_1
Steady operation time	T_2, t_2, n_2
Stopping (slowing) time	T_3, t_3, n_3
Break time	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 of model number selection

Select a model number according to the following flowchart.
If you find a value exceeding that from the ratings, you should review it with the upper-level model number or consider reduction of conditions including the load torque.

Calculate the average load torque applied on the output side of Harmonic Drive 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 (r/min)

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

↓

Tentatively select a model No. under the following condition:
$T_{av} \leqq$ Average load torque (See the rating table on page 074) — 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 rotational speed (ni *max*) from the maximum output rotational speed (no *max*) and the reduction ratio (R).

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

↓

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

OK ↓

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

OK ↓

Check whether T_1 and T_3 are equal to or less than the permissible peak torque (Nm) value at start and stop from the ratings. — NG

OK ↓

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

OK ↓

Calculate the lifetime and check whether it meets the specification requirement.
T_r: Output torque
n_r: Permissible average input rotational 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 determined.

Check the description in Caution below.

Review of the operation conditions, model No and reduction ratio.

Caution

Check impacts by speed reducer temperature rise, vibration during acceleration and deceleration and other factors if the operating conditions are as specified below. Study to "increase the speed reducer size", "review the operating conditions" and other means if it becomes necessary to study safety. Exercise reasonable caution especially when operating conditions are close to continuous operation.
Average load torque (*Tav*) > Permissible maximum value of average load torque (see page 074)
Calculate average input rotational speed (ni *av*) > Permissible average input rotational speed (nr)

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 (r/min)

<Normal operation pattern>

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

<Maximum rotational speed>

Max. output rotational speed	no *max* = 120 r/min
Max. input rotational speed	ni *max* = 5,000 r/min (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).

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

Calculate the average output rotational speed based on the load torque pattern: no *av* (r/min)

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

▼

Select a model number temporarily 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 074) of model No. 25 and reduction ratio of 11.) → NG

OK ▼

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

$$\frac{5{,}000\ r/min}{120\ r/min}=41.7\geqq 21$$

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

▼

Calculate the average input rotational speed (ni *av*) from the average output rotational speed (no *av*) and reduction ratio (R):
ni *av* = 46.2 r/min・11= 508 r/min ≦ Permissible average input rotational speed of model No. 25 3,000 (r/min) → NG

OK ▼

Check whether the maximum input rotational speed is equal to or less than the values specified in the rating table.
ni *max* = 1,320 r/min ≦ 5,600 r/min (maximum rotational input speed of model No. 25) → NG

OK ▼

Check whether T_1 and T_3 are equal to or less than the peak torques (Nm) on start and stop in the rating table.
T_1 = 70 Nm ≦ 100 Nm (Peak torques on start and stop of model No. 25)
T_3 = 35 Nm ≦ 100 Nm (Peak torques on start and stop of model No. 25) → NG

OK ▼

Check whether Ts is equal to or less than the values of the momentary max. torque (Nm) in the rating table.
T_s = 120 Nm ≦ 140 Nm (momentary max. torque of model No. 25) → NG

OK ▼

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

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

→ NG

OK ▼

As a result of the preceding steps, HPF-25A-11 is determined.

Check the description in Caution at the bottom of page 072

Review of the operation conditions, model No and reduction ratio.

Rating Table

The hollow shaft type of the HPF series is unique high-precision speed reducer unit of 1/11 low speed reduction. This features the hollow shaft that can be coaxial with the I/O shaft.

Table 074-1

Model	Reduction ratio	Rated output torque *1		Permissible max. value of ave. load torque *2		Permissible peak torque at start/stop *3		Permissible max. momentary torque *4		Permissible ave. input rotational speed *5	Permissible max. input rotational speed *6	Inertia moment Flange output	Mass Flangeoutput
		Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm	r/min	r/min	$\times 10^{-4}$kgm²	kg
25	11	21	2.1	48	4.9	100	10.2	170	17.3	3000	5600	1.63	3.8
32	11	44	4.5	100	10.2	220	22.4	450	45.9	3000	4800	3.84	7.2

