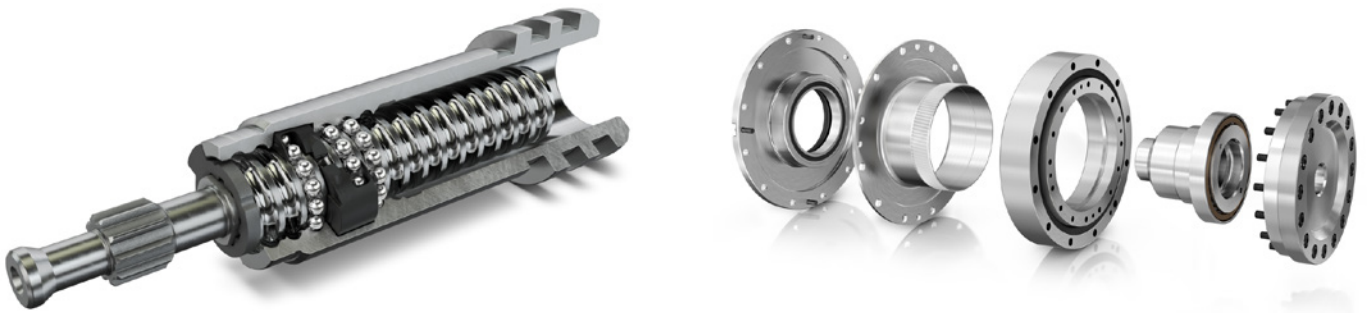


Humanoid Component Advancements

Schaeffler discusses motion control and robotic strategies moving forward

Matthew Jaster, Senior Editor



Schaeffler sees a significant pathway to produce precise components for humanoid robots at high volume including ball screws and strain wave gears.

Schaeffler continues to advance key technologies shaping the future of mobility and motion. One area of interest—humanoid robots—is where Schaeffler is developing advanced component and system capabilities for the next generation of robotics. *PTE* recently had the opportunity to discuss these technologies with Al Makke, engineering director, humanoid robotics, North America, at Schaeffler Group USA.

First, please tell us what the response was like at CES 2025 to Schaeffler's Humanoid Technology Exhibit?

It was good. The interactive humanoid “hologram” was an eye catcher. Several different people in the humanoid sector stopped by whether it was competitors, investors, suppliers, potential customers. The show was really effective. We must answer the question frequently, “Is Schaeffler making their own humanoids?” And the

resounding answer is, no, right? We do want to showcase what we can achieve as a supplier to humanoid OEMs, however. Industry observers noted the exhibit's emphasis on Schaeffler's expanded motion product portfolio, a development bolstered by the company's recent merger with Vitesco Technologies. This strategic move has enhanced Schaeffler's manufacturing and research capabilities, positioning it as a comprehensive provider of motion solutions across various sectors. Overall, the response was positive, with attendees and industry experts recognizing the company's innovative approach to motion technology and its impact on the future of robotics.

How about the significance of the Agility Robotics investment as well as your use of generative AI across the product portfolio?

Schaeffler's strategic investment in Agility Robotics and its integration

of generative AI technologies are pivotal steps in enhancing its capabilities in the humanoid robotics sector. In November 2024, Schaeffler made a minority investment in Agility Robotics, the creators of the bipedal humanoid robot, Digit. This partnership includes plans to deploy Digit robots across Schaeffler's global network of 100 plants by 2030, aiming to revolutionize manufacturing and logistics operations. The collaboration is expected to accelerate the adoption of humanoid robots in industrial settings, enhancing automation and operational efficiency.

Schaeffler has been proactive in incorporating generative AI across its product portfolio. Collaborating with Siemens, the company introduced Siemens Industrial Copilot, an AI-powered assistant designed to optimize engineering and operational tasks. This tool aids automation engineers in generating code for programmable logic controllers (PLCs) through natural language

inputs, streamlining complex programming tasks and reducing the potential for errors. Additionally, the Industrial Copilot assists maintenance teams in swiftly identifying and resolving machine errors, thereby minimizing downtime and enhancing overall efficiency.

