

Harmonic Drive® Gears



Harmonic
Drive SE

Gear component sets

Gears with output bearing

Individual solutions



Robotics, Handling & Automation | Mechanical Engineering |
Medical Technology | Special Environments | Aerospace

Our inspiration

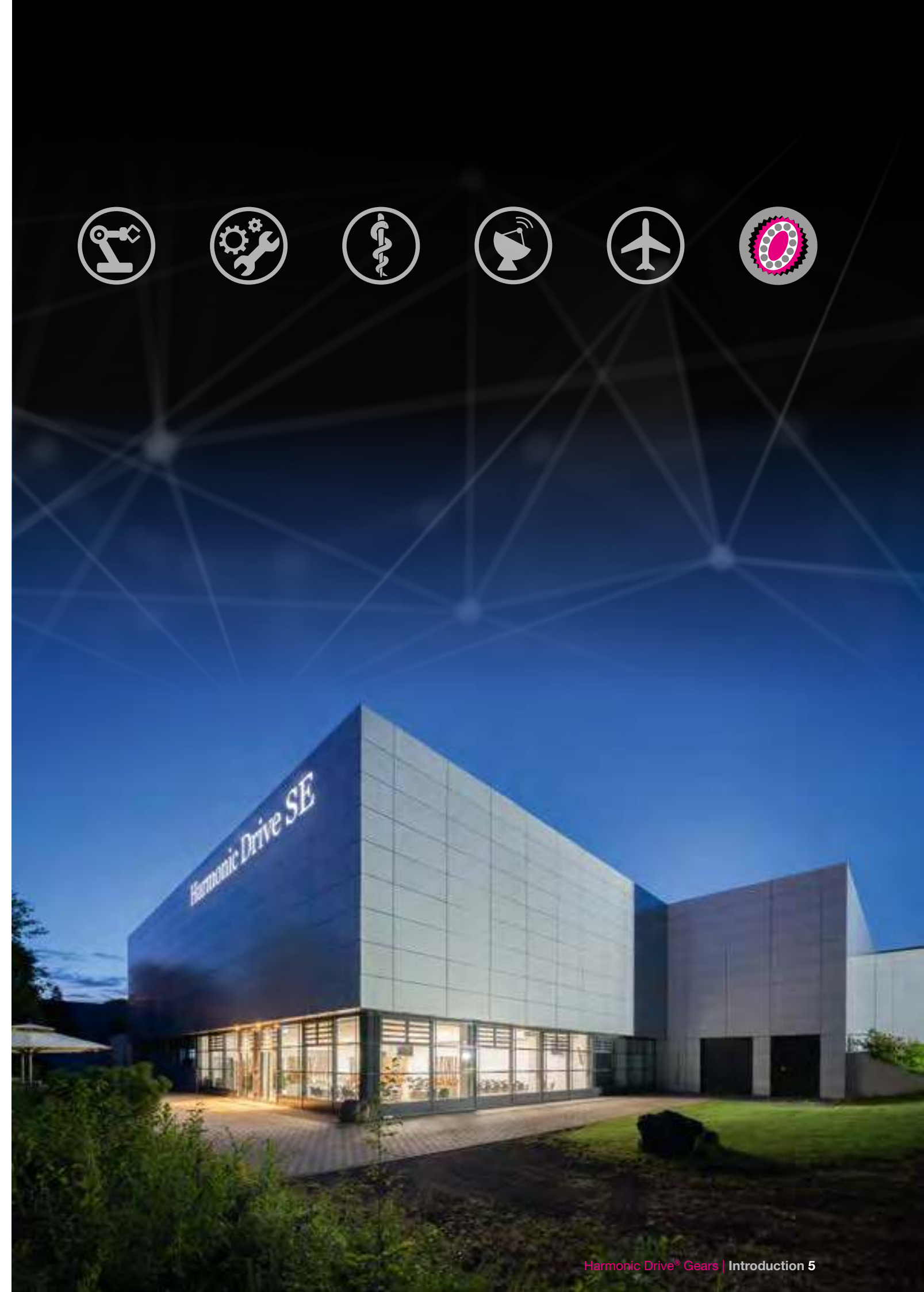
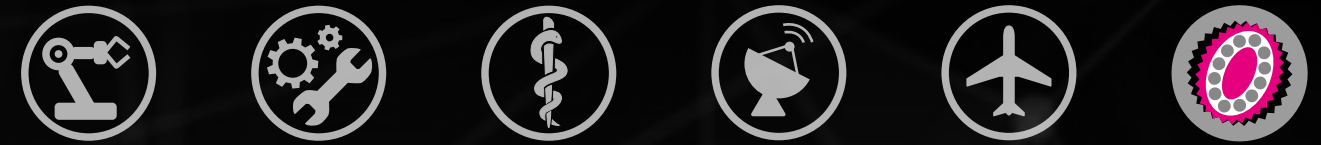
With either Apollo 15 on the moon or in the depths of the rough oceans, for more than 50 years, we have been providing significant applications across the planet and beyond with our drive solutions. We, as an industry leader in high precision drive technology, have not only continued to expand our portfolio based on the unique Harmonic Drive® Strain Wave Gear but have also recognised the requirements of modern, trend setting markets and applications: The future of drive technology is intelligent, sustainable and efficient.

Thanks to their special characteristics, which have been continuously developed over decades, Harmonic Drive® Gears and Actuators are perfectly suited to important key industries, including robotics, handling & automation, mechanical engineering, medical technology, special environments and aerospace.

Highest precision and quality for our customers are key principles of our corporate culture. Eighty percent of our products that leave our factory in Limburg/Lahn are special versions and are therefore specially developed, designed and manufactured according to customer specifications - from space saving gear component sets to intelligent drive systems.

Due to the high complexity in the configuration of suitable drive technology components, we partner and advise our customers comprehensively. The proposed solution for the drive task to be realised is developed in close cooperation to enable the subsequent integration into the application environment without any problems. Vital for this are, on the one hand, the high flexibility and, on the other hand, the customised scope of services and the integration level. The result is an optimal, highly individualised drive solution.

Successfully shaping the future together with, and for our customers, in demanding industries is a sign of our innovative strength in the field of high precision drive technology.



Your global partner

You will find our sophisticated drive solutions all over the globe and even beyond - regardless of whether you are on the Red Planet or the Blue Planet: Motors, actuators and systems from Harmonic Drive SE are used wherever the highest demands are made on quality and reliability. Production and development sites at the highest technological level in Germany, Japan and USA, as well as subsidiaries in Europe and Asia, ensure that we can offer highly specialised and intelligent drive solutions and mechatronic systems worldwide.

