

# Technologies for Helping Make New Dreams Come True

—Servo technologies that contribute to medical, welfare, and food fields—

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## 1. Introduction

There has been a heightened interest in human health of late in light of the impact of infectious diseases and the changes they have wrought on our ways of life. Medical and welfare equipment has therefore also been advancing greatly to meet these new challenges. Automation of food production lines which sustain our lives has also been accelerating in consideration of food safety, leading to greater expectations for servo systems products.

We have applied servo systems technologies that we have cultivated over many years in the industrial machinery market to the advanced medical, welfare, and food fields with the aim of developing servo technology which can help people and machines work together harmoniously.

Staying healthy to continue contributing to society is the dream and desire of both people and society.

This article introduces our products and technologies which contribute to human health and food safety. It will highlight four examples in the medical, welfare, and food fields where our servo products and technologies help make new dreams come true.

## 2. Contributing to a Long, Healthy Life (medical): Radiation Therapy Equipment

Technology for cancer radiation therapy is advancing daily. Dedicated stereotactic radiotherapy (SRT) for intracranial therapy these days is capable of delivering submillimeter (0.1 mm units) level irradiation precision, and is equipped with a function for correcting the position of the patient by providing image guidance during therapy.

This chapter introduces actuator (linear servo motor) development technology that has contributed to the development of new radiation therapy equipment that is capable of generating radiation beams from a number of directions, including non-coplanar beams, by combining

rotary axes, and does not require a large shield.

### 2.1 Overview of equipment

Figure 1 shows the appearance of the radiation therapy equipment. The main features of this equipment are:

- (1) There is no need for a large scale shielded room. Because self-shielded design.
- (2) Radiation beams can be directed at the target area from all directions using multiple rotary axes.
- (3) Innovative safety function: real-time dose verification system.
- (4) This new equipment achieves submillimeter level irradiation precision, and is equipped with a function for correcting the patient position by providing image guidance during therapy.



Fig. 1 Radiation therapy equipment appearance

The  $\theta$ -axis used to rotate the irradiating part of the equipment consists of multiple axes, allowing the affected area to be irradiated from a wider angle. Accurate positioning of the irradiation area is realized by these rotary axes together with the treatment bed used to convey the patient. The treatment bed has three axes, and is capable of three-dimensional motion. This allows the patient to be treated by accurately directing radiation at the affected area of the head.

We developed linear servo motors used in the rotary axes

for the irradiating part of the equipment, and the driving axes which move the treatment bed.

## 2.2 Product specifications (linear servo motors)

This section provides an outline of the linear motors used for the  $\theta$ -axis. Figure 2 shows where our linear motors are used in the unit.

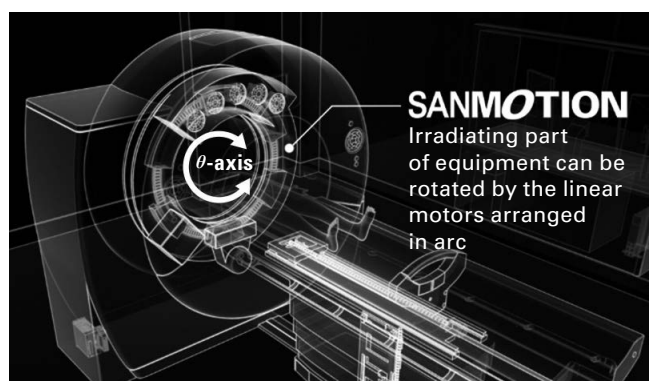


Fig. 2 Where our linear motors are used

The  $\theta$ -axis is a key axis which determines the irradiation angle, and load inertia to rotate the entire shielded structure about this axis is large. Therefore, positioning operation is required to be accurate.

To achieve this, we developed a linear motor with magnets arranged in the circumferential direction, and linear motor coils arranged in an arc. Conventional rotary motors require conversion mechanisms such as belt mechanisms, and factors such as backlash and drops in rigidity hinder control. However, high-accuracy control can be achieved using direct drive with arc linear motors.

Figure 3 shows the appearance of the arc linear motor armature.

Using direct drive offers a greater movement radius, and allows the required number of coils to be arranged, thereby generating sufficient torque for rotation.

Cogging thrust generally increases by arranging magnets in an arc, but a low level of cogging similar to that when arranging magnets linearly has been realized by devising a system which cancels cogging thrust inside the coils.

