

# PRECISION AUTOMATION WITH MINIATURE ROBOT ARMS FOR LIFE SCIENCE AND INDUSTRY

Miniature robots are starting to make a significant impact in many industries, offering several advantages over their larger counterparts.



They require fewer resources to operate, making them easily scalable and enabling facilities to gradually automate processes without major investments or reorganization. Their compact size allows them to access confined spaces and perform small, repetitive movements with high precision. Moreover, their lightweight nature ensures safety when working alongside humans. As labor shortages persist, these versatile robots are proving to be a practical solution for maintaining productivity.

Chieftek's two miniature robotic arms, the S0 and DB0, are expanding possibilities to automate tasks that have traditionally relied on manual execution. This white paper will explore the capabilities of these tabletop robots, and how they are useful for a wide variety of applications in life sciences and manufacturing.



Small is smart  
Small is beauty  
Miniature brings infinity



## KEY FEATURES OF S0 AND DB0

The S0, weighing just 4 kg, is the world's smallest collaborative robot. Featuring movement along six axes — with infinite maneuverability in the wrist and joints, and 360° base and shoulder motion — the S0 boasts a class-leading repeatability of  $\pm 10 \mu\text{m}$ . Slightly larger at 4.7 kg, the DB0 industrial robot provides slightly less maneuverability than the S0 but achieves a repeatability of  $\pm 5 \mu\text{m}$  with high rigidity. The DB0 also includes a built-in control pad for path control. Both the S0 and DB0 miniature robotic arms can move payloads of up to 0.5 kg.

Primarily designed and manufactured by Chieftek, the S0 and DB0 offer high degrees of freedom, allowing for adaptability to various workspaces. Their exceptional repeatability makes them ideal for tasks requiring high precision, such as small part assembly, path tracking and positioning. Due to their compact nature, the S0 and DB0 provide high space efficiency.

Both models are equipped with custom-designed large-bore frameless motors, strain-wave gearing with high ratios, and dual-feedback systems consisting of optical and magnetic absolute encoders. The S0 and DB0 also feature high-performance servo drives, low noise levels, and high-efficiency driver electronics for minimizing heat generation.

PARAMETER		UNIT	DB0 ROBOT: INDUSTRIAL	S0 ROBOT: COLLABORATIVE
RATED PAYLOAD		kg	0.5	0.5
MAX PAYLOAD		kg	0.5	1
REACH	Vertical	mm	465	446
	Horizontal	mm	327	370
REPEATABILITY		$\mu\text{m}$	$\pm 5$	$\pm 10$
WEIGHT		kg	4.7	4
POWER SUPPLY		V · A	48 Vdc · 5A	
BRAKES — <i>which axes</i>			1, 2, 3, 4	1, 2, 3, 4, 5, 6
COMMUNICATION			TCP/IP or Modbus TCP to controller EtherCAT to robot	
MAXIMUM MOTION RANGE	J1 — Base		+175° to -175°	$\pm 360^\circ$
	J2 — Shoulder		+160° to -15°	$\pm 360^\circ$
	J3 — Elbow		+145° to -80°	$\pm 360^\circ$
	J4 — Wrist		+175° to -175°	$\pm 360^\circ$
	J5 — Wrist		+90° to -90°	$\pm 360^\circ$
	J6 — Wrist		Infinite	
<i>Overall reach (range)</i>			Smaller	Wider
<i>Path flexibility</i>			Less	More
MAXIMUM SPEED <i>depends on the center of gravity offset</i>	J1 — Base		180°/sec	
	J2 — Shoulder		180°/sec	154°/sec
	J3 — Elbow		180°/sec	180°/sec
	J4 — Wrist		360°/sec	288°/sec
	J5 — Wrist		360°/sec	324°/sec
	J6 — Wrist		360°/sec	324°/sec
MAXIMUM TCP SPEED		mm/s	1000	600

*A side-by-side comparison of the S0 and DB0. (Source: Chieftek.)*

Chieftek's robotic arms employ a collision detection system that tracks kinematics to sense collisions, eliminating the need for external sensors. This system, coupled with adjustable sensitivity, ensures safe human-robot interaction when operating the miniature robots.

