Multi-axis AC Servo Amplifier with EtherCAT Interface "SANMOTION R ADVANCED MODEL"

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1. Introduction

In recent years, servo systems are being used in an increasingly wider range of equipment, and many of these are multi-axis systems which control multiple motors.

In the past, there were many cases of configuring systems using as many single-axis servo amplifiers as there were motor axes. However, the demand for open frame and configuration matching the specific system is increasing from the perspective of cost reduction. Moreover, there is a growing demand for flexible multi-axis systems to achieve equipment differentiation.

In 2009, Sanyo Denki released EtherCAT interface product ahead of the industry as a "SANMOTION R ADVANCED MODEL" , single-axis type. Currently, the amount of equipment featuring EtherCAT interface is rapidly increasing. This time, we have developed a multi-axis AC servo amplifier for injection molding machines, conveyance equipment and so on optimal, which can provide user advantages of system overall.

This paper provides an overview of the Multi-axis AC Servo Amplifier with EtherCAT Interface product and introduces its features.

2. Background of the Development

Sanyo Denki has developed multi-axis products up until now, however recent market needs made us realize the necessity of product development which gives more advantages from the aspect of the performance, functionality ,cost, etc and is able to contribute to improving user market competitiveness. The performances being demanded include high speed control cycles, high speed communication cycles, improved response and accurate synchronization. We believed a multi-axis system with the latest network performance added to our most recent servo amplifier platform was required to meet these demands. As a solution to such a situation, we developed this product based on the following concept of [The 3 'Fs'].

(1) **F**AST
Improved user market competitiveness through high speed control and communication.

(2) **F**LEXIBILITY
Improved freedom of servo configuration and maintainability through the motor, encoder and servo amplifier.

(3) **F**USION
Cost-performance advantages through fusion with user systems.

3. Product Overview

3.1 Appearance

Figures 1, 2 and 3 show the control unit, power unit and amplifier unit.

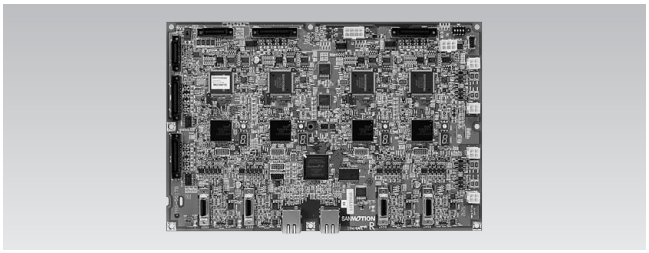


Fig. 1: Control unit

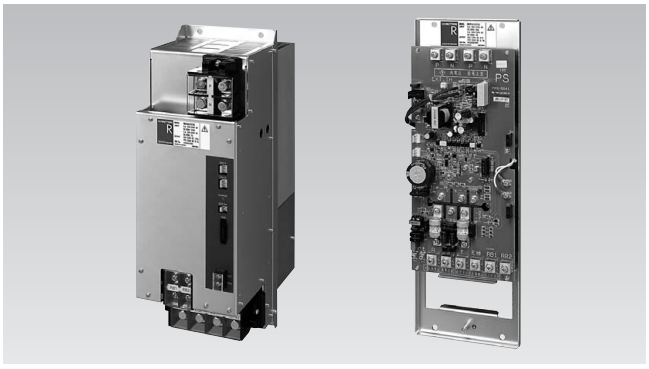


Fig. 2: Power unit

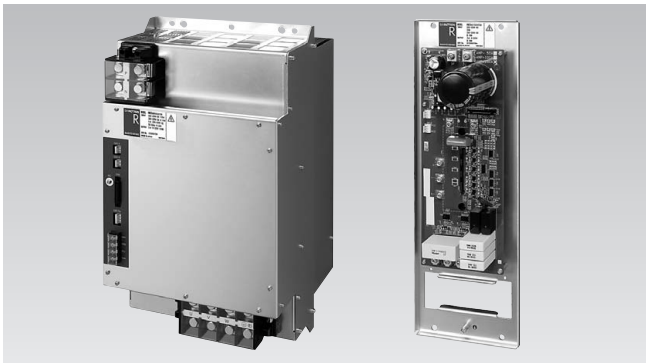


Fig. 3: Amplifier unit

3.2 Specifications

The new model inherits the assets of the single-axis “SANMOTION R ADVANCED MODEL” with EtherCAT interface model (hereinafter “single-axis RS2 EtherCAT model), and achieves a faster communication cycle and improved functions and deploys as a multi-axis system.

