Confidential

Independent Market Research on Integrated Micro Transmission and Drive Systems Industry

For ZHAOWEI 兆威

February, 2026

Signature _____

Date February 27, 2026

FROST & SULLIVAN 沙利文

Glossary (1/4)

Term	Definition
CAGR （复合增长率）	compound annual growth rate
Integrated Micro Transmission and Drive Systems Solutions（一体化微型传动和驱动系统解决方案）	Integrated micro transmission and drive solutions refer to power output units that combine micro transmission structures, drive components, electronic control, and sensors into a highly compact and coordinated system. Compared with traditional micro transmission and drive systems, integrated transmission and drive systems solutions place significantly higher demands on enterprise capabilities. To achieve greater customization and control precision, companies must possess in-house design and manufacturing capabilities across the entire value chain—including transmission mechanisms, drive units, electronic control systems, and sensing technologies. This full-stack integration enables tighter component coordination, enhanced performance optimization, and better adaptability to specific application scenarios.
Dexterous Hand（灵巧手）	a critical actuator subsystem of embodied robots, enabling fine manipulation and complex interaction tasks. It performs picking, gripping, and XYZ-axis movements, enabling high-precision operations. It comprises four core systems: a micro drive system that provides power, a micro transmission system that delivers power to the fingers, a micro sensing system that monitors position, velocity, and acceleration, and a micro control system that uses sensing data to precisely manage the drive and transmission through software and algorithms.
Degree of Freedom（自由度）	refer to the number of independently controllable movements or axes of rotation, such as finger flexion, extension, abduction, and pronation.
Active Degree of Freedom（主动自由度）	referring to joint movements directly controlled by the drive source.
Plastic Pellets（塑料粒子）	Plastic pellets are small, solid granules (typically 2–5 mm in diameter) used as the raw material for manufacturing plastic products. They come in various types, including thermoplastics, thermosets, and engineering plastics, and are commonly used in injection molding, extrusion, blow molding, and 3D printing processes.
Physical AI（物理AI）	refers to AI models that understand and interact with the real world through mechanical motion, typically embedded in autonomous machines such as robots or self-driving vehicles.

Source: Frost & Sullivan

Glossary (2/4)

Term	Definition
Coreless Motor（空心杯电机）	a type of electric motor that eliminates the traditional iron core in the rotor, instead using a hollow (cored-less) coil structure. It offers advantages such as lightweight, fast response, high starting torque, low inertia, and no cogging torque. It is widely used in precision applications like drone servos, medical instruments, robotic joints, and micro-drive systems.
Harmonic Reducers（谐波减速器）	precision gear mechanism based on elastic deformation, composed mainly of a flexspline, a wave generator, and a circular spline. It offers high gear ratios, excellent positioning accuracy, compact structure, high transmission efficiency, and near-zero backlash. Harmonic reducers are widely used in robotics, aerospace, semiconductor machinery, and medical equipment requiring precise motion control.
Prosthetic Hand（假肢手）	an assistive device designed to restore partial or full hand function for individuals with upper limb loss. Types include mechanical (passive), myoelectric, and advanced bionic hands. Modern prosthetic hands integrate sensors, servo actuators, batteries, and microcontrollers to enable multiple grip patterns. They are often controlled via muscle signals (EMG) or neural interfaces, and are used in medical rehabilitation, daily assistance, and human-machine interface research.
planetary gearbox（行星齿轮箱）	a transmission system consisting of a central sun gear, multiple planet gears, and an outer ring gear. known for its compact structure, high torque density, and large gear ratio, it is commonly used in robotics, aerospace, and precision automation industries.
Gear Module（齿轮模数）	refers to the parameter of the size of the gear tooth profile, calculated as the quotient of the pitch divided by the circumference ratio π, in millimeters
Gear Accuracy（齿轮精度）	the gear accuracy system determined by the national standard gb/t10095 2008, with 13 levels of accuracy, where level 0 is the highest and level 12 is the lowest
Micro Gear（微型齿轮）	gears with a module less than 0.5mm, also known as micro module gears
Micro Motor（微型电机）	motors with small volume and capacity, generally with output power below tens of watts, with special requirements for application, performance, and environmental condition
Brushed Motor（有刷电机）	a rotating motor containing a brush device that converts electrical energy into mechanical energy (motor) or mechanical energy into electrical energy (generator)

Source: Frost & Sullivan

Glossary (3/4)

Term	Definition
Metal Powder Injection Molding（金属粉末注射成型）	a process that mixes micron-scale metal powders with binders for injection molding, followed by debinding and sintering to obtain high-precision, high-strength metal parts.
Powder Metallurgy Molding（粉末冶金成型）	a production process that uses metal powders or mixtures of metal and non-metal powders as raw materials, which are formed and sintered to manufacture metal materials, composite materials, and various types of products.
Machining（切削加工）	employed for processing high-precision metal gears, utilizing micro milling/grinding and other techniques, suitable for the fine machining of micro shaft components, among others.
Mold Flow Analysis（模流分析）	using data simulation software, completing the simulation and simulation of the injection molding process through a computer, obtaining some data results, and using these results to evaluate the feasibility of the mold scheme, improving the mold design and product design schemes
Micrometer（微米）	a unit of length measurement, symbolized as μm, where 1 micrometer is equivalent to one millionth of a meter
Micro transmission Components（微型传动组件）	as the core for energy transmission, using low-module micro gear modules of 0.5mm and below, featuring low noise, lightweight, miniaturization, and low backlasha unit of length measurement, symbolized as μm, where 1 micrometer is equivalent to one millionth of a meter
Brushless Motor（无刷电机）	a motor without a brush device, using semiconductor switching devices to achieve electronic commutation, converting electrical energy into mechanical energy (motor) or mechanical energy into electrical energy (generator)
Mold Forming Method（模具成型法）	a general term for various methods of forming parts using molds as tools
Plastic Injection Molding（塑料注射成型）	a plastic processing technique where plastic is plasticized in the heated cylinder of an injection molding machine and then injected by a plunger or reciprocating screw into the closed mold cavity to form the product. this method is used to manufacture lightweight micro gears and transmission structures.
Manufacturing Execution System（MES）（制造执行系统）	manufacturing execution system, which is the production process execution system for manufacturing enterprises, is a set of production information management systems oriented towards the workshop execution layer of manufacturing enterprises

Source: Frost & Sullivan

Glossary (4/4)

Term	Definition
Embodied Robot	a physical intelligent system capable of interacting with its environment through structure, sensing, and control. It emphasize the critical role of the body in intelligence and behavior, typically featuring flexible mobility and sensory capabilities to perform complex tasks. Humanoid and non-humanoid embodied robots are two different forms of embodied robotics.
Micro motor Components（微型电机组件）	covering brushed/brushless dc motors, stepper motors, etc., serving as the driving force source of the system. compared to traditional motors, they offer advantages such as high speed, low noise, low resonance, and high power density, suitable for precision applications requiring rapid response and size sensitivity, such as dexterous hands
Micro electronic Control Systems and Sensors（微型电控及传感器）	the intelligent control center and sensors of the system, working in tandem with micro motors and micro transmission systems to achieve high-precision motion sensing, speed, and load control. the electronics control integrates sensing and control algorithms to adapt to various working conditions
Industrial "Four Basics "(工业“四基”)	the "four basics" of industry are the abbreviation for key basic materials, core basic components (elements), advanced basic processes, and industrial technology foundations

Source: Frost & Sullivan

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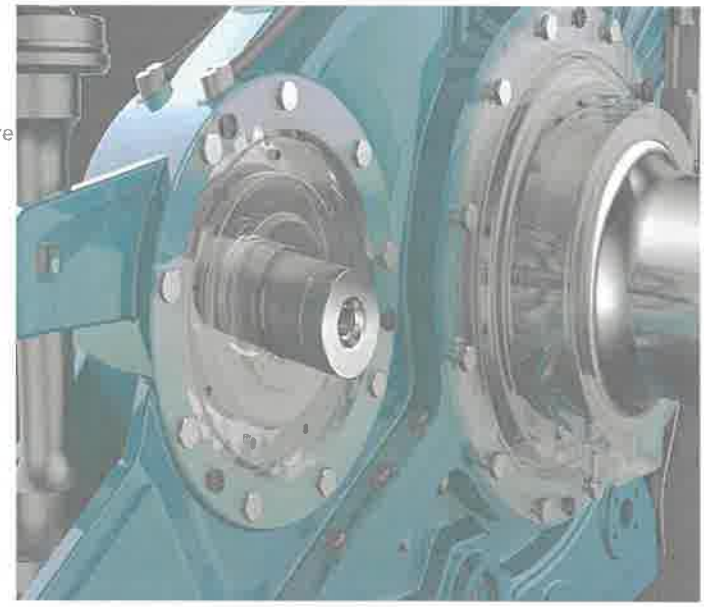
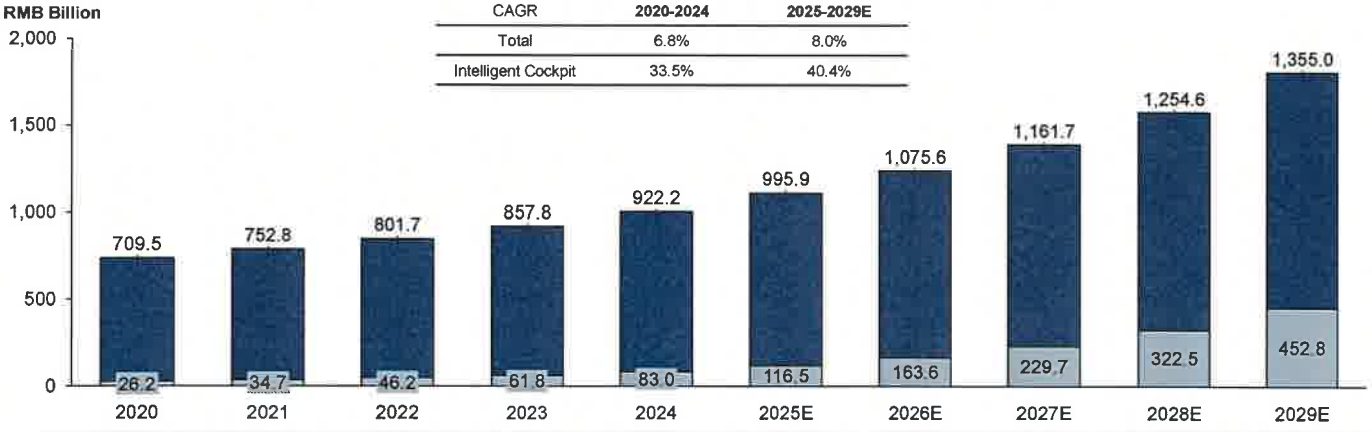


Overview of Macro-Economic Environment

China Intelligent Automotive Market Size, 2020-2029E

Intelligent Automotive Market Size (China), 2020-2029E

CAGR	2020-2024	2025-2029E
Total	6.8%	8.0%
Intelligent Cockpit	33.5%	40.4%



- Covering intelligent automotive vehicles and cabin components, China's intelligent automotive sector has grown from RMB 709.5 billion in 2020 to RMB 922.2 billion in 2024, representing a CAGR of 6.8% during the period. Driven by automotive industry innovations, particularly the rapid development of new energy and autonomous driving technologies, the market size for intelligent automotive vehicles in China is projected to reach RMB995.9billion in 2025 and grow at a CAGR of 8.0% to RMB1,355.0 billion by 2029.
- Currently, the intelligent cockpit market is experiencing rapid growth, with China's market size expanding from RMB 26.2 billion in 2020 to RMB 83.0 billion in 2024, representing a CAGR of 33.5%. It is expected to reach RMB 116.5 billion in 2025 and further grow at a CAGR of 40.4% to RMB 452.8 billion by 2029.

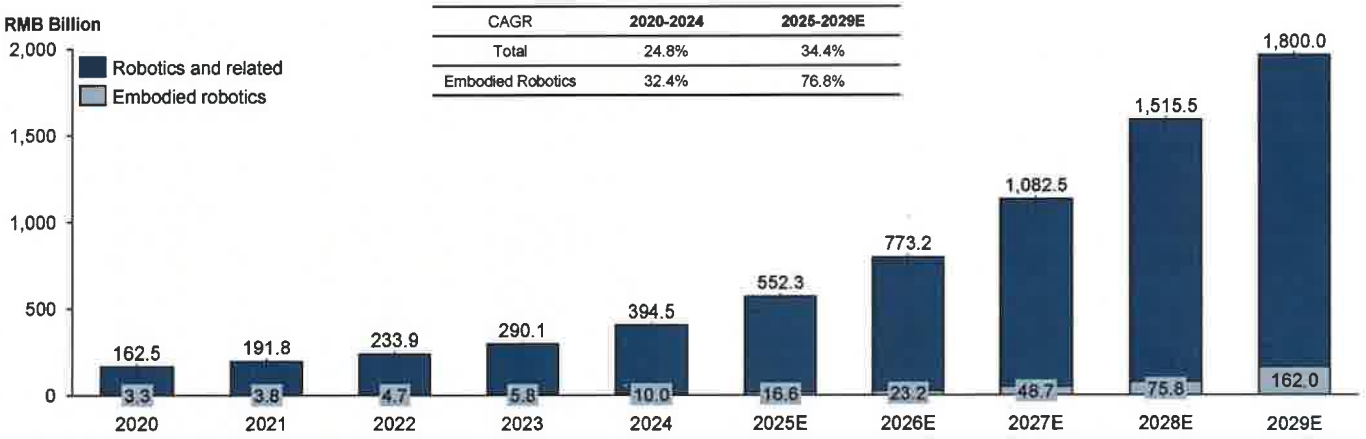
Source: Frost & Sullivan

Overview of Macro-Economic Environment

Global Robotics Market Size, 2020-2029E

Robotics Market Size(Global), 2020-2029E

CAGR	2020-2024	2025-2029E
Total	24.8%	34.4%
Embodied Robotics	32.4%	76.8%



- The global robotics and related industries market has grown from RMB 162.5 billion in 2020 to RMB 394.5 billion in 2024, at a CAGR of 24.8%. Driven by advancements in sensors, micro transmission and drive systems, and the integration of AI, IoT (Internet of Things), and big data technologies, the global robotics market is projected to reach RMB 552.3 billion in 2025 and expand further to RMB 1,800.0 billion by 2029, at a CAGR of 40.0%.
- Among them, the Embodied Robotics market size has grown from RMB 3.3 billion in 2020 to RMB 10.0 billion in 2024, with a CAGR of 32.4%. It is expected to reach RMB16.6 billion in 2025 and will grow to RMB162.0billion by 2029, with a CAGR of 76.8%.

Source: Frost & Sullivan

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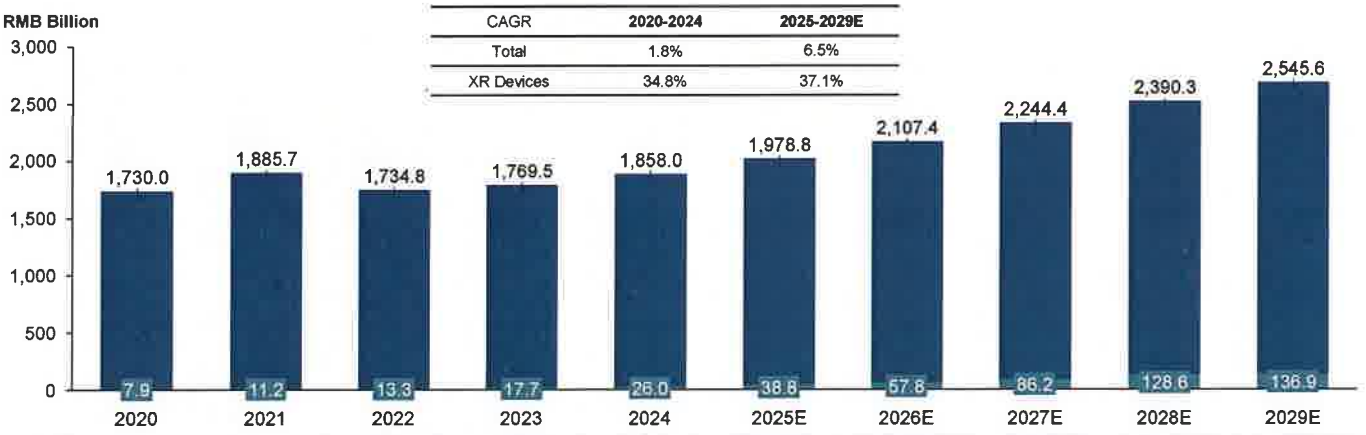
Overview of Macro-Economic Environment

China Consumer Technology Market Size, 2020-2029E

Consumer Technology Market Size (China), 2020-2029E

CAGR	2020-2024	2025-2029E
Total	1.8%	6.5%
XR Devices	34.8%	37.1%



- Consumer technology sector includes terminal products such as smartphones, computers, smart home devices, and smart wearable devices. China's consumer technology market grew from RMB 1,730.0 billion in 2020 to RMB 1,858.0 billion in 2024, with a CAGR of 1.8%. It is expected to reach RMB 1,978.8 billion by 2025 and grow at a CAGR of 6.5% to RMB 2,545.6 billion by 2029, promoting concurrent growth in the micro transmission and drive systems market.
- In particular, the XR devices market in China grew from RMB 7.9 billion in 2020 to RMB 26.0 billion by 2024, at a CAGR of 34.8% during the period. In the future, it will reach RMB 38.8 billion in 2025, growing from a CAGR of 37.1% to RMB 136.9 billion in 2029, with technological breakthroughs and an ever-expanding content ecosystem.

Source: Frost & Sullivan

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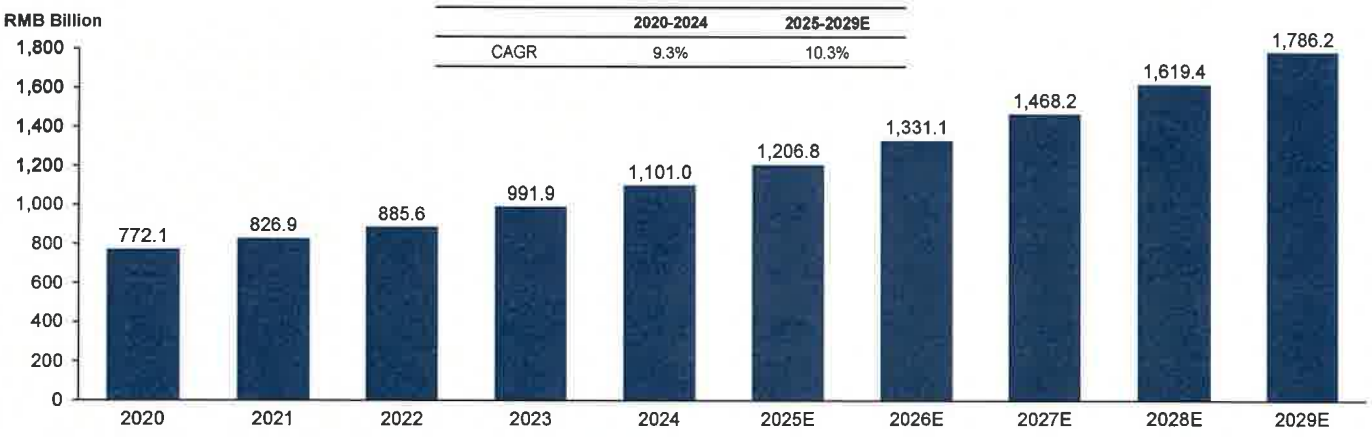
Overview of Macro-Economic Environment in China

China Healthcare technology Market Size, 2020-2029E

Healthcare technology Market Size (China), 2020-2029E



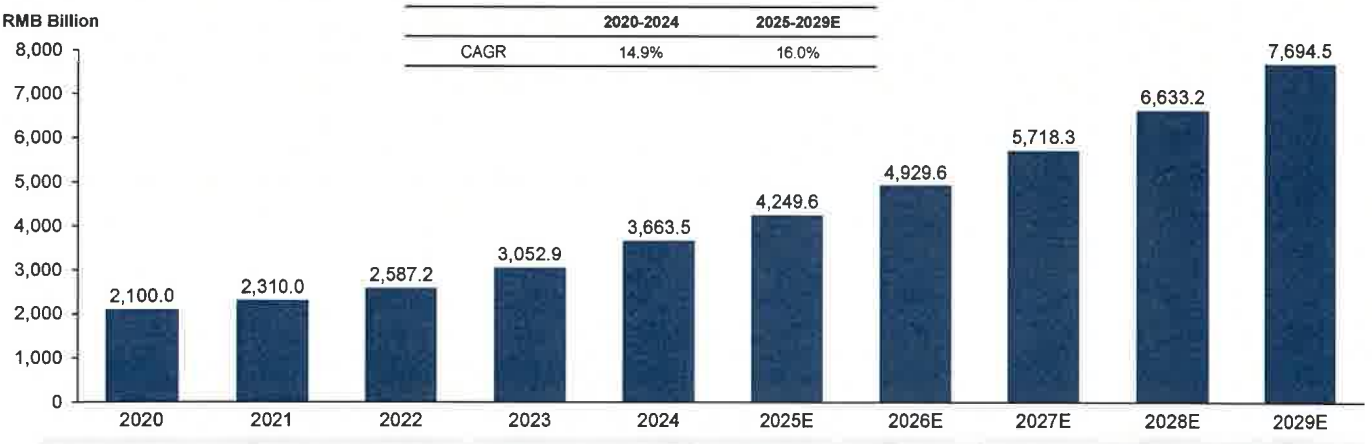
- The healthcare technology sector encompasses precision medical devices and automated medical applications, including medical robotic arm joints, insulin pumps, analgesia pumps, staplers, and auto-injectors.
- China's healthcare technology market increased from RMB 772.1 billion in 2020 to RMB 1,101.0 billion in 2024, with a CAGR of 9.3%. It is projected to reach RMB 1,206.8 billion by 2025 and grow at a CAGR of 10.3% to RMB 1,786.2 billion by 2029, there by driving synchronous growth in the micro transmission and drive systems market.

Source: Frost & Sullivan

Overview of Macro-Economic Environment in China

China Advanced Industry and Smart Manufacturing Sector Market Size, 2020-2029E

Advanced Industry and Smart Manufacturing Sector Market Size (China), 2020-2029E



- The advanced industrial and smart manufacturing sector refers to modern manufacturing paradigms driven by high-precision and intelligent technologies, such as CNC (Computer numerical control) machine tools and automated conveyor systems.
- China's advanced industrial and smart manufacturing market has grown from RMB2,100.0 billion in 2020 to RMB 3,663.5 billion in 2024, achieving a CAGR of 14.9%. Driven by structural industrial upgrading and increasing demand for high-performance CNC machine tool replacements, the market is projected to reach RMB 4,249.6 billion in 2025 and expand at a 16.0% CAGR to RMB 7,694.5 billion by 2029.

Source: Frost & Sullivan

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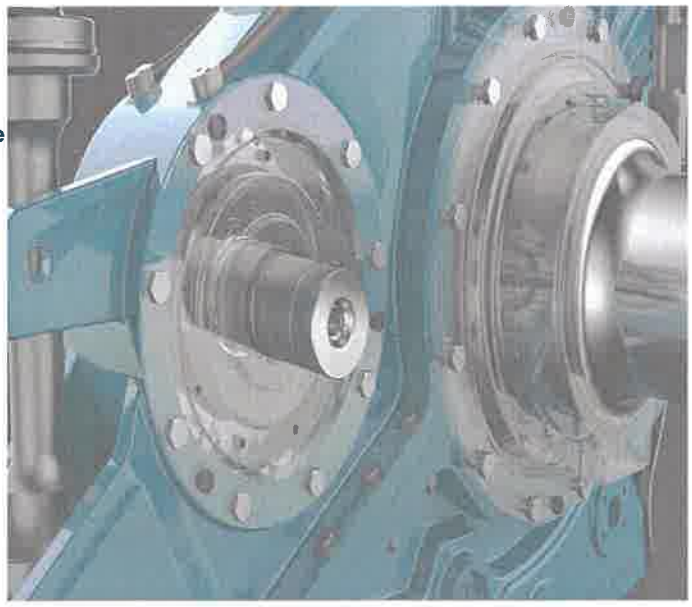


Overview of Global Integrated Micro Transmission and Drive Systems Market

Definition and Classification

Integrated Micro Transmission and Drive Systems Definition and Classification

Integrated micro transmission and drive systems refer to comprehensive power output units that achieve structural, functional, and performance-level synergy and integrated packaging by combining micro transmission components (such as gearboxes, drive shafts, and transmission structures) with micro drive units (including micro motors and their drive control circuits) through system-level design and integration. These systems encompass not only complete mechanical transmission and drive units, but also supporting electronic control and software modules to meet the comprehensive requirements of high performance, precision, compactness, and reliability in complex application scenarios. Specifically, integrated micro transmission and drive systems include:

- **Micro Transmission Systems:** High-precision micro gearboxes, reducers, drive shafts, and other micro mechanical transmission elements
- **Micro Drive Systems:** Micro motors and associated motor drive control circuits (such as PWM drivers and servo control modules)
- **Integrated Design:** Highly integrated mechanical structures and electrical systems of transmission and drive components, forming either a unified product or a modular system
- **Control and Communication Interfaces:** Equipped with intelligent control modules and communication interfaces tailored to system requirements, enabling precise motion control and real-time status monitoring

Comparison of Micro Transmission System and Traditional Transmission System

Classification Criteria	Micro Transmission System	Traditional Transmission System
Product Specifications	Small, Micro	Medium to Large
Main Materials	Engineering Plastics, Metal Powders	Gear Steel
Production Processes	Mold Forming, Including Plastic Injection Molding, Metal Powder Injection Molding, Powder Metallurgy Forming, etc.	Metal Machining, Including Gear Hobbing, Gear Milling, Gear Shaping, Gear Grinding, etc.
Main Functions	Control and Regulation, Transmission of Motion	Transmission of Power
Application Fields	Emerging Industries such as Communication Equipment, Smartphones, Smart Home Appliances, Service Robots, and Traditional Industries such as Automotive Electronics, Medical Devices	Traditional Industrial Sectors such as Automotive Transmissions, Construction Machinery, Ships, Power Equipment, Electric Tools

Overview of Global Integrated Micro Transmission and Drive Systems Market

Key Technologies

➢ The key technologies in Global Integrated micro transmission and drive system industry involve a number of interdisciplinary fields, and their definitions, roles and application scenarios are listed below:

- **Design and Development Technology:** In micro transmission and drive system, the loads transmitted are typically not large, but the product and component dimensions and tolerances are required to be small, and the transmission of motion must be accurate. This places high demands on the design of micro precision gears and gearboxes. The design and development of micro transmission and drive system directly impact key indicators such as transmission efficiency, accuracy, and noise, which in turn significantly affect the overall performance of the machine.

  Since micro transmission and drive system primarily use mold forming processes, the design of their components must take into account the characteristics of mold forming processes. This includes considering factors such as the shape and size accuracy of the gear cavity, shrinkage deformation, and other effects. Additionally, the strength of the gears must be verified and subjected to mechanical simulation. Therefore, it is necessary to establish new design methods, form unified design standards, and develop corresponding design software to meet the design requirements of micro transmission and drive system.

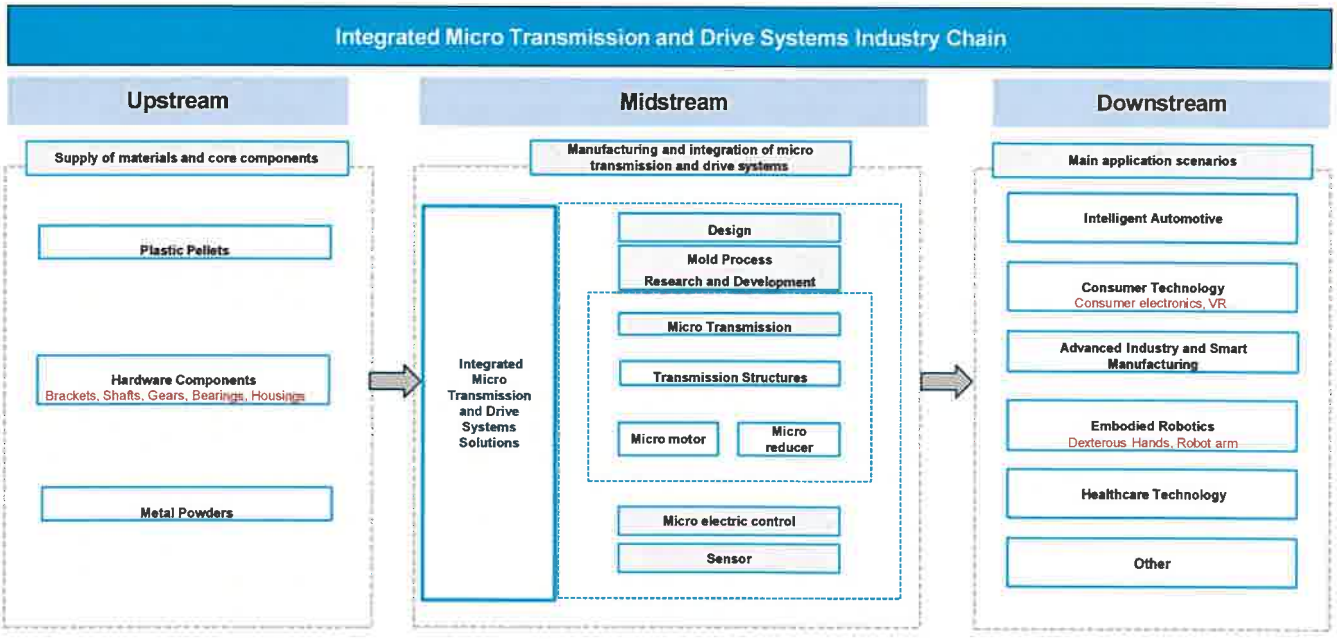
- **Mold and precision machining technology:** Micro transmission and drive systems primarily use mold forming processes, making micro gear molds a core technology. The design and manufacturing level of these molds to a certain extent determines the technical level of micro transmission and drive systems. In terms of micro gear mold design, it is necessary to calculate the tooth profile parameters of the cavity based on product parameters and shrinkage rates.

  In terms of precision machining capabilities, the production and manufacturing of micro transmission and drive systems require high-precision machining equipment. High-performance wire cutting machines, EDM machines, gear hobbing machines, injection molding machines, machining centers, and other important equipment are indispensable. The processing accuracy, wire diameter used, surface finish, and other indicators of the equipment are also correspondingly high, with the main equipment's processing accuracy needing to reach the micron level. Therefore, micro mold design and precision machining capabilities become the core elements in the production and manufacturing process of micro transmission and drive systems.

- **Precision testing technology:** The performance of micro transmission and drive systems directly affects the operating conditions of downstream complete machines. Therefore, it is necessary to conduct comprehensive testing of the performance indicators of micro transmission and drive systems. Comprehensive testing of performance indicators such as accuracy, efficiency, noise, lifespan, waterproofing, dustproofing, vibration resistance, high and low temperature resistance, and drop resistance for micro transmission and drive systems becomes an effective guarantee for the high safety, high reliability, and high stability of the products. It also becomes an important criterion for downstream customers, especially global well-known customers, when choosing suppliers.

Overview of Global Integrated Micro Transmission and Drive Systems Market

Value Chain （1/2）



Overview of Global Integrated Micro Transmission and Drive Systems Market

Value Chain （2/2）

Integrated Micro Transmission and Drive Systems Industry Chain Analysis

➢ Integrated micro transmission and drive systems are core components within the "Four Basics" of industrial development—namely, core basic components, key basic materials, advanced basic crafts, and industrial technology foundations. The industry's value chain can be segmented into upstream, midstream, and downstream sectors:

- Upstream encompasses the supply of raw materials, including plastic pellets, hardware components, and metal powders.
- Midstream involves the manufacturing and integration of micro transmission and drive systems, covering research and development, production, and system integration processes. Integrated micro transmission and drive systems solutions, which consolidate micro transmission and drive capabilities, present higher technological barriers within this segment.
- Downstream applications are extensive, spanning intelligent automotive, consumer technology, healthcare technology, smart homes, advanced industry and smart manufacturing, and robotics sectors.

Overview of Global Integrated Micro Transmission and Drive Systems Market

Historical Development

The micro transmission and drive systems industry has evolved from individual components to industry-specific integrated solutions, and its development can be divided into three stages:

The Development History of Micro Transmission and Drive Systems

Micro Transmission and Drive Systems Stage	Transmission Structures and Components Phase 1	Micro Transmission and Drive Systems Solutions Phase 2	Integrated Micro Transmission and Drive Systems Solutions Phase 3
Products			
Main Feature	• This initial phase focused on the design and manufacturing of components such as gearboxes, bearings, and transmission structures, primarily serving basic power transmission functions, for example, horizontal transmission modules in automotive seat adjustment systems. • During this stage, product integration and the miniaturization of gears and other components gradually improved, laying a technical foundation for precision machining and micro transmission design.	• With increasing downstream demand for high precision and miniaturization, the industry advanced to the integration of motors and gearboxes, introducing modular products like the 3.4mm micro planetary gearbox. This stage marked the industry's initial capability in miniaturization. However, products remained largely standardized, lacking sufficient industry customization and comprehensive integration capabilities.	• To meet customized high-precision control requirements, the industry has entered a stage of integrated system design. Integrated micro transmission and drive systems solutions combine micro transmission structures, micro motors, micro electronic control systems, and sensors. Designed for specific scenarios and driven by the demand for miniaturized systems, these solutions require companies to possess full-stack capabilities covering the entire value chain to deliver scenario-based solutions. These systems are widely adopted across intelligent automotive, consumer technology, advanced industry, smart manufacturing, and robotics sectors.

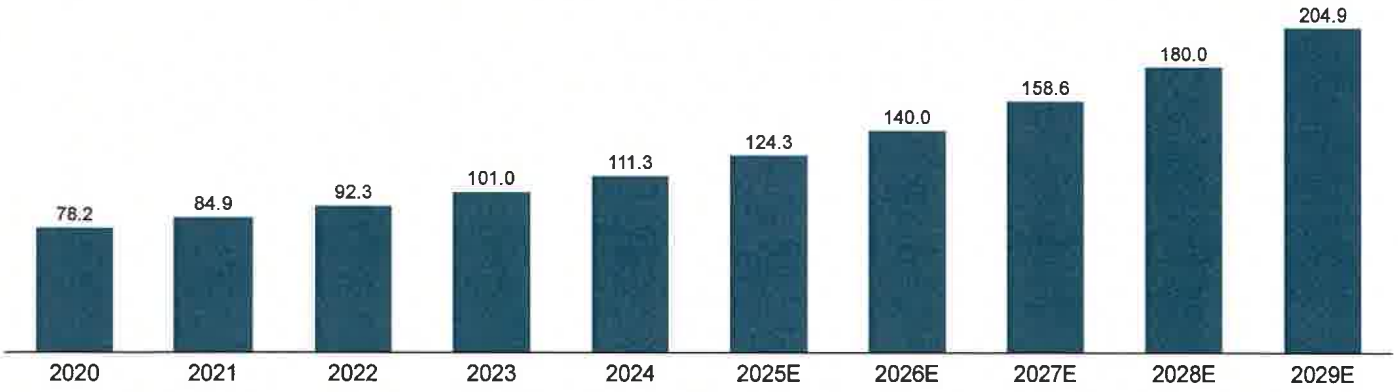
Overview of Global Micro Transmission and Drive Systems Market

Integrated Micro Transmission and Drive Systems Market Size , 2020-2029E

Global Integrated Micro Transmission and Drive Systems Market Size , 2020-2029E

RMB Billion

CAGR	2020-2024	2025E-2029E
Total	9.2%	13.3%



- Driven by broader application scenarios and the growing need for scenario-based design, Global integrated micro transmission and drive systems industry expanded from RMB 78.2 billion in 2020 to RMB 111.3 billion in 2024, representing a CAGR of 9.2%.
- Looking ahead, propelled by industrial upgrading and technological advancements, the industry is expected to continue expanding, reaching RMB 124.3 billion by 2025 and growing at a CAGR of 13.3% to RMB 204.9 billion by 2029.

Source: Frost & Sullivan

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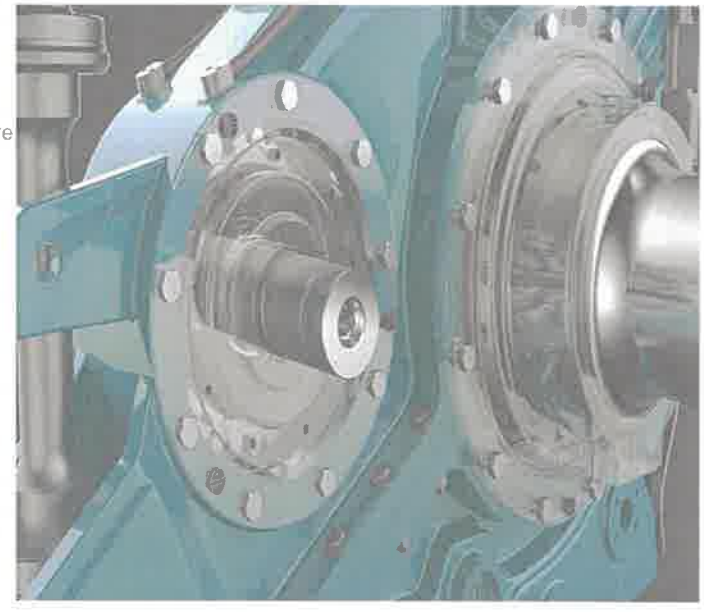


Overview of Downstream Application Scenarios

Intelligent Automotive Sector

Intelligent Automotive Sector Definition

➢ This encompasses intelligent automotives and cockpit components. Integrated Micro transmission and drive systems are extensively utilized in scenarios such as central control screens, electric rear wings, and automotive chassis, enhancing safety and comfort. For instance, in intelligent cockpit sector, central control screen swing actuators integrate DC motors with worm gear transmissions to enable left-right rotation of the screen; In intelligent automotive chassis, electronic parking systems employ optimized gear structures and multi-stage planetary transmission designs to address high-torque output requirements within compact spaces.

The Application of Integrated Micro Transmission and Drive Systems in Intelligent Automotive Sector

Intelligent Cockpit Sector		
Center Panel Offset Actuator		• The center control screen deflection actuator adopts a combination of DC motor, parallel drive and worm gear drive to realize the function of deceleration and torsion increase. The device drives the spindle that carries the screen, so that the center control screen can be rotated left or right by 15° to face the driver or co-passenger as needed.
Rotary actuator for center console		• Rotary actuator for center console of the center control screen adopts the combination structure of brushless DC motor, one-stage worm gear transmission and parallel transmission to realize the rotation switch of the screen from 0-90° between the horizontal and vertical screens. The stop position has a built-in buffer structure to ensure that the screen rotation process is more stable and smooth.
Sun screen actuator		• The sun screen actuator utilizes an innovative planetary drive design that integrates the motor with the rotary shaft. High reduction ratios and high torque output are achieved in a compact structure, allowing the sun screen to open and close around the motor's center axis. The design is a clever blend of practicality and entertainment.
Rear ceiling screen actuator		• The rear ceiling screen actuator drives the screen to rotate by driving the product shell, which can realize the adjustment of multiple preset angles, making it easy for users to adjust flexibly according to their viewing needs. At the same time, the built-in limit locking function can keep the screen stably positioned even under bumpy road conditions.
Handrail screen drive actuator		• Handrail screen drive actuator uses a high-precision motor and reducer combination to provide torque and speed to achieve smooth screen deployment. Compact and lightweight, this solution features silent operation, multi-angle hovering, and excellent vibration resistance.

Overview of Downstream Application Scenarios

Intelligent Automotive Sector

The Application of Integrated Micro Transmission and Drive Systems in Intelligent Automotive Sector

Automotive Chassis		
AGS Actuator		• The AGS actuator solves the challenges of achieving high torque output, low-noise operation, and extended clutch life in a miniaturized structure by designing a dedicated gearbox solution for automotive clutch valve systems.
Electronic Parking Brake System		• By optimizing the gear tooth design and analyzing the multi-stage planetary transmission, the electronic parking brake system solves the problem of achieving large torque output in a compact structure, thus providing sufficient braking force for the vehicle to prevent skidding. At the same time, the precise gear meshing significantly reduces operating noise and enhances the comfort of the entire vehicle.
Steering Wheel Electric Adjustment		• The steering wheel electric adjustment actuator is mounted on the steering column and adopts a two-stage screw structure to drive the column to realize high-speed expansion and contraction, thus realizing the efficient stowage function of the steering wheel.

**Intelligentization and connectivity have become the primary directions and trends in the automotive industry's recent development. The functional positioning of automobiles is shifting from mere transportation tools to intelligent mobile living spaces. Under this trend, miniature transmission and drive systems—characterized by their compactness, low noise, and high efficiency—are widely used in various applications that enhance vehicle safety and comfort.*

Overview of Downstream Application Scenarios

Intelligent Automotive Sector

The Application of Integrated Micro Transmission and Drive Systems in Intelligent Automotive Sector

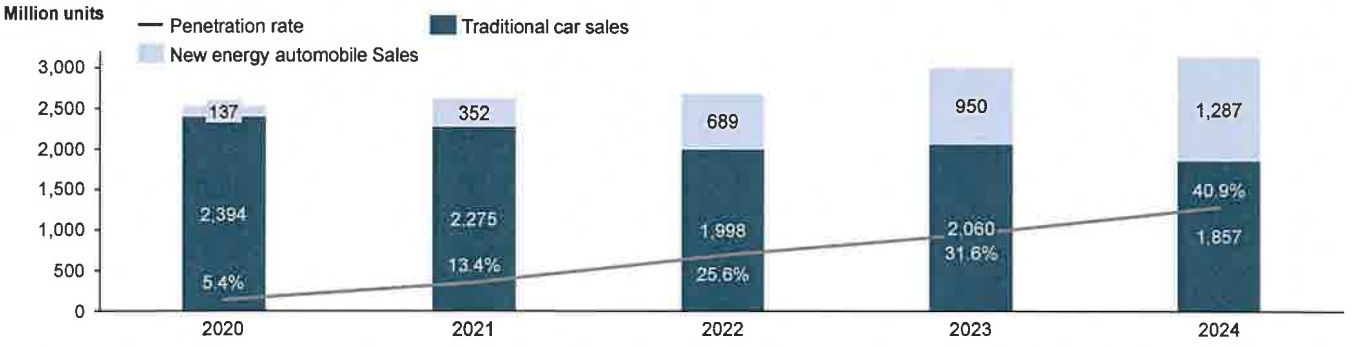
Automotive Electronics		
LIDAR Tuning Module		• The LIDAR adjustment module adopts stepping motor with worm and helical gear structure, which can realize the dynamic positioning operation of the radar components, and can realize 360° degree environment sensing, which can help to improve the safety of driving under complicated road conditions.
Automotive Tail Lift Drive System		• The automotive tailgate drive system adopts a compact worm gear transmission structure, realizing multi-position height adjustment of the tailgate and self-locking in various positions, ensuring operational stability and improving vehicle aerodynamic performance at high speeds.
Automotive Tailgate Retractable Actuator		• Automotive Tailgate Retractable Actuator adopts motor-driven planetary reduction system to transmit the torque to the wire rod through the output spline rotation, so as to drive the tailgate spacer to realize the lifting and lowering motion. The actuator can output large supporting torque in limited space and is widely used in tailgate lifting and lowering systems for SUVs, sedans and other types of passenger cars.
Hidden Door Handle Actuator		• The Hidden Door Handle Actuator utilizes a compact micro-drive design that achieves high torque output in a small footprint to smoothly actuate the retracting and retracting motion of the door handle. It offers the advantage of space-saving and easy vehicle integration, as well as continuous and stable high torque output, and is precision engineered for long life and durable duty cycle.

Overview of Downstream Application Scenarios

Intelligent Automotive Sector

The penetration rate of new energy automobile in China is continuously increasing, driving the rapid development of the integrated micro transmission and drive systems sector

China's New Energy Automobile Sales (Million units) and Penetration Rate (%), 2020-2024



- The market is accelerating the transformation of the automotive industry towards intelligence and electrification. The growth momentum of the Chinese new energy automobile market is strong. The intelligent vehicle market is booming, bringing new opportunities to the integrated micro transmission and drive systems field. Since 2021, the sales volume of new energy electric vehicles has significantly increased, with sales exceeding 10 million units in 2024 and a new energy automobile penetration rate reaching 40.9%. The market's acceptance of intelligent vehicles is steadily increasing, and the level of vehicle intelligence has become a focal point of competition. This has led to a continuous expansion of the automotive electronics market, creating a broad application space for micro transmission and drive systems.

Source: Frost & Sullivan

Overview of Downstream Application Scenarios

Consumer Technology Sector

Consumer Technology Sector Definition

➢ Consumer technology sector includes terminal products such as smartphones, computers, smart home devices, and smart wearable devices. Applications of integrated micro transmission and drive systems include features like interpupillary distance adjustment in VR/AR glasses.

Consumer Technology Sector Classification, 2000-Present

Desktop Internet

Mainstream products: digital cameras, PC computers, feature phones

- Around 2000, laptops entered a period of rapid growth, replacing desktops as the driving product of the electronics industry
- In 2000, the first touch-screen cell phone was introduced.
- 2002: Color display screens were introduced, and cameras appeared on cell phones for the first time.
- In 2005, compact digital camera products have been marketed.

- At this stage, the consumer electronics industry was characterized by single-computer intelligence, i.e., intelligent devices could not establish interconnections.

Mobile Internet

Mainstream products: smartphones, tablets

- In 2010, the release of Apple's iPhone 4 opened up the smartphone era
- At this stage, interconnectivity was established between smart devices, and the intelligent experience scene was continuously enriched and upgraded

Internet of Everything

Mainstream products: wearable devices, VR/AR devices, smart home

- In August 2021, the attention of VR industry is dramatically increased
- In 2022, diversification and intellectualization, smart screen, curved screen, etc. appeared and became popular
- At this stage, the Internet of Things and other emerging technologies, and consumer electronics products to accelerate the speed of integration, the new form of the product is rich, the consumer electronics industry into the era of the Internet of Everything, the original Huawei and other head of the cell phone manufacturers are also gradually involved in the development of the whole consumer electronics categories

Overview of Downstream Application Scenarios

Consumer Technology Sector

The Application of Integrated Micro Transmission and Drive Systems in Consumer Technology Sector

Consumer Technology

Pupil Adjustment Module

Flat Panel Camera Module

- The Pupil Adjustment Driver Module is designed for VR headsets and similar devices to enhance the user's visual experience. The **system precisely adjusts the distance between the lenses to match the pupil** distance of different users to achieve a clear and comfortable imaging effect.
- The use of advanced one-piece molding process and the integrated design of the gearbox housing and bracket structure simplifies the assembly process, improves transmission efficiency and adjustment precision, and effectively reduces operating noise, creating a more cost-effective solution that significantly optimizes the user's viewing experience. In addition, the compact and efficient structural design is suitable for the integration of various VR headsets and smart glasses.
- By lifting and lowering the camera structure, users can easily adjust the camera to face downward for filming textbook content, thus realizing a blended learning experience that seamlessly integrates online and offline. This solution not only improves the students' experience, but also enhances the product's sense of technology and premium.