What additional investments are enhancing Schaeffler's position in the humanoid robotics sector?

Schaeffler participates in three different ways in the humanoid sector. We are a user of humanoids in our production plants, a supplier of components to humanoid "OEMs", and a supplier of machines to humanoid manufacturers.

Schaeffler has undertaken several strategic initiatives to strengthen its position in the humanoid robotics sector:

Our merger with Vitesco Technologies expanded Schaeffler's global presence, added new manufacturing facilities, and enhanced its research and development capabilities. The integration of Vitesco's expertise has enriched Schaeffler's motion technology portfolio, enabling the company to offer comprehensive solutions essential for the development and production of humanoid robots [Editor's note: see sidebar on page 22].

Schaeffler is leveraging advanced artificial intelligence and vertical integration to enhance its production technologies. A notable example is EMMA, a mobile collaborative robot (cobot) designed to improve flexibility and precision in dynamic manufacturing environments. EMMA exemplifies Schaeffler's commitment to integrating AI-driven automation solutions, which are crucial for the efficient production and operation of humanoid robots.

What are the greatest challenges for offering components for humanoid robotics?

From my viewpoint at Schaeffler as a component and joint actuator supplier, there are two key challenges.

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CES 2025

Matthew Jaster, Senior Editor

One key highlight during my first visit to CES 2025 in Las Vegas was Schaeffler's Humanoid Technology Exhibit, an interactive display highlighting Schaeffler's key role in enabling motion through advanced robotics. During the show, Mike Paschke, industrial automation national sales manager, gave our group a comprehensive tour of the exhibit—highlighting how Schaeffler is shaping the next generation of robotics from a component as well as a system level.

"Basically, there's eight new motion technology families," Paschke said. "This breaks down into the full portfolio of products Schaeffler can offer. The idea here being each of these building blocks really comprises the full system. Now as a company we must start thinking about battery technology, sensors, power electronics for humanoid robots, and how these system capabilities translate to high volume manufacturing."

The merger with Vitesco Technologies, completed on October 1, 2024, expands Schaeffler's presence globally, adding new manufacturing plants and boosting the company's research and development capabilities. Schaeffler's solutions now cover the entire spectrum of motion, from power transmission to energy generation and sustainability, allowing for a seamless integration of technologies. Especially in the field of electromobility, Schaeffler can now offer customers a comprehensive product range and can therefore derive even greater benefit from the growth potential in the electromobility market.

Schaeffler's Dynamic Performance Vehicle at CES 2025 highlighted the full range of technologies for chassis systems and electrified powertrains, augmented by the addition of Vitesco Technologies. The company can now deliver a battery electric vehicle solution, featuring all vital components and systems required for a complete electrified powertrain. The interactive exhibit demonstrated these solutions—from components and systems for light passenger cars to heavy-duty applications.

First, the industry is rushing to find the right actuator architectures and performance for each joint. This is resulting in very different joint designs and architectures (rotary vs. linear actuators and even more diverging solutions within the rotary actuator family and the linear actuator family). The only apparent consensus now is strainwave gear-based actuators which virtually every humanoid OEM is using in at least some joints. There's a large focus on performance, and if the "ChatGPT moment for general robotics is truly around the corner" and that humanoids will truly reach the volume projections that we hear about, then we must start thinking about scaling these components for high volume production. Schaeffler's background in high volume production for the automotive industry in combination with our understanding of these new joint actuator requirements will give us a good seat at the table to address these challenges.

Second, we must understand as an industry the unique requirements of humanoid robots and how they differ from traditional robots. Right sizing the requirements will enable us to explore high volume solutions that will support the bullish outlook on the market.

What role do bearings play in these applications, and why is a customizable approach so critical?

Lightweight, high torque density, and low friction will continue to be important for smooth humanoid control and battery life management. Customized bearings might be necessary in certain actuators and certain positions, but it's wise to pursue standardized solutions where possible especially when we talk about mass production in the coming years.

How do the components Schaeffler provides compare to hydraulic or pneumatic systems?

