Development of the AC Servo Amplifier "SANMOTION R" Series ADVANCED MODEL TypeS

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1. Introduction

The AC servo amplifier "SANMOTION R" released in 2005 underwent an improved ease of installation and increased productivity, due in large part to the addition of higher performance auto-tuning and vibration controls. However, demand for resources and tight competition have strengthened the need to conserve resources and boost productivity. This document introduces the AC servo amplifier "SANMOTION R" Series ADVANCED MODEL, designed in response to these conditions.

2. Product Overview

The AC servo amplifier "SANMOTION R" Series ADVANCED MODEL is a single axis, self-powered amplifier available in 3 models, from 15 A to 50A. Applicable motors include "SANMOTION R" Series, "SANMOTION Q" Series motors, and "SANMOTION P" Series rotary motors, as well as linear and direct drive motors. Applicable encoders include serial communication type (absolute/incremental, resolver/optical) and A, B, Z pulse encoders, meaning the device has a wide range of applicability with both motors and encoders. Command input can be either pulse-chain input or analog voltage input, as well as serial communication.

To reduce the amount of resources consumed, the servo amplifier uses small chips, a narrow-pitch QFP-type ASIC, and a BGA-type CPU. Additionally, by optimizing cooling and reducing the number of parts, as well as by shrinking the power circuit through the use of bootstrap-switching power, the new device is 15% smaller than conventional products. It should also be noted that the next-generation IPM reduces energy consumption by as much as 19%.

Connectors emphasize usability, so connectors are compatible with the conventional connectors used to connect to the master controller. Additionally, there are 2 serial connectors and 2 built-in encoder connectors, as well as a hardware gate-off connector and a monitor connector. The encoder cable enables connection to the encoder battery in case it needs to be mounted.

Fig. 1 shows the 15 A, 30 A and 50 A models of this product. Table 1 shows the servo amplifier specifications.

Fig. 1: AC servo amplifier "SANMOTION R" Series ADVANCED MODEL 15 A, 30 A and 50 A models

Table 1: AC servo amplifier "SANMOTION R" Series ADVANCED MODEL specifications

Power voltage	AC 200 V (15 A and 30 A models can also use AC 100 V)
Amplifier output	15 A, 30 A, 50 A
Applicable motor capacity	30 W to 1.5 kW (R, Q, P Series)
Applicable encoders	2048 to 1,048,576 P/R (Serial) 500 to 65535 x 4 P/R (A, B, Z pulse)
Control functions	Position, speed, torque control, model following control, full close control
Control method	Sine wave PWM control
Position command	Pulse train (5 MPPS,1.25 MPPS)
Speed/torque command	Analog voltage
Speed control range	1:5000 (internal command)
Frequency characteristic	1200 Hz (high speed sampling)
Sequence signal	Input 8 ch., output 8 ch.
Communication features	RS-232C/RS-422A
Operating ambient temperature	0 to 55 ˚C
Structure	Tray type
Standards and compliance	UL, CE, and RoHS directive

3. Product Features

3.1 High output torque control

The torque control system optimizes the distribution of the dq axis current according to torque command and minimizes the current to the motor when there is no load, while continuing to efficiently drive the motor with magnetomotive force phase difference angle control used in conventional systems. The dq axis current control system provides the best controls to AC servo motor current up through high frequencies according to the dq axis current command. The AC servo amplifier "SANMOTION R" Series ADVANCED MODEL uses an improved dq axis current control and optimizes excitation current control when the induced voltage on the motor is high to achieve higher torque at fast rotation speeds. Fig. 2 shows an example of torque versus rotation speed characteristics. Torque is increased by 15% at the highest rotation speed. This will reduce the time of acceleration or deceleration if the motor rotation is speeding up or slowing down.

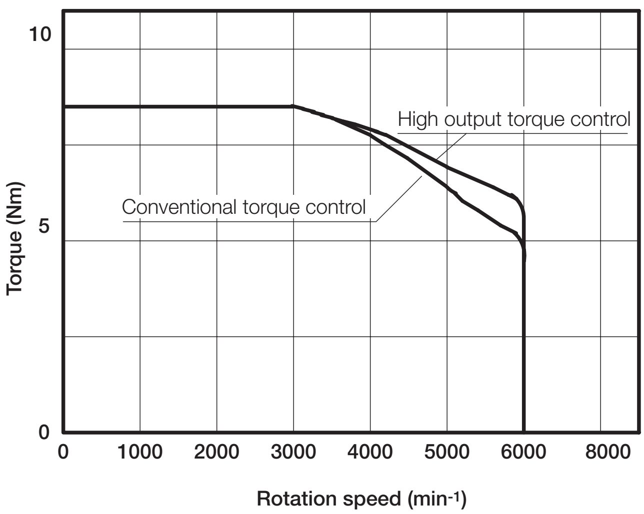

Fig. 2: Torque vs. rotation speed characteristics

3.2 High response position and velocity control

The basic position and velocity control system adds high following control and a disturbance observer to velocity proportional-plus-integral control and position proportional control, and it is designed to be compatible with the AC servo amplifier "SANMOTION R". The AC servo amplifier "SANMOTION R" Series ADVANCED MODEL builds on this, adding improved responsiveness and synchronizing position and velocity controls with current control, thus reducing waste time to 1/6. Additionally, the standard encoder communication speed is 1.6 times faster than conventional products, and the sampling time for velocity control is also half of the conventional time. This reduction in processing time doubles the velocity-loop frequency response compared to conventional products. Fig. 3 shows the frequency response characteristics for velocity control.

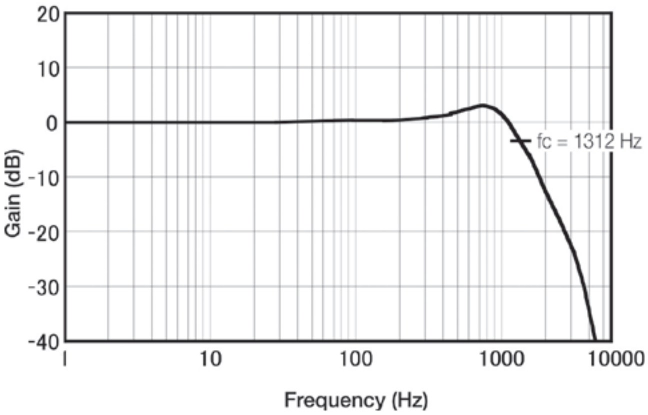

Fig 3: Frequency response curve

3.3 Model following control

The AC servo amplifier "SANMOTION R" Series ADVANCED MODEL uses model following control to improve responsiveness and robustness compared to the conventional product. Model following control makes up a model that includes a mechanical system and the model is used to perform feedback control. An ideal model is emulated, thus greatly improving operation properties. Additionally, the AC servo amplifier "SANMOTION R" Series ADVANCED MODEL adapts to the inertia of the model using inertial identification results grounded in statistical signal processing during auto tuning. This means that model following control is also more resistant to the effects of inertial fluctuations.

Furthermore, using model following control and a disturbance observer simultaneously achieves the high responsiveness from the model following control and the disturbance suppression of the disturbance observer. This satisfies responsiveness, disturbance suppression and robustness.

3.4 Model following damping control

In order to increase productivity, recent manufacturing devices tend to have rapid acceleration and deceleration. Taking chip mounters as an example, rapid acceleration and deceleration of devices causes vibrations and worsens positioning time. Fig. 4 shows an example of a device with moving parts on a basement. The

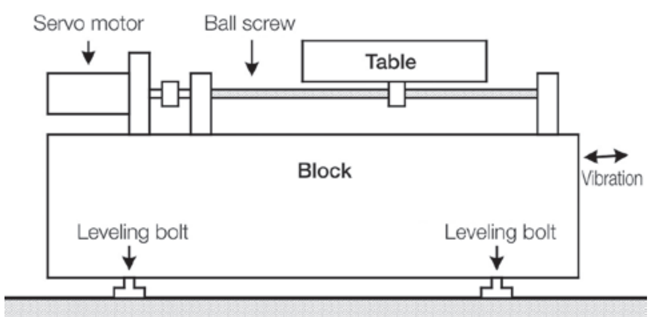

Fig. 4: Movable unit mounted atop a block

moving parts consist of a servo motor, ball screw, and table. When the motor performs rapid acceleration, the counteraction adds force to the basement. If the leveling bolts have low rigidity, the basement may start to vibrate.

The AC servo amplifier “SANMOTION R” Series ADVANCED MODEL uses model following damping control to prevent this.

Model following damping control makes up a model that includes a mechanical system with vibration. Compensation in the model control unit suppresses vibration, becoming the foundation of a vibrationless model. Thus, the model following control uses a model where vibration does not occur to perform feedback control. This results in a motor drive that suppresses vibration and responds to rapid changes in speed.

Additionally, it includes feed-forward damping control that was used in conventional products, allowing damping control to be used simultaneously. Thus, model following damping control suppresses vibration of the base and feed-forward damping control suppresses vibrations that lead to stiffness of the ball screw. Total vibration of the whole mechanical system is suppressed, and driving by rapid acceleration and deceleration becomes possible.

Fig. 5 shows the machine system displayed in Fig. 4 undergoing acceleration or deceleration, with the measurement of the relative positions of the table and the block. (a) shows no damping control. (b) shows feed-forward damping control only. (c) shows model following damping control and feed-forward damping control. Using model following damping control reduces table positioning setting time by 50% over using feed-forward damping control alone.

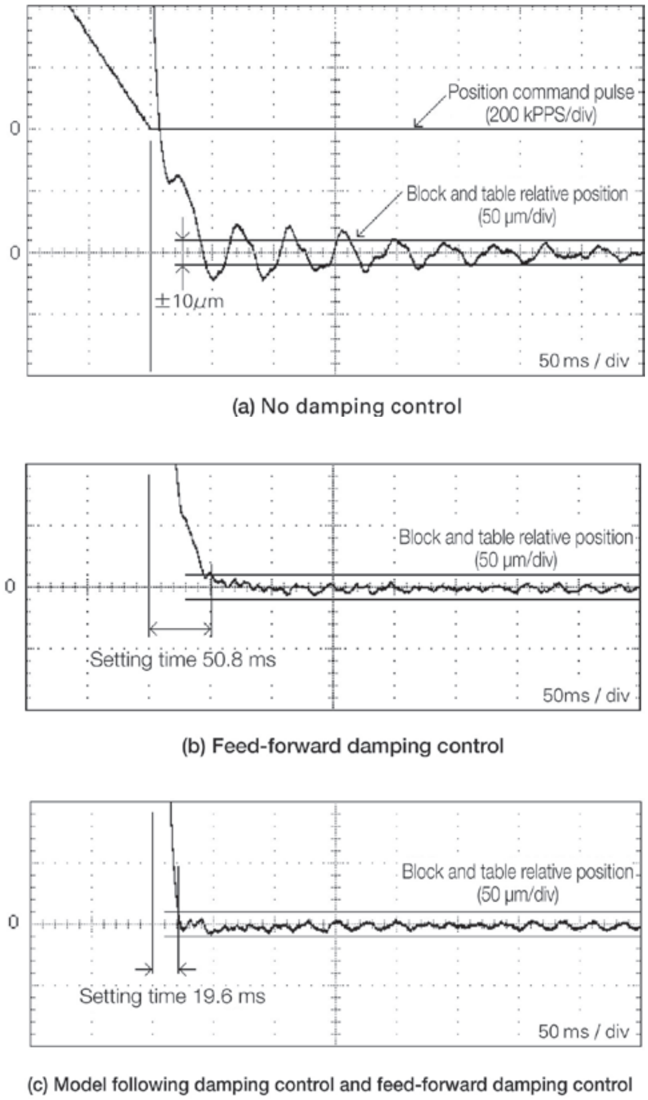

Fig. 5: Damping control characteristics

3.5 Setup software

The setup software has been redesigned to support multiple windows to improve usability. Each servo amplifier has 2 serial connectors to connect to the host computer or other servo amplifier, allowing up to 15 servo amplifiers to be daisychained at once. The setup software manages the servo amplifier configuration as a project.

The operating trace function can now display internal data in up to ten channels. There are also many other functions included to improve usability, such as a 16-trace data-overlay function, cursor vertical axis reading function, inter-cursor data reading function, internal trigger mode, and enlarged waveform save function. Additionally, a system analysis function is included. This uses an M-sequence signal to measure the frequency characteristics of the mechanical system so that the model following damping control parameters can be set easily. Fig. 6 shows the setup software operation screen.

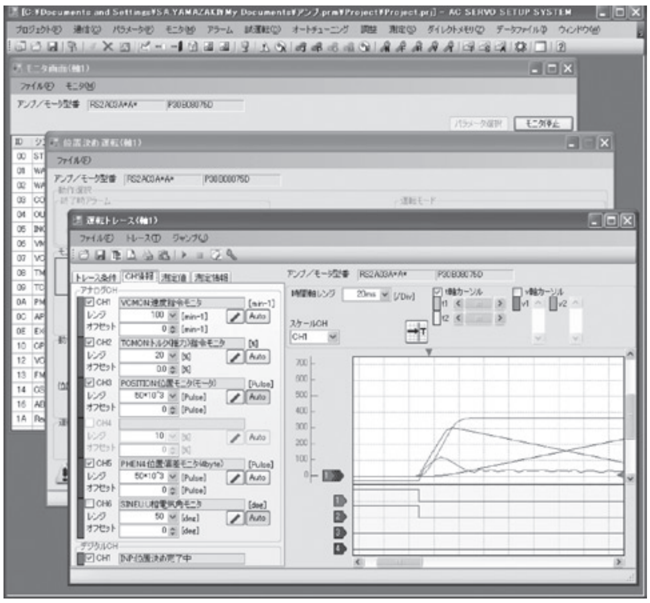

Fig. 6: Setup software operation screen

3.6 Hardware gate-off function

A hardware gate-off function has been installed in order to improve safety. This function stops operations by cutting off power to the moving parts (motor), allowing multiple gate turnoff for IPM via a specialized connector.

Table 2 shows the new functions of the AC servo amplifier "SANMOTION R" Series ADVANCED MODEL Type S.

Table 2: New functions for AC servo amplifier "SANMOTION R" Series ADVANCED MODEL

1	**High responsiveness**	- High output torque control - Position, velocity, current system simultaneous control - high speed sampling - Model following control
2	**High accuracy**	- Position command movement average filter - High segmentation compliant electronic gear - High resolution position signal output (pulse frequency division) - Forward rotation, reverse rotation independent internal torque control function
3	**Damping control**	- Model following damping control (compatible with feed-forward damping control)
4	**Auto tuning**	- Model following auto tuning - Feed-forward gain manual setting function during auto tuning
5	**Improved usability**	- Daisy chain connector - Serial communication function - Motor auto-identification function
6	**Setup software**	- Multiple window function - Daisy chain connection function for up to 15 units - Project management function
		[Operating trace] - 10 channel operating trace function - Trace data overlay function - Cursor vertical axis reading function - Inter-cursor data reading function - Effective value calculation function - Internal trigger function - Enlarged waveform save function
		[System analysis] - Parameter setting function for model following damping controls
7	**Safety**	- Hardware gate off function
8	**Maintainability**	- Alarm status display function - Alarm history timestamp function

4. Conclusion

This document has provided an overview of the AC servo amplifier "SANMOTION R" series ADVANCED MODEL. Using this servo amplifier provides the following effects.

(1) Allowing a reduction in the size of the cabinet that contains the servo amplifier, reducing energy and resource consumption for the device.

(2) Using serial communication between servo amplifiers allows a daisy chain of direct connections, making wiring simple because there is no need for an interchange circuit.

(3) High output torque control reduces the acceleration and deceleration time at fast rotation speeds, while high responsiveness, model following control, and model following damping control greatly reduce positioning time, together greatly increasing device throughput.

(4) Model following damping control and feed-forward damping control combine to reduce device vibration and therefore reduce the mechanical noise.

(5) Improvements in position processing resolution and the position command movement average filter result in improved resolution for positioning. Additionally, this will improve processing accuracy of devices such as processing machines.

(6) Improved operating trace functions result in oscilloscope-like operability allowing measurement of motor operation characteristics and helping the properties of the machine to be understood.

(7) The addition of multiple window functionality to the setup software allows parameters to be set while observing measurment data, making mechanical tuning more efficient.

(8) The setup software can manage up to 15 amplifiers. With two serial connectors attached to each amplifier, the amplifiers no longer need to be rewired when loading parameters, thus greatly reducing system startup time.

(9) The hardware gate off function improves safety.

(10) The alarm status display and the alarm history timestamp function allow better identification of alarm causes, improving maintainability.

As stated above, the AC servo amplifier "SANMOTION R" Series ADVANCED MODEL includes a variety of functions to support resource conservation and increased productivity. Operability and maintainability are also greatly improved by using this amplifier. Additionally, the design is compatible with various types of motors and encoders, allowing expansion into a large number of fields. The AC servo amplifier "SANMOTION R" Series ADVANCED MODEL, when applied to a chip mounter such as a PTP high speed positioning application, will lead to significant improvements over conventional products.

The next step is evolved devices compatible with all types of networks and all types of power supply specifications. Our goal is to advance servo technology for even greater availability, productivity, and quality.


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