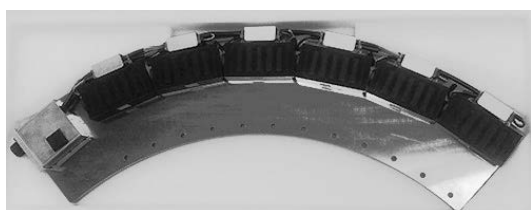


Fig. 3 Arc linear motor armature

The technology enabling low cogging thrust developed here is being used in the development of a new need for dedicated intracranial radiation therapy equipment.

## 3. Contributing to a Long, Healthy Life (medical): Mammography Units (breast cancer screening units)

Mammography is a dedicated radiographic technique for imaging the breast. It is one of the most effective methods of diagnostic imaging indispensable for the early detection of breast cancer. This chapter introduces the actuator technology used in mammography units. This technology makes it possible to detect changes at an early stage that would not normally be noticed by patients during their daily lives.

### 3.1 Overview of equipment

Figure 4 shows the mammography unit appearance, and Figure 5 shows where our DC servo motors are used in the unit.

Our DC servo motors are used to rotate and move the compression plate vertically. Mammograms are carried out by first placing the area to be examined between the unit's two plates. The compression plate gradually applies pressure to the area and holds at a level appropriate for the examination, and the area is then irradiated with radiation and ultrasonic waves.



Fig. 4 Mammography unit appearance

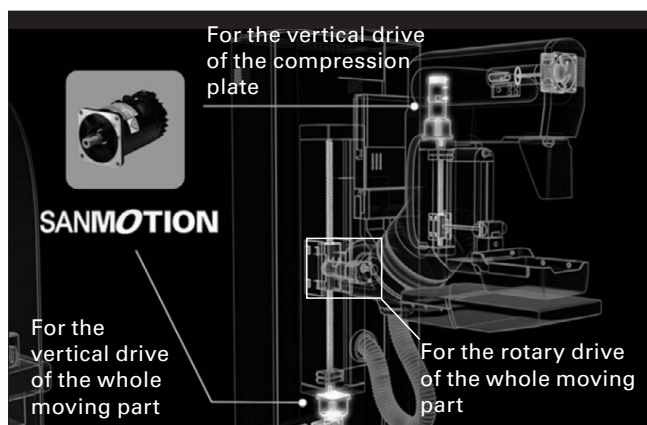


Fig. 5 Mammography unit motor arrangement

### 3.2 Human body-friendly control

The breasts of those undergoing examination differ in many ways in terms of size, shape, and firmness, and thus delicate pressure control of the compression plate is required. The control can be easily done with DC servo motors. By simply monitoring the current flowing to DC servo motors, the subtle pressure applied to the plate can easily be controlled, minimizing physical strain such as pain in the area being examined.

### 3.3 Safety ensured by low-voltage motors

Since mammography involves the compression plate coming into direct contact with the human body, safety against electrical shock had to be ensured for electric actuators. To this end, it is necessary to use servo motors that support 40 VDC or lower voltages. Our *SANMOTION K* series DC servo motors meet this requirement, and we have a standard lineup of low-voltage models.<sup>(1)</sup>

### 3.4 Reliability in high-radiation environments

The structure of DC servo motors is such that control is relatively easy when compared with AC servo motors, and commutation sensors are not required unlike AC servo motors. There is no need for electronic components such as hall sensors, ensuring highly reliable control even in environments exposed to high levels of radiation.

### 3.5 Equipment noise reduction

Mammography often involves placing electric actuators in locations relatively close to the patient body. Consequently, noise produced by actuators and harmonic noise generated by inverters can sometimes cause the patient discomfort or stress. The structure of DC servo motors is such that the harmonic noise-producing windings are located in the rotating part of the motor, reducing the harmonic noise

emitted from the motor. Furthermore, our *SANMOTION K* DC servo motors have a revised structure that achieved reduced noise<sup>(1)</sup>. This allows patients to be examined without having to worry about stressful motor noise.

## 4. Contributing to Living Independently (welfare): Wearable Robots for Active Living Support<sup>(2)</sup>

With its super-aging society, Japan is seeking ways to allow the elderly to continue to enjoy healthy lives without assistance. This chapter introduces “human-friendly wearable robot” development technology involving actuators and servo amplifiers we have developed. This robot has been designed to assist those who have become physically impaired due to diminished physical ability, or who have been injured in the course of their work.

### 4.1 Overview of equipment

The “human-friendly wearable robots,” in which we were involved in the development, have been designed to be lightweight and easy and comfortable to wear. The purpose of this robot is to help the elderly or patients walk independently, to assist with nursing care of them, and for the rehabilitation of those with disabilities.

The two main features of this robot are:

- (1) Coordinated control (control technology)
  - User’s movement can be improved more naturally not by forcibly improving their movement through robot movements, but by its human-like cooperative motion assistance. That is, despite being a robot, this robot can assist the user’s movement just as a human being does.
- (2) Non exoskeleton type exterior mechanisms
  - These wearable robots have a plastic, non-exoskeleton structure that mimics the human skeletal structure rather than the rigid metallic exoskeleton structure often seen in conventional assistance robots, making it both lightweight and easy-to-wear, ensuring maximum freedom of movement.

Figure 6 shows the configuration of a wearable robot. This wearable robot consists mainly of a jointed frame, which forms the external mechanism worn by the user, an actuator unit (4 axes) that assists the user’s motion, and a controller that controls the actuator. We developed the linear servo motors in the actuator unit and the servo amplifier in the controller.

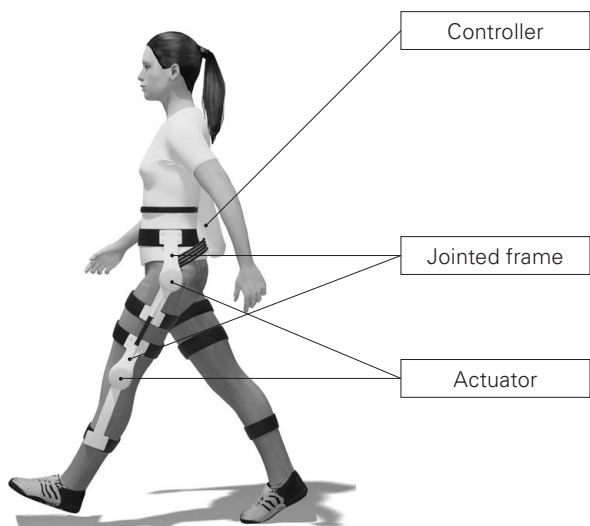


Fig. 6 Wearable robot equipment configuration

## 4.2 Actuator configuration and motor specifications

The actuator consists of a gear, motor, encoder, and torque sensor. A palm-sized flat motor is used.

With wearable robots, the wearer must bear an extra load determined by the weight and size of the actual device, and this demands stricter conditions than those required by other robots in terms of size and weight reduction. To achieve the first aim of miniaturization, we developed a flat structure with bearings and the encoder arranged on the inside of the electromagnetic part of the motor. To keep weight to a minimum, we developed a mechanism which exerts minimal restrictions on the user with a lightweight design achieved through such means as making the frame thinner.

## 4.3 Development of servo amplifier for wearable robots

We have also been striving to reduce the size and weight of the servo amplifier used to drive the motors to realize the concept of “can be worn just like clothes” for a robotic suit worn on the body to support the independence of those requiring care.

### 4.3.1 Miniaturization and weight reduction

The entire servo system, including the drive unit, is worn on the body; heat dissipation and safety have been assured while employing an open frame configuration with a control board and power board so as not to compromise comfort.

For increased wearability, we designed the servo system to be lightweight and compact so that it can fit in the controller box on the back.

Our standard servo amplifiers control motors with

multiple LSI components such as CPUs, ASICs, and memory. To reduce the number of components used in the servo amplifier, we employed the CPU-based current detection function and encoder interface function, created software to control the current that had previously been done by a ASIC, and developed a control circuit capable of controlling two motor axes with a single CPU. Also, by developing a compact, lightweight 4-axis integrated servo amplifier capable of being stored in the controller on the back, we have succeeded in realizing the product concept of “a robot that can be worn just like clothes.”

## 5. Contributing to Improving Food Environments: Development of Robots for Food Packaging Lines

In line with changes in food culture and life style, new food supply methods are being established involving the use of convenience stores and courier services. Greater emphasis has been placed on safety and hygiene in food processing and packaging plants, but the aging population in Japan has made it difficult to secure the labor required for such work. To meet this challenge, the use of production site automation and unmanned operation is accelerating.

The use of high-speed parallel link robots for food production facilities with high production volumes has been attracting much attention.

This chapter introduces parallel link robot development technology that uses our motion controllers for use in handling robots for food production lines.

### 5.1 Overview of equipment

The equipment we were involved in developing was a post-packaging box filling line process using a parallel link robot. An image-processing unit detects products being carried on a belt conveyor. A robot then follows the products, picks them up, and finally packs them into boxes. This equipment is collectively known as a conveyor tracking system. Figure 7 shows an overview of the system.

The box filling process requirements can be met with a robot and belt conveyor coordinated with upstream processes. However, our motion controller has been revised to add capabilities to allow installed robots to be changed, moved, and expanded freely.

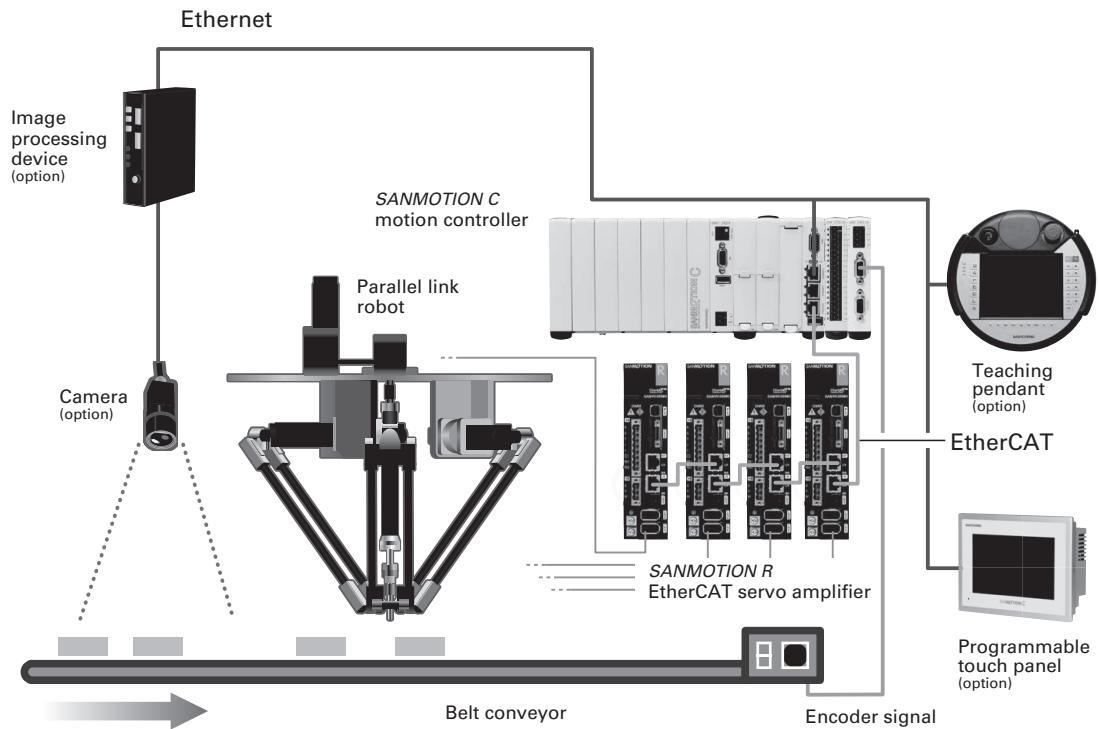


Fig. 7 Conveyor tracking system configuration

## 5.2 Robot control technology

There are a number of issues involved in developing a production system that uses robots, such as training personnel to have robot expertise and prolonged development periods.

To solve such issues, our *SANMOTION C* motion controller features technologies and functions to support robot development, which are introduced below.

### 5.2.1 Parallel link robot posture control

As shown in Figure 8, the *SANMOTION C* motion controller has a mechanism setting tool, which makes it possible to control robot posture easily.

Robot posture can be controlled simply by setting the type of robot to be developed, arm length, and gear ratio. Posture control does not require complicated calculations, therefore the burden of program development placed on customers is reduced.

