

## Meeting the Technical Demands for AMR & AGV Wheel Drives

by Jim Leonard

Drive wheels for autonomous mobile robot platforms benefit from the inherent characteristics of Harmonic Planetary® gearheads. This paper will discuss those characteristics as a function of the HPG series planetary design and technology.



HPG Gearheads

The Harmonic Planetary® HPG Series stands out from the crowd. Its design enables exceedingly smooth, high-torque transmission in a very compact form factor.

The compact form factor, which is a typical design requirement for AGV and AMR propulsion systems, is largely achieved by incorporating an integral full complement cross roller bearing (CRB) assembly. The CRB, by design, comes

in a narrow, single row configuration and can handle moment loads comparable to a double row bearing or a pair of angular contact bearings which are significantly wider.

The CRB used in the HPG Series is preloaded and provides an accurate and highly rigid output to which the wheel can be directly attached. Inherent in roller bearing technology is the line contact between rolling elements and hardened raceways. Line contact minimizes elastic deformation under extreme loads and as such, the single row CRB exhibits high-load capacity and a resistance to shock loading. In a CRB design, roller elements are placed orthogonally to one another between the raceways. The resulting construction is capable of accepting loads from all directions simultaneously. As such, radial, axial and tilting moment loads are all supported within the

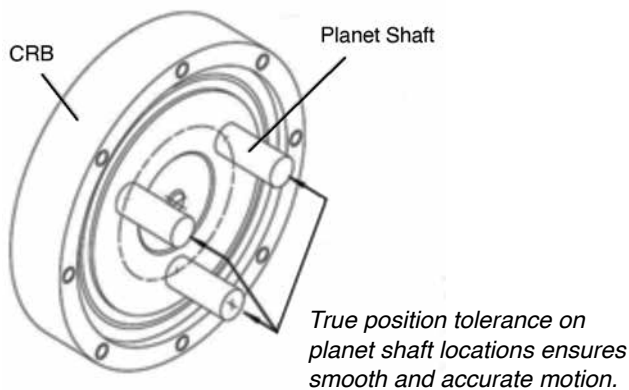


Cross Roller Bearing Construction

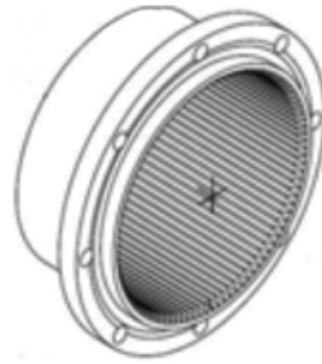
compact CRB construction. CRB service life is a function of load and speed and can be reliably calculated, thus ensuring service life expectations can be met with proper product selection.

The structure of the Harmonic Planetary<sup>®</sup> gear is highly integrated with the CRB. This integration allows for further size reduction of the gearhead envelope and also simplifies the internal design. The inner race of the roller bearing is multi-functional. It acts as both the output planet carrier of the planetary gear as well as the rotating output flange. The output flange includes a piloting feature and a tapped mounting hole pattern that makes wheel attachment easy and error free. Cross roller bearing technology and its integration provides a compact solution that can handle the reaction forces of the wheel drive configurations that are typical of mobile robot platforms.

To provide a smooth and reliable transmission, a compensating ring gear is incorporated along with tightly toleranced planet pin locations combined with a true running planet carrier.



The elasto-mechanical behavior of the ring gear design compensates for slight interferences between meshing parts, allowing for the gearbox to be easily back driven.



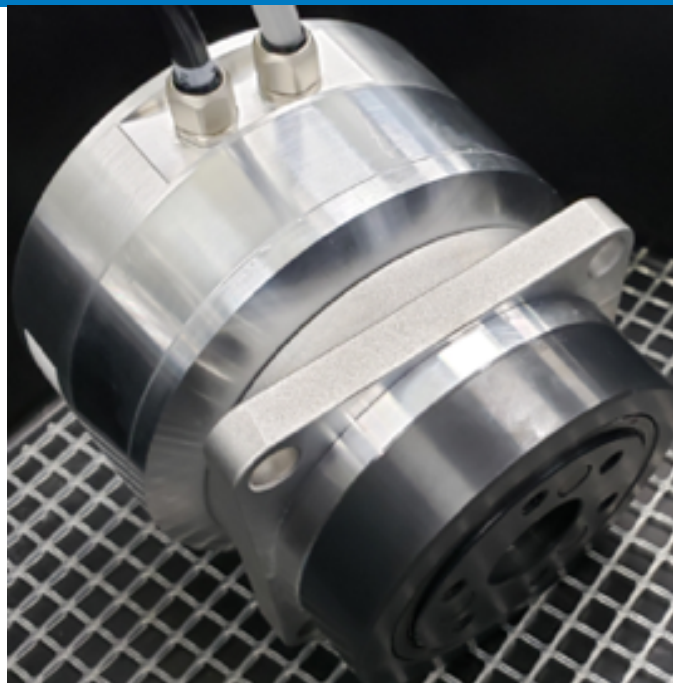
*While torsionally rigid, the compensating ring gear exhibits radial compliance in the area of 1-2 microns.*