Increased Precision and Control: Electric actuators offer finer control over movement, making humanoid robots more adaptable to complex tasks. Hydraulic systems, while powerful, can be difficult to precisely regulate due to fluid dynamics.

Lower Maintenance and Complexity: Hydraulic systems require pumps, valves, and high-pressure fluid lines, leading to potential leaks, high maintenance requirements, and complex routing. Electric actuation simplifies the design, reducing maintenance needs.

Better Energy Efficiency: Hydraulic systems consume more power due to

continuous fluid circulation, whereas electric actuators use energy more efficiently by only consuming power when needed.

Reduced Weight and Space: Hydraulic systems require large reservoirs, hoses, and pumps, adding weight and bulk. Electric actuators allow for a more compact and lighter design.

Scalability for Practical Applications: Moving towards electric actuators aligns with broader industry trends, making the technology more viable for real-world applications in logistics, manufacturing, and other fields.

This shift reflects a broader movement in humanoid robotics, where electric actuation is becoming the preferred standard for its balance of power, efficiency, and scalability.

Humanoid robotic components are getting smaller. Can you discuss a few advantages to agility, sustainability and efficiency with smaller drive technology?

The trend toward miniaturization in humanoid robotics is unlocking higher agility, lower power consumption, greater sustainability, and cost reductions, making humanoids more practical, scalable, and efficient for real-world applications. As compact actuators, motors, and reducers



Schaeffler's Humanoid Technology Exhibit was a booth highlight at CES 2025 in Las Vegas.



Part of Schaeffler's "Guide Motion" family of products and solutions: thin section bearings.



Part of Schaeffler's "Generate Motion" family of products and solutions: rotary actuator.

continue to advance, humanoid robots will become faster, more dexterous, and more widely adopted across industries. In general, lighter humanoids are faster.

What additional areas outside of humanoid robotics can benefit from this type of electromechanical actuation?

I already see a lot of parallels between humanoid actuators and automotive active suspension actuators. With L3+ autonomous vehicles in our future, comfort requirements are increasing and approaching humanoid actuators in the legs and arms from a requirements standpoint. I can think of a few other applications that would have similar requirements for actuator bandwidth, back drivability, safe state, etc.

Why is Schaeffler's system design approach so important moving forward?

Based on the automotive suspension parallel, I would extend your question to include automotive and e-Mobility applications. I think we have the tools and business processes to pull ideas from various parts of our business to develop holistic solutions and not just component solutions. We've seen such successes in a short period of time with transforming current sensor technologies from ex-Vitesco into relevant force sensors for humanoid actuators, and we have many similar irons in the fire right now. I think our humanoid display at CES is going to evolve significantly over the next couple of years.

How will humanoid and industrial robotic applications evolve in the coming years?

