

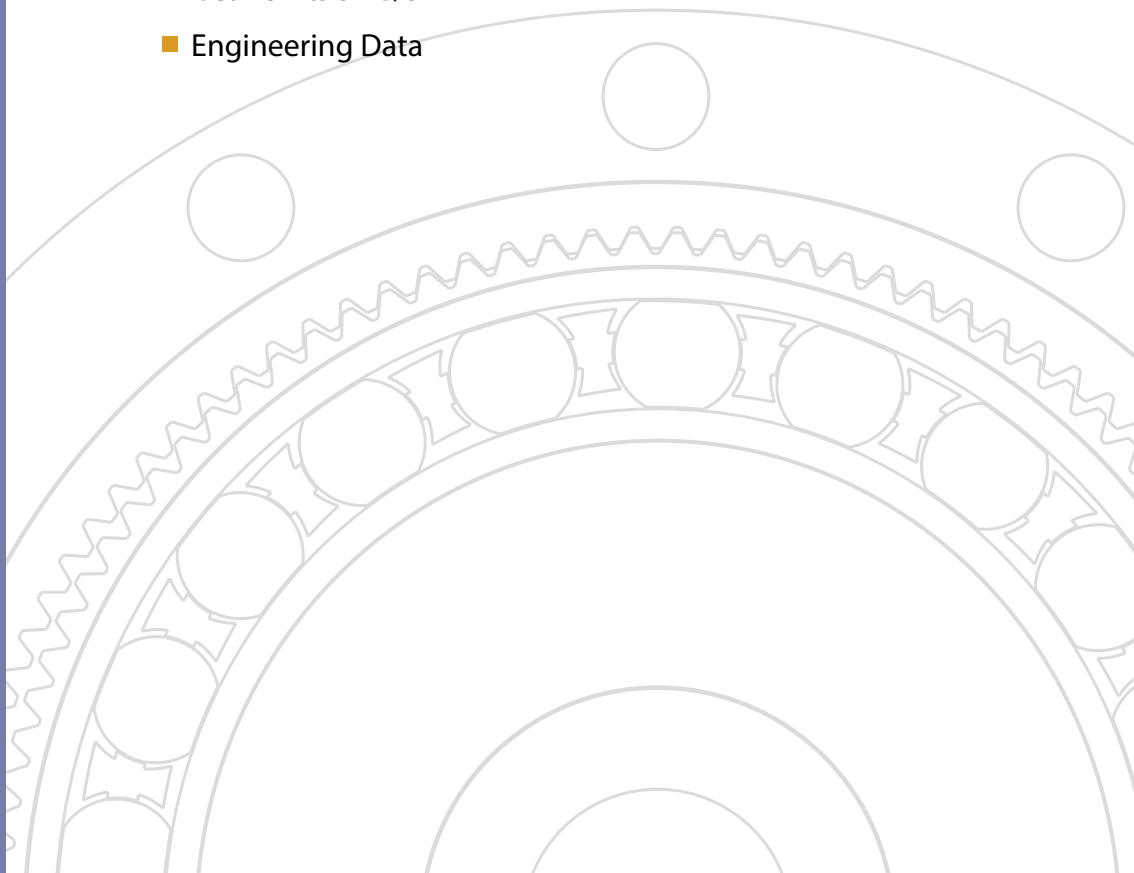
HarmonicDrive®

Speed Reducers for Precision Motion Control

HarmonicDrive® Reducer Catalog

■ Gear Units SHG/SHF

■ Engineering Data

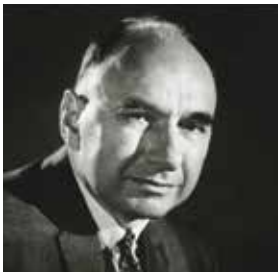


Excellent Technology for Evolving Industries

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

With over 50 years of experience, our expert engineering and production teams continually develop enabling technologies for the evolving motion control market. We are proud of our outstanding engineering capabilities and successful history of providing customer specific solutions to meet their application requirements.

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



C. Walton Musser
Patented Strain Wave
Gearing in 1955

Operating Principle of HarmonicDrive® Gears

A simple three-element construction combined with the unique operating principle puts extremely high reduction ratio capabilities into a very compact and lightweight package. The high-performance attributes of this gearing technology including, zero-backlash, high-torque-to-weight ratio, compact size, and excellent positional accuracy, are a direct result of the unique operating principles.



Wave Generator

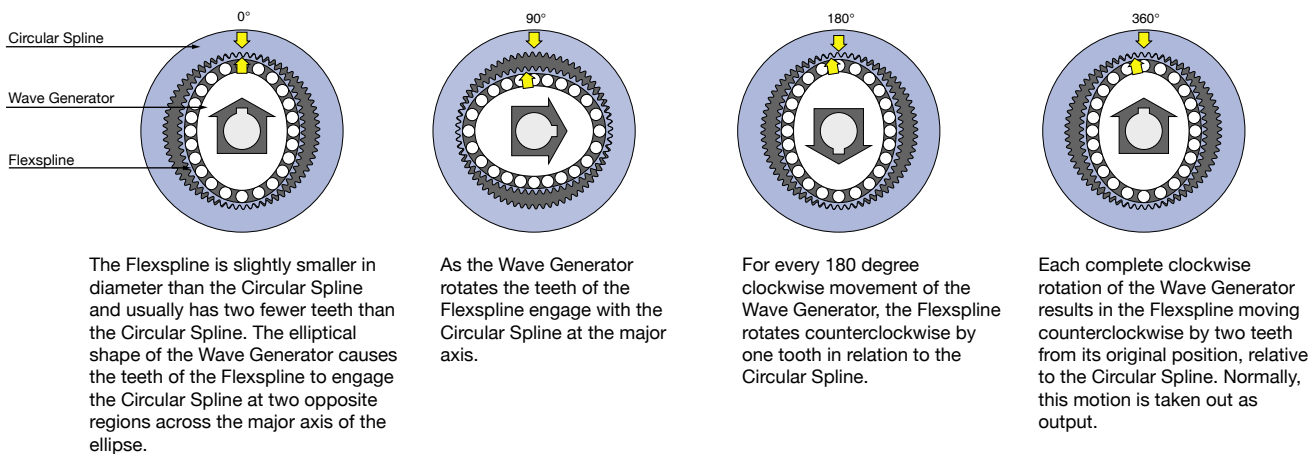
The Wave Generator is a thin, raced-ball bearing fitted onto an elliptical hub. This serves as a high-efficiency torque converter and is generally mounted onto the input or motor shaft.

Flexspline

The Flexspline is a non-rigid, thin cylindrical cup with external teeth on the open end of the cup. The Flexspline fits over the Wave Generator and takes on its elliptical shape. The Flexspline is generally used as the output of the gear.

Circular Spline

The Circular Spline is a rigid ring with internal teeth. It engages the teeth of the Flexspline across the major axis of the Wave Generator ellipse. The Circular Spline has two more teeth than the Flexspline and is generally mounted onto a housing.



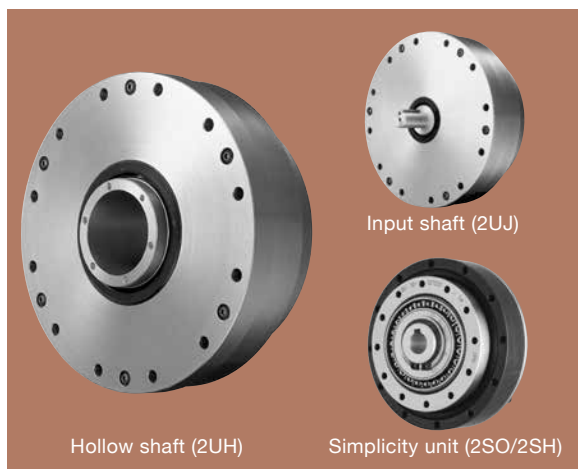
Development of HarmonicDrive® Speed Reducers



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



Features



SHG/SHF series gear units

The SHG/SHF series gear unit is an easy-to-use gearhead solution. An accurate, highly rigid cross roller bearing is built in to directly support the external load.

Features

- Zero backlash
- Large bore with hollow through hole
- Input shaft option available
- Flat shape, compact and simple design
- High-torque capacity
- High stiffness
- High-positional and rotational accuracies
- Coaxial input and output

Configurations

The SHG/SHF gearheads are available in 4 variations allowing the customer to choose the best configuration for their application.

- Large-diameter hollow shaft: (2UH)
- Input shaft (2UJ)
- Easier to use: Simplicity unit (2SO)
Hollow shaft simplicity unit (2SH)

Series

SHG: high torque

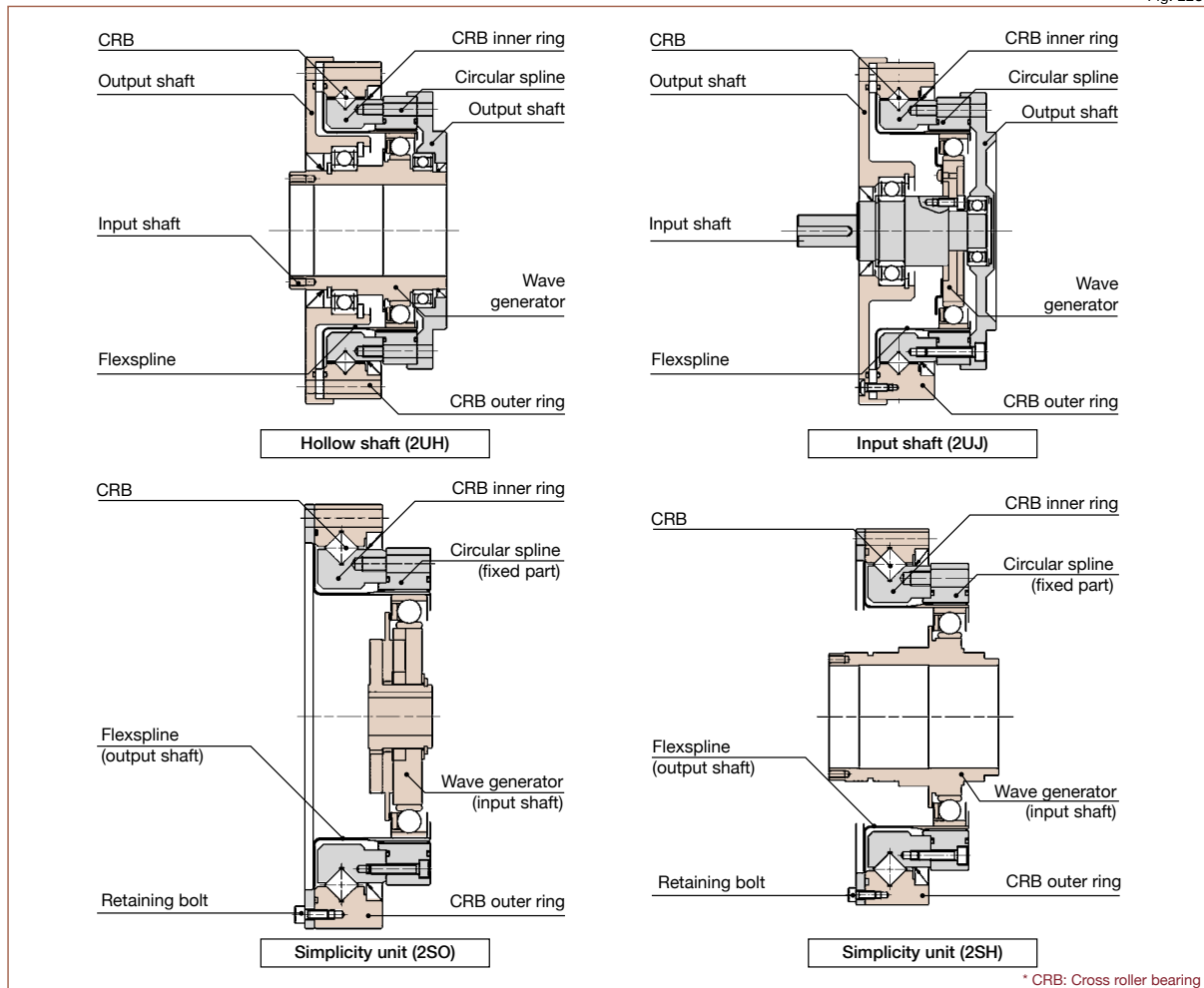
- Torque capacity has been improved by 30% compared to the SHF series.
- The life has been improved by 43% (10,000 hours) compared to the SHF series.

SHF: standard torque

- Reduction ratio of 30:1 added for high speed.

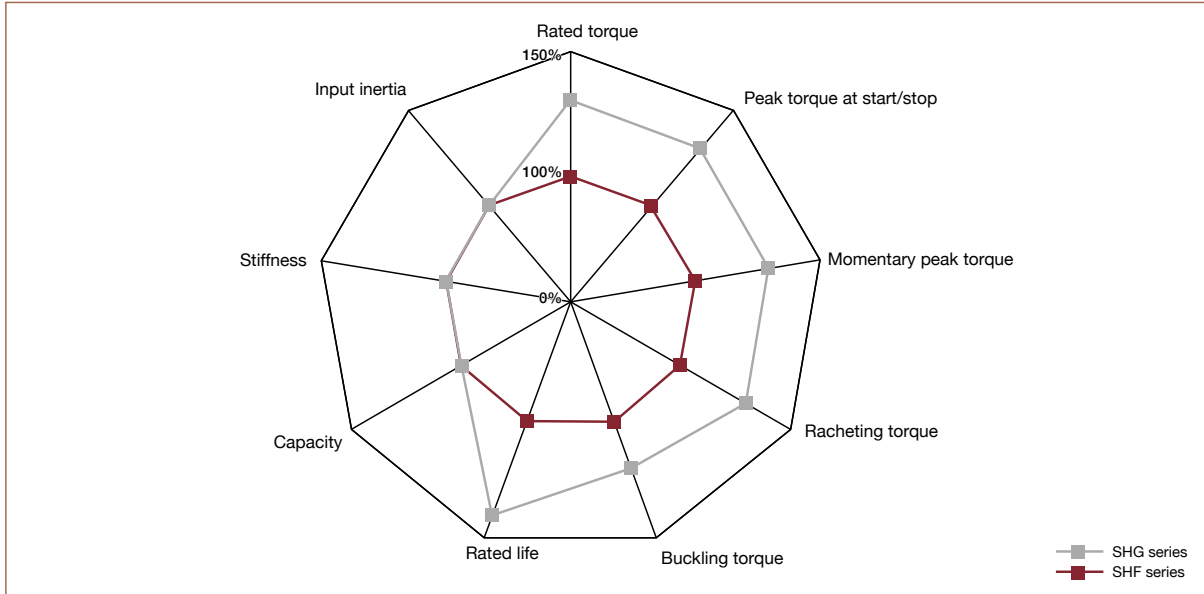
Structure of the SHG/SHF series gear unit

Fig. 228-1



Comparison between SHG/SHF series and CSF series

Graph 229-1



Ordering Code

SHG - 25 - 100 - 2UH - SP

Series	Size	Ratio ^{*1}						Model	Special specification
SHG	14	50	80	100	—	—	—	2A-GR = Component set (2A-R for sizes 14, 17) 2UH = Hollow shaft 2UJ = Input shaft 2SO = Simplicity unit (Std. structure) 2SH = Simplicity unit (Hollow shaft)	LW = Lightweight SP = Special specification code Blank = Standard product
	17	50	80	100	120	—	—		
	20	50	80	100	120	160	—		
	25	50	80	100	120	160	—		
	32	50	80	100	120	160	—		
	40	50	80	100	120	160	—		
	45	50	80	100	120	160	—		
	50	—	80	100	120	160	—		
	58	—	80	100	120	160	—		
	65	—	80	100	120	160	—		

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

SHF - 25 - 100 - 2UH - SP

Series	Size	Ratio ^{*1}						Model	Special specification
SHF	11 ^{*2}	—	50	—	100	—	—	2A-GR = Component set (2A-R for sizes 14, 17) 2UH = Hollow shaft 2UJ = Input shaft 2SO = Simplicity unit (Std. structure) 2SH = Simplicity unit (Hollow shaft)	LW = Lightweight SP = Special specification code Blank = Standard product
	14	30	50	80	100	—	—		
	17	30	50	80	100	120	—		
	20	30	50	80	100	120	160		
	25	30	50	80	100	120	160		
	32	30	50	80	100	120	160		
	40	—	50	80	100	120	160		
	45	—	50	80	100	120	160		
	50	—	50	80	100	120	160		
	58	—	50	80	100	120	160		

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

*2: Size 11 is only available in SHF-2UH

Technical Data

Rating table

■ SHG series

Table 230-1

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

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

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

Rating table

SHF series

Table 231-1

Size	Ratio	Rated torque at 2000rpm		Limit for repeated peak torque		Limit for average torque		Limit for momentary peak torque		Maximum input speed (rpm)		Limit for average input speed (rpm)	
		Nm	kgfm	Nm	kgfm	Nm	kgfm	Nm	kgfm	Oil lubricant	Grease lubricant	Oil lubricant	Grease lubricant
11	50	3.5	0.36	8.3	0.85	5.5	0.56	17	1.73	14000	8500	6500	3500
	100	5	0.51	11	1.12	8.9	0.91	25	2.55				
14	30	4.0	0.41	9.0	0.92	6.8	0.69	17	1.7	14000	8500	6500	3500
	50	5.4	0.55	18	1.8	6.9	0.70	35	3.6				
	80	7.8	0.80	23	2.4	11	1.1	47	4.8				
	100	7.8	0.80	28	2.9	11	1.1	54	5.5				
17	30	8.8	0.90	16	1.6	12	1.2	30	3.1	10000	7300	6500	3500
	50	16	1.6	34	3.5	26	2.6	70	7.1				
	80	22	2.2	43	4.4	27	2.7	87	8.9				
	100	24	2.4	54	5.5	39	4.0	110	11				
20	120	24	2.4	54	5.5	39	4.0	86	8.8	10000	6500	6500	3500
	30	15	1.5	27	2.8	20	2.0	50	5.1				
	50	25	2.5	56	5.7	34	3.5	98	10				
	80	34	3.5	74	7.5	47	4.8	127	13				
25	100	40	4.1	82	8.4	49	5.0	147	15	7500	5600	5600	3500
	120	40	4.1	87	8.9	49	5.0	147	15				
	160	40	4.1	92	9.4	49	5.0	147	15				
	30	27	2.8	50	5.1	38	3.9	95	9.7				
32	50	39	4.0	98	10	55	5.6	186	19	7000	4800	4600	3500
	80	63	6.4	137	14	87	8.9	255	26				
	100	67	6.8	157	16	108	11	284	29				
	120	67	6.8	167	17	108	11	304	31				
40	160	67	6.8	176	18	108	11	314	32	5600	4000	3600	3000
	30	54	5.5	100	10	75	7.7	200	20				
	50	76	7.8	216	22	108	11	382	39				
	80	118	12	304	31	167	17	568	58				
45	100	137	14	333	34	216	22	647	66	5000	3800	3300	3000
	120	137	14	353	36	216	22	686	70				
	160	137	14	372	38	216	22	686	70				
	50	137	14	402	41	196	20	686	70				
50	80	206	21	519	53	284	29	980	100	4500	3500	3000	2500
	100	265	27	568	58	372	38	1080	110				
	120	294	30	617	63	451	46	1180	120				
	160	294	30	647	66	451	46	1180	120				
58	50	176	18	500	51	265	27	950	97	4000	3000	2700	2200
	80	313	32	706	72	390	40	1270	130				
	100	353	36	755	77	500	51	1570	160				
	120	402	41	823	84	620	63	1760	180				
58	160	402	41	882	90	630	64	1910	195	4000	3000	2700	2200
	50	122	12	715	73	175	18	1430	146				
	80	372	38	941	96	519	53	1860	190				
	100	470	48	980	100	666	68	2060	210				
58	120	529	54	1080	110	813	83	2060	210	4000	3000	2700	2200
	160	529	54	1180	120	843	86	2450	250				
	50	176	18	1020	104	260	27	1960	200				
	80	549	56	1480	151	770	79	2450	250				
58	100	696	71	1590	162	1060	108	3180	325	4000	3000	2700	2200
	120	745	76	1720	176	1190	121	3330	340				
	160	745	76	1840	188	1210	123	3430	350				

- (Note) 1. Oil lubrication is standard for gear units size 50 or larger with a reduction ratio of 50. Use grease lubrication within half the rated torque.
2. Moment of inertia: $I = \frac{1}{4} GD^2$
3. See Rating Table Definitions on Page 12 for details of the terms.
4. Size 11 is only available in 2UH.

Positional accuracy

See "Engineering data" for a description of terms.

Table 232-1

Ratio	Specification	Size	11	14	17	20	25	32	40 or more
30	Standard product	×10 ⁻³ rad	—	5.8	4.4	4.4	4.4	4.4	—
		arc min	—	2	1.5	1.5	1.5	1.5	—
	Special product	×10 ⁻³ rad	—	—	—	2.9	2.9	2.9	—
		arc min	—	—	—	1	1	1	—
50 or more	Standard product	×10 ⁻³ rad	5.8 (4.4)	4.4	4.4	2.9	2.9	2.9	2.9
		arc min	2 (1.5)	1.5	1.5	1	1	1	1
	Special product	×10 ⁻³ rad	—	2.9	2.9	1.5	1.5	1.5	1.5
		arc min	—	1	1	0.5	0.5	0.5	0.5

Note 1: * The parenthesized value of size 11 indicates the value for reduction ratio 100.

Hysteresis loss

See "Engineering data" for a description of terms.

Table 232-2

Ratio	Unit	Size	11	14	17	20	25	32	40 or more
30		×10 ⁻³ rad	—	8.7	8.7	8.7	8.7	8.7	—
		arc min	—	3.0	3.0	3.0	3.0	3.0	—
50		×10 ⁻³ rad	5.8	5.8	5.8	5.8	5.8	5.8	5.8
		arc min	2.0	2.0	2.0	2.0	2.0	2.0	2.0
80 or more		×10 ⁻³ rad	5.8	2.9	2.9	2.9	2.9	2.9	2.9
		arc min	2.0	1.0	1.0	1.0	1.0	1.0	1.0

Backlash

See "Engineering data" for a description of terms.

Table 232-3

Ratio	Size	11	14	17	20	25	32	40	45	50	58	65
30	×10 ⁻³ rad	—	29.1	16.0	13.6	13.6	11.2	—	—	—	—	—
	arc sec	—	60	33	28	28	23	—	—	—	—	—
50	×10 ⁻³ rad	Note 1	17.5	9.7	8.2	8.2	6.8	6.8	5.8	5.8	4.8	—
	arc sec	Note 1	36	20	17	17	14	14	12	12	10	—
80	×10 ⁻³ rad	—	11.2	6.3	5.3	5.3	4.4	4.4	3.9	3.9	2.9	2.9
	arc sec	—	23	13	11	11	9	9	8	8	6	6
100	×10 ⁻³ rad	Note 1	8.7	4.8	4.4	4.4	3.4	3.4	2.9	2.9	2.4	2.4
	arc sec	Note 1	18	10	9	9	7	7	6	6	5	5
120	×10 ⁻³ rad	—	—	3.9	3.9	3.9	2.9	2.9	2.4	2.4	1.9	1.9
	arc sec	—	—	8	8	8	6	6	5	5	4	4
160	×10 ⁻³ rad	—	—	—	2.9	2.9	2.4	2.4	1.9	1.9	1.5	1.5
	arc sec	—	—	—	6	6	5	5	4	4	3	3

Note 1: For size 11, the wave generator is a solid wave generator. See "Engineering data" for details.

Torsional stiffness

See "Engineering data" for a description of terms.