Perhaps you will think of us the next time you fly beyond the horizon in an aircraft of the Airbus family: High precision Harmonic Drive® Gears for aviation help you fly safely and have the world at your feet right now.

„It is never a question as to whether it can be done –
it is only whether one cares to spend the time and effort.“

C. Walton Musser, Inventor of the Strain Wave Gear



Harmonic
Drive SE



Your idea, our engineering, your drive solution

We know that the configuration of suitable components is complex. Together with you, we can therefore develop a complete solution proposal for the drive task. Starting with the selection of the most suitable gears and the matching motor and sensor components, we can configure the complete drive axis for your application.

In doing so, we draw on decades of experience. Since 1970, we have been building on a sizeable number of complex drive solutions, giving our customers a definite technological edge. All design elements can be customised and optimally matched to each other. Integration into the application always takes place in close partnership with our customers. The key factors here are, on the one hand, the high flexibility and, on the other hand, the individual scope of services and the level of integration. The result will be optimal overall solution for your application.

In our modern development centre, a team of more than 40 designers and engineers is available on a daily basis. Up-to-date design and calculation tools, self designed tools for fast analytical calculations and equally established FEM supported methods are in place. In the directly connected test field, the newly developed actuators and drive systems are verified for performance and functionality with the help of specific test benches. The knowledge gained from this is fed back into development and gives the basis for further optimisation.

We produce your transmission solution beginning with lot size 1

In addition to a few standard products with higher quantities, our production is dominated by many specialised and diverse assemblies in smaller quantities down to lot size 1. This is because almost all products that leave our premises are configured together with you specifically according to your wishes and requirements and then manufactured in house. In order to achieve this high flexibility in production, we have developed an intelligent setup concept with which we can even manufacture lot size 1 economically.

Production lines per size enable us to change setups smoothly and therefore ensure maximum flexibility - even for small lot sizes. In order to meet these requirements throughout the entire value chain, we rely on longterm supplier relationships based on mutual partnership in the area of supply chain management, which we continuously develop into efficient supplier structures and therefore synchronise with our production system. In this way, we fulfil your wishes individually, no matter what the quantity.

i In the chapter „Individual solutions“ you will find a selection of customised designs that we can realise according to your wishes and requirements.

Highly precise and backlash free gear component sets form the central element of Harmonic Drive® Gears and Servo Actuators. Harmonic Drive® Gear Component Sets consist of only three precision components:

Circular Spline

The Circular Spline is designed as a rigid ring with internal teeth. The Circular Spline has two teeth more than that of Flexspline.

Flexspline

The Flexspline is a high strength, torsionally stiff yet flexible component with external teeth, which reliably transmits high loads.

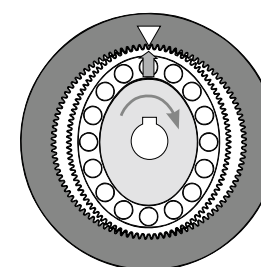
Wave Generator

The Wave Generator is the driven element of the transmission. The elliptical shaped Wave Generator is fitted with a specially designed thin race ball bearing assembly.

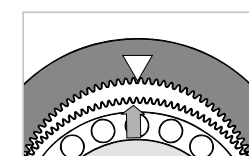
By inserting the Wave Generator into the Flexspline, the Flexspline assumes the elliptical shape of the Wave Generator. The rotating Wave Generator causes the Flexspline to radially deform.

The assembled gear has two diametrically opposed tooth engagement areas around the major axis of the ellipse. The rotation of the Wave Generator causes the meshing of Flexspline with the Circular Spline to move around circumference. Since the Flexspline has two teeth less than the Circular Spline, rotating the Wave Generator leads to a relative movement between the Flexspline and the Circular Spline.

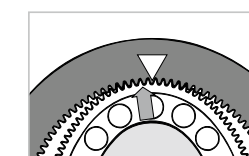
Harmonic Drive® Gears and Servo Actuators are used wherever zero backlash, extraordinary precision and high reliability are required – in all areas where drive technology is required.



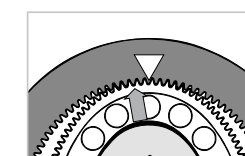
1. Start



2. 1/4 Input rotation



3. 1/2 Input rotation



4. 1/1 Input rotation

FURTHER INFORMATION regarding the strain wave gear principle can be found at www.harmonicdrive.co.uk in section Technology - Harmonic Drive® Strain Wave Gears.

Harmonic Drive® Gears

Harmonic Drive® Gears consist of three individual components – Circular Spline, Flexspline and Wave Generator. Gear component sets with extremely compact design ensures installation in applications with the most demanding space requirements. Gears with output bearings ease integration by combining the precise component sets with high capacity tilt resistant output bearings.



Catalogue
Harmonic Drive® Gears

GEAR COMPONENT SETS



CSG-/HFUC-2A



CPL-2A



CSD-2A



SHG-/HFUS-2A

GEARS WITH OUTPUT BEARING



CSG-/HFUC-2UH



CSF-ULW



CPU-M/H/S



CSD-2UH/2UF



SHG-/HFUS-
2UH/2SH/2SO



SHD-2SH



CSF Mini



PMG



CSF-2UP



FBS-2UH

Harmonic Drive® Servo Actuators

Harmonic Drive® Servo Actuators are the perfect combination of highly dynamic compact servo motors, precision Harmonic Drive® Gear Component Sets and integral high load capacity, tilt resistant output bearings.



Catalogue
Harmonic Drive® Mechatronics

SERVO ACTUATORS WITH HOLLOW SHAFT



IHD



BHA



CanisDrive®



AlopexDrive



FHA-C Mini

SERVO ACTUATORS WITH SOLID SHAFT



LynxDrive



FLA

Harmonic Planetary Gears

Harmonic Planetary Gears have lower gear ratios usually operating higher speeds where there is often the need for very high precision. Our special design with a flexible ring gear in the output stage means that we guarantee constant high precision over the entire lifetime – we call this Permanent Precision®!



Catalogue
Harmonic Planetary Gears



HPN



HPGP



HPG-R



The proven gear components, output bearings, motors and encoder systems form the basis for different product groups of Harmonic Drive SE in the field of high precision drive technology. Harmonic Drive® Gears or Harmonic Planetary Gears are the starting point for all products. In combination with a servo motor and a motor feedback system, highly integrated, compact and powerful servo actuators are created.

