Development of *SANMOTION G* AC Servo Systems

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1. Introduction

SANYO DENKI has developed many servo system products over the years, and these systems have contributed to improving the value of customers' equipment as well as to industrial development. Among them in particular, our *SANMOTION R* AC servo systems are still used by many customers due to their high performance and extensive lineup.

Servo systems are essential devices that impact machinery performance, quality, and reliability, and further improvements in performance and functionality are necessary. Moreover, electrically powered equipment efficiency improvements, energy savings, and natural resources saving are also important as measures to counter global heating. The role played by servo systems is becoming more important than ever for industrial development and to resolve problems facing the global environment.

In response to these expectations, we developed new *SANMOTION G* AC servo systems. The new servo system offers servo motors, holding brakes, encoders, and servo amplifiers have been renewed from *SANMOTION R* based on the concepts of "powerful" and "friendly" servo systems.

"Powerful" means that high servo performance and highly reliable products that can be used with peace of mind in various regions and environments. "Friendly" means products that deliver energy savings, that are compact and lightweight, that are friendly to the global environment, and that are easy to use.

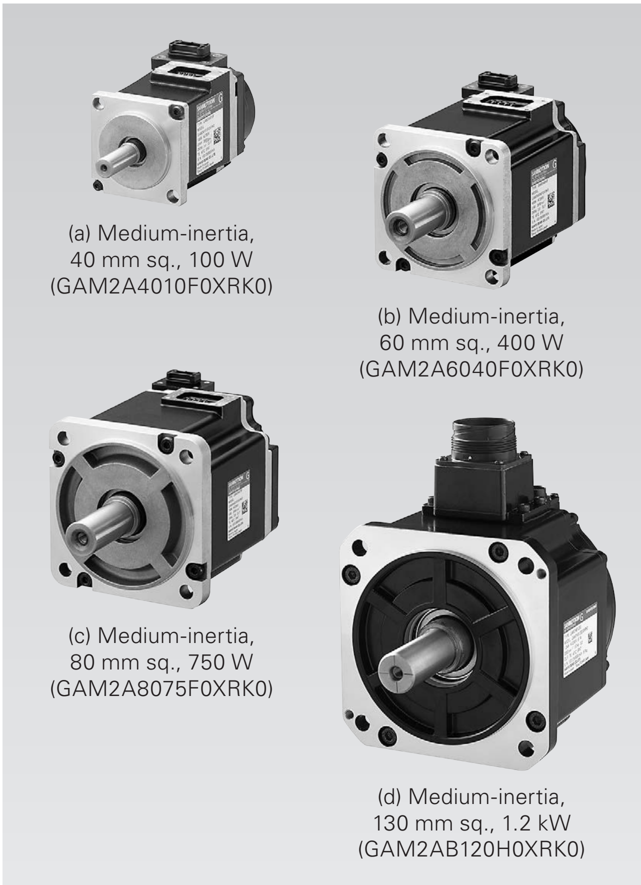
This article will begin by showing the appearance of our new products and product lineup, as well as product specifications. Next we'll introduce the "powerful" and "friendly" features of our new products, and the development points.

2. Product Overview

This chapter provides an overview of the new *SANMOTION G* AC servo system products including servo motors, encoders, and servo amplifiers.

2.1 Servo motors and encoders

Figure 1 shows some of the new servo motors. Tables 1 and 2 list the servo motor lineup, and Table 3 shows the specifications of typical servo motor models and encoder.



(a) Medium-inertia, 40 mm sq., 100 W (GAM2A4010F0XRK0)

(b) Medium-inertia, 60 mm sq., 400 W (GAM2A6040F0XRK0)

(c) Medium-inertia, 80 mm sq., 750 W (GAM2A8075F0XRK0)

(d) Medium-inertia, 130 mm sq., 1.2 kW (GAM2AB120H0XRK0)

Fig. 1 Servo motor appearance

The lineup comprises a total of 37 models, with 13 low-inertia models ranging from a 40 mm sq., 50 W model to a 100 mm sq., 1.5 kW model, and 24 medium-inertia models ranging from a 40 mm sq., 30 W model to a 130 mm sq., 1.2 kW model. The lineup includes the same 31 models as the current *SANMOTION R* series, as well as new 40 mm sq., 150 W, 60 mm sq., 600 W, and 80 mm sq., 1 kW models.

The 40 mm sq. to 86 mm sq. models feature an integrated power cable and holding brake cable, and new 6-core integrated connector. The power and holding brake connector, and the encoder connector are directly secured to the motor unit with screws, allowing them to be securely fastened. The 100 mm sq. to 130 mm sq. models employ a circular push-pull connector for easier assembling.

Our combination encoder lineup contains a compact, slim, battery-less absolute encoder with maximum resolution of 27 bits, and a single-turn absolute encoder, realizing high resolution and shorter motor length.

Custom options available are with/without holding brake, with/without oil seal, and circular/keyway shaft.