Table 232-4

Symbol	Size	11	14	17	20	25	32	40	45	50	58	65
T ₁	Nm	0.8	2.0	3.9	7.0	14	29	54	76	108	168	235
	kgfm	0.082	0.2	0.4	0.7	1.4	3.0	5.5	7.8	11	17	24
T ₂	Nm	2.0	6.9	12	25	48	108	196	275	382	598	843
	kgfm	0.2	0.7	1.2	2.5	4.9	11	20	28	39	61	86
Reduction ratio 30	K ₁	×10 ⁻³ Nm/rad	—	0.19	0.34	0.57	1.0	2.4	—	—	—	—
		kgfm/arc min	—	0.056	0.10	0.17	0.30	0.70	—	—	—	—
	K ₂	×10 ⁻³ Nm/rad	—	0.24	0.44	0.71	1.3	3.0	—	—	—	—
		kgfm/arc min	—	0.07	0.13	0.21	0.40	0.89	—	—	—	—
	K ₃	×10 ⁻³ Nm/rad	—	0.34	0.67	1.1	2.1	4.9	—	—	—	—
		kgfm/arc min	—	0.10	0.20	0.32	0.62	1.5	—	—	—	—
	θ ₁	×10 ⁻³ rad	—	10.5	11.5	12.3	14	12.1	—	—	—	—
		arc min	—	3.6	4.0	4.1	4.7	4.3	—	—	—	—
	θ ₂	×10 ⁻³ rad	—	31	30	38	40	38	—	—	—	—
		arc min	—	10.7	10.2	12.7	13.4	13.3	—	—	—	—
Reduction ratio 50	K ₁	×10 ⁻³ Nm/rad	0.22	0.34	0.81	1.3	2.5	5.4	10	15	20	31
		kgfm/arc min	0.066	0.1	0.24	0.38	0.74	1.6	3.0	4.3	5.9	9.3
	K ₂	×10 ⁻³ Nm/rad	0.3	0.47	1.1	1.8	3.4	7.8	14	20	28	44
		kgfm/arc min	0.09	0.14	0.32	0.52	1.0	2.3	4.2	6.0	8.2	13
	K ₃	×10 ⁻³ Nm/rad	0.32	0.57	1.3	2.3	4.4	9.8	18	26	34	54
		kgfm/arc min	0.096	0.17	0.4	0.67	1.3	2.9	5.3	7.6	10	16
	θ ₁	×10 ⁻³ rad	3.6	5.8	4.9	5.2	5.5	5.5	5.2	5.2	5.5	5.2
		arc min	1.2	2.0	1.7	1.8	1.9	1.9	1.8	1.8	1.9	1.8
	θ ₂	×10 ⁻³ rad	8.0	16	12	15.4	15.7	15.7	15.4	15.1	15.4	15.1
		arc min	2.6	5.6	4.2	5.3	5.4	5.3	5.2	5.3	5.2	5.2

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

Table 233-1

Symbol		Size		11	14	17	20	25	32	40	45	50	58	65
	T ₁	Nm	0.8	2.0	3.9	7.0	14	29	54	76	108	168	235	
		kgfm	0.82	0.2	0.4	0.7	1.4	3.0	5.5	7.8	11	17	24	
	T ₂	Nm	2	6.9	12	25	48	108	196	275	382	598	843	
		kgfm	0.2	0.7	1.2	2.5	4.9	11	20	28	39	61	86	
Reduction ratio 80 or more	K ₁	×10 ³ Nm/rad	0.27	0.47	1	1.6	3.1	6.7	13	18	25	40	54	
		kgfm/arc min	0.08	0.14	0.3	0.47	0.92	2.0	3.8	5.4	7.4	12	16	
	K ₂	×10 ³ Nm/rad	0.34	0.61	1.4	2.5	5.0	11	20	29	40	61	88	
		kgfm/arc min	0.1	0.18	0.4	0.75	1.5	3.2	6.0	8.5	12	18	26	
	K ₃	×10 ³ Nm/rad	0.44	0.71	1.6	2.9	5.7	12	23	33	44	71	98	
		kgfm/arc min	0.13	0.21	0.46	0.85	1.7	3.7	6.8	9.7	13	21	29	
	θ ₁	×10 ⁻⁴ rad	3	4.1	3.9	4.4	4.4	4.4	4.1	4.1	4.4	4.1	4.4	
		arc min	1	1.4	1.3	1.5	1.5	1.5	1.4	1.4	1.5	1.4	1.5	
	θ ₂	×10 ⁻⁴ rad	6	12	9.7	11.3	11.1	11.6	11.1	11.1	11.1	11.1	11.3	
		arc min	2.2	4.2	3.3	3.9	3.8	4.0	3.8	3.8	3.8	3.8	3.9	

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

Ratcheting torque

See "Engineering data" for a description of terms.

SHG series

Table 233-2
Unit: Nm

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

SHF series

Table 233-3
Unit: Nm

Ratio	Size	11	14	17	20	25	32	40	45	50	58
30		—	59	100	170	340	720	—	—	—	—
50		34	88	150	220	450	980	1800	2700	3700	5800
80		—	110	200	350	680	1400	2800	3900	5400	8200
100		43	84	160	260	500	1000	2100	3100	4100	6400
120		—	—	120	240	470	980	1900	2800	3800	5800
160		—	—	—	220	450	980	1800	2600	3600	5600

Buckling torque

See "Engineering data" for a description of terms.

SHG series

Table 233-4
Unit: Nm

Size	14	17	20	25	32	40	45	50	58	65
All ratios	210	420	700	1300	2800	5200	7600	10400	16200	22800

SHF series

Table 233-5
Unit: Nm

Size	11	14	17	20	25	32	40	45	50	58
All ratios	90	140	270	440	890	1750	3750	5400	7500	11800

Checking output bearing

A precision cross roller bearing is built in the unit type to directly support the external load (output flange). Please calculate maximum moment load, life of cross roller bearing, and static safety factor to fully maximize the performance of housed unit (gearhead).

See Pages 030 to 034 of "Engineering data" for each calculation formula.

■ Checking procedure

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

Calculate the maximum moment load (M_{max}).

Maximum moment load (M_{max}) $\leq$ allowable moment (M_c)

(2) Checking the life

Calculate the radial load (F_{rav}) and the average axial load (F_{av}).

Calculate the radial load coefficient (x) and the axial load coefficient (y).

Calculate the lifetime

(3) Checking the static safety coefficient

Calculate the static equivalent radial load coefficient (P_o).

Check the static safety coefficient. (f_s)

■ Output bearing specifications

The specifications of the cross roller are shown in Table 234-1.

Specifications

Table 234-1

Size	Pitch circle	Offset	Basic rated load				Allowable moment load Mc		Moment stiffness Km	
	d _p	R	Basic dynamic rated load C		Basic static rated load C ₀				×10 ⁴ Nm/rad	kgfm/arc min
	m	m	×10 ³ N	kgf	×10 ³ N	kgf	Nm	kgfm		
11	0.043	0.018	52.9	540	75.5	770	74	7.6	6.5	1.8
14	0.050	0.0217	58	590	86	880	74	7.6	8.5	2.5
17	0.060	0.0239	104	1060	163	1670	124	12.6	15.4	4.6
20	0.070	0.0255	146	1490	220	2250	187	19.1	25.2	7.5
25	0.085	0.0296	218	2230	358	3660	258	26.3	39.2	11.6
32	0.111	0.0364	382	3900	654	6680	580	59.1	100	29.6
40	0.133	0.044	433	4410	816	8330	849	86.6	179	53.2
45	0.154	0.0475	776	7920	1350	13800	1127	115	257	76.3
50	0.170	0.0525	816	8330	1490	15300	1487	152	351	104
58	0.195	0.0622	874	8920	1710	17500	2180	222	531	158
65	0.218	0.072	1300	13300	2230	22700	2740	280	741	220

* The basic dynamic rated load is the static radial load needed to result in a basic dynamic rated life of one million rotations.

* The basic static rated load is the static load that produces a contact stress of 4 kN/mm² in the center of the contact area between the rolling element receiving the maximum load.

* The moment stiffness value is an average.

* Allowable moment load is the maximum moment load that may be applied to the output shaft. Please adhere to these values for optimum performance. Moment stiffness is a reference value. The minimum value is approximately 80% of the displayed value.

* Allowable axial or radial load is the value that satisfies the reducer life when either a radial load or an axial load is applied to the main shaft. (When radial load is $L_r + R = 0$ mm, and axial load is $L_a = 0$ mm)

For the following size and gear ratio combinations, the life of the cross roller bearing operating at the allowable moment load is less than the life of the wave generator bearing ($L_{10} = 7000$ hr) operating at 2000rpm and rated torque. Special consideration should be made in designing the load condition and the lifetime. (see "Life of the wave generator" on Page 012).

Life of cross roller bearing < Life of Gearhead

Table 234-2

Size	Ratio		
11	50	—	100
14	50	80	100
17	50	80	—
20	50	—	—

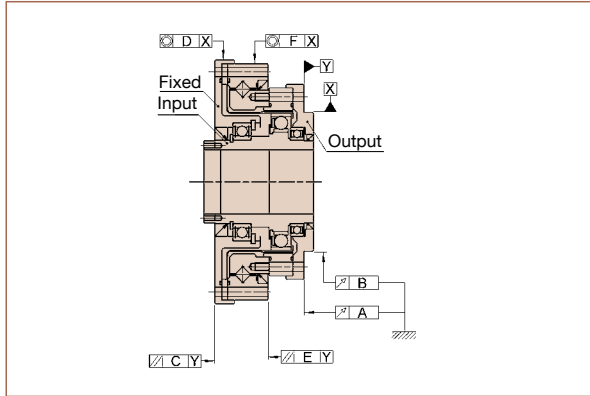
Output bearing and housing tolerances

Flexspline fixed

Input: Wave generator
Output: Circular spline
Fixed: Flexspline

Hollow Shaft (2UH)

Fig. 235-1



Input shaft (2UJ)

Fig. 235-2

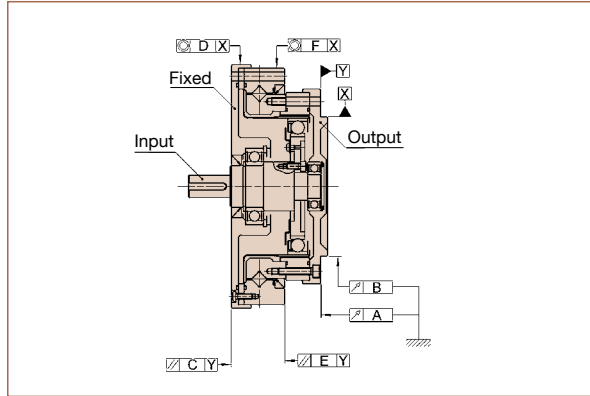


Table 235-1
Unit: mm

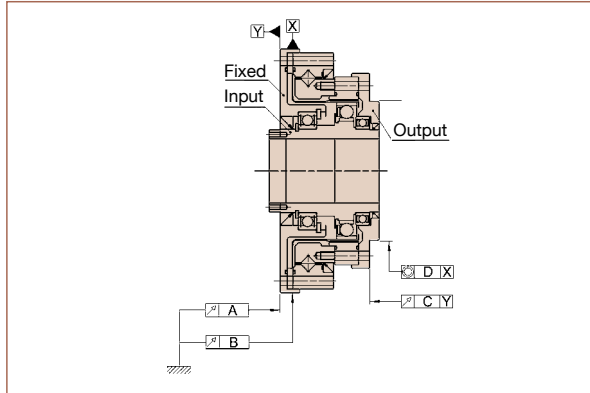
Symbol \ Size	11	14	17	20	25	32	40	45	50	58	65
A	0.033	0.033	0.038	0.040	0.046	0.054	0.057	0.057	0.063	0.063	0.067
B	0.035	0.035	0.035	0.039	0.041	0.047	0.050	0.053	0.060	0.063	0.063
C	0.053	0.064	0.071	0.079	0.085	0.104	0.111	0.118	0.121	0.121	0.131
D	0.053	0.053	0.050	0.059	0.061	0.072	0.075	0.078	0.085	0.088	0.089
E	0.039	0.040	0.045	0.051	0.057	0.065	0.071	0.072	0.076	0.076	0.082
F	0.038	0.038	0.038	0.047	0.049	0.054	0.060	0.065	0.067	0.070	0.072

Circular spline fixed

Input: Wave generator
Output: Flexspline
Fixed: Circular spline

Hollow shaft (2UH)

Fig. 235-3



Input shaft (2UJ)

Fig. 235-4

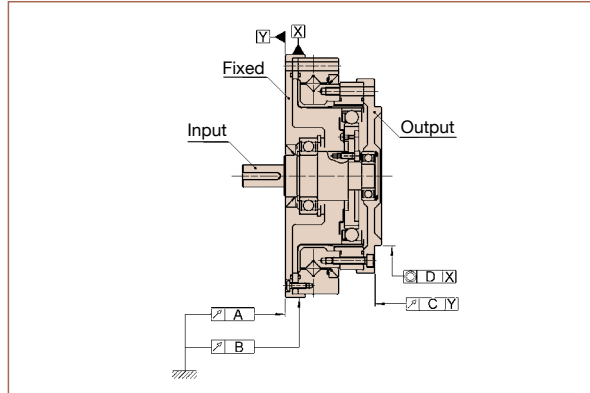


Table 171-2
Unit: mm

Symbol \ Size	11	14	17	20	25	32	40	45	50	58	65
A	0.027	0.037	0.039	0.046	0.047	0.059	0.060	0.070	0.070	0.070	0.076
B	0.031	0.031	0.031	0.038	0.038	0.045	0.048	0.050	0.050	0.050	0.054
C	0.053	0.064	0.071	0.079	0.085	0.104	0.111	0.118	0.121	0.121	0.131
D	0.053	0.053	0.053	0.059	0.061	0.072	0.075	0.078	0.085	0.088	0.089

Rotational direction and reduction ratio

The rotational direction and the reduction ratio vary depending on the flange to be fixed for the unit type.

■ Flexspline fixed

Input: Wave generator

Output: Circular spline

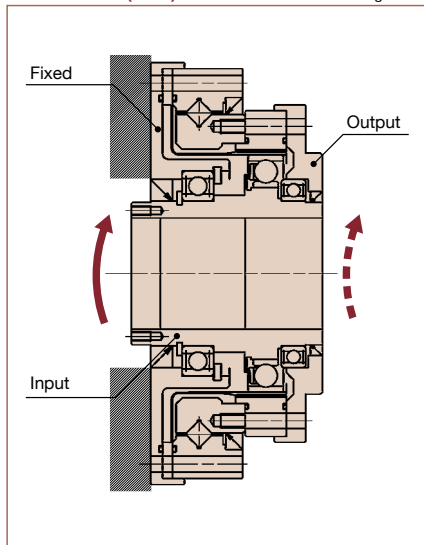
Fixed: Flexspline

Output rotational direction:
Same rotational direction as
the input

$$\text{Reduction ratio (i): } i = \frac{1}{R+1}$$

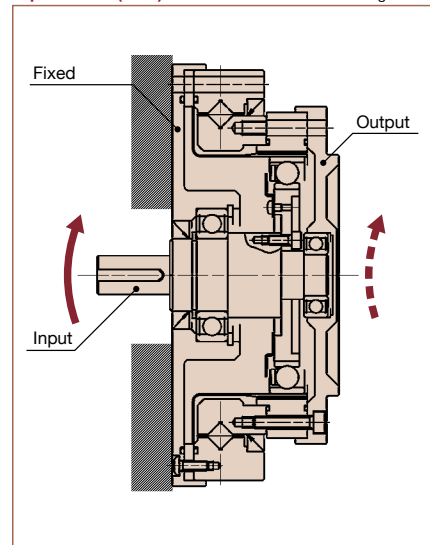
Hollow shaft (2UH)

Fig. 236-1



Input shaft (2UJ)

Fig. 236-2



■ Circular spline fixed

Input: Wave generator

Output: Flexspline

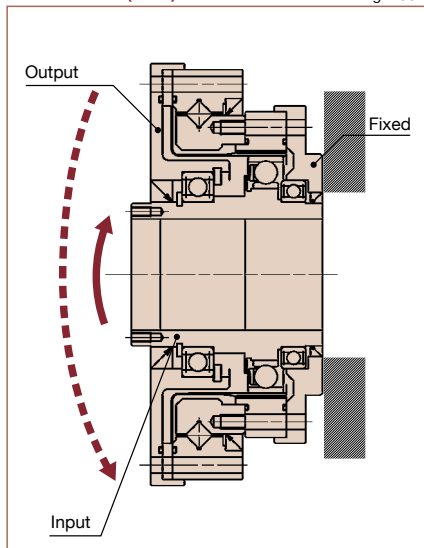
Fixed: Circular spline

Output rotational direction:
Opposite rotational direction
to the input

$$\text{Reduction ratio (i): } i = \frac{-1}{R}$$

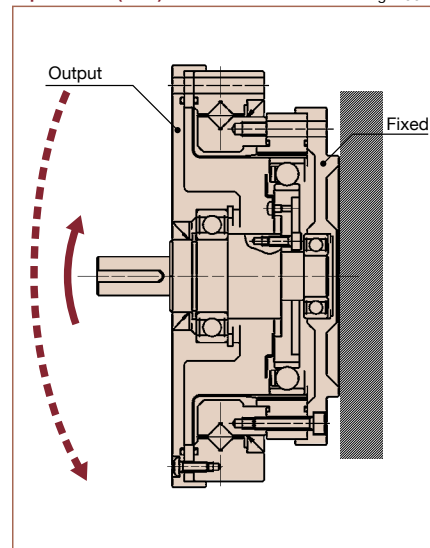
Hollow shaft (2UH)

Fig. 236-3



Input shaft (2UJ)

Fig. 236-4



Rotational direction



Input



Output

Design Guide

Lubrication

The standard lubricant for Harmonic Drive® gear units is Harmonic Grease SK-1A and SK-2 (Harmonic Grease 4B No.2 for the cross roller bearing). Harmonic Grease 4B No.2 is also available for long-life. The specifications of the grease are described on Page 016.

Sealing mechanism

- Rotating and sliding area Oil seal (with a spring). Take care regarding flaws on the shaft.
- Flange mating face and mating O-ring and seal adhesive. Take care regarding the distortion on the plane and how the O-ring is engaged.
- Screw hole area Use a screw lock agent (LOCKTITE 242 is recommended) or seal tape.

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

Rust prevention

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

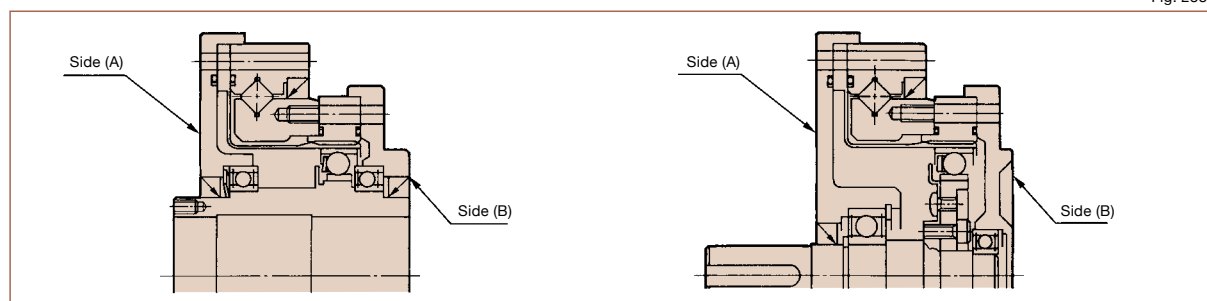
Installation accuracy

For peak performance of the gear, it is essential that the following tolerances be observed when assembly is complete. Pay careful attention to the following points and maintain the recommended assembly tolerances. In addition, perform the appropriate installation according to each series, because the torque capacity of SHG series is larger than SHF series.

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

Installation and transmission torque

Fig. 238-1



SHG series: (A) Side-installation and Torque Transmission Capacity

Table 238-1

Item \ Size		14	17	20	25	32	40	45	50	58	65
Number of bolts		8	12	12	12	12	12	18	12	16	16
Bolt size		M3	M3	M3	M4	M5	M6	M6	M8	M8	M10
Pitch circle	mm	64	74	84	102	132	158	180	200	226	258
Clamp torque	Nm	2.4	2.4	2.4	5.4	10.8	18.4	18.4	44	44	74
Transmission torque	Nm	128	222	252	516	1069	1813	3098	4163	6272	9546

SHF series: (A) Side-installation and Torque Transmission Capacity

Table 238-2

Item \ Size		11	14	17	20	25	32	40	45	50	58
Number of bolts		4	8	12	12	12	12	12	18	12	16
Bolt size		M3	M3	M3	M3	M4	M5	M6	M6	M8	M8
Pitch circle	mm	56.4	64	74	84	102	132	158	180	200	226
Clamp torque	Nm	2.0	2.0	2.0	2.0	4.5	9.0	15.3	15.3	37	37
Transmission torque	Nm	47	108	186	206	431	892	1509	2578	3489	5236

(Table 238-1, 238-2/Notes)

1. The material of the thread must withstand the clamp torque.
2. Recommended bolt: JIS B 1176 socket head cap screw / Strength Range: JIS B 1051 12.9 or more
3. Torque coefficient: $K=0.2$
4. Clamp coefficient: $A=1.4$
5. Friction coefficient on the surface contacted: $\mu=0.15$
6. Use washers for SHG/SHF-LW.

SHG series: (B) Side-installation and Torque Transmission Capacity

Table 239-1

Size		14	17	20	25	32	40	45	50	58	65
Item											
Number of bolts		8	16	16	16	16	16	12	16	12	16
Bolt size		M3	M3	M3	M4	M5	M6	M8	M8	M10	M10
Pitch circle	mm	44	54	62	77	100	122	140	154	178	195
Clamp torque	Nm	2.4	2.4	2.4	5.4	10.8	18.36	44	44	89	89
Transmission torque	Nm	88	216	248	520	1080	1867	2914	4274	5927	8658

SHF series: (B) Side-installation and Torque Transmission Capacity

Table 239-2

Size		11	14	17	20	25	32	40	45	50	58
Item											
Number of bolts		6	8	16	16	16	16	16	12	16	12
Bolt size		M3	M3	M3	M3	M4	M5	M6	M8	M8	M10
Pitch circle	mm	37	44	54	62	77	100	122	140	154	178
Clamp torque	Nm	2	2.0	2.0	2.0	4.5	9.0	15.3	37	37	74
Transmission torque	Nm	46	72	176	206	431	902	1558	2440	3587	4910

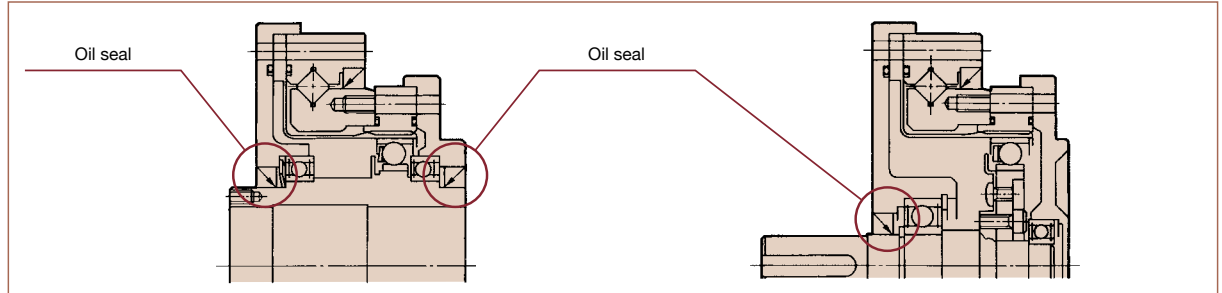
(Table 239-1, 239-2/Notes)

1. The material of the thread must withstand the clamp torque.
2. Recommended bolt: JIS B 1176 hexagonal bolt / Strength: JIS B 1051 12.9 or more
3. Torque coefficient: $K=0.2$
4. Clamp coefficient $A=1.4$
5. Friction coefficient on the surface contacted: $\mu=0.15$

Installation Recommendations**■ Installation on the periphery of the oil seal**

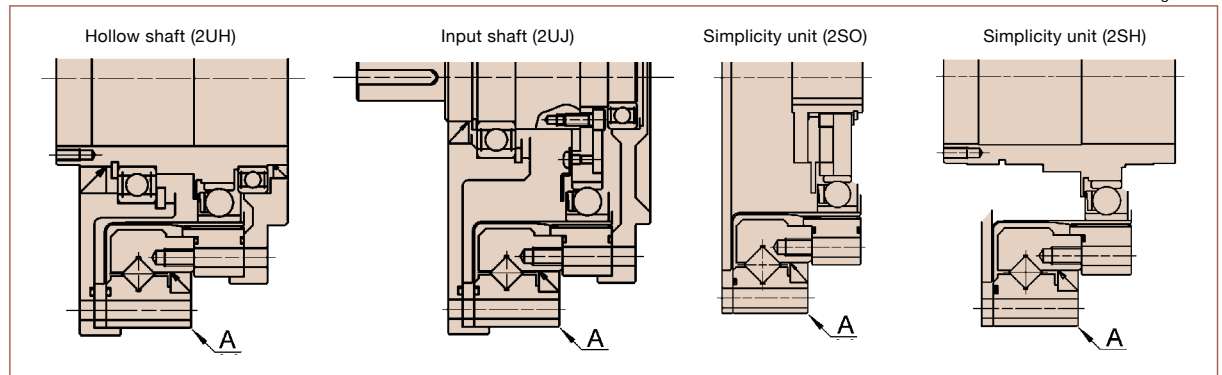
Install an oil seal on the mounting face so that they have a space of at least 1 mm between them to avoid interference with each other.

Fig. 240-1

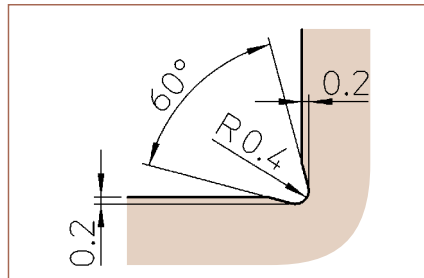
**■ Manufacturing for Mating Part and Housing**

When the housing interferes with corner "A", an undercut in the housing is recommended as shown below.

Fig. 240-2



Recommended Housing Undercut

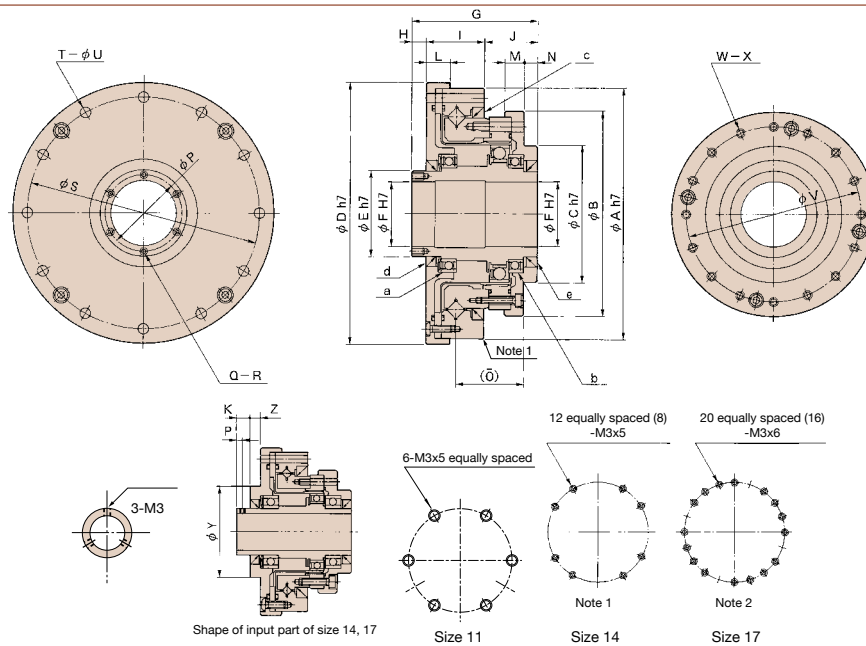
Fig. 240-3
Unit: mm

Outline Dimensions (2UH)

Outline dimensions (2UH)

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

Fig. 241-1



Note 1: See recommended housing undercut on previous page. The dimension tolerances that are not specified vary depending on the manufacturing method. Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing.

* Please refer to the confirmation drawing for detailed dimensions.

Dimensions (2UH)

Table 241-1
Unit: mm

Symbol		Size	11	14	17	20	25	32	40	45	50	58	65
φ A h7			62	70	80	90	110	142	170	190	214	240	276
φ B	SHG/SHF Series		45.3	54	64	75	90	115	140	160	175	201	221
	SHG/SHF-LW Series		—	52	62	73	88	115	140	160	168	195	213
φ C h7			30.5	36	45	50	60	85	100	120	130	150	160
φ D h7			64	74	84	95	115	147	175	195	220	246	284
φ E h7			18	20	25	30	38	45	59	64	74	84	96
φ F H7			14	14	19	21	29	36	46	52	60	70	80
G			48	52.5	56.5	51.5	55.5	65.5	79	85	93	106	128
H			14	12	12	5	6	7	8	8	9	10	14
I			19	20.5	23	25	26	32	38	42	45	52	56.5
J			15	20	21.5	21.5	23.5	26.5	33	35	39	44	57.5
K			6.5	6.5	6.5	—	—	—	—	—	—	—	—
L			8	9	10	10.5	10.5	12	14	15	16	17	18
M	SHG/SHF Series		6.5	8	8.5	9	8.5	9.5	13	12	12	15	19.5
	SHG/SHF-LW Series		—	11.5	12	13.5	15.5	20.5	25	27	30	35	42.5
N			6.5	7.5	8.5	7	6	5	7	7	7	7	12
O			17.5	21.7	23.9	25.5	29.6	36.4	44	47.5	52.5	62.2	72
φ P (P)			—	(2.5)	(2.5)	25.5	33.5	40.5	52	58	67	77	88
Q			—	3	3	6	6	6	6	6	6	8	6
R			—	M3	M3	M3×6	M3×6	M3×6	M4×8	M4×8	M4×8	M4×8	M5×10
φ S			56.4	64	74	84	102	132	158	180	200	226	258
T			4	8	12	12	12	12	12	18	12	16	16
φ U			3.5	3.5	3.5	3.5	4.5	5.5	6.6	6.6	9	9	11
φ V			37	44	54	62	77	100	122	140	154	178	195
W			6	12 E. A. 8	20 E. A. 16	16	16	16	16	12	16	12	16
X	SHG/SHF Series	M3X5	M3×5	M3×6	M3×6	M4×7	M5×8	M6×10	M8×10	M8×11	M10×15	M10×15	
		φ3.4X4	φ3.5×11.5	φ3.5×12	φ3.5×13.5	φ4.5×15.5	φ5.5×20.5	φ6.6×25	φ9×28	φ9×30	φ11×35	φ11×42.5	
	SHG/SHF-LW Series	—	M3×5	M3×6	M3×6	M4×7	M5×8	M6×10	M8×10	M8×11	M10×15	M10×15	
			φ3.5×11.5	φ3.5×12	φ3.5×13.5	φ5×15.5	φ6×20.5	φ7×25	φ9×27	φ9×30	φ11×35	φ11×42.5	
φ Y			36	36	45	—	—	—	—	—	—	—	—
Z			7.5	5.5	5.5	—	—	—	—	—	—	—	—
a			6804 ZZ	6804 ZZ	6805 ZZ	6806 ZZ	6808 ZZ	6909 ZZ	6912 ZZ	6913 ZZ	6915 ZZ	6917 ZZ	6920 ZZ
b	SHG/SHF Series		6704 ZZ	6804 ZZ	6805 ZZ	6806 ZZ	6808 ZZ	6809 ZZ	6812 ZZ	6813 ZZ	6815 ZZ	6817 ZZ	6820 ZZ
	SHG/SHF-LW Series		—	6804 ZZ	6805 ZZ	6806 ZZ	6808 ZZ	6809 ZZ	6812 ZZ	6813 ZZ	6815 ZZ	6817 ZZ	6820 ZZ
c			D41.950.95	D49585	D59685	D69785	D84945	D1101226	D1321467	D1521707	D1681868	D1932129	D21623811
d	SHG/SHF Series		S18274	S20304.5	S25356	S30405	S38475	S45607	S60789	S658510	S759510	S8511012	S10012513
	SHG/SHF-LW Series		—	S20304.5	S25356	S30405	S38475	S45607	S60789	S658510	S759510	S8511012	S10012513
e	SHG/SHF Series		S18274	S20304.5	S25356	S30405	S38475	S45555	S59685	S59685	S69785	S84945	S961128
	SHG/SHF-LW Series		—	S20304.5	S25356	S30405	S38475	S45555	S59685	S59685	S69785	S84945	S961128

Mass (2UH)

Table 242-1

Unit: kg

Symbol	Size	11	14	17	20	25	32	40	45	50	58	65
2UH		0.53	0.71	1.00	1.38	2.1	4.5	7.7	10.0	14.5	20.0	28.5
2UH-LW (Lightweight)		—	0.55	0.8	1.1	1.6	3.6	6.2	8	11.8	16.4	23.3

Moment of Inertia (2UH)

Table 242-2

Symbol	Size	11	14	17	20	25	32	40	45	50	58	65
Moment of inertia	I $\times 10^{-3} \text{kgm}^2$	0.080	0.091	0.193	0.404	1.070	2.85	9.28	13.8	25.2	49.5	94.1
	J $\times 10^{-3} \text{kgfms}^2$	0.082	0.093	0.197	0.412	1.090	2.91	9.47	14.1	25.7	50.5	96.0

Starting torque (2UH)

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

Table 242-3

Unit: Ncm

Ratio	Size	11	14	17	20	25	32	40	45	50	58	65
30		—	11	30	43	64	112	—	—	—	—	—
50		7.1	8.8	27	36	56	85	136	165	216	297	—
80		—	7.5	25	33	50	74	117	138	179	244	314
100		5.9	6.9	24	32	49	72	112	131	171	231	297
120		—	—	24	31	48	68	110	126	165	223	287
160		—	—	—	31	47	67	105	122	156	213	276

Backdriving torque (2UH)

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

Table 242-4

Unit: Ncm

Ratio	Size	11	14	17	20	25	32	40	45	50	58	65
30		—	5.4	17	23	35	57	—	—	—	—	—
50		4.6	5.3	16	22	34	51	82	99	129	178	—
80		—	7.2	24	31	48	70	112	133	172	234	301
100		7.6	8.2	29	38	59	86	134	158	205	278	356
120		—	—	34	45	69	97	158	182	237	322	413
160		—	—	—	59	90	128	201	233	299	408	530

No-load running torque

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

Measurement condition

Table 242-5

Ratio			
Lubricant	Grease lubrication	Name	Harmonic Grease SK-1A
			Harmonic Grease SK-2
		Quantity	Recommended quantity

Torque value is measured after 2 hours at 2000rpm input.

■ Compensation Value in Each Ratio

No-load running torque of the gear varies with ratio. The graphs indicate a value for ratio 100. For other gear ratios, add the compensation values from table on the right. (Table 242-6).

No-Load Torque Compensation

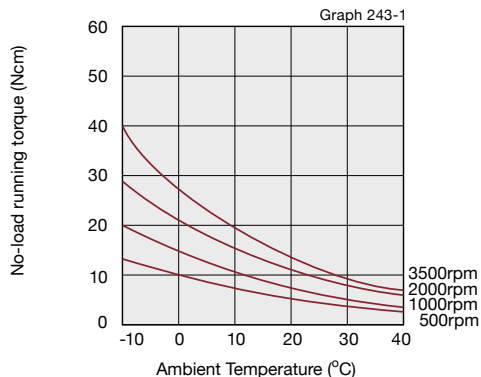
Table 242-6

Unit: Ncm

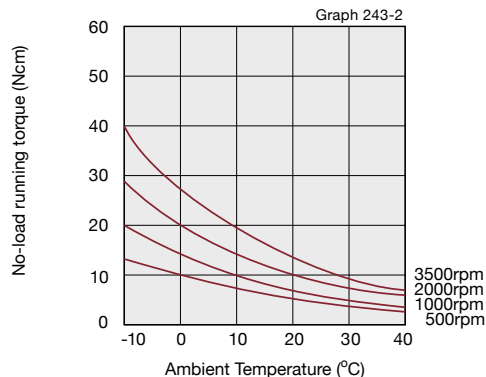
Size	Ratio	30	50	80	120	160
11		—	+0.5	—	—	—
14		+2.6	+1.1	+0.2	—	—
17		+4.1	+1.8	+0.4	-0.2	—
20		+5.9	+2.6	+0.5	-0.4	-0.8
25		+9.6	+4.2	+0.8	-0.6	-1.3
32		+18.3	+8.0	+1.5	-1.1	-2.5
40		—	+13.3	+2.4	-1.7	-4.0
45		—	+18.2	+3.3	-2.4	-5.5
50		—	+23.9	+4.3	-3.1	-7.2
58		—	+34.6	+6.2	-4.4	-10.3
65		—	—	+8.1	-5.8	-13.7

No-load running torque

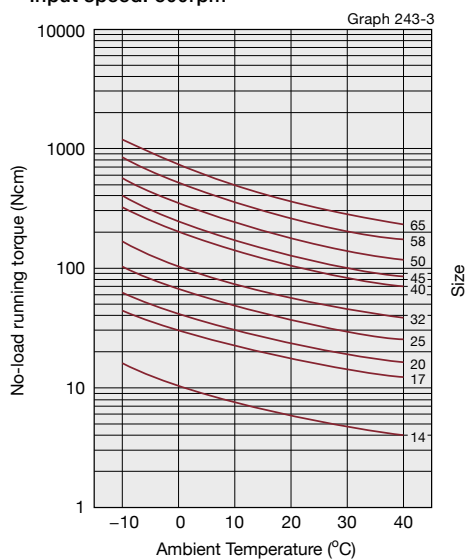
SHF-11 Ratio: 50



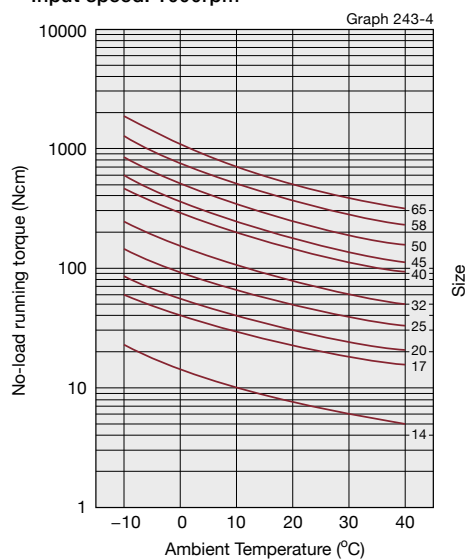
SHF-11 Ratio: 100



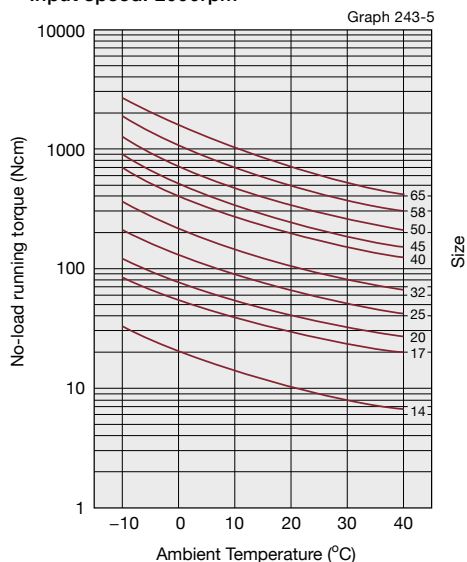
SHG/SHF-14 to 65 Ratio: 100
Input speed: 500rpm



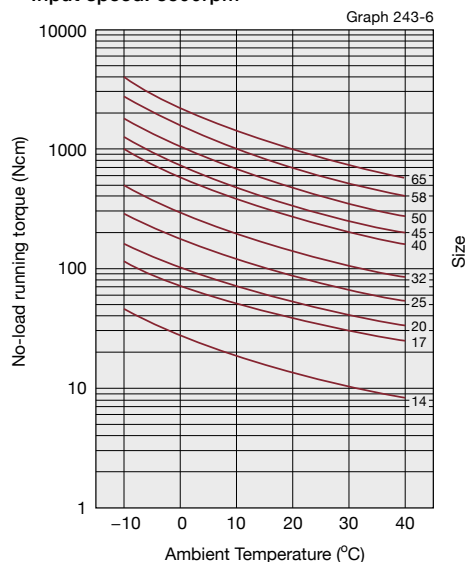
SHG/SHF-14 to 65 Ratio: 100
Input speed: 1000rpm



SHG/SHF-14 to 65 Ratio: 100
Input speed: 2000rpm



SHG/SHF-14 to 65 Ratio: 100
Input speed: 3500rpm



*The values in this graph are average values ($\bar{X}$). $\sigma \approx 20\%$

Efficiency

The efficiency varies depending on the following conditions.

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

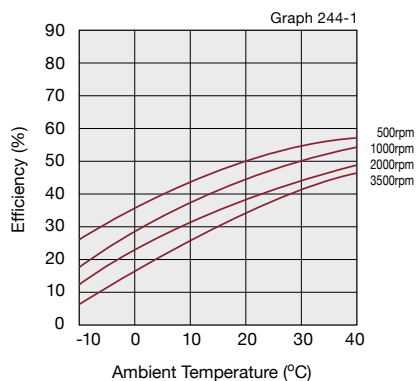
Measurement condition

Table 244-1

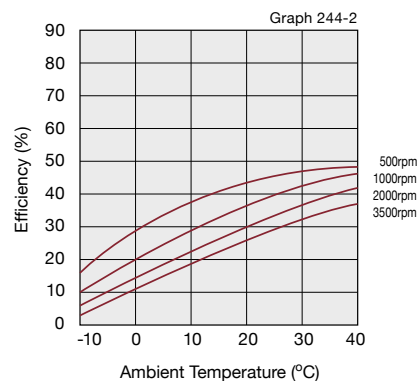
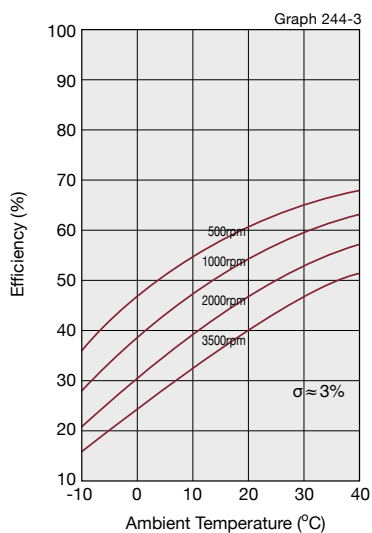
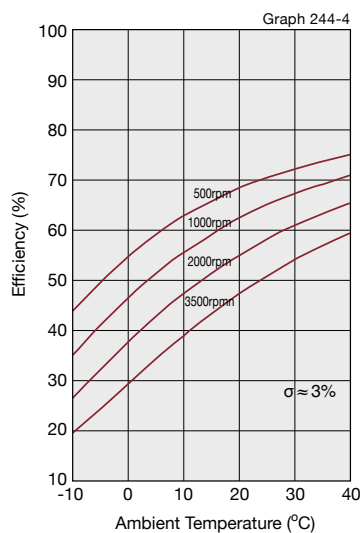
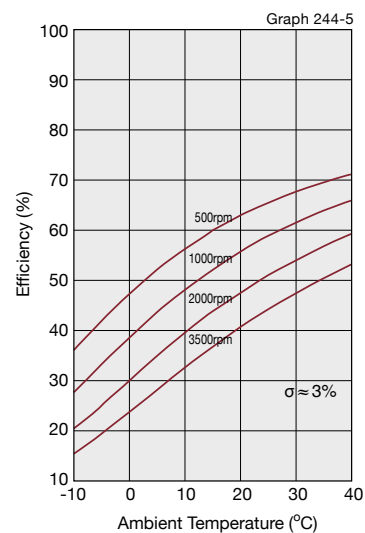
Installation	Based on recommended tolerance		
Load torque	The rated torque shown in the rating table (see page 230 and 231)		
Lubricant	Grease lubrication	Name	Harmonic Grease SK-1A
		Quantity	Harmonic Grease SK-2
			Recommended quantity

■ Efficiency at rated torque

SHF-11 Ratio 50



SHF-11 Ratio 100

SHG/SHF-14 to 65
Ratio 30SHG/SHF-14 to 65
Ratio 50, 80, 100, 120SHG/SHF-14 to 65
Ratio 160

*The values in this graph are average values ($\bar{X}$). $\sigma \approx 20\%$

Efficiency compensaiton coefficient and compensaiton amount

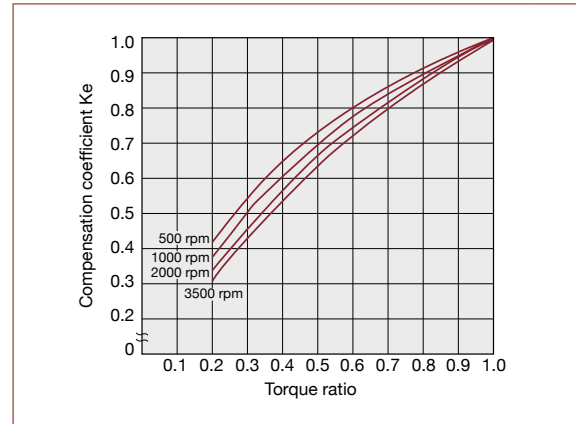
Efficiency compensation coefficient by load torque

When the load torque is lower than the rated torque, the efficiency value decreases. Calculate the compensation coefficient K_e from Graphs 245-1 and 245-2.

* When the load torque is higher than the rated torque, efficiency compensation value K_e is 1.

Efficiency compensation 2UH

Graph 245-1

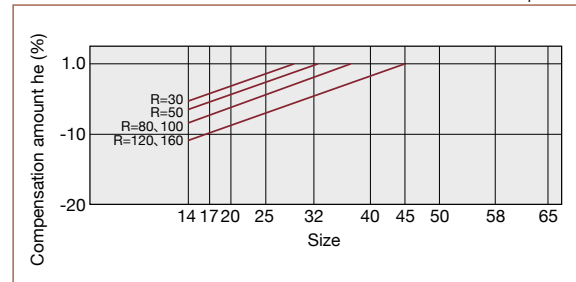


Efficiency compensation amount by size

The unit type is equipped with a supporting bearing and oil seal on the input side. The degree of impact varies depending on the size. Calculate the compensation amount for efficiency at the rated torque using the size from Graph 245-2.

Efficiency compensation 2UH

Graph 245-2



Efficiency compensation calculation formula

Calculate the efficiency by the "Efficiency compensation coefficient by load torque" and the "Efficiency compensation amount by the size" from the following formula.

Calculation formula

Formula 245-1

$$\text{Efficiency } \eta = K_e \times (\eta_R + \eta_e)$$

Symbols of the calculation formula

Table 245-1

η	Efficiency	-----
K_e	Efficiency compensation coefficient	See Graph 245-1.
η_R	Efficiency at the rated torque	See Graph 244-1 through 244-5.
η_e	Efficiency compensation amount	See Graph 245-2.

Continuous Operating Time (2UH)

The internal temperature rises due to the effect of the oil seal and the supporting bearing used for the input shaft (high-speed rotation side) for SHF-2UH. Observe the operating time shown in Table 246-2 for continuous operation.

The operating time shown in Table 246-2 is calculated based on the time required for the temperature inside the unit to rise to 80°C and for the oil seal temperature to rise to 100°C. Take care not to exceed the temperature given above in conducting continuous operation. The following review will be necessary if the temperature exceeds the value given above. Contact us in such an event.

- Change of timing to replace lubricant
- Change of lubricant
- Measures against lubricant leakage accompanied by the pressure rise inside the unit
- Measures against deterioration due to heat on the oil seal area

Setting condition

Table 246-1

Operating temp.	25°C (ambient)
Input rotational speed	2,000 rpm
Installation of the unit	Fix the flexspline. Output on the circular spline.

Continuous operating time

Table 246-2

Size	Operating time	Continuous operating time at no-load operation (min)	Continuous operating time at the rated load (min)
11		90	60
14		90	60
17		90	60
20		90	60
25		60	45
32		45	35
40		40	30
45		35	25
50		30	20
58		20	15
65		15	10

* Contact us as the continuous operating time may vary significantly depending on the operating condition.

Performance Data for the Input Bearing for Hollow Shaft (2UH)

The Hollow Shaft incorporated in the SHF-2UH unit is supported by two deep groove single row ball bearings. For peak performance of the SHF-2UH it is essential that the following specifications for input bearing be observed. The input part to fully bring out the performance of the unit type. Figure 247-1 shows the points of application of forces. See Table 247-1 for the size of (a) and (b). Graphs 247-1 and 247-2 show the relation between the maximum allowable radial and axial loads.

The values in Graph 247-1 and 247-2 are those assuming that the average input rotational speed is 2,000 rpm and the basic rated life, L10, is 7,000 hours.

Example: If the hollow shaft of a SHF-40-2UH unit is subjected to an axial load of 500 N. The maximum allowable radial force will be 400 N.