Harmonic Drive® Gears

Gear Component Sets

Harmonic Drive® Gear Component Sets work according to the strain wave gear principle and are characterised by high single stage gear ratios, zero backlash and precise motion as well as maximum torques with low weight and compact dimensions. Consisting of only three components Circular Spline, Flexspline and Wave Generator, they enable maximum flexibility in design integration. Harmonic Drive® Gear Component Sets are ideal for applications with existing output bearings. By using the existing bearings and housing structure, they can be used to achieve both a low total weight and a compact design within the application.

Gears with output bearing

Harmonic Drive® Gears with output bearings combine precise gear component sets with a tilt resistant cross roller or four point contact bearing. Due to its compact design and its high concentricity and accuracy, the output bearing complements perfectly with the strain wave gear. Different gear types allow use in different gear configurations. Motor mounted gearboxes provide the prerequisites for providing direct and easy interfacing of servomotors to the gear with little engineering and assembly expense. The hollow shaft gear allows the central implementation of supply cables and shafts.

Harmonic Drive® Servo Actuators

The continuously increasing demands placed on servo actuators require, among other things, perfect interaction between the motor, gears, motor feedback system and controller. To guarantee characteristics such as precision and dynamics, servo actuators from Harmonic Drive SE have a high degree of compatibility.

The option to choose between a zero backlash strain wave gear and a low backlash planetary gear. The tilt resistant output bearing enables the direct attachment of high payloads without additional support and thus permits a simple and space saving design. In addition, there are numerous possible combinations for the motor winding and the motor feedback system as well as choices for brakes, connecting cables and connectors. Due to the flexibility in the configuration of the motor winding and the motor feedback system, the compatibility with almost all servo controllers of

the market is guaranteed. The latest IHD Series also has an integrated drive controller and a dual measuring system for direct control of the position at the gearbox output. This system can be easily implemented in the application by means of fieldbus interfaces.

Harmonic Planetary Gears

Requirements of the market for gears that support high speeds or low ratios often require the highest precision. Harmonic Planetary Gears meet this requirement. Due to their integrated motor connection with clamping element and motor flange, they allow easy mounting of servo motors. The special design with a flexible ring gear in the last stage ensures consistently high precision over the entire service life - we call this Permanent Precision®.

GEARS WITH OUTPUT BEARING

| Series | CSG-2UH/ HFUC-2UH | CPU-M | CPU-H | CPU-S | SHG-2UH/ HFUS-2UH | SHG-2SH/ HFUS-2SH | SHG-2SO/ HFUS-2SO | FBS-2UH |
|------------------------------------|---|---|---|--|---|---|---|---|
| |  |  |  |  |  |  |  |  |
| Type | M | M | CH | S | CH | OH | M | CH |
| Torque capacity and service life | ●●●/●● | ●● | ●● | ●● | ●●●/●● | ●●●/●● | ●●●/●● | ● |
| Transmission accuracy | ●●● | ●●● | ●●● | ●●● | ●●● | ●●● | ●●● | ●● |
| Small outer diameter | ●● | ● | ● | ● | ● | ● | ● | ●● |
| Short design | ●● | ●● | ● | ● | ● | ●● | ●● | ● |
| Tilting moment output bearing | ●● | ●●● | ●●● | ●●● | ●●● | ●●● | ●●● | ●● |
| Low weight | ●● | ● | ● | ● | ● | ●● | ●● | ● |
| Chapter / Page | 2.1 / 98 | 2.3 / 130 | 2.3 / 130 | 2.3 / 130 | 2.5 / 178 | 2.5 / 178 | 2.5 / 178 | 2.10 / 260 |
| Key data | | | | | | | | |
| Maximum torque [Nm] | 9 ... 6840 | 9 ... 1840 | 9 ... 1840 | 9 ... 1840 | 9 ... 3419 | 9 ... 3419 | 9 ... 3419 | 25 ... 106 |
| Tilting moment output bearing [Nm] | 41 ... 4210 | 73 ... 2222 | 73 ... 2222 | 73 ... 2222 | 74 ... 2740 | 74 ... 2740 | 74 ... 2740 | 93 ... 129 |
| Hollow shaft diameter [mm] | - | - | 14 ... 70 | - | 14 ... 80 | 14 ... 80 | - | 41.0 ... 55.1 |
| Configurations | | | | | | | | |
| Sizes | 14 ... 90 | 14 ... 58 | 14 ... 58 | 14 ... 58 | 14 ... 65 | 14 ... 65 | 14 ... 65 | 25, 32 |
| Ratio | 30 ... 160 | 30 ... 160 | 30 ... 160 | 30 ... 160 | 30 ... 160 | 30 ... 160 | 30 ... 160 | 30 ... 100 |

GEAR COMPONENT SETS

| CSG-/HFUC-2A | CPL-2A | CSD-2A | SHG-/HFUS-2A |
|---|---|---|---|
|  |  |  |  |
| CT | CT | CT | ST |
| ●●●/●● | ●● | ● | ●●●/●● |
| ●●● | ●●● | ●●● | ●●● |
| ●●● | ●●● | ●●● | ●● |
| ●● | ●● | ●●● | ●● |
| - | - | - | - |
| ●● | ●●● | ●●● | ●● |
| 1.1 / 26 | 1.2 / 46 | 1.3 / 60 | 1.4 / 72 |
| 1.8 ... 9180 | 9 ... 372 | 12 ... 823 | 9 ... 3419 |
| - | - | - | - |
| - | 13.5 ... 36.0 | 11 ... 50 | - |
| 8 ... 100 | 14 ... 32 | 14 ... 50 | 14 ... 65 |
| 30 ... 160 | 30 ... 160 | 50 ... 160 | 30 ... 160 |