Overview of Downstream Application Scenarios

Healthcare Technology Sector

Healthcare Technology Sector Definition

- This encompasses precision medical devices and automated medical treatment scenarios. Integrated micro transmission and drive systems are widely applied in medical robotic arm joints, insulin pumps, analgesia pumps, staplers, and auto-injectors. For example, in micro insulin pumps, stepper motors drive lead screws to slide to achieve precise control.

Type Name	Definition	Type Examples
Class I	The Class I is medical devices that have a low level of risk and whose safety and effectiveness can be ensured by the implementation of routine management.	Surgical instruments (knives, scissors, forceps, tweezers, hooks), gua sha boards, medical X-ray films, surgical gowns, surgical caps, examination gloves, gauze bandages, drainage bags, etc.
Class II	The Class II is medical devices with moderate risk that require strict control and management to ensure their safety and efficacy.	Medical suture needles, sphygmomanometers, thermometers, electrocardiographs, electroencephalographs, microscopes, acupuncture needles, biochemical analysis systems, hearing aids, ultrasound sterilization equipment, non-absorbable sutures, etc.
Class III	The Class III is medical devices that have higher risks and require special measures of strict control and management to ensure their safety and effectiveness.	Implantable cardiac pacemakers, corneal contact lenses, IOLs, ultrasound tumor focusing knives, hemodialysis devices, implantable devices, vascular stents, comprehensive anesthesia machines, dental implant materials, medical absorbable sutures, intravascular catheters,medical robotic arm joints, etc.

- In recent years, the number of medical device product registrations in China has shown significant growth. In particular, the number of first registrations of Class III medical devices has achieved double-digit growth for two consecutive years, with the number of registrations reaching 1,844 in 2024, a year-on-year increase of 63%. Meanwhile, the number of first-time registrations of Class II and Class I medical devices maintains steady growth, with the number of registrations reaching 13,334 and 28,508 respectively in 2024.
- In addition, influenced by China's policy of encouraging medical device innovation, the number of approvals for innovative medical devices has increased significantly, with 55 approvals in 2024, representing a 57.1% year-on-year increase.

Overview of Downstream Application Scenarios

Healthcare Technology Sector

The Application of Integrated Micro Transmission and Drive Systems in Healthcare Technology Sector

Healthcare Technology		
Minimally invasive electric anastomosis drive system		• The system drives the planetary gearbox through the electric motor to realize the anastomosis mechanism's forward and backward movement, thus realizing efficient and precise tissue suturing, improving the flexibility of the anastomosis operation and overall performance, and contributing to more efficient and precise surgical procedures. • The drive system is characterized by high torque output, compact structure and low noise operation. By integrating a high-performance motor with a planetary gearbox, the system realizes a strong torque output in a limited space, which is especially suitable for minimally invasive surgery, a highly space-sensitive application. In addition, the system provides excellent noise and vibration control during operation, which helps create a more comfortable operating environment for the surgical staff and reduces intraoperative fatigue.
Orthopedic Surgical Wound Cleaning Pump System		• The Orthopaedic Surgical Wound Cleaning Pump System is designed to enhance the efficiency and safety of orthopaedic surgery by precisely controlling the flushing flow rate. The system adopts a combination of DC motor and face gear transmission structure, supporting multi-position flow adjustment, enabling the surgeon to flexibly regulate the rinsing intensity according to the specific surgical needs. • The program is characterized by adjustable flow rate, convenient operation and low noise operation. Through the multi-speed adjustment function, it realizes personalized control of wound cleaning intensity and ensures the cleaning effect of the operation area. The humanized design also simplifies the intraoperative operation process, enabling the surgeon to focus more on the surgery itself. In addition, the system's low noise performance during operation helps create a quieter, more focused surgical environment.

Overview of Downstream Application Scenarios

Healthcare Technology Sector

The Application of Integrated Micro Transmission and Drive Systems in Healthcare Technology Sector

Healthcare Technology		
Medical insulin syringe pumps		• Designed to enhance the precision and reliability of insulin delivery in diabetes management. The system employs a stepper motor with a parallel drive structure to drive a screw and nut assembly to precisely control the advancement of the injection piston for individualized dosage subcutaneous injection. • The compact and lightweight design of the system makes it easy to integrate into a variety of insulin injection equipment, providing users with greater flexibility and convenience. At the same time, the drive system operates with low noise and high output torque, which ensures performance and significantly improves user comfort.
Bone Drill Micro Drive System		• Designed to enhance the performance and reliability of orthopedic surgical instruments. The system adopts a high-frequency brushless motor, which enables high-speed rotation of the drill, ensuring accurate drilling while effectively reducing noise and optimizing the surgical environment.
Nursing Glasses Gearbox		• Designed to enhance the functionality of vision care devices such as vision correction instruments. This advanced drive system can be linked with the customer's lens magnet to precisely control the slider's travel distance, enabling intelligent focus adjustment of the lens during the user's wearing process, resulting in a personalized and comfortable visual experience. • The gearbox is compact and lightweight, and can be easily integrated into all types of eye care equipment without affecting the appearance and styling of the product. The solution significantly improves the effectiveness of vision care and orthodontic treatments by realizing precise and automatic lens adjustments.

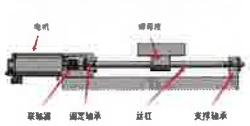
Overview of Downstream Application Scenarios

Advanced Industry and Smart Manufacturing Sector

Advanced Industry and Smart Manufacturing Sector Definition

- This refers to modern manufacturing forms driven mostly by high-precision and smart technologies. Integrated Micro transmission and drive systems are extensively used in various industrial manufacturing equipment, such as CNC machines and conveyors. For instance, in CNC machine production processes, integrated micro transmission and drive solutions achieve positioning accuracy at the 0.1mm level.
- Among them, CNC machine tools are widely used in the integrated micro transmission and drive systems industry. CNC machine tools can be divided into screw CNC machine tools and all-direct-drive CNC machine tools according to the transmission mode; screw CNC machine tools are the mainstream CNC machine tools at present, and the all-direct-drive CNC machine tools have a greater advantage in high-speed and high-precision.

CNC machine tools (classified according to transmission method)

Classifications	Definition	Structural Examples	Comparison of characteristics
Screw CNC machine tools	❑ Screw CNC machine tools refer to the use of a screw-nut sub-system to convert rotary motion into linear motion in their feed drive systems. ❑ Screws can be divided into trapezoidal screws, ball screws and planetary screws. Screw CNC machine tools mainly use screw products for ball screws.	**Screw drive structure** 	❑ Currently, ball screws are used as the main drive for screw machines. A screw machine is usually equipped with three sets of screw rails, which are used in all three linear axes of XYZ. ❑ In terms of advantages, compared with traditional transmission methods such as gears, hydraulics, chains, etc., screw machine tools can realize micron-level motion control, higher wear resistance, and so on. Compared with the direct-drive structure, the screw drive has a more complete industrial support, and for the CNC system requirements are lower. ❑ From the disadvantage point of view, screw CNC machine tools will appear screw and guide rail assembly does not fit the problem, there will also be a Y-axis single drive caused by the problem.
Full direct drive CNC machine tools	❑ Full direct-drive CNC machine tools mainly refer to CNC machine tools that use linear motors in the machine's feed drive system and electric spindles for the spindle. ❑ Direct drive technology refers to the use of electromagnetic technology to directly convert electrical energy into linear or rotary mechanical energy.	**direct-drive construction** 	❑ Direct drive is characterized by simple structure, no wear and tear, low noise and easy maintenance. ❑ In terms of advantages, fully direct-drive machine tools can have lower energy consumption due to the use of linear motors. At the same time, full direct-drive CNC machine tools can also realize the system interpolation accuracy of less than 1 nanometer, circular accuracy can be less than 1μm, usually applicable to the higher demand for precision parts processing. ❑ From the disadvantage point of view, full direct drive CNC machine tools will have machine structure rigidity problems and scale installation position design problems.

Overview of Downstream Application Scenarios

Advanced Industry and Smart Manufacturing Sector

The Application of Integrated Micro Transmission and Drive Systems in Advanced Industry and Smart Manufacturing Sector		
Advanced Industry and Smart Manufacturing Sector		
Drum Motor Drive Systems		• It is a highly integrated motorized pulley, which combines motor, gearbox and electric control system in a single unit with compact structure and high efficiency. The product is characterized by small size, convenient installation and easy operation, and is widely used in food transportation, industrial automation, airport and high-speed rail security check systems, etc.
Valve Actuator		• The valve actuator adopts the integrated design of electric control, gearbox transmission and drive motor, and has certain self-locking ability. The product is characterized by small volume, high temperature resistance, strong load capacity, low noise, high cost performance and long service life.
Precision Dispenser Screw Valve Drive System		• Designed to meet the critical need for accurate and consistent application of materials. This advanced system integrates a planetary reduction gearbox for the rotating screw with a hollow cup brushless motor to achieve high precision dosing by driving the screw within the stator chamber. The design ensures a stable and uniform dispensing flow, dramatically improving the performance and reliability of the dispensing equipment. The system has the significant advantages of low noise, high precision and long life.
5G Base Station RCU Module		• An all-in-one RCU module solution covering both hardware and driver module design. The solution can be used in conjunction with the customer's software system to remotely adjust the downward tilt angle of the base station's radiated signal antenna to precisely control the location and range of network coverage.

Overview of Downstream Application Scenarios

Embodied Robotics Sector

This refers to humanoid and non-humanoid embodied robots that serve complex and high-precision scenarios. Integrated Micro transmission and drive systems provide precise control for embodied robots.

➢ The application of Integrated micro transmission and drive systems in the robotics industry can be systematically categorized by three dimensions: robot type, drive technology, and application scenarios:

Robot Type	Drive/Transmission Technology	Core Components	Typical Application Scenarios	Case Studies/Technical Features
Bionic Soft Robots	- Triboelectric Nanogenerator (TENG) Drive - Photothermal Drive - Dielectric Elastomer Drive	Flexible materials, nanogenerators, AI feedback	Minimally invasive surgery, environmental exploration, biomimetic motion	Worm-like soft robots (positioning error Octopus-inspired grippers (multi-DOF control)
Medical Robots	- Magnetic Micro-Drive Systems - Planetary Gearbox + Torque Feedback - Shape Memory Alloy (SMA) Drive	Micro reducers, coreless motors, magnetic modules	Capsule robots (GI tract inspection) Surgical robots (precision injection, vascular intervention)	Magnetic capsule robots (5-DOF motion) Zhaowei's precision injection
Service Robots	- DC Gear Motors + Worm Gear Drives - Harmonic Drive Integration - Smart Home Modules	Planetary gears, ball screws, low-noise motors	Home cleaning robots, educational robots, food service robots	Zhaowei's Sweeping robot drive system Smart curtain modules
Industrial Robots	- High-Torque-Density Motors - Mid-Mounted Motor Platforms - AI Dynamic Control Systems	Roller motors, harmonic drives, torque sensors	Warehouse sorting, automotive welding, precision assembly	Logistics sorting roller motors
Micro Aerial Vehicles (MAVs)	- Piezoelectric Resonance Drive - Nanogenerator Energy Systems - Photothermal-Mechanical Drive	Piezoelectric ceramics, lightweight gears	Environmental monitoring, military reconnaissance, disaster rescue	Insect-scale aircraft Self-powered nano-drive flight (no external power supply)
Humanoid Robots	- 17-DOF Dexterous Hand Systems - Tendon Drives + Micro Servo Motors - Multi-Sensor Fusion	Micro servo motors, harmonic drives, tactile sensors	Precision grasping, human-robot interaction, complex motions	Zhaowei's Dexterous Hands (17 integrated motors) Tesla Optimus articular drive (0.01° precision)
Micro Surgical Robots	- Gradient Magnetic Field Drive - Pulsed Magnetic Rotation Control - Micro Hydraulic Drive	Magnetic modules, micro pumps, precision gearboxes	Cardiovascular intervention, neurosurgery, implantable devices	Magnetic continuum robots (3-5 DOF vascular navigation) Biodegradable micro-drive capsules
Educational/Entertainment Robots	- Low-Cost DC Motor Drives - Simplified Gearbox Drives - Modular Design	Plastic gears, coreless motors, open-source controllers	STEM education kits, interactive toys, theme park robots	Educational robot joints Disney IP robots

Overview of China's Integrated Micro Transmission and Drive Systems Market

Definition and Classification

Integrated Micro Transmission and Drive Systems Definition

- Integrated micro transmission and drive systems refer to comprehensive power output units that achieve structural, functional, and performance-level synergy and integrated packaging by combining micro transmission components (such as gearboxes, drive shafts, and transmission structures) with micro drive units (including micro motors and their drive control circuits) through system-level design and integration. These systems encompass not only complete mechanical transmission and drive units, but also supporting electronic control and software modules to meet the comprehensive requirements of high performance, precision, compactness, and reliability in complex application scenarios.

Core Components

Micro Transmission Components

Serving as the core of energy transmission, these components utilize micro gear modules with a module of 0.5mm or less, characterized by low noise, lightweight, compact size, and minimal backlash.

Micro Motor Components

- Including brushed/brushless DC motors and stepper motors, these serve as the system's power source. Compared to traditional motors, they offer advantages such as high speed, low noise, low resonance, and high power density, making them suitable for size-sensitive precision applications requiring compact size and rapid response, such as dexterous hands.

Micro electronic Control systems and Sensors

Acting as the intelligent control center of the system, these components work in coordination with micro motors and micro transmission systems to achieve high-precision motion sensing and control of speed and load. The electronic control integrates sensing and control algorithms to meet the requirements of various operating conditions.

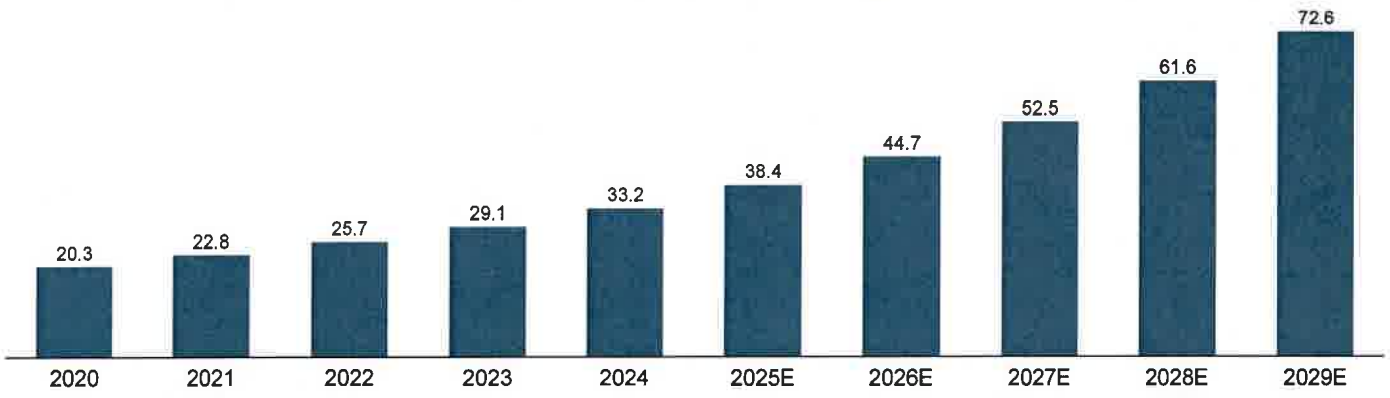
Overview of China's Integrated Micro Transmission and Drive Systems Market

Integrated Micro Transmission and Drive Systems Market Size , 2020-2029E

China Integrated Micro Transmission and Drive Systems Market Size , 2020-2029E

CAGR	2020-2024	2025E-2029E
Total	13.0%	17.3%

RMB Billion



- Driven by rising downstream demand and increasing adoption across high-growth sectors, China integrated micro transmission and drive systems industry expanded from RMB 20.3 billion in 2020 to RMB 33.2 billion in 2024, reflecting a CAGR of 13.0%.
- Looking ahead, underpinned by accelerated industrial transformation and the shift toward high-performance, miniaturized systems, the industry is expected to continue expanding, reaching RMB 38.4 billion by 2025 and growing at a CAGR of 17.3% to RMB 72.6 billion by 2029.

Source: Frost & Sullivan

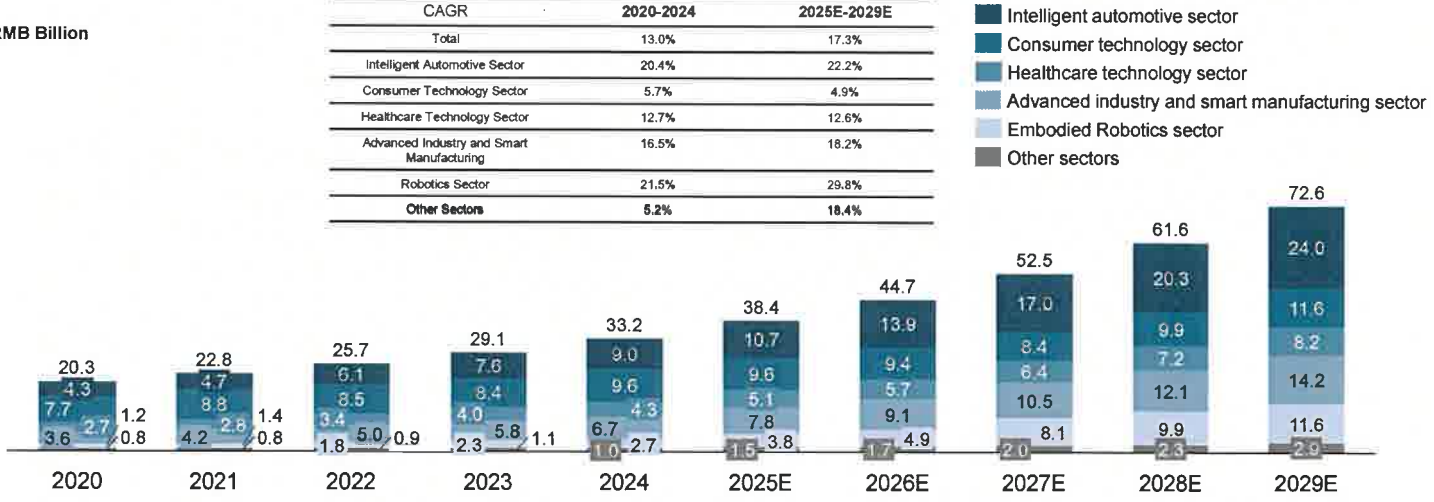
Overview of China's Integrated Micro Transmission and Drive Systems Market

Integrated Micro Transmission and Drive Systems Market Size , 2020-2029E

Integrated Micro Transmission and Drive Systems Market Size (China) Downstream Application Scenarios, 2020-2029E

RMB Billion

CAGR	2020-2024	2025E-2029E
Total	13.0%	17.3%
Intelligent Automotive Sector	20.4%	22.2%
Consumer Technology Sector	5.7%	4.9%
Healthcare Technology Sector	12.7%	12.6%
Advanced Industry and Smart Manufacturing	16.5%	18.2%
Robotics Sector	21.5%	29.8%
Other Sectors	**5.2%**	**18.4%**



- Integrated micro transmission and drive systems are widely applied across various fields, such as intelligent automotive, consumer technology, healthcare technology, advanced industry and smart manufacturing, embodied robotics, and other sectors. Among these, benefiting from the trend of automotive industry intelligence, intelligent automotive is the most widely used sub-sector for Integrated micro transmission and drive systems. In 2024, the market size of Integrated micro transmission and drive systems in the intelligent automotive sector accounted for approximately 27% of the total Integrated micro transmission and drive systems market size.

Source: Frost & Sullivan

Overview of China's Integrated Micro Transmission and Drive Systems Market

Policy Analysis

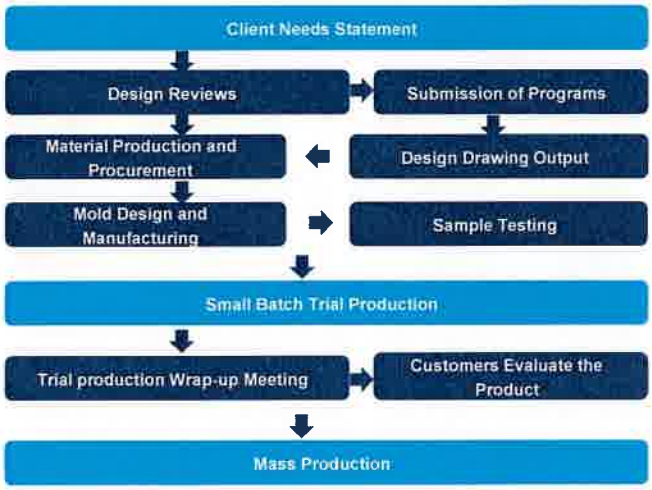
Regulations	Issuing year	Issuer	Description
Measures on Creating New Consumption Scenarios and Cultivating New Growth Drivers 《关于打造消费新场景培育消费新增长点的措施》	2024-06	National Development and Reform Commission and three other ministries	Expands the functions of intelligent robots in healthcare, industry, entertainment, and services; explores the development of humanoid robots.
Opinions on Developing the Silver Economy and Enhancing the Well-being of the Elderly 《关于发展银发经济增进老年人福祉的意见》	2024-01	The State Council	Proposes promoting the application of intelligent terminals such as service robots and wearable devices in elderly care scenarios.
Guiding Opinions on the Innovative Development of Humanoid Robots 《人形机器人创新发展指导意见》	2023-11	Ministry of Industry and Information Technology	By 2025, an initial innovation system for humanoid robots will be established, with breakthroughs in key technologies such as the "brain," "cerebellum," and "limbs," ensuring secure and effective supply of core components.
Implementation Plan for the Standardization Pilot Project of Emerging Industries (2023–2035) 《新产业标准化领航工程实施方案（2023—2035年）》	2023-08	Ministry of Industry and Information Technology and three other ministries	Focuses on standardization of emerging and future industries, forming the "8+9" key domains for new industry standards. Emerging industries include eight areas such as new energy, new materials, and new energy vehicles; future industries include nine areas such as humanoid robots and generative artificial intelligence.
Opinions on Further Unlocking Consumption Potential and Promoting Sustained Consumption Recovery 《关于进一步释放消费潜力促进消费持续恢复的意见》	2022-04	The State Council	Focuses on automobiles and home appliances; encourages enterprises to carry out promotional activities in rural areas; supports qualified regions in promoting the adoption of new energy vehicles and green smart home appliances in the countryside.
National Standardization Development Outline 《国家标准化发展纲要》	2021-10	The State Council	Strengthening core foundational components (electronic components), advanced fundamental processes, key basic materials, and industrial technology infrastructure standards development
Guiding Opinions on Accelerating the Cultivation and Development of High-Quality Manufacturing Enterprises 《关于加快培育发展制造业优质企业的指导意见》	2021-06	Ministry of Industry and Information Technology of the PRC and five other ministries	Enhancing independent innovation capabilities of high-quality enterprises; intensifying R&D and demonstration applications of key core technologies, products, and equipment in foundational components, basic electronic components, foundational software, and high-end instrumentation.
New Energy Vehicle Industry Development Plan (2021–2035) 《新能源汽车产业发展规划（2021—2035年）》	2020-11	The State Council	Establish a key component technology supply system based on three core areas: power batteries and management systems, drive motors and power electronics, and connectivity and intelligent technologies. Strengthen development of key components and systems for intelligent connected vehicles.
Intelligent Vehicle Innovation Development Strategy 《智能汽车创新发展战略》	2020-02	National Development and Reform Commission of the PRC and 10 other ministries	By 2025, establish the fundamental framework for technological innovation, industrial ecosystem, infrastructure, regulations and standards, product supervision, and cybersecurity for standard intelligent vehicles in China. Achieve mass production of conditionally autonomous intelligent vehicles and market deployment of highly autonomous vehicles in specific environments.

Overview of China's Integrated Micro Transmission and Drive Systems Market

Business Model Analysis

- The business model of China's integrated micro transmission and drive industry is centered on customer needs, ensuring product quality and market adaptability through rigorous design, production and testing processes, and ultimately mass production.

Integrated Micro Transmission and Drive Systems Market Business Model



Business Model Analysis

- **Production Model:** Due to the different fields and application scenarios of the customers in China's integrated micro transmission and drive systems industry, the products show customized characteristics, with many subdivided types and specifications. Therefore, the company's production mainly adopts the "production based on sales" mode, not only to meet the individual needs of customers, but also to reduce the inventory backlog and improve the capital turnover rate.
- **Research and Development Model:** China integrated micro transmission and drive systems needs to develop one or more molds for each product. Due to the large number of product types and subdivided models, there are certain differences in specifications, technical level, production difficulty and precision, and the products are basically customized products.
- **Procurement Model:** China integrated micro transmission and drive systems company's customized products determine the company's main use of "sales to procurement" procurement model. Except for a small number of general-purpose materials such as plastic pellets, the company's raw materials are purchased according to customer orders or order forecasts.
- **Sales Model:** Most of the integrated micro transmission and drive systems companies in China adopt the direct sales model. The companies generally contact customers through online platform promotion, participation in exhibitions, participation in bidding, referrals from old customers, technical exchanges, etc., to obtain customer demand information, and develop and produce products according to the customer's product demand.

Overview of China's Integrated Micro Transmission and Drive Systems Market

Key Market Drivers

Growing Demand for Miniaturization and Precision in Downstream Applications	• To enhance product competitiveness, downstream manufacturers increasingly demand miniaturized integrated micro transmission and drive systems. These systems offer compact, high- performance solutions, with micro gearboxes playing a pivotal role in enabling size reduction. As applications become more complex and space-constrained, there is also a growing emphasis on the precision of micro gearboxes, which directly affects transmission efficiency, noise levels, and overall system stability. As early adopters prove the value of miniaturization and precision, their use is expanding across sectors, driving the broader development of the integrated micro transmission and drive system industry.
Rising Customization Requirements Across Application Scenarios	• Growing demand for scenario-specific customization and high-precision motion control is a key driver behind the evolution of the integrated micro transmission and drive system industry. As downstream sectors—such as intelligent automotive, consumer technology, and robotics—seek compact, high-performance solutions, integrated micro transmission and drive systems have emerged to meet these needs. These systems combine micro transmission structures, motors, control modules, and sensors into a unified architecture, pushing companies to develop full-stack capabilities across design, production, and integration to stay competitive.
Surging Demand for Upgraded Intelligent Automotive Configurations	• With the accelerated development of intelligent automotives, OEMs' demand for high-precision drive systems is growing rapidly, with intelligent cockpit serving as a core source of demand. For instance, integrated micro transmission and drive systems are widely applied in intelligent cockpit features such as motorized air vents, automated display lift mechanisms and haptic feedback systems in touch panels. Additionally, integrated micro transmission and drive systems are increasingly utilized in key automotive subsystems due to their precision, compactness, and high integration. Electronic Parking Brake (EPB) systems enable direct and accurate actuation of brake calipers, reducing system size and supporting advanced features such as auto-hold and hill-start assist.
Continued Growth of the XR Device Market	• XR refers to technologies including Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR), with devices such as head-mounted displays and smart glasses enabling immersive interaction. The XR device market is currently in a rapid growth phase, with China's market size growing from RMB7.9 billion in 2020 to RMB26.0 billion in 2024, achieving a CAGR of 34.8%. It is projected to reach RMB38.8 billion in 2025 and grow further at a CAGR of 37.1% to RMB136.9 billion by • 2029, promoting the simultaneous growth of the integrated micro transmission and drive system market.

Overview of China's Integrated Micro Transmission and Drive Systems Market

Key Market Drivers

Technological Innovation Driving Industrial Upgrading	• Integrated packaging technology and intelligent control technology are key drivers of Industry 4.0. For example, drum motors, integrate motors, reducers, sensors, and controllers within the drum, saving installation space and enabling stepless speed control via smart drives, with a wide speed adjustment range (0.1-60Hz), and are widely used in conveyors, mixers, fans, and other industrial equipment.
Expansion of Physical AI Applications	• Physical AI refers to AI models that understand and interact with the real world through mechanical motion, typically embedded in autonomous machines such as robots or self-driving vehicles. Integrated micro transmission and drive systems serve as the core hardware foundation enabling physical AI to interact with the physical world. For instance, in the field of intelligent automotives, micro drive technologies (such as drive-by-wire chassis solutions) are critical for enabling autonomous vehicle responses. In the future, as AI interactions with the real world increase, the market size for integrated micro transmission and drive systems is expected to expand further.
Policy Support	• Policy support continues to strengthen. In 2024, the MIIT released the Implementation Plan for the Industrial Foundation Strengthening Project (2023-2025), providing that precision gears, micro motors and other components are key areas under the "Four Basics" initiative. Additionally, in June 2024, the National Development and Reform Commission issued the Measures for Creating New Scenarios and Cultivating New Growth Drivers, encouraging the expansion of intelligent robot functions across healthcare, industrial, entertainment, and service sectors, further boosting downstream demand.

Overview of China's Integrated Micro Transmission and Drive Systems Market

Key Development Trends

The transmission, motor, and electronic control systems are advancing toward higher levels of miniaturization and integration	• In terms of miniaturization, the use of compact components, such as micro sensors, gearboxes and motors, has notably reduced system size and weight, making them well-suited for space-constrained applications like robotics and Intelligent automotive sector.
Continuous Evolution of Intelligent Drives	• China's integrated micro transmission and drive system market is accelerating towards greater intelligence. The next-generation solutions will integrate higher levels of intelligent sensing capabilities, relying on sensor technology to achieve high-precision perception, self-diagnosis, and adaptive control within drive systems. Sensor technology enhances integrated micro transmission and drive systems by enabling precise sensing, real-time feedback, and adaptive control, which are critical for achieving higher intelligence, efficiency, and reliability in compact and complex applications such as intelligent automotive and embodied robotics.
Manufacturing Processes and High-End Equipment Becoming Core Competencies	• The industry's dependence on precision manufacturing processes and high-end manufacturing equipment will continue to deepen. The inventory of such equipment is critical for enhancing process capabilities and will become a key element of future corporate competitiveness. For example, in gear injection molding, the speed of a typical injection molding machine is • 100mm/s, while high-end machines can achieve 300-500mm/s, effectively shortening injection cycles and reducing molding costs by 30%. In precision machining, high-end equipment such as laser welding machines and laser marking machines better meet the requirements for high precision, high efficiency, and pollution-free processing compared to conventional machines. In precision inspection, the use of CT inspection equipment to detect internal defects can more effectively shorten production cycles and improve yield rates compared to conventional equipment and manual visual inspection.