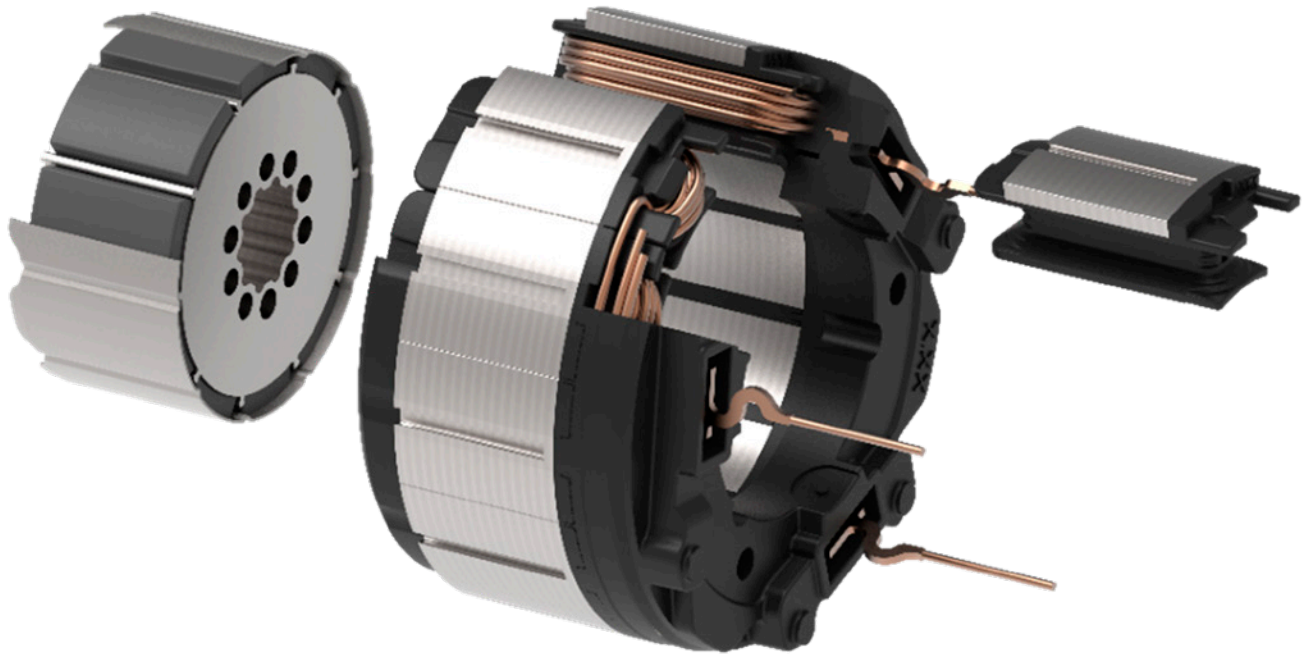
Based on Morgan Stanley's "The Humanoid 100" report, the evolution of humanoid and industrial robotic applications in the coming years will be shaped by advancements in AI, automation, semiconductor technology, and supply

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Part of Schaeffler's "Drive Motion" family of products and solutions: brushless DC motors.

chain development. Here are the key trends and expectations:

We'll see the expansion of humanoid robotics from prototypes to real-world applications in areas such as manufacturing, logistics, and health-care. Humanoids will be integrated into factories, warehouses, and customer service, assisting in tasks that are physically demanding or require fine motor skills. Humanoid OEMs are leading the push toward practical humanoid robots that could be deployed at scale.

AI models will enhance humanoid robots' ability to learn from human demonstrations and adapt in real-time. Additionally, the increased use of vision-based AI, LiDAR, and force/torque sensors will improve robots' ability to interact with complex environments. Digital twins and reinforcement learning will accelerate training, allowing humanoids to perform real-world tasks with minimal human intervention.

We'll also see improvements in battery technology. Battery companies are working on high-density, long-life lithium-ion batteries to power humanoid robots efficiently. The transition from hydraulic to

all-electric humanoids (e.g., Boston Dynamics' new Atlas) will improve energy efficiency and enable longer operating times.

While China currently dominates the robotics supply chain, particularly in motors, semiconductors, and rare-earth materials, western companies are investing heavily to catch up. In the next 5–10 years, humanoids could become as commonplace in workplaces as industrial robots are today, reshaping labor markets and productivity worldwide. However, the key path to scalable humanoids is ensuring safe operations along side humans anywhere; whether that's at the workplace or at home. This will expand the possible use cases significantly.

Is there anything you'd like to add about Schaeffler's components in the humanoid robotic industry?

Schaeffler is widely perceived as a component supplier in the humanoid robotic industry, and that is apparent in some of the market research studies that have been produced over the last couple of years. We have furthered our product portfolio

significantly in e-Mobility, powertrain and chassis, as well as humanoid robotics where we can leverage our "Motion Families" to ideate and produce high value actuators for our customers. From sensors, transmissions, bearings, and software to completely integrated actuators and controllers, we have a robust product portfolio that is supported by our vertical integration to make a difference in the humanoid robotic sector, and we're nothing short of excited about playing our role.

[schaeffler.us](https://www.schaeffler.us)

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Additional Resources:

"Actuation Challenges in Robotics Today" (PTE June 2023)

powertransmission.com/actuation-challenges-in-robotics-today

"Planetary Gear Rethought" (PTE online article April 2023)

powertransmission.com/planetary-gear-rethought