Input bearing specifications

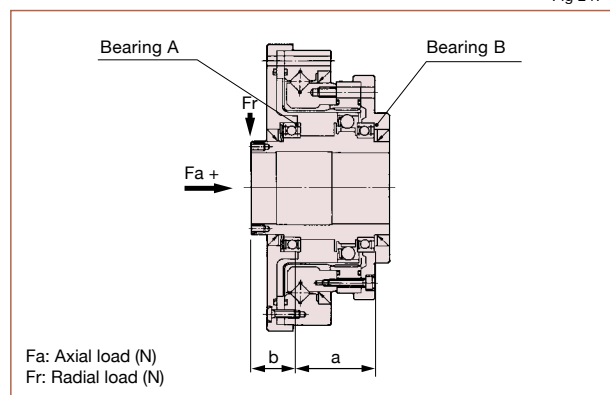
Table 247-1

Size	Bearing A			Bearing B			a (mm)	b (mm)	Maximum radial load Fr(N)
	Model	Basic dynamic rated load	Basic static rated load	Model	Basic dynamic rated load	Basic static rated load			
		Cr(N)	Cor(N)		Cr(N)	Cor(N)			
11	6804ZZ	4000	2470	6704ZZ	1400	720	25.7	15.5	—
14	6804ZZ	4000	2470	6804ZZ	4000	2470	27	16.5	230
17	6805ZZ	4300	2950	6805ZZ	4300	2950	29	17.5	250
20	6806ZZ	4500	3450	6806ZZ	4500	3450	27	15.5	275
25	6808ZZ	4900	4350	6808ZZ	4900	4350	29.5	16.5	250
32	6909ZZ	14100	10900	6809ZZ	5350	5250	33	23	770
40	6912ZZ	19400	16300	6812ZZ	11500	10900	39.5	27.5	1060
45	6913ZZ	17400	16100	6813ZZ	11900	12100	44	28.5	900
50	6915ZZ	24400	22600	6815ZZ	12500	13900	49	31.5	1370
58	6917ZZ	32000	29600	6817ZZ	18700	20000	56.2	36.5	1720
65	6920ZZ	42500	36500	6820ZZ	19600	21200	67	44.5	2300

Fig 247-1

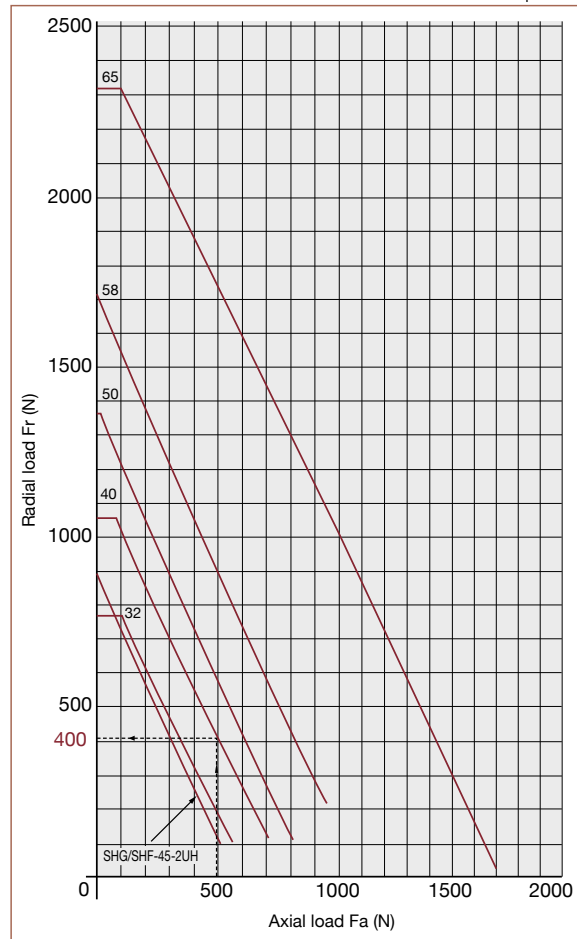
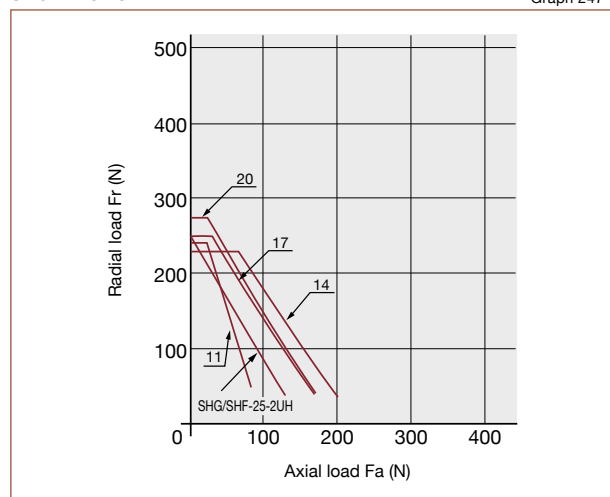
Size 32 to 65

Graph 247-2



Size 11 to 25

Graph 247-1

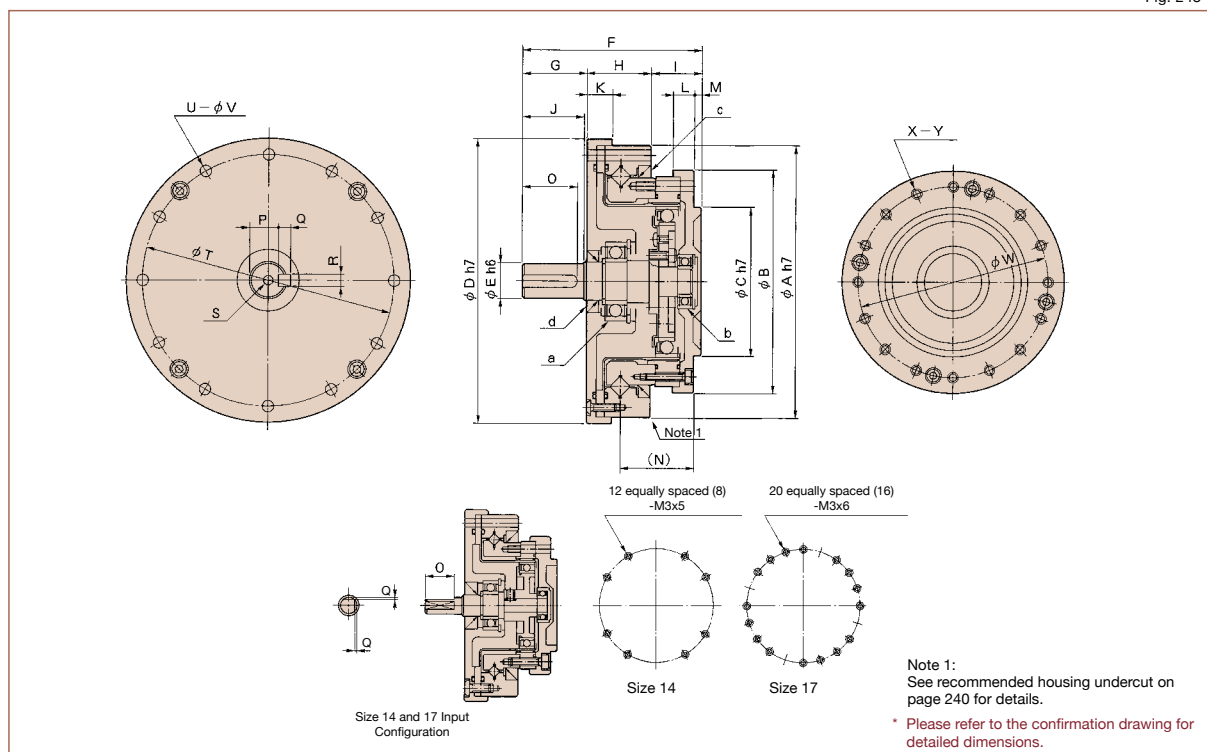


Outline Dimensions (2UJ)

Outline Dimensions (2UJ)

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

Fig. 248-1



Dimensions (2UJ)

Table 248-1
Unit: mm

Symbol	Size	14	17	20	25	32	40	45	50	58	65
$\phi A h7$		70	80	90	110	142	170	190	214	240	276
ϕB		54	64	75	90	115	140	160	175	201	221
$\phi C h7$		36	45	50	60	85	100	120	130	150	160
$\phi D h7$		74	84	95	115	147	175	195	220	246	284
$\phi E h6$		6	8	10	14	14	16	19	22	22	25
F		50.5	56	63.5	72.5	84.5	100	108	121	133	156
G		15	17	21	26	26	31	31	37	37	42
H		20.5	23	25	26	32	38	42	45	52	56.5
I		15	16	17.5	20.5	26.5	31	35	39	44	57.5
J		14	16	20	25	25	30	30	35	35	40
K		9	10	10.5	10.5	12	14	15	16	17	18
L		8	8.5	9	8.5	9.5	13	12	12	15	19.5
M		2.5	3	3	3	5	5	7	7	7	12
N		21.7	23.9	25.5	29.6	36.4	44	47.5	52.5	62.2	72
O		11	12	16.5	22.5	22.5	27.5	28	33	33	39
P		—	—	8.2 $\frac{0.1}{1}$	11 $\frac{0.1}{1}$	11 $\frac{0.1}{1}$	13 $\frac{0.1}{1}$	15.5 $\frac{0.1}{1}$	18.5 $\frac{0.1}{1}$	18.5 $\frac{0.1}{1}$	21 $\frac{0.1}{1}$
Q		0.5	0.5	3 $\frac{0.025}{1}$	5 $\frac{0.030}{1}$	5 $\frac{0.030}{1}$	5 $\frac{0.030}{1}$	6 $\frac{0.030}{1}$	6 $\frac{0.030}{1}$	6 $\frac{0.030}{1}$	7 $\frac{0.036}{1}$
R		—	—	3 $\frac{0.025}{1}$	5 $\frac{0.030}{1}$	5 $\frac{0.030}{1}$	5 $\frac{0.030}{1}$	6 $\frac{0.030}{1}$	6 $\frac{0.030}{1}$	6 $\frac{0.030}{1}$	8 $\frac{0.036}{1}$
S		—	—	M3x6	M5x10	M5x10	M5x10	M6x12	M6x12	M6x12	M8x16
ϕT		64	74	84	102	132	158	180	200	226	258
U		8	12	12	12	12	12	18	12	16	16
ϕV		3.5	3.5	3.5	4.5	5.5	6.6	6.6	9	9	11
ϕW		44	54	62	77	100	122	140	154	178	195
X		12 E. A. 8	20 E. A. 16	16	16	16	16	12	16	12	16
Y		M3x5	M3x6	M3x6	M4x7	M5x8	M6x10	M8x10	M8x11	M10x15	M10x15
a		$\phi 3.5 \times 11.5$	$\phi 3.5 \times 12$	$\phi 3.5 \times 13.5$	$\phi 4.5 \times 15.5$	$\phi 5.5 \times 20.5$	$\phi 6.6 \times 25$	$\phi 9 \times 28$	$\phi 9 \times 30$	$\phi 11 \times 35$	$\phi 11 \times 42.5$
b		698 ZZ	6900 ZZ	6902 ZZ	6002 ZZ	6004 ZZ	6006 ZZ	6206 ZZ	6207 ZZ	6208 ZZ	6209 ZZ
c		695 ZZ	697 ZZ	698 ZZ	6900 ZZ	6902 ZZ	6003 ZZ	6004 ZZ	6005 ZZ	6006 ZZ	6007 ZZ
d		D49585	D59685	D69785	D84945	D1101226	D1321467	D1521707	D1681868	D1932129	D21623811
		G8184	D10205	D15255	D15255	D20355	D30457	D30457	D35557	D40607	D45607

Mass (2UJ)Table 249-1
Unit: kg

Symbol	Size	14	17	20	25	32	40	45	50	58	65
Mass (kg)		0.66	0.94	1.38	2.1	4.4	7.3	9.8	13.9	19.4	26.5

Moment of Inertia (2UJ)

Table 249-2

Symbol	Size	14	17	20	25	32	40	45	50	58	65
Moment of inertia	I $\times 10^{-4} \text{kgm}^2$	0.025	0.059	0.137	0.320	1.20	3.41	5.80	9.95	20.5	35.5
	J $\times 10^{-4} \text{kgfms}^2$	0.026	0.060	0.140	0.327	1.22	3.48	5.92	10.2	20.9	36.2

Starting torque (2UJ)

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

Table 249-3
Unit: Ncm

Ratio	Size	14	17	20	25	32	40	45	50	58	65
30		6.8	11	19	26	63	—	—	—	—	—
50		5.7	9.7	14	22	41	72	94	125	178	—
80		4.4	7.2	11	15	29	52	68	88	125	163
100		3.7	6.5	9.9	14	27	47	60	80	113	147
120		—	6.2	9.3	13	24	44	55	74	105	137
160		—	—	8.6	12	23	39	50	66	94	122

Backdriving torque (2UJ)

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

Table 249-4
Unit: Nm

Ratio	Size	14	17	20	25	32	40	45	50	58	65
30		3.5	5.9	10	16	31	—	—	—	—	—
50		3.4	5.8	8.4	13	25	43	56	75	107	—
80		4.2	6.9	10	15	28	50	65	85	120	154
100		4.5	7.8	12	17	33	56	72	96	135	176
120		—	8.9	13	19	34	63	79	106	151	198
160		—	—	17	23	43	75	96	126	181	235

No-load running torque

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

Measurement condition

Table 250-1

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

■ Compensation Value in Each Ratio

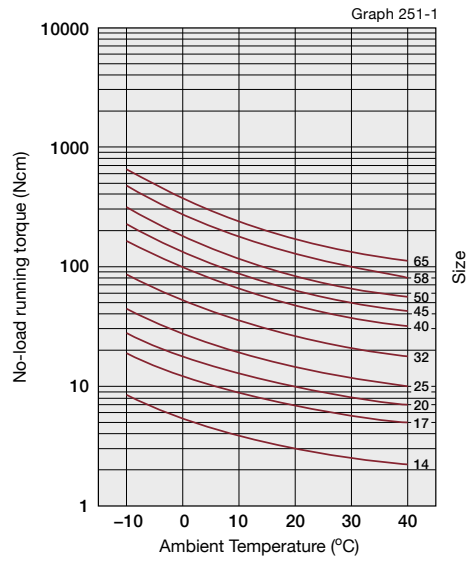
No-load running torque of the gear varies with ratio. Graphs 251-1 to 251-4 show the values for a reduction ratio of 100. For other gear ratios, add the compensation values in the right-hand table (Table 250-2).

No-Load Torque Running Torque Compensation ValueTable 250-2
Unit: Ncm

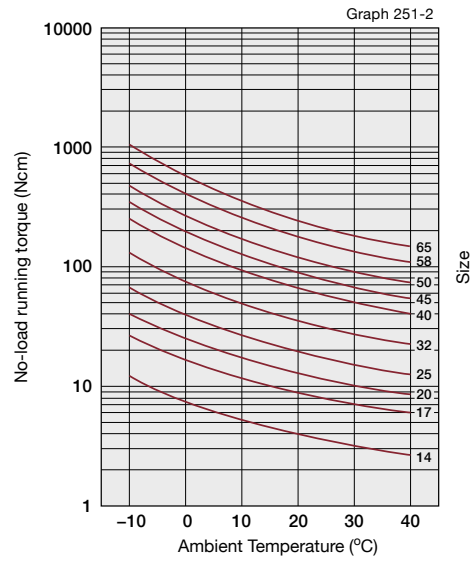
Size \ Ratio	30	50	80	120	160
14	+2.6	+1.1	+0.2	—	—
17	+4.1	+1.8	+0.4	-0.2	—
20	+5.9	+2.6	+0.5	-0.4	-0.8
25	+9.6	+4.2	+0.8	-0.6	-1.3
32	+18.3	+8.0	+1.5	-1.1	-2.5
40	—	+13.3	+2.4	-1.7	-4.0
45	—	+18.2	+3.3	-2.4	-5.5
50	—	+23.9	+4.3	-3.1	-7.2
58	—	+34.6	+6.2	-4.4	-10.3
65	—	—	+8.1	-5.8	-13.7

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

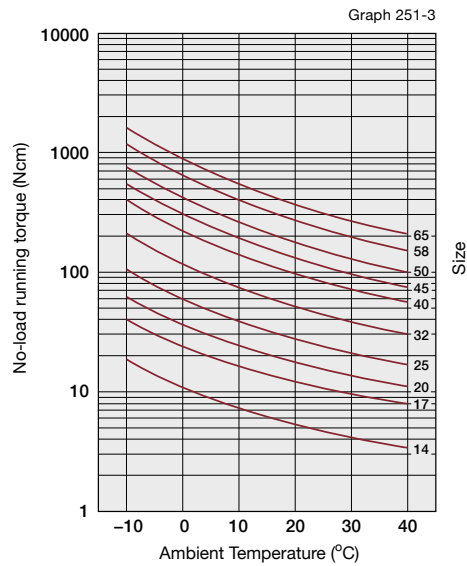
Input speed: 500rpm



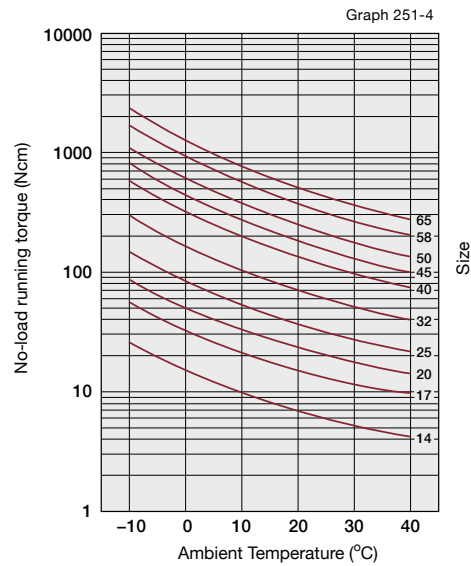
Input speed: 1000rpm



Input speed: 2000rpm



Input speed: 3500rpm



*The values in this graph are average values (X). $\sigma \approx 20\%$

Efficiency

The efficiency varies depending on the following conditions.

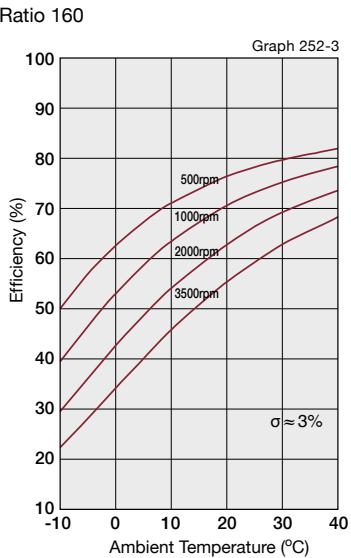
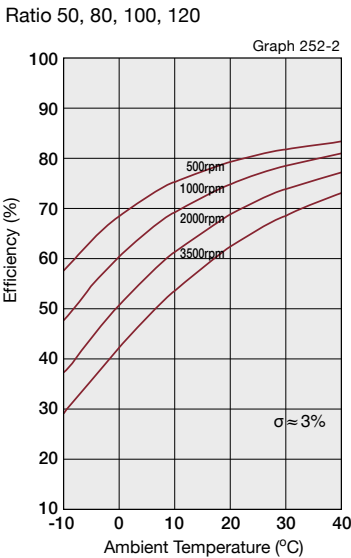
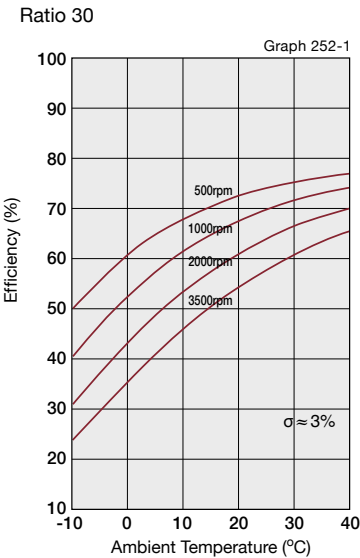
- Reduction ratio
- Input rotational speed
- Load torque
- Temperature
- Lubrication (Type and quantity)

Measurement condition

Table 252-1

Installation	Based on recommended tolerance		
Load torque	The rated torque shown in the rating table (see page 230 and 231)		
Lubricant	Grease lubrication	Name	Harmonic Grease SK-1A
		Quantity	Recommended quantity

Efficiency at rated torque



Efficiency compensation coefficient and efficiency compensation amount

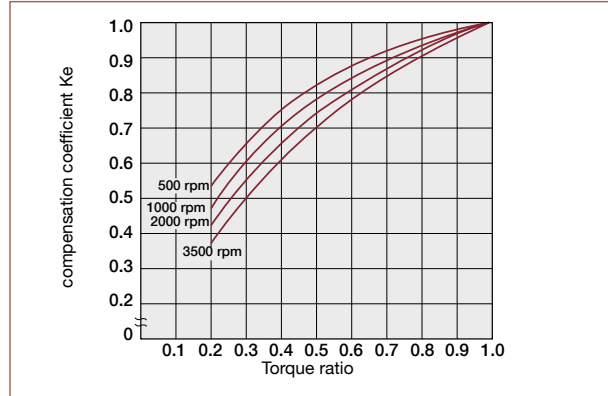
Efficiency compensation coefficient by load torque

When the load torque is lower than the rated torque, the efficiency value decreases. Calculate compensation coefficient K_e from Graph 253-1.

* When the load torque is higher than the rated torque, efficiency compensation value K_e is 1.

Efficiency compensation coefficient of 2UJ (input shaft)

Graph 253-1

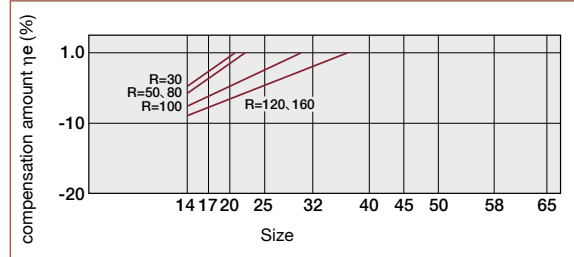


Efficiency compensation amount by the size

The unit type is equipped with a supporting bearing and oil seal on the input side. The degree of impact varies depending on the size. Calculate the compensation amount " η_e " for efficiency at the rated torque using the size from Graph 253-2.

Efficiency compensation of 2UJ (input shaft)

Graph 253-2



Efficiency compensation calculation formula

Calculate the efficiency by the "Efficiency compensation coefficient by load torque" and the "Efficiency compensation amount by the size" from the following formula.

Calculation formula

Formula 253-1

$$\text{Efficiency } \eta = K_e \times (\eta_R + \eta_e)$$

Symbols for the calculation formula

Table 253-1

η	Efficiency	-----
K_e	Efficiency compensation coefficient	See Graph 253-1.
η_R	Efficiency at the rated torque	See Graph 252-1 through 252-3.
η_e	Efficiency compensation amount	See Graph 253-2.

Performance Data for the Input bearing (2UJ)

The input shaft of the 2UJ is supported by two single-row deep-groove bearings. For peak performance of the SHF-2UJ it is essential that the following Specification for Input Bearing be observed -

Figure 254-1 shows the points of application of forces. See Table 254-1 for the dimensions (a) and (b). Graphs 254-1 and 254-2 show the Maximum Allowable Radial and Axial Loads.

The values in Graph 254-1 and 254-2 are based on an average input speed of 2,000 rpm and a mean bearing life of $L_{10}=7,000h$.

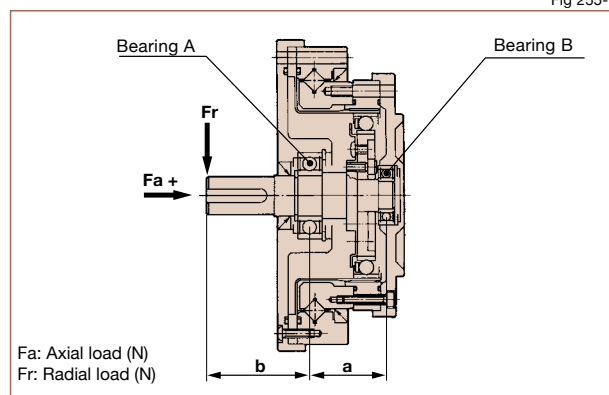
Example: If the input shaft of a SHF-40-2UJ unit is subjected to an axial load (F_a) of 500 N. The maximum allowable radial force will be 400 N.

