HarmonicPlanetary®
HPG Standard Series

Size
6 Sizes

11, 14, 20, 32, 50, 65

Peak torque
5Nm – 3200Nm

Reduction ratio
Single Stage: 3:1 to 9:1, Two Stage: 11:1 to 50:1

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

Low Backlash for Life

Innovative ring gear 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.

High efficiency
Up to 95%

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

Easy mounting to a wide variety of servomotors
Quick Connect™ coupling

CONTENTS

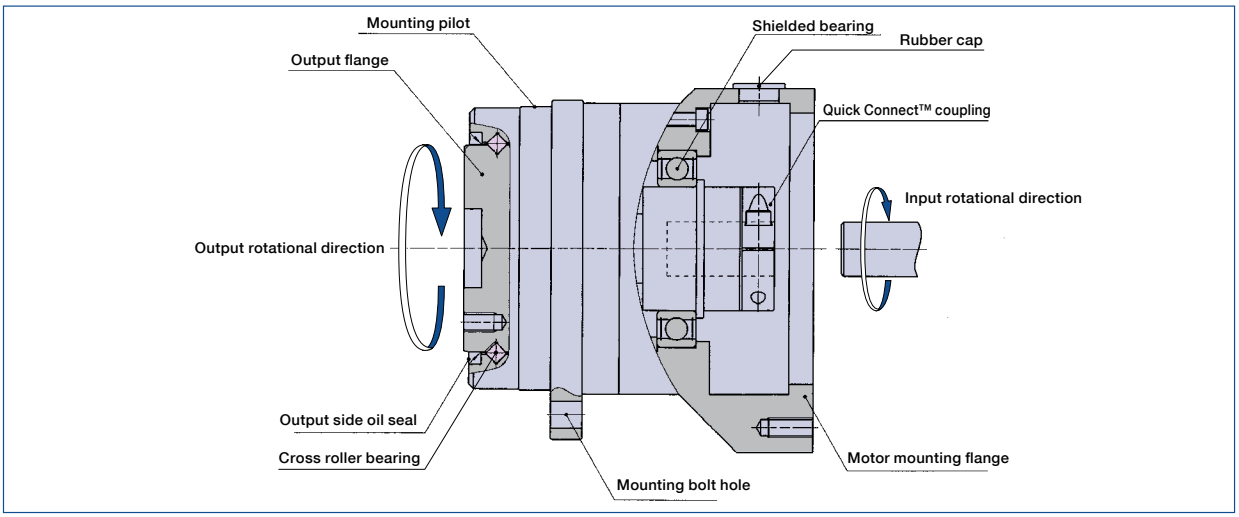
Rating Table 2
Performance 3
Backlash and Torsional Stiffness 4
Outline Dimensions 5-10
Product Sizing & Selection 11-12

HPG - 20 A - 05 - BL3 - D - F0 - Motor Model Number

Model Name	Size	Design Revision	Reduction Ratio	Backlash	Input Side Bearing	Output Configuration	Input Configuration & Options
HarmonicPlanetary® HPG Standard	11	B	5, 9, 21, 37, 45	BL1: Backlash less than 1 arc-min (Sizes 14 to 65) BL3: Backlash less than 3 arc-min	D: Input side contact sealed bearing (DDU) Z: Input side bearing with double non-contact shields	F0: Flange output J20: Straight shaft (without key) J60: Straight shaft (with key and center tapped hole)	This code represents the motor mounting configuration. Please contact us for a unique part number based on the motor you are using.
	14	A	3, 5, 11, 15, 21, 33, 45			F0: Flange output J2: Straight shaft (without key) J6: Straight shaft (with key and center tapped hole) (J2, J6 for Size 65 is also available)	
	20						
	32						
	50						
	65		4, 5, 12, 15, 20, 25, 40, 50				

Gearhead Construction

Figure 030-1



Rating Table

Table 031-1

Size	Ratio	Rated Torque *1	Limit for Repeated Peak Torque *2	Limit for Momentary Torque *3	Max. Average Input Speed *4	Max. Input Speed *5	Mass*6	
							Shaft	Flange
		Nm	Nm	Nm	rpm	rpm	kg	kg
11	5	5	10	20	3000	10000	0.18	0.14
	9		5					
	21	8	10				0.24	0.20
	37	9						
	45	10						
14	3	7	15	37	3000	5000	0.50	0.40
	5	11	30	56		6000		
	11	15		63			0.60	0.50
	15	16						
	21	17						
	33	20						
	45	22						
20	3	17	64	124	3000	4000	1.6	1.2
	5	38	100	217		6000		
	11	46	117				1.8	1.4
	15	58	107					
	21	58						
	33	70	117					
	45	73	106					
32	3	60	225	507	3000	3600	4.3	2.9
	5	120	300	650		6000		
	11	160	330				4.9	3.5
	15	170	300					
	21	190						
	33	200	330					
	45	240	300					
50	3	160	850	1200	2000	3000	13	10
	5	290	1110	1850		4500		
	11	340	1200	2180			15	12
	15	400	1250					
	21	450	1140					
	33	470						
	45	560	1130					
65	4	870	2890	4500	2000	2500	32*7	22
	5	900	3100			3000		
	12	1020					47*7	37
	15	1260	3200					
	20	1370	3100					
	25	1470	3200					
	40	1320	1900					
	50	1650	2200					

*1: Rated torque is based on L_{50} life of 20,000 hours at rated input speed.
*2: The limit for torque during start and stop cycles.
*3: The limit for torque during emergency stops or from external shock loads. Always operate below this value. Calculate the number of permissible events to ensure it meets required operating conditions.
*4: 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.
*5: Maximum instantaneous input speed.
*6: The mass is for the gearhead only (without input shaft coupling & motor flange). Please contact us for the mass of your specific configuration.
*7: Flange output is standard for the size 65 gearhead. Shaft type (J2 & J6) is also available. 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.

