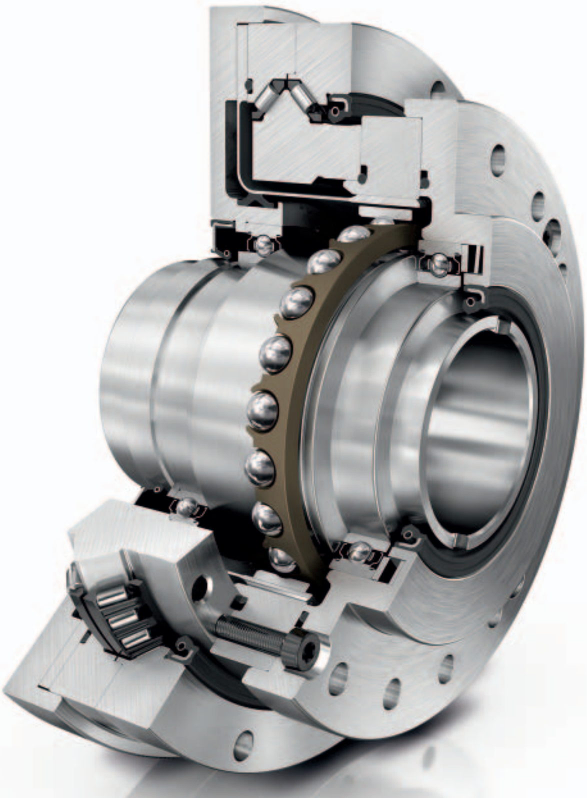

Precision Strain Wave Gears

Series RT

Foreword

Ultra Precision Drives

In drive systems intended for robots, machine tools and use in industrial automation, for example, gears are a key component that have a significant influence on positioning and repeat accuracy, service life and the dynamics of the overall solution.

Increased precision, reduced cycle times and extended machine runtimes are of global importance for industrial automation across all sectors. With this in mind, Schaeffler has consolidated its development expertise, production technology, products and services in the field of precision strain wave gears under the umbrella of Ultra Precision Drives.

Products with this label surpass the current state of the art and, in some cases, set the benchmark in the market. We seek to achieve nothing less.

Our Ultra Precision Drives cover a rated torque range of 10 Nm to over 7 000 Nm with two gear types – precision strain wave gears and precision planetary gears. This gives the industry a choice of precision strain wave gears for small cobots through to large industrial robots, for secondary and main axes in machine tools, and positioning drives for a wide variety of automation tasks.

Precision strain wave gears

In this publication, the precision strain wave gears of both the High Torque RT1 and Standard Torque RT2 series are described in detail. These currently cover a maximum torque range of 18 Nm to 484 Nm. Both series have comparable sizes and variants. Precision strain wave gears of the High Torque RT1 series exceed the Standard Torque RT2 series by an average of 30% in terms of torque and 40% in terms of service life. Precision strain wave gears of the Standard Torque RT2 series are characterised by an extensive portfolio of sizes, variants and gear reduction ratios. Precision strain wave gears of the High Torque RT1 series are also available with an integrated torque sensor as RT1-T, which does not introduce any additional elasticity into the drive train.

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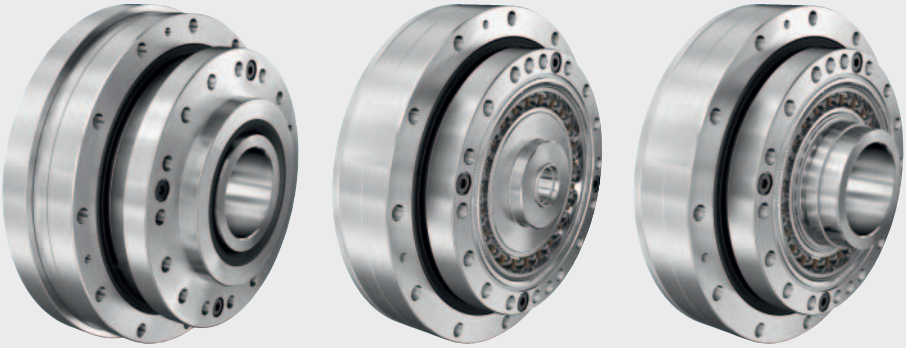
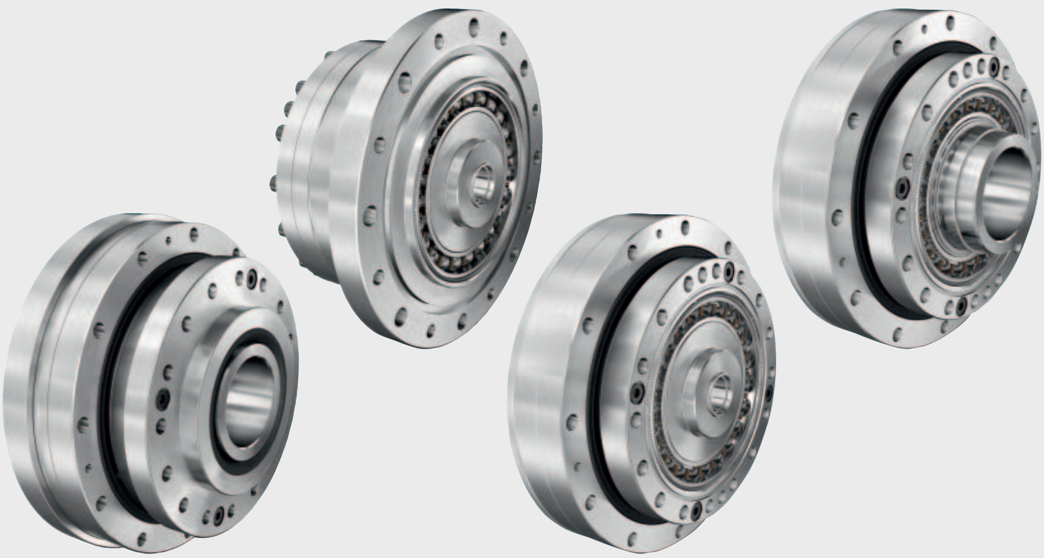
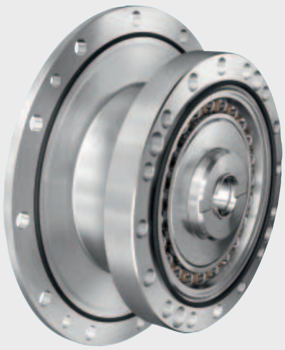






Precision strain wave gears
High Torque RT1

- Sizes:
  14, 17, 20, 25, 32
- Gear reduction ratios:
  50, 80, 100, 120, 160
- Maximum torque:
  23 Nm to 484 Nm

Variant:
HAT

- Version:
  CS, BHS, BMS, UHS

Precision strain wave gears
Standard Torque RT2

- Sizes:
  14, 17, 20, 25, 32
- Gear reduction ratios:
  50, 80, 100, 120, 160
- Maximum torque:
  18 Nm to 372 Nm

Variant:
HAT

- Version:
  CS, BHS, BMS, UHS

Variant:
CUP

- Version:
  CS, BMS

Sensorised precision strain wave gear
High Torque RT1-T

- Sizes:
  14, 17, 25, 32
- Gear reduction ratios:
  100, 160
- Maximum torque:
  36 Nm to 484 Nm

Variant:
HAT

- Version:
  UHS-T

SCHAEFFLER

Technical principles

Structure and functional principle
Series and versions
Gear preselection
Gear design
Service life
Lubrication
Torsional angle
Efficiency
Output bearings
Sensorised precision strain wave gear

Technical principles

Structure and functional principle

Structure

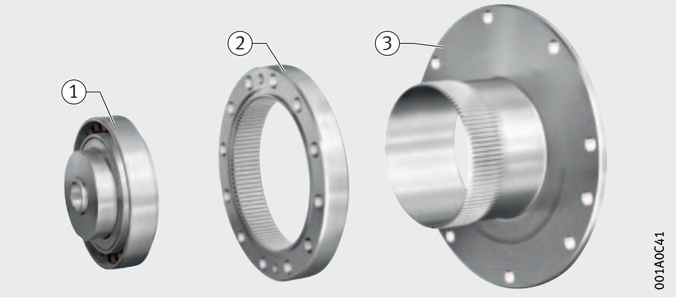
The precision strain wave gears of series RT consist of three main components.

The Wave Generator is an elliptical drive element with a premounted thin section bearing. The flexible, torsionally rigid Flexspline with external teeth surrounds the Wave Generator. The Circular Spline wraps around the Flexspline as a rigid ring gear.

The external teeth of the Flexspline mesh with the internal teeth of the Circular Spline. Due to its function, the internal toothing has two teeth more than the external toothing.

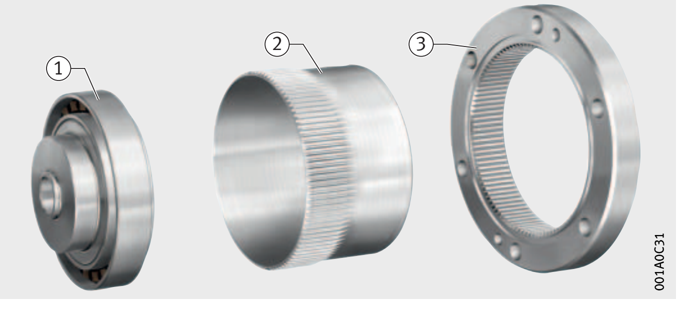
The Flexspline is available in two different designs as variant HAT or variant CUP. In variant HAT, the base of the Flexspline runs outwards. This creates a large passage opening, which permits the use of large hollow shafts. In variant CUP, the base of the Flexspline runs inwards. This design is predominantly used in the construction of compact drive systems.

Depending on the version, further components are added to the precision strain wave gear, such as an output bearing, input shaft and housing, for quick and easy integration into the application. Precision strain wave gears of the High Torque RT1 series are available with an integrated torque sensor for measuring the forces that occur.



① Wave Generator
② Circular Spline
③ Flexspline

Figure 1
Components
Component Set, variant HAT

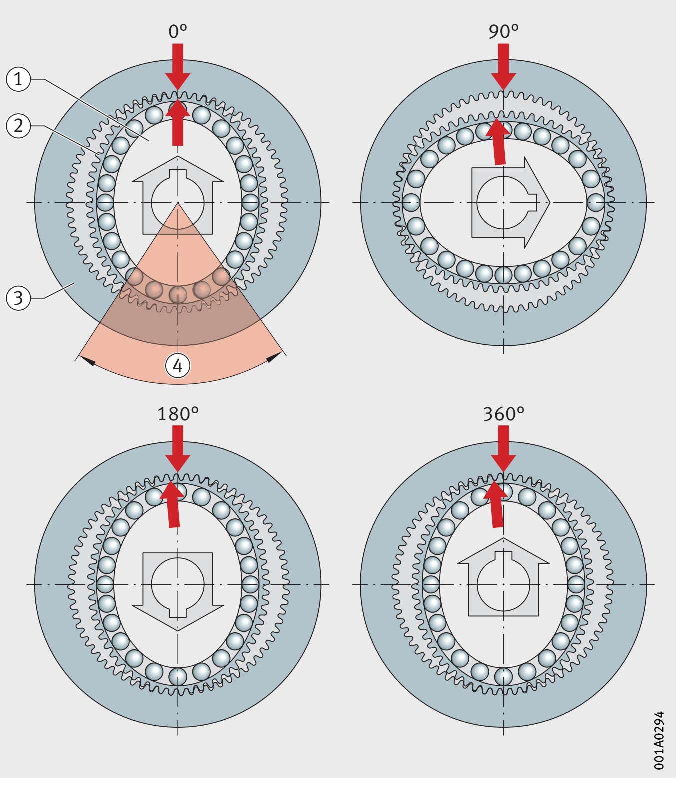


① Wave Generator
② Flexspline
③ Circular Spline

Figure 2
Components
Component Set, variant CUP

Functional principle

After assembly, the Flexspline assumes the elliptical shape of the Wave Generator. The rotating Wave Generator causes circumferential deformation of the Flexspline. The external teeth of the Flexspline mesh with the internal teeth of the Circular Spline at the vertical axis of the ellipse via two large, symmetrically opposed tooth engagement areas. The rotating Wave Generator results in permanent circumferential meshing of the internal teeth with the external teeth. Since the Flexspline has two fewer teeth than the Circular Spline, the Flexspline and Circular Spline move relative to each other by two gear teeth per input revolution.



(1) Wave Generator
(2) Flexspline
(3) Circular Spline
(4) Tooth engagement area

Figure 3
Functional principle

Series and versions

Lifetime precision

Precision strain wave gears of the High Torque RT1 and Standard Torque RT2 series are characterised by extremely high positional accuracy over the entire service life. Their characteristic features include low weight and a compact design. The backlash- and wear-free toothing as well as a high torque density permit particularly compact drive solutions for very high loads.

The High Torque RT1 series is characterised by increased performance and achieves a torque that is up to 30% higher and a service life that is up to 40% longer than the Standard Torque RT2 series. Version UHS-T (series RT1-T) offers precise torque measurement with the integrated torque sensor.

The Standard Torque RT2 series offers a wide variety of sizes, gear reduction ratios and versions.

Typical areas of application are:

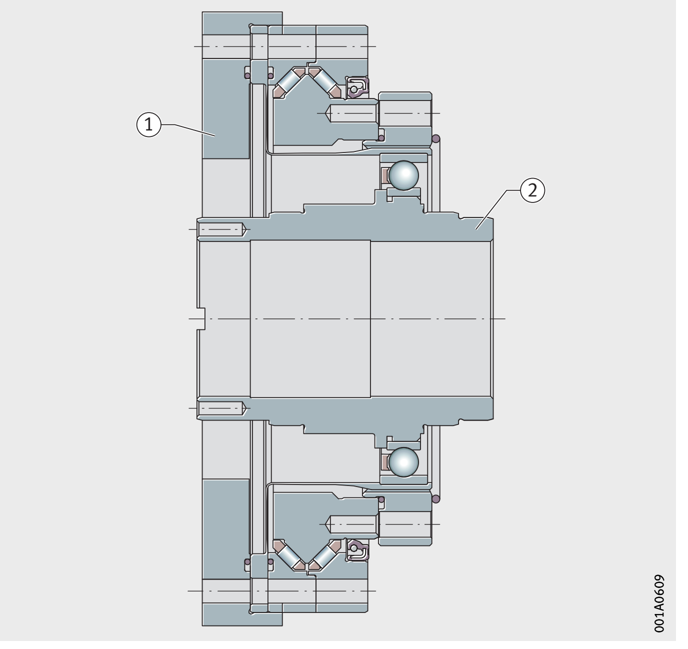
- Robots and handling
- Medical equipment
- Industrial machinery
- Machine tools

Versions

The RT precision strain wave gears offer a large variety of sizes and gear reduction ratios and are available in three versions:

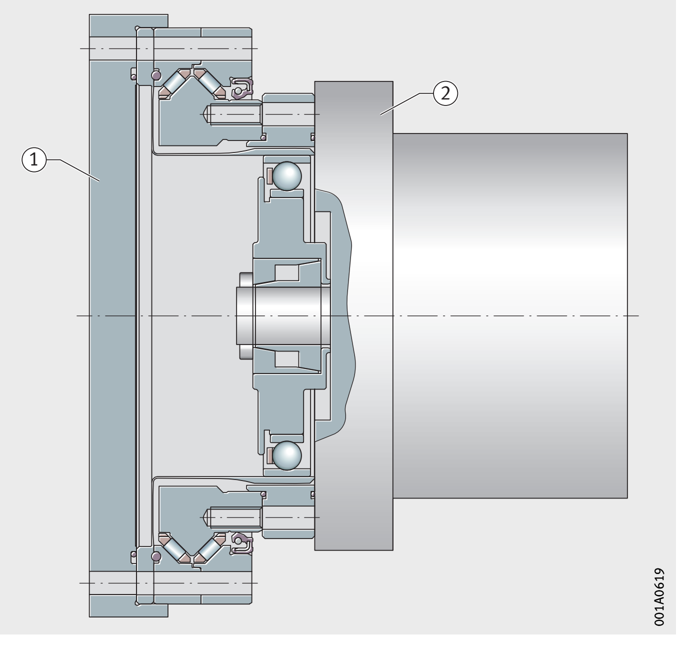
- Component Set (CS):
  - comprising the three main components of a strain wave gear
- Basic Unit (BHS, BMS):
  - additionally includes a heavy-duty output bearing
- Unit (UHS, UHS-T):
  - fully premounted and sealed,
    optionally with integrated torque sensor

The precision strain wave gears are available with a large hollow shaft for mounting a hollow shaft motor (version BHS, UHS), for direct motor attachment (version BMS) or with an integrated torque sensor (version UHS-T).



① Output flange
② Gear input for hollow shaft motor

Figure 1
Precision strain wave gear
with large hollow shaft



① Output flange
② Motor

Figure 2
Precision strain wave gear
for direct motor attachment

Gear preselection

Application

Strain wave gears can be used in various industries and application areas. The strain wave gear is selected according to the required torque or necessary stiffness.