Input bearing specifications

Table 254-1

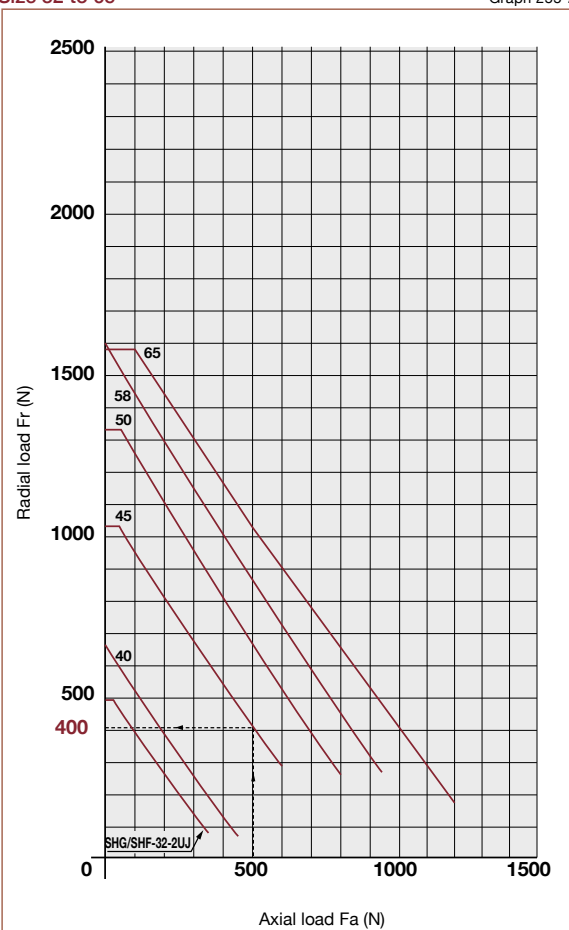
Size	Bearing A			Bearing B			a (mm)	b (mm)	Maximum radial load Fr (N)
	Model	Basic dynamic rated load	Basic static rated load	Model	Basic dynamic rated load	Basic static rated load			
		Cr (N)	Cor (N)		Cr (N)	Cor (N)			
14	698ZZ	2240	910	695ZZ	1080	430	20	14	110
17	6900ZZ	2700	1270	697ZZ	1610	710	23.5	21	135
20	6902ZZ	4350	2260	698ZZ	2240	910	26.5	23.3	210
25	6002ZZ	5600	2830	6900ZZ	2700	1270	28	28	270
32	6004ZZ	9400	5000	6902ZZ	4350	2260	36	27	490
40	6006ZZ	13200	8300	6003ZZ	6000	3250	43	32.5	660
45	6206ZZ	19500	11300	6004ZZ	9400	5000	47.5	34.5	1030
50	6207ZZ	25700	15300	6005ZZ	10100	5850	53	39	1330
58	6208ZZ	29100	17800	6006ZZ	13200	8300	62.5	40	1600
65	6209ZZ	32500	20500	6007ZZ	16000	10300	79	63	1650

Fig 255-1



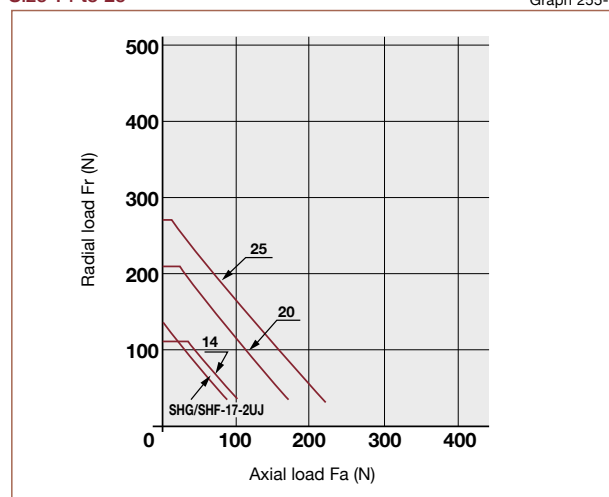
Size 32 to 65

Graph 255-2



Size 14 to 25

Graph 255-1

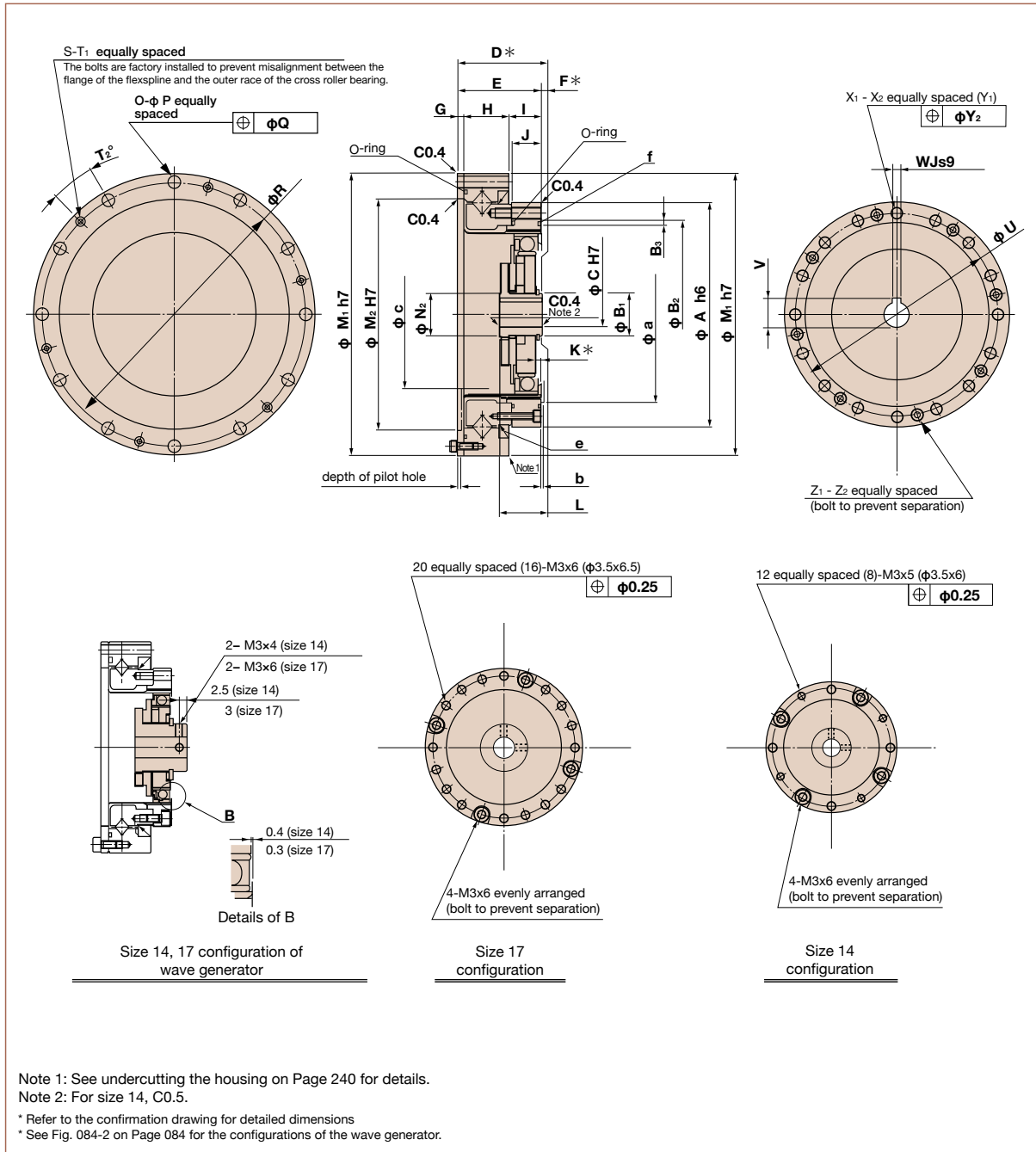


Outline Dimensions

Outline Dimensions (2SO)

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

Fig. 255-1



Dimensions (2SO)

Table 256-1
Unit : mm

Symbol	SIZE	14	17	20	25	32	40	45	50	58	65
ϕA h6		50	60	70	85	110	135	155	170	195	215
ϕB_1		14	18	21	26	26	32	32	32	40	48
ϕB_2		—	—	—	—	—	—	128	141	163	180.4
ϕB_3		—	—	—	—	—	—	2.7	2.7	2.7	2.7
ϕC	Standard (H7)	6	8	9	11	14	14	19	19	22	24
	Max. dimen.	8	10	13	15	15	20	20	20	25	30
D*	SHF Series	28.5 ⁰ _{-0.8}	32.5 ⁰ _{-0.9}	33.5 ⁰ _{-1.0}	37 ⁰ _{-1.1}	44 ⁰ _{-1.1}	53 ⁰ _{-1.1}	58 ⁰ _{-1.2}	64 ⁰ _{-1.3}	75.5 ⁰ _{-1.3}	—
	SHG Series	28.5 ⁰ _{-0.4}	32.5 ⁰ _{-0.4}	33.5 ⁰ _{-0.4}	37 ⁰ _{-0.5}	44 ⁰ _{-0.6}	53 ⁰ _{-0.6}	58 ⁰ _{-0.6}	64 ⁰ _{-0.7}	75.5 ⁰ _{-0.7}	83 ⁰ _{-0.7}
E		23.5	26.5	29	34	42	51	56.5	63	73	81.5
F*		5	6	4.5	3	2	2	1.5	1	2.5	1.5
G		2.4	3	3	3.3	3.6	4	4.5	5	5.8	6.5
H		14.1	16	17.5	18.7	23.4	29	32	34	40.2	43
I		7	7.5	8.5	12	15	18	20	24	27	32
J		6	6.5	7.5	10	14	17	19	22	25	29
K*	SHF Series	0.4	0.3	0.1	2.1	2.5	3.3	3.7	4.2	4.8	—
	SHG Series	1.4	1.6	1.5	3.5	4.2	5.6	6.3	7	8.2	9.5
L	SHF Series	17.6 ⁰ _{-0.1}	19.5 ⁰ _{-0.1}	20.1 ⁰ _{-0.1}	20.2 ⁰ _{-0.1}	22 ⁰ _{-0.1}	27.5 ⁰ _{-0.1}	27.9 ⁰ _{-0.1}	32 ⁰ _{-0.1}	34.9 ⁰ _{-0.1}	—
	SHG Series	18.5 ⁰ _{-0.1}	20.7 ⁰ _{-0.1}	21.5 ⁰ _{-0.1}	21.6 ⁰ _{-0.1}	23.6 ⁰ _{-0.1}	29.7 ⁰ _{-0.1}	30.5 ⁰ _{-0.1}	34.8 ⁰ _{-0.1}	38.3 ⁰ _{-0.1}	44.6 ⁰ _{-0.1}
ϕM_1 h7		70	80	90	110	142	170	190	214	240	276
ϕM_2 H7		48	60	70	88	114	140	158	175	203	232
ϕN_2		—	—	—	—	—	32	—	32	—	48
O		8	12	12	12	12	12	18	12	16	16
ϕP		3.5	3.5	3.5	4.5	5.5	6.6	6.6	9	9	11
ϕQ		0.25	0.25	0.25	0.25	0.25	0.3	0.3	0.5	0.5	0.5
ϕR		64	74	84	102	132	158	180	200	226	258
S		2	4	4	4	4	6	6	6	8	8
T ₁		M3×6	M3×6	M3×8	M3×8	M4×8	M4×10	M4×8	M5×12	M5×12	M6×16
T ₂ (angle)		22.5°	15°	15°	15°	15°	15°	10°	15°	11.25°	11.25°
ϕU		44	54	62	77	100	122	140	154	178	195
V		—	—	10.4	12.8	16.3	16.3	21.8	21.8	24.8	27.3
W Js9		—	—	3	4	5	5	6	6	6	8
X ₁	12 E. A. 8	12 E. A. 16	16	16	16	16	16	12	16	12	16
X ₂	M3×5	M3×6	M3×6	M4×7	M5×8	M6×10	M8×10	M8×11	M10×15	M10×15	M10×15
Y ₁	$\phi 3.5 \times 6$	$\phi 3.5 \times 6.5$	$\phi 3.5 \times 7.5$	$\phi 4.5 \times 10$	$\phi 5.5 \times 14$	$\phi 6.6 \times 17$	$\phi 9 \times 19$	$\phi 9 \times 22$	$\phi 11 \times 25$	$\phi 11 \times 29$	
Y ₂	0.25	0.25	0.25	0.25	0.25	0.3	0.5	0.5	0.5	0.5	0.5
Z ₁	4	4	4	4	4	4	4	8	8	6	8
Z ₂	M3×6	M3×6	M3×8	M3×10	M4×16	M5×20	M5×20	M5×25	M6×25	M6×30	
Minimum housing clearance	ϕa	38	45	53	66	86	106	119	133	154	172
	b	1	1	1.5	1.5	1.5	2	2	2	2.5	2.5
	ϕc	31	38	45	56	73	90	101	113	131	150
d		1.7	2.1	2	2	2	2	2.3	2.5	2.9	3.5
e		D49585	D59685	D69785	D84945	D1101226	D1321467	D1521707	D1681868	D1932129	D21623811
f		—	—	—	—	—	—	d1 121.5 d2 2.0	S135	d1 157.0 d2 2.0	S175

- The following dimensions can be modified to accommodate customer-specific requirements.

Wave Generator : C
 Flexspline : O and P
 Circular Spline : X₁ and X₂

- *The D, F and K values indicate relative position of individual gearing components (wave generator, flexpline, circular spline). Please strictly adhere to these values when designing your housing and mating parts.
- Please note that the circular spline face of sizes 14 through 40 does not incorporate an O-ring groove. Please provide alternate sealing arrangements.
- Due to the deformation of the Flexspline during operation, it is necessary to provide a minimum housing clearance, dimensions ϕa , b, c.

Wave generator is removed when the product is delivered.

Mass (2SO)

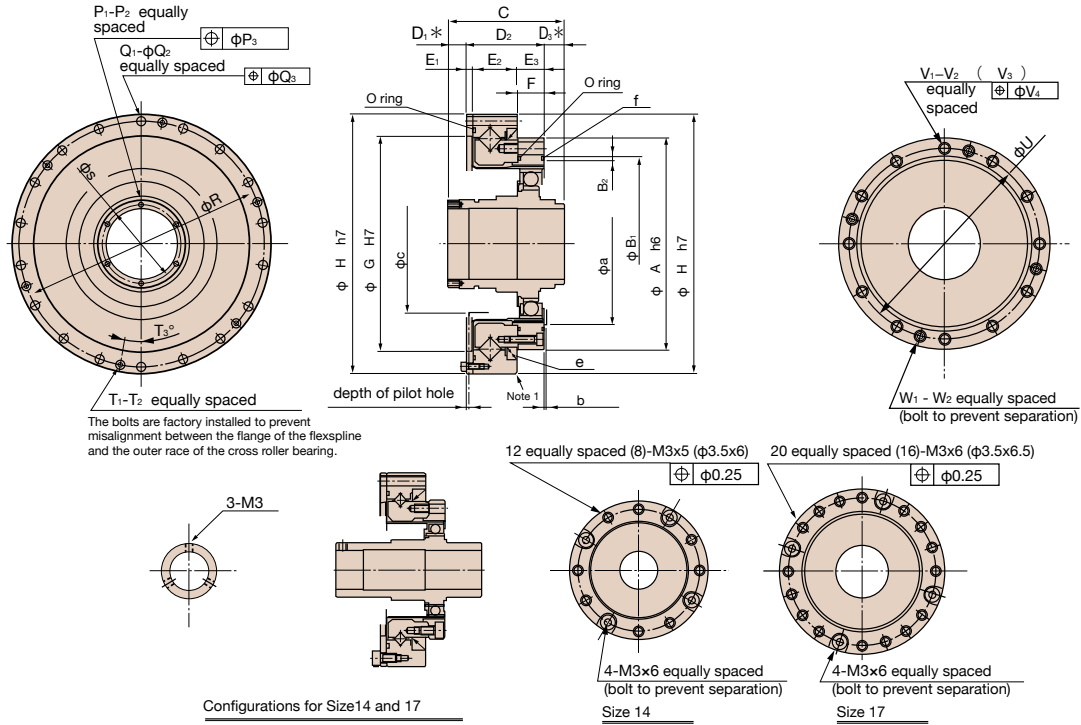
Table 256-2
Unit: kg

Symbol	Size	14	17	20	25	32	40	45	50	58	65
Mass (kg)		0.41	0.57	0.81	1.31	2.94	5.1	6.5	9.6	13.5	19.5

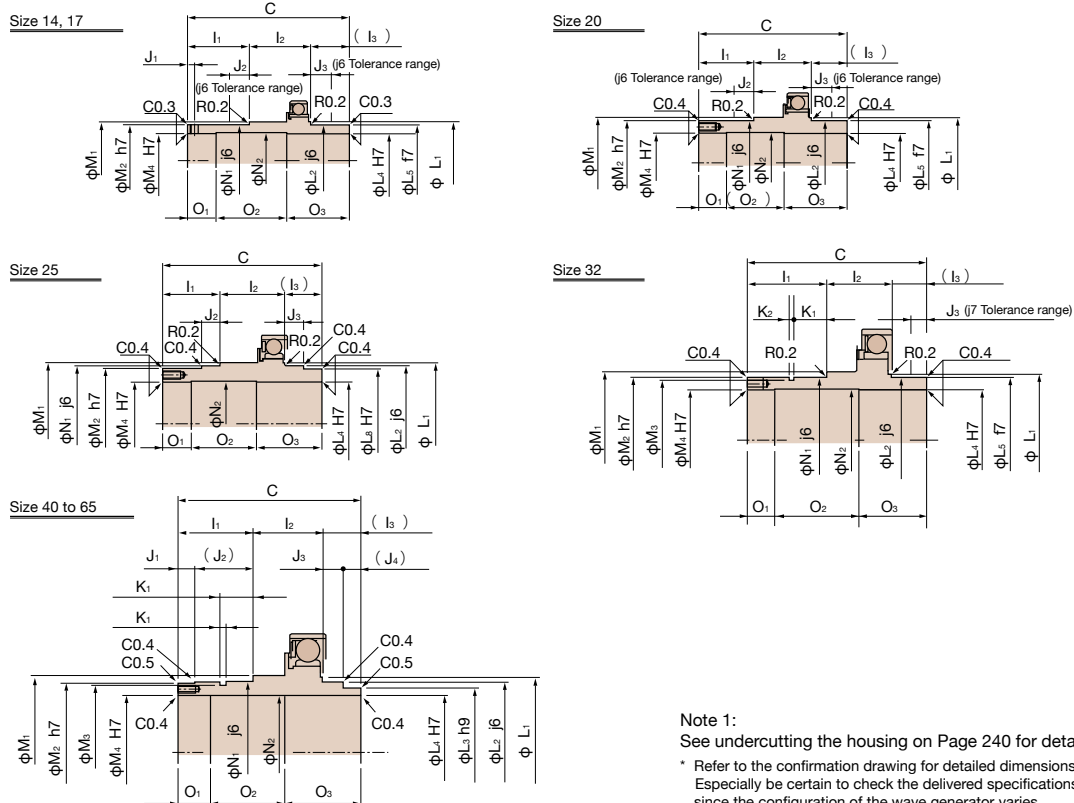
Outline Dimensions (2SH)

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

Fig. 257-1



Configurations Of Wave Generator All Sizes



Note 1:
See undercutting the housing on Page 240 for details.
* Refer to the confirmation drawing for detailed dimensions. Especially be certain to check the delivered specifications since the configuration of the wave generator varies depends on the size. (* Also see Fig. 084-2 on Page 084.)

Dimensions (2SH)

Table 258-1
Unit : mm

Symbol	Size	14	17	20	25	32	40	45	50	58	65
ϕA h6		50	60	70	85	110	135	155	170	195	215
ϕB_1		—	—	—	—	—	—	128	141	163	180.4
B_2		—	—	—	—	—	—	2.7	2.7	2.7	2.7
C		52.5 ^{+0.8} _{-0.1}	56.5 ^{+0.9} _{-0.1}	51.5 ^{+1.0} _{-0.1}	55.5 ^{+1.1} _{-0.1}	65.5 ^{+1.1} _{-0.1}	79 ^{+1.1} _{-0.1}	85 ^{+1.2} _{-0.1}	93 ^{+1.3} _{-0.1}	106 ^{+1.3} _{-0.1}	128 ^{+1.3} _{-0.1}
D_1 *	SHF	16 ^{+0.4} ₀	16 ^{+0.4} ₀	9.5 ^{+0.4} ₀	10 ^{+0.5} ₀	12 ^{+0.6} ₀	13 ^{+0.6} ₀	13.5 ^{+0.6} ₀	15 ^{+0.7} ₀	16 ^{+0.7} ₀	21 ^{+0.7} ₀
	SHG	16 ^{+0.4} ₀	16 ^{+0.4} ₀	9.5 ^{+0.4} ₀	10 ^{+0.5} ₀	12 ^{+0.6} ₀	13 ^{+0.6} ₀	13.5 ^{+0.6} ₀	15 ^{+0.7} ₀	16 ^{+0.7} ₀	21 ^{+0.7} ₀
D_2		23.5	26.5	29	34	42	51	56.5	63	73	81.5
D_3 *		13	14	13	11.5	11.5	15	15	15	17	25.5
E_1		2.4	3	3	3.3	3.6	4	4.5	5	5.8	6.5
E_2		14.1	16	17.5	18.7	23.4	29	32	34	40.2	43
E_3		7	7.5	8.5	12	15	18	20	24	27	32
F		6	6.5	7.5	10	14	17	19	22	25	29
ϕG H7		48	60	70	88	114	140	158	175	203	232
ϕH h7		70	80	90	110	142	170	190	214	240	276
Wave generator dimensions	I_1	20 ^{+0.1}	21.5 ^{+0.1}	19 ^{+0.1}	20 ^{+0.1}	29 ^{+0.1}	34 ^{+0.1}	35 ^{+0.1}	39.5 ^{+0.1}	45.3 ^{+0.1}	54.5 ^{+0.1}
	I_2	20 ^{+0.1}	21.5 ^{+0.1}	20 ^{+0.1}	22.5 ^{+0.1}	23.5 ^{+0.1}	28 ^{+0.1}	32.5 ^{+0.1}	36 ^{+0.1}	40.7 ^{+0.1}	—
	I_3	(12.5)	(13.5)	(12.5)	(13)	(13)	(17)	(17.5)	(17.5)	(20)	—
	J_1	2.5	2.5	—	—	—	—	8	9	10	14
	J_2	7	7	7	6.5	—	—	(27)	(30.5)	(35.3)	(40.5)
	J_3	7	7	7	6.5	—	9.5	9.5	9.5	12.5	11.5
	J_4	—	—	—	—	—	(7.5)	(8)	(8)	(7.5)	(11.5)
	K_1	—	—	—	—	13.9	15.1	15.6	18.6	21.1	23.1
	K_2	—	—	—	—	1.9	2.2	2.7	2.7	3.2	3.1
	ϕL_1	22	27	32	42	47	62	69	79	90	106
	ϕL_2 j6	20	25	30	40	45	60	65	75	85	100
	ϕL_3 h9	—	—	—	38	—	59	59	69	84	96
	ϕL_4 H7	14	19	21	29	36	46	52	60	70	80
	ϕL_5 f7	20	25	30	—	45	—	—	—	—	—
	ϕM_1	22	27	32	42	49	65	70	80	91.5	111
	ϕM_2 h7	20	25	30	38	45	59	64	74	84	96
	ϕM_3	—	—	—	—	42.5	57	62	72	81.5	96.5
	ϕM_4 H7	14	19	21	29	36	46	52	60	70	80
	ϕN_1 j6	20	25	30	40	45	60	65	75	85	100
	ϕN_2	14.5	19.5	21.5	29.5	36.5	46.5	52.5	60.5	70.5	80.5
	O_1	10	10	10	10	10	12	15	15	15	20
	O_2	22.5	24.5	(19.5)	22.5	(30.5)	(35)	35	41	48	54
	O_3	20	22	22	23	25	32	35	37	43	54
P_1		3	3	6	6	6	6	6	6	8	6
P_2		M3	M3	M3×6	M3×6	M3×6	M4×8	M4×8	M4×8	M4×8	M5×10
ϕP_3		—	—	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Q_1		8	12	12	12	12	12	18	12	16	16
ϕQ_2		3.5	3.5	3.5	4.5	5.5	6.6	6.6	9	9	11
ϕQ_3		0.25	0.25	0.25	0.25	0.25	0.3	0.3	0.5	0.5	0.5
ϕR		64	74	84	102	132	158	180	200	226	258
ϕS		—	—	25.5	33.5	40.5	52	58	67	77	88
T_1		2	4	4	4	4	6	6	6	8	8
T_2		M3×6	M3×6	M3×8	M3×8	M4×8	M4×10	M4×10	M5×12	M5×12	M6×16
T_3 (angle)		22.5°	15°	15°	15°	15°	15°	10°	15°	11.25°	11.25°
ϕU		44	54	62	77	100	122	140	154	178	195
V_1		12 E.A. 8	20 E.A. 16	16	16	16	16	12	16	12	16
V_2		M3×5	M3×6	M3×6	M4×7	M5×8	M6×10	M8×10	M8×11	M10×15	M10×15
V_3		$\phi 3.5 \times 6$	$\phi 3.5 \times 6.5$	$\phi 3.5 \times 7.5$	$\phi 4.5 \times 10$	$\phi 5.5 \times 14$	$\phi 6.6 \times 17$	$\phi 9 \times 19$	$\phi 9 \times 22$	$\phi 11 \times 25$	$\phi 11 \times 29$
V_4		0.25	0.25	0.25	0.25	0.25	0.3	0.5	0.5	0.5	0.5
W_1		4	4	4	4	4	4	4	8	6	8
W_2		M3×6	M3×6	M3×8	M3×10	M4×16	M5×20	M5×20	M5×25	M6×25	M6×30
Minimum housing clearance	ϕa	38	45	53	66	86	106	119	133	154	172
	b	1	1	1.5	1.5	1.5	2	2	2	2.5	2.5
	ϕc	31	38	45	56	73	90	101	113	131	150
d		1.7	2.1	2	2	2	2	2.3	2.5	2.9	3.5
e		D49585	D59685	D69785	D84945	D1101226	D1321467	D1521707	D1681868	D1932129	D21623811
f		—	—	—	—	—	—	d1 121.5 d2 2.0	S135	d1 157.0 d2 2.0	S175

- As the flexspline is subject to elastic deformation, the housing clearance should be ϕa , b, c or more and it should not exceed.
- *The D_1 and D_3 sizes indicated by an asterisk are the mounting positions in the shaft direction and allowance of the three parts (wave generator, flexspline, circular spline). Strictly observe these tolerances.

- The circular spline of sizes 14 to 40 does not have an O-ring groove (symbol: f) for sealing. Account for sealing during design and installation.

Wave generator is removed when the product is delivered.

Mass (2SH)

Table 259-1
Unit: kg

Symbol	Size	14	17	20	25	32	40	45	50	58	65
Mass		0.45	0.63	0.89	1.44	3.1	5.4	6.9	10.2	14.1	20.9

Lubrication

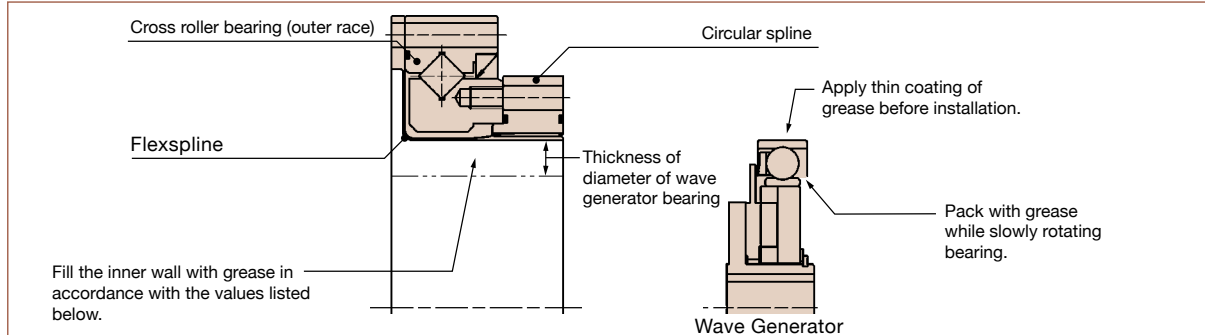
Standard lubrication for SHG/SHF series is grease.
See "Engineering data" on Page 016 for details of the lubricant.