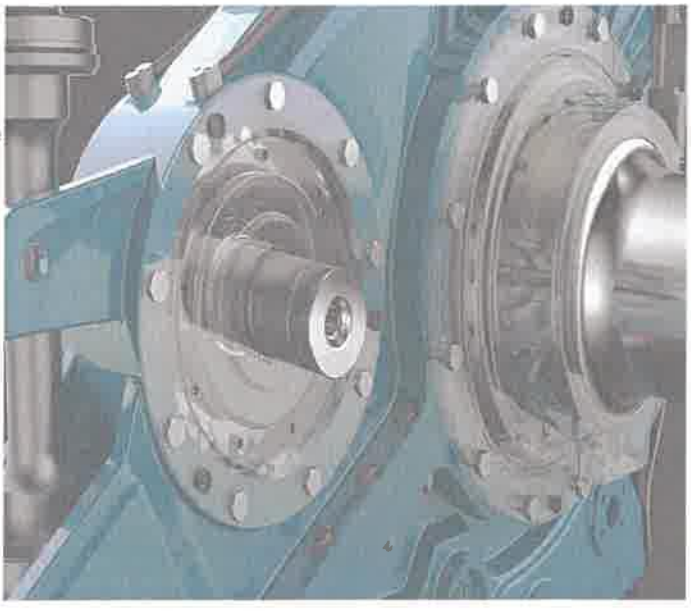
Overview of China's Integrated Micro Transmission and Drive Systems Market

Key Development Trends

Deepening of Scenario-Based Demand

- Application scenarios are becoming increasingly diverse, requiring integrated micro transmission and drive systems to precisely match specific needs, thus placing higher demands on companies' understanding of industry requirements and capabilities in customized design. For example, in the medical device sector, orthopedic surgical wound irrigation pump systems must dynamically adjust irrigation pressure (0.1-0.5MPa) according to different surgical sites and possess waterproof and corrosion- resistant characteristics. Leading companies use motor-driven screw mechanisms to achieve high-precision control, reducing system response times to 0.3 seconds and employing medical-grade encapsulation materials, significantly improving surgical efficiency and safety.

Agenda



Overview of Embodied Robotics Market

Definition and Classification of Embodied Robotics

Embodied Robotics Definition

- An embodied robot is a physical intelligent system capable of interacting with its environment through structure, sensing, and control. It emphasizes the critical role of the body in intelligence and behavior, typically featuring flexible mobility and sensory capabilities to perform complex tasks. Humanoid and non-humanoid embodied robots are two different forms of embodied robotics.

Embodied Robotics Classification

Embodied Robotic Platforms	The robot platform is a standardized hardware carrier that integrates sensing, decision-making, and motion control modules, providing the robot with basic computing power, energy management and task scheduling frameworks.
Embodied Manipulator Arms	Robotic arm is a multi-degree-of-freedom motion device composed of joints, connecting rods, and drive system, and its core technology includes: precision reducer, servo drive system, end-effector interface, etc.
Embodied Dexterous Hands	The dexterous hand is an end-effector that mimics the structure and function of the human hand. It serves as a key component for humanoid robots and certain specialized robots, possessing conventional picking and gripping functions.

Overview of Embodied Robotics Market

Definition and Classification of Dexterous Hands

Dexterous Hands Definition

- Dexterous hands are a critical actuator subsystem of embodied robots, enabling fine manipulation and complex interaction tasks. It performs picking, gripping, and XYZ-axis movements, enabling high-precision operations. It comprises four core systems: a micro drive system that provides power, a micro transmission system that delivers power to the fingers, a sensing system that monitors position, velocity, and acceleration, and a micro control system that uses sensing data to precisely manage the drive and transmission through software and algorithms. An embodied robot typically uses two dexterous hands. Among all components, dexterous hands generally have the highest unit value, accounting for approximately 20–25% of the total value of an embodied robot.

Embodied Robot Dexterous Hands	• End-effectors specifically designed for embodied robots, with the primary goal of mimicking human hand structure and functions to achieve highly flexible and delicate operations.
Specialized Robot Dexterous Hands	• End-effectors designed for specific fields such as industry, healthcare, and scientific research, aimed at efficiently and precisely completing designated tasks.

Overview of Embodied Robotics Market

Dexterity Hands Core Systems

Dexterous Hand is Composed of Four Core Systems:

➢ It comprises four core systems: a micro drive system that provides power, a micro transmission system that delivers power to the fingers, a sensing system that monitors position, velocity, and acceleration, and a micro control system that uses sensing data to precisely manage the drive and transmission through software and algorithms.

Types of micro drive systems	• Motor drive, hydraulic drive, pneumatic drive, and shape memory alloy drive. Among these, motor drive is the mainstream solution in the industry due to its high standardization, high precision, fast response, and high compatibility.
Types of micro transmission systems	• Lead screw transmission, tendon-driven transmission, gear/worm gear transmission. Lead screw transmission offers high load capacity, precision, and strength, while tendon-driven transmission saves space but is more complex and has a shorter lifespan; these two types are currently the mainstream solutions in the industry.

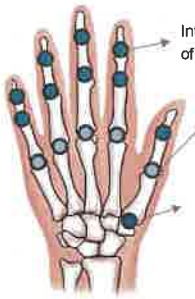
Dexterous Hand Key Performance Indicators:

➢ One key performance metric of a dexterous hand is its number of active degrees of freedom (DOF), representing joint movements directly driven by the actuator. The active DOF defines the hand's flexibility and operational complexity, with some reaching up to 24 DOFs across fingers, palm, and wrist. More active DOFs enable complex motions but demand advanced algorithmic control.

High-end dexterous hand	• Industry standards typically define a high-end dexterous hand as having at least five fingers, 16 active DOFs, a motor no-load speed of >50,000 RPM, and equipped with advanced sensors and intelligent control systems.

Overview of Embodied Robotics Market

Directions for Dexterous Hands



Interphalangeal joint: 1 degree of freedom of flexion and extension

Metacarpophalangeal joints: 2 flexion/extension & adduction/flexion degrees of freedom

Carpometacarpal joint: 2 flexion/extension & pronation/adduction degrees of freedom

Four fingers: 4 joints per finger, 3 degrees of freedom

Root of little finger: 1 opposite palm freedom

Thumb: 5 joints, 5 degrees of freedom

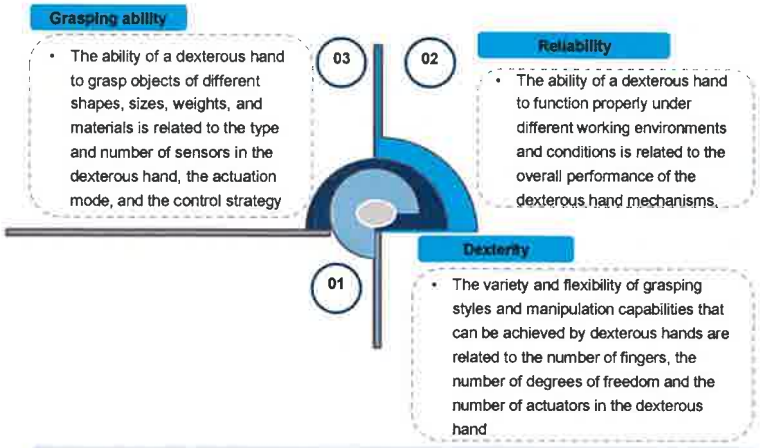
Wrist: 2 degrees of freedom

Dexterous hands are expected to replace some of the functions of the human hand in the future

- Dexterous hand is developed based on the structure and function of human hand, aiming to be able to replace the function of human hand to operate objects flexibly and stably. The human hand has 21 degrees of freedom, among which the thumb has 5 degrees of freedom, 1 degree of freedom for flexion/extension between fingers, 2 degrees of freedom for flexion/extension & extensor/addressor in metacarpophalangeal joint and carp metacarpophalangeal joint respectively, and the remaining four fingers have a total of 16 degrees of freedom, with 1 degree of freedom for two interphalangeal joints, and 2 degrees of freedom for flexion/extension/addressor in one metacarpophalangeal joint.
- The dexterous hand is capable of grasping, screwing light bulbs, stacking cups, picking up eggs and other fine movements, and has part of the functions of the human hand, and in the future, with the advancement of technology, the dexterous hand is expected to reach a higher level of dexterity and replace the human hand to carry out some of the work.

Overview of Embodied Robotics Market

Three Elements that Affect Dexterity Hands Performance



➢ Reliability refers to the ability of the dexterous hand to work normally under different working environments and conditions, and is related to the comprehensive performance of the dexterous hand's various mechanisms. Currently, dexterous manipulators are mostly rope-driven, which is more flexible, but require additional tensioning devices, which are easy to wear out and affect the service life, and at the same time, their gripping force is not large, and there is a big gap between the large load operation and human hands, so to improve the reliability, it is necessary to use more and more complex actuators and sensing solutions.

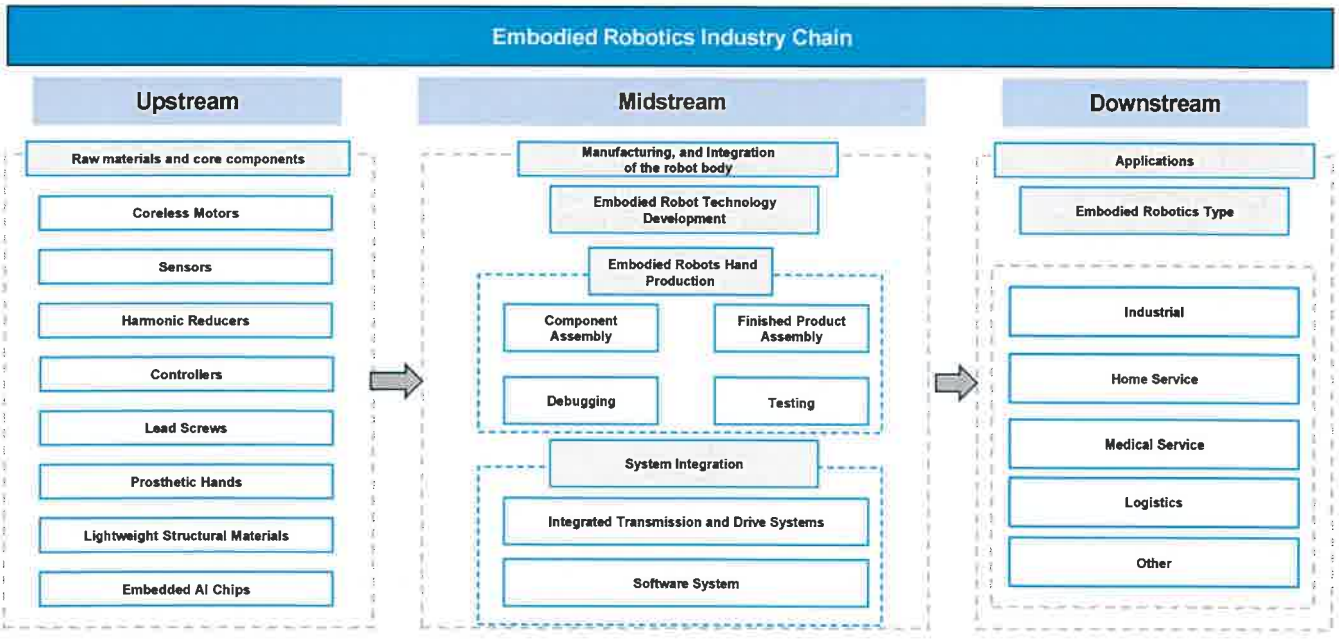
Dexterity, grasping ability, and reliability are the three main elements that affect the performance of a dexterous hand

➢ Dexterity refers to the variety and flexibility of grasping methods and manipulation capabilities that a dexterous hand can achieve, and is related to the number of fingers, degrees of freedom, and actuators of the dexterous hand. In general, the greater the number of fingers and degrees of freedom, the greater the dexterity, but it also increases the complexity and cost of the system. Dexterous hand actuators can be categorized into full drive and underdrive. Full drive means that each degree of freedom of the dexterous hand can be controlled independently, which has higher dexterity; underdrive means that the number of actuators of the dexterous hand is less than the number of degrees of freedom, which can simplify the system, but it will reduce the dexterity.

➢ Grasping capability refers to the ability of the dexterous hand to grasp objects of different shapes, sizes, weights, and materials, and is related to the type and number of sensors of the dexterous hand, the actuator mode, and the control strategy. Generally speaking, the more types and numbers of sensors, the stronger the dexterous hand's sensing ability, and the more accurate it can obtain and feedback the information of shape, texture, position and force of the object, so as to improve the stability and reliability of grasping. Meanwhile, the grasping weight ratio is also an important indicator of grasping ability. Grip ratio is the ratio between the weight of the object grasped vertically by the dexterous hand and the weight of the dexterous hand itself. At present, the grip ratio of dexterous hand is much smaller than that of human hand, according to the research, the grip ratio of human hand is about 12, while the grip ratio of Shadow dexterous hand is only 1.2.

Overview of Embodied Robotics Market

Value Chain （1/2）



Overview of Embodied Robotics Market

Value Chain （2/2）

Embodied Robotics Industry Chain Analysis

- The embodied robotics industry integrates multidisciplinary technologies, including artificial intelligence, robotics, sensing, and advanced manufacturing, to create intelligent agents capable of perception, cognition, motion, and interaction.

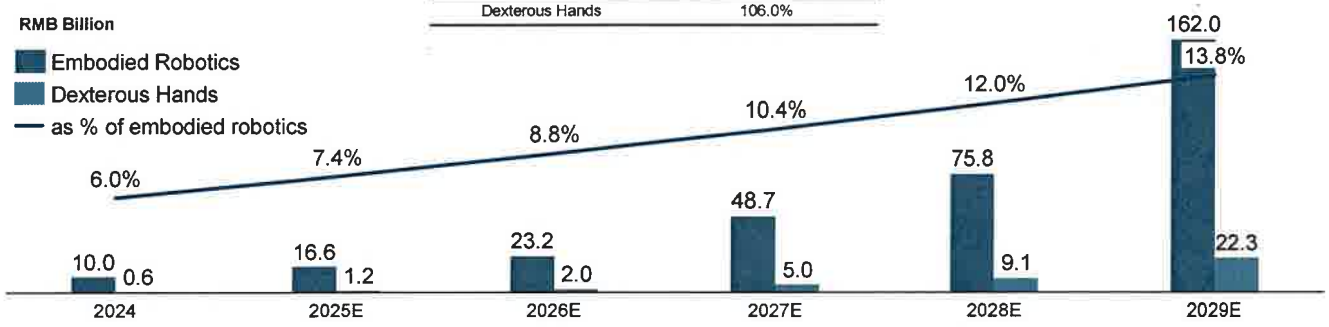
- The upstream segment mainly includes raw materials and core components required for embodied robots, such as coreless motors, sensors, harmonic reducers, controllers, and Embedded AI Chips, with coreless motors and reducers being the primary cost drivers.
- The midstream segment involves manufacturing and integration of robot body, covering the technology development, production, and system integration of embodied robots.
- The downstream segment comprises various types of embodied robots, including those used in industrial, home service, medical service, logistics, and other application scenarios.

Overview of Embodied Robotics Market

Embodied Robotics Market Size, 2025E-2029E

Embodied Robotics and Dexterous Hands Market Size (Global), 2025-2029E

CAGR	2024-2029E
Embodied Robotics	74.5%
Dexterous Hands	106.0%



- Although embodied robotics are still in the early stages of commercialization, downstream manufacturers have already planned future applications, such as Da Vinci surgical robots and minimally invasive surgical robots. Based on the estimated potential demand from downstream application fields, the global market size for embodied robotics is expected to grow from RMB 10.0 billion in 2024 to RMB 162.0 billion in 2029, with a CAGR of 74.5%.
- Driven by the increase in price and usage rate brought about by technological advances, the penetration rate of dexterous hands in the humanoid robot industry has increased rapidly. Its market size is expected to grow from RMB 0.6 billion in 2025 to RMB 22.3 billion in 2029, with an CAGR of 106.0%.

Source: Frost & Sullivan

Overview of Embodied Robotics Market

Key Market Drivers

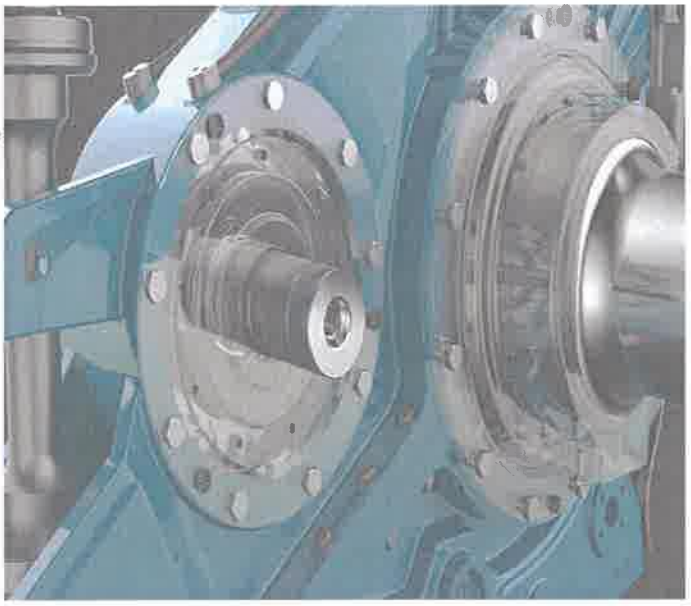
Expansion of Downstream Applications and Demand Upgrades	• In fields such as intelligent automotives, consumer electronics, medical devices, advanced manufacturing, and robotics, Embodied robots can replace manual labor in executing high-precision or hazardous operations. For example, they improve efficiency and quality in industrial manufacturing and have achieved operation precision of 0.1-0.3mm in medical devices, supporting complex applications like minimally invasive surgery.
Continuous Intelligent Upgrading of Dexterous Hands	• Ongoing advancements in artificial intelligence have significantly improved the accuracy and stability of dexterous hands. Technologies such as image recognition, deep learning, and intelligent control have greatly enhanced their perception and decision-making capabilities. AI-powered sensors, leveraging deep learning and multimodal fusion algorithms, can increase grasp success rates by approximately 10%, accelerating the evolution of dexterous hands toward higher intelligence and biomimicry. As a result, the rising intelligence of dexterous hands will directly benefit embodied robots, enhancing their overall cognitive capabilities, adaptability, and task execution performance.
Policy Support Driving Continuous Market Expansion	• In recent years, governments worldwide have actively introduced policies to accelerate the development of embodied robotics. In January 2023, the MIIT and 16 other departments jointly released the "Robot+" Application Action Plan" to promote the deep integration of robotics with the real economy and accelerate smart manufacturing and industrial upgrades. In October 2023, the MIIT issued the "Guidelines for the Innovative Development of Humanoid Robots explicitly calling for breakthroughs in key technologies such as dexterous hands and robotic arms. Furthermore, in October 2024, the European Union launched the "Industry 5.0 Strategy" advocating for the deep integration of robotics into manufacturing systems and identifying dexterous hands as one of the core components of future factories.

Overview of Embodied Robotics Market

Key Development Trends

Optimization of Micro Drive System in embodied robots	• Integrating drivers into the palm or fingers through compact structural designs enhances the flexibility and efficiency of embodied robots, enabling fine operations across various scenarios. This design facilitates easier sensor measurement, maintenance, and replacement, while reducing transmission structure complexity.
Higher Degrees of Freedom and Precision of dexterous hands	• The growing demand from downstream sectors for intelligent, high-precision, and customized dexterous hands is driving embodied robots toward higher degrees of freedom and greater reliability. Precision requirements for the transmission and drive systems of dexterous hands have significantly increased. For example, in microsurgical applications, dexterous hands must support operational precision of 0.1-0.3mm and positioning errors within 0.3 degrees. Additionally, in embodied robotics applications, achieving fine operations like human hands requires higher degrees of freedom to adapt to complex scenarios.
Extension of Dexterous Hand Lifespan in Embodied Robots	• The lifespan of dexterous hands globally is expected to gradually extend with technological advancements. Early products typically had a lifespan of 3-8 years due to design complexity and limited practical experience. As industry players gain more experience in integrated layouts, motor deployment, and material selection, leading companies are achieving product lifespans of up to 10 years, This improvement supports the transition of embodied robots from research and demonstration environments to high-duty industrial and commercial applications.

Agenda



Competitive Landscape

Ranking of Global Integrated Micro Transmission and Drive Systems Industry

- Based on revenue in 2024, the top five integrated micro transmission and drive systems companies collectively account for 7.2% of the market share. These companies have capabilities in design, development, manufacturing, and integration of micro transmission and drive systems, holding a leading position in the market.

Ranking of Integrated Micro Transmission and Drive Systems Companies by Revenue in global, 2024

Rank	Name	Revenue (RMB Billion)	Market Share (%)
1	Company A	2.0	1.8%
2	Company B	1.7	1.5%
3	Company C	1.6	1.4%
4	The Company	1.5	1.4%
5	Company D	1.2	1.1%
Others		103.3	92.8%
Total		111.3	100.00%

- In 2024, the Company achieved revenue of RMB 1.5 billion from integrated micro transmission and drive systems in Global, accounting for approximately 1.4% of the market share, ranking No.4 among Global integrated micro transmission and drive systems companies and demonstrating a significant market leadership advantage.

Source: Frost & Sullivan

Competitive Landscape

Ranking of China's Integrated Micro Transmission and Drive Systems Industry

- Based on revenue in 2024, the top five integrated micro transmission and drive systems companies collectively account for 9.0% of the market share. These companies have capabilities in design, development, manufacturing, and integration of micro transmission and drive systems, holding a leading position in the market.

Ranking of Integrated Micro Transmission and Drive Systems Companies by Revenue in China, 2024

Rank	Name	Revenue (RMB Billion)	Market Share (%)
1	The Company	1.3	3.9%
2	Company A	0.5	1.4%
3	Company C	0.5	1.4%
4	Company D	0.4	1.2%
5	Company B	0.4	1.1%
Others		30.2	91.0%
Total		33.2	100.0%

- In 2024, the Company achieved revenue of RMB 1.3 billion from integrated micro transmission and drive systems in China, accounting for approximately 3.9% of the market share, ranking first among Chinese integrated micro transmission and drive systems companies and demonstrating a significant market leadership advantage.

Source: Frost & Sullivan

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Competitive Landscape

Ranking of Strength Comparison of Global High-End Dexterous Hand Players

- There are multiple dimensions for evaluating the competitiveness of dexterous hand companies within the industry. At the product level, key factors include driver configuration, achievable lifespan, and active degrees of freedom. At the market level, focus is placed on market promotion and deployment progress. Among high-degree-of-freedom dexterous hands currently available in the market, our product ranks first in terms of integration and performance.

Comprehensive Competitiveness Comparison of Leading Global Dexterous Hand Players
(Based on Key Competitive Dimensions, as of Dec 31, 2024)

Company	Achievable lifespan	Active degrees of freedom	Market processes	Dexterous Hands Related Income (2024)
The company	10 Years	17 (independent drive per joint)	Commercial Launch and Market Operations	>10 million
Company E	5 Years	17 (independent drive per joint)	Commercial Launch and Market Operations	>10 million
Company F	3~5 Years	16 (independent drive per joint)	Development and Prototype Testing	<5 million
Company G	3~5 Years	15 (independent drive per joint)	Development and Prototype Testing	<5 million
Company H	5 Years	12 (independent drive per joint)	Development and Prototype Testing	<5 million
Company I	3~5 Years	9 (centralized drive)	Commercial Launch and Market Operations	5-10 million
Company J	5~8 Years	15 (centralized drive)	Commercial Launch and Market Operations	5-10 million
Company K	5~8 Years	15	Proof of Concept and Demand Analysis	<5 million

Source: Frost & Sullivan

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Competitive Landscape

Ranking of China's Integrated Micro Transmission and Drive Systems Industry

Ranking of Integrated Micro Transmission and Drive Systems Companies by Patent Quantity in China (Based on the total number of patents related to Integrated micro transmission and drive systems)		
Rank	Name	Total Patent Quantity (Item)
1	The Company	382
2	Company D	372
3	Company L	302
4	Company M	297
5	Company N	89

- The number of invention patents is an important indicator for measuring the technological R&D capabilities and innovation capabilities of integrated micro transmission and drive systems companies. According to the patent quantity ranking of the top five integrated micro transmission and drive systems companies in China, the company ranks first with a total of 382 patents.

Source: Frost & Sullivan

Competitive Landscape

Entry Barriers(1/2)

Technical Barriers	• China's integrated micro drive solutions industry is highly interdisciplinary, covering fields such as machinery, electricity, materials, information, and control. Product development relies on precision motor selection, system design, and gear technology, with high technical complexity, requiring companies to have strong R&D and design capabilities, which pose significant technical barriers. • Dexterous hand development integrates cutting-edge technologies such as machinery, electronics, AI, and sensing, facing challenges such as high-precision control, multi-degree-of-freedom design, and complex sensing, putting forward higher requirements for the technical and innovative capabilities of new entrants.
Talent Barriers	• China's integrated micro drive solutions industry is highly professional, with high requirements for design, process, and management talents. New entrants need to invest substantial time and resources to cultivate talents, facing significant talent barriers. • In the dexterous hand field, barriers focus on cutting-edge technologies such as high-precision control, complex motion modeling, advanced sensing, and intelligent algorithms, with a high dependence on high-end R&D and algorithm talents, further raising the entry threshold.
Customer and Certification Barriers	• The customer certification cycle in the industry is relatively long (1-3 years), requiring companies to have strong technical, supply, and quality control capabilities. After the establishment of cooperation, the replacement cost is high, making it difficult for new entrants to break through quickly. • In the robotic dexterous hand field, especially for scenarios such as industrial automation and high-end medical care, customer needs are more professional, and product certification standards for reliability, safety, and functionality are stricter, further increasing the certification difficulty.

Competitive Landscape
Entry Barriers(2/2)

Capital Barriers	• China's integrated micro drive solutions industry requires substantial capital investment, especially in large-scale production and R&D, involving the procurement of advanced production, testing, and experimental equipment, as well as raw material management and so on, which constitute capital barriers for new entrants. • The robotic dexterous hand field also faces high R&D and manufacturing costs, increasing capital pressure and risks.

Competitive Landscape
Company Profile (1/4)

The Company	• The company headquartered in Shenzhen, the company is a high-tech enterprise with its core business in micro transmission and drive systems, integrated micro drive solutions, precision injection molded parts and precision molds. Its business covers intelligent automotive, consumer products, medical devices, advanced industrial manufacturing, robotics and other related fields.
Company A	• Company A is a publicly listed company headquartered in Japan. It primarily engages in the development and manufacturing of precision motors, micro transmission systems, and related drive components, serving applications in consumer electronics, automotive, industrial automation, and robotics.
Company B	• Company B is a privately held company headquartered in Switzerland. It primarily engages in the development and manufacturing of high-precision drive systems, including micro motors, gearheads, controllers, and encoders, widely used in robotics, medical devices, industrial automation, and aerospace applications.
Company C	• Company C is a privately held company headquartered in Germany. It primarily engages in the development and production of compact, high-performance drive systems, including coreless DC motors, precision gearheads, and motion controllers, serving fields such as medical technology, laboratory automation, aerospace, and industrial robotics.

Competitive Landscape
Company Profile (2/4)

Company D	• Company D is a publicly listed company headquartered in Hong Kong, China. It primarily engages in the development and manufacturing of motion subsystems and precision drive systems, including micro motors, actuators, and related components, serving a wide range of industries such as automotive, smart home, power tools, and industrial automation.
Company E	• Company E is a publicly traded company headquartered in the United States. It primarily designs and manufactures electric vehicles, energy storage systems, and solar energy solutions.
Company F	• Company F is a publicly traded company headquartered in China. It primarily engages in the development of LiDAR • sensing solutions and perception software for autonomous vehicles.
Company G	• Company G is a privately held company headquartered in China. It primarily engages in the development of intelligent quadruped robots and general-purpose mobile platforms, integrating advanced AI, sensing, and control technologies for diverse application scenarios.

Competitive Landscape
Company Profile (3/4)

Company H	• Company H is a privately held company headquartered in China. It primarily engages in the development of collaborative robotic arms and flexible automation solutions.
Company I	• Company I is a privately held company headquartered in Germany. It primarily engages in the development of clamping technology and gripping systems used in automation, robotics, and machine tools.
Company J	• Company J is a privately held company headquartered in Italy. It primarily engages in the development of soft robotics and adaptive grippers.
Company K	• Company K is a publicly listed company headquartered in Japan. It primarily engages in the development of electrical and electronic equipment, offering products ranging from factory automation systems to HVAC, elevators, semiconductors, and satellites.

Competitive Landscape
Company Profile (4/4)

Company L	• Company L is a publicly listed company headquartered in China. It primarily engages in the design and manufacturing of miniaturized acoustic components, precision structural parts, and advanced sensor and actuator modules for smartphones and smart devices.
Company M	• Company M is a publicly listed company headquartered in China. It primarily engages in the development and production of micro motors and drive systems, serving applications in automotive, home appliances, healthcare, and industrial automation.
Company N	• Company N is a publicly listed company headquartered in China. It primarily engages in the design and manufacturing of precision motion control systems, including stepper motors, servo drives, and integrated automation solutions for industrial and medical applications.

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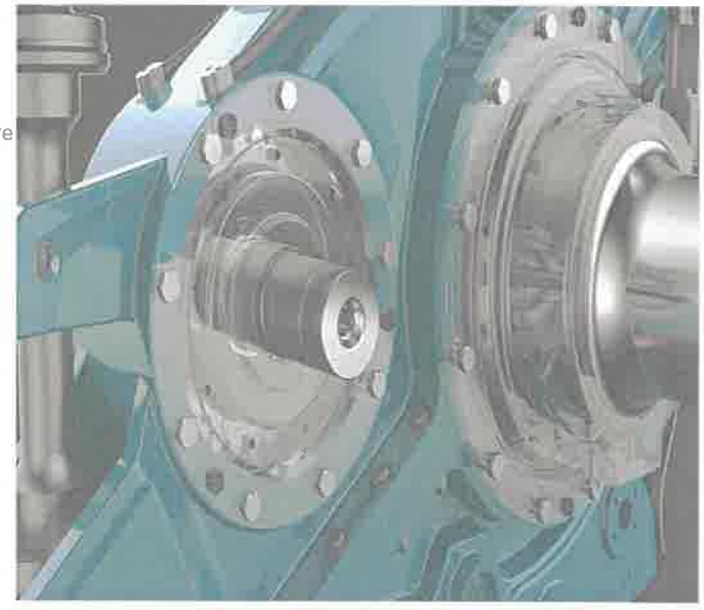
Agenda



Appendices

- To date, the company have developed three major platform-based products under ZHAOWEI brand, targeting high-potential industry verticals such as humanoid robotics, high-end intelligent consumer products and advanced manufacturing. Particularly, in the rapidly emerging field of humanoid robotics, company have developed highly-integrated micro drive modules that power company industry-leading dexterous hand solution, capable of precisely replicating human grip and fine-motion control. As the first company in China to release a commercialized dexterous hand product, company have established collaborative partnerships across the industry value chain and commenced company global commercialization journey.
- The company have cultivated a large and loyal base of blue-chip customers by virtue of company strong track record of delivering superior product performance, robust quality assurance, and a complete portfolio of one-stop, industry-customized drive solutions. Particularly, company customer base includes leading enterprises spanning a wide spectrum of industries and geographies. For example, in the intelligent automotive sector, company serve the top five OEMs and tier 1 suppliers in both China and globally.
- The company solutions have already achieved leading positions across multiple application niches. In the rapidly emerging XR sector, company are the exclusive supplier of miniature IPD adjustment modules for a flagship MR product of a global industry leader, securing the No. 1 market share in this segment. In the automotive sector, where company have built a strong track record over the past decades, company rank No. 1 in several niche product categories, such as rotating and flip screen systems for intelligent cockpits and drive systems for automotive rear spoilers. In addition, company provide micro drive systems to leading brands of robotic vacuum cleaners, achieving a market share of over 30% in this segment.
- Leveraging company tri-integrated innovation strategy, company have achieved rapid R&D innovation and accelerated product commercialization, securing a first-mover advantage in the development of dexterous hands. As the first company in China to release a commercialized dexterous hand product, company have established collaborative partnerships across the industry value chain and commenced company global commercialization journey. company dexterous hand commercialization progress ranks among the most advanced worldwide.
- The company have cultivated a large and loyal base of blue-chip customers by virtue of company strong track record of delivering superior product performance, robust quality assurance, and a complete portfolio of one-stop, industry-customized drive solutions. Particularly, company customer base includes leading enterprises spanning a wide spectrum of industries and geographies. For example, in the intelligent automotive sector, company serve the top five OEMs and tier 1 suppliers in both China and globally.
- Among high-degree-of-freedom dexterous hands currently available in the market, The company's product ranks first in terms of integration and performance.
- The company's proprietary gear testing and calibration capabilities allow us to mass-produce high-accuracy MIM and PM gears with superior strength and consistency, widely used in automotive, smart home and medical applications.

Appendices

- The company have pioneered MIM technology for ultra-small gears in collaboration with renowned institutions. Notably, company have successfully developed a 64-cavity mold for producing 0.753mm micro gears, achieving ultra-high-volume daily output of over two million units. company have also implemented closed-loop de-binding systems to improve batch consistency and introduced a white-light interferometry-based metrology solution for high-precision gear inspection. As a result, company became the first company in the world to achieve large-scale, high-quality and high-efficiency production of ultra-small MIM gears.
- The Company's miniature transmission and drive products used in XR devices achieve a precision of 0.05 mm per second of travel. In addition, the Company has developed specialized blade motors for minimally invasive surgical instruments such as staplers. These products are designed for use in narrow surgical spaces, including laparoscopic and thoracoscopic procedures, and enable micron-level precision with flexible angle adjustment. This enhances surgical stability and accuracy in complex procedures, while addressing the limitations of traditional staplers in terms of noise interference and output torque.
- In recent years, the rapid development of information technology, the accelerated commercialization of 5G, breakthroughs in artificial intelligence, and the widespread adoption of AI foundation models have further expanded the market scope of consumer technology—covering areas such as smart consumer electronics, smart home devices, and wearable technology.
- At the same time, as an upstream participant in the medical industry, the Company observes a growing trend toward automation and intelligence in medical devices, where drive systems play a critical role. The Company actively engages in R&D and production across consumer and medical technology applications—including AR/VR, smart home systems, insulin pumps, and surgical staplers—offering customers competitive and innovative solutions.
- With the advancement of Industry 4.0 and the goals of "Made in China 2025," the company has intensified its presence in the industrial equipment sector, focusing on import substitution of precision core components. By integrating electrical, hydraulic, and hybrid technologies across plastic molding, metal forming, gear stamping, gearbox design, and embedded electronic control programming, the company develops thinner, lighter, smaller, and more functional industrial drive systems to support customer product upgrades. These solutions are widely applicable to valves, pumps, base station antennas, electric drum conveyors, and other electro-hydraulic, electromechanical, and hybrid applications.
- As humanoid robot technology matures and scales up, the dexterous hand—an essential end-effector—has become a critical technology. It not only reflects the functional capabilities of humanoid robots but also serves as a core hardware component driving their intelligence and human-likeness. The company focuses on the R&D and manufacturing of integrated solutions and core components for dexterous hands in embodied intelligent robots. As a fusion of AI and advanced manufacturing, the dexterous hand is both a physical interface for human-machine interaction and a comprehensive intelligent terminal.
- As a leading player in the domestic industry, the cpmpany has achieved revenue exceeding RMB 100 million in sectors including telecommunications, automotive electronics, smart home, and robotic vacuum cleaners.

Appendices

- The Company achieved revenue of approximately RMB 0.17 billion from intelligent automotive integrated micro transmission and drive systems in 2024, accounting for approximately 25.0% of the market share, ranking first among companies in China's intelligent automotive cabin integrated micro transmission and drive systems industry, with a significant market position advantage.
- The Company achieved revenue of approximately RMB 35.2 million from XR device integrated micro transmission and drive systems in 2024, accounting for approximately 50.0% of the market share, ranking first among companies in China's XR device integrated micro transmission and drive systems industry, with a significant market position advantage.
- The company held a market share of over 30% in micro transmission and drive systems for cleaning robots based on 2024 revenue.
- In the XR sector, the motor adjusts interpupillary distance by driving gears to indirectly move the optical module. To achieve high-precision adjustment, small-sized precision gears are critical within the motor module. Globally, only the company and IMS can produce gears with diameters under 5mm. IMS mainly serves the watch and automotive electronics sectors, making it a non-direct competitor. Among current mainstream products, only PICO adopts a motorized interpupillary adjustment solution, with the company as its exclusive supplier. Leveraging this first-mover advantage, the company is well-positioned to expand into more major clients.
- The "Red Sail Award" is a prestigious recognition presented by the city of Shenzhen to honor outstanding enterprises and institutions in the field of advanced manufacturing. In 2022, the award evaluated companies across six key dimensions: strategic decision-making, market expansion, resource integration, system management, innovation and R&D, and continuous improvement. The company stood out among over 300 contenders and was honored with the Red Sail Award alongside leading companies from various industries.
- At last year's China Hi-Tech Fair in Shenzhen, the company unveiled the world's first dexterous hand featuring a fully integrated drive unit within the finger joints, incorporating miniature reducers, motors, control units, and electronic skin sensors.
- The company's new dexterous hand features:
  - High Dexterity: Designed with 17-20 degrees of freedom (DoF) based on bionic principles, with each finger having ≥3 DoF. Powered by a microdrive controller with a main frequency of up to 600 MHz and supported by a high-density, highly integrated, and layout-optimized PCB design, it delivers precise force output and rapid response, significantly enhancing human-like dexterity.
  - High Reliability: The core high-efficiency, high power-density transmission module is designed for a service life of ≥10 years.
  - High Precision: The transmission module offers a backlash of ≤1°, motor control error of ≤0.3°, and is equipped with ≥3 integrated perception sensors.

Appendices

- Tendon-driven transmission, which mimics human tendons, is currently the most widely used method in dexterous hand research. It offers advantages such as long-distance actuation, high transmission efficiency, and adaptive grasping capabilities. However, it also presents challenges in terms of limited precision, complex manufacturing, and shorter service life.
  - Advantages: Compared with other transmission methods, tendon-driven systems allow actuators to be externally placed, enabling long-distance force transmission within the confined space of a dexterous finger—this is their most prominent advantage. Additionally, tendon systems often use sliding bearings, resulting in lower friction and higher efficiency. In certain designs, adjusting tendon stiffness can also enable adaptive grasping.
  - Limitations: Due to the inherent low stiffness and high elasticity of tendons, variations in tendon length can lead to instability in position and force control, reducing transmission accuracy. Preload mechanisms are required, and compensation must be made in control algorithms, increasing system complexity. Moreover, friction caused by the preload can shorten the system's lifespan. These factors collectively raise the technical challenges of tendon-driven transmission.
- In the transmission system of dexterous hands, the hybrid use of miniature screws and tendons creates a synergistic effect. The screw provides high-precision, low-friction linear motion for accurate positioning of rigid joints, while the tendon, with its compliance, enables multi-degree-of-freedom motion and adaptability to complex scenarios. Their functions are complementary—tendons compensate for the screw's lack of flexibility, and screws address the precision degradation and tension control challenges of tendons, together overcoming the limitations of single-mode transmission in dynamic response and load capacity; Through structural optimization, the screw handles high-precision linear actuation, while the tendon manages spatial force transmission and shock absorption, significantly enhancing overall system performance. However, if the design suffers from imbalanced weight distribution or control mismatches, accumulated friction may lead to performance bottlenecks. Therefore, lightweight design and optimized coordinated control are essential to fully unlock the advantages of this hybrid transmission system.
- Ball screws offer medium to high load capacity, with dynamic loads ranging from 50–500 N, and a service life of approximately 20,000 to 50,000 hours; Roller screws provide very high load capacity, handling dynamic loads of 500–5,000 N, with a service life of up to 50,000 to 100,000 hours; Sliding screws support low loads of around 10–100 N, with a shorter service life of approximately 5,000 to 10,000 hours.
- Flexible pressure tactile sensing electronic skin is capable of detecting tactile pressure by mimicking certain structural features of human skin. It functions by converting pressure stimuli into electrical signals, enabling the measurement of applied pressure based on signal variations. When the output electrical signals are weak, signal amplification is typically required. To enhance measurement accuracy, surface morphology and device structure are often optimized to improve the sensitivity, response time, and recovery time of the electronic skin.

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- With server platform upgrades, demand for multilayer PCBs is rising. In general-purpose servers, PCBs are primarily used in backplanes, LC motherboards, LC Ethernet cards, storage cards, and power modules. As platforms advance and transmission speeds increase, the need for high-layer-count PCBs grows. PCIe 4.0 supports transmission speeds of 16 Gbps, typically requiring 12–16 PCB layers. With the transition to PCIe 5.0 and speeds reaching 36 Gbps, the required PCB layer count exceeds 16.
- Multilayer PCBs are widely used across various electronic applications, including:
  - Consumer Electronics: Multilayer PCBs play a critical role in devices such as smartphones, tablets, gaming consoles, and wearables, providing essential power and signal routing. The compact design and high component density enabled by these PCBs contribute to the portability and sleek form factors of everyday electronics.
  - Telecommunications: In this sector, multilayer PCBs facilitate smooth transmission of voice, data, and video signals across networks, ensuring reliable and efficient communication.
  - Industrial Control Systems: Multilayer PCBs are essential for managing complex control systems, monitoring mechanisms, and automation processes. Applications include machine control panels, robotics, and industrial automation, where they serve as foundational support systems.
  - Medical Devices: These PCBs are vital for ensuring precision, reliability, and compactness in medical technology. They are widely used in diagnostic instruments, patient monitoring systems, and life-saving medical equipment.
- The Company's micro transmission system has been recognized as a National Manufacturing Single Champion in China.
- The Company currently offers over 1,000 product specifications and is the first in the world to achieve mass production of micro transmission systems under 6 mm in size, with a monthly output exceeding 2 million units.
- In the intelligent automotive sector, the Company's integrated micro transmission and drive systems have a wide range of applications within vehicles. Future growth is expected to be driven by increases in per-vehicle value and a growing customer base. The Company's revenue from automotive electronics is projected to achieve a compound annual growth rate (CAGR) of approximately 31.7% over the next three years.
- The company is one of the very few enterprises in China to operate an end-to-end in-house manufacturing system that spans the full value chain of micro transmission and drive solutions, from system design and precision mold development to gear component fabrication, integrated assembly and performance testing.
- In 2015, the Company successfully developed a micro gear reducer with a diameter of 3.4 mm, establishing its leading position in the industry. To date, only two companies worldwide—IMS and the Company—are capable of producing gear reducers with diameters under 5 mm, representing the smallest micro gear reducers in the world.

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- The Company is the first in China to successfully commercialize dexterous hands.
- As of October 31, 2023, China ranks among the global leaders in patent counts related to auditory technology, entertainment experience, and intelligent interaction within the smart cockpit sector, surpassing European and Japanese brands.
- We developed China's smallest 3.4mm micro transmission system; we are also the world's first company to mass-produce micro transmission systems under 6mm with high quality and efficiency.
- The company's proprietary gear testing and calibration capabilities allow them to mass-produce high-accuracy MIM and PM gears with superior strength and consistency, widely used in automotive, smart home and medical applications.
- The Company has continued to improve its operational efficiency. In 2024, it achieved revenue of RMB 1.52 billion, representing a year-on-year increase of 26.4%; the gross profit margin reached 31.4%, up 2.4 percentage points from the previous year. The Company's products are primarily developed on a customized basis according to client requirements. Entry into a client's supply chain typically requires a qualification and verification cycle of 1 to 3 years. This process demands significant industry experience and technical capabilities, making it difficult for downstream customers to easily switch suppliers. As a result, it facilitates the establishment of long-term and stable cooperative relationships between the Company and its clients.
- In the context of a highly customized business model involving numerous non-standard projects, the Company's core competitiveness lies primarily in its accumulated "know-how" in design and manufacturing, which provides a significant first-mover advantage. At the same time, the Company is accelerating its transition toward a platform-based approach. This includes the independent development of design platforms, enhancement of automated processing and assembly capabilities, and continuous improvement in standardization and modularization across all stages. Platformization facilitates the transferability of processes, enabling the replication and expansion of the Company's "know-how" across a wider range of application areas. In addition, the Company is the exclusive supplier of the Pico electric interpupillary distance adjustment system. Globally, only the Company and Germany's IMS possess the capability to produce precision gears with diameters below 6mm, establishing high technical barriers and a differentiated competitive advantage.
- The core technologies in material formulation include the application of engineering plastics and metal powders, integration of multifunctional composite materials, nanoscale lubrication, and control of material shrinkage rates. Core technologies in gear architecture involve micro-module gears and adaptability across various gear types. In micromechanical design, core technologies encompass precision machining of mold cavities, miniaturized integrated design, and structural strength simulation. For motion control, the core technologies include precision drive algorithms, performance testing, and thermal stability control of the system.
- The average industry timeline for a robotic vacuum cleaner project, from project initiation to small-batch production, is approximately six months.

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- The Company's dexterous hand products feature 17 to 20 degrees of freedom, with fully integrated drive units embedded within the joints. Designed for a service life of no less than 10 years, the product has already undergone field validation at Bao'an Airport, demonstrating an approximately 42% improvement in sorting efficiency. Commercialization efforts are expected to accelerate in 2025.The mid-mounted motor and drum motor are among the Company's three major platform-based product lines. As technology-extended offerings, they target applications in new energy vehicles and industrial automation, and have already secured a portion of the market share.
- With rising living standards and ongoing technological advancement, consumer awareness and willingness to purchase smart home products continue to grow. At the same time, governments in multiple countries are supporting the smart home industry through policies such as tax incentives and subsidies, further driving market expansion. Technological progress has led to improvements in product performance and reductions in cost, which will also accelerate the large-scale adoption of smart home products.
- The electrification and digitalization of downstream industries have led to a significant increase in order volume. For example, in the Intelligent automotive sector, digitalization has driven order volume up by more than 50%, while delivery cycles have shortened by approximately 30%. In Advanced industry and smart manufacturing sector sectors, orders for industrial robots have increased by 41% during this transformation. The growth in downstream application demand will further require companies to expand production capacity to meet increasing needs.
- The company can achieve mass production of injection-molded gears with a precision of up to ISO Grade 7, surpassing the industry average of ISO Grade 8 to ISO Grade 9 in gear machining accuracy
- "Drum motor": integrated, sealed drive unit for conveyor rollers that combines the electric motor, gear reduction, and bearings within a rotating cylindrical drum shell, eliminating external mechanical components.
- "Platform-based products": The company products developed through tri-integrated innovation strategy, featuring the integration of our research and development results and higher level of standardization, which currently primarily include servo motor series, drum motor and dexterous hand.
- "Servo motor": closed-loop electromechanical device that uses position or speed feedback to precisely control angular position, velocity, and acceleration in motion control systems through real-time error correction.
- The downstream sectors that our solutions are developed and manufactured for are characterized by evolving technologies, increasing competition, changing industry standards and shifting market demands, among others.
- As a result, the company face challenges that the company inventories could become obsolete due to such developments.
- The company established early mover advantage in automotive electronics, having entered the global supply chain of the world's largest automotive components supplier.
- The company proprietary and self-manufactured core drive module for humanoid robots and dexterous hand products represent a strategic leap forward.

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- Enterprises in the industry typically enter into framework VMI agreements with large customers, followed by delivery schedule or individual VMI orders that specify the details of each delivery. Such VMI arrangements were not uncommon in the sectors that our customers operate in, such as the automotive sector.
- The company's leased properties subject to non-registration was primarily used as office premises and R&D facilities. There were abundant alternative premises that suit such operating needs.
- The flexibility of the form of investments or acquisitions that we may be involved in, our Directors and industry consultant are of the view that there is sufficient number of targets.
- As of the LPD, based on further commercial considerations and evaluations, there are approximately 230 companies in China and overseas markets that may be considered as potential investment, acquisition and licensing targets.
- The Global and China's integrated micro transmission and drive systems market are highly fragmented, with over 500 and 200 players operating across different segments and regions respectively.