## Harmonic Planetary<sup>®</sup> advantages and characteristics:

- The maximum backdriving torque is quantified in the product ratings; in an automated platform, backdrivability can be a convenient feature in the event that a robot requires a tow to a charging station or maintenance area.
- Ring gear compensation minimizes concentrated tooth contact stresses, results in predictable starting torque characteristics and minimizes torque ripple in the transmission.
- The HPG gearing with ring gear compensation yields a high-efficiency transmission reaching 90-95% at rated input torque and speed.
- Aluminum alloy housings are employed, minimizing weight yet providing sufficient strength and rigidity to provide reliable propulsion for mobile robots.
- HPG planetary gearheads are lubricated for life and maintenance free.
- Planetary design in an HPG gearbox includes either 3 or 4 planet construction, depending on the power density required by the application.
- Load sharing in a planetary drive train with ring gear compensation is optimized, ensuring equal planet gear loading on needle bearings and gear teeth.
- Harmonic Planetary<sup>®</sup> gearheads are available with straight cut gear geometry. This produces lower friction at the gear mesh and requires less bearing constraint; as such, straight cut gear

trains can be more compact axially. Automated mobile robots benefit from a light weight, compact drive train as more of the available power can be used to accelerate and transport loads.

- Helical gearing is also an option with the Harmonic Planetary<sup>®</sup> design. Inherent in helical gearing is a smoother and more gradual tooth engagement. This results in lower audible noise levels and lower vibration. Due to the nature of helical gearing, reaction forces from the mesh require additional bearing support. As such, gearheads with helical gears tend to have a slightly longer overall length.
- Harmonic Planetary<sup>®</sup> gearheads are configured with a Quick Connect<sup>®</sup> motor adaptation for easy motor mounting. This motor mounting system includes a compression coupling designed to clamp onto a smooth motor shaft. Input flanges and coupling bores are machined to ensure concentricity and perpendicularity requirements for optimal performance and service life.
- The Quick Connect<sup>®</sup> system connection method provides quick and reliable connection between the gearhead and motor. It also allows for motors and gearheads to be disassembled for maintenance and serviceability.
- Actuators (motor and gearhead integrated into a single housing) using Harmonic Planetary<sup>®</sup> technology are also available. Actuator solutions are engineered in close consultation with original equipment manufacturers who require specific motion control attributes in their motor technology. Position feedback, winding design, communication and drive compatibility are just a few of the many considerations for successful actuator development and deployment. Benefits include the optimization of size, weight, and inertia, all of which benefits a drive train for mobile robot propulsion.



*Integrated servo actuator using Harmonic Planetary<sup>®</sup> technology*



*Quick Connect<sup>®</sup> motor adaptation allows for quick and error free motor assembly.*



# HPG Cross-Roller Bearing Construction

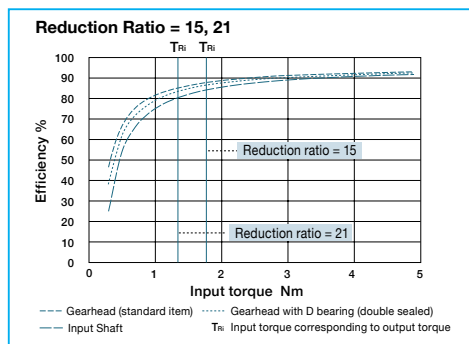


*Integrated cross-roller bearing and planet carrier provides a compact solution with excellent load and rigidity characteristics.*



## High Efficiency

95%+ efficiency; curves available for every size and ratio\*



## Low Backlash for Life

Innovative ring gear inherently compensates for interference between meshing parts, ensuring consistent, low backlash for the life of the gearhead.

## High Load Capacity Output Bearing

A cross-roller bearing is integrated with the output flange to provide high moment stiffness, high load capacity and precise positioning accuracy.

## Easy Mounting to a wide variety of Servomotors

Quick Connect<sup>®</sup> motor adaptation system includes a compression style servo coupling and piloted adapter flange.

## Flange Output Standard

Flanged output is standard for convenient, stable wheel mounting.

## Lightweight with Good Shock Resistance

Designed for lightweight and impact resistance.

**HarmonicDrive<sup>®</sup>**

[www.HarmonicDrive.net](http://www.HarmonicDrive.net) 800.921.3332

\* Efficiency ratings are graphically illustrated in relation to input torque. Please refer to the main catalog for detailed information.