*1: Output torque set based on the life of L_{10} = 20000 hours when input rotational speed is 3000 r/min, which is the rated rotational speed of ordinary servo motors.
*2: Permissible maximum value of average load torque calculated based on a load torque pattern (page 072). A life of 2000 hours or more is a criterion when operated at an input speed of 2000 r/min.
*3: Permissible maximum value of torque applied on start and stop in operation cycles.
*4: Permissible maximum value for impact torque in an emergency stop and for external impact torque. Operation exceeding these ranges may cause damages to reducers.
*5: The permissible average input rotational speed is set so as to limit the temperature rise due to the heat generated by the speed reducer. The value of the temperature rise depending on the heat radiation conditions of the speed reducer installation parts (housing) arranged by the customers and on the ambient temperature. It is appropriate to regard the surface temperature 70°C of the speed reducer as the reference upper limit.
*6: Permissible maximum input rotational speed in operation modes other than continuous operation.

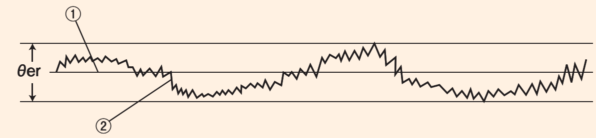
Performance Table

Table 074-2

Model	Reduction ratio	Angle transmission precision *1		Repeatability *2	Starting torque *3		Overdrive starting torque *4		No-load running torque *5	
		arc min	$\times 10^{-4}$rad	arc sec	cNm	kgfcm	Nm	kgfm	cNm	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: Angle transmission precision indicates the difference between (1) logical rotating angle and (2) actual rotating angle of output when any rotating angle is given as an input. The values in the table are maximum values.

Figure 074-1

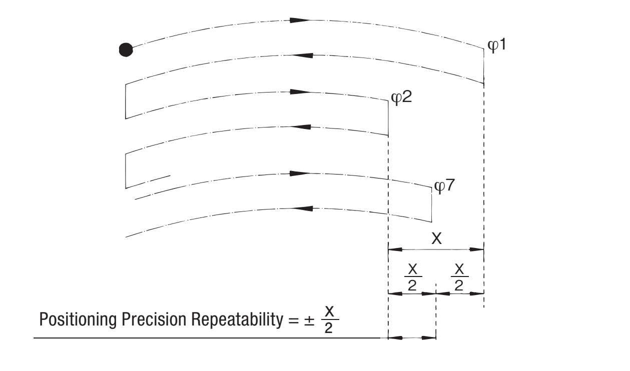


θer : Angle transmission precision
θ_1 : Input rotating angle
θ_2 : Actual output rotating angle
R : Reduction ratio of HPG series

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

*2: The repeatability is determined by repeating positioning in a given position from the same direction seven times, by measuring stop positions of the output shaft and by calculating the maximum difference. Measured values are indicated in angles (degrees) and are prefixed with "±" to 1/2 of the maximum differences. The values in the table are maximum values.

Figure 074-2



*3: Starting torque means the momentary “starting torque” with which the output side starts rotation when a torque is applied on the input side. The values in the table are maximum values.

Table 074-3

Load	No load
HPF speed reducer surface temperature	25°C

*4: Overdrive starting torque means the momentary “starting torque” with which the input side starts rotation when a torque is applied on the output side. The values in the table are maximum values.

Table 074-4

Load	No load
HPF speed reducer surface temperature	25°C

*5: No-load running torque means the torque on the input side required to put the speed reducer under a no-load condition. The values in the table are average values.

Table 074-5

Input speed	3000 r/min
Load	No load
HPF speed reducer surface temperature	25°C

Torque - Torsion Characteristic

Table 075-1

Hollow Shaft Unit Type Standard Item

Model	Reduction Ratio	Backlash		Torsional quantity on one side at T_R X 0.15 D		Torsional rigidity A/B	
		arc min	×10⁻⁴rad	arc min	×10⁻⁴rad	kgfm/arc min	×100Nm/rad
25	11	3.0	8.7	2.0	5.8	1.7	570
32	11	3.0	8.7	1.7	4.9	3.5	1173

Torsional rigidity windup curve

Anchoring the speed reducer input and casing and applying a torque to the output part will generate torsion in the output part in accordance with the applied torque. Change the torque slowly in the order of: (1) Forward output torque, (2) Zero, (3) Reverse output torque, (4) Zero and (5) Forward output torque. A loop of (1) → (2) → (3) → (4) → (5) (return to (1)) will be drawn in Fig. 075-1.