Table 1 Servo motor lineup (Low inertia)

Flange size	Rated output	Power supply voltage		Servo motor model no.	Newly added model
		100 V	200 V		
40 mm sq.	50 W	✓	✓	GAM1*4005F0	–
	100 W	✓	✓	GAM1*4010F0	–
	150 W	–	✓	GAM1A4015F0	✓
60 mm sq.	200 W	✓	✓	GAM1*6020F0	–
	400 W	–	✓	GAM1A6040F0	–
	600 W	–	✓	GAM1A6060F0	✓
80 mm sq.	750 W	–	✓	GAM1A8075*0	–
	1 kW	–	✓	GAM1A8100F0	✓
100 mm sq.	1 kW	–	✓	GAM1AA100*0	–
	1.5 kW	–	✓	GAM1AA150*0	–

Table 2 Servo motor lineup (Medium inertia)

Flange size	Rated output	Power supply voltage		Servo motor model no.	Newly added model
		100 V	200 V		
40 mm sq.	30 W	✓	✓	GAM2*4003F0	–
	50 W	✓	✓	GAM2*4005F0	–
	100 W	✓	✓	GAM2*4010F0	–
	150 W	–	✓	GAM2A4015*0	✓
60 mm sq.	100 W	✓	✓	GAM2*6010F0	–
	200 W	✓	✓	GAM2*6020F0	–
	400 W	–	✓	GAM2A6040F0	–
	600 W	–	✓	GAM2A6060*0	✓
80 mm sq.	200 W	–	✓	GAM2A8020F0	–
	400 W	–	✓	GAM2A8040F0	–
	750 W	–	✓	GAM2A8075*0	–
	1 kW	–	✓	GAM2A8100F0	✓
86 mm sq.	750 W	–	✓	GAM2A9075F0	–
	1 kW	–	✓	GAM2A9100*0	–
100 mm sq.	750 W	–	✓	GAM2AA075F0	–
	1 kW	–	✓	GAM2AA100F0	–
	1.5 KW	–	✓	GAM2AA150*0	–
130 mm sq.	550 W	–	✓	GAM2AB055D0	–
	1.2 kW	–	✓	GAM2AB120*0	–

Table 3 Servo motor (typical models) and encoder specifications

Items \ Servo motor model no.			Low-inertia: GAM1A				Medium-inertia: GAM2A					
			4010F0	6040F0	8075F0	A150H0	4010F0	6040F0	8075F0	9100F0	A100F0	B120H0
Flange size	–	mm	40 sq.	60 sq.	80 sq.	100 sq.	40 sq.	60 sq.	80 sq.	86 sq.	100 sq.	130 sq.
Rated output	P_R	W	100	400	750	1500	100	400	750	1000	1000	1200
Rated torque	T_R	N·m	0.318	1.27	2.39	4.8	0.318	1.27	2.39	3.18	3.18	5.8
Continuous torque at stall	T_S	N·m	0.353	1.37	2.55	4.9	0.318	1.37	2.55	3.92	3.92	6.0
Peak torque at stall	T_P	N·m	1.18	4.8	8.5	18.0	1.18	4.8	8.5	14.3	14.7	20.0
Rated speed	N_R	min^{-1}	3000	3000	3000	3000	3000	3000	3000	3000	3000	2000
Maximum speed	N_{max}	min^{-1}	6500	6500	6500	3000	6500	6500	6500	6500	6000	4000
Rated armature current	I_R	A_{rms}	1.00	2.8	5.9	5.2	0.99	2.9	5.9	6.0	5.5	6.7
Continuous armature current at stall	I_S	A_{rms}	1.05	2.8	5.7	3.8	0.96	2.9	5.9	6.8	6.2	6.6
Peak armature current	I_P	A_{rms}	4.1	12.0	22.0	15.5	3.6	10.8	21.4	25.7	26.5	26.5
Rotor inertia: Without brake	J_M	$\times 10^{-4}$ kg·m^2 (GD^2/4)	0.0259	0.213	0.739	1.98	0.06	0.466	1.56	2.45	3.97	7.78
Rotor inertia: With brake	J_M	$\times 10^{-4}$ kg·m^2 (GD^2/4)	0.0324	0.272	0.936	2.31	0.067	0.524	1.76	2.75	4.30	8.86
Encoder inertia	J_S	$\times 10^{-4}$ kg·m^2 (GD^2/4)	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025
Motor length: Without brake	LL	mm	93.5	110	125	156.5	68	85.5	92.0	127	128	100.5
Motor length: With brake	LL	mm	122	132.5	155.5	193	100.5	111.5	126	153	146	135.5
Mass: Without brake	W_E	kg	0.52	1.4	2.9	5.0	0.4	1.3	2.2	3.4	4.1	5.5
Mass: With brake	W_E	kg	0.71	1.8	3.7	6.6	0.6	1.6	3.0	4.2	4.9	7.1
Encoder resolution	–	–	17-bit (131,072 steps), 20-bit (1,048,576 steps), 23-bit (8,388,608 steps), 27-bit (134,217,728 steps)									
Multi-turn encoder	–	–	Batteryless									

2.2 Servo amplifier overview

Figure 2 shows some of the new servo amplifiers. The connectors for the power supply and motor power were changed to a spring-type, push-pull connector for improved workability and safety than the current models.

As shown in Table 4, the lineup contains a total of 21 models based on the power supply voltage, combined servo motor, and host controller and interface specifications. The 100 V type consists of 3 models, with output current capacity of 10 A, 20 A, and 30 A, and the 200 V type consists of 4 models, with output current capacity of 10 A, 20 A, 30 A, and 50 A.

(a) 30 A
EtherCAT type
(GADSA03AH24)

(b) 50 A
Analog/pulse input type
(GADSA05AA00)

Fig. 2 Servo amplifier

An EtherCAT type and analog/pulse train command input type have been prepared for the host controller and interface. The analog/pulse train command input type is available in SINK or SOURCE type as a general-purpose output specification.