A user-friendly interpreter enables developers to create motion programs through a simple click-and-configure process where code can be inserted. The S0 and D00 also feature hand-guided teaching, which simplifies robot programming further by allowing users to physically guide the robot through desired movements. This intuitive method enables rapid path creation, making robotic automation accessible to a wider range of users.

Chieftek's simulator feature accurately replicates robotic arm motion, allowing users to test, verify and optimize programs in a virtual environment without affecting the physical robot. It supports single-joint operation and speed override for developing and testing robotic arm applications safely and efficiently.

In zero-gravity mode, dimensional dragging constraints allow users to specify free dragging dimensions along lines and planes, and constrain rotation or movement in linear axes. This feature is relevant for various tasks, such as ensuring that the end-of-arm tool remains perpendicular to a pallet plane, or maintaining the same orientation and distance to a workpiece.

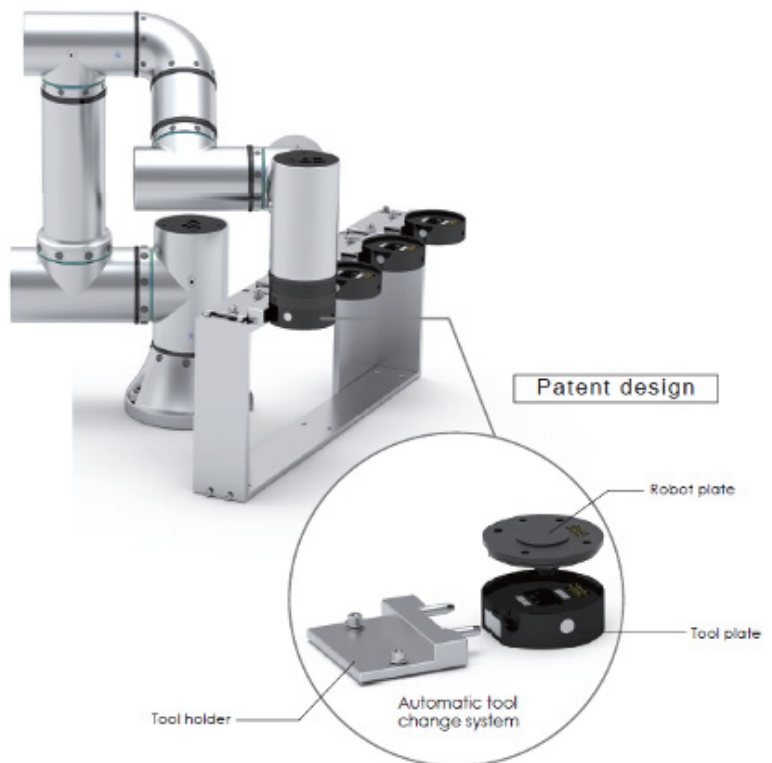
Chieftek's automated tool dimension calculation feature simplifies tool setup by automatically determining end-effector dimensions based on robot pose data, eliminating manual input and potential errors. Using zero-gravity mode, users can manually position the robot at various angles, aiming the tool at the same spot to measure and save the tool's dimensions without importing parameters.

The automatic PCS Coordinate System Configuration feature automatically calculates and sets the robotic arm's coordinate system. This is done by physically dragging the arm to teach points on the axis and plane of the coordinate system—again, bypassing the need to import any parameters.

Chieftek's robotic arm system offers streamlined integration and control. Devices are configured on EtherCAT, while APIs and SDKs provide a flexible platform for developers. An Android tablet app further enhances usability, enabling remote operation for teaching and programming.

## **AUTOMATIC TOOL CHANGER SYSTEM**

Chieftek employs a novel automatic tool changer system in its miniature robotic arms, which enhances multitasking and space efficiency while reducing downtime during tool changes.



*Chieftek's automatic tool changer system. (Image: Chieftek.)*

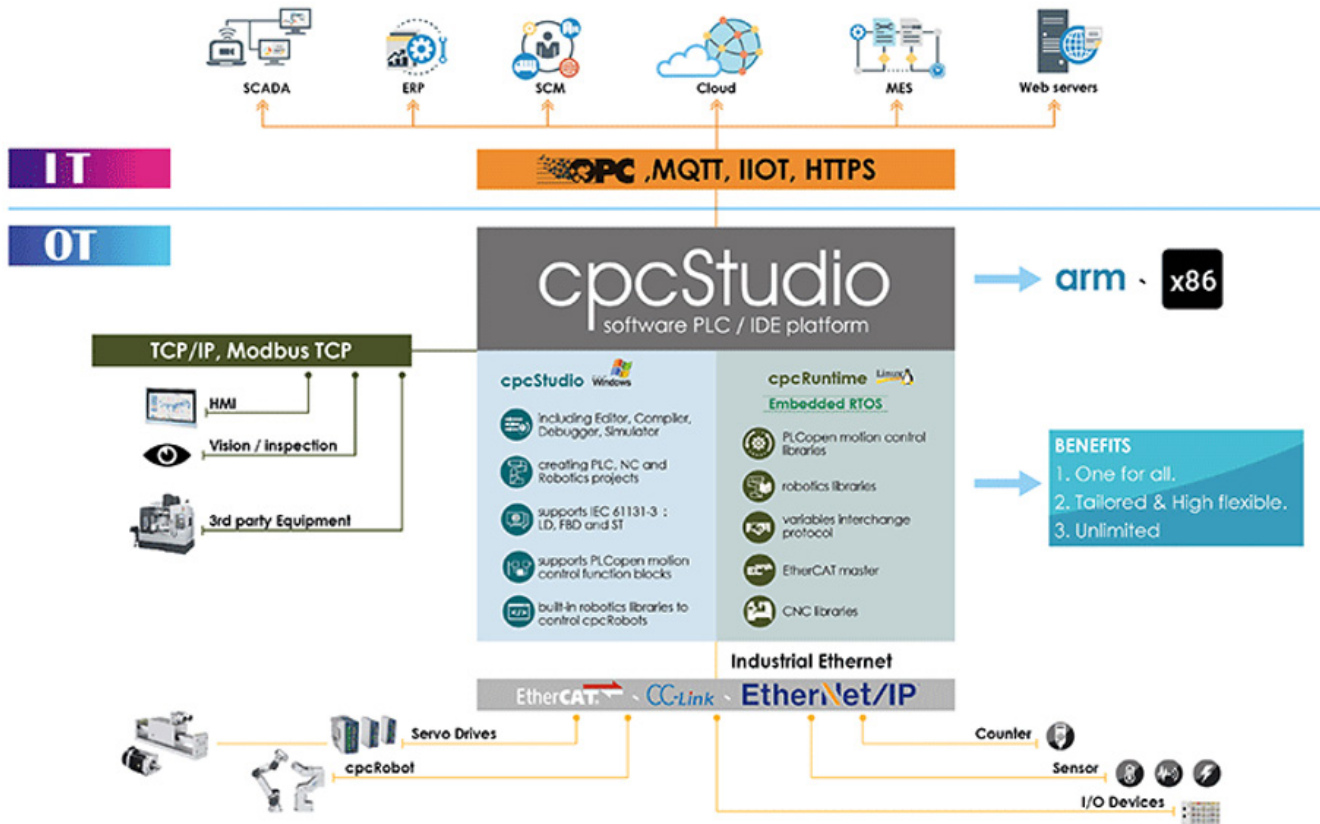
The unique patented design features four different tool plates and includes a holder, tool/robot joint and various connectors. The tool plates can be easily engaged and disengaged without human intervention. The system eliminates dependency on external air pressure or power, ensuring stability and reliability.

Since the system universally connects to the wrist without adapters when using Chieftek's tool plates, it avoids excessive load consumption on the robot arm. The use of a permanent magnet to fix the connecting plate and tool holder reduces mechanical wear.

Chieftek also provides customized electrical connectors to suit various tools for different applications, offering eight wires for custom signal usage at both the robot base and the tool end.

## CPCSTUDIO: SOFTWARE PLC/IDE PLATFORM

cpcStudio is Chieftek's highly flexible integrated development environment (IDE) that enables collaboration with third-party PLCs. By transforming industrial computers into real-time PLCs, cpcStudio liberates users from hardware constraints, allowing them to select the optimal equipment for their specific project needs.



Chieftek's software PLC/IDE platform, cpcStudio, can collaborate with third-party PLCs. (Image: Chieftek.)

In addition to adopting the standard IEC 61131-3 programming language, cpcStudio provides a variety of libraries that can integrate with Chieftek's miniature robots through familiar PLC languages like ST and FBD.

cpcStudio also supports versatile industrial communication protocols, including EtherCAT, Modbus and TCP/IP. It features a customizable and user-friendly interface for efficient software development and can be embedded in hardware with CPU and Linux OS. As a result, specific PLC controllers can be created for commercial or in-house use.

## **APPLICATIONS OF S0 AND DBO MINIATURE ROBOTS IN LIFE SCIENCES**

### **LABORATORIES AND LARGE-SCALE MEDICAL RESEARCH CENTERS**

The S0 and DBO miniature robotic arms are great for laboratory settings where space availability is an issue. Their compact size and maneuverability make them suitable for integration into existing laboratory workflows without extensive redesigns.

Miniature robotic arms enhance efficiency by automating repetitive tasks, allowing scientists to focus on higher-level analysis and innovation. These robots excel in tasks requiring high precision and repeatability, which is crucial for R&D applications. Furthermore, they can handle hazardous materials and reduce human exposure to potentially harmful substances — for instance, in restricted-access biotechnology laboratories.

### **PHYSIOTHERAPY**

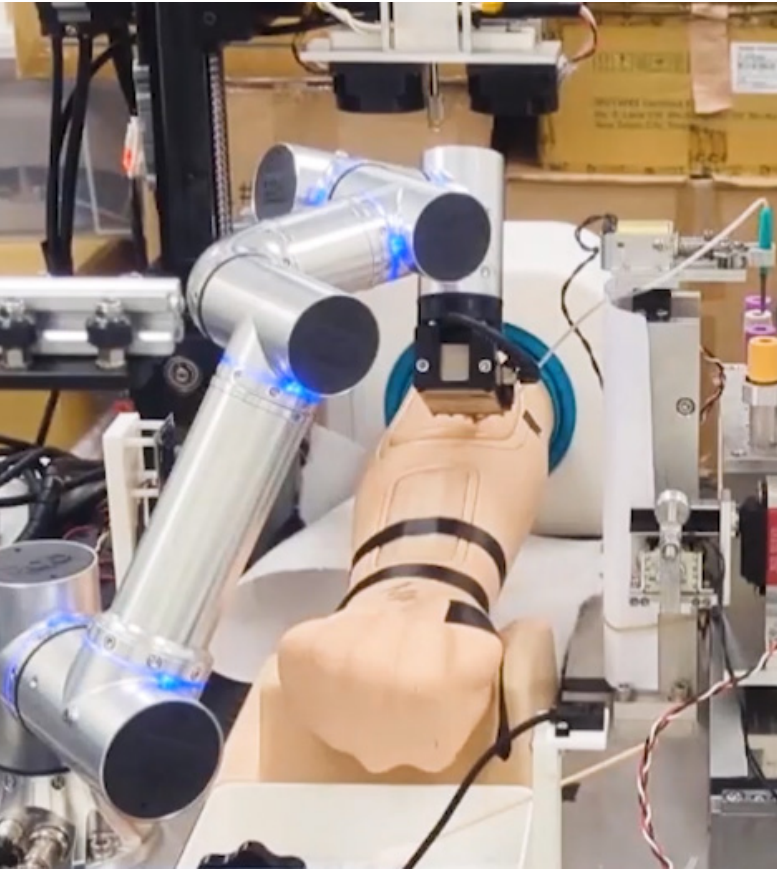
The S0 and DBO can even be used in rehabilitation. Robotic physiotherapy can supplement traditional manual therapy by assisting with repetitive exercises, reducing time demands on therapists and allowing more patients to receive therapy simultaneously. Certified by the FDA, Chieftek's miniature robots can be programmed through hand-guided teaching to follow specific upper arm motions.



*The S0 performs repetitive exercises to assist in upper limb physiotherapy. (Image: Chieftek.)*

## BLOOD DRAW

One novel application of Chieftek's miniature robots is phlebotomy. Thanks to its path tracking abilities, the S0 can perform blood draws with high precision, using a specific light spectrum detector that can accurately identify difficult-to-find veins.



*In-house testing of the S0's blood draw capabilities.  
(Image: Chieftek.)*

## APPLICATIONS OF S0 AND DBO MINIATURE ROBOTS IN MANUFACTURING

The S0 and DBO perform well in a wide range of manufacturing applications, including assembly, pick-and-place, sorting and palletizing.

For example, the miniature robots are ideal for conveyor tending in small-scale food, beverage and semiconductor applications. Their low inertia and collision detection capabilities make them suitable for collaborative tasks on the factory floor.

The agility and precision of Chieftek's miniature robots makes them valuable in the assembly of small products such as watches, syringes and circuit boards, which require robots with excellent repeatability. Due to the high speeds of their base and wrist joints, the S0 and DBO can handle, orient and sort through high volumes of workpieces, including delicate, expensive components in medical and semiconductor operations. Their high axis counts offer enhanced flexibility for complex tasks.

The compact, foldable design of Chieftek's S0 six-axis robot makes it perfect for tabletop applications such as scanning and gluing. The S0 and DBO are also useful in dispensing applications, especially involving hazardous chemicals.

## ABOUT CHIEFTEK PRECISION CO. (CPC)

Chieftek Precision USA and the cpc business began with the design and manufacture of miniature linear guides. As business grew, so did cpc's product line. Today cpc's linear guide offerings include general-purpose ARC series for automation machine tools; HRC and ERC series for heavy machine tools; and the RR series with roller bearings for applications needing high rigidity and precision while under extra heavy load.

cpc's linear guides are compatible with industry-standard sizes while providing superior rigidity and precision.

Not satisfied with being just a mechanical-component provider, cpc began an intensive R&D effort into the field of linear motors. The result is the P series ironless linear motors — with the highest thrust density and efficiency of its kind. Next came C series iron-core linear motors — the most compact linear motors in the industry and delivering high thrust with low cogging force. To lower the technical barrier of entry for those more familiar with traditional belt or ballscrew-driven systems, cpc packaged its linear motors into the Compact Linear Stage (CLS/CLMS) series and customized linear motor stages, tables, and subsystems. Such products integrate the linear motor, linear guide and

positioning systems into a compact readily usable package — so less technically inclined customers don't need to concern themselves with the details of mechanical, electrical and electronic integration.

As linear motors can't operate without a control system, the next logical step for cpc was the TC1 series servo drive. The TC1 series features high-power-density easy-to-use autotuning and an advanced feature set to aid machine builders in creating breakthrough products. Spanning the fields of mechanical, electrical and electronics, the release of TC1 sets another milestone for cpc on its path towards becoming a total mechatronics provider for linear motion control and a global manufacturer of electronic instruments and electromechanical devices.

The latest technology offerings from cpc are miniature industrial robot arms — the six-axis designs detailed in this white paper. For more information on cpc's miniature linear guides, motion controls and miniature robotics, visit [chieftek.com](http://chieftek.com) or [check out this video of the S0 cobot demonstrating advanced pathfinding in a space-limited application](#). Also be sure to download a complementary PDF on Chieftek's miniature robotic arms at [engineeringwhitepapers.com](http://engineeringwhitepapers.com).



LINEAR MOTION TECHNOLOGY



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MOTION CONTROL TECHNOLOGY