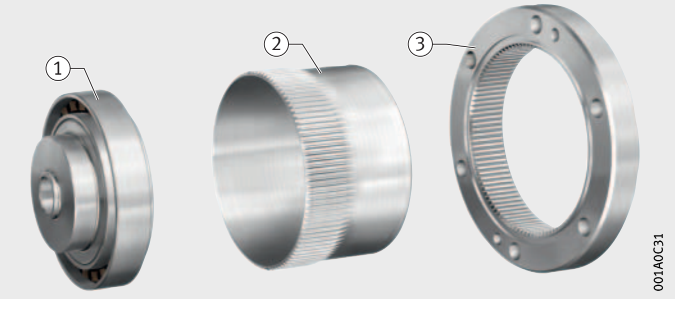
Preselection of precision strain wave gears

The following guidelines are intended to assist in the selection of a precision strain wave gear:

- Selecting the version:
  - CS:
    Component Set
  - BHS:
    Basic Unit with hollow shaft
  - BMS:
    Basic Unit for motor shaft
  - UHS:
    Unit with hollow shaft
  - UHS-T:
    Unit with hollow shaft and integrated torque sensor
- Determining the maximum torque and average torque:
  - the gear size is determined by the torques and the available installation space:
    14, 17, 20, 25, 32
- Determining the maximum speed and average speed:
  - the gear reduction ratio is determined by the speeds:
    50, 80, 100, 120, 160

Input and output arrangement

Various input and output arrangements can be achieved with precision strain wave gears of series RT, resulting in different gear reduction ratios.



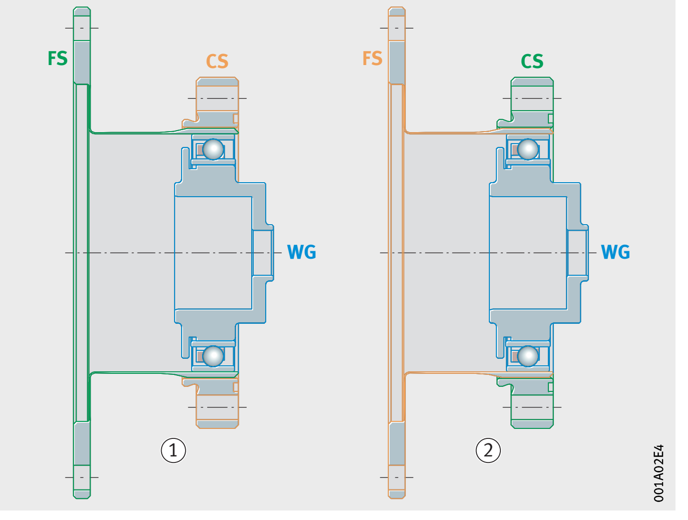
① Wave Generator
② Flexspline
③ Circular Spline

Figure 1
Main components of
a precision strain wave gear

Gear reduction ratio

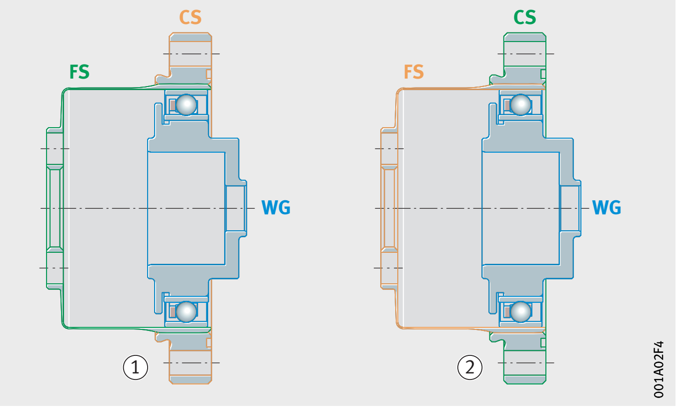
$$i = \frac{\text{input drive speed}}{\text{output drive speed}}$$

The values for the typical gear reduction ratio are derived from the input arrangement.



① Input arrangement 1
② Input arrangement 2

Figure 2
Variant HAT



① Input arrangement 1
② Input arrangement 2

Figure 3
Variant CUP

Gear reduction ratio of the precision strain wave gear and direction of rotation

Feature	Input arrangement	
	1	2
Gear reduction ratio	$= -\frac{i}{1}$	$= \frac{i+1}{1}$
Wave Generator	Input	Input
Flexspline	Output	Fixed
Circular Spline	Fixed	Output
Direction of rotation Input versus output	Reversal of direction of rotation	Same direction of rotation

Torque-based dimensioning

The following procedure describes the dimensioning of a strain wave gear based on the load cycle.

For dimensioning of the strain wave gear, the following values must be calculated in the specified order:

- Average output torque $T_{out\ av}$
- Maximum output torque $T_{out\ max}$
- Collision torque $T_{out\ K}$
- Average input drive speed $n_{in\ av}$
- Maximum input speed $n_{in\ max}$

The limit values specified in the procedure must not be exceeded. If the limit values cannot be observed with the selected gear size, a larger gear size must be selected.

Average output torque

First, the average output torque that acts on the strain wave gear during the load cycle is determined.

T = torque
n = speed
t = time

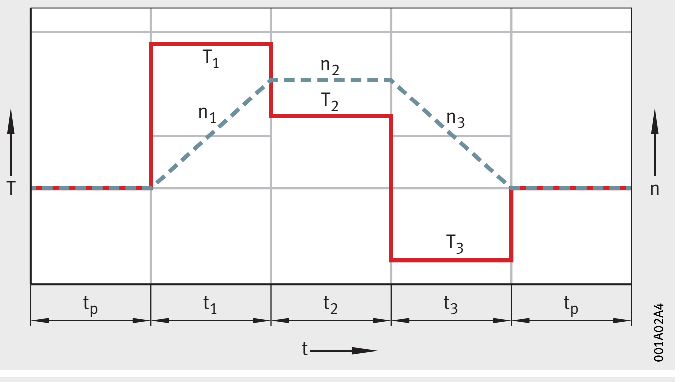


Figure 1
Load cycle

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

The determined average output torque of the load $T_{out\ av}$ is compared with the average torque of the strain wave gear T_A.

The average output torque $T_{out\ av}$ must not exceed the value from the technical datasheet T_A.

$$T_{out\ av} \leqq T_A$$

$T_{out\ av}$ Average load torque	Nm
n_n, n_1, n_2 Load speed stages	min^{-1}
T_n, T_1, T_2 Load torque stages	Nm
t_n, t_1, t_2 Load time stages	s
T_A Average torque	Nm

Maximum output torque

The determined maximum output torque $T_{out\ max}$ of the load indicates the currently required acceleration and deceleration torque in the load cycle.

The maximum output torque $T_{out\ max}$ of the highly dynamic application must not exceed the maximum torque T_R of the strain wave gear.

$$T_{out\ max} \leqq T_R$$

$T_{out\ max}$ Maximum load torque	Nm
T_R Maximum torque	Nm

Collision torque

In the event of an emergency stop during operation, the strain wave gear may be subjected to a brief collision torque $T_{out\ K}$.
In such cases, damage to the gear and thus a reduced service life cannot be ruled out. The number of emergency stops that occur during operation should be kept to a minimum and remain below the specified collision torque T_M of the strain wave gear.

$$T_{out\ K} \leqq T_M$$

$T_{out\ K}$ Collision torque during operation	Nm
T_M Collision torque	Nm

Average input drive speed

In order to ensure the longest possible service life of the Wave Generator bearing, the average input drive speed $n_{in\ av}$ must not exceed the average input drive speed $n_{av\ max}$ of the strain wave gear during a load cycle.

$$n_{in\ av} = \frac{|n_1| \cdot t_1 + |n_2| \cdot t_2 + \ldots + |n_n| \cdot t_n}{t_1 + t_2 + \ldots + t_n + t_p} \cdot i$$

$$n_{in\ av} = n_{out\ av} \cdot i$$

$$n_{in\ av} \leqq n_{av\ max}$$

$n_{in\ av}$ $\quad$ min^{-1}
Average input drive speed

n_n, n_1, n_2 $\quad$ min^{-1}
Load speed stages

t_n, t_1, t_2, t_p $\quad$ s
Load time stages

i $\quad$ –
Gear reduction ratio

$n_{out\ av}$ $\quad$ min^{-1}
Average output drive speed

$n_{av\ max}$ $\quad$ min^{-1}
Maximum average input drive speed

Maximum input drive speed

The maximum input drive speed $n_{in\ max}$ determined in the load cycle must not exceed the maximum input drive speed n_{max} of the strain wave gear. The maximum input drive speed n_{max} may only be used briefly in the load cycle due to the occurring temperature increase.

$$n_{in\ max} = n_{out\ max} \cdot i$$

$$n_{in\ max} \leqq n_{max}$$

$n_{in\ max}$ $\quad$ min^{-1}
Maximum load input speed

$n_{out\ max}$ $\quad$ min^{-1}
Maximum load output drive speed

i $\quad$ –
Gear reduction ratio

n_{max} $\quad$ min^{-1}
Maximum input drive speed of the strain wave gear

Stiffness-based dimensioning

In special applications, a high level of stiffness is more important than dimensioning of the strain wave gear based on load cycles, for example:

- Medical equipment
- Metal processing
- Optical equipment

Stiffness-based dimensioning of the strain wave gear must always be performed in addition to torque-based dimensioning, in order to determine the resonance frequency of the application.

$$f_n = \frac{1}{2\pi} \cdot \sqrt{\frac{K_1}{J}}$$

$$n_n = f_n \cdot 30 \text{ min}^{-1}$$

f_n Hz
Resonance frequency

K_1 Nm/rad
Torsional rigidity

J $kg \cdot m^2$
Load moment of inertia

n_n min^{-1}
Speed

Empirical values for f_n

Application	Resonance frequency f_n ≧ Hz
Axes in robotics	8
Standard applications in mechanical engineering	15
Machining axes in machine tools	20

Service life of Wave Generator bearings

The service life of the Wave Generator bearing is calculated in accordance with the following procedure (DIN ISO 281).

The reference values are the rated output torque from the technical data and a reference input speed of n_N = 2 000 min^{-1}.

$$L_{10} = L_n \cdot \frac{n_N}{n_{in\ av}} \cdot \left(\frac{T_N}{T_{out\ av}}\right)^3$$

Series	Version	Nominal service life L_n h	Reference speed n_N min^{-1}	Revolutions of the Wave Generator bearing
RT1	CS, BHS, BMS, UHS	10 000	2 000	$1{,}2 \cdot 10^9$
RT1-T	UHS-T	10 000	2 000	$1{,}2 \cdot 10^9$
RT2	CS, BHS, BMS, UHS	7 000	2 000	$0{,}84 \cdot 10^9$

T = torque
n = speed
t = time

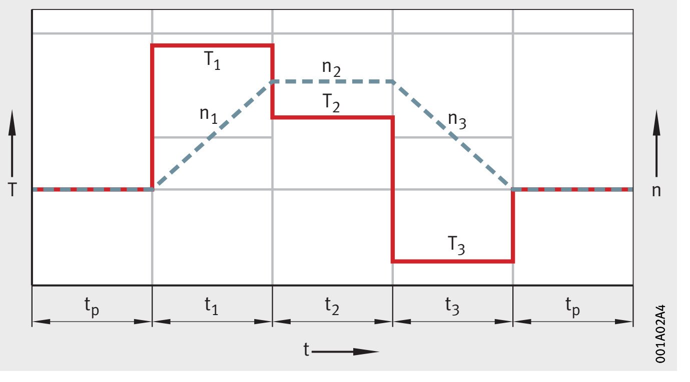


Figure 1
Load cycle

$$n_{in\,av} = \frac{|n_1| \cdot t_1 + |n_2| \cdot t_2 + \ldots + |n_n| \cdot t_n}{t_1 + t_2 + \ldots + t_n + t_p} \cdot i$$

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

L_{10} Service life	h
L_n Nominal service life	h
n_N Rated speed	min^{-1}
T_N Rated torque	Nm
$n_{in\,av}$ Average input speed	min^{-1}
$T_{out\,av}$ Average load torque	Nm
n_n, n_1, n_2 Load speed stages	min^{-1}
t_n, t_1, t_2, t_p Load time stages	s
i Gear reduction ratio	–
T_n, T_1, T_2 Load torque stages	Nm

Service life

Service life of output bearings

The service life in continuous operation and in swivel type operation is calculated using the following equations.

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

$$L_{oc} = \frac{10^6}{60 \cdot n_{oc}} \cdot \frac{180}{\varphi} \cdot \left(\frac{C}{f_w \cdot P_c}\right)^B$$

L_{10} h
Service life

B –
Life exponent

C N
Basic radial dynamic load rating

n_{av} min^{-1}
Average speed

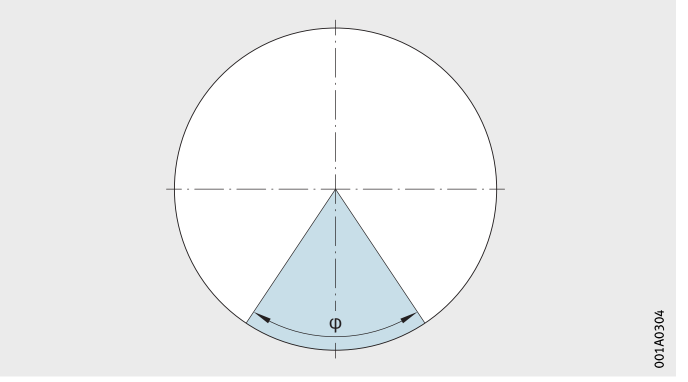
f_w –
Operating factor

P_c N
Equivalent dynamic bearing load

L_{oc} h
Life with swivel motion

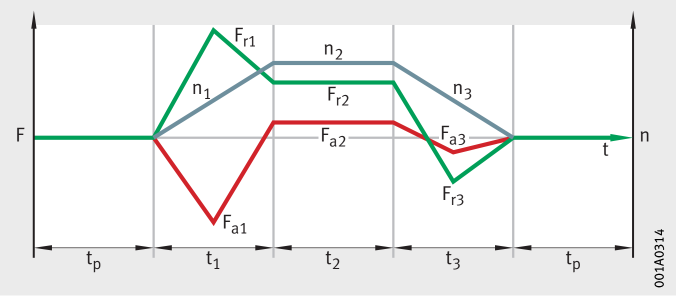
n_{oc} –
Number of oscillations per minute

φ °
Swivel angle



Cycle = 2 · φ

Figure 2
Cycle in swivel-type operation



F = load
t_1, t_2, t_3, t_p = load time stages
n, n_1, n_2, n_2 = load speed stages
F_{r1}, F_{r2}, F_{r3} = radial force stages of the load
F_{a1}, F_{a2}, F_{a3} = axial force stages of the load

Figure 3
Bearing load diagram

Service life

$$n_{out\ av} = \frac{|n_1| \cdot t_1 + |n_2| \cdot t_2 + \ldots + |n_n| \cdot t_n}{t_1 + t_2 + \ldots + t_n + t_p}$$

$$F_{a\ av} = \left(\frac{|n_1| \cdot t_1 \cdot (|F_{a1}|)^B + |n_2| \cdot t_2 \cdot (|F_{a2}|)^B + \ldots + |n_n| \cdot t_n \cdot (|F_{an}|)^B}{|n_1| \cdot t_1 + |n_2| \cdot t_2 + \ldots + |n_n| \cdot t_n} \right)^{\frac{1}{B}}$$

$$F_{r\ av} = \left(\frac{|n_1| \cdot t_1 \cdot (|F_{r1}|)^B + |n_2| \cdot t_2 \cdot (|F_{r2}|)^B + \ldots + |n_n| \cdot t_n \cdot (|F_{rn}|)^B}{|n_1| \cdot t_1 + |n_2| \cdot t_2 + \ldots + |n_n| \cdot t_n} \right)^{\frac{1}{B}}$$

$$M_{av} = \left(\frac{|n_1| \cdot t_1 \cdot (|M_1|)^B + |n_2| \cdot t_2 \cdot (|M_2|)^B + \ldots + |n_n| \cdot t_n \cdot (|M_n|)^B}{|n_1| \cdot t_1 + |n_2| \cdot t_2 + \ldots + |n_n| \cdot t_n} \right)^{\frac{1}{B}}$$

$$P_C = x \cdot \left(F_{r\ av} + \frac{2M_{av}}{d_M} \right) + y \cdot F_{a\ av}$$

$n_{out\ av}$ — $\min^{-1}$
Average output drive speed

n_n, n_1, n_2 — $\min^{-1}$
Load speed stages

t_n, t_1, t_2, t_p — s
Load time stages

B — –
Life exponent

$F_{a\ av}$ — N
Average axial force

F_{an}, F_{a1}, F_{a2} — N
Axial force stages of the load

$F_{r\ av}$ — N
Average radial force

F_{rn}, F_{r1}, F_{r2} — N
Radial force stages of the load

M_{av} — Nm
Average tilting moment

M_n, M_1, M_2 — N
Tilting moment

P_C — N
Equivalent dynamic bearing load

x — –
Radial load factor

y — –
Axial load factor

d_M — mm
Mean bearing diameter

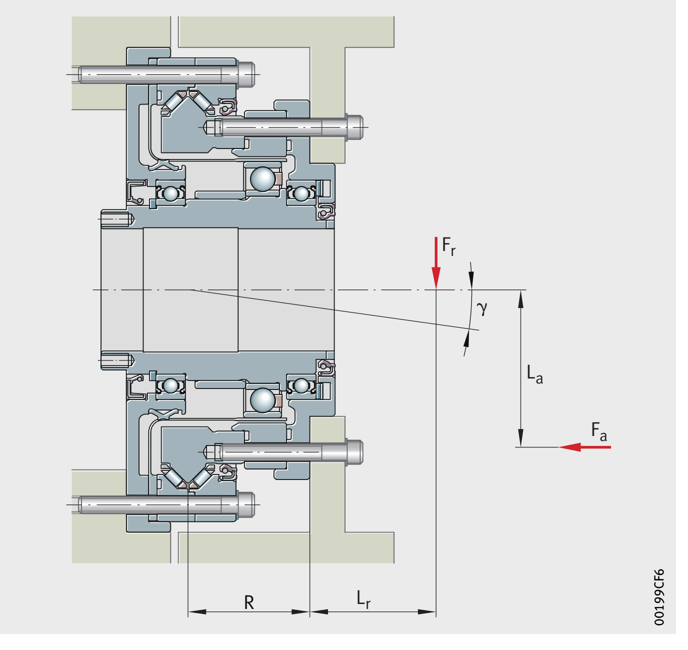
Selection	Load factor	
	radial x	axial y
$\frac{F_{a\,av}}{F_{r\,av} + \frac{2M_{av}}{d_M}} \leqq 1{,}5$	1	0,45
$\frac{F_{a\,av}}{F_{r\,av} + \frac{2M_{av}}{d_M}} > 1{,}5$	0,67	0,67

Bearing type	Exponent B
Needle roller bearing	$\frac{10}{3}$

Operating conditions	Operating factor f_w	
	from	up to
No shocks, no vibrations	1	1,2
Normal load	1,2	1,5
Shocks, vibrations	1,5	3

Permissible static tilting moment

The permissible static tilting moment is calculated as follows in the event of a static load.