Description:
Type: Gear Component Set
CT - Cup Type Gear
ST - Silk Hat Type Gear

| Series | CSD-2UH | CSD-2UF | SHD-2SH | CSF-ULW | CSF Mini (different versions) | PMG | CSF-2UP |
|------------------------------------|---|---|---|---|---|---|---|
| |  |  |  |  |  |  |  |
| Type | M | M | M | M | M/S | M/S | M |
| Torque capacity and service life | ● | ● | ● | ●● | ●● | ● | ●● |
| Transmission accuracy | ●●● | ●●● | ●●● | ●●● | ●●● | ●● | ●●● |
| Small outer diameter | ●● | ● | ●● | ●● | ●●● | ●●● | ●● |
| Short design | ●●● | ●●● | ●●● | ●●● | ●●● | ● | ●●● |
| Tilting moment output bearing | ●● | ●●● | ●● | ●● | ● | ● | ●●● |
| Low weight | ●●● | ●●● | ●●● | ●●● | ●●● | ●●● | ●● |
| Chapter / Page | 2.4 / 160 | 2.4 / 160 | 2.6 / 202 | 2.2 / 118 | 2.7 / 216 | 2.8 / 238 | 2.9 / 248 |
| Key data | | | | | | | |
| Maximum torque [Nm] | 12 ... 823 | 12 ... 453 | 12 ... 453 | 1.8 ... 92 | 0.09 ... 28 | 0.3 ... 14.7 | 1.8 ... 28 |
| Tilting moment output bearing [Nm] | 41 ... 759 | 91 ... 849 | 37 ... 424 | 2.9 ... 18.9 | 0.27 ... 13.2 | - | 15 ... 75 |
| Hollow shaft diameter [mm] | - | 9 ... 37 | 11 ... 40 | 3 ... 19 | - | - | - |
| Configurations | | | | | | | |
| Sizes | 14 ... 50 | 14 ... 40 | 14 ... 40 | 8 ... 20 | 3 ... 14 | 5 ... 14 | 8 ... 14 |
| Ratio | 50 ... 160 | 50 ... 160 | 50 ... 160 | 30 ... 160 | 30 ... 100 | 50 ... 110 | 30 ... 100 |

Description:
Type: Gear with output bearing
M Motor mounting gear
OH Open hollow shaft gear
CH Closed hollow shaft gear
S Input shaft gear

●●● perfect ●● optimal ● good

It is always fascinating to find out the areas where our products are used. Here you will find a selection of the industries in which we are represented.



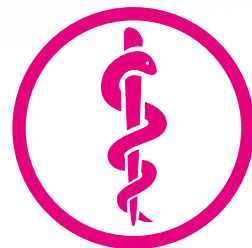
Robotics, handling & automation

For a long time, robots have been taking over tasks which are too monotonous for humans to produce to the highest quality. With modern programming and performance improvements from drive technology, these aides are now entering fields which were unthinkable a short time ago. This cooperation between man and robot has become an important trend in recent years – one meets each other in some sense.



Mechanical engineering

Is it possible to strike a Euro coin at a distance of a hundred metres? It is not only possible but must absolutely be achievable if high value machine tools are to be manufactured. Harmonic Drive® Products are used in particular at sites where space is limited. The layout in such cases is not defined by torque but rather by rigidity or by hollow shaft diameter.



Medical technology

It is not only world class athletes who want to be fit again quickly after an operation, and today in most cases, recovery is being supported by more technologies which permit targeted training of the body parts affected. The secret of success is programmable movement sequences which can be implemented via a precision actuator. Reliable and precise drive technology is also a fundamental design requirement in the field of surgery.

Challenge us with your application – together we can find the appropriate solution.

Special environments

The highest requirements for use in the harshest environmental conditions, such as extreme temperatures or other climatic peculiarities, can be achieved with Harmonic Drive® Products. System applications in defence, vacuum and safety technology or in the depths of our oceans are frequently confronted with such extreme conditions, where the integrated components have to prove themselves once again.


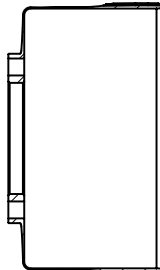
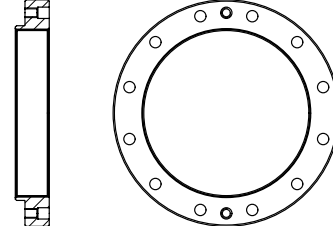
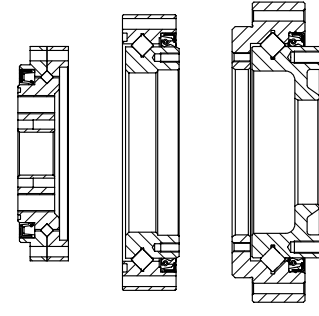
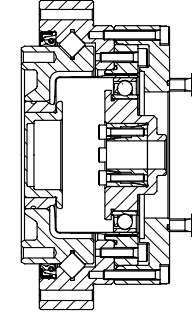
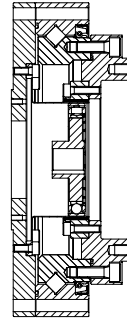
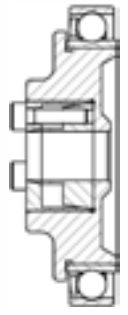
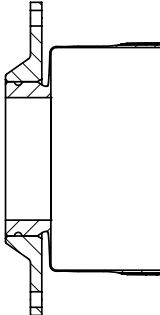
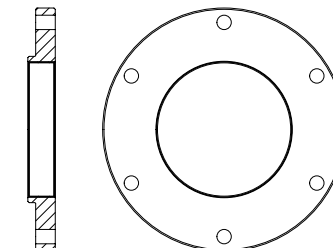
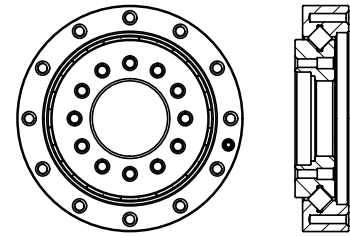
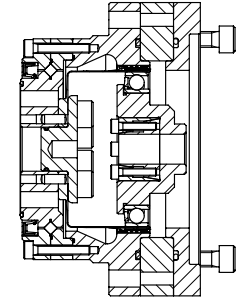
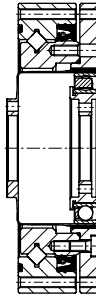
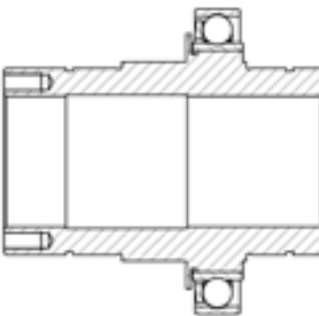

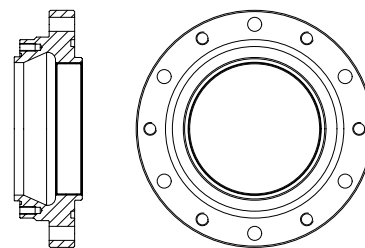
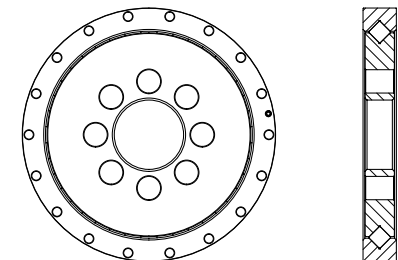
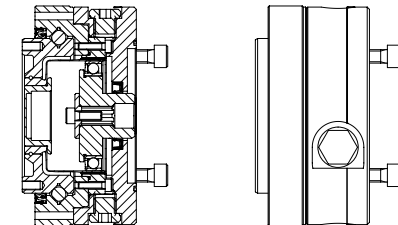
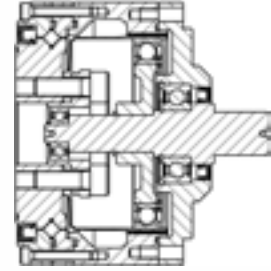