Application guide

As the gear unit is shipped with the outer race of the cross roller bearing and the flexspline temporarily bolted together, grease is not applied other than the gear teeth. Refer to the following application guide for grease application instructions

Application guide

Table 259-1



Application quantity

Table 259-2
Unit: g

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

When to replace grease

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

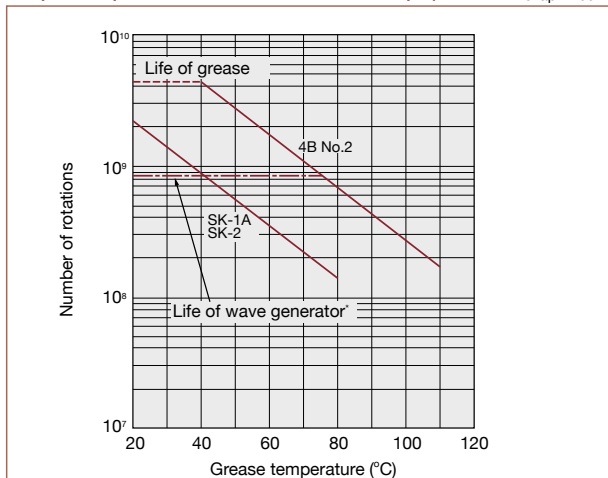
Formula when average load torque exceeds rated torque

Formula 259-1

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

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

Graph 259-2



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

Calculation formula

Table 259-3

L_{GT}	Replacement timing if average load torque exceeds rated torque	Number of input revolutions	-----
L_{GTn}	Replacement timing if average load torque is equal to or less than rated torque (or use formulas, i.e. $T_{av} \leq T_r$)	Number of input revolutions	See Fig. 259-2.
T_r	Rated torque	Nm	See the "Rating table" on page 230 and 231.
T_{av}	Average load torque	Nm	Calculation formula: See Page 14.

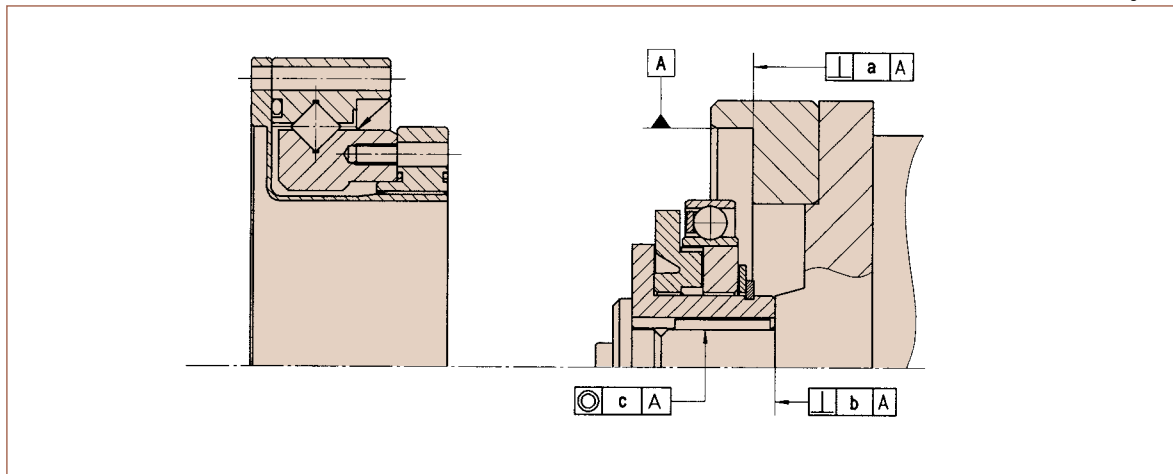
Other precautions

1. Avoid using it with other grease. The gear should be in an individual case when installed.
2. If you use the gear with the wave generator facing upward (see Figure 050-2 on Page 50) at low-speed rotation (input rotational speed: 1000 rpm or less) and in one direction, please contact us as it may cause lubrication problems.
3. Fill the gap between the wave generator and the input cover (motor flange) with grease to use the wave generator facing upward or downward (see Figure 094-2 on Page 094).

Installation accuracy

Maintain the recommended tolerances shown in Figure 260-1 and Table 260-1 for peak performance.

Fig. 260-1

Table 260-1
Unit: mm

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

* The value in the parentheses indicates that Wave Generator does not have an Oldham coupling.

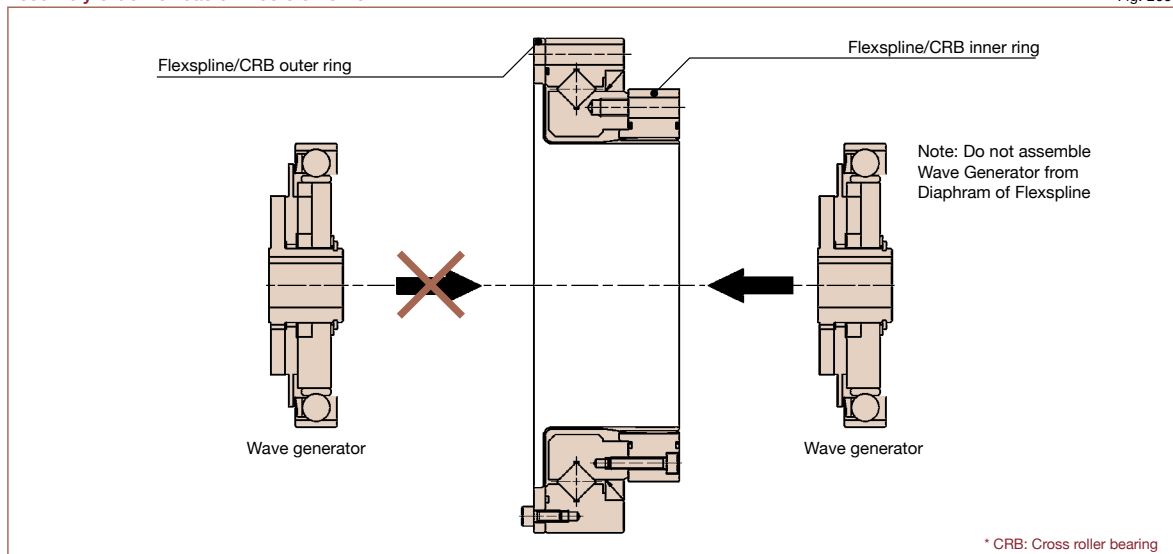
Installation Recommendations

■ Installation sequence

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

Assembly order for basic three elements

Fig. 260-2



■ Precautions on assembly

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

Wave generator

1. Avoid applying undue axial force to the wave generator during installation. Rotating the wave generator bearing while inserting it is recommended and will ease the process.
2. Extra care must be given to ensure that concentricity and inclination are within the specified limits (see page 253).
3. Installation bolts on the Wave Generator and Flexspline should not interfere each other.

Circular spline

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

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

Flexspline

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

Rust prevention

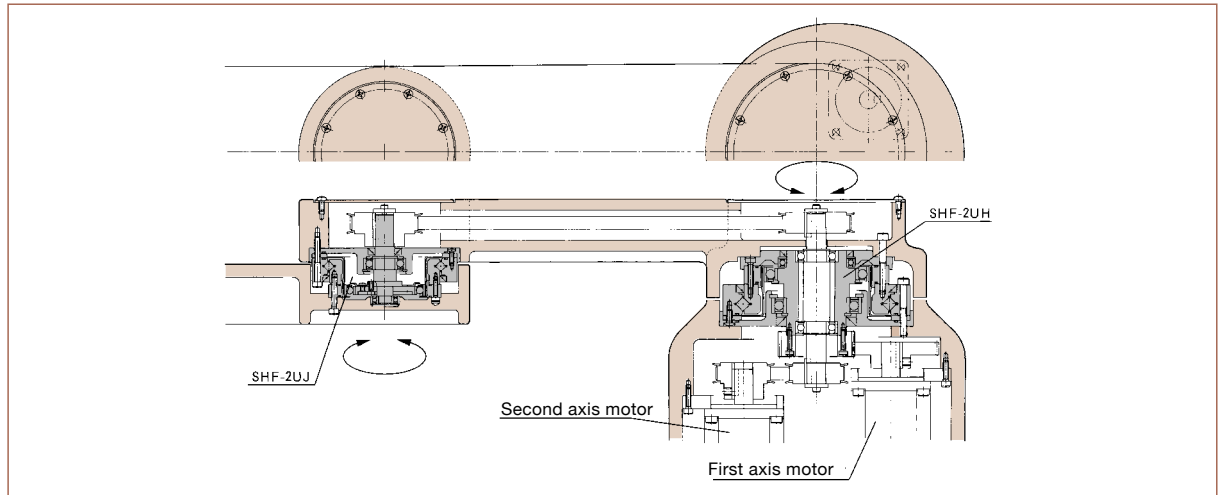
Although Harmonic Drive® gears come with some corrosion protection, the gear can rust if exposed to the environment. The gear external surfaces typically have only a temporary corrosion inhibitor and some oil applied. If an anti-rust product is needed, please contact us to review the options.

Application

Typical example of a Scara-type robot two-axis arrangement using SHF-2UH and SHF-2UJ gear units.

The robot arm is equipped with SHF-2UH and SHF-2UJ Series units. The hollow shaft of the first axis unit is used to pilot the shaft driving the second axis unit. This allows both motors to be mounted in the base of the robot, minimizing the moment of inertia of the arm.

Fig. 262-1

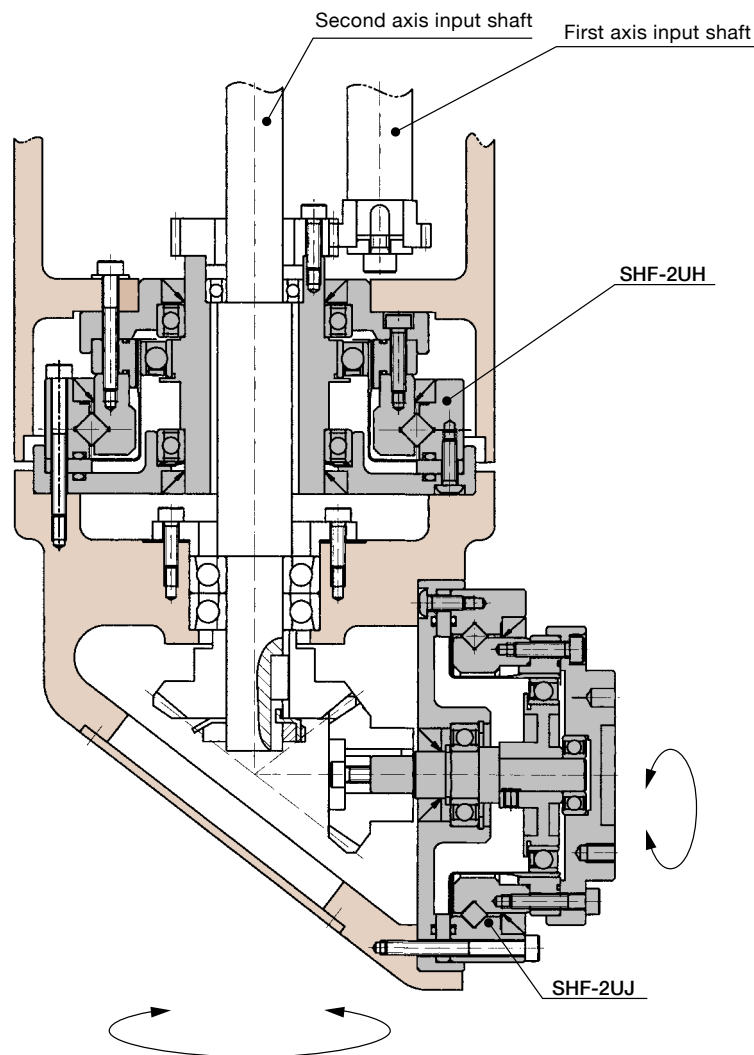


Typical example of a wrist joint arrangement in a gantry-type robot using SHF-2UH and SHF-2UJ gear units.

This robot wrist axis design incorporates both SHF-2UH and SHF-2UJ units.

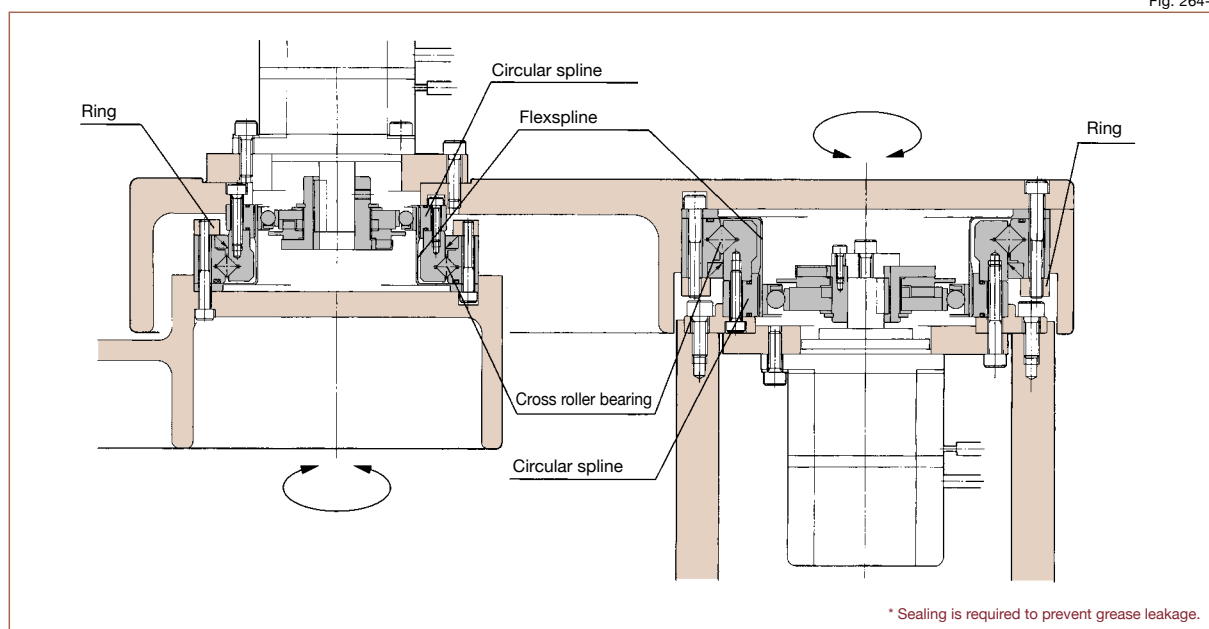
The second axis is driven through the hollow shaft of the first axis gear. This design has number of advantages, including the compact design and low inertia for the second axis.

Fig. 263-1



Typical example of a Scara-type robot two-axis arrangement using SHF-2SO simplicity unit.

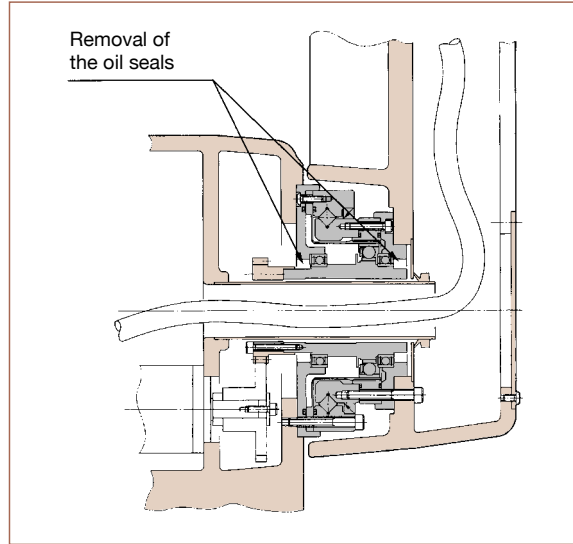
Specially designed units are used in the robot arm featured below. The Simplicity units feature SHF-2SO component sets combined with integral cross roller bearing, circular spline and flexspline. It is important to note that the motor can be assembling from both sides of the unit.



Typical example of the use of SHF-2UH gear unit with rotary shaft seals removed.

Friction generated by the rotary shaft seals on the high-speed side can result in a temperature rise in the SHF-2UH gearhead during operation. This application example shows the SHF-2UH gearhead with its rotary shaft seals removed. The removal of one or both of these seals should only be carried out if other measures have been undertaken to prevent lubricant leakage or if a leakage can be ruled out due to the installation position.

Fig. 265-1



Engineering Data

Engineering Data

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Tooth Profile

■ S tooth profile

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

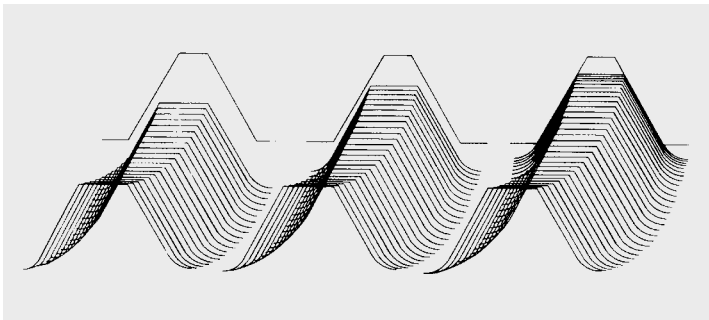
Additionally the large tooth root radius increases the tooth strength compared with an involute tooth. This technological innovation results in high torque, high torsional stiffness, long life and smooth rotation.

*Patented

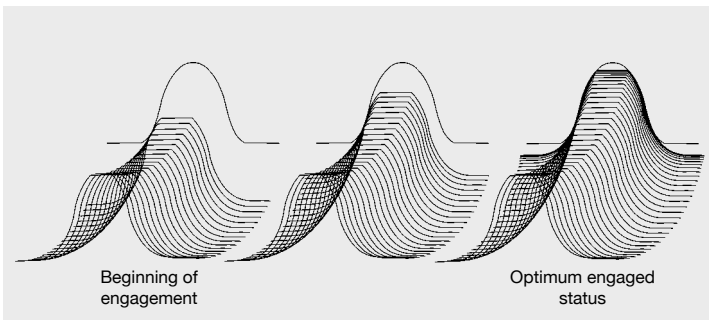
Engaged route of teeth

Fig. 009-1

Conventional tooth profile

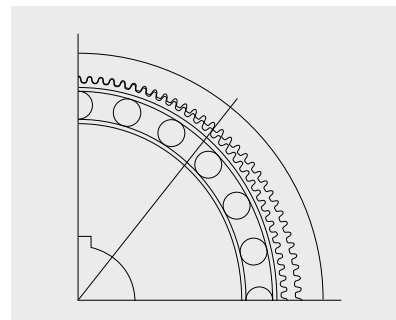
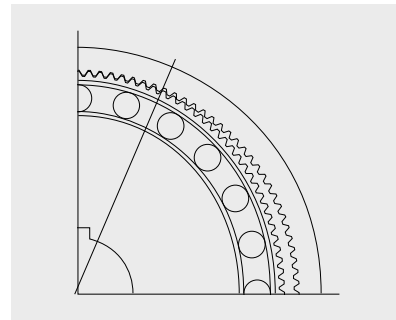


S tooth profile



Engaged area of teeth

Fig. 009-2



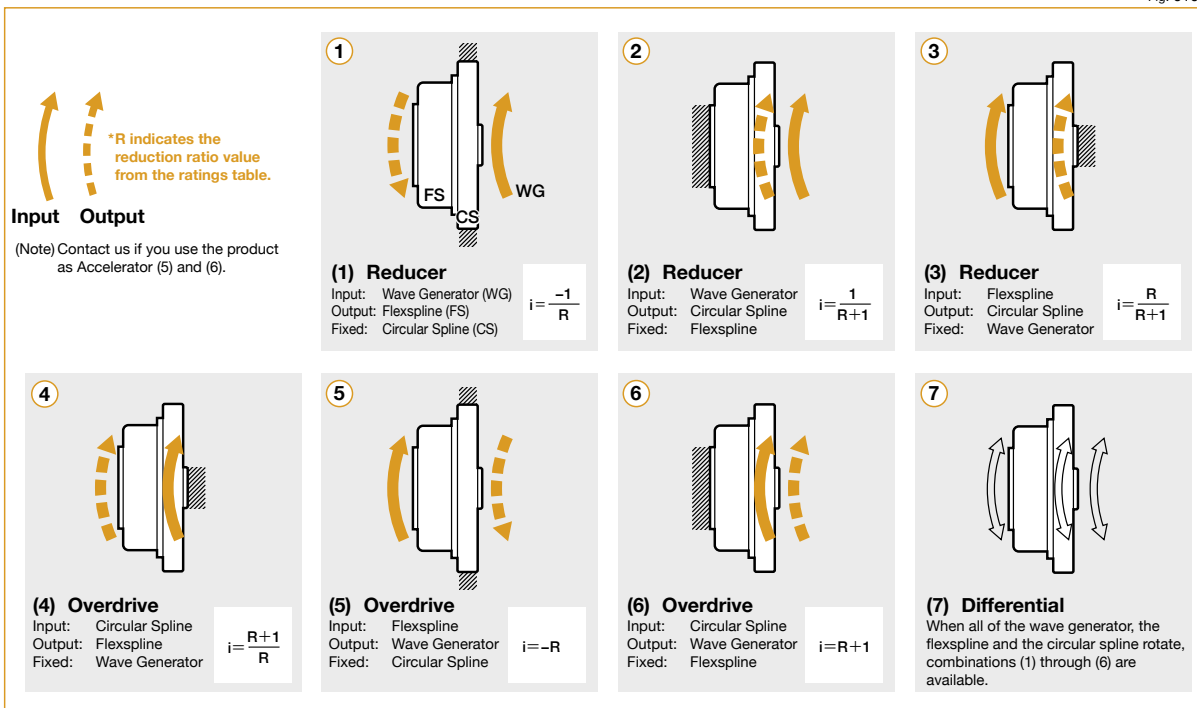
Rotational direction and reduction ratio

Cup Style

Series: CSG, CSF, CSD, CSF-mini

Rotational direction

Fig. 010-1

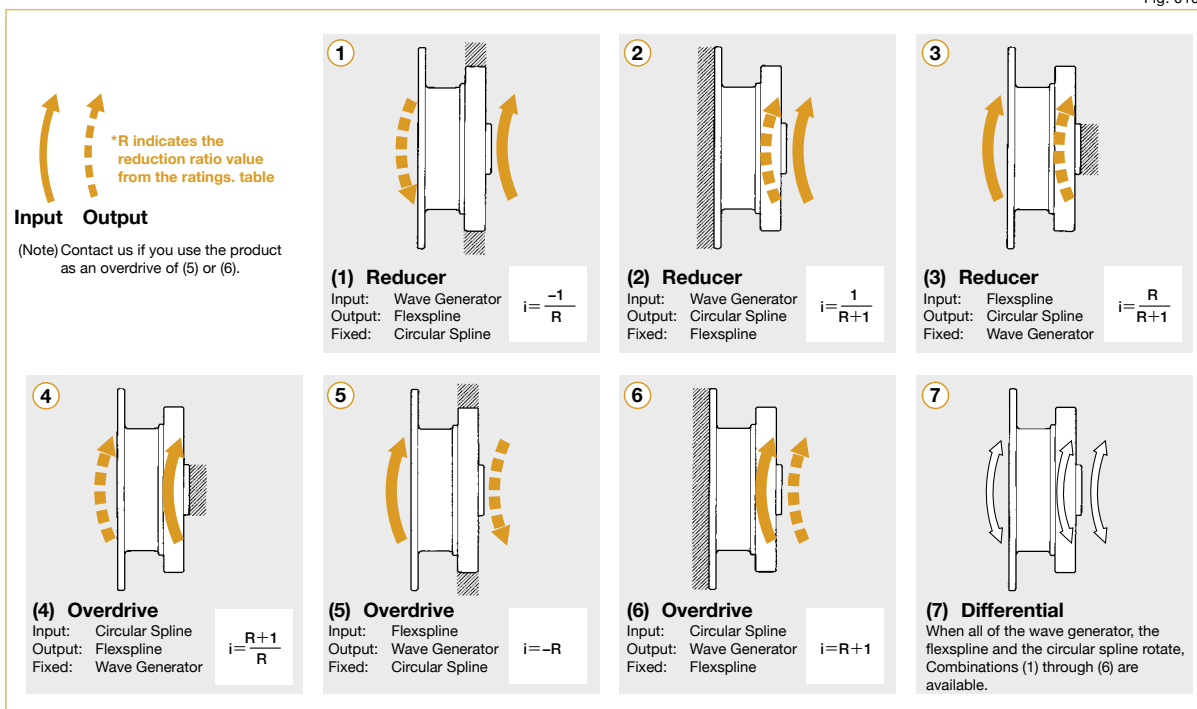


Silk hat

Series: SHG, SHF, SHD

Rotational direction

Fig. 010-2

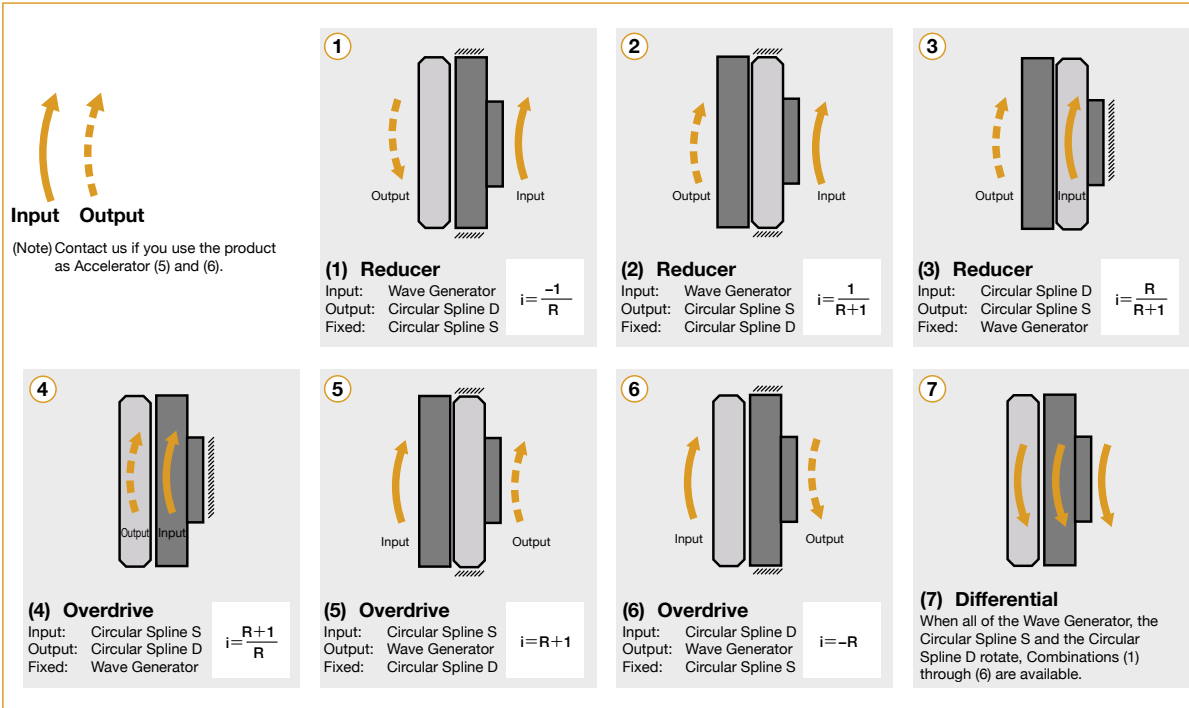


Pancake

Series: FB and FR

■ Rotational direction

Fig. 11-1



■ Reduction ratio

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

Number of teeth of the Flexspline: Z_f
Number of teeth of the Circular Spline: Z_c

► Input: Wave Generator
Output: Flexspline
Fixed: Circular Spline

Reduction ratio $i_1 = \frac{1}{R_1} = \frac{Z_f - Z_c}{Z_f}$

► Input: Wave Generator
Output: Circular Spline
Fixed: Flexspline

Reduction ratio $i_2 = \frac{1}{R_2} = \frac{Z_c - Z_f}{Z_c}$

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

Example

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

► Input: Wave Generator
Output: Flexspline
Fixed: Circular Spline

Reduction ratio $i_1 = \frac{1}{R_1} = \frac{200 - 202}{200} = \frac{-1}{100}$

► Input: Wave Generator
Output: Circular Spline
Fixed: Flexspline

Reduction ratio $i_2 = \frac{1}{R_2} = \frac{202 - 200}{202} = \frac{1}{101}$

Rating Table Definitions

See the corresponding pages of each series for values.