F_r = radial force
γ = tilting angle
L_a = distance
F_a = axial force
R = distance to bearing centre
L_r = distance

Figure 4
Diagram showing
the tilting moment calculation

Service life

$$M = F_r \cdot (L_r + R) + F_a \cdot L_a$$

$$f_s = \frac{C_0}{P_0}$$

$$P_0 = x \cdot \left(F_r + \frac{2M}{d_M} \right) + y \cdot F_a$$

$$M_0 = \frac{d_M \cdot C_0}{2 \cdot f_s}$$

M	Tilting moment	Nm
F_r	Radial force	N
L_r, L_a	Distance	m
R	Distance to bearing centre	m
F_a	Axial force	N
f_s	Static safety factor	–
C_0	Basic radial static load rating	N
P_0	Equivalent static bearing load	N
x	Radial load factor	–
y	Axial load factor	–
d_M	Mean bearing diameter	m
M_0	Permissible static tilting moment	Nm

Operating condition	Static safety factor f_s	
	from	up to
Normal load	1,5	2
Shocks, vibrations	2	3

$$\gamma = \frac{M}{K_B}$$

γ	Tilt angle	arcmin
M	Tilting moment	Nm
K_B	Tilting rigidity	Nm/arcmin

Lubrication

Lubricants

The technical data and service life of strain wave gears are primarily determined by the lubricant used. The performance data and properties of strain wave gears can only be guaranteed if approved lubricants are used.

Features		Lubricant L325
Temperature range of the lubricant		–15 °C to +135 °C
Gear operating range		0 °C to +40 °C
Base oil		Mineral oil
Thickener		Lithium soap
Colour		Yellow
Consistency class		2
Base oil viscosity	+40 °C	37 mm^2/s
	+100 °C	5,5 mm^2/s
Drop point		≧ +190 °C

Safety data sheet and technical data available by agreement.

Lubricant service life and influence of temperature

The properties of strain wave gears are influenced principally by the condition of the lubricant used.

Lubricant temperature < +35 °C

For applications in which the following conditions apply, the initial lubrication of the strain wave gear is sufficient for the entire service life L_n:

- Rated torque and rated speed (2 000 min^{-1}) are not exceeded in the usage cycle.
- The lubricant temperature does not exceed < +35 °C.

Increased lubricant temperature

For applications with an increased lubricant temperature, a lubricant change is recommended to preserve the gear properties. The following applies:

- High Torque RT1:
  - lubricant temperature ≧ +35 °C
- Standard Torque RT2:
  - lubricant temperature ≧ +40 °C

Lubrication

The number of strain wave gear revolutions until lubricant change is calculated as follows:

For application with $T_{out\ av} \leqq T_N$:

$$WGT_{grease\ N} = 6 \cdot 10^9 \cdot e^{-(0{,}046 \cdot \vartheta_{grease})}$$

For applications with $T_{out\ av} > T_N$:

$$WGT_{grease} = 6 \cdot 10^9 \cdot e^{-(0{,}046 \cdot \vartheta_{grease})} \cdot \left(\frac{T_N}{T_{out\ av}}\right)^3$$

$WGT_{grease\ N}$ –
Number of strain wave gear revolutions at $T_{out\ av} \leqq T_N$

ϑ_{grease} °C
Lubricant temperature

WGT_{grease} –
Number of strain wave gear revolutions at $T_{out\ av} > T_N$

T_N Nm
Rated torque

$T_{out\ av}$ Nm
Average load torque

The interval in hours until lubricant change is calculated as follows:

$$GCI = \frac{WGT}{n_{in\ av} \cdot 60}$$

GCI h
Time until lubricant change

WGT –
Number of strain wave gear revolutions

$n_{in\ av}$ min^{-1}
Average input speed

$WGT_{grease\ N}$ = number of strain wave gear revolutions at $T_{out\ av} \leqq T_N$
ϑ_{grease} = lubricant temperature
GCI = time until lubricant change

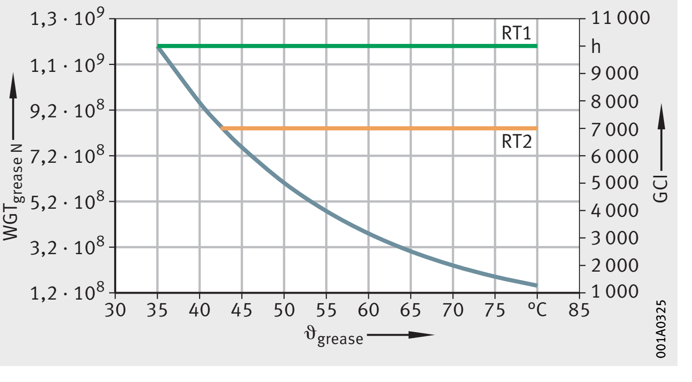


Figure 1
Series RT1, RT2
lubricant change interval at rated torque

Torsional angle

Calculation of the torsional angle

The torsional angle at the gear output for a load case with torque T is calculated using the following equations.

Torque ranges

$T \leqq T_1$	$T_1 \leqq T \leqq T_2$	$T > T_2$
$\varphi = \frac{T}{K_1}$	$\varphi = \frac{T_1}{K_1} + \frac{T - T_1}{K_2}$	$\varphi = \frac{T_1}{K_1} + \frac{T_2 - T_1}{K_2} + \frac{T - T_2}{K_3}$

T Torque	Nm
T_1 Torque limit 1	Nm
T_2 Torque limit 2	Nm
φ Angle	rad
K_1, K_2, K_3 Torsional rigidity	Nm/rad

Size	Torque	
	T_1	T_2
14	2	6,9
17	3,9	12
20	7	25
25	14	48
32	29	108

φ = angle
T = torque
T_1 = torque limit 1
T_2 = torque limit 2
K_1, K_2, K_3 = torsional rigidity

① Lower torque range
② Medium torque range
③ Upper torque range

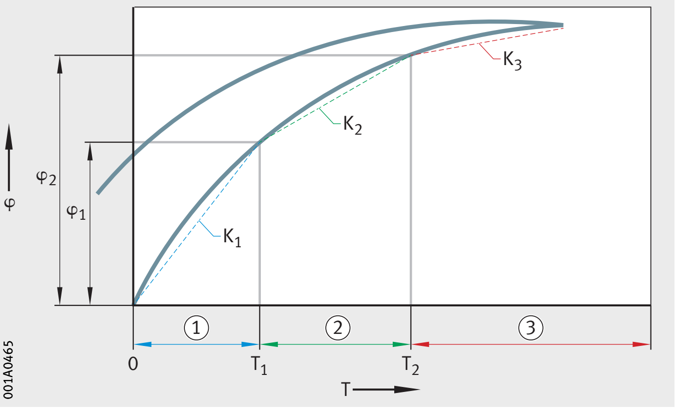


Figure 1
Calculation of the torsional angle

Efficiency

The efficiency given is for lubrication with standard lubricant, load with rated speed and rated torque, and a gear temperature of +20 °C.

Version CS

Size	Gear reduction ratio i				
	50 %	80 %	100 %	120 %	160 %
14	71	71	67	–	–
17	78	77	77	74	–
20	78	77	77	74	70
25	78	77	77	74	70
32	78	77	77	74	70

Version BHS, BMS

Size	Gear reduction ratio i				
	50 %	80 %	100 %	120 %	160 %
14	66	66	62	–	–
17	73	72	72	69	–
20	73	72	72	69	65
25	73	72	72	69	65
32	73	72	72	69	65

Scatter around 3%.

Version UHS

Size	Gear reduction ratio i				
	50 %	80 %	100 %	120 %	160 %
14	49	47	47	–	–
17	50	48	48	46	–
20	51	49	49	47	40
25	53	51	51	49	42
32	55	53	53	51	44

Scatter around 3%.

Version UHS-T

Size	Gear reduction ratio i	
	100 %	160 %
14	47	–
17	48	–
20	49	40
25	51	42
32	53	44

Scatter around 3%.

Output bearings

Data on the output bearings

The double row angular contact needle roller bearings of series XZU are precisely designed to the high requirements for precision strain wave gears in terms of running behaviour, tilting rigidity, load carrying capacity and compactness.

The needle rollers in the double row angular contact needle roller bearing XZU are guided in an optimised cage design, so that no friction occurs between the individual rolling elements. The high load carrying capacity of the output bearing can support high loads, rendering additional support bearing arrangements superfluous in many cases. The tilt-resistant double row angular contact needle roller bearing XZU keeps the precision strain wave gear free from external loads, thereby ensuring a long service life and consistent accuracy.

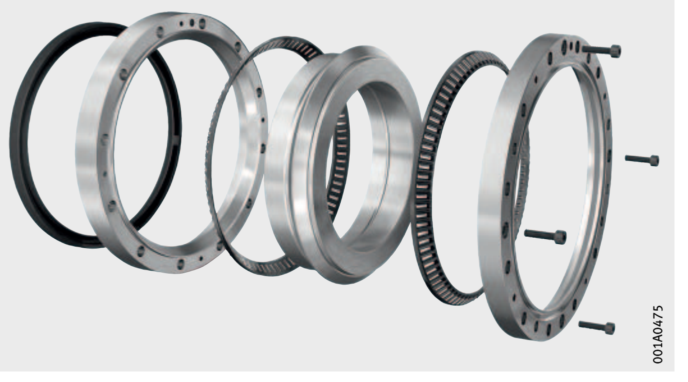


Figure 1
Exploded view of
output bearing XZU

Output bearing XZU-H for version BHS, BMS, UHS, UHS-T

Features	Symbol	Unit	Size				
			14	17	20	25	32
Pitch circle ∅	d_M	mm	54,5	63,7	73,3	89,1	116,4
Distance[1]	R	mm	9,8	10,7	11,5	13,4	15,4
Basic radial dynamic load rating[2]	C	N	4 850	8 800	10 500	13 300	23 700
Basic radial static load rating	C_0	N	11 900	21 900	27 000	35 000	72 000
Basic axial dynamic load rating	C_a	N	6 800	12 400	14 800	18 800	33 000
Basic axial static load rating	C_{0a}	N	29 500	55 000	68 000	88 000	180 000
Permissible dynamic tilting moment[3]	$M_{dyn\ max}$	Nm	74	124	187	258	580
Permissible static tilting moment[4]	M_0	Nm	162	348	494	778	2 090
Permissible axial load[5]	F_A	N	3 510	6 410	7 650	9 720	17 070
Permissible radial load[5]	F_R	N	2 500	4 550	5 430	6 870	12 250
Tilting rigidity[6]	K_B	Nm/arcmin	30	55	91	150	460

[1] Distance between the centre of the bearing and the screw mounting surface on the inner ring.

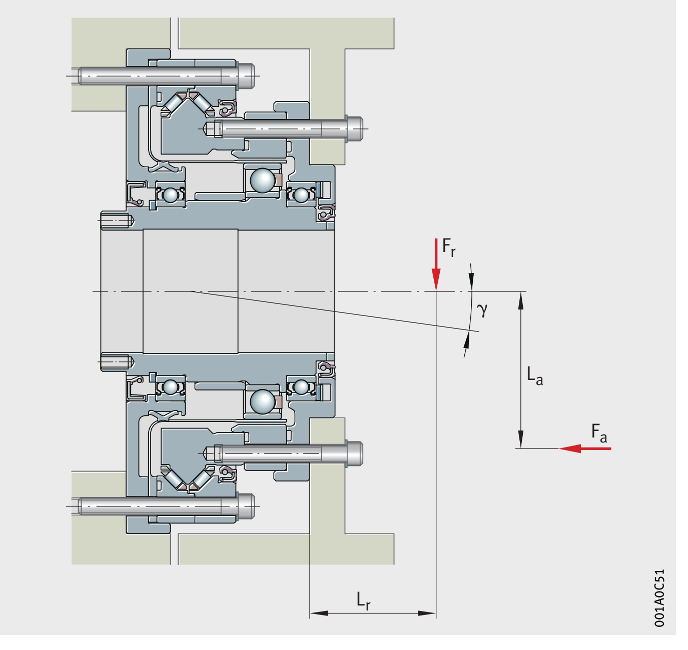
[2] For life calculation with dynamic equivalent radial load P_c.

[3] $M_{dyn\ max}$ describes the maximum permissible tilting moment in the dynamic state and does not refer to the service life of the bearing.

[4] Valid for a static load and a safety factor of $f_s = 2$.

[5] Permissible load for $L_{h\ 10} = 10\,000$ h, at $n_{av} = 15$ min^{-1}, $M = 0$ and F_r or $F_a = 0$ in each case, pure axial or radial load.

[6] Calculated values from simulation.



F_r = radial force
γ = tilting angle
L_a = distance
F_a = axial force
L_r = distance

Figure 2
Output bearing XZU-H for version BHS, BMS, UHS, UHS-T

Output bearing XZU-C for version BMS

Features	Symbol	Unit	Size				
			14	17	20	25	32
Pitch circle ∅	d_M	mm	37	45	54,5	67	89,1
Distance[1)]	R	mm	9,4	9,4	9,4	10,6	12,4
Basic radial dynamic load rating[2)]	C	N	3 900	4 300	4 850	9 300	13 300
Basic radial static load rating	C_0	N	7 800	9 500	11 900	24 100	35 000
Basic axial dynamic load rating	C_a	N	5 500	6 000	6 800	13 100	18 800
Basic axial static load rating	C_{0a}	N	19 600	23 800	29 500	60 000	88 000
Permissible dynamic tilting moment[3)]	$M_{dyn\ max}$	Nm	41	64	91	156	313
Permissible static tilting moment[4)]	M_0	Nm	75	106	162	403	778
Permissible axial load[5)]	F_A	N	2 840	3 100	3 510	6 770	9 720
Permissible radial load[5)]	F_R	N	2 010	2 220	2 500	4 810	6 870
Tilting rigidity[6)]	K_B	Nm/arcmin	17	30	50	91	150

1) Distance between the centre of the bearing and the screw mounting surface on the inner ring.

2) For life calculation with dynamic equivalent radial load P_c.

3) $M_{dyn\ max}$ describes the maximum permissible tilting moment in the dynamic state and does not refer to the service life of the bearing.

4) Valid for a static load and a safety factor of $f_s = 2$.

5) Permissible load for $L_{h\ 10} = 10\,000$ h, at $n_{av} = 15\ min^{-1}$, M = 0 and F_r or F_a = 0 in each case, pure axial or radial load.

6) Calculated values from simulation.

F_a = axial force
L_a = distance
γ = tilting angle
F_r = radial force
L_r = distance

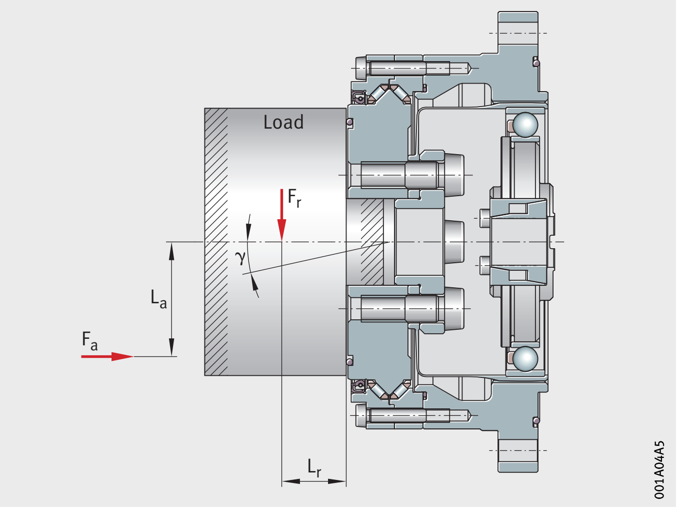


Figure 3
Output bearing XZU-C for version BMS

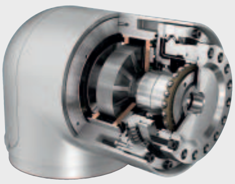
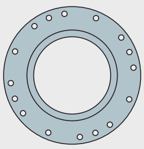
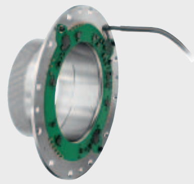
Sensorised precision strain wave gear

Structure

The sensorised precision strain wave gear with integrated torque sensor is particularly suitable for applications that require a high degree of sensitivity.

Components

The sensorised precision strain wave gear consists of a precise strain wave gear, a torque sensor and an electronic sensor system that picks up the torque signal directly from the Flexspline.

Joint	Sensor element	Electronic system	Speed controller
	 +	 +	

Torque sensor with Sensotect coating

Sensotect is a sensory coating that facilitates expansion in the functions of components.

This coating system is used for the continuous measurement of force and torque on two-dimensional and three-dimensional component geometries. The Sensotect coating is applied by means of PVD technology and subsequent laser structuring directly onto the component surface.

Concept
Torque sensor

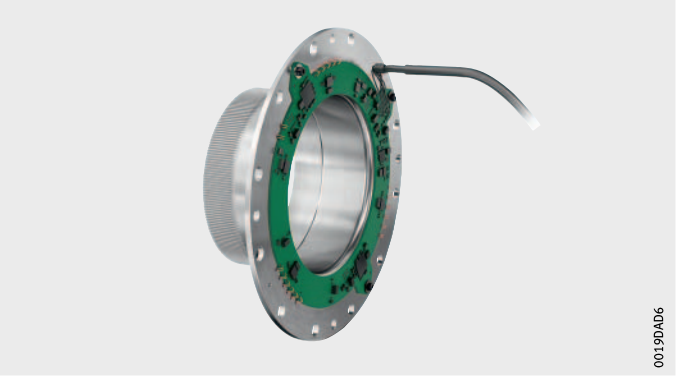


Figure 1
Flexspline with integrated electronic control and signal processing system

A system of strain gauges is applied directly to the flange section of the Flexspline (Sensotect coating).

The Sensotect technology combines standard strain gauge material with the option of individually adapting the structure to the deformation properties.

The electronic control and signal processing system is also adapted directly to the Flexspline, in order to keep the connecting cables as short as possible.

The signals of all strain gauges are processed by a neuronal network running a multilayer perceptron AI.

Functional safety

The torque sensor has been developed to support functional safety requirements up to ISO 13849 Category 3 PL c. It has a redundant multi-channel design and other functions, such as:

- Plausibility check in the interface
  (cyclic redundancy check, life counter)
- Microcontroller prepared for functional safety
- Wire break detection

Measurement

The precise measurement of minimal changes in force and torque within the joints using sensorised precision strain wave gears supports “smooth direct teaching” and makes operation significantly easier.

Accuracy

Most influencing factors take effect outside of the sensor element and consequently have an impact on accuracy.

Each sensorised precision strain wave gear is calibrated and subsequently checked before delivery to the customer, taking into account the effects on the measurement chain. This guarantees a full scale accuracy value of 1,5% for the main measurement range, applicable to the entire precision strain wave gear.

Increased performance and higher sensitivity

The Sensotect coating with a layer thickness of 10 μm offers excellent long-term stability and is unaffected by temperature influences. The Sensotect coating enables direct torque measurement with a high degree of sensitivity and minimal deviation in hysteresis and linearity. Since the sensorised precision strain wave gear does not require any additional installation space, it has no effect on the mechanical system or torsional rigidity. The advantages of this technology are demonstrated in cobots, for example.

Compared with the larger industrial robots, cobots have been significantly disadvantaged to date due to their slimline design and greater elasticity. The slimline cobot structure vibrates noticeably at higher accelerations, particularly in positioning with maximum deceleration. The advantages gained through high velocities and accelerations with short cycle times are lost due to longer settling times in positioning.

The use of the sensorised precision strain wave gear in each joint of a cobot, combined with vibration compensation by robot manufacturers using control technology, offers active vibration compensation with improved dynamics and increased velocities with simultaneous positioning accuracy.

The measurement of force and torque changes in the joints also supports self-optimisation of the cobots.

Figure 2
Cobot with precision strain wave gear RT1-T

Sensorised precision strain wave gear

Comparison

With external torque sensors, the torsional rigidity of a joint can drop to between 25% and 60% of its original value due to the additional elasticity introduced. With the concept developed by Schaeffler, the torsional rigidity of the joint is retained 100%.

In the case of strain wave gears with an external torque sensor, there are many factors influencing the measurement chain. Sensorised precision strain wave gears from Schaeffler are calibrated and checked prior to delivery, taking into account the effects on the measurement chain.

The differences between the two concepts are described below.

Integrated torque sensor (Schaeffler solution)

With the Flexspline, an existing component in the drive train is used. The torque can be measured without an additional elastic element.

① Sensorised precision strain wave gear RT1-T
② Cobot joint

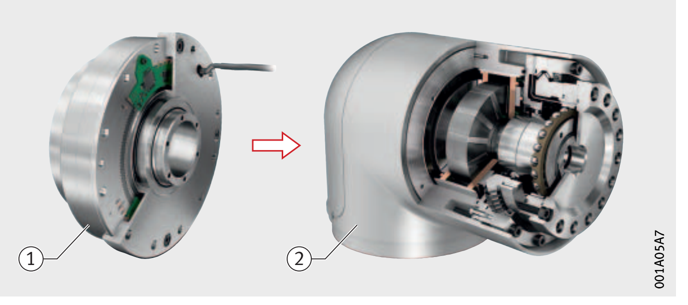
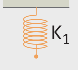


Figure 3
Sensorised precision strain wave gear RT1-T as an integral component of a joint



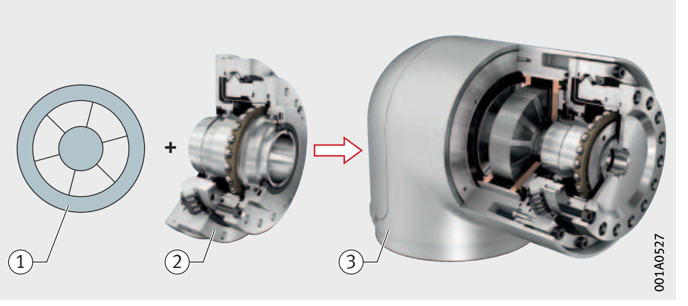
$$K_{tot} = K_1$$

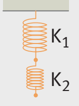
Features when using the sensorised precision strain wave gear from Schaeffler:

- System stiffness remains at 100%
- Additional weight approx. 10 g
- No additional installation space required
- No negative influence on the relevant joint parameters
- Guaranteed full scale measurement accuracy of 1,5% for the main measurement range, applicable to the entire precision strain wave gear

External torque sensor (conventional solution)

The torque is measured with an additional elastic element.





$$K_{tot} = \frac{K_1 \cdot K_2}{K_1 + K_2}$$

① Sensor
② Precision strain wave gear
③ Cobot joint

Figure 4
External torque sensor as additional elastic element

Features when using an external torque sensor:

- Reduction in system stiffness to approx. 25% to 60%
- Additional weight approx. 200 g
- Additionally required installation space approx. 15 mm
- The measurement accuracy of the external torque sensor decreases under the influence of various external factors on the entire strain wave gear.

Sensor concept and torsional rigidity

The effect that the torsional rigidity of internal and external torque sensors has on dynamic behaviour can be explained by comparing both of these concepts in an extreme case, in which the motor accelerates with a mass moment of inertia of 7,6 kgm^2 from zero and then decelerates the drive until it returns to a stop.

The RT1-T precision strain wave gear from Schaeffler with integrated torque sensor provides the basis for this.

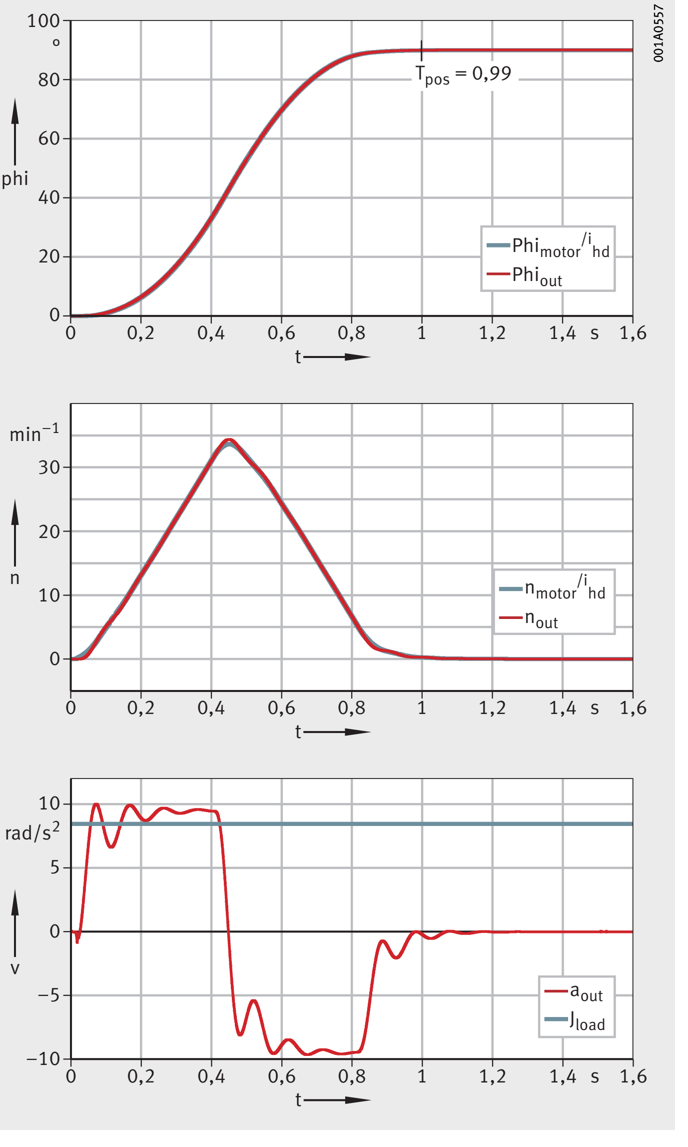


Figure 5
Precision strain wave gear RT1-T with internal sensor

The RT1 precision strain wave gear from Schaeffler with external sensors provides a basis for comparison here.

The positioning time is 1 s. Considerably unstable behaviour is demonstrated with very large acceleration peaks.

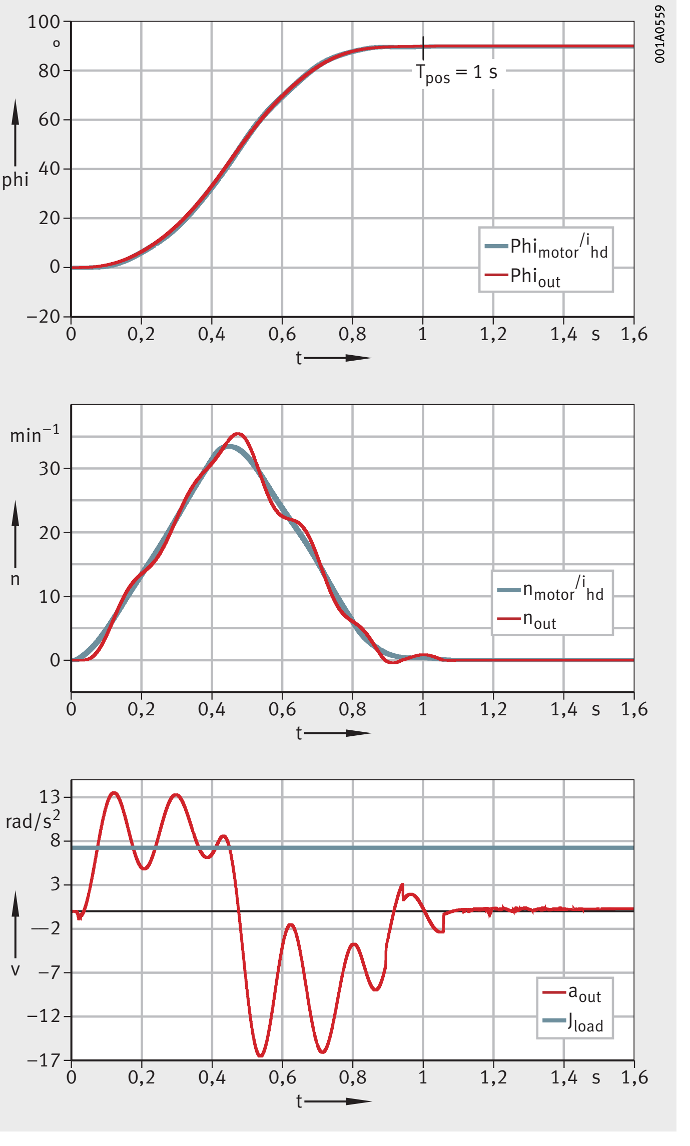


Figure 6
Precision strain wave gear RT1 with external sensor

In order to improve dynamic behaviour, the control parameters were adjusted in this simulation. As a result, reductions in the acceleration peaks were achieved, but at the expense of the positioning time, which increases to 1,298 s.

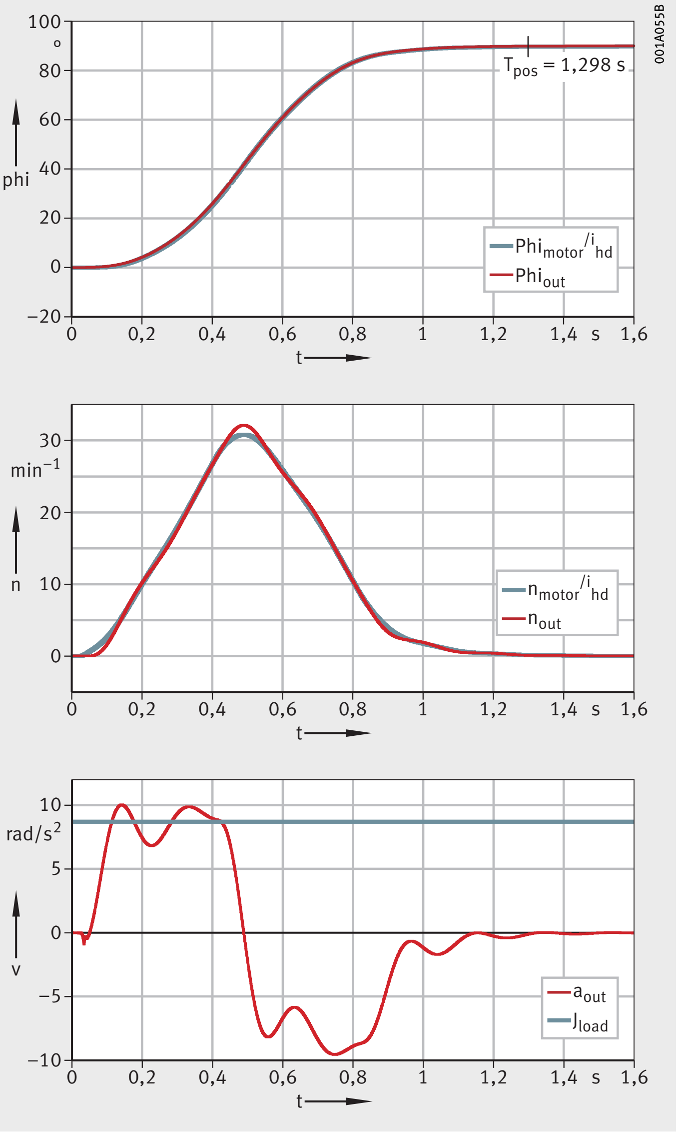


Figure 7
Precision strain wave gear RT1
with external sensor

The simulation was performed for the rotational axis of a single joint. Naturally, the conditions for six joints and the correspondingly variable spatial positions of a cobot are considerably more complex, with considerably greater effects. The simplified example does, however, illustrate the positive influence of torque sensors on the positioning time, if they do not reduce the torsional rigidity of the joint.

SCHAEFFLER

Precision strain wave gears RT1

High Torque

Precision strain wave gears RT1

Component Set

H-..-CS

Basic Unit Hollow Shaft

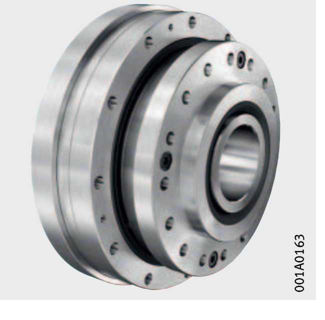
H-..-BHS

Basic Unit Motor Shaft

H-..-BMS

Unit Hollow Shaft

H-..-UHS



Precision strain wave gears RT1

Features

Precision strain wave gears of the High Torque RT1 series are compact, lightweight gears with a high positioning accuracy.

They permit very high torques with lifetime precision in a small installation space. The torque range extends from 23 Nm to 484 Nm. Precision strain wave gears of the High Torque RT1 series are available in five different sizes and with five different gear reduction ratios. They are available as a Component Set, variant HAT.

Compared with the Standard Torque RT2 series, the High Torque RT1 series is characterised by a torque that is up to 30% higher and a service life that is up to 40% longer.

Version		Gear characteristic		
		Variant HAT	Output bearing	Drive side
Component Set	CS	●	–	Direct motor attachment with clamping element
Basic Unit Hollow Shaft	BHS	●	●	With hollow shaft
Basic Unit Motor Shaft	BMS	●	●	Direct motor attachment with clamping element
Unit Hollow Shaft	UHS	●	●	Sealed gearbox with housing and hollow shaft

Precision strain wave gears RT1

Component Set (CS)

Version CS is the basic version of all gear variants and consists of the three main components of a strain wave gear:

- Wave Generator
- Flexspline
- Circular Spline

The precision strain wave gears of the RT1 series are based on the Component Set, variant HAT. This variant is particularly suitable for applications that require a large hollow shaft. The Component Set, variant HAT, offers excellent positioning accuracy and lifetime precision with low weight and compact dimensions. The housing, output bearing arrangement and input shaft can be configured according to requirements and can be adapted for the desired drive solution.

Figure 1
RT1-H-..-CS

Basic Unit Hollow Shaft (BHS)

Version BHS consists of a Component Set, variant HAT, and a tilt-resistant, double row angular contact needle roller bearing XZU as the output bearing.

A particular feature of this version is the central hollow shaft, which permits the passage of a mechanical shaft or the necessary energy supply cables, for example.

The hollow shaft, low weight and short overall length reduce the design effort in many applications.

Figure 2
RT1-H-..-BHS

Basic Unit Motor Shaft (BMS)

Version BMS consists of a Component Set, variant HAT, a tilt-resistant, double row angular contact needle roller bearing XZU as the output bearing, and an integrated clamping element for motor attachment.

The integrated clamping element ensures a backlash-free and economical connection between the motor shaft and precision strain wave gear. The precise and tilt-resistant output bearing and simple motor connection minimise possible installation errors.

Figure 3
RT1-H-..-BMS

Unit Hollow Shaft (UHS)

Version UHS consists of a Component Set, variant HAT, and a tilt-resistant, double row angular contact needle roller bearing XZU as the output bearing.

The fully sealed version UHS is suitable for axial or parallel motor attachment and can be integrated into the application with minimal design and assembly work.

A particular feature of this version is the central hollow shaft, which permits the passage of a mechanical shaft or the necessary energy supply cables, for example.

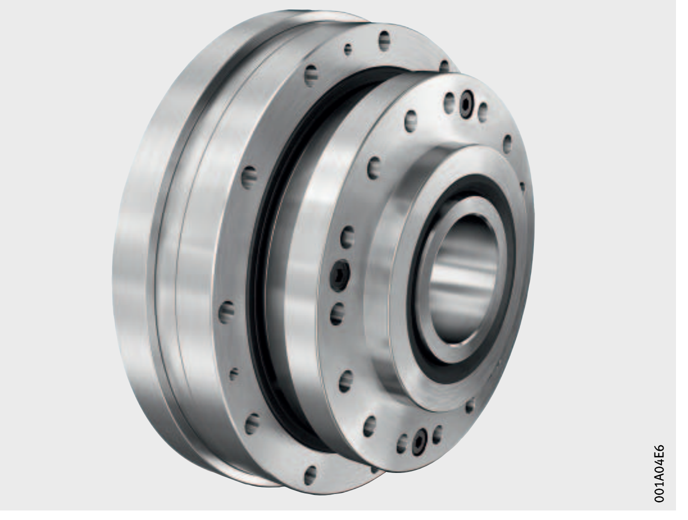


Figure 4
RT1-H-..-UHS

Ordering example, ordering designation

Structure of the ordering designation for precision strain wave gears of the High Torque RT1 series.

RT1 – H – 25 – 100 – UHS

Short code

RT1	Robot Transmission High Torque

Variant

H	HAT standard variant

Size

14 to 32	Size

Nominal gear ratio

50 to 160	Gear ratio e.g. 50:1

Version

CS	Component Set
BHS	Basic Unit Hollow Shaft
BMS	Basic Unit Motor Shaft
UHS	Unit Hollow Shaft

001A15C0

Figure 5
Structure of the ordering designation

Ordering example

Series High Torque RT1	RT1
Variant HAT	H
Size	25
Gear ratio, for example 100:1	100
Basic Unit Hollow Shaft	UHS

Ordering designation

RT1-H-25-100-UHS

Explanation of symbols

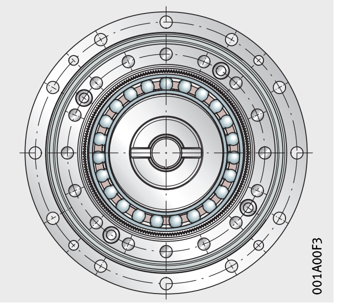
The explanations refer to the data in the following product tables.

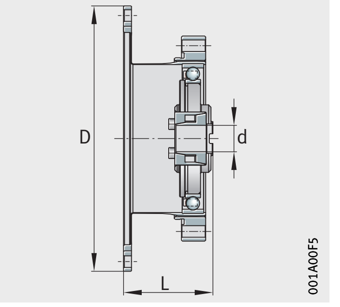
i Gear reduction ratio	–
T_R Maximum torque	Nm
T_A Average torque	Nm
T_N Rated torque	Nm
T_M Collision torque	Nm
n_{max} Maximum input drive speed	min^{-1}
$n_{av\ max}$ Average input drive speed	min^{-1}
φ_{TA} Transmission accuracy	arcmin
φ_R Repeat accuracy	arcmin
φ_H Hysteresis loss	arcmin
J Mass moment of inertia	10^{-4} kg·m^2
K_1 Torsional rigidity	Nm/rad
K_2 Torsional rigidity	Nm/rad
K_3 Torsional rigidity	Nm/rad
T_{NLST} No load starting torque at +20 °C	mNm
T_{NLRT} No load running torque at +20 °C and 2 000 min^{-1}	mNm
T_{BT} Back driving torque at +20 °C	Nm
m Mass	kg
D Diameter	nm
L Length	mm
d Shaft diameter	nm

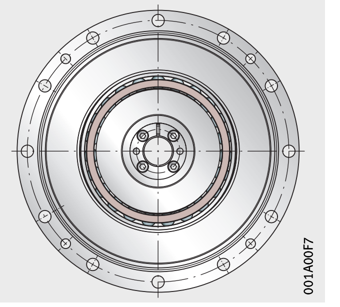
Product table

Designation	Performance data									
	i	T_R Nm	T_A Nm	T_N Nm	T_M Nm	n_{max} min^{-1}	$n_{av\ max}$ min^{-1}	φ_{TA} arcmin	φ_R arcmin	φ_H arcmin
RT1-H-14-CS	50	23	9	7	46	8 500	3 500	$< 1,5$	$< \pm 0,1$	< 2
	100	36	14	10	70					< 1
RT1-H-17-CS	50	44	34	21	91	7 300	3 500	$< 1,5$	$< \pm 0,1$	< 2
	100	70	51	31	143					< 1
	120	70	51	31	112					< 1
RT1-H-20-CS	100	107	64	52	191	6 000	3 500	< 1	$< \pm 0,1$	< 1
RT1-H-25-CS	50	127	72	51	242	5 600	3 500	< 1	$< \pm 0,1$	< 2
	100	204	140	87	369					< 1
	120	217	140	87	395					< 1
RT1-H-32-CS	80	395	217	153	738	4 800	3 500	< 1	$< \pm 0,1$	< 1
	120	459	281	178	892					< 1
	160	484	281	178	892					< 1

CAD download:
https://cdn.schaeffler-ecommerce.com/downloads/robotics/RT1-H-..-CS.zip







							Mass	Dimensions		
J 10^{-4} kg·m^2	K_1 Nm/rad	K_2 Nm/rad	K_3 Nm/rad	T_{NLST} mNm	T_{NLRT} mNm	T_{BT} Nm	≈ m kg	D mm	L mm	d mm
0,036	3 400	4 700	5 700	33	36	1,74	0,11	70	23,5	6
	4 700	6 100	7 100	21	35	2,21				
0,065	8 100	11 000	13 000	61	53	2,68	0,18	80	26,5	8
	10 000	14 000	16 000	29	51	3,06				
	10 000	14 000	16 000	27	51	3,41				
0,155	16 000	25 000	29 000	37	105	3,89	0,31	90	29	9
0,36	25 000	34 000	44 000	120	199	6,32	0,48	110	34	11
	31 000	50 000	57 000	69	195	7,26				
	31 000	50 000	57 000	63	195	7,96				
1,34	67 000	110 000	120 000	160	401	13,5	0,89	142	42	14
	67 000	110 000	120 000	130	399	16,4				
	67 000	110 000	120 000	120	398	20,2				

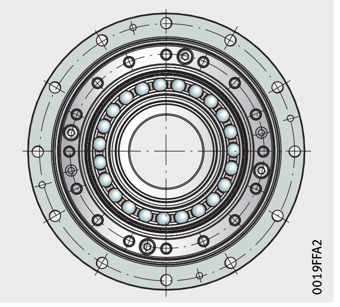
Precision strain wave gears

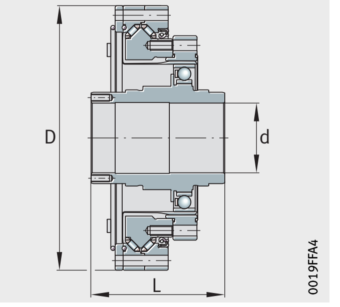
Series RT1-H-..-BHS

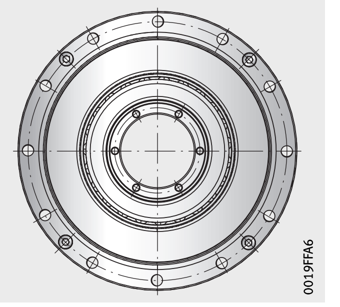
Product table

Designation	Performance data									
	i	T_R Nm	T_A Nm	T_N Nm	T_M Nm	n_{max} min^{-1}	$n_{av\,max}$ min^{-1}	φ_{TA} arcmin	φ_R arcmin	φ_H arcmin
RT1-H-14-BHS	50	23	9	7	46	8 500	3 500	$< 1,5$	$< \pm 0,1$	< 2
	100	36	14	10	70					< 1
RT1-H-17-BHS	50	44	34	21	91	7 300	3 500	$< 1,5$	$< \pm 0,1$	< 2
	100	70	51	31	143					< 1
	120	70	51	31	112					< 1
RT1-H-20-BHS	100	107	64	52	191	6 000	3 500	< 1	$< \pm 0,1$	< 1
RT1-H-25-BHS	50	127	72	51	242	5 600	3 500	< 1	$< \pm 0,1$	< 2
	100	204	140	87	369					< 1
	120	217	140	87	395					< 1
RT1-H-32-BHS	80	395	217	153	738	4 800	3 500	< 1	$< \pm 0,1$	< 1
	120	459	281	178	892					< 1
	160	484	281	178	892					< 1

CAD download:
https://cdn.schaeffler-ecommerce.com/downloads/robotics/RT1-H-..-BHS.zip







							Mass	Dimensions		
J 10^{-4} kg·m²	K_1 Nm/rad	K_2 Nm/rad	K_3 Nm/rad	T_{NLST} mNm	T_{NLRT} mNm	T_{BT} Nm	≈ m kg	D mm	L mm	d mm
0,08	3 400	4 700	5 700	33	36	1,74	0,41	70	52,5	14
	4 700	6 100	7 100	21	35	2,21				
0,17	8 100	11 000	13 000	61	53	2,68	0,59	80	56,5	19
	10 000	14 000	16 000	29	51	3,06				
	10 000	14 000	16 000	27	51	3,41				
0,35	16 000	25 000	29 000	37	105	3,89	0,83	90	51,5	21
1,01	25 000	34 000	44 000	120	199	6,32	1,39	110	55,5	29
	31 000	50 000	57 000	69	195	7,26				
	31 000	50 000	57 000	63	195	7,96				
2,37	67 000	110 000	120 000	160	401	13,5	2,87	142	65,5	36
	67 000	110 000	120 000	130	399	16,4				
	67 000	110 000	120 000	120	398	20,2				

Precision strain wave gears

Series RT1-H-..-BMS

Product table

Designation	Performance data									
	i	T_R Nm	T_A Nm	T_N Nm	T_M Nm	n_{max} min^{-1}	$n_{av\ max}$ min^{-1}	φ_{TA} arcmin	φ_R arcmin	φ_H arcmin
RT1-H-14-BMS	50	23	9	7	46	8 500	3 500	< 1,5	< ±0,1	< 2
	100	36	14	10	70					< 1
RT1-H-17-BMS	50	44	34	21	91	7 300	3 500	< 1,5	< ±0,1	< 2
	100	70	51	31	143					< 1
	120	70	51	31	112					< 1
RT1-H-20-BMS	100	107	64	52	191	6 000	3 500	< 1	< ±0,1	< 1
RT1-H-25-BMS	50	127	72	51	242	5 600	3 500	< 1	< ±0,1	< 2
	100	204	140	87	369					< 1
	120	217	140	87	395					< 1
RT1-H-32-BMS	80	395	217	153	738	4 800	3 500	< 1	< ±0,1	< 1
	120	459	281	178	892					< 1
	160	484	281	178	892					< 1

CAD download:
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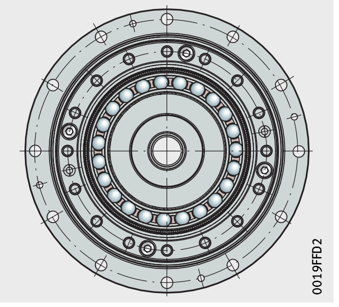

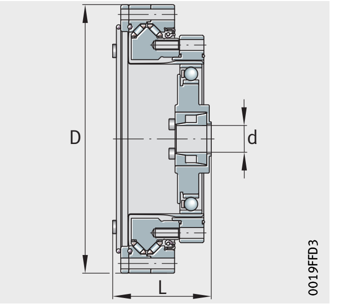

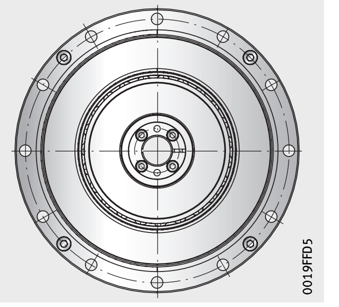

							Mass	Dimensions		
J	K_1	K_2	K_3	T_{NLST}	T_{NLRT}	T_{BT}	≈ m	D	L	d
10^{-4} kg·m^2	Nm/rad	Nm/rad	Nm/rad	mNm	mNm	Nm	kg	mm	mm	mm
0,036	3 400	4 700	5 700	33	36	1,74	0,37	70	28,5	6
	4 700	6 100	7 100	21	35	2,21				
0,065	8 100	11 000	13 000	61	53	2,68	0,52	80	33	8
	10 000	14 000	16 000	29	51	3,06				
	10 000	14 000	16 000	27	51	3,41				
0,155	16 000	25 000	29 000	37	105	3,89	0,72	90	33,5	9
0,36	25 000	34 000	44 000	120	199	6,32	1,2	110	37	11
	31 000	50 000	57 000	69	195	7,26				
	31 000	50 000	57 000	63	195	7,96				
1,34	67 000	110 000	120 000	160	401	13,5	2,53	142	44	14
	67 000	110 000	120 000	130	399	16,4				
	67 000	110 000	120 000	120	398	20,2				

Precision strain wave gears

Series RT1-H-..-UHS

Product table

Designation	Performance data									
	i	T_R Nm	T_A Nm	T_N Nm	T_M Nm	n_{max} min^{-1}	$n_{av\,max}$ min^{-1}	φ_{TA} arcmin	φ_R arcmin	φ_H arcmin
RT1-H-14-UHS	50	23	9	7	46	8 500	1 000	< 1,5	< ±0,1	< 2
	100	36	14	10	70					< 1
RT1-H-17-UHS	50	44	34	21	91	7 300	1 000	< 1,5	< ±0,1	< 2
	100	70	51	31	143					< 1
	120	70	51	31	112					< 1
RT1-H-20-UHS	100	107	64	52	191	6 000	1 000	< 1	< ±0,1	< 1
RT1-H-25-UHS	50	127	72	51	242	5 600	1 000	< 1	< ±0,1	< 2
	100	204	140	87	369					< 1
	120	217	140	87	395					< 1
RT1-H-32-UHS	80	395	217	153	738	4 800	1 000	< 1	< ±0,1	< 1
	120	459	281	178	892					< 1
	160	484	281	178	892					< 1

CAD download:
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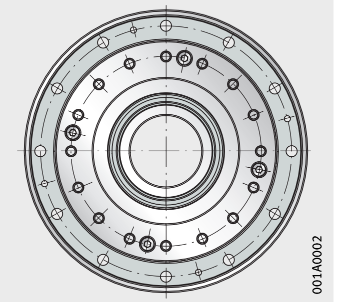
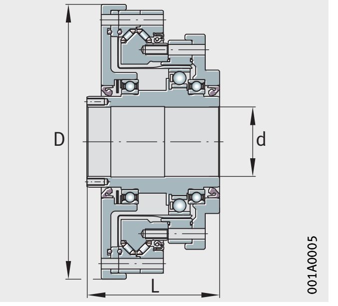
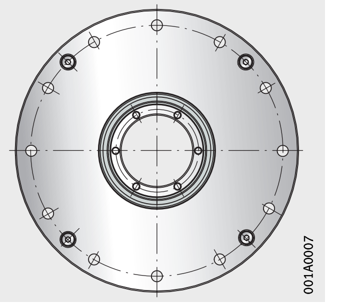






							Mass	Dimensions		
J 10^{-4} kg·m^2	K_1 Nm/rad	K_2 Nm/rad	K_3 Nm/rad	T_{NLST} mNm	T_{NLRT} mNm	T_{BT} Nm	≈ m kg	D mm	L mm	d mm
0,08	3 400	4 700	5 700	88	101	4,63	0,67	74	52,5	14
	4 700	6 100	7 100	69	100	7,26				
0,17	8 100	11 000	13 000	270	260	14,2	0,92	84	56,5	19
	10 000	14 000	16 000	240	260	25,3				
	10 000	14 000	16 000	240	260	30,3				
0,35	16 000	25 000	29 000	320	370	33,7	1,35	95	51,5	21
1,01	25 000	34 000	44 000	560	604	29,5	2,05	115	55,5	29
	31 000	50 000	57 000	490	600	51,6				
	31 000	50 000	57 000	480	599	60,6				
2,37	67 000	110 000	120 000	740	1 002	62,3	4,14	147	65,5	36
	67 000	110 000	120 000	680	999	85,8				
	67 000	110 000	120 000	670	997	113				

SCHAEFFLER

Precision strain wave gears RT2

Standard Torque

Precision strain wave gears RT2

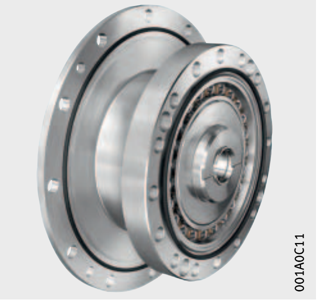
Product overview Precision strain wave gears RT2

Component Set

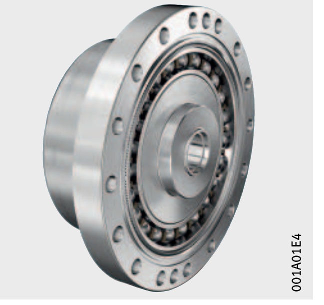
Variant HAT

Variant CUP

H-..-CS



C-..-CS



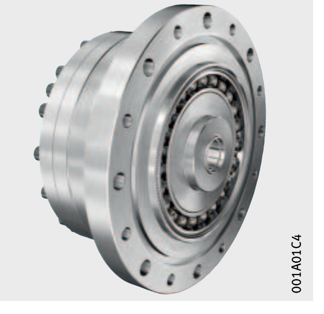
Basic Unit Hollow Shaft

H-..-BHS

Basic Unit Motor Shaft

H-..-BMS

C-..-BMS



Unit Hollow Shaft

H-..-UHS

Precision strain wave gears RT2

Features

Precision strain wave gears of the High Torque RT2 series are compact, lightweight gears with a high positioning accuracy.

They permit very high torques with lifetime precision in a small installation space. The torque range extends from 18 Nm to 372 Nm. Precision strain wave gears of the High Torque RT2 series are available in five different sizes and with five different gear reduction ratios. They are available as a Component Set, variant HAT and variant CUP.

Version		Gear characteristic			
		Variant HAT	Variant CUP	Output bearing	Drive side
Component Set	CS	●	●	–	Direct motor attachment with clamping element
Basic Unit Hollow Shaft	BHS	●	–	●	With hollow shaft
Basic Unit Motor Shaft	BMS	●	●	●	Direct motor attachment with clamping element
Unit Hollow Shaft	UHS	●	–	●	Sealed gearbox with housing and hollow shaft

Component Set (CS)

Version CS is the basic version of all gear variants and consists of the three main components of a strain wave gear:

- Wave Generator
- Flexspline
- Circular Spline

Version CS is available in two variants as:

- Variant HAT,
  for applications that require a large central hollow shaft
- Variant CUP,
  for the realisation of compact, lightweight drive systems

Both variants are supplied without a housing, input shaft and output bearing and therefore offer numerous degrees of freedom for creative drive solutions. Version CS offers excellent positioning accuracy and lifetime precision with low weight and compact dimensions.

Figure 1
RT2-H-..-CS

Figure 2
RT2-C-..-CS

Basic Unit Hollow Shaft (BHS)

Version BHS consists of a Component Set, variant HAT, and a tilt-resistant double row angular contact needle roller bearing XZU as the output bearing.

A particular feature of this version is the central hollow shaft, which permits the passage of a mechanical shaft or the necessary energy supply cables, for example.

The hollow shaft, low weight and short overall length reduce the design effort in many applications.

Figure 3
RT2-..-..-BHS

Basic Unit Motor Shaft (BMS)

Version BMS consists of a Component Set, variant HAT or variant CUP, a tilt-resistant, double row angular contact needle roller bearing XZU as the output bearing, and an integrated clamping element for motor attachment.

The integrated clamping element ensures a backlash-free and economical connection between the motor shaft and precision strain wave gear. The precise and tilt-resistant output bearing and simple motor connection minimise possible installation errors.

Figure 4
RT2-H-..-BMS

Figure 5
RT2-C-..-BMS

Unit Hollow Shaft (UHS)

Version UHS consists of a Component Set, variant HAT, and a tilt-resistant, double row angular contact needle roller bearing XZU as the output bearing.

The fully sealed version UHS is suitable for axial or parallel motor attachment and can be integrated into the application with minimal design and assembly work.

A particular feature of this version is the central hollow shaft, which permits the passage of a mechanical shaft or the necessary energy supply cables, for example.

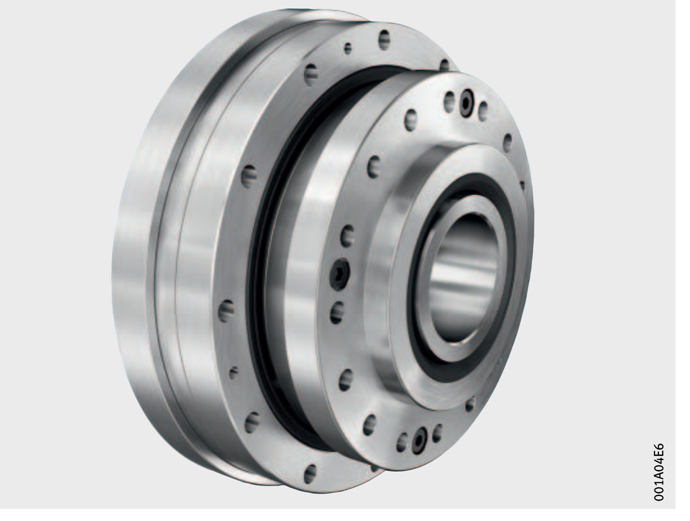


Figure 6
RT2-H-..-UHS

Ordering example, ordering designation

Structure of the ordering designation for precision strain wave gears of the Standard Torque RT2 series.

RT2 – H – 25 – 100 – UHS

Short code

RT2	Robot Transmission Standard Torque

Variant

H	HAT standard variant
C	CUP variant

Size

14 to 32	Size

Nominal gear ratio

50 to 160	Gear ratio e.g. 50:1

Version

CS	Component Set
BHS	Basic Unit Hollow Shaft
BMS	Basic Unit Motor Shaft
UHS	Unit Hollow Shaft

001A15D0

Figure 7
Structure of the ordering designation

Ordering example

Series Standard Torque RT2	RT2
Variant HAT	H
Size	25
Gear ratio, for example 100:1	100
Basic Unit Hollow Shaft	UHS

Ordering designation

RT2-H-25-100-UHS

Precision strain wave gears RT2

Explanation of symbols

The explanations refer to the data in the following product tables.

i Gear reduction ratio	–
T_R Maximum torque	Nm
T_A Average torque	Nm
T_N Rated torque	Nm
T_M Collision torque	Nm
n_{max} Maximum input drive speed	min^{-1}
$n_{av\ max}$ Average input drive speed	min^{-1}
φ_{TA} Transmission accuracy	arcmin
φ_R Repeat accuracy	arcmin
φ_H Hysteresis loss	arcmin
J Mass moment of inertia	10^{-4} kg·m^2
K_1 Torsional rigidity	Nm/rad
K_2 Torsional rigidity	Nm/rad
K_3 Torsional rigidity	Nm/rad
T_{NLST} No load starting torque at +20 °C	mNm
T_{NLRT} No load running torque at +20 °C and 2 000 min^{-1}	mNm
T_{BT} Back driving torque at +20 °C	Nm
m Mass	kg
D Diameter	nm
L Length	mm
d Shaft diameter	nm

Precision strain wave gears

Series RT2-H-..-CS

Product table

Designation	Performance data									
	i	T_R Nm	T_A Nm	T_N Nm	T_M Nm	n_{max} min^{-1}	$n_{av\ max}$ min^{-1}	φ_{TA} arcmin	φ_R arcmin	φ_H arcmin
RT2-H-14-CS	50	18	6,9	5,4	35	8 500	3 500	< 1,5	< ±0,1	< 2
	80	23	11	7,8	47					< 1
	100	28	11	7,8	54					< 1
RT2-H-17-CS	50	34	26	16	70	7 300	3 500	< 1,5	< ±0,1	< 2
	80	43	27	22	87					< 1
	100	54	39	24	110					< 1
	120	54	39	24	86					< 1
RT2-H-20-CS	50	56	34	25	98	6 000	3 500	< 1	< ±0,1	< 2
	80	74	47	34	127					< 1
	100	82	49	40	147					< 1
	120	87	49	40	147					< 1
	160	92	49	40	147					< 1
RT2-H-25-CS	50	98	55	39	186	5 600	3 500	< 1	< ±0,1	< 2
	80	137	87	63	255					< 1
	100	157	108	67	284					< 1
	120	167	108	67	304					< 1
	160	176	108	67	314					< 1
RT2-H-32-CS	50	216	108	76	382	4 800	3 500	< 1	< ±0,1	< 2
	80	304	167	118	568					< 1
	100	333	216	137	647					< 1
	120	353	216	137	686					< 1
	160	372	216	137	686					< 1

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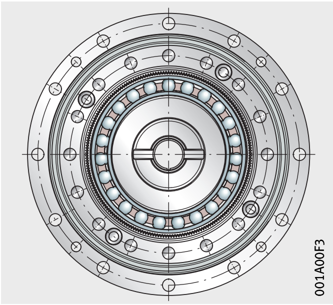

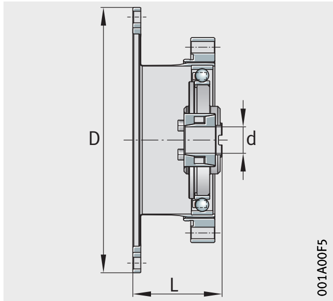

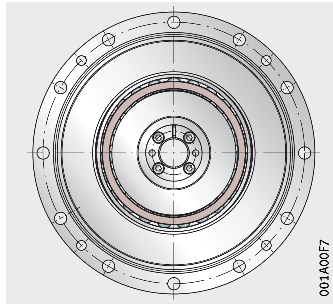

							Mass	Dimensions		
J 10^{-4} kg·m^2	K_1 Nm/rad	K_2 Nm/rad	K_3 Nm/rad	T_{NLST} mNm	T_{NLRT} mNm	T_{BT} Nm	≈ m kg	D mm	L mm	d mm
0,036	3 400	4 700	5 700	33	36	1,74	0,11	70	23,5	6
	4 700	6 100	7 100	24	35	2,02				
	4 700	6 100	7 100	21	35	2,21				
0,065	8 100	11 000	13 000	61	53	2,68	0,18	80	26,5	8
	10 000	14 000	16 000	33	51	2,78				
	10 000	14 000	16 000	29	51	3,06				
	10 000	14 000	16 000	27	51	3,41				
0,155	13 000	18 000	23 000	66	107	3,47	0,31	90	29	9
	16 000	25 000	29 000	41	106	3,45				
	16 000	25 000	29 000	37	105	3,89				
	16 000	25 000	29 000	33	105	4,17				
	16 000	25 000	29 000	29	104	4,88				
0,36	25 000	34 000	44 000	120	199	6,32	0,48	110	34	11
	31 000	50 000	57 000	77	196	6,48				
	31 000	50 000	57 000	69	195	7,26				
	31 000	50 000	57 000	63	195	7,96				
	31 000	50 000	57 000	55	194	9,26				
1,34	54 000	78 000	98 000	260	407	13,7	0,89	142	42	14
	67 000	110 000	120 000	160	401	13,5				
	67 000	110 000	120 000	150	400	15,8				
	67 000	110 000	120 000	130	399	16,4				
	67 000	110 000	120 000	120	398	20,2				

Precision strain wave gears

Series RT2-C-..-CS

Product table

Designation	Performance data								
	i	T_R Nm	T_A Nm	T_N Nm	T_M Nm	n_{max} min^{-1}	$n_{av\ max}$ min^{-1}	φ_{TA} arcmin	φ_R arcmin	φ_H arcmin
RT2-C-14-CS	50	18	6,9	5,4	35	8 500	3 500	< 1,5	< ±0,1	< 2
	80	23	11	7,8	47					< 1
	100	28	11	7,8	54					< 1
RT2-C-17-CS	50	34	26	16	70	7 300	3 500	< 1,5	< ±0,1	< 2
	80	43	27	22	87					< 1
	100	54	39	24	110					< 1
	120	54	39	24	86					< 1
RT2-C-20-CS	50	56	34	25	98	6 000	3 500	< 1	< ±0,1	< 2
	80	74	47	34	127					< 1
	100	82	49	40	147					< 1
	120	87	49	40	147					< 1
	160	92	49	40	147					< 1
RT2-C-25-CS	50	98	55	39	186	5 600	3 500	< 1	< ±0,1	< 2
	80	137	87	63	255					< 1
	100	157	108	67	284					< 1
	120	167	108	67	304					< 1
	160	176	108	67	314					< 1
RT2-C-32-CS	50	216	108	76	382	4 800	3 500	< 1	< ±0,1	< 2
	80	304	167	118	568					< 1
	100	333	216	137	647					< 1
	120	353	216	137	686					< 1
	160	372	216	137	686					< 1

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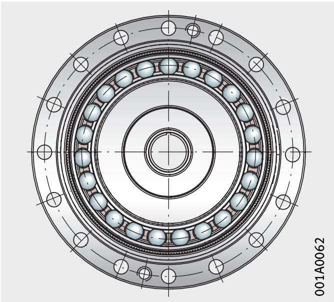
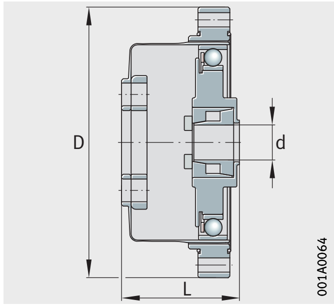
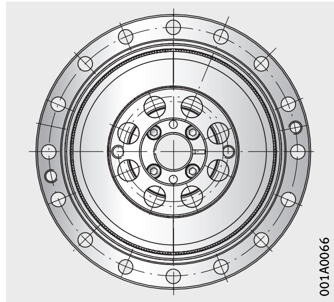
https://cdn.schaeffler-ecommerce.com/downloads/robotics/RT2-C-..-CS.zip







							Mass	Dimensions		
J 10^{-4} kg·m^2	K_1 Nm/rad	K_2 Nm/rad	K_3 Nm/rad	T_{NLST} mNm	T_{NLRT} mNm	T_{BT} Nm	≈ m kg	D mm	L mm	d mm
0,036	3 400	4 700	5 700	33	36	1,74	0,1	50	28,5	6
	4 700	6 100	7 100	24	35	2,02				
	4 700	6 100	7 100	21	35	2,21				
0,065	8 100	11 000	13 000	61	53	2,68	0,14	60	33	8
	10 000	14 000	16 000	33	51	2,78				
	10 000	14 000	16 000	29	51	3,06				
	10 000	14 000	16 000	27	51	3,41				
0,155	13 000	18 000	23 000	66	107	3,47	0,23	70	33,5	9
	16 000	25 000	29 000	41	106	3,45				
	16 000	25 000	29 000	37	105	3,89				
	16 000	25 000	29 000	33	105	4,17				
	16 000	25 000	29 000	29	104	4,88				
0,36	25 000	34 000	44 000	120	199	6,32	0,38	85	37	11
	31 000	50 000	57 000	77	196	6,48				
	31 000	50 000	57 000	69	195	7,26				
	31 000	50 000	57 000	63	195	7,96				
	31 000	50 000	57 000	55	194	9,26				
1,34	54 000	78 000	98 000	260	407	13,7	0,87	110	44	14
	67 000	110 000	120 000	160	401	13,5				
	67 000	110 000	120 000	150	400	15,8				
	67 000	110 000	120 000	130	399	16,4				
	67 000	110 000	120 000	120	398	20,2				

Precision strain wave gears

Series RT2-H-..-BHS

Product table

Designation	Performance data									
	i	T_R Nm	T_A Nm	T_N Nm	T_M Nm	n_{max} min^{-1}	$n_{av\ max}$ min^{-1}	φ_{TA} arcmin	φ_R arcmin	φ_H arcmin
RT2-H-14-BHS	50	18	6,9	5,4	35	8 500	3 500	< 1,5	< ±0,1	< 2
	80	23	11	7,8	47					< 1
	100	28	11	7,8	54					< 1
RT2-H-17-BHS	50	34	26	16	70	7 300	3 500	< 1,5	< ±0,1	< 2
	80	43	27	22	87					< 1
	100	54	39	24	110					< 1
	120	54	39	24	86					< 1
RT2-H-20-BHS	50	56	34	25	98	6 000	3 500	< 1	< ±0,1	< 2
	80	74	47	34	127					< 1
	100	82	49	40	147					< 1
	120	87	49	40	147					< 1
	160	92	49	40	147					< 1
RT2-H-25-BHS	50	98	55	39	186	5 600	3 500	< 1	< ±0,1	< 2
	80	137	87	63	255					< 1
	100	157	108	67	284					< 1
	120	167	108	67	304					< 1
	160	176	108	67	314					< 1
RT2-H-32-BHS	50	216	108	76	382	4 800	3 500	< 1	< ±0,1	< 2
	80	304	167	118	568					< 1
	100	333	216	137	647					< 1
	120	353	216	137	686					< 1
	160	372	216	137	686					< 1

CAD download:
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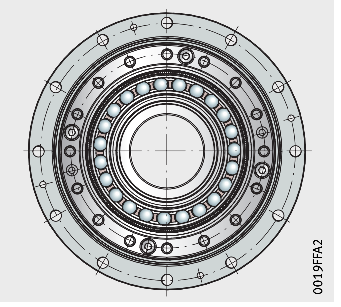

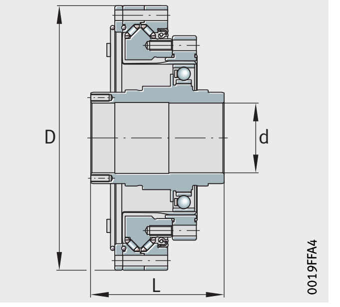

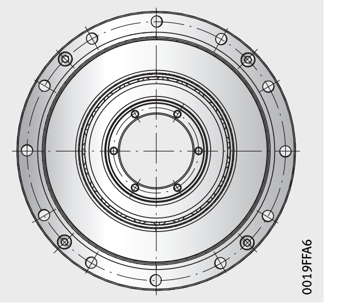

							Mass	Dimensions		
J 10^{-4} kg·m^2	K_1 Nm/rad	K_2 Nm/rad	K_3 Nm/rad	T_{NLST} mNm	T_{NLRT} mNm	T_{BT} Nm	≈ m kg	D mm	L mm	d mm
0,08	3 400	4 700	5 700	33	36	1,74	0,41	70	52,5	14
	4 700	6 100	7 100	24	35	2,02				
	4 700	6 100	7 100	21	35	2,21				
0,17	8 100	11 000	13 000	61	53	2,68	0,59	80	56,5	19
	10 000	14 000	16 000	33	51	2,78				
	10 000	14 000	16 000	29	51	3,06				
	10 000	14 000	16 000	27	51	3,41				
0,35	13 000	18 000	23 000	66	107	3,47	0,83	90	51,5	21
	16 000	25 000	29 000	41	106	3,45				
	16 000	25 000	29 000	37	105	3,89				
	16 000	25 000	29 000	33	105	4,17				
	16 000	25 000	29 000	29	104	4,88				
1,01	25 000	34 000	44 000	120	199	6,32	1,39	110	55,5	29
	31 000	50 000	57 000	77	196	6,48				
	31 000	50 000	57 000	69	195	7,26				
	31 000	50 000	57 000	63	195	7,96				
	31 000	50 000	57 000	55	194	9,26				
2,37	54 000	78 000	98 000	260	407	13,7	2,87	142	65,5	36
	67 000	110 000	120 000	160	401	13,5				
	67 000	110 000	120 000	150	400	15,8				
	67 000	110 000	120 000	130	399	16,4				
	67 000	110 000	120 000	120	398	20,2				

Precision strain wave gears

Series RT2-H-..-BMS

Product table

Designation	Performance data									
	i	T_R Nm	T_A Nm	T_N Nm	T_M Nm	n_{max} min^{-1}	$n_{av\ max}$ min^{-1}	φ_{TA} arcmin	φ_R arcmin	φ_H arcmin
RT2-H-14-BMS	50	18	6,9	5,4	35	8 500	3 500	$< 1{,}5$	$< \pm 0{,}1$	< 2
	80	23	11	7,8	47					< 1
	100	28	11	7,8	54					< 1
RT2-H-17-BMS	50	34	26	16	70	7 300	3 500	$< 1{,}5$	$< \pm 0{,}1$	< 2
	80	43	27	22	87					< 1
	100	54	39	24	110					< 1
	120	54	39	24	86					< 1
RT2-H-20-BMS	50	56	34	25	98	6 000	3 500	< 1	$< \pm 0{,}1$	< 2
	80	74	47	34	127					< 1
	100	82	49	40	147					< 1
	120	87	49	40	147					< 1
	160	92	49	40	147					< 1
RT2-H-25-BMS	50	98	55	39	186	5 600	3 500	< 1	$< \pm 0{,}1$	< 2
	80	137	87	63	255					< 1
	100	157	108	67	284					< 1
	120	167	108	67	304					< 1
	160	176	108	67	314					< 1
RT2-H-32-BMS	50	216	108	76	382	4 800	3 500	< 1	$< \pm 0{,}1$	< 2
	80	304	167	118	568					< 1
	100	333	216	137	647					< 1
	120	353	216	137	686					< 1
	160	372	216	137	686					< 1

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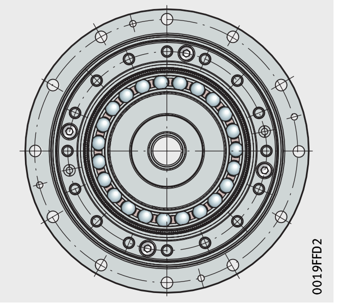

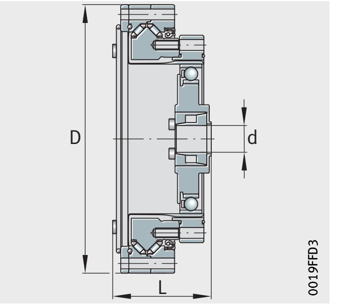

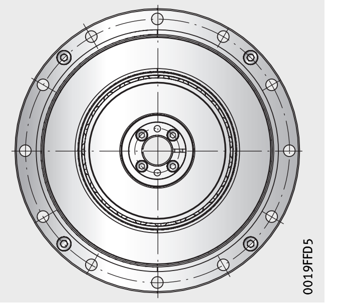

							Mass	Dimensions		
J 10^{-4} kg·m^2	K_1 Nm/rad	K_2 Nm/rad	K_3 Nm/rad	T_{NLST} mNm	T_{NLRT} mNm	T_{BT} Nm	≈ m kg	D mm	L mm	d mm
0,036	3 400	4 700	5 700	33	36	1,74	0,37	70	28,5	6
	4 700	6 100	7 100	24	35	2,02				
	4 700	6 100	7 100	21	35	2,21				
0,065	8 100	11 000	13 000	61	53	2,68	0,52	80	33	8
	10 000	14 000	16 000	33	51	2,78				
	10 000	14 000	16 000	29	51	3,06				
	10 000	14 000	16 000	27	51	3,41				
0,155	13 000	18 000	23 000	66	107	3,47	0,72	90	33,5	9
	16 000	25 000	29 000	41	106	3,45				
	16 000	25 000	29 000	37	105	3,89				
	16 000	25 000	29 000	33	105	4,17				
	16 000	25 000	29 000	29	104	4,88				
0,36	25 000	34 000	44 000	120	199	6,32	1,2	110	37	11
	31 000	50 000	57 000	77	196	6,48				
	31 000	50 000	57 000	69	195	7,26				
	31 000	50 000	57 000	63	195	7,96				
	31 000	50 000	57 000	55	194	9,26				
1,34	54 000	78 000	98 000	260	407	13,7	2,53	142	44	14
	67 000	110 000	120 000	160	401	13,5				
	67 000	110 000	120 000	150	400	15,8				
	67 000	110 000	120 000	130	399	16,4				
	67 000	110 000	120 000	120	398	20,2				

Precision strain wave gears

Series RT2-C-..-BMS

Product table

Designation	Performance data									
	i	T_R Nm	T_A Nm	T_N Nm	T_M Nm	n_{max} min^{-1}	$n_{av\ max}$ min^{-1}	φ_{TA} arcmin	φ_R arcmin	φ_H arcmin
RT2-C-14-BMS	50	18	6,9	5,4	35	8 500	3 500	< 1,5	< ±0,1	< 2
	80	23	11	7,8	47					< 1
	100	28	11	7,8	54					< 1
RT2-C-17-BMS	50	34	26	16	70	7 300	3 500	< 1,5	< ±0,1	< 2
	80	43	27	22	87					< 1
	100	54	39	24	110					< 1
	120	54	39	24	86					< 1
RT2-C-20-BMS	50	56	34	25	98	6 000	3 500	< 1	< ±0,1	< 2
	80	74	47	34	127					< 1
	100	82	49	40	147					< 1
	120	87	49	40	147					< 1
	160	92	49	40	147					< 1
RT2-C-25-BMS	50	98	55	39	186	5 600	3 500	< 1	< ±0,1	< 2
	80	137	87	63	255					< 1
	100	157	108	67	284					< 1
	120	167	108	67	304					< 1
	160	176	108	67	314					< 1
RT2-C-32-BMS	50	216	108	76	382	4 800	3 500	< 1	< ±0,1	< 2
	80	304	167	118	568					< 1
	100	333	216	137	647					< 1
	120	353	216	137	686					< 1
	160	372	216	137	686					< 1

CAD download:
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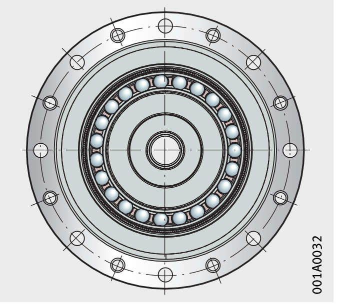

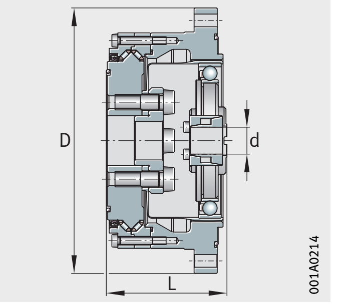

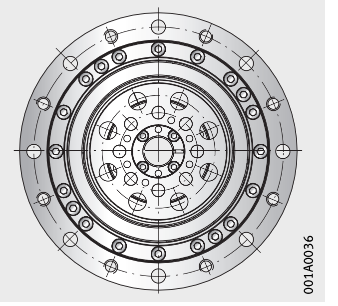

							Mass	Dimensions		
J 10^{-4} kg·m²	K_1 Nm/rad	K_2 Nm/rad	K_3 Nm/rad	T_{NLST} mNm	T_{NLRT} mNm	T_{BT} Nm	≈ m kg	D mm	L mm	d mm
0,036	3 400	4 700	5 700	33	36	1,74	0,49	73	41	6
	4 700	6 100	7 100	24	35	2,02				
	4 700	6 100	7 100	21	35	2,21				
0,065	8 100	11 000	13 000	61	53	2,68	0,62	79	45	8
	10 000	14 000	16 000	33	51	2,78				
	10 000	14 000	16 000	29	51	3,06				
	10 000	14 000	16 000	27	51	3,41				
0,155	13 000	18 000	23 000	66	107	3,47	0,89	93	45,5	9
	16 000	25 000	29 000	41	106	3,45				
	16 000	25 000	29 000	37	105	3,89				
	16 000	25 000	29 000	33	105	4,17				
	16 000	25 000	29 000	29	104	4,88				
0,36	25 000	34 000	44 000	120	199	6,32	1,4	107	52	11
	31 000	50 000	57 000	77	196	6,48				
	31 000	50 000	57 000	69	195	7,26				
	31 000	50 000	57 000	63	195	7,96				
	31 000	50 000	57 000	55	194	9,26				
1,34	54 000	78 000	98 000	260	407	13,7	3	138	62	14
	67 000	110 000	120 000	160	401	13,5				
	67 000	110 000	120 000	150	400	15,8				
	67 000	110 000	120 000	130	399	16,4				
	67 000	110 000	120 000	120	398	20,2				

Precision strain wave gears

Series RT2-H-..-UHS

Product table

Designation	Performance data									
	i	T_R Nm	T_A Nm	T_N Nm	T_M Nm	n_{max} min^{-1}	$n_{av\ max}$ min^{-1}	φ_{TA} arcmin	φ_R arcmin	φ_H arcmin
RT2-H-14-UHS	50	18	6,9	5,4	35	8 500	1 000	< 1,5	< ±0,1	< 2
	80	23	11	7,8	47					< 1
	100	28	11	7,8	54					< 1
RT2-H-17-UHS	50	34	26	16	70	7 300	1 000	< 1,5	< ±0,1	< 2
	80	43	27	22	87					< 1
	100	54	39	24	110					< 1
	120	54	39	24	86					< 1
RT2-H-20-UHS	50	56	34	25	98	6 000	1 000	< 1	< ±0,1	< 2
	80	74	47	34	127					< 1
	100	82	49	40	147					< 1
	120	87	49	40	147					< 1
	160	92	49	40	147					< 1
RT2-H-25-UHS	50	98	55	39	186	5 600	1 000	< 1	< ±0,1	< 2
	80	137	87	63	255					< 1
	100	157	108	67	284					< 1
	120	167	108	67	304					< 1
	160	176	108	67	314					< 1
RT2-H-32-UHS	50	216	108	76	382	4 800	1 000	< 1	< ±0,1	< 2
	80	304	167	118	568					< 1
	100	333	216	137	647					< 1
	120	353	216	137	686					< 1
	160	372	216	137	686					< 1

CAD download:
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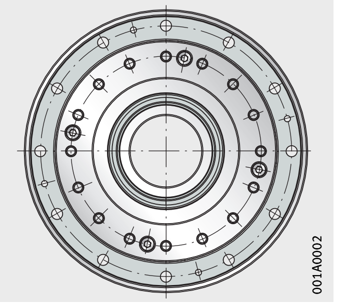
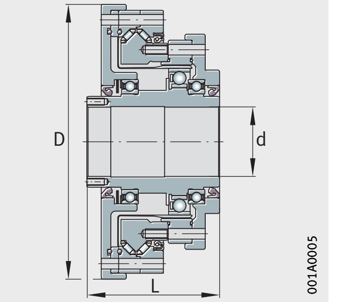
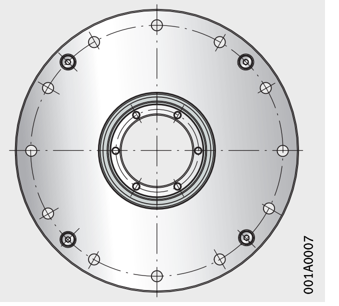






J 10^{-4} kg·m²	K_1 Nm/rad	K_2 Nm/rad	K_3 Nm/rad	T_{NLST} mNm	T_{NLRT} mNm	T_{BT} Nm	Mass ≈ m kg	Dimensions D mm	L mm	d mm
0,08	3 400	4 700	5 700	88	101	4,63	0,67	74	52,5	14
	4 700	6 100	7 100	75	100	6,32				
	4 700	6 100	7 100	69	100	7,26				
0,17	8 100	11 000	13 000	270	262	14,2	0,92	84	56,5	19
	10 000	14 000	16 000	250	260	21,1				
	10 000	14 000	16 000	240	260	25,3				
	10 000	14 000	16 000	240	260	30,3				
0,35	13 000	18 000	23 000	360	373	19	1,35	95	51,5	21
	16 000	25 000	29 000	330	371	27,8				
	16 000	25 000	29 000	320	370	33,7				
	16 000	25 000	29 000	310	370	39,2				
	16 000	25 000	29 000	310	369	52,2				
1,01	25 000	34 000	44 000	560	604	29,5	2,05	115	55,5	29
	31 000	50 000	57 000	500	601	42,1				
	31 000	50 000	57 000	490	600	51,6				
	31 000	50 000	57 000	480	599	60,6				
	31 000	50 000	57 000	470	599	79,2				
2,37	54 000	78 000	98 000	850	1 008	44,7	4,14	147	65,5	36
	67 000	110 000	120 000	740	1 002	62,3				
	67 000	110 000	120 000	720	1 000	75,8				
	67 000	110 000	120 000	680	999	85,8				
	67 000	110 000	120 000	670	997	113				

SCHAEFFLER

Sensorised precision strain wave gear RT1-T

High Torque

Sensorised precision strain wave gear RT1-T

Product overview Sensorised precision strain wave gear RT1-T

Unit Hollow Shaft

With integrated torque sensor

H-..-UHS-T

Sensorised precision strain wave gear RT1-T

Features

Unit Hollow Shaft with integrated torque sensor (UHS-T)

Version UHS-T consists of a Component Set, variant HAT, with an integrated torque sensor and a tilt-resistant, double row angular contact needle roller bearing XZU as the output bearing. The fully sealed version UHS-T is suitable for axial motor attachment and can be integrated into the application with minimal design and assembly work.

A particular feature of this version is the central hollow shaft, which permits the passage of the necessary supply cables, for example.

The technical data for the precision strain wave gear of the High Torque RT1 series remain unaffected by the integration of the torque sensor.

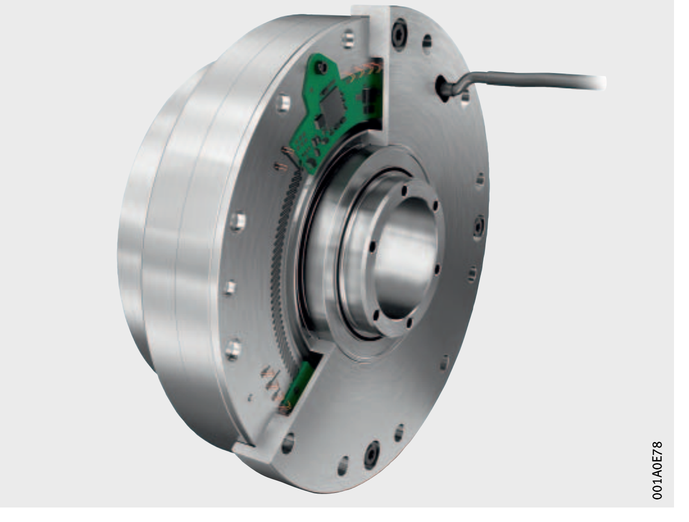


Figure 1
RT1-H-..-UHS-T

Sensorised precision strain wave gear RT1-T

Sensor specifications

Technical data

General					
Designation		RT1-H-..-UHS-T			
Size		14	17	25	32
Sensor characteristics					
Main measurement range (= RPT)	± Nm	36	70	204	484
Accuracy (with main measurement range)[1]	± % FS	1,5			
Maximum measurement range (= MPT)	± Nm	70	143	369	892
Resolution	bit	16			
Output resolution					
Communication		SPI			
		Open wire ends			
		Connector customisable			
Cable length	mm	438 ±8,1 mm			
Operating conditions					
Power supply	VDC	5 ±0,5 V			
Current consumption	mA	500			
Operating temperature range	°C	+0 – +80			
Standards					
Environment-specific capability		EN 61000-6-2, EN 61326-1			
		EN 61000-6-3 (CISPR 11, EN 55011)			
		In accordance with IEC 68000			
		UL94 V-0			
		EU Directive CE 2011/65/EU			
Suitable for robot-assisted use		In accordance with DIN EN ISO 10218-1, DIN EN ISO 10218-2			

[1] FS = ± MPT.

Ordering example, ordering designation

Structure of the ordering designation for precision strain wave gears of the High Torque RT1 series with integrated torque sensor.

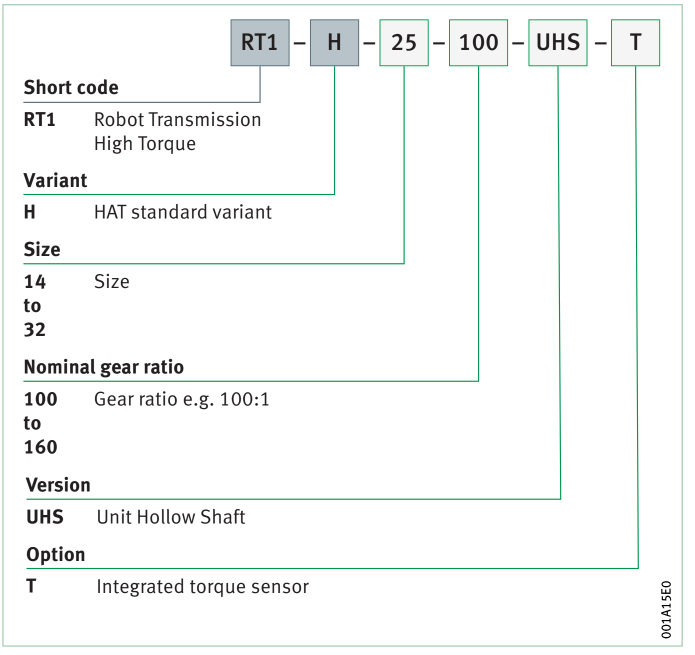


Figure 2
Structure of the ordering designation

Ordering example

Series High Torque RT1	RT1
Variant HAT	H
Size	25
Gear ratio, for example 100:1	100
Basic Unit Hollow Shaft	UHS
Integrated torque sensor	T

Ordering designation

RT1-H-25-100-UHS-T

Sensorised precision strain wave gear RT1-T

Explanation of symbols

The explanations refer to the data in the following product tables.

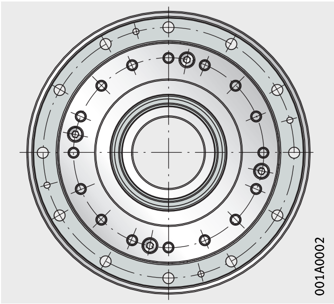
i Gear reduction ratio	–
T_R Maximum torque	Nm
T_A Average torque	Nm
T_N Rated torque	Nm
T_M Collision torque	Nm
n_{max} Maximum input drive speed	min^{-1}
$n_{av\ max}$ Average input drive speed	min^{-1}
φ_{TA} Transmission accuracy	arcmin
φ_R Repeat accuracy	arcmin
φ_H Hysteresis loss	arcmin
J Mass moment of inertia	10^{-4} kg·m^2
K_1 Torsional rigidity	Nm/rad
K_2 Torsional rigidity	Nm/rad
K_3 Torsional rigidity	Nm/rad
T_{NLST} No load starting torque at +20 °C	mNm
T_{NLRT} No load running torque at +20 °C and 2 000 min^{-1}	mNm
T_{BT} Back driving torque at +20 °C	Nm
m Mass	kg
D Diameter	nm
L Length	mm
d Shaft diameter	nm

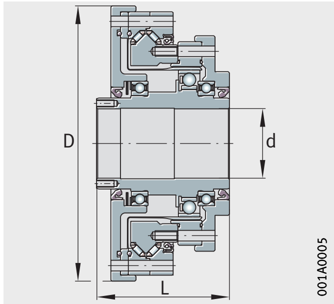
Precision strain wave gears

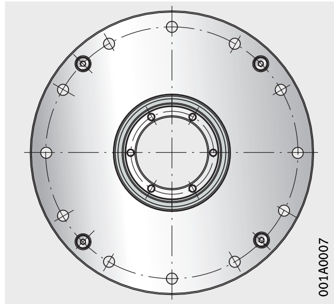
Series RT1-H-..-UHS-T

Product table

Designation	Performance data									
	i	T_R Nm	T_A Nm	T_N Nm	T_M Nm	n_{max} min^{-1}	$n_{av\,max}$ min^{-1}	φ_{TA} arcmin	φ_R arcmin	φ_H arcmin
RT1-H-14-UHS-T	100	36	14	10	70	8 500	1 000	$< 1,5$	$< \pm 0,1$	< 1
RT1-H-17-UHS-T	100	70	51	31	143	7 300	1 000	$< 1,5$	$< \pm 0,1$	< 1
RT1-H-25-UHS-T	100	204	140	87	369	5 600	1 000	< 1	$< \pm 0,1$	< 1
RT1-H-32-UHS-T	160	484	281	178	892	4 800	1 000	< 1	$< \pm 0,1$	< 1







							Mass	Dimensions		
J	K_1	K_2	K_3	T_{NLST}	T_{NLRT}	T_{BT}	≈ m	D	L	d
10^{-4} kg·m^2	Nm/rad	Nm/rad	Nm/rad	mNm	mNm	Nm	kg	mm	mm	mm
0,08	4 700	6 100	7 100	69	100	7,26	0,67	74	52,5	14
0,17	10 000	14 000	16 000	240	260	25,3	0,92	84	56,5	19
1,01	31 000	50 000	57 000	490	600	51,6	2,05	115	55,5	29
2,37	67 000	110 000	120 000	670	997	113	4,14	147	65,5	36

Glossary

A

Average application torque $T_{out\ av}$	Calculated average application torque with variable load cycle.
Average gear input drive speed $n_{av\ max}$	Permissible average input drive speed of the strain wave gear. The catalogue value must not be exceeded in the application.
Average input speed of the application $n_{in\ av}$	Average input speed of the application with variable load cycle.
Average torque T_A	Limit value of the strain wave gear for the average torque. The catalogue value must not be exceeded in the application.

B

Basic radial dynamic load rating C	Permissible dynamic load on the output bearing in dynamic operation.
Buckling torque	Theoretically calculated value derived from the design of the strain wave gear. In a static gear state and with externally applied torque, buckling occurs at around $T_{Buckling} \geqq 16 \times T_N$.

C

Circular Spline	Cylindrical component of the strain wave gear with internal teeth.
Collision torque T_M	If an emergency stop is required during operation, the strain wave gear may be subjected to a brief collision torque. In such cases, damage to the strain wave gear and thus a reduced service life cannot, however, be ruled out. The magnitude and number of emergency stops that occur during operation should be kept to a minimum and remain below the specified collision torque of the precision strain wave gear.

D

Dedoidal	Dedoidal assembly refers to a phenomenon in which the Flexspline skips a tooth on one side.
Distance to bearing centre R	Distance between the load application point and the output bearing centre.

F

Flexspline	Flexible, torsionally rigid component of the strain wave gear with external teeth.
Functional safety	Part of a system that is dependent on the correct functioning of the safety system and on other risk-mitigating measures.

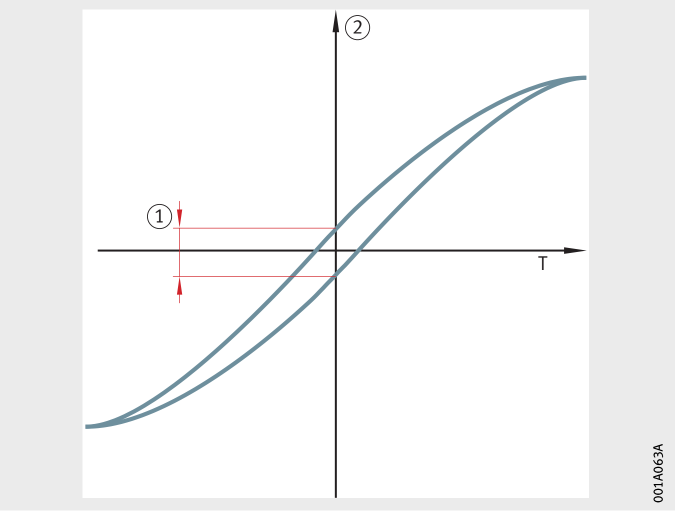
G

Gear reduction ratio i	Ratio of input drive speed to output drive speed.

H

Hysteresis curve

The torque diagram of a strain wave gear has the typical characteristics of a hysteresis curve. The hysteresis curve does not usually pass through the coordinate origin. The angular deviation at zero torque is defined as the hysteresis loss.



T = torque

① Hysteresis loss
② Torsion angle

Figure 1
Hysteresis curve

M

Mass m

Mass of a standard strain wave gear without packaging.

Mass moment of inertia J

Mass moment of inertia at the gear input.

Maximum gear input drive speed n_{max}

Maximum input drive speed that can be used in highly dynamic applications. In order to avoid an impermissible rise in temperature, the maximum input drive speed is permitted for a brief period only. The catalogue value must not be exceeded in the application.

Maximum torque T_R

Maximum acceleration and deceleration torque that can be used for brief periods in highly dynamic applications. This value must not be exceeded in the application.

Mean bearing diameter d_M

Mean diameter of the rolling element raceway at the output bearing.

N

No load backdriving torque

Minimum torque required to backdrive the strain wave gear, starting from the gear output with freely rotatable Wave Generator and a gear temperature of +20 °C.

No load running torque

Running torque in no load operation, determined at a gear temperature of +20 °C and an input speed of 2 000 min^{-1}.

No load starting torque

Starting torque in no load operation, determined at a gear temperature of +20 °C.

Nominal service life L_N

Nominal service life at rated torque and rated speed. This value is 10 000 hours for precision strain wave gears of series RT1 and RT1-T, and 7 000 hours for series RT2.

Glossary

P

Permissible axial load F_A
Permissible axial load with rotating output bearing, without tilting moment and radial load.

Permissible dynamic tilting moment $M_{dyn\ max}$
Maximum permissible tilting moment in dynamic state. This not only takes account of the output bearing life but also the necessary installation requirements of the strain wave gear.

Permissible radial load F_R
Permissible radial load with rotating output bearing, without tilting moment and axial load.

Permissible static tilting moment M_0
Maximum permissible tilting moment in a static state.

R

Ratcheting torque
A theoretically calculated value derived from the design of a strain wave gear. In the dynamic gearing state, ratcheting occurs at an applied torque of approximately $T_{Ratcheting} \geqq 8 \times T_N$. Tooth contact is lost and the teeth slide over each other.

Rated speed n_N
Rated input speed for calculating the life of the Wave Generator and for determining the efficiency.

Rated torque T_N
Reference torque for calculating the life of the Wave Generator and determining the efficiency. When loaded with rated torque and running at rated speed (2 000 min^{-1}), the Wave Generator bearing will reach the nominal service life with a failure probability of 10% for the value L_{10}.

Repeat accuracy
Important characteristic of strain wave gears. In the determination of repeat accuracy, a defined position is repeatedly approached from the same direction. The deviation between the target value and the actual position achieved is measured.

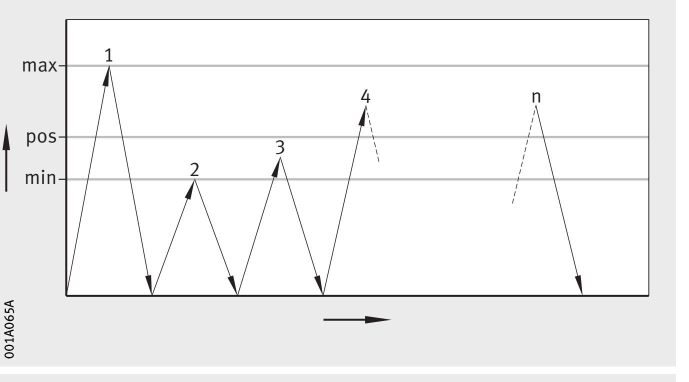


Figure 2
Repeat accuracy

$$\text{Repeat accuracy} = \pm \frac{\varphi_{max} - \varphi_{min}}{2}$$

S

Service life L_{10}

The value L_{10} indicates the anticipated service life for a loaded strain wave gear.

Size

Derived from the pitch circle diameter of the Flexspline in inches multiplied by 10.

T

Tilting angle Y

Tilting angle at the output bearing under tilting moment.

Tilting moment M

Tilting moment at output bearing.

Tilting rigidity K_B

Ratio of applied tilting moment and tilting angle at the output bearing.

Torsional rigidity

Describes the resistance of the strain wave gear to elastic deformation through an applied torque. The torsional angle in a loaded state at the output of the strain wave gear is measured while the strain wave gear input is blocked. The torsional rigidity is the quotient derived from the applied torque and the measured torsional angle. Since torsional rigidity is not linear across the entire torque range, the transmission function $\varphi = f(T)$ is divided into three load ranges. The values for the given torsional rigidity are average values determined in numerous tests.

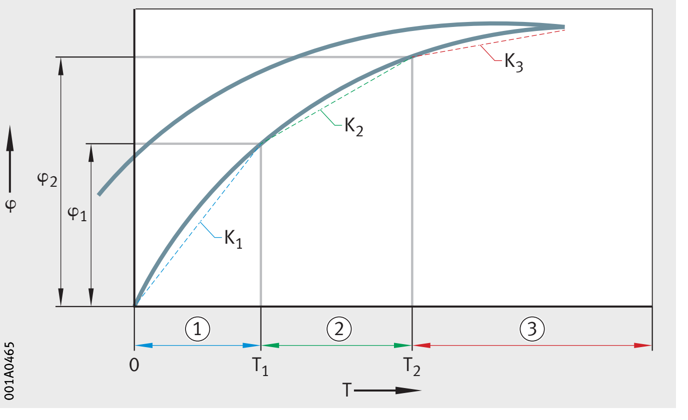


Figure 3
Torsional rigidity

Transmission accuracy

Positional deviation between the measured input position and the measured output position. The transmission accuracy is measured for one direction of rotation and for one complete revolution at gear output. The result is the maximum difference between the variances.

(1) Transmission accuracy
(1) Output drive angle
(1) Maximum rotation error

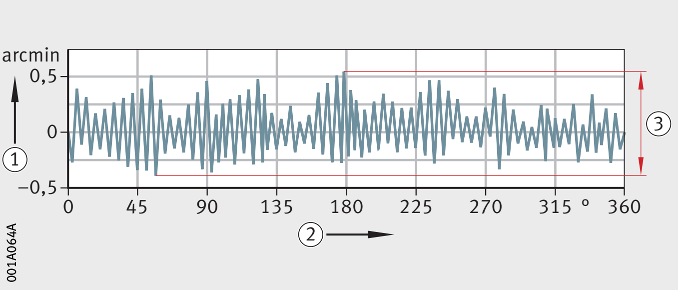


Figure 4
Transmission accuracy

Glossary

W

Wave Generator

Elliptical drive element of the strain wave gear with thin section bearing (Wave Generator).

Working range

The following graphic shows the different working ranges of the strain wave gear. The load at the gear output increases from the operating range, through the collision range, up to the critical working range.

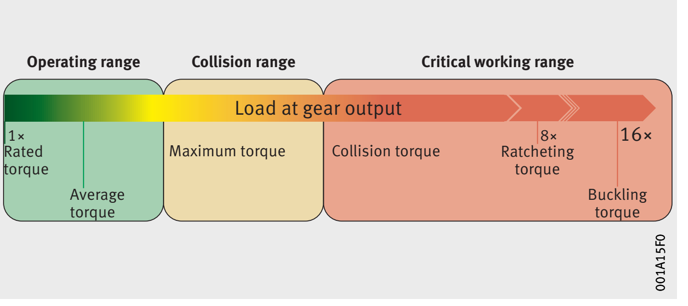


Figure 5
Working range

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