The inclination in the region from "0.15 x output torque" to "Output torque" is small. The torsional rigidity of the HPF series is an average value of this inclination. The inclination in the region from "zero torque" to "0.15 x output torque" is large. This is caused by uneven distribution such as fine uneven contact of the engaging parts and load of the planet gears under a light load.

Calculation of total torsional quantity (Windup)

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

Formula 075-1

● Calculation formula

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

Symbols in calculation formula

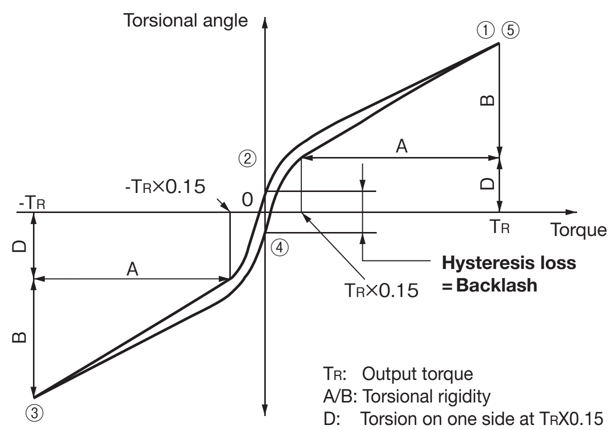
Symbol	Description	Reference
θ	Total torsional quantity	——
D	Torsional quantity on one side at output torque x 0.15 torque	See Fig. 075-1, Table 075-1
T	Load torque	——
T_L	Output torque x 0.15 torque (=T_RX0.15)	See Fig. 075-1
A／B	Torsional rigidity	See Fig. 075-1, Table 075-1

Backlash (Hysteresis Loss)

The zero-torque width (2) - (4) in Fig. 075-1 "Torque-torsional angle diagram" is called a hysteresis loss. The hysteresis loss between "Forward output torque" and "Reverse output torque" is defined as backlash of the HPF series. At the time of pre-shipment factory inspection, the backlash of the HPF series is less than 3 minutes (1 minute or less for customized products).