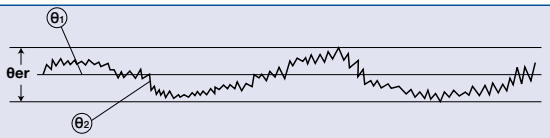
Performance Table

Table 032-1

Size	Ratio	Accuracy *1		Repeatability *2	Starting torque *3		Backdriving torque *4		No-load running torque *5	
		arc min	×10⁻⁴rad	arc sec	Ncm	kgfcm	Nm	kgfm	Ncm	kgfcm
11	5	5	14.5	±30	4.0	0.41	0.20	0.020	5.0	0.51
	9				3.7	0.37	0.33	0.034	2.5	0.26
	21				2.9	0.29	0.60	0.061	1.3	0.13
	37				1.6	0.17		0.062	0.90	0.092
	45				1.4	0.15	0.64	0.066	0.80	0.082
14	3	4	11.6	±20	14	1.5	0.43	0.044	21	2.1
	5				8.6	0.88			9.8	1.0
	11				8.0	0.82	0.90	0.092	4.9	0.50
	15				7.4	0.75	1.1	0.11	2.9	0.30
	21				5.2	0.53		0.12		
	33				3.3	0.34			2.0	0.20
	45				2.4	0.25				
20	3	4	11.6	±15	31	3.2	0.93	0.095	50	5.1
	5				19	1.9			28	2.9
	11				15	1.6	1.7	0.17	15	1.5
	15				12	1.2	1.8	0.18	11	1.1
	21				9.3	0.95	2.0	0.20	8.8	0.90
	33				6.4	0.65	2.1	0.22	5.9	0.60
	45				4.7	0.48			4.9	0.50
32	3	4	11.6	±15	56	5.7	1.7	0.17	135	14
	5				33	3.4			73	7.4
	11				27	2.7	2.9	0.30	38	3.9
	15				25	2.5	3.7	0.38	29	3.0
	21				22	2.3	4.7	0.48	24	2.4
	33				15	1.5	4.8	0.49	14	1.4
	45				11	1.2	5.1	0.52	13	1.3
50	3	3	8.7	±15	134	14	4.0	0.41	250	26
	5				80	8.2			130	13
	11				45	4.6	5.0	0.51	60	6.1
	15				40	4.1	6.0	0.61	47	4.8
	21				36	3.7	7.6	0.78	40	4.1
	33				24	2.4	7.8	0.80	24	2.5
	45				20	2.0	8.9	0.91	20	2.0
65	4	3	8.7	±15	288	29	12	1.2	420	43
	5				240	24			360	37
	12				125	13	15	1.5	190	19
	15				110	11	17	1.7	160	16
	20				95	10	19	1.9	130	13
	25				84	8.6	21	2.1	110	11
	40				75	7.7	30	3.1	76	7.7
	50				70	7.1	35	3.6	64	6.6

*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 032-1

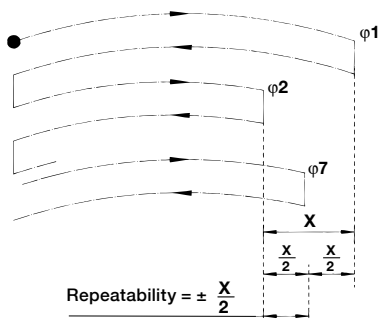


θer : Accuracy
θ1 : Input angle
θ2 : Actual output angle
R : Gear reduction ratio

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

*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 032-2



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

Table 032-2

Load	No load
HPG speed reducer surface temperature	25°C

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

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

Table 032-3

Load	No load
HPG speed reducer surface temperature	25°C

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

Table 032-4

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

Backlash and Torsional Stiffness

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

Table 033-1

Size	Ratio	Backlash arc min	Backlash ×10⁻⁴rad	Torsion angle on one side at TR X 0.15 D arc min	Torsion angle on one side at TR X 0.15 D ×10⁻⁴rad	Torsional stiffness A/B kgfm/arc min	Torsional stiffness A/B ×100Nm/rad
11	5	3.0	8.7	2.5	7.3	0.065	22
	9, 21, 37, 45			3.0	8.7		
14	3, 5, 11, 15, 21, 33, 45	3.0	8.7	2.2	6.4	0.14	47
				2.7	7.9		
20	3, 5, 11, 15, 21, 33, 45	3.0	8.7	1.5	4.4	0.55	180
				2.0	5.8		
32	3, 5, 11, 15, 21, 33, 45	3.0	8.7	1.3	3.8	2.2	740
				1.7	4.9		
50	3, 5, 11, 15, 21, 33, 45	3.0	8.7	1.3	3.8	14	4700
				1.7	4.9		
65	4, 5, 12, 15, 20, 25, 40, 50	3.0	8.7	1.3	3.8	38	13000
				1.7	4.9		

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

Table 033-2

Size	Ratio	Backlash arc min	Backlash ×10⁻⁴rad	Torsion angle on one side at TR X 0.15 D arc min	Torsion angle on one side at TR X 0.15 D ×10⁻⁴rad	Torsional stiffness A/B kgfm/arc min	Torsional stiffness A/B ×100Nm/rad
11	not available						
14	3, 5, 11, 15, 21, 33, 45	1.0	2.9	1.1	3.2	0.14	47
				1.7	4.9		
20	3, 5, 11, 15, 21, 33, 45	1.0	2.9	0.6	1.7	0.55	180
				1.1	3.2		
32	3, 5, 11, 15, 21, 33, 45	1.0	2.9	0.5	1.5	2.2	740
				1.0	2.9		
50	3, 5, 11, 15, 21, 33, 45	1.0	2.9	0.5	1.5	14	4700
				1.0	2.9		
65	4, 5, 12, 15, 20, 25, 40, 50	1.0	2.9	0.5	1.5	38	13000
				1.0	2.9		

Torsional stiffness curve

With the input of the gear locked in place, a torque applied to the output flange will torsionally deflect in proportion to the applied torque. We generate a torsional stiffness curve by slowly applying torque to the output in the following sequence:
(1) Clockwise torque to T_R, (2) Return to Zero, (3) Counter-Clockwise torque to $-T_R$, (4) Return to Zero and (5) again Clockwise torque to T_R.
A loop of (1) > (2) > (3) > (4) > (5) will be drawn as in Fig. 033-1.
The torsional stiffness in the region from "0.15 x T_R" to "T_R" is calculated using the average value of this slope. The torsional stiffness in the region from "zero torque" to "0.15 x T_R" is lower. This is caused by the small amount of backlash plus engagement of the mating parts and loading of the planet gears under the initial torque applied.

Calculation of total torsion angle

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

Formula 033-1

● Calculation formula

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

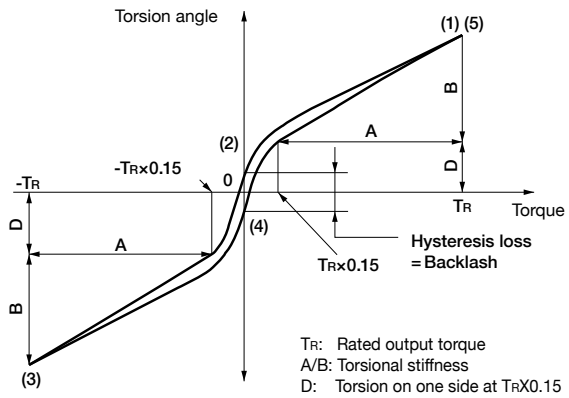
θ	Total torsion angle	——
D	Torsion angle on one side at output torque x 0.15 torque	See Fig. 033-1, Table 033-1, Table 033-2
T	Load torque	——
T_L	Output torque x 0.15 torque (=T_RX0.15)	See Fig. 033-1
A/B	Torsional stiffness	See Fig. 033-1, Table 033-1 to 2

Backlash (Hysteresis loss)

The vertical distance between points (2) & (4) in Fig. 033-1 is called a hysteresis loss. The hysteresis loss between "Clockwise load torque T_R" and "Counter Clockwise load torque $-T_R$" is defined as the backlash of the HPG series. Backlash of the HPG series is less than 3 arc-min (1 arc-min or less for a reduced backlash option).

Torque-torsion angle diagram

Figure 033-1



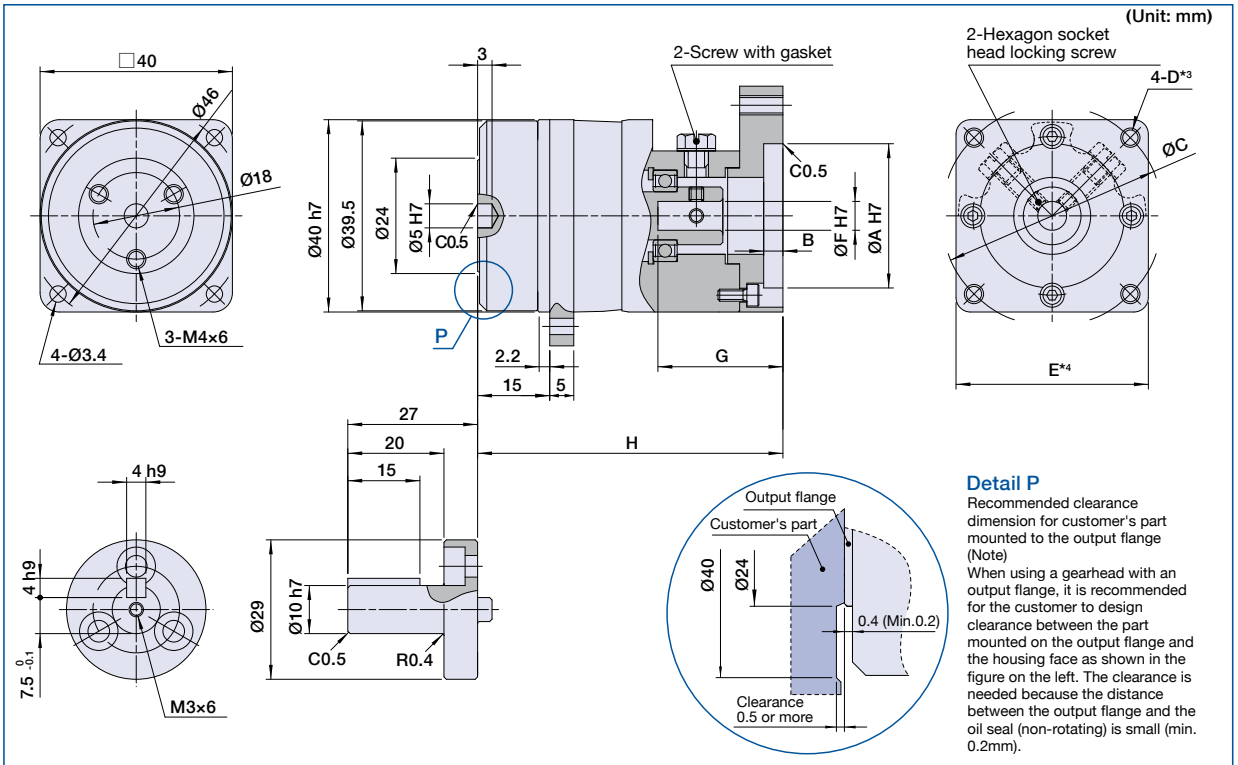
T_R: Rated output torque
A/B: Torsional stiffness
D: Torsion on one side at T_RX0.15

HPG-11 Outline Dimensions

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

Figure 034-1

(Unit: mm)



Detail P

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

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

Dimension Table

(Unit: mm) Table 034-1

	Flange	Coupling	A (H7)		B	C		F (H7)		G		H *1	K	Mass (kg) *2	
			Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical		Shaft	Flange
Single Stage	Type I	1	20	50	4	28	70	5	8	17.5	26	54.5	21	0.34	0.30
Two Stage	Type I	1	20	50	4	28	70	5	8	17.5	26	63.5	30	0.34	0.30

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

Moment of Inertia

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

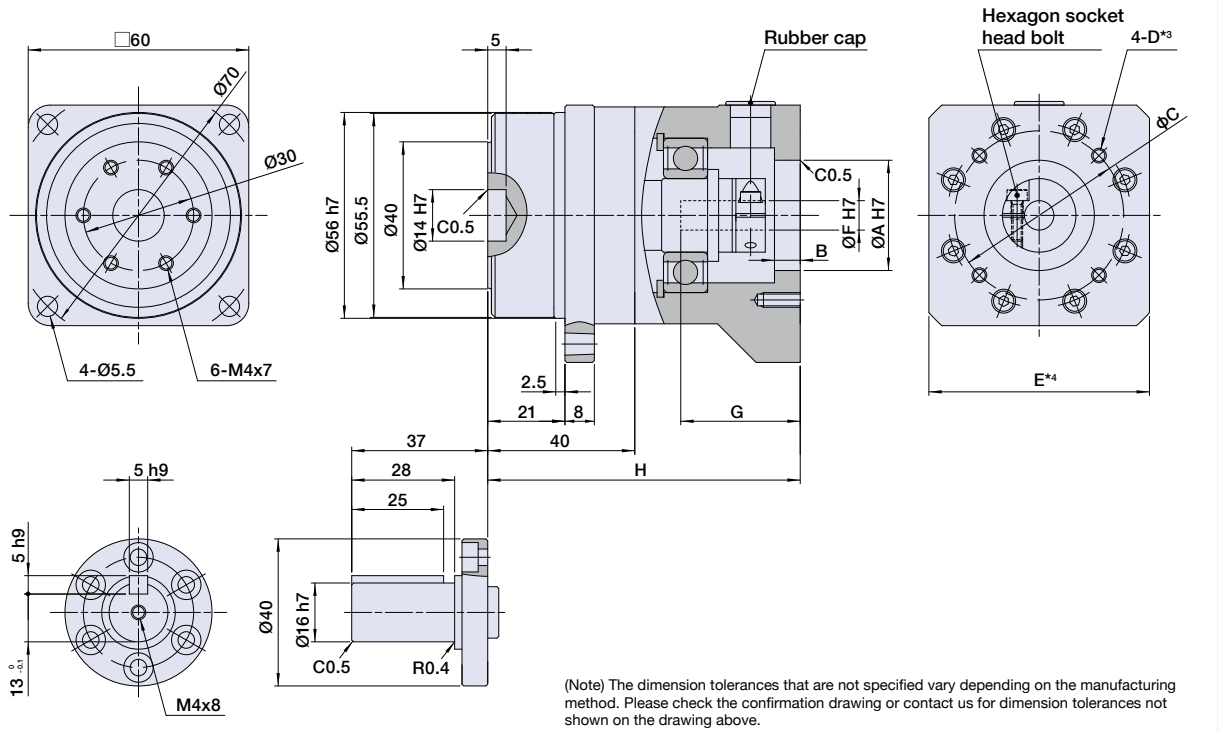
	Coupling \ Ratio	5	9	21	37	45
HPG 11	1	0.005	0.003	0.004	0.0027	0.0025

HPG-14 Outline Dimensions

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

Figure 035-1

(Unit: mm)



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

Dimension Table

(Unit: mm) Table 035-1

Flange	Coupling	A (H7)		B	C		F (H7)		G		H *1	Mass (kg) *2	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	Shaft	Flange
Type I	1	30	58	7	35	74	6.0	7.8	21.5	32.5	85	1.07	0.95
Type II	2	40	70	7	45	84	9.0	14.2	25.8	33.8	85	1.12	1.00

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

Moment of Inertia

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

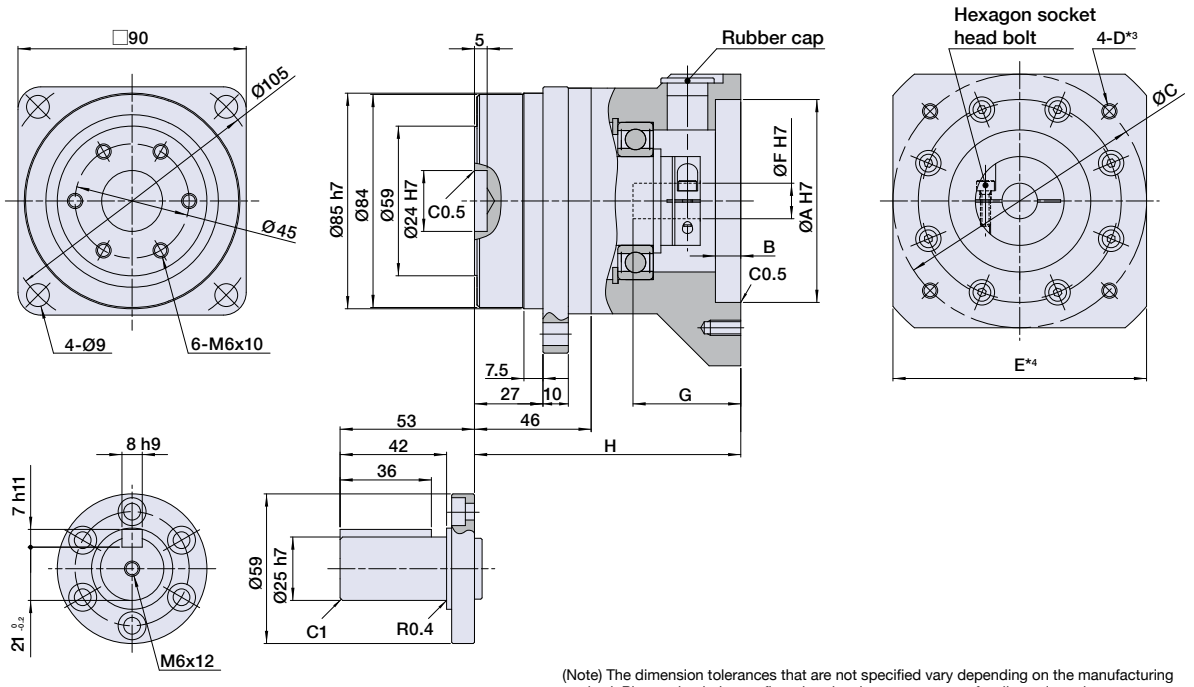
	Coupling \ Ratio	3	5	11	15	21	33	45
HPG 14	1	-	-	0.06	0.058	0.05	0.044	0.044
	2	0.26	0.207	0.197	0.180	0.171	0.167	0.165

HPG-20 Outline Dimensions

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

Figure 036-1

(Unit: mm)



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

Dimension Table

(Unit: mm) Table 036-1

Flange	Coupling	A (H7)		B	C		F (H7)		G		H *1	Mass (kg) *2	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	Shaft	Flange
Type I	1	50	72	8	55	80	7.0	19.6	23.0	36.5	98.0	3.1	2.7
Type II	1	80	98	10	90	120	7.0	19.6	30.0	42.5	105.0	3.3	2.9
Type III	3	30	45	10	35	50	7.0	7.8	21.0	31.0	93.5	2.6	2.2
Type IV	1	46	70	10	55	96	7.0	19.6	30.0	42.5	105.0	3.3	2.9

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

Moment of Inertia

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

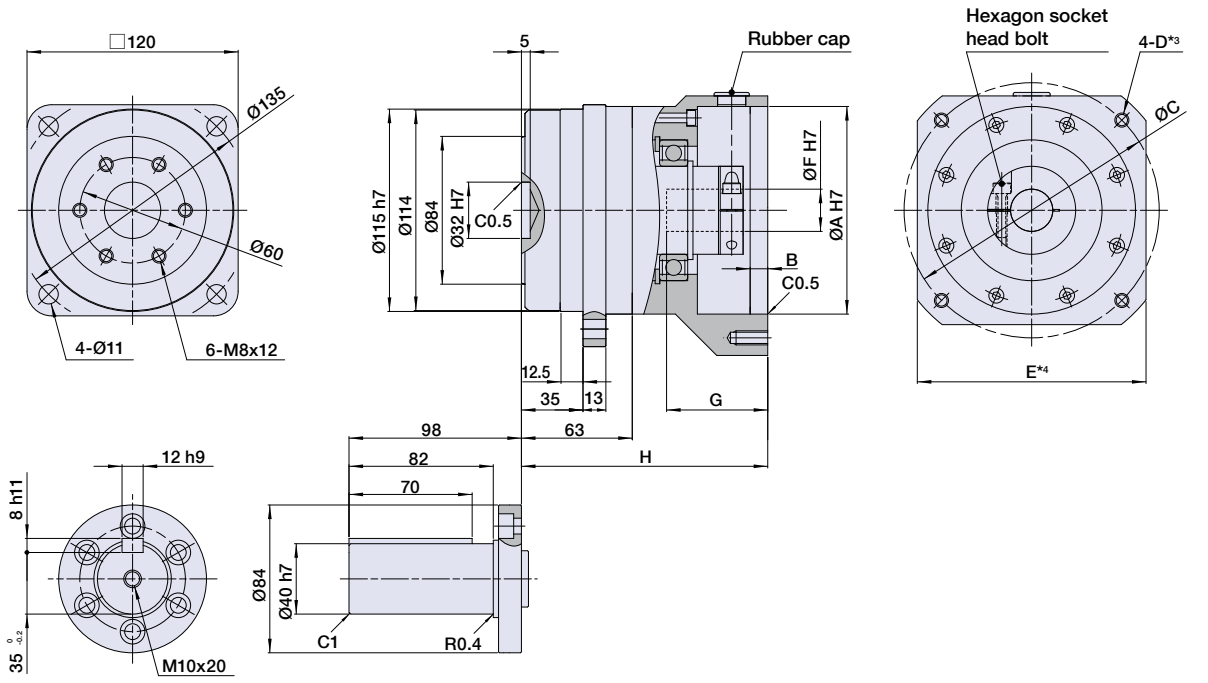
	Coupling \ Ratio	3	5	11	15	21	33	45
HPG 20	1	1.1	0.7	0.6	0.56	0.49	0.45	0.45
	3	-	-	-	-	0.11	0.065	0.063