The line-up comprises of 1 control unit model (4-axes integrated), 4 power unit models (7.8 kW, 16 kW, 27 kW, 37 kW) and 6 amplifier unit models (50 A, 100 A, 150 A, 300 A, 600 A, 900 A). Tables 1 to 3 show general product specifications for each unit.

The applicable motors are mainly "SANMOTION R", and a part of the "SANMOTION Q" and "SANMOTION P" series.

The applicable encoders are the absolute encoder and incremental encoder, and for the former, the asynchronous type that apply standardly at the single-axis RS2 EtherCAT model, and the Manchester coding type are allowable. The encoder configuration can support both resolver battery-free type and optic battery backup type. And for multi-turn processing method, absolute system or incremental system are supported. Furthermore, while conventionally it was necessary to change hardware for the different encoder each, the new model has greatly improved flexibility as it is only necessary to change the pin assignment of the cables for the different encoder each to connect the same hardware.

Table 1: Control unit specifications

No. of controlled axes	Up to 4 (EtherCAT Interface)
Device profile	CAN application protocol over EtherCAT (CoE)
Dimensions	W285 mm x H190 mm x D15 mm

Table 2 Power unit specifications

Input power	Control circuit: 200 - 230 V AC +10%, -15% 50/60 Hz ±3 Hz (single-phase)			
	Main circuit: 200 - 230 V AC +10%, -15% 50/60 Hz ±3 Hz (three-phase)			
Input power capacity	13 kVA	27 kVA	46 kVA	64 kVA
Rated output capacity	7.8 kW	16 kW	27 kW	37 kW
Applicable amplifier unit capacity	50 A - 300 A	50 A - 300 A	600 A	900 A
Shape	Open frame	Open frame	Enclosure	Enclosure
Dimensions	W154 x H460 x D129 mm	W154 x H460 x D125 mm	W150 x H460 x D294 mm	W200 x H460 x D305 mm

Table 3: Amplifier unit specifications

Input power	Control circuit 240 to 358 V DC Main circuit 240 to 358 V DC		
Applicable encoders	Optical incremental / absolute		
Amplifier capacity	50 A	100 A	150 A
Applicable motor capacity	1.0 kW to 1.5 kW	1.8 kW to 3.5 kW	4.5 kW to 7 kW
Shape	Open frame	Open frame	Open frame
Dimensions	W154 x H460 x D171 mm	W154 x H460 x D169 mm	W154 x H460 x D169 mm
Amplifier capacity	300 A	600 A	900 A
Applicable motor capacity	7.5 kW to 15 kW	18 kW to 30 kW	37 kW to 45 kW
Shape	Open frame	Enclosure	Enclosure
Dimensions	W164 × H460 × D191 mm	W260 × H460 × D294 mm	W450 × H460 × D305 mm

3.3 Features and performance

Tables 4, 5 and 6 show the main performances, built-in functions and supported control modes, respectively.

The shortest communication cycle of the single-axis RS2 EtherCAT model was 500 μ sec, however the new model has achieved a 4 times of this speed, 125 μ sec. Moreover, by adding feedback synchronization control and power consumption monitoring, as well as implementing S-curve motion profile in speed control as a new control profile, we have realized a product superior to the single-axis RS2 EtherCAT model in both performance and function.

Table 4: Performance

Control cycle	125 μ sec
Communication speed	100 Mbps (EtherCAT)
Shortest communication cycle	125 μ sec
Transmission data volume	256 bytes (for all IN/OUT of 4 axes total)
Synchