# Building a Low-Carbon Society
## —Energy- and resource-saving initiatives—

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## 1. Introduction

In recent years, the increasing impact of global warming and the natural disasters caused by climate change have brought the urgent need to realize a low-carbon society.

We, SANYO DENKI, have been engaged in initiatives of "technology for protecting the global environment" and "technology for saving energy," and developed and offered various Servo Systems products aligned with them. In our production sites, we have made consistent efforts such as reducing power and raw material usage.

This article introduces Servo Systems products and technologies that contribute to energy and resource conservation with the aim of realizing a low-carbon society. It also introduces the energy-saving technologies and the 3 R's initiatives (Reduce, Reuse, and Recycle) in our production.

## 2. Products and Technologies for Achieving Low-Carbon Society

This chapter introduces our products and technologies that contribute to a low-carbon society.

First, regardng our servo motors, we present the features of the *SANMOTION G* servo motor, which is more compact, lightweight, and energy-efficient than its predecessor. Next, regarding our servo amplifiers, we present the *SANMOTION G* servo amplifier, which boasts significantly reduced $CO_2$ emissions compared to its predecessor, as well as a power regeneration device, which contributes to the effective use of electricity.

### 2.1 Servo motor and technology

Servo motors are energy conversion devices that convert electrical energy into mechanical energy. To contribute to a low-carbon society, it is crucial that the conversion of electrical energy into mechanical energy is done more efficiently.

The *SANMOTION G* AC servo system, which we launched in May 2022, features a higher energy conversion efficiency than its predecessor and is one of our low-carbon products. This section introduces the *SANMOTION G*'s servo motors.

#### 2.1.1 The *SANMOTION G* servo motors

We pursue compactness, light weight, and high efficiency in the development of servo motors. The latest *SANMOTION G* servo system not only achieves improved servo performance than its predecessor, the *SANMOTION R* servo system, but is also environmentally friendly.

Figure 1 shows the *SANMOTION G* servo motor and amplifier. The following sebsections describe the features of the servo motor, as well as our energy-saving and industrial waste reduction initiatives related to it.

(a) Servo motor (GAM2A6040F0XRK0) (b) Servo amplifier (GADSA02AH24)

Fig. 1 The *SANMOTION G* servo system

**(1) Reduced size and weight, increased output, and resource savings**

For the *SANMOTION G* servo motor, we have optimized the electromagnetic field design and winding of the motor unit and holding brake. Moreover, improvements have been made to the connector arrangement and motor construction, and the size of the encoder has been reduced, significantly shortening the motor length. Figure 2 compares the lengths of the motors. With the *SANMOTION R*'s high torque and high power maintained, the new motors have been made up to 22% shorter and up to 26% lighter. As a result, the volume of the servo motor components has been reduced by up to 28%, saving resources.

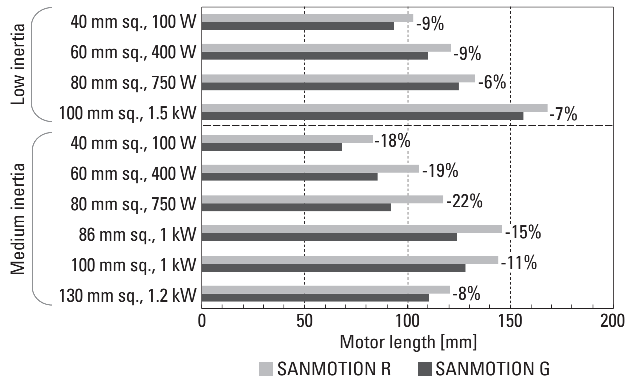


Fig. 2 Motor length comparison

### (2) Increased energy efficiency

Although there is a trade-off between shortening the motor length and improving efficiency, we achieved reduced power loss and up to 9% higher efficiency by optimizing the electromagnetic field design as mentioned earlier, improving the winding fill factor, and using low-loss materials. Furthermore, for the holding brake, we have optimized the electromagnetic field design and structure, along with improvements in the winding fill factor, achieving up to 44% lower power consumption. In addition, current consumption of the encoder has been reduced by 26% compared to our current product. It was eco-designed and features high efficiency and energy savings.

Thanks to these efforts, based on the Life Cycle Assessment (LCA), the new product demonstrates substantial reductions in $CO_2$ emissions, achieving up to a 48.3% decrease.[1] In this way, the product contributes more to achieving a low-carbon society than the current product.

Table 1 shows the LCA results of servo motors, presenting a comparison of energy usage and $CO_2$ emissions between the current *SANMOTION R* and the new *SANMOTION G*.

### (3) Higher encoder resolution and reduced industrial waste

The built-in encoder is a high-resolution battery-less absolute encoder with a maximum resolution of 27 bits. The high resolution enables stable repetitive motion and high-precision positioning. This encoder eliminates the need for battery backup for retaining multi-turn data when the power is turned off. Consequently, there are no batteries that need to be periodically replaced, contributing to natural resource saving, reduced industrial waste, and improved maintainability.

## 2.2 Servo amplifier and technology

Servo amplifiers have been required to have: high-efficiency conversion technology, effective use of energy, and motion control technology linked with the IoT (Internet of Things) technology and AI (artificial intelligence) to share information with and manage machinery.

In the following subsections, we present two low-carbon products: the *SANMOTION G* servo amplifier, which emits less $CO_2$ than its predecessor; and a power regeneration device, which makes effective use of the regenerative power from servo motors.

### 2.2.1 The *SANMOTION G* servo amplifiers

When developing a new servo amplifier, we aim to achieve a weight reduction and higher energy conversion efficiency.

In order for the *SANMOTION G* servo amplifier to have

Table 1 LCA results of servo motors

| LCA results | Size | Rated output | SANMOTION R (R2) (Current product) | SANMOTION G (GAM2) (New product) | Reduced by |
|---|---|---|---|---|---|
| Energy usage | 40 mm sq. | 100 W | 1,727 Mcal | 1,643 Mcal | 4.8% |
| | 60 mm sq. | 400 W | 2,728 Mcal | 2,575 Mcal | 5.6% |
| | 80 mm sq. | 750 W | 4,347 Mcal | 3,401 Mcal | 21.8% |
| | 100 mm sq. | 1 kW | 4,382 Mcal | 3,374 Mcal | 23.0% |
| | 130 mm sq. | 1.2 kW | 10,585 Mcal | 5,443 Mcal | 48.6% |
| $CO_2$ emissions | 40 mm sq. | 100 W | 447 kg | 426 kg | 4.8% |
| | 60 mm sq. | 400 W | 706 kg | 670 kg | 5.1% |
| | 80 mm sq. | 750 W | 1,127 kg | 881 kg | 21.8% |
| | 100 mm sq. | 1 kW | 1,141 kg | 877 kg | 23.1% |
| | 130 mm sq. | 1.2 kW | 2,739 kg | 1,416 kg | 48.3% |

Table 2 LCA results of servo amplifiers

| LCA results | Amplifier capacity | SANMOTION R 3E Model (Current product) | SANMOTION G (New product) | Reduced by |
|---|---|---|---|---|
| Energy usage | 10 A | 905 Mcal | 736 Mcal | 18.7% |
| | 20 A | 2,412 Mcal | 2,259 Mcal | 6.3% |
| | 30 A | 3,797 Mcal | 3,654 Mcal | 3.8% |
| | 50 A | 6,257 Mcal | 5,826 Mcal | 6.9% |
| $CO_2$ emissions | 10 A | 233 kg | 189 kg | 18.9% |
| | 20 A | 638 kg | 602 kg | 5.6% |
| | 30 A | 1,000 kg | 963 kg | 3.7% |
| | 50 A | 1,630 kg | 1,520 kg | 6.7% |

an improved power density, we have improved the maximum output current by up to 5% by using a power semiconductor device with low heat generation and optimizing the thermal design. Moreover, we selected and used components that have low current consumption ratings, reducing the total power consumption by up to 22%. At the same time, the selected components are also smaller in size, achieving a weight reduction of up to 5.5%.

Compared based on Life Cycle Assessment (LCA) using these values in the calculation, it can be said that the new product produces up to 18.9% less(1) $CO_2$ emissions than the current product, contributing to achieving a low-carbon society.

Table 2 shows the LCA results of servo amplifiers, providing a comparison of energy usage and $CO_2$ emissions between the current *SANMOTION R 3E Model* and new *SANMOTION G* amplifiers.

The servo amplifiers feature the monitoring of power consumption of servo systems by calculating the data collected from sensors. By displaying the electricity consumption status to customers who use our servo systems, this feature can contribute to the efficient use of electricity, both in machinery and across entire factories.

## 2.2.2 Power regeneration device

Systems that are used for machinery consume electricity the most when powering a motor to drive a load equipment. On the other hand, however, when decelerating or coming to a halt during motion, the load applied to the motor acts in the reverse direction of the driving force, causing the motor to function as a generator.

Conventionally, the regenerative power generated used to be for the most part dissipated as heat through resistors, a process we refer to as the regenerative resistor method. However, electricity cannot be used effectively with this method.

Recently, we have developed a product equipped with the power regeneration capabilities to effectively use regenerative power, and this is used by many of our customers. Figure 3 shows an example configuration of a power regeneration device.

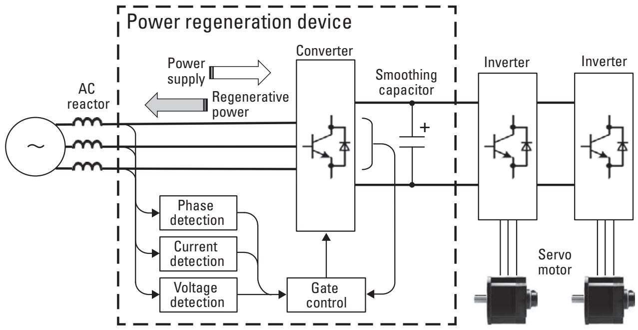


Fig. 3 Power regeneration device

A power regeneration device comprises a converter featuring an IGBT bridge with a free-wheeling diode. This circuit is designed for both forward and reverse power conversion. The regenerative power generated by the servo motor flows through the inverter and charges the smoothing capacitor. Subsequently, the energy is fed back to the power grid through reverse conversion by the converter.

The control method of power regeneration is the 120° current method,(2) which involves detecting the phase of the power supply voltage and only regenerates power in 120° intervals of the power supply voltage. With this method, the frequency of IGBT switching is much smaller than that of the PWM method, resulting in minimized loss and leakage current. In this way, the power regeneration method avoids converting the regenerative power into wasted heat. Unlike the regenerative resistor method, it can be used more effectively as energy for other machinery.

The power regeneration technology in products results in lower losses and reduced power consumption. This not only enables the efficient use of energy but also significantly contributes to the realization of a low-carbon society.

## 3. Low-Carbon Initiatives in Production

This chapter introduces examples of our energy-saving and waste-reduction initiatives in production. It first presents energy-saving technologies for the electroplating line and the bonding process as initiatives in the manufacturing processes. Then, it introduces examples of the 3 R's (Reduce, Reuse, and Recycle) efforts as initiatives on our production sites.

### 3.1 Energy-saving technology in production processes

We put quite an energy-saving design effort when revising our existing manufacturing equipment and developing new equipment. This section highlights examples of our initiatives in the electroplating line as an improvement of existing equipment, and energy-saving technology in the newly developed magnet bonding unit.

#### 3.1.1 Energy-saving initiative in electroplating line

The electroplating line includes a rinsing process that sprays water to clean products. Figure 4 shows the rinsing process of the electroplating line. During rinsing, the discharge flow rate must be adjusted to prevent workpieces from falling or water from splashing due to the water pressure. Before improving the equipment, the pump operation of drawing water up from the tank used to be working at full capacity at all times, and workers had to manually adjust the flow rate with a regulator valve, resulting in wasted power.

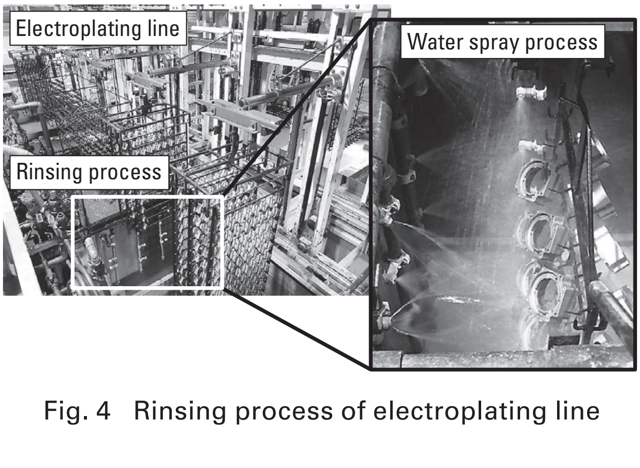


Fig. 4 Rinsing process of electroplating line

Modifications were made to adjust the discharge flow rate by controlling the pump operation using the inverter installed for the drive motor of the pump, leading to a reduction in power consumption.

This improvement has resulted in significant energy savings by controlling the pump operation, which used to be at full capacity all the time, through control of the drive motor. Power consumption of the rinsing process was reduced to approximately 1/2 compared to before the improvement.

#### 3.1.2 Energy-saving technology in the magnet bonding process (from heating furnace to high-frequency induction heater)

Along with the new *SANMOTION G* servo motors, we also developed a new magnet bonding unit.

This unit uses high-frequency induction heating technology to accelerate the thermal curing of the adhesive to bond the magnets to the rotor to achieve greatly reduced power consumption.

Figure 5 illustrates the principle behind high-frequency induction heating technology.

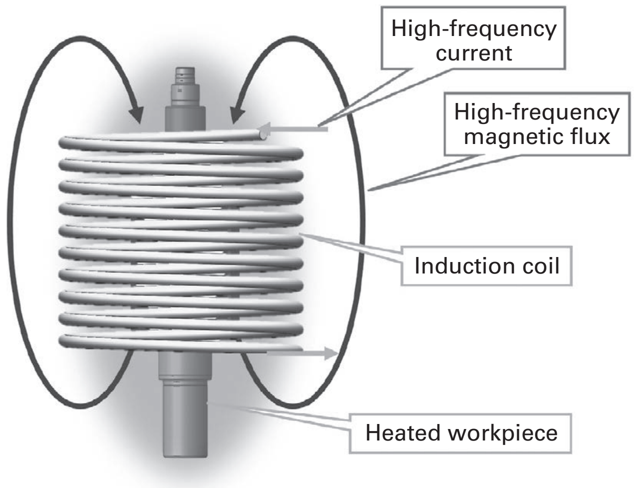


Fig. 5 High-frequency induction heater illustrated

In the magnet bonding process for the current product, a drying oven is used for thermal curing of the adhesive. The drying oven needs to maintain the heating temperature, which requires the heater to be left turned on from the beginning to the end of the operation regardless of whether workpieces are present, continuously consuming power.

The high-frequency induction heating technology used for the newly developed unit allows quick heating of workpieces and consumes power only during the heating process. This has led to a significant reduction in power consumption compared to the drying oven. The power consumption per rotor has been reduced to approximately one-third that of the drying oven method.

### 3.2 The 3 R's in production

At the production sites of Servo Systems products, we are promoting the principles of the 3 R's (Reduce, Reuse, and Recycle). These principles guide our behaviors, aiming to mitigate environmental impact and facilitate the capitalization of resources. This section introduces specific examples of the initiatives.

#### 3.2.1 The "Reduce" initiative

We are promoting an initiative to change the packaging materials for delivering Servo Systems products to customers, replacing corrugated cardboard boxes with reusable, returnable boxes, as shown in Figure 6. The use of returnable boxes reduces the energy required for the production of corrugated cardboard boxes and the consumption of forest resources.

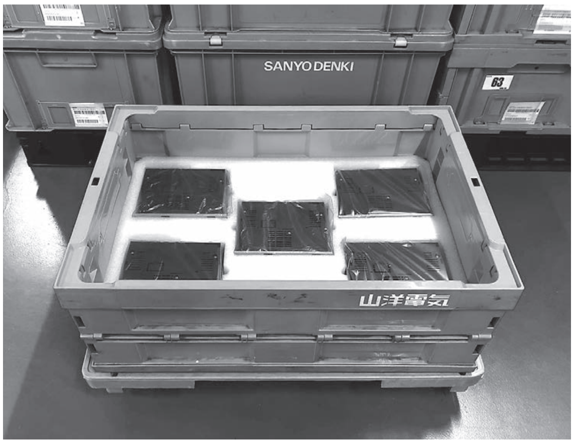


Fig. 6 Returnable delivery boxes for servo amplifiers

#### 3.2.2 The "Reuse" initiative

To promote resource circulation by reducing and recycling plastic waste, the Plastic Resource Circulation Act was enacted in April 2022.

Our Servo Systems Division promotes the sustainable use of resources by returning plastic containers for electronic components, as shown in Figure 7, to the manufacturer for reuse. The reuse of plastic containers also helps component manufacturers avoid procurement risks such as soaring resin material prices and material shortages.

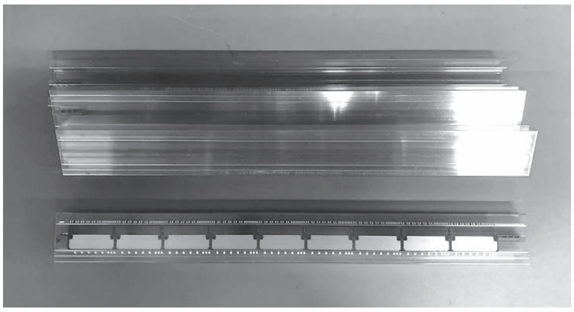

Fig. 7 Plastic containers for electronic components

#### 3.2.3 The "Recycle" initiative

We promote material recycling by selling expired solder generated in the PCB manufacturing process and solder scrap oxidized in manufacturing processes to waste recyclers. Figure 8 illustrates the flow of solder scrap recycling. Recycling valuable mineral resources such as tin and silver contained in solder makes consumption and production more sustainable. It also reduces the need to mine for new mineral resources, reducing the impact on the global environment and ecosystems.

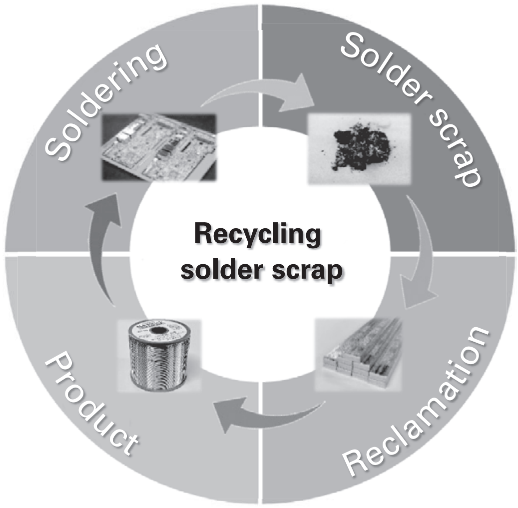


Fig. 8 Flow of solder scrap recycling

## 4. Conclusion

This article has introduced Servo Systems products and technologies that contribute to the reduction of $CO_2$ emissions by saving resources and energy to achieve a low-carbon society. It has also presented the electroplating line and the magnet bonding unit as examples of energy-saving technologies in the production processes. Furthermore, it has introduced examples of the 3 R's initiatives at our production sites.

The *SANMOTION G* servo motors and amplifiers, which are compact and lightweight, contribute to energy and resource savings thanks to their high conversion efficiency. The power regeneration device achieves power savings by effectively supplying the regenerative power of motors to other machinery.

The electroplating line reduces power consumption by controlling pump operations in the rinsing process. In the magnet bonding process, use of the high-frequency induction heating technology has achieved reductions in production time and power consumption.

In the 3 R's initiatives in production, we have reduced our environmental impact by using returnable boxes to reduce the use of corrugated cardboard boxes, reusing plastic containers, and recycling solder scraps.

In the future, expectations for servo system technologies that contribute to a low-carbon society are anticipated to grow even higher. We intend for our servo systems to continue to meet these expectations and protect the global environment and human life.

Reference

(1) Yasushi Misawa and 15 others: "Development of *SANMOTION G* AC Servo Systems"
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(2) Yuji Ide and 5 others: "Servo Amplifier Technology Contributing to Effective Use of Power"
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