HPG-32 Outline Dimensions

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

Figure 037-1

(Unit: mm)



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

Dimension Table

(Unit: mm) Table 037-1

Flange	Coupling	A (H7)		B	C		F (H7)		G		H *1	Mass (kg) *2	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	Shaft	Flange
Type I	1	110	120	10	120	155	10.0	28.6	31.0	57.5	140	7.8	6.4
Type II	1	70	100	7	80	112	10.0	28.6	30.0	56.5	139	7.8	6.4
Type III	3	50	100	10	80	112	14.0	19.6	25.8	38.8	139	7.5	6.1
Type IV	1	70	95	10	80	115	10.0	28.6	41.0	67.5	150	7.9	6.5
Type V	1	70	110	10	80	155	10.0	28.6	45.0	71.5	154	9.5	8.1

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

Moment of Inertia

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

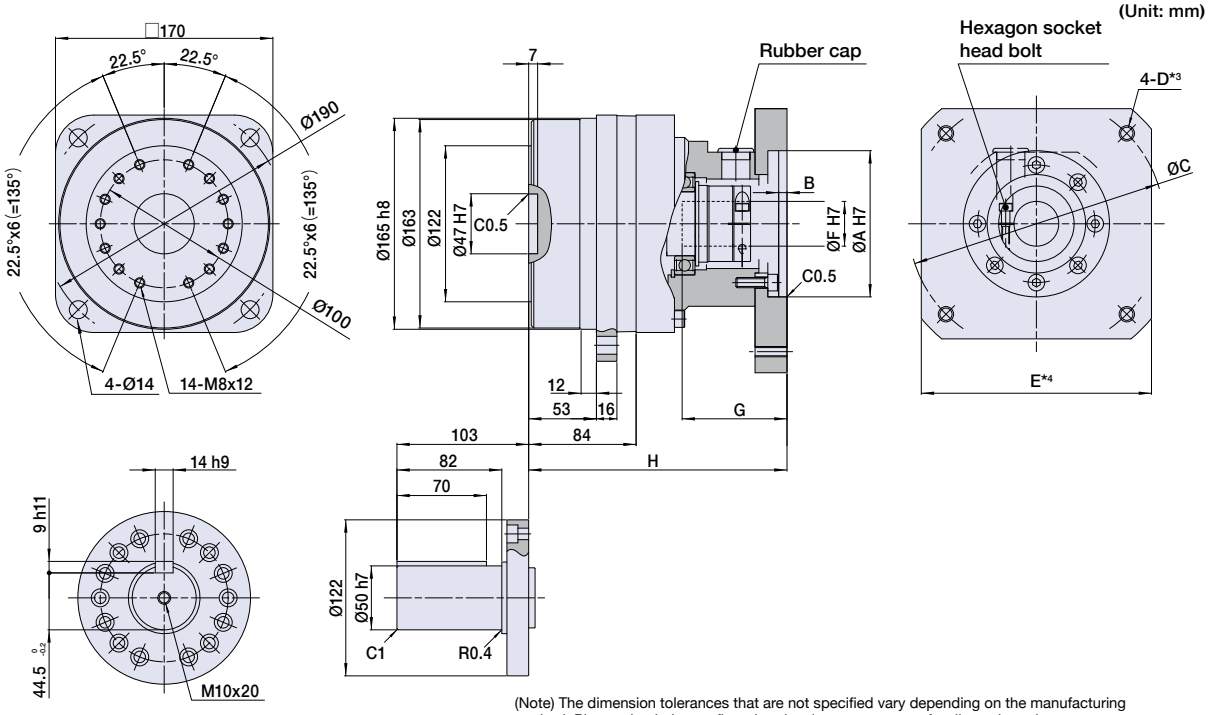
	Coupling \ Ratio	3	5	11	15	21	33	45
HPG 32	1	5.6	3.9	3.4	3.2	3	2.8	2.8
	2	-	-	-	-	0.84	0.52	0.61

HPG-50 Outline Dimensions

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

Figure 038-1

(Unit: mm)



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

Dimension Table

(Unit: mm) Table 038-1

Flange	Coupling	A (H7)		B	C		F (H7)		G		H *1	Mass (kg) *2	
		Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	Shaft	Flange
Type I	1	70	200	15	90	235	19.0	41.0	45.0	81.0	202	20.2	17.2
Type II	1	70	200	15	90	235	19.0	41.0	45.0	81.0	243.5	20.4	17.4
Type III	2	80	115	10	100	150	19.0	41.0	31.5	55.0	176	19.0	16.0
Type IV	1	70	200	15	90	235	19.0	41.0	45.0	81.0	202	27.5	24.5

Refer to the confirmation drawing for detailed dimensions. Dimensions of typical products are shown. Please contact us for other mounting options if the configurations shown above are not suitable for your particular motor.
*1 May vary depending on motor interface dimensions.
*2 The mass will vary slightly depending on the ratio and on the inside diameter of the input shaft coupling. Use type IV flange for motors weighing over 65 kg.
*3 Tapped hole for motor mounting screw.
*4 E dimension for Flange Type I, II and IV is dependent on motor selection.

Moment of Inertia

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

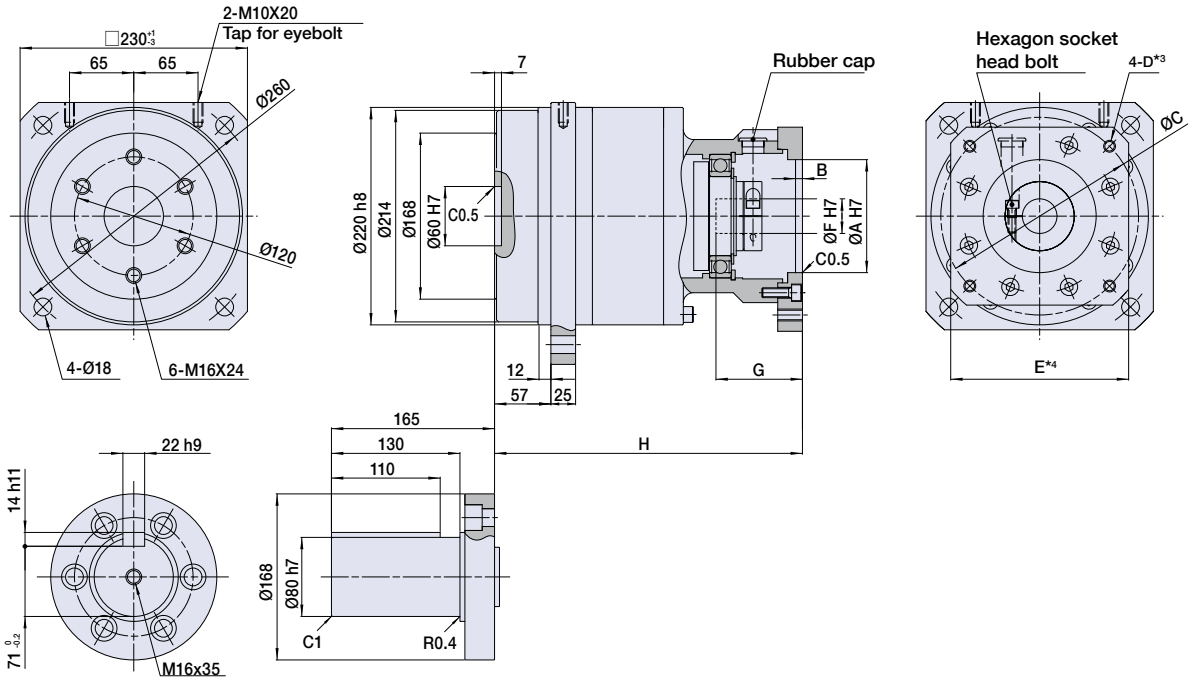
	Coupling \ Ratio	4	5	11	15	21	33	45
HPG 50	1	23	12	8.8	8.8	7	6	5.9
	2	-	-	-	7.7	5.8	4.8	4.7

HPG-65 Outline Dimensions

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

Figure 039-1

(Unit: mm)



(Note) The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing above. The flange output is standard, the shaft output is optional.

Dimension Table

(Unit: mm) Table 039-1

	Flange	Coupling	A (H7)		B	C		F (H7)		G		H *1	Mass (kg) *2	
			Min.	Max.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Typical	Shaft	Flange
Single Stage	Type I	1	125	230	15	150	265	35.0	43.9	63.0	87.5	241.5	48.0	38.0
Two Stage	Type I	1	125	230	15	150	265	35.0	43.9	63.0	87.5	311.5	52.0	42.0

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

Moment of Inertia

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

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

Product Sizing & Selection

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

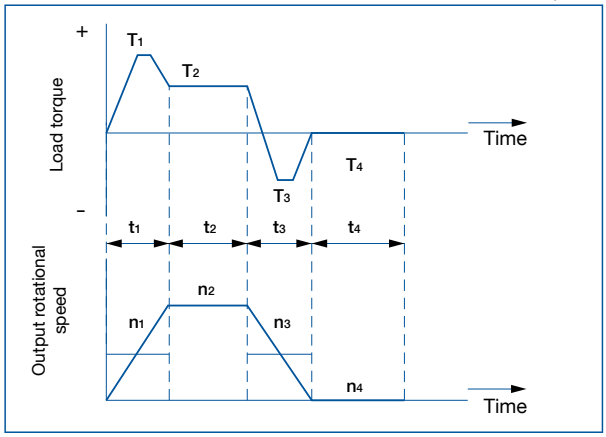
In general, a servo system rarely operates at a continuous load and speed. The input speed, load torque change and a comparatively large torque is applied during start and stop. Unexpected impact torques may also be applied.

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 040-1



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	no *max* ≧ n_1 to n_n
Max. input rotational speed	ni *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_{50} = L (hours)

Flowchart for selecting a size

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

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

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

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

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

Make a preliminary model selection with the following condition: Tav ≦ 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*).

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

(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).

ni *max*=no *max* • R

Calculate the average input speed (ni *av*) from the average output speed (no *av*) and the reduction ratio (R): ni *av* = no *av*·R ≦ 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.
ni *max* ≦ 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 Ts 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
nr: Max. average input speed

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

— NG

OK

The model number is confirmed.

Refer to the Caution note below.

Review the operation conditions, size and reduction ratio.

Caution

If 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 = 180 Nm

<Required life>

L_{50} = 30,000 (hours)

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

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

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

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

Make a preliminary model selection with the following conditions. T*av* = 30.2 Nm ≦ 70 Nm. (**HPG-20A-33** is tentatively selected based on the average load torque (see the rating table) of size 20 and reduction ratio of 33.)

NG → Refer to the Caution note at the bottom of page 40.

OK

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

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

Calculate the maximum input speed (ni *max*) from the maximum output speed (no *max*) and reduction ratio (R): ni *max* = 120 rpm・33 = 3,960 rpm

Calculate the average input speed (ni *av*) from the average output speed (no *av*) and reduction ratio (R):
ni *av* = 46.2 rpm・33= 1,525 rpm ≦ Max average input speed of size 20 3,000 rpm

NG → Refer to the Caution note at the bottom of page 40.

OK

Check whether the maximum input speed is equal to or less than the values specified in the rating table.
ni *max* = 3,960 rpm ≦ 5,000 rpm (maximum input speed of size 20)

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

OK

Check whether T_1 and T_3 are within peak torques (Nm) on start and stop in the rating table.
T_1 = 70 Nm ≦ 117 Nm (Limit for repeated peak torque, size 20)
T_3 = 35 Nm ≦ 117 Nm (Limit for repeated peak torque, size 20)

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

OK

Check whether T_S is equal to or less than limit for momentary torque (Nm) in the rating table.
T_S = 180 Nm ≦ 217 Nm (momentary max. torque of size 20)

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

OK

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

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

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

OK

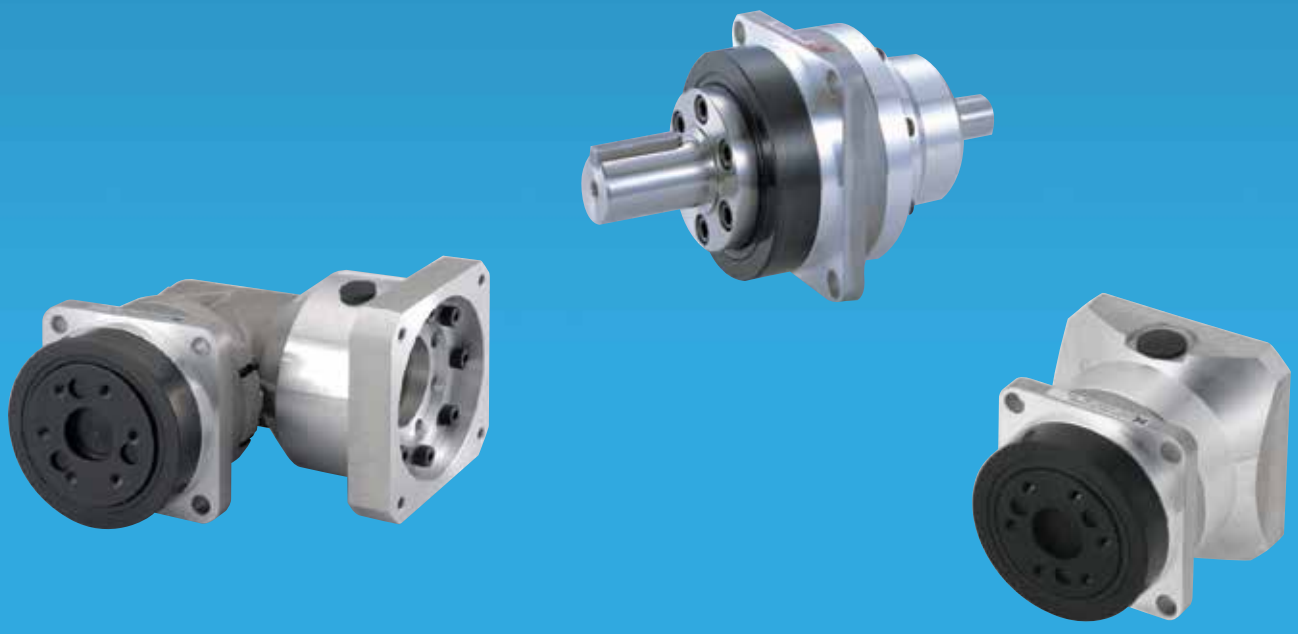
The selection of model number HPG-20A-33 is confirmed from the above calculations.

HarmonicPlanetary® HPGP／HPG Series

The thin wall flexible gear technology used for HarmonicDrive® gearing is applied to the internal gear of our planetary gear speed reducers. It allows the internal gear to deform elastically thus maintaining low backlash for the life of the gearhead, without the need for adjustment.

Planetary gears have simultaneous meshing between the sun gear and planet gears and between the planet gears and the internal gear. Some manufacturers try to reduce the backlash by controlling the dimensional precision of the parts, however this causes interference of meshing parts due to dimensional errors, resulting in uneven input torque and noise. Harmonic Planetary gears use a thin wall elastic internal gear which allows a preload of the gear and compensates for interference between meshing parts. The Harmonic Planetary® gear series incorporates this internal gear which maintains low backlash for the life of the speed reducer.

- **Low backlash: Less than 3 arc-min (Less than 1 arc-min also available)**
- **Low gear ratios, 3:1 to 50:1**
- **High efficiency**
- **High load capacity by integrating structure with cross roller bearing**
- **High-torque capacity**

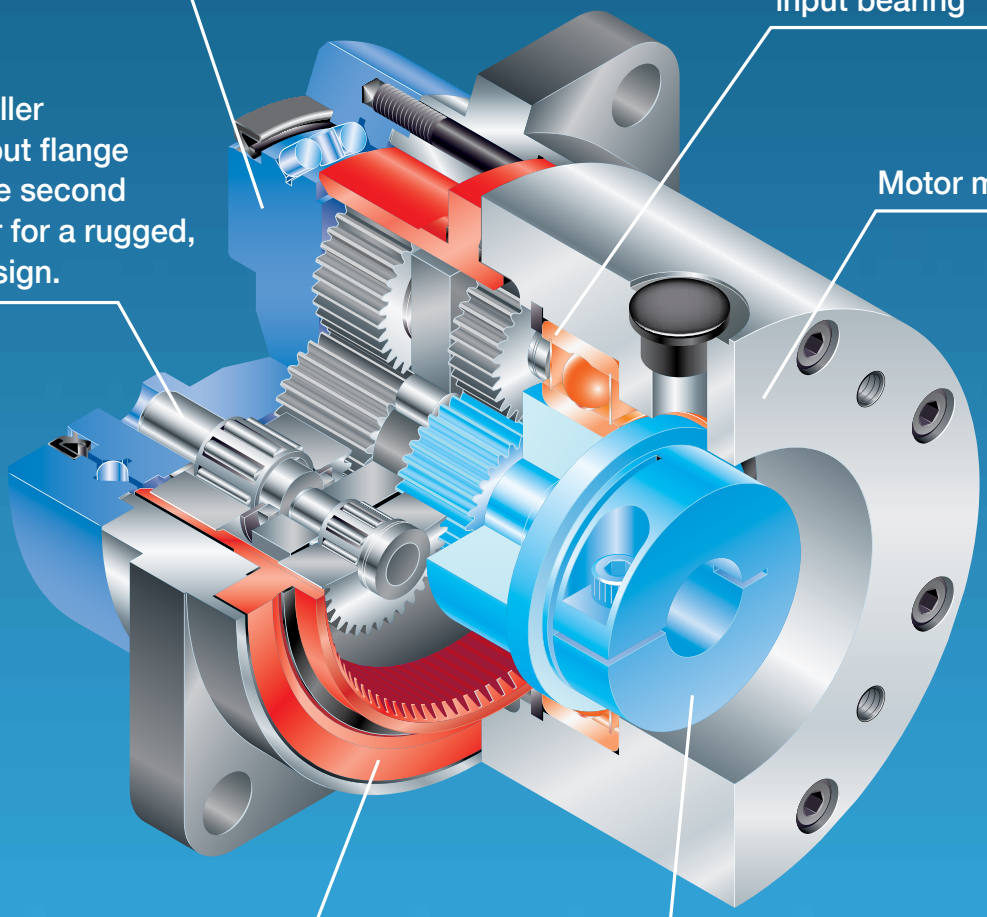


Robust cross roller bearing and output flange are integrated to provide high moment stiffness, high load capacity and precise positioning accuracy.

Shielded or sealed input bearing

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

Motor mounting flange



Backlash compensating internal gear

Quick Connect™ coupling for easy mounting of any servomotor

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

HPGP/HPG Series Table 129-1, -2 and -3 indicate the specifications for gearhead, right angle and input shaft unit, and cross roller bearing.

Table 129-1

Size	Pitch circle dp m	Offset amount R m	Basic rated load: Basic dynamic load rating C*1 N	Basic rated load: Basic dynamic load rating C*1 kgf	Basic rated load: Basic static load rating Co*2 N	Basic rated load: Basic static load rating Co*2 kgf	Allowable moment load Mc*3 Nm	Allowable moment load Mc*3 Kgfm	Moment stiffness Km*4 ×10⁴ Nm/rad	Moment stiffness Km*4 Kgfm/arc min
11	0.0275	0.006	3116	318	4087	417	9.50	0.97	0.88	0.26
14	0.0405	0.011	5110	521	7060	720	32.3	3.30	3.0	0.90
20	0.064	0.0115	10600	1082	17300	1765	183	18.7	16.8	5.0
32	0.085	0.014	20500	2092	32800	3347	452	46.1	42.1	12.5
50	0.123	0.019	41600	4245	76000	7755	1076	110	100	29.7
65	0.170	0.023	90600	9245	148000	15102	3900	398	364	108

Table 129-2

Size	Reduction ratio	Allowable radial load*5 N	Allowable axial load*5 N
11	5	280	430
	(9)	340	510
	21	440	660
	37	520	780
	45	550	830
14	(3)	400	600
	5	470	700
	11	600	890
	15	650	980
	21	720	1080
	33	830	1240
	45	910	1360
20	(3)	840	1250
	5	980	1460
	11	1240	1850
	15	1360	2030
	21	1510	2250
	33	1729	2580
	45	1890	2830

* The ratio specified in parentheses is for the HPG Series.

Table 129-3

Size	Reduction ratio	Allowable radial load*5 N	Allowable axial load*5 N
32	(3)	1630	2430
	5	1900	2830
	11	2410	3590
	15	2640	3940
	21	2920	4360
	33	3340	4990
	45	3670	5480
50	(3)	3700	5570
	5	4350	6490
	11	5500	8220
	15	6050	9030
	21	6690	9980
	33	7660	11400
	45	8400	12500
65	4	8860	13200
	5	9470	14100
	12	12300	18300
	15	13100	19600
	20	14300	21400
	25	15300	22900
	(40)	17600	26300
	(50)	18900	28200

* The ratio specified in parentheses is for the HPG Series.