Aerospace


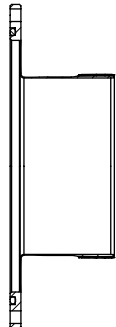
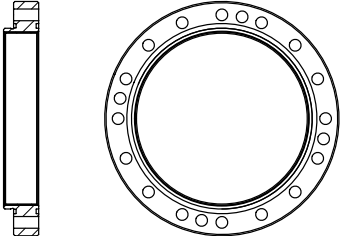
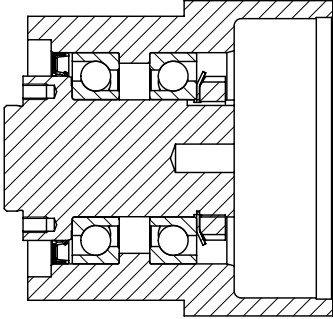
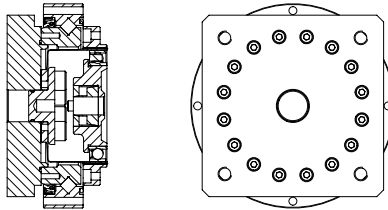

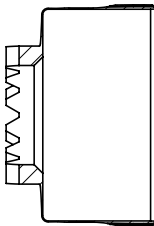
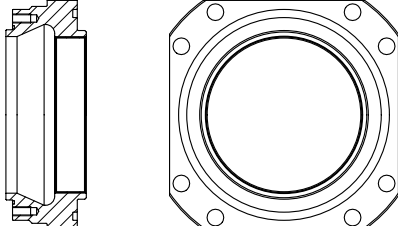

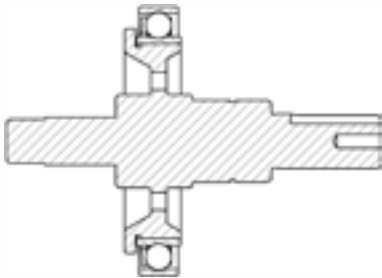
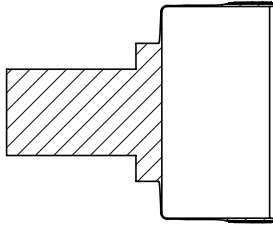
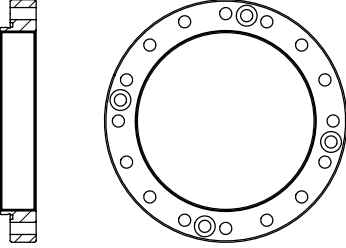
Our products have been working maintenance free in space for over 50 years, have been installed in aircraft for over 30 years and function under extreme low temperatures. Special materials, lightweight products and dry lubricants are specially developed for the aerospace industry.



Individual solutions for Harmonic Drive® Gear Component Sets and Gears with output bearing

| Wave Generator | Flexspline | Circular Spline | Output bearing | Motor adaptation | Design combinations |
|---|--|---|---|---|---|
| Oldham coupling with feather key | Flexspline with enlarged central bore hole | Circular Spline with modified bore hole pattern | Selection of different output bearing types | Gear with adapter flange | Combination of gear component set and output bearing of different sizes |
|  <p>The Oldham coupling is used to compensate concentricity and coaxiality errors of the motor shaft. Different bore diameters are possible.</p> |  <p>The large Flexspline bore offers maximum space for the feed through of supply lines and drive shafts.</p> |  <p>Customised design of bores and threads.</p> |  <p>Different output bearing types allow a flexible adjustment to the load situation of the application.</p> |  <p>Simplified motor assembly by using a gear including adapter flange suitable for the selected motor.</p> |  <p>For high demands on the load capacity of the output bearing and lower torque requirements on the gear.</p> |
| Solid Wave Generator with clamping set | Flexspline with welded output flange | Circular Spline with modified outer diameter | Special output bearing in intermediate sizes | Motor connection with two piece adapter flange | Combination of gear component set and output bearing of different product series |
|  <p>The Solid Wave Generator with clamping set enables a backlash free connection of the Wave Generator to the motor shaft.</p> |  <p>The welded Flexspline connection enables the safe transmission of overloads as well as the individual adaptation to the design environment.</p> |  <p>Customised design of the Circular Spline.</p> |  <p>Special output bearing in intermediate size, e. g. to reduce the outside diameter.</p> |  <p>The two piece adapter flange is required in some motor adaptations when the bore pitch circles of the gearbox and motor are similar.</p> |  <p>Combination of a CSG-2A Gear Component Set and the HFUS output bearing in order to achieve a short overall length.</p> |
| Wave Generator with hollow shaft | Flexspline with Friction Shim | Design of the Circular Spline as gear housing | Special output bearing with customised interface | Gear with oil lubrication | Gear with reduced outer diameter |
|  <p>The Wave Generator with hollow shaft enables the central feed through of supply lines and drive shafts. The hollow shaft can be individually adapted to the application.</p> |  <p>The Friction Shim increases the transmittable torque of the Flexspline bolted joint and therefore ensures a higher overload capacity.</p> |  <p>Integration of the gear housing into the design of the Circular Spline.</p> |  <p>Adaptation to the design environment by a bearing with customised interface.</p> |  <p>Oil inlet and outlet screw for the lubrication with oil, integrated into the adapter flange (optional use of oil inspection glass)</p> |  <p>A reduced outer diameter is achieved by modified housing geometry.</p> |

Individual solutions for Harmonic Drive® Gear Component Sets and Gears with output bearing

| Wave Generator | Flexspline | Circular Spline | Output bearing | Motor adaptation | Design combinations |
|---|---|---|--|------------------|--|
| Solid Wave Generator with internal spline | Flexspline with O ring groove | Circular Spline with additional O ring groove | Double row bearings | | Gear with customised output flange |
|  <p>The internal spline enables an interlocking connection between the Wave Generator and the input shaft.</p> |  <p>Space saving integration of a seal.</p> |  <p>Space saving integration of a seal.</p> |  <p>By selecting two preloaded roller bearings, a design with a small outer diameter can be achieved.</p> | |  <p>By an individual design of the gear output flange an additional customer flange can be omitted.</p> |
| Ring shaped Wave Generator | Flexspline with axial spline | Square design Circular Spline | Output bearing with corrosion protection | | |
|  <p>The ring shaped Wave Generator allows a low mass as well as a reduced inertia of the drive shaft, as well as a large central bore.</p> |  <p>The axial spline in combination with a central nut enables an interlocking connection of the Flexspline to the output flange.</p> |  <p>To avoid overlapping with interfering components.</p> |  <p>The output bearing can be coated in order to increase the corrosion protection.</p> | | |
| Wave Generator with input shaft design | Flexspline with integrated output shaft | Circular Spline with counter sunk bores | | | |
|  <p>The Wave Generator with input shaft enables the direct connection of a pre-stage, such as a belt stage. The shaft can be adapted individually.</p> |  <p>High overload capacity, compactness and weight reduction due to Flexspline with integrated output shaft. The output shaft can be customised.</p> |  <p>To avoid overlapping by sunk screw heads.</p> | | | |

Selected examples of customised gears

Illustration 4.1 **Lightweight gear based on CPL-2A Gear Component Set**

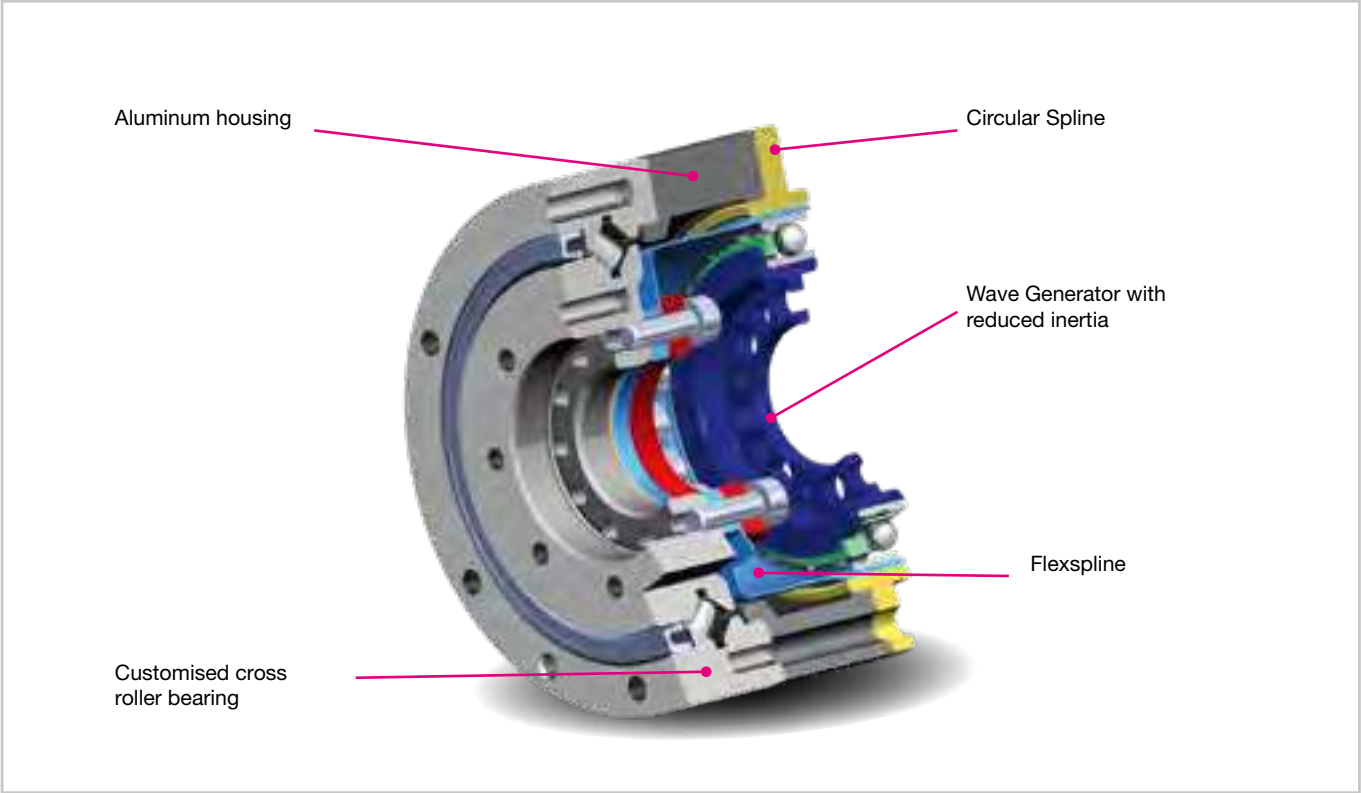


Illustration 4.2 **Gear for robotic axis with customised hollow shaft for adaptation of rotor magnets, encoder and brake**