Table 5 shows the main specifications of the new servo amplifiers. In comparison with the current model, responsiveness has been enhanced, and servo performance has been improved with an extensive range of control and compensation functions.

Servo tuning can be performed easier using the “SANMOTION MOTOR SETUP SOFTWARE” tool (hereinafter abbreviated to SETUP SOFTWARE) and the linked frequency characteristics measurement function and Advanced Tuning function.

To allow the new product to be used in various regions and environments, environmental durability to conditions such as altitude and ambient temperature have been improved, and reliability has been increased. Moreover, the product has been equipped with an extensive range of monitoring functions used to estimate remaining part life, and monitor the power supply condition and communication quality, improving maintainability.

Table 4 Servo amplifier product lineup

Power supply voltage		Compatible motors	GPO interface		Servo amplifier model no.
100 V	200 V	Rated output	EtherCAT	Analog/Pulse	
✓	–	Up to 30 W	–	Sinking output	GADSE01*A**
✓	–	Up to 30 W	–	Sourcing output	GADSE01*B**
✓	–	Up to 30 W	✓	–	GADSE01*H**
✓	–	Up to 100 W	–	Sinking output	GADSE02*A**
✓	–	Up to 100 W	–	Sourcing output	GADSE02*B**
✓	–	Up to 100 W	✓	–	GADSE02*H**
✓	–	Up to 200 W	–	Sinking output	GADSE03*A**
✓	–	Up to 200 W	–	Sourcing output	GADSE03*B**
✓	–	Up to 200 W	✓	–	GADSE03*H**
–	✓	Up to 150 W	–	Sinking output	GADSA01*A**
–	✓	Up to 150 W	–	Sourcing output	GADSA01*B**
–	✓	Up to 150 W	✓	–	GADSA01*H**
–	✓	Up to 400 W	–	Sinking output	GADSA02*A**
–	✓	Up to 400 W	–	Sourcing output	GADSA02*B**
–	✓	Up to 400 W	✓	–	GADSA02*H**
–	✓	Up to 1.5 kW	–	Sinking output	GADSA03*A**
–	✓	Up to 1.5 kW	–	Sourcing output	GADSA03*B**
–	✓	Up to 1.5 kW	✓	–	GADSA03*H**
–	✓	Up to 2.5 kW	–	Sinking output	GADSA05*A**
–	✓	Up to 2.5 kW	–	Sourcing output	GADSA05*B**
–	✓	Up to 2.5 kW	✓	–	GADSA05*H**

Table 5 Servo amplifier main specifications

Items		Amplifier capacity	10 A	20 A	30 A	50 A
200 V	Control power supply voltage range		200 to 240 VAC +10%, -15%			
	Main circuit power supply voltage range		Single-/3-phase 200 to 240 VAC +10%, -15%; 300 VDC ±20%			
	Compatible motors	3-phase (single-phase/DC in parentheses)	Up to 150 W	Up to 400 W	Up to 1.5 kW (up to 750 W)	Up to 2.5 kW (up to 1.5 kW)
100 V	Main/Control circuit power supply voltage range		Single-phase 100 to 120 VAC +10%, -15%; 150 VDC ±20%			–
	Compatible motors		Up to 30 W	Up to 100 W	Up to 200 W	–
Continuous output current / Peak current			1.2 Arms / 4.3 Arms	3.1 Arms / 12 Arms	5.2 Arms / 16.3 Arms	12 Arms / 26.5 Arms
Altitude / Operating ambient temperature / Vibration resistance			2000 m or less / 0 to 60˚C / 6.0 m/s²			
Dimensions			40 W × 160 H × 130 D		50 W × 160 H × 130 D	85 W × 160 H × 130 D
Mass			0.8 kg or less		0.9 kg or less	1.6 kg or less
Structure / Cooling system			Tray type / Passive air cooling	Tray type / Forced air cooling		
Compatible motor types			• Rotary motors • Linear servo motors • Direct drive motors			
Compatible encoders			• Absolute encoders (battery-less, single-turn, and battery backup types) • Wire saving incremental encoder • HEIDENHAIN's EnDat2.2 encoder			
Performances and functions	Responsiveness and maximum applicable resolution		• 3.5 kHz (speed loop frequency response) • 134,217,728 steps per rotation (27 bit)			
	Control functions, compensation functions		• Tandem operation control • Quadrant projection compensation • Gravity compensation • Dual position feedback control • Friction compensation • Disturbance observer			
	Interface		• EtherCAT, analog/pulse train command input			
	Mechanical vibrations, resonance suppression		• Model following vibration suppression • Vibration suppression for trajectory control • CP vibration control • Torque command notch filter (variable width) • FF vibration suppression • Adaptive notch filter • Minor-vibration control			
	Servo tuning		• Frequency characteristics measurement • Advanced tuning • Auto tuning responsiveness (7 characteristics, 40 levels)			
	Start-up, monitoring, diagnosis		• Virtual motor operation • Drive recorder • System power consumption monitoring • Input power supply monitoring • Control power supply frequency monitoring • Encoder/EtherCAT communication quality monitoring • Remaining electrolytic capacitor life • Remaining holding brake life • Regenerative resistor power consumption monitoring • Encoder temperature monitoring • Amplifier temperature monitoring • Relay counter • Relay sticking detection			
Compliance with standards	UL / CSA		UL 61800-5-1 / C22.2 No. 274-13			
	Low Voltage Directive / EMC Directive		EN 61800-5-1 / EN 61800-3, EN 61326-3-1			
	Functional safety		ISO 13849-1 PL=e, EN 61508 SIL3, EN 62061 SILCL3			
	KC Mark		KN 61000-6-2, KN 61000-6-4			
	Other		CE Mark, UKCA Mark, RoHS Directive			

3. Features

3.1 "Powerful" servo performance

3.1.1 High-power, high-precision servo motor

The new product features an optimized servo motor, holding brake electromagnetic field construction, and winding specifications. 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. Torque density has been improved by reducing the size of the motor, while maintaining the high torque characteristics of the *SANMOTION R* series. Torque density is the torque produced per unit volume, and the larger the value, the more torque that is produced with smaller motor.

Figure 3 shows a comparison of peak torque density. Peak torque density has been improved by up to 13% for low inertia, and up to 28% for medium inertia compared to the current model.

The developed encoder is a high-resolution battery-less absolute encoder, and the resolution can be selected from 17-bit, 20-bit, 23-bit, or 27-bit. Enhancing encoder resolution has made it possible to realize stable repeat operation and highly-responsive positioning.

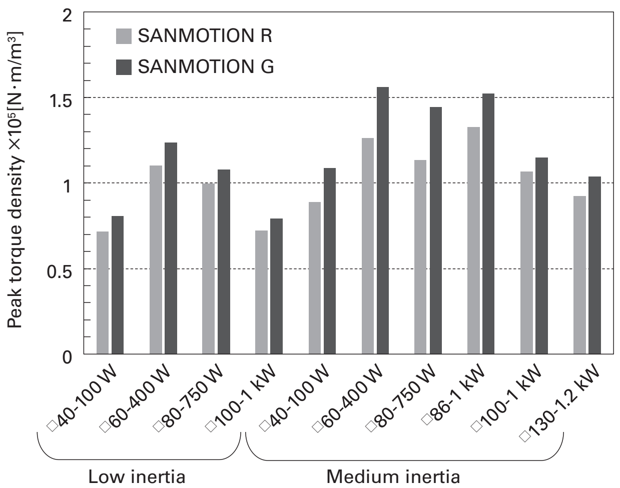


Fig. 3 Comparison of peak torque density

3.1.2 Extended output range

Figure 4 shows a comparison of torque vs. rotation speed characteristics (T-N characteristics). By optimizing the winding specification, the maximum rotation speed of the motor has been increased from 6,000 min^{-1} to 6,500 min^{-1}, an 8% improvement over the current model. The servo amplifier voltage use rate during high-speed rotation, a voltage saturation condition, has been improved, and the motor torque in the high-speed rotation range has been improved by up to 7% by increasing the voltage applied to the motor.

By doing so, the motor output range has expanded by 15%, allowing acceleration and deceleration time to be reduced.

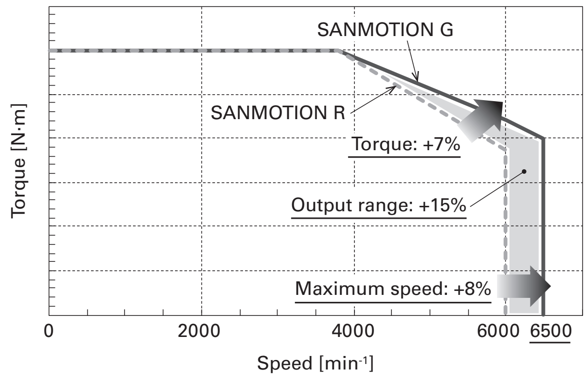


Fig. 4 Comparison of servo motor torque-speed characteristics

3.1.3 Improved responsiveness and shortened positioning time

Figure 5 shows the closed loop frequency response for the speed control system. The responsiveness of the current control system has been doubled over the current model by increasing the control cycle speed and improving the current detection accuracy. And by improving the torque control system, the frequency response of the speed control system has been improved by approximately 1.6 times (3.5 kHz) over the current model.

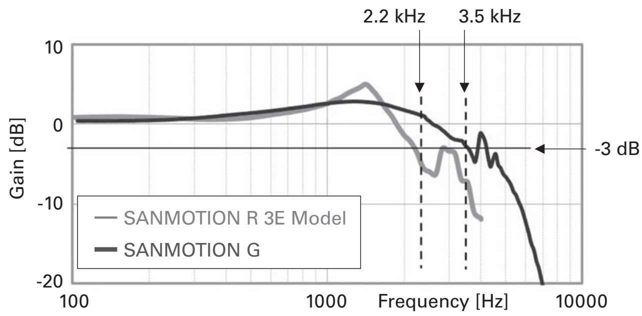


Fig. 5 Comparison of frequency response in speed control system

Figure 6 shows positioning settling characteristics. Using the "SETUP SOFTWARE" tuning function (Advanced Tuning), the positioning settling time has been reduced by 1/3 over the current model by compensating the impact of friction and gravity that hinders settling.

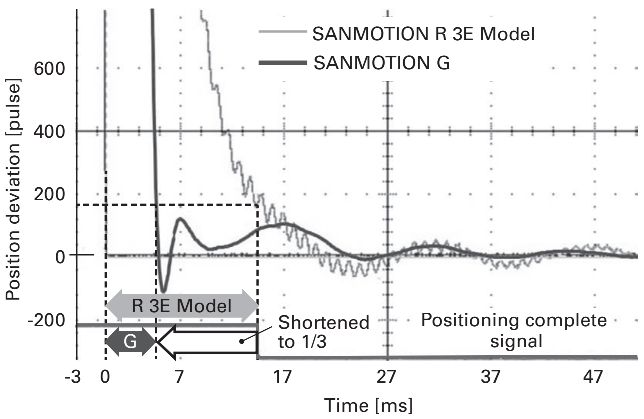


Fig. 6 Positioning characteristics

3.2 "Powerful" environmental durability

3.2.1 Enhanced environmental durability

Table 6 shows a comparison of environmental durability between the current product and new product. The new product can be used in more regions and in harsher environments than the current product.

The higher the altitude, the more air pressure drops, leading to lower air density, and this in turn results in a drop in heat radiation efficiency and withstand voltage. We stipulated a design that would allow the product to be used at altitudes twice as high as the current model, as well as the applicable test method. By clearing these strict tests, we were able to realize a product that can be used at altitudes of up to 2,000 m. Moreover, we significantly expanded the servo motor vibration resistance to twice the 24.5 m/s^2 value for the current model to 50 m/s^2. We also developed a high-reliability holding brake with minimal abnormal friction material wear, and this maintains holding torque even in high-temperature and high-humidity conditions.

Both the servo motor and servo amplifier can be used safely with derating specifications stipulated for each usage condition.

Table 6 Environmental durability comparison with current product

Items	Product	SANMOTION R (Current product)	SANMOTION G (New product)
Altitude	Motor	1,000 m or below	2,000 m or below (may require derating)
	Amplifier		
Vibration resistance	Motor	24.5 m/s^2 (10 Hz to 2 kHz)	50 m/s^2 (10 Hz to 2 kHz)
	Amplifier	4.9 m/s^2 (10 to 55 Hz)	6.0 m/s^2 (10 to 150 Hz)
Ambient temperature	Amplifier	0 to 55°C	0 to 60°C (may require derating)
Ambient humidity	Amplifier	90% RH or less (non-condensing, non-frozen)	95% RH or less (non-condensing, non-frozen)

3.2.2 Reduced radiated emissions

The main cause of rising emission levels is parts that work at high speed and with high accuracy. To address this, we analyzed the PCB magnetic near field, and optimized the pattern layout.

Figure 7 shows the servo amplifier (capacity: 30 A) radiated emissions. As the obtained data in this chart shows, the radiated emissions level in the high frequency range caused by reference clock signals such as those from the oscillator have been significantly lowered than the current model. By carrying out this test using a 10 m anechoic chamber in the new building of our Technology Center completed in 2021, we were able to significantly shorten the evaluation period.

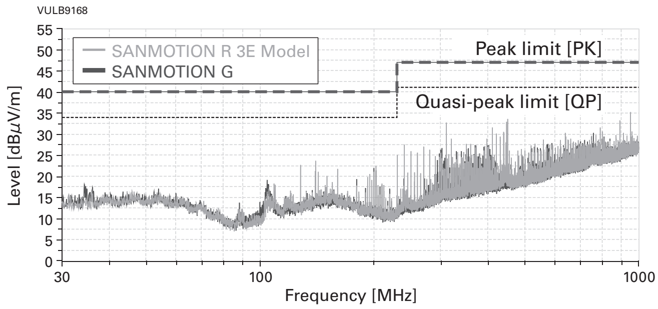


Fig. 7 Radiated emissions (10 m, horizontal)

3.3 "Powerful" maintainability

3.3.1 Preventive maintenance functions

We equipped the servo system with a remaining part life function for the parts used in servo motors and servo amplifiers to help with failure prevention and maintenance.

The motor holding brake is calculated from the amount of rotation when the motor is stopped by braking with respect to the wear limit. Electrolytic capacitor deterioration is calculated from the main circuit power supply and servo ON condition. The remaining life of the fan motor and relays is calculated from the operating time and operation count with respect to the expected life.

Failures can be prevented by systematically replacing and overhauling servo motors and servo amplifiers based on this information.

3.3.2 Environmental diagnosis

We added functions to help with servo system installation environment diagnosis. Table 7 shows a list of environmental monitoring items. Error rates, etc. for EtherCAT communication and encoder communication have also been included. These functions allow products to be used safely and with peace of mind by conducting surveys of customers' operating environments to make improvements as quickly as possible.

Main circuit rectifier voltage monitoring detects peak voltage value through 3-phase full-wave rectification of the input power supply voltage. Control power supply frequency monitoring detects power supply frequency in 1 Hz increments. Monitoring of these parameters provide the status of overvoltage, voltage fluctuations, and frequency fluctuations, helping customers diagnose power supply environments and identify the cause when errors occur.

Table 7 Environmental monitoring items list

Monitoring item	Monitoring name	Output unit
Input voltage	Main circuit rectifier voltage monitoring	V
	Main circuit DC voltage monitoring	V
Frequency	Control power supply frequency monitoring	0.1 Hz
Communication quality	Motor encoder communication error rate	–
	External encoder communication error rate	–
	EtherCAT communication error rate	–

3.3.3 Early diagnosis

We added sub-codes to alarm codes to improve troubleshooting when alarms occur. Each alarm code is subdivided up into to 15 types of cause, and these are displayed as sub-codes.

This helps identify the cause quickly, reducing equipment downtime.

3.4 "Friendly" to (global) environment

3.4.1 High-efficiency, compact, lightweight servo motor

Figure 8 compares the motor length and Figure 9 compares the motor weight of the current and new models (without holding brake in both figures). As mentioned earlier, the servo motor length and weight have been reduced by improving the electromagnetic field and motor mechanism and reducing the size of the encoder. The motor length has been shortened by up to 11% for low-inertia models and by up to 22% for medium-inertia models. The motor weight has been reduced by up to 12% for low-inertia models and up to 26% for medium-inertia models. Also, the reduced motor length and weight have led to a reduction in the amount of materials used by up to 28%.

Although shortening motor length usually reduces its efficiency, we achieved up to 9% higher efficiency by optimizing the electromagnetic field, improving the winding fill factor, and using low-loss materials. This resulted in up to 48.3 % lower CO_2 emissions.

Use in combination with a battery-less absolute 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 resources saving, reduced industrial waste, and improved maintainability.

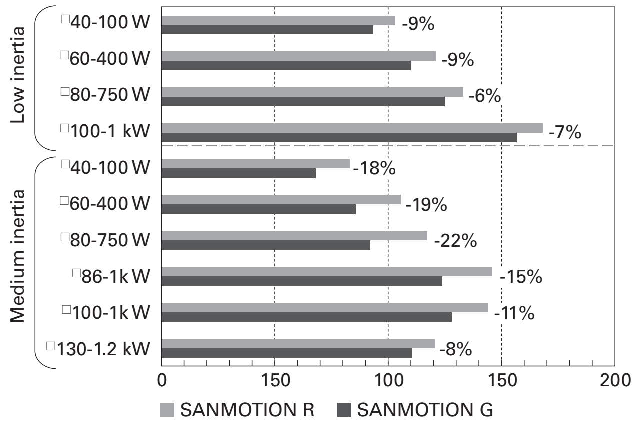


Fig. 8 Comparison of motor length (Without holding brake)

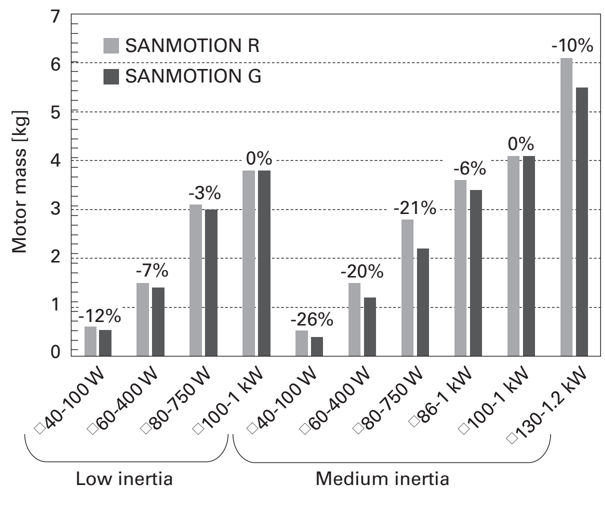


Fig. 9 Comparison of motor mass (Without holding brake)

3.4.2 Servo amplifier with low loss

To increase servo amplifier output, we improved the maximum output current of the power device by up to 5%. To increase responsiveness, switching frequency of the power device has been made 16% faster under normal conditions and up to 55% faster in the mode for reducing the noise caused by switching frequency when the motor is stopped. Increased output current and faster switching frequency usually result in increased loss and lower efficiency. Despite this, amplifier power consumption has been reduced by up to 22% by replacing high power consumption parts. This resulted in up to 18.9% lower CO_2 emissions.

Moreover, by reducing part size and optimizing thermal design, amplifier weight has been reduced by up to 5.5% while maintaining the same size as the current models.

3.5 "Friendly" to operators

3.5.1 High-precision measurement of machinery characteristics

High-precision system analysis has been added to our conventional system analysis to offer a new measurement mode. Conventionally, a dedicated measurement device (servo analyzer) was used to measure machinery frequency characteristics including servo control loop with high precision. The new amplifier achieves high-precision measurement by generating sinusoidal commands, calculating the frequency spectrum, and executing the frequency analysis of SETUP SOFTWARE.

3.5.2 Optimized tuning of servo parameters

We developed Advanced Tuning, which measures machinery characteristics and optimize parameters for it.

Advanced Tuning automatically performs the following series of characteristic measurements and parameter adjustments in (1) to (4).

(1) Adjust feedback control parameters using the conventional system analysis.
(2) Using friction and gravity measurement, estimate friction and gravity and then compensate.
(3) Using the high-precision system analysis, adjust feedback control parameters more precisely to ensure stability.
(4) In positioning operation, adjust model control parameters to improve responsiveness.

This optimizes adjustments and shortens startup time, improving ease of use.

3.5.3 Update of motor parameters

SETUP SOFTWARE is revised with a new servo motor parameter update function. Previously, it was necessary to update the firmware to run servo motor models that were newly added to the lineup.

With this new servo system, the servo motor parameters can be updated easily by the customer on site using SETUP SOFTWARE.

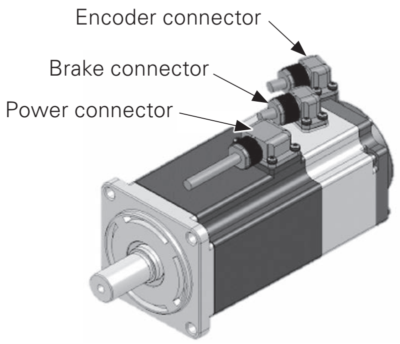
3.6 "Friendly" to customers

3.6.1 Makes replacement easy

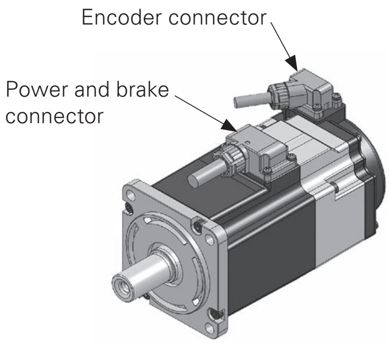
The servo motor has the same flange dimensions, mounting dimensions, and output shaft shape as the *SANMOTION R* for mounting compatibility. The motor power cable and holding brake cable on the current model were separate, but they have been integrated into a single cable as shown in Figure 10, reducing the number of parts.

The servo amplifier has the same external dimensions and mounting dimensions as the current model. Current functionality has been retained, and newly developed compensation and functions have been added.

By enhancing compatibility, *SANMOTION G* can be easily substituted into customers' existing equipment.



(a) SANMOTION R (Current product)

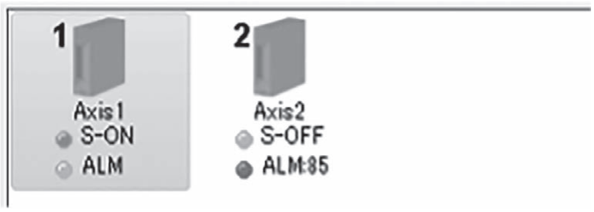


(b) SANMOTION G (New product)

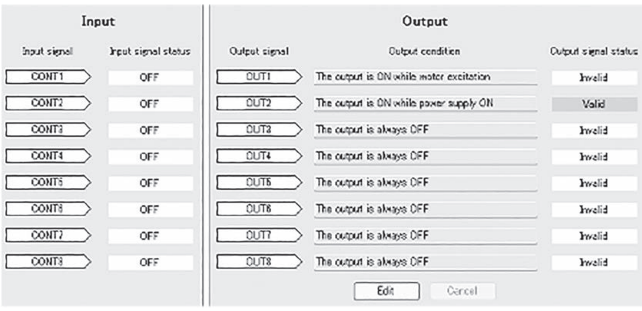
Fig. 10 Servo motor connectors

3.6.2 Increased visibility and usability

The same "SETUP SOFTWARE" interface is used, improving visibility and ease of use. As shown in Figure 11, the servo amplifier status and general-purpose input/output status can be intuitively grasped by displaying them visually on the screen.



(a) Servo amplifier status display



(b) GPIO status display

Fig. 11 Monitoring screens on SETUP SOFTWARE

4. Key Points of Development

To improve productivity and quality over the current model, it was necessary to construct a test environment in which designs which allowed products to be manufactured on automated lines and various tests could be performed automatically. This chapter introduces aspects of the development and creative ideas we incorporated into our development work.

4.1 Increased servo motor productivity and production quality

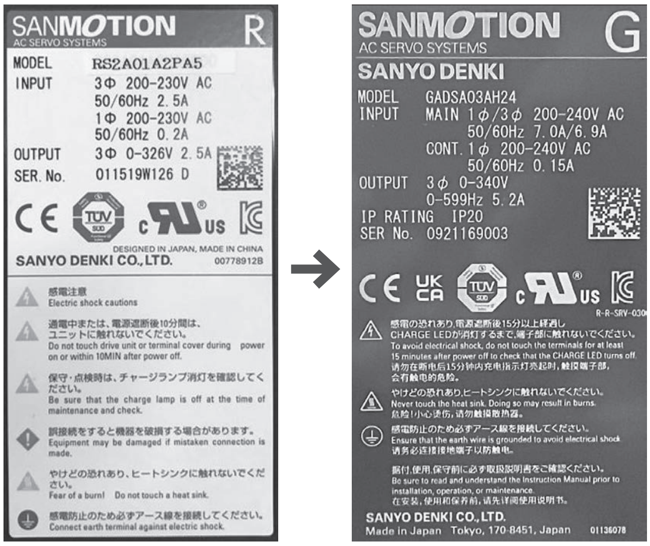
All servo motor models were constructed with an aluminum frame, and the structural skeleton was unified using a similar design. The basic construction is the same for all models, making it possible to switch between production models quickly. Moreover, assembly of the stator and rotor, key motor components, was automated for each process for improved productivity.

New automatic equipment used to produce the rotating disk module is adopted for the encoder. The rotating disk centering and bonding processes that were previously carried out manually are now carried out using a camera and robot, and this has greatly improved productivity.

4.2 Increased servo amplifier productivity and production quality

4.2.1 Increased productivity

As shown in Figure 12, the main servo amplifier nameplate has been changed from the label for the current model, which involved attaching a printed seal, to a nameplate that is printed directly onto the amplifier body with a laser marker, eliminating the need for manual label attachment work.