*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

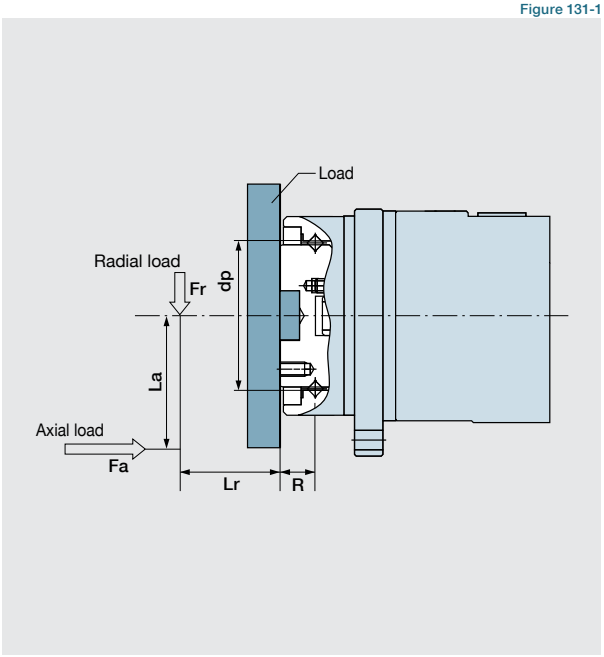
Maximum load moment load (M*max*) is obtained as follows. Make sure that M*max* ≦ Mc.

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

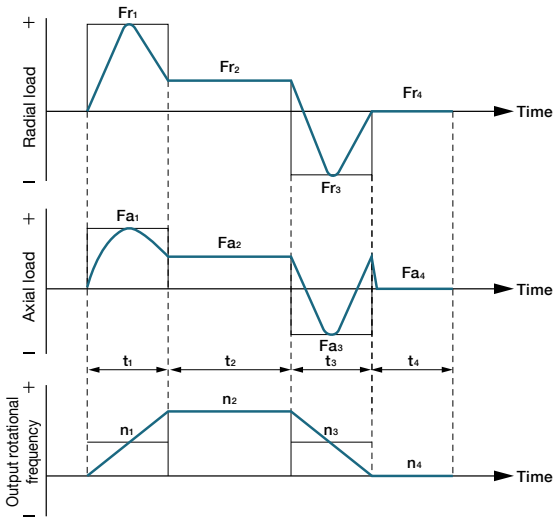
Formula	X	Y
$\frac{Fa_{av}}{Fr_{av}+2(Fr_{av}(Lr+R)+Fa_{av}\cdot La)/dp} \leqq 1.5$	1	0.45
$\frac{Fa_{av}}{Fr_{av}+2(Fr_{av}(Lr+R)+Fa_{av}\cdot La)/dp} > 1.5$	0.67	0.67

Fr*av*	Average radial load	N (kgf)	See "How to 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

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

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

$$P_c=X\cdot\left(F_{rav}+\frac{2(F_{rav}(L_r+R)+F_{aav}\cdot L_a)}{d_p}\right)+Y\cdot F_{aav}$$

F_{rav}	Average radial load	N (kgf)	See "How to calculate the ave. load."
F_{aav}	Average axial load	N (kgf)	
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	–	
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

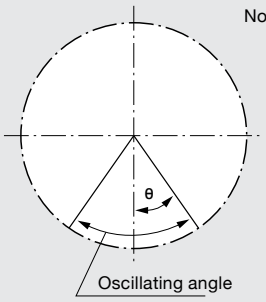
Calculate the life of the cross roller bearing during oscillating movement by Formula 132-3.

Formula 132-3

$$L_{oc}=\frac{10^6}{60\times n1}\times\frac{90}{\theta}\times\left(\frac{C}{f_w\cdot P_c}\right)^{10/3}$$

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

$$f_s=\frac{C_o}{P_o}$$

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

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

Formula 132-5

$$P_o=F_{rmax}+\frac{2M_{max}}{d_p}+0.44F_{amax}$$

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

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

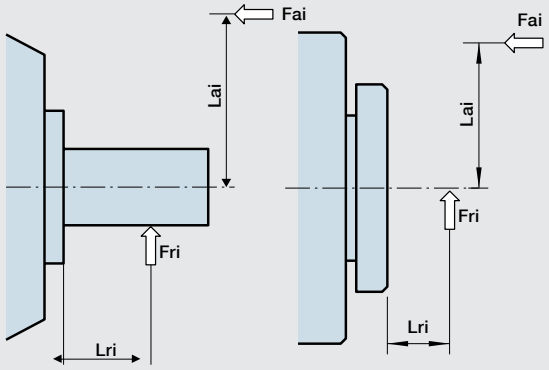
$$Mi\ max = Fri\ max \cdot Lri + Fai\ max \cdot Lai$$

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* ≦ Mc (Permissible moment load)
Fai *max* ≦ Fac (Permissible axial load)

Figure 134-1

External load influence diagram

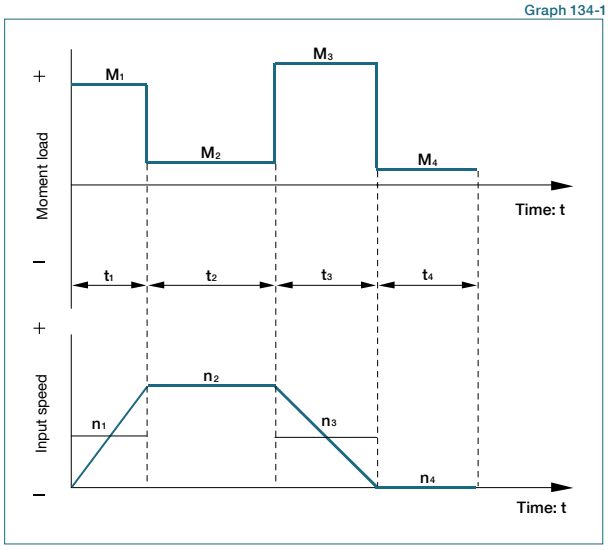


How to calculate average load (Average moment load, average axial load, average input rotational frequency)

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 × Mi *av* + 1.426 × Fai *av*
14	0.137 × Mi *av* + 1.232 × Fai *av*
20	0.109 × Mi *av* + 1.232 × Fai *av*
32	0.071 × Mi *av* + 1.232 × Fai *av*
50	0.053 × Mi *av* + 1.232 × Fai *av*
65	0.041 × Mi *av* + 1.232 × Fai *av*

Dynamic equivalent radial load HPF

Table 134-2

Size	Pci
25	121 × Mi *av* + 2.7 × Fai *av*
32	106 × Mi *av* + 2.7 × 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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Rev 02-15