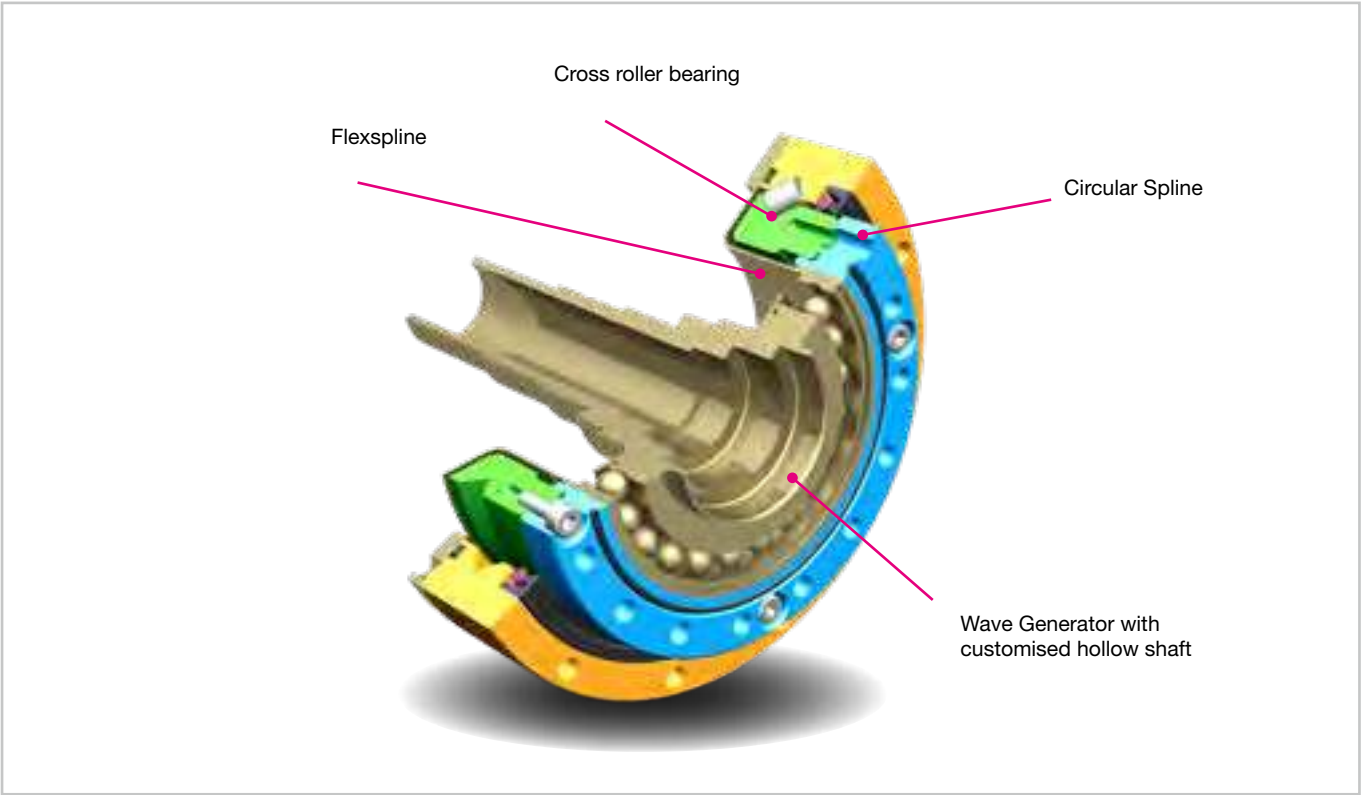


Illustration 4.3 **Swivel joint for X-ray system based on the SHG-2UH Hollow Shaft Gear, bevel gear pre-stage and a toothed belt pre-stage**

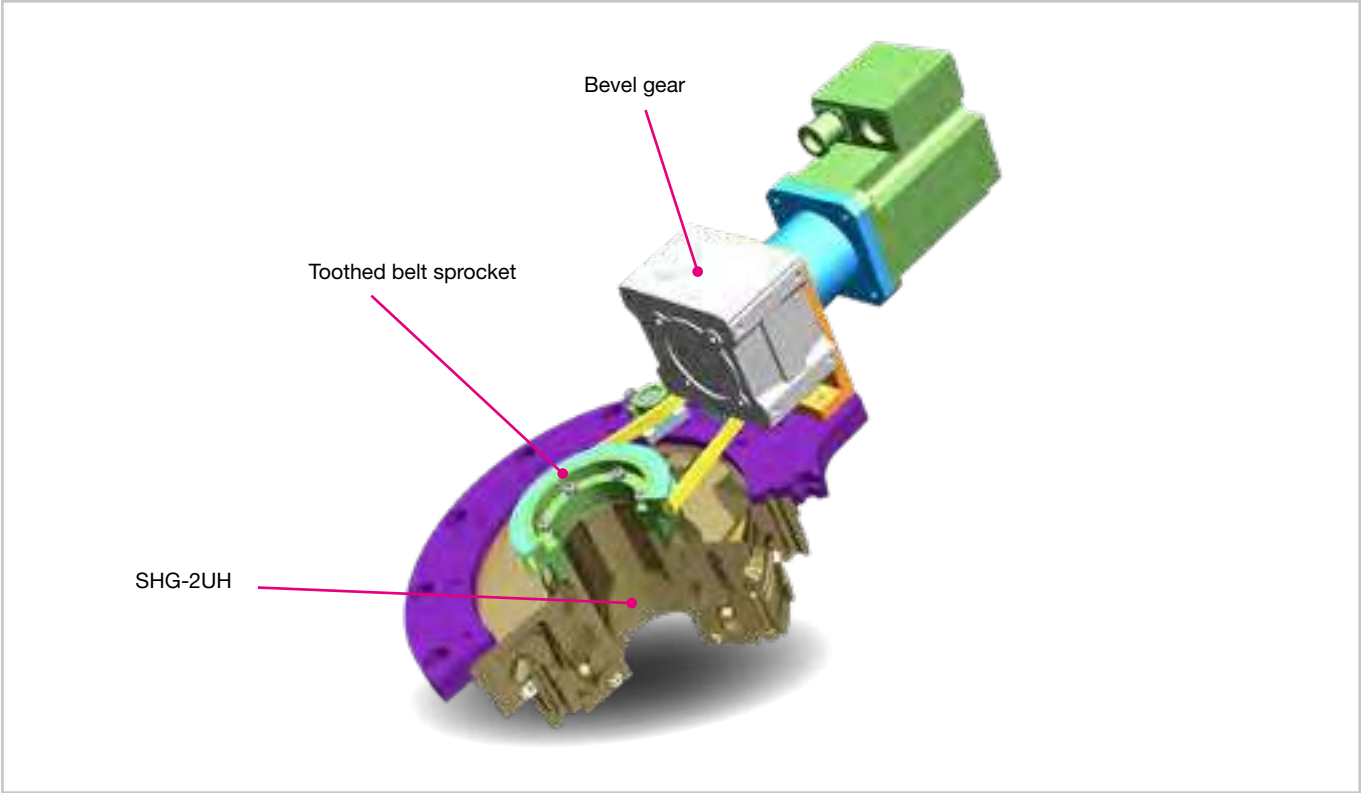
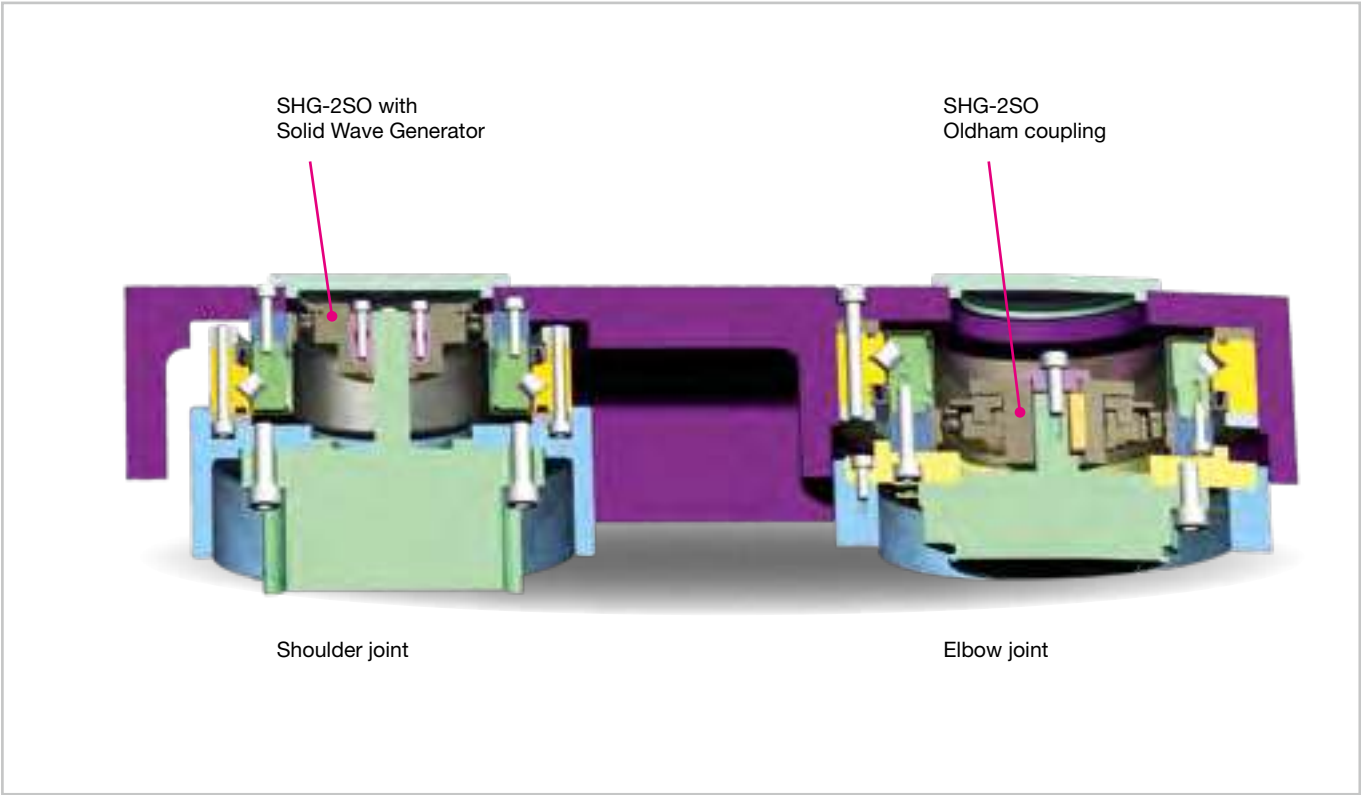


Illustration 4.4 **Two SCARA robot axes based on SHG-2SO with motor adaptation**



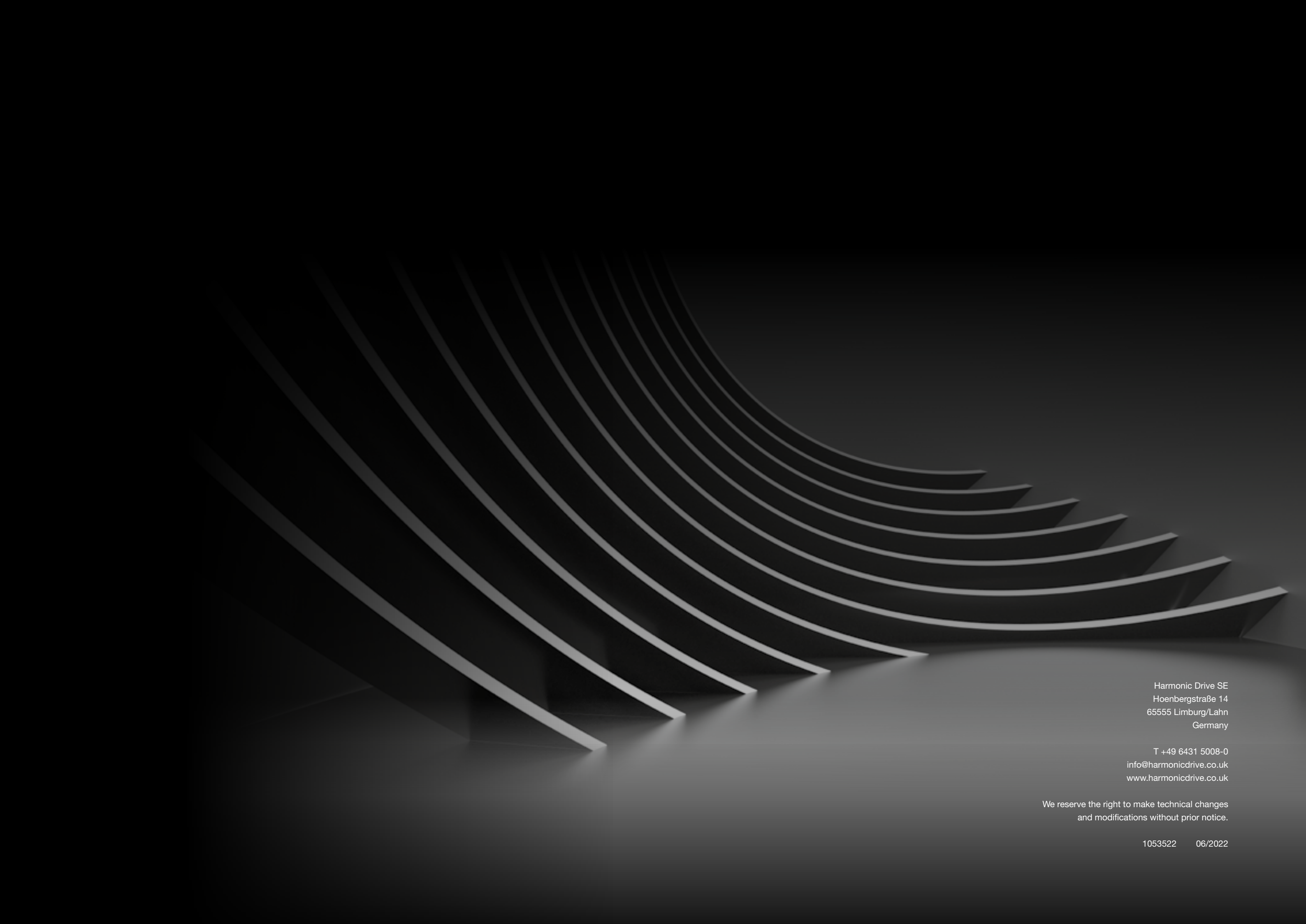
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