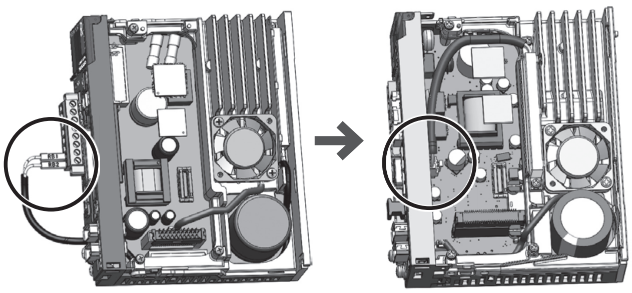
(a) SANMOTION R
(Current product)

(b) SANMOTION G
(New product)

Fig. 12 Text printed label (left) and laser-printed text (right)

As shown in Figure 13, the wiring for the built-in regenerative resistor in the current model is connected to the connector on the front after assembly is complete, and the work was complex. On the new product, the connector is connected to a board inside the servo amplifier.

Wiring no longer becomes trapped, making work easier.



(a) SANMOTION R
RS3A02 (current product)

(b) SANMOTION G
GADSA02 (new product)

Fig. 13 Built-in regenerative resistor wiring

Firmware is written automatically when assembling by the automated line robot. The weight of the write jig is greater than the withstand load of the robot hand, and so the jig has been installed on the robot unit. A 3 m cable is required to connect the write jig to the tip of the robot arm, but the cable from the manufacturer is only 0.2 m long, and so cannot be used.

In response to this, we produced a communication jig capable of transmitting high-speed signals corresponding to automatic writing using the robot over long distances as shown in Figure 14.

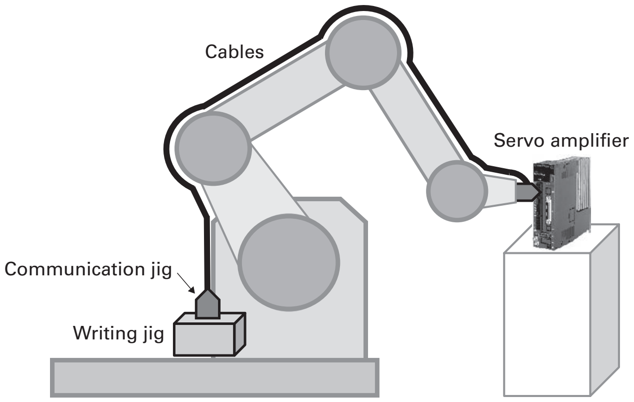


Fig. 14 Automatic writing using robot

4.2.2 Increased software quality

Servo systems are used in a variety of applications. Conditions and environments tend to be complex, and it is difficult to carry out exhaustive testing manually.

To carry out effective and efficient testing for this development, we constructed a test simulator capable of simulating the actual operating environment. We created a template for the test pattern, and developed a tool used to run tests by automatically generating patterns based on condition settings. For the test simulator, we created vertical and horizontal units, as well as a rotary unit. By anticipating the customer's actual equipment, we were able to carry out various tests by using a proximity sensor, holding brake, loading device, speed reducer, and external encoder.

This helped us to discover potential defects at an early stage, ensuring stable quality in a short space of time.

5. Conclusion

This article provided a product overview, and introduced the features and development points of the *SANMOTION G* AC servo system developed based on the concepts of "powerful" and "friendly."

In comparison with the current model, the *SANMOTION G* offers the following enhancements.

(1) Peak torque density improved by up to 28%, and the output range in the high-speed area expanded 1.15 times. By increasing the encoder resolution by 16 times (max. 27 bit) and the speed loop frequency response by 1.6 times (3.5 kHz), we were able to realize stable, highly-responsive operation.

(2) We improved vibration resistance by 2 times for the servo motor, and 1.2 times for the servo amplifier. We increased the altitude at which the product can be used from 1,000 m to 2,000 m, and expanded the operating temperature range. Improving the environmental durability allows the product to be used in a variety of regions, even in harsh environments.

(3) We equipped the new product with functions such as holding brake and electronic component life prediction, and input power supply and communication quality monitoring to help with servo system preventive maintenance, and equipment environment monitoring and diagnosis. These functions have led to improved machinery maintainability.

(4) We made the system smaller and lighter by reducing the servo motor length by up to 22%, and reducing the weight by up to 26%. We realized energy savings by reducing servo motor energy loss by up to 8%, holding brake power consumption by up to 44%, and servo amplifier energy loss by up to 22%.

(5) We were able to shorten equipment startup time with an Advanced Tuning function used to measure machine characteristics with high accuracy, and automatically adjust servo parameters to their optimum values.

(6) The motor power and holding brake cables have been integrated. The cable connector direction can also be changed, increasing the degree of wire freedom to make wiring work easier.

(7) The new product has exterior size and mounting interchangeability with the current model, and functionality has been retained, allowing the current model to be easily substituted for the new product.

This *SANMOTION G* AC servo system features significantly evolved servo performance and higher reliability, and can be used at high power even in harsh environments for peace of mind. Energy savings, and size and weight reductions have been realized, making the new product both easier to use, and friendly to both the global environment and to users.

In the future, we intend to expand the series lineup, and develop optimally customized products tailored to customer applications through development with deep customer involvement.

Note 1: Current servo motors refer to SANMOTION R motors.
Note 2: Current servo amplifiers refer to SANMOTION R 3E Model amplifiers.
Note 3: EtherCAT® is a registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany.

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