■ Rated torque

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

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

During acceleration and deceleration the Harmonic Drive® gear experiences a peak torque as a result of the moment of inertia of the output load. The table indicates the limit for repeated peak torque.

■ Limit for Average Torque

In cases where load torque and input speed vary, it is necessary to calculate an average value of load torque. The table indicates the limit for average torque. The average torque calculated must not exceed this limit. (calculation formula: Page 14)

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

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

■ Maximum Average Input Speed Maximum Input Speed

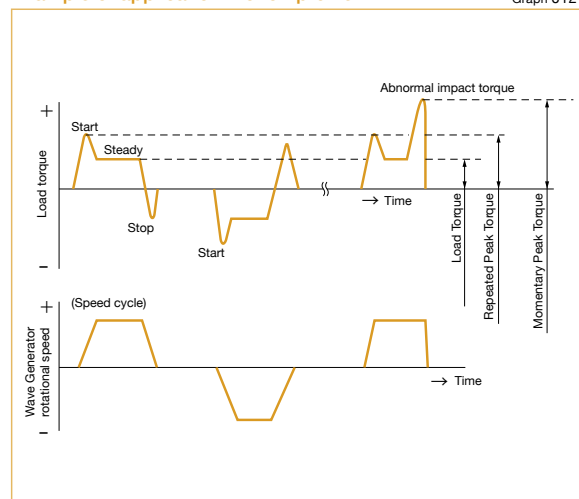
Do not exceed the allowable rating. (calculation formula of the average input speed: Page 14).

■ Moment of Inertia

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

Example of application motion profile

Graph 012-1



Life

■ Life of the wave generator

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

Table 012-1

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

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

Calculation formula for Rated Lifetime

Formula 012-1

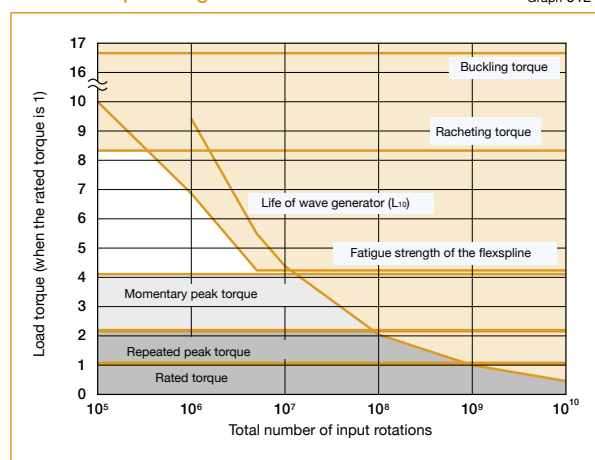
$$L_h = L_n \cdot \left(\frac{T_r}{T_{av}} \right)^3 \cdot \left(\frac{N_r}{N_{av}} \right)$$

Table 012-2

L _n	Life of L ₁₀ or L ₅₀
T _r	Rated torque
N _r	Rated input speed
T _{av}	Average load torque on the output side (calculation formula: Page 14)
N _{av}	Average input speed (calculation formula: Page 14)

Relative torque rating

Graph 012-2



* Lubricant life not taken into consideration in the graph described above.

* Use the graph above as reference values.

Torque Limits

Strength of flexspline

The Flexspline is subjected to repeated deflections, and its strength determines the torque capacity of the Harmonic Drive® gear. The values given for Rated Torque at Rated Speed and for the allowable Repeated Peak Torque are based on an infinite fatigue life for the Flexspline.

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

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

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

Calculation formula

Formula 013-1

$$N = \frac{1.0 \times 10^4}{2 \times \frac{n}{60} \times t}$$

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

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

Buckling torque

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

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

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

Ratcheting torque

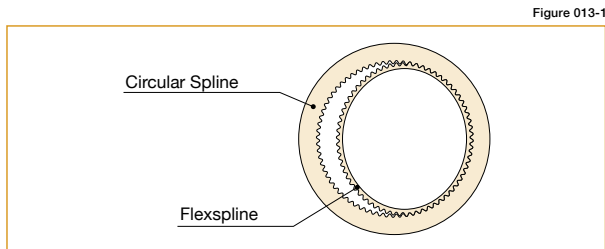
When excessive torque (8 to 9 times rated torque) is applied while the gear is in motion, the teeth between the Circular Spline and Flexspline may not engage properly.

This phenomenon is called ratcheting and the torque at which this occurs is called ratcheting torque. Ratcheting may cause the Flexspline to become non-concentric with the Circular Spline. Operating in this condition may result in shortened life and a Flexspline fatigue failure.

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

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

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



"Dedoidal" condition.

Product Sizing & Selection

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

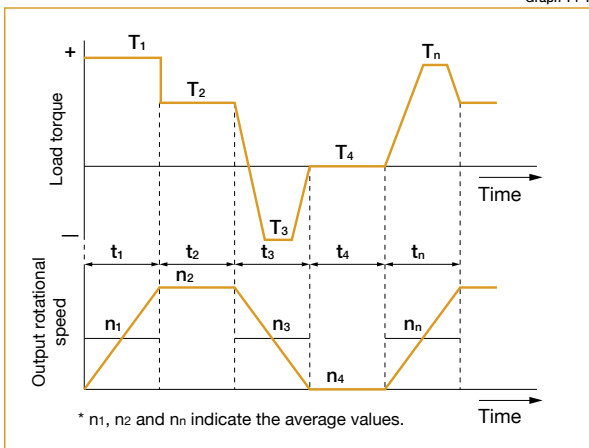
These fluctuating load torques should be converted to the average load torque when selecting a model number.

As an accurate cross roller bearing is built in the direct external load support (output flange), the maximum moment load, life of the cross roller bearing and the static safety coefficient should also be checked.

■ Checking the application motion profile

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

Graph 14-1



Obtain the value of each application motion profile.

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

Normal operation pattern

Starting (acceleration)	T_1 , t_1 , n_1
Steady operation (constant velocity)	T_2 , t_2 , n_2
Stopping (deceleration)	T_3 , t_3 , n_3
Dwell	T_4 , t_4 , n_4

Maximum rotational speed

Max. output speed	$n_{o\ max}$
Max. input rotational speed (Restricted by motors)	$n_{i\ max}$

Emergency stop torque

When impact torque is applied	T_s , t_s , n_s
-------------------------------	-----------------------

Required life

$$L_{10} = L \text{ (hours)}$$

■ Flowchart for selecting a size

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

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

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

Make a preliminary model selection with the following conditions.

$T_{av} \leq$ Limit for average torque torque

(See the rating table of each series).

Calculate the average output speed: n_{av} (rpm)

$$n_{av} = \frac{n_1 \cdot t_1 + n_2 \cdot t_2 + \dots + n_n \cdot t_n}{t_1 + t_2 + \dots + t_n}$$

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

$$\frac{n_{i\ max}}{n_{o\ max}} \geq R$$

Calculate the average input rotational speed from the average output rotational speed (n_{av}) and the reduction ratio (R): $n_{i\ av}$ (rpm)

$$n_{i\ av} = n_{av} \cdot R$$

Calculate the maximum input rotational speed from the max. output rotational speed ($n_{o\ max}$) and the reduction ratio (R): $n_{i\ max}$ (rpm)

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

Check whether the preliminary model number satisfies the following condition from the rating table.

$$n_{i\ av} \leq \text{Limit for average speed (rpm)}$$

$$n_{i\ max} \leq \text{Limit for maximum speed (rpm)}$$

NG

OK

Check whether T_1 and T_3 are less than the repeated peak torque specification.

NG

OK

Check whether T_s is less than the the momentary peak torque specification.

NG

OK

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

$$N_s = \frac{10^4}{2 \cdot \frac{n_s \cdot R}{60} \cdot t} \dots \dots N_s \leq 1.0 \times 10^4$$

NG

OK

Calculate the lifetime.

$$L_{10} = 7000 \cdot \left(\frac{T_r}{T_{av}} \right)^3 \cdot \left(\frac{n_r}{n_{i\ av}} \right) \text{ (hours)}$$

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

NG

OK

The model number is confirmed.

Review the operation conditions and model number

Example of model number selection

Value of each application motion profile

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

Normal operation pattern

Starting (acceleration)	$T1 = 400 \text{ Nm}$, $t1 = 0.3 \text{ sec}$, $n1 = 7 \text{ rpm}$
Steady operation (constant velocity)	$T2 = 320 \text{ Nm}$, $t2 = 3 \text{ sec}$, $n2 = 14 \text{ rpm}$
Stopping (deceleration)	$T3 = 200 \text{ Nm}$, $t3 = 0.4 \text{ sec}$, $n3 = 7 \text{ rpm}$
Dwell	$T4 = 0 \text{ Nm}$, $t4 = 0.2 \text{ sec}$, $n4 = 0 \text{ rpm}$

Maximum rotational speed

Max. output speed	$n_{o \max} = 14 \text{ rpm}$
Max. input speed (Restricted by motors)	$n_{i \max} = 1800 \text{ rpm}$

Emergency stop torque

When impact torque is applied	$T_s = 500 \text{ Nm}$, $t_s = 0.15 \text{ sec}$, $n_s = 14 \text{ rpm}$
-------------------------------	--

Required life

$L_{10} = 7000$ (hours)

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

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

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

Calculate the average output rotational speed: n_{av} (rpm)

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

Obtain the reduction ratio (R).

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

Calculate the average input rotational speed from the average output rotational speed (n_{av}) and the reduction ratio (R): n_{iav} (rpm)

$$n_{iav} = 12 \text{ rpm} \cdot 120 = 1440 \text{ rpm}$$

Calculate the maximum input rotational speed from the maximum output rotational speed (n_{max}) and the reduction ratio (R): n_{imax} (rpm)

$$n_{imax} = 14 \text{ rpm} \cdot 120 = 1680 \text{ rpm}$$

Check whether the preliminary selected model number satisfies the following condition from the rating table.

$$n_{iav} = 1440 \text{ rpm} \leq 3600 \text{ rpm} \text{ (Max average input speed of size 40)}$$

$$n_{imax} = 1680 \text{ rpm} \leq 5600 \text{ rpm} \text{ (Max input speed of size 40)}$$

NG

OK

Check whether $T1$ and $T3$ are equal to or less than the repeated peak torque specification.

$$T1 = 400 \text{ Nm} \leq 617 \text{ Nm} \text{ (Limit of repeated peak torque of size 40)}$$

$$T3 = 200 \text{ Nm} \leq 617 \text{ Nm} \text{ (Limit of repeated peak torque of size 40)}$$

NG

OK

Check whether T_s is equal to or less than the momentary peak torque specification.

$$T_s = 500 \text{ Nm} \leq 1180 \text{ Nm} \text{ (Limit for momentary torque of size 40)}$$

NG

OK

Calculate the allowable number (N_s) rotation during impact torque and confirm $\leq 1.0 \times 10^4$

$$N_s = \frac{10^4}{2 \cdot \frac{14 \text{ rpm} \cdot 120}{60} \cdot 0.15 \text{ sec}} = 1190 \leq 1.0 \times 10^4$$

NG

OK

Calculate the lifetime.

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

Check whether the calculated life is equal to or more than the life of the wave generator (see Page 12).

$$L_{10} = 7610 \text{ hours} \geq 7000 \text{ (life of the wave generator: } L_{10})$$

NG

OK

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

Review the operation conditions, size and reduction ratio

Lubrication

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

Gear Units: CSG/CSF 2UH and 2UH-LW; CSD-2UF and -2UH; SHG/SHF-2UH and 2UH-LW; SHG/SHF-2UJ; CSF Supermini, CSF Mini, and CSF-2UP.

Grease lubricant is standard for lubricating the gear units. You do not need to apply grease during assembly as the product is lubricated and shipped.

See Page 19 for using lubricant beyond the temperature range in table 16-2.

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

Grease lubricant

Types of lubricant

Harmonic Grease® SK-1A

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

Harmonic Grease® SK-2

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

Harmonic Grease® 4B No.2

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

(Note)

- Grease lubrication must have proper sealing, this is essential for 4B No.2.
Rotating part: Oil seal with spring is needed.
Mating part: O ring or seal adhesive is needed.
- The grease has the highest deterioration rate in the region where the grease is subjected to the greatest shear (near wave generator).
Its viscosity is between JIS No.0 and No.00 depending on the operation.

Table 016-3

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

Grease specification

Table 016-4

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

Name of lubricant

Table 016-1

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

Temperature

Table 016-2

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

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

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

Compatible grease by size

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

Ratios 30:1

Table 016-5

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

Ratios 50:1* and above

Table 016-6

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

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

○: Standard grease

△: Semi-standard grease

□: Recommended grease for long life and high load

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

Grease characteristics

Table 016-7

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

Excellent :◎

Good :○

Use Caution :△

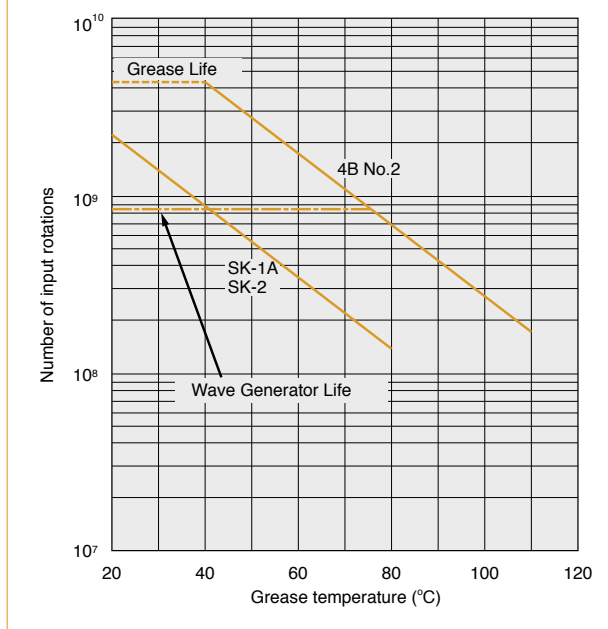
■ When to replace grease

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

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

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

Graph 017-1



Calculation formula when the average load torque exceeds the rated torque

Formula 017-1

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

Formula Symbols

Table 017-1

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

■ Other precautions

1. Avoid mixing different kinds of grease. The gear should be in an individual case when installed.
2. Please contact us when you use HarmonicDrive® gears at constant load or in one direction continuously, as it may cause lubrication problems.
3. Grease leakage. A sealed structure is needed to maintain the high durability of the gear and prevent grease leakage.

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

Precautions on using Harmonic Grease® 4B No.2

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

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

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

■ Precautions

- (1) Stir Grease

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

- (2) Aging (running-in)

The aging before the main operation softens the applied grease. More effective greasing performance can be realized when the grease is distributed around each contact surface.

Therefore, the following aging methods are recommended.

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

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

Note: Strict sealing is required to prevent grease leakage.

Oil lubricant**■ Types of oil**

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

Table 018-1

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

■ When to replace oil

First time 100 hours after starting operation

Second time or after Every 1000 operation hours or every 6 months

Note that you should replace the oil earlier than specified if the operating condition is demanding.

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

■ Other precautions

1. Avoid mixing different kinds of oil. The gear should be in an individual case when installed.
2. When you use size 50 or above at max allowable input speed, please contact us as it may cause lubrication problems.

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

Lubricant for special environments

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

Harmonic Grease 4B No.2

Table 019-1

Type of lubricant	Operating temperature range	Available temperature range
Grease	-10°C to + 110°C	-50°C to + 130°C

Harmonic Grease 4B No.2

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

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

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

High temperature lubricant

Table 019-2

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

Low temperature lubricant

Table 019-3

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

Torsional Stiffness

Stiffness and backlash of the drive system greatly affects the performance of the servo system. Please perform a detailed review of these items before designing your equipment and selecting a model number.

■ Stiffness

Fixing the input side (wave generator) and applying torque to the output side (flexspline) generates a torsional angle almost proportional to the torque on the output side. Figure 020-1 shows the torsional angle at the output side when the torque applied on the output side starts from zero, increases up to $+T_0$ and decreases down to $-T_0$. This is called the "Torque – torsion angle diagram," which normally draws a loop of $0 - A - B - A' - B' - A$. The slope described in the "Torque – torsion angle diagram" is represented as the spring constant for the stiffness of the HarmonicDrive® gear (unit: Nm/rad).

As shown in Figure 020-2 "Spring Constant Diagram" is divided into 3 regions, and the spring constants in the area are represented by K_1 , K_2 and K_3 .

K_1 The spring constant when the torque changes from [zero] to $[T_1]$

K_2 The spring constant when the torque changes from $[T_1]$ to $[T_2]$

K_3 The spring constant when the torque changes from $[T_2]$ to $[T_3]$

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

■ Example for calculating the torsion angle

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

When the applied torque is T_1 or less, the torsion angle θ_{L1} is calculated as follows:

$$\begin{aligned}\theta_{L1} &= T_{L1}/K_1 \\ &= 2.9/3.1 \times 10^4 \\ &= 9.4 \times 10^{-5} \text{ rad (0.33 arc min)}\end{aligned}$$

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

$$\begin{aligned}\theta_{L2} &= \theta_1 + (T_{L2} - T_1)/K_2 \\ &= 4.4 \times 10^{-4} + (39 - 14)/5.0 \times 10^4 \\ &= 9.4 \times 10^{-4} \text{ rad (3.2 arc min)}\end{aligned}$$

When a bidirectional load is applied, the total torsion angle will be $2 \times \theta_{Lx}$ plus hysteresis loss.

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

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

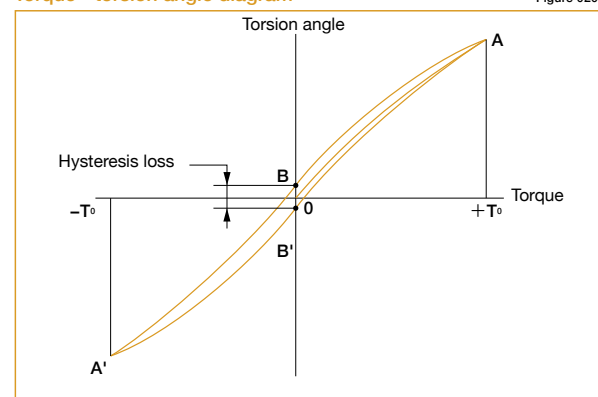
■ Hysteresis loss (Silk hat and cup style only)

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

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

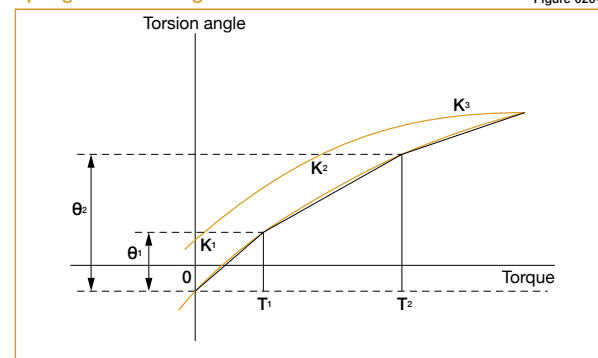
Torque - torsion angle diagram

Figure 020-1



Spring constant diagram

Figure 020-2



■ Backlash (Silk hat and cup style only)

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

Positional Accuracy

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

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

Example of measurement

Graph 021-1

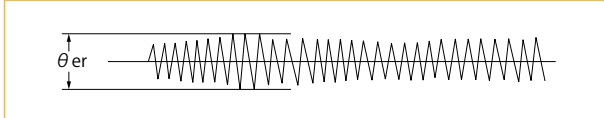


Table 021-1

θ_{er}	Transmission accuracy
θ_1	Input angle
θ_2	Actual output angle
R	Reduction ratio

Formula 021-1

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

Vibration

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

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

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

Formula 021-2

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

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

How to calculate resonant frequency of the system

Formula 021-3

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

Formula variables

Table 021-2

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

Starting Torque

Starting torque is the torque value applied to the input side at which the output first starts to rotate. The values in the table of each series indicate the maximum value, and the lower-limit value indicates approximately $\frac{1}{2}$ to $\frac{1}{3}$ of the maximum value.

Measurement conditions:

No-load, ambient temperature: +20°C

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

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

Backdriving Torque

Backdriving torque is the torque value applied to the output side at which the input first starts to rotate. The values in the table are maximum values, typical values are approximately $\frac{1}{2}$ of the maximum values.

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

Measurement conditions:

No-load, ambient temperature: +20°C

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

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

No-Load Running Torque

No-load running torque is the torque which is required to rotate the input side (high speed side), when there is no load on the output side (low speed side). The graph of the no-load running torque shown in this catalog depends on the measurement conditions shown in Table 023-1.

Add the compensation values shown by each series to all reduction ratios except 100:1.

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

Measurement condition

Table 023-1

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

* Contact us for oil lubrication.

Efficiency

The efficiency varies depending on the following conditions.

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

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

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

Measurement condition

Table 023-2

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

* Contact us for oil lubrication.

Efficiency compensation coefficient

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

Example of calculation

Efficiency η (%) under the following condition is obtained from the example of CSF-20-80-2A-GR.

Input rotational speed: 1000 rpm

Load torque: 19.6 Nm

Lubrication method: Grease lubrication (Harmonic Grease SK-1A)

Lubricant temperature: 20°C

Since the rated torque of size 20 with a reduction ratio of 80 is 34 Nm (Ratings: Page 039), the torque ratio α is 0.58.

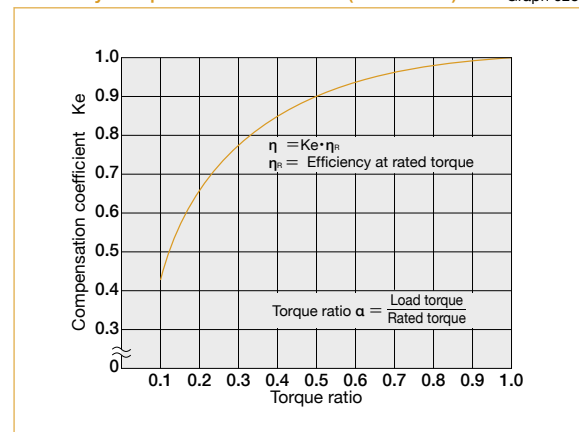
($\alpha = 19.6/34 = 0.58$)

- The efficiency compensation coefficient is $K_e = 0.93$ from Graph 023-1.