Figure 075-1

Torque-torsional angle diagram



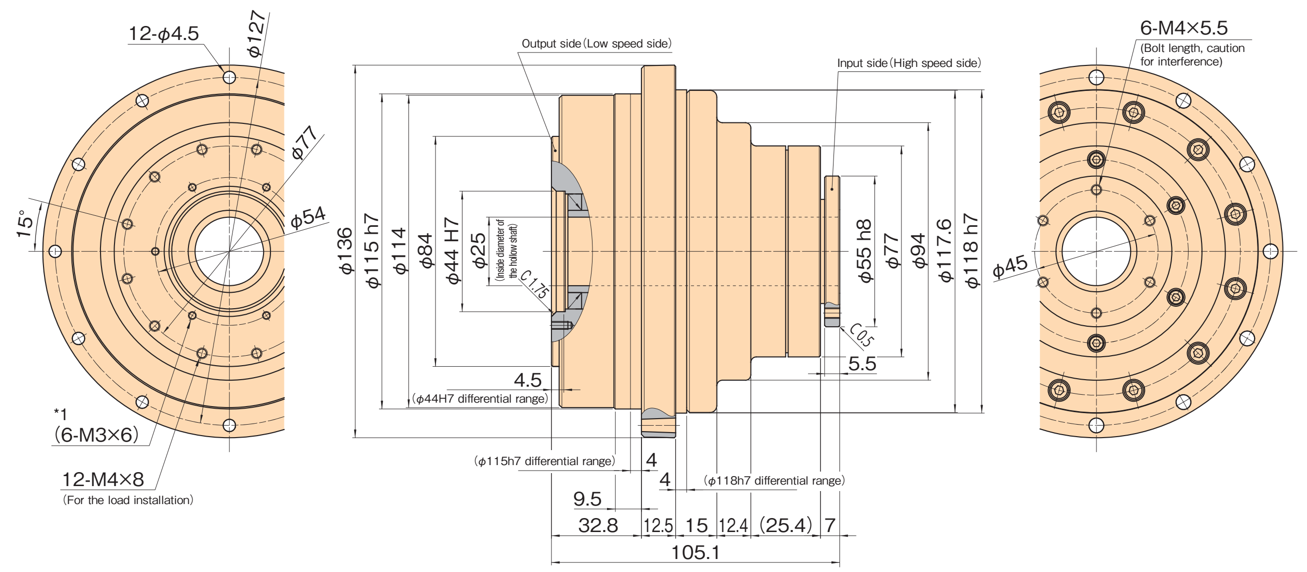
Dimensional Outline Drawing

Only principal dimensions are shown in the dimension diagrams. For detailed dimensions and shapes, refer to the delivery specification drawings we provide.
For the specifications of the input side bearing of the hollow shaft unit type, refer to page 108.
You can download the CAD data of this product from the following homepage. URL: http://www.hds.co.jp/

Dimensional outline drawing — Model No. 25

Figure 076-1

(Unit: mm)



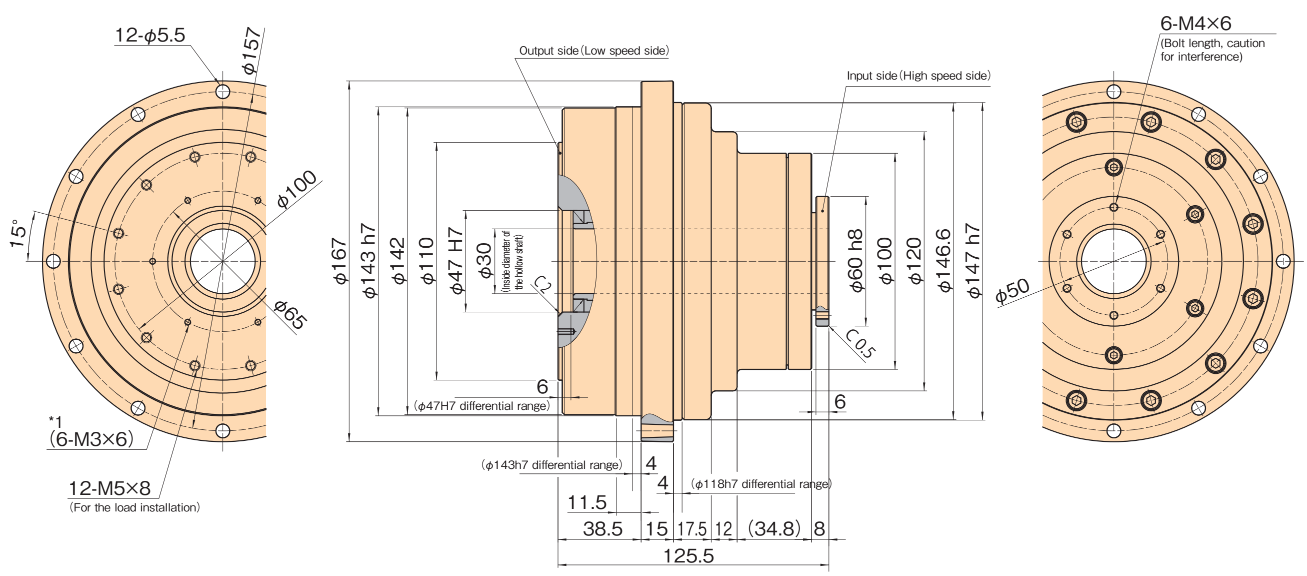
*1: Inside diameter part of the hollow shaft is synchronized with the input shaft and rotates.
Use it when installing the inside diameter sleeve from output side to input side. (This is not for the load installation).

* The differential range may differ depending on the method for manufacturing parts (molded articles, machining articles).
Contact us for the differential range of the size that is not described.

Dimensional outline drawing — Model No. 32

Figure 076-2

(Unit: mm)



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