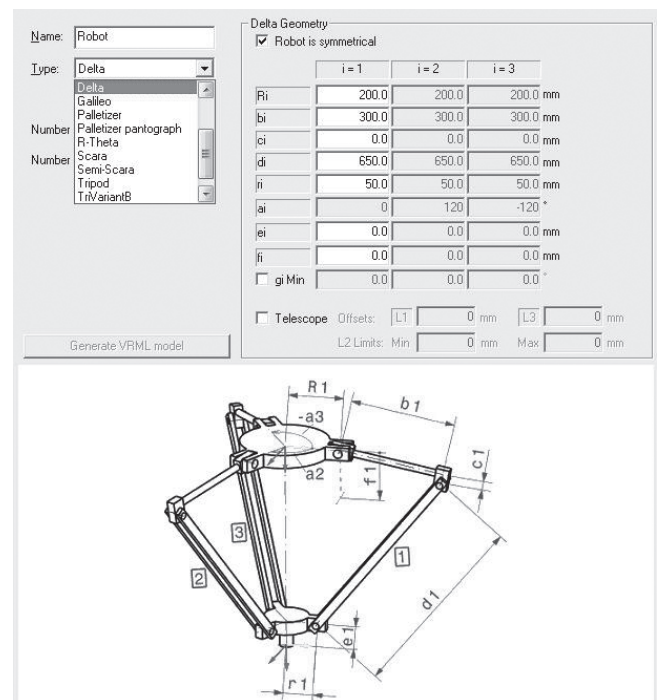


Fig. 8 Robot mechanism setting tool

Food production lines are expected to use multiple robots, therefore flexibility is required in terms of expanding robot processes and making installation changes. Figure 9 shows the construction and installation method of the special parallel link robot with which our motion controller was combined to save space in the production line.

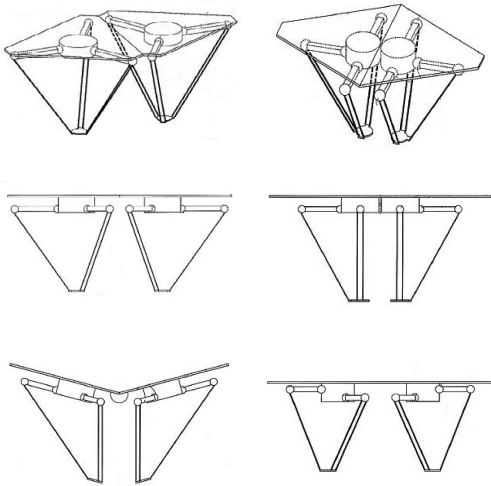


Fig. 9 Parallel link robot specialized mechanisms and construction methods

### 5.2.2 Teaching/programming function

We provide a dedicated teaching pendant for *SANMOTION C* shown in Figure 10 to allow robot motion to be programmed easily. The wizard navigation, shown in Figure 11, makes it easy to make complex belt conveyor and camera installation adjustments. Robot operation commands shown in Table 1 can be used to operate robots easily. These functions allow robot motion to be programmed quickly.



Front view

Side view

Fig. 10 Teaching pendant appearance



Fig. 11 Belt conveyor and camera setting screen

Table 1 Example of main robot language commands

Command name	Description
<b>PTP</b>	Point-to-point motion
<b>LIN</b>	Linear interpolation motion
<b>CIRC</b>	Circular interpolation motion
<b>PTPRel</b>	Distance-specified PTP motion
<b>LINRel</b>	Distance-specified linear interpolation motion
<b>StopRobot</b>	Robot stop
<b>WaitFinished</b>	Wait for robot command to process
<b>RefRobotAxis</b>	Homing operation
<b>TOOL</b>	Tool coordinates setting
<b>Ovl</b>	Overlap setting (Path)
<b>Ramp</b>	Acceleration/deceleration curve setting
<b>WaitTime</b>	Wait time (timer)
<b>DIN.Wait</b>	Wait for digital input
<b>Dout. Set</b>	Digital output setting (BOOL)
<b>WHILE ... DO</b>	Iterative control
<b>IF ... THEN</b>	Branch instruction

Using the robot development support technology of *SANMOTION C*, even users with no robot expertise can develop robot motion programs quickly. By providing total support with robot installation, development, and programming, we contribute to the realization of unmanned operation and automation.

## 6. Conclusion

This article introduced the following four cases where our products and technology are used to help make new dreams for people's lives come true.

- (1) Linear servo motor technology for radiation therapy equipment
- (2) DC servo motor technology used in mammography
- (3) Servo technology for wearable robots
- (4) Motion control technology for food packaging parallel robots

These servo technologies support medical treatment and food environments. Servo technologies tend to be thought of as technologies used in industrial machinery only, but as this article has highlighted, servo technology also has a significant role to play in medical and welfare equipment, as well as equipment for the food production industry. We will continue to develop servo technology that allows people and medical and welfare equipment to work together, and provide products and services that can contribute to good health and making people happy.

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