- Efficiency η at load torque 19.6 Nm: $\eta = K_e \cdot \eta_R = 0.93 \times 78 = 73\%$

Efficiency compensation coefficient (CSF series)

Graph 023-1



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

Design Guidelines

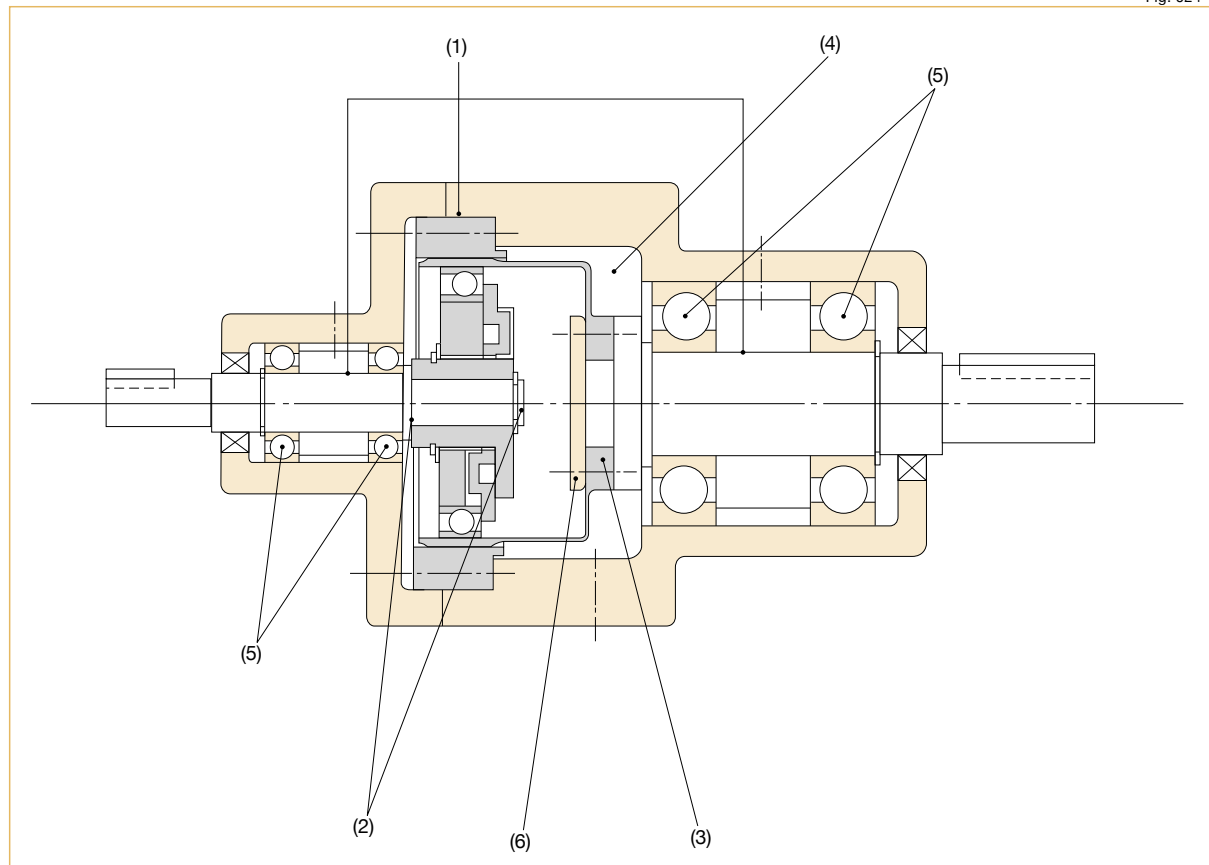
Design guideline

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

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

- (1) Input shaft, Circular Spline and housing must be concentric.
- (2) When operating, an axial force is generated on the wave generator. Input bearings must be selected to accommodate this axial load. See page 27.
- (3) Even though a HarmonicDrive® gear is compact, it transmits large torques. Therefore, assure that all required bolts are used to fasten the circular spline and flexspline and that they are tightened to the recommended torque.
- (4) As the flexspline is subject to elastic deformation, the A minimal clearance between the flexspline and housing is required. Refer to "Minimum Housing Clearance" on the drawing dimension tables.
- (5) The input shaft and output shaft are supported by anti-friction bearings. As the wave generator and flexspline elements are meant to transmit pure torque only, the bearing arrangement needs to isolate the harmonic gearing from external forces applied to either shaft. A common bearing arrangement is depicted in the diagram.
- (6) A clamping plate is recommended (item 6). Its purpose is to spread fastening forces and to avoid any chance of making physical contact with the thin section of the flexspline diaphragm. The clamping plate shall not exceed the diaphragm's boss diameter and is to be designed in accordance with catalog recommendations.

Fig. 024-1



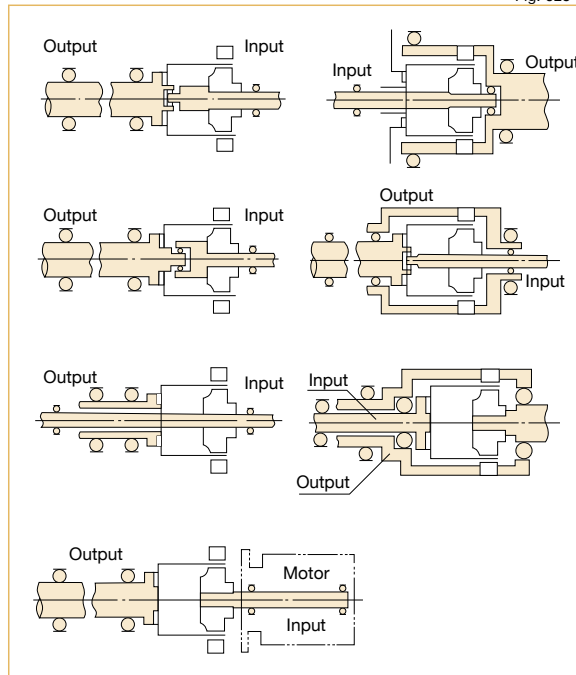
Bearing support for the input and output shafts

For the component sets, both input and output shafts must be supported by two adequately spaced bearings in order to withstand external radial and axial forces without excessive deflection. In order to avoid damage to the component set when limited external loads are anticipated, both input and output shafts must be axially fixed.

Bearings must be selected whose radial play does not exceed ISO-standard C 2 class or "normal" class. The bearings should be axially and radially preloaded to eliminate backlash.

Examples of correct bearing arrangements are shown in fig 025-1.

Fig. 025-1



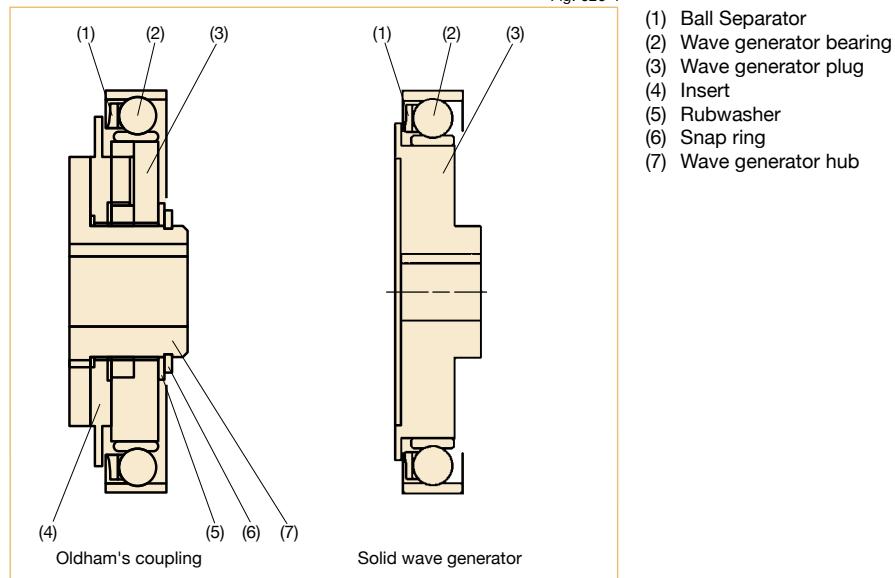
Wave generator

■ Structure of the wave generator

The wave generator includes an Oldham's coupling type with a self-aligning structure and an integrated solid wave generator without a self-aligning structure, and which is used depends on the series.

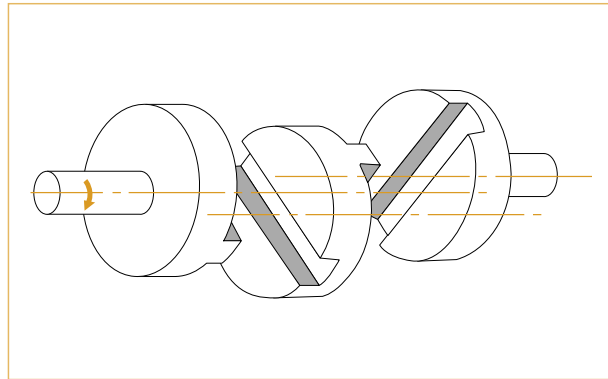
See the diagram of each series for details. The basic structure of the wave generator and the shape are shown below.

Fig. 026-1



Structure of Oldham's coupling

Fig. 026-2



Maximum hole diameter of wave generator

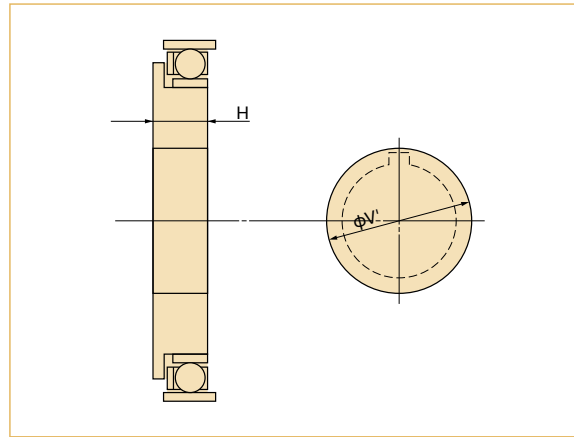
The standard hole dimension of the wave generator is shown for each size. The dimension can be changed within a range up to the maximum hole dimension. We recommend the dimension of keyway based on JIS standard. It is necessary that the dimension of keyways should sustain the transmission torque.

* Tapered holes are also available.

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

Hole diameter of the wave generator

Fig. 027-1



Hole diameter of the wave generator hub with Oldham coupling

Table 027-1
Unit: mm

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

Maximum hole diameter without Oldham Coupling

Table 027-2
Unit: mm

Size	8	11	14	17	20	25	32	40	45	50	58	65	80	90	100
Max. hole dia. $\Phi V'$	10	14	17	20	23	28	36	42	47	52	60	67	72	84	95
Min. plug thick. $H_{B.1}$	5.7	6.7	7.2	7.6	11.3	11.3	13.7	15.9	17.8	19	21.4	23.5	28.5	31.3	34.9

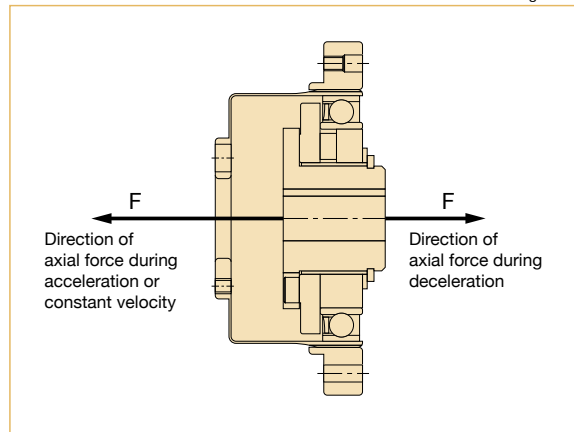
Axial Force of Wave Generator

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

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

Axial force direction of the wave generator

Fig. 027-2



Formula for Axial Force

Table 027-3

Reduction ratio	Calculation formula
30	$F = 2 \times \frac{T}{D} \times 0.07 \times \tan 32^\circ$
50	$F = 2 \times \frac{T}{D} \times 0.07 \times \tan 30^\circ$
80 or more	$F = 2 \times \frac{T}{D} \times 0.07 \times \tan 20^\circ$

Symbols for Formula

Table 027-4

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

Calculation example

Formula 027-1

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

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

$$F = 380N$$

Assembly Precautions

Sealing

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

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

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

Sealing recommendations for gear units

Table 028-1

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

Assembly precautions

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

■ Precautions on the wave generator

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

■ Precautions on the circular spline

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

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

■ Precautions on the flexspline

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

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

■ Rust prevention

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

"Dedoidal" state

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

■ How to check "dedoidal"

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

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

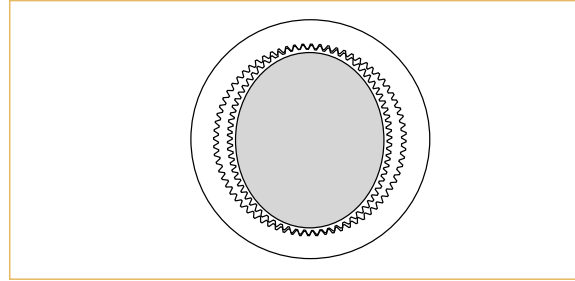
- 1) Slowly turn the input shaft with your hand in a no-load condition. If you can turn it with average force, it is normal. If it turns irregularly, it may be "dedoidal".
- 2) Turn the wave generator in a no-load condition if it is attached to a motor. If the average current value of the motor is about 2 to 3 times the normal value, it may be "dedoidal".

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

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

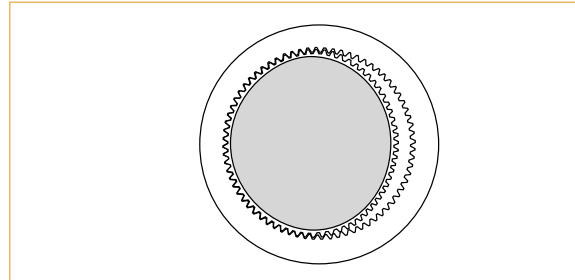
Normal engagement status

Fig. 029-1



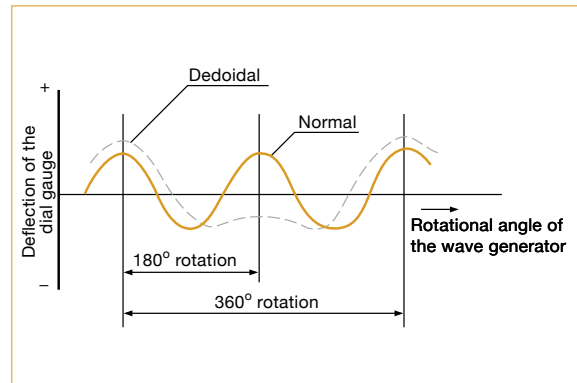
"Dedoidal" status

Fig. 029-2



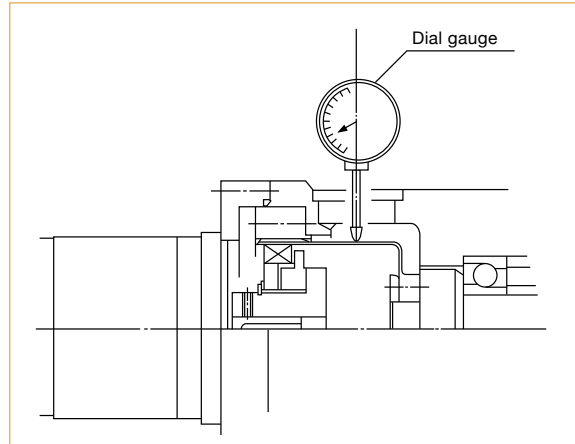
Deflection of the dial gauge

Graph 029-3



Measuring the deflection on the body of the flexspline

Fig. 029-4



Checking Output Bearing

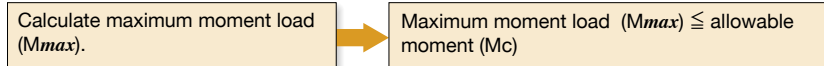
A precision cross roller bearing is built in the unit type and the gear head type to directly support the external load (output flange) (precision 4-point contact ball bearing for the CSF-mini series).

Please calculate maximum moment load, life of cross roller bearing, and static safety factor to fully maximize the performance of a housed unit (gearhead).

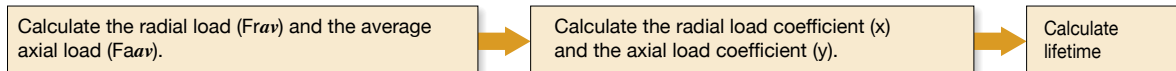
- See the corresponding pages on each series for cross roller bearing specifications.

Checking procedure

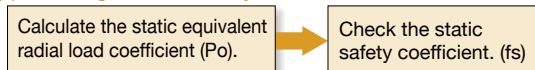
(1) Checking the maximum moment load (M_{max})



(2) Checking the life



(3) Checking the static safety coefficient



How to calculate the maximum moment load

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

Formula 030-1

$$M_{max} = F_{rmax} (L_r + R) + F_{amax} \cdot L_a$$

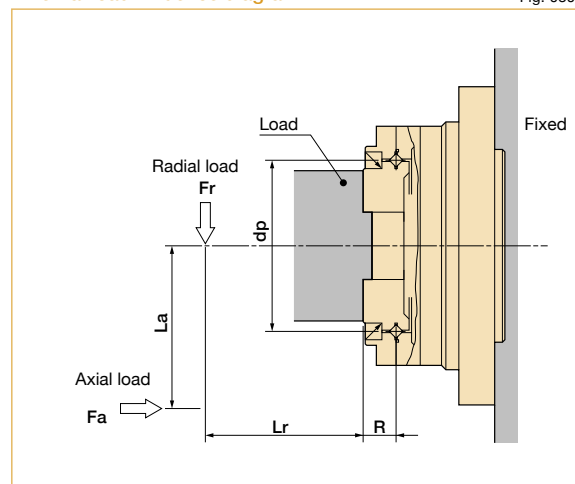
Symbols for Formula 030-1

Table 030-1

F_{rmax}	Max. radial load	N(kgf)	See Fig. 030-1.
F_{amax}	Max. axial load	N(kgf)	See Fig. 030-1.
L_r, L_a	—	m	See Fig. 030-1.
R	Offset amount	m	See Fig. 030-1 and "Specification of the output bearing" of each series.

External load influence diagram

Fig. 030-1



How to calculate the average load

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

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

How to calculate the average radial load (F_{rav})

Formula 031-1

(Cross roller bearing)

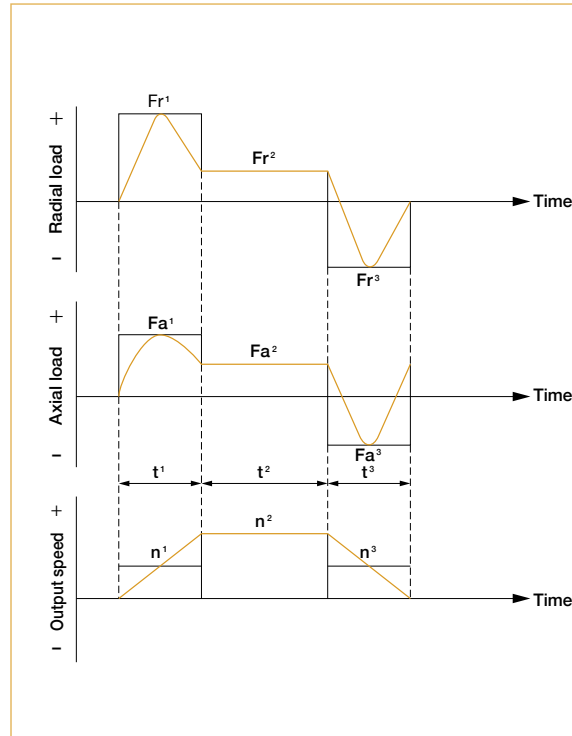
$$F_{rav} = \sqrt[10/3]{\frac{n_1 t_1 (IF_{r1})^{10/3} + n_2 t_2 (IF_{r2})^{10/3} + \dots + n_n t_n (IF_{rn})^{10/3}}{n_1 t_1 + n_2 t_2 + \dots + n_n t_n}}$$

(4-point contact ball bearing)

$$F_{rav} = \sqrt[3]{\frac{n_1 t_1 (IF_{r1})^3 + n_2 t_2 (IF_{r2})^3 + \dots + n_n t_n (IF_{rn})^3}{n_1 t_1 + n_2 t_2 + \dots + n_n t_n}}$$

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

Graph 031-1



How to calculate the average axial load (F_{aav})

Formula 031-2

(Cross roller bearing)

$$F_{aav} = \sqrt[10/3]{\frac{n_1 t_1 (IF_{a1})^{10/3} + n_2 t_2 (IF_{a2})^{10/3} + \dots + n_n t_n (IF_{an})^{10/3}}{n_1 t_1 + n_2 t_2 + \dots + n_n t_n}}$$

(4-point contact ball bearing)

$$F_{aav} = \sqrt[3]{\frac{n_1 t_1 (IF_{a1})^3 + n_2 t_2 (IF_{a2})^3 + \dots + n_n t_n (IF_{an})^3}{n_1 t_1 + n_2 t_2 + \dots + n_n t_n}}$$

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

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

Formula 031-3

$$N_{av} = \frac{n_1 t_1 + n_2 t_2 + \dots + n_n t_n}{t_1 + t_2 + \dots + t_n}$$

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

Formula 031-4

How to calculate the load coefficient	X	Y
$\frac{F_{aav}}{F_{rav} + 2(F_{rav}(L_r + R) + F_{rav} \cdot L_a) / dp} \leq 1.5$	1	0.45
$\frac{F_{aav}}{F_{rav} + 2(F_{rav}(L_r + R) + F_{rav} \cdot L_a) / dp} > 1.5$	0.67	0.67

Symbols for Formula 031-4

Table 031-1

F_{rav}	Average radial load	N(kgf)	See "How to calculate the average load." See Formula 031-1.
F_{aav}	Average axial load	N(kgf)	See "How to calculate the average load." See Formula 031-2.
L_r, L_a	_____	m	See fig. 030-1
R	Offset amount	m	See Fig. 030-1 and "Main roller bearing specifications" of each series
dp	Pitch circle diameter of a roller	m	See Fig. 030-1 and "Specification of the output bearing" of each series.

Life of the output bearing

Calculate life of the output bearing by Formula 032-1.

You can calculate the dynamic equivalent radial load (Pc) by Formula 032-2.

Formula 032-1

(Cross roller bearing)

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

(4-point contact ball bearing)

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

Symbols for Formula 032-1

Table 032-1

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

Formula 032-2

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

Symbols for Formula 032-2

Table 032-2

F_{rav}	Average radial load	N (kgf)	See "How to calculate the average load." See Formula 031-1.
F_{aav}	Average axial load	N (kgf)	See "How to calculate the average load." See Formula 031-2.
d_p	Pitch circle diameter	m	See Fig. 030-1 and "Specification of the output bearing" of each series.
X	Radial load coefficient	--	See Formula 031-4.
Y	Axial load coefficient	--	See Formula 031-4.
L_r, L_a	---	m	See Figure 030-1.
R	Offset	m	See Fig. 030-1 and "Specification of the output bearing" of each series.

Load coefficient

Table 032-3

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

How to calculate life during oscillating motion

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

Formula 033-1

(Cross roller bearing)

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

(4-point contact ball bearing)

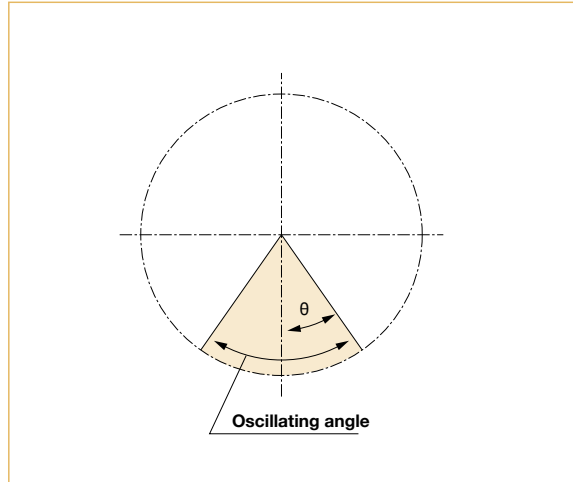
$$Loc = \frac{10^6}{60 \times n1} \times \frac{90}{\theta} \times \left(\frac{C}{fw \cdot Pc} \right)^3$$

Symbols for Formula 033-1

Table 033-1

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

Fig. 033-1



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

How to calculate the static safety coefficient

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

Formula 034-1

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

Formula 034-2

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

Symbols for Formula 034-1

Table 034-1

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

Static Safety Coefficient

Table 034-3

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

Symbols for Formula 034-2

Table 034-2

F_{rmax}	Max. radial load	N(kgf)	See "How to calculate the maximum moment load" on Page 030.
F_{amax}	Max. axial load	N(kgf)	
M_{max}	Max. moment load	Nm(kgfm)	
d_p	Pitch circle diameter of a roller	m	See Fig. 030-1 and "Specification of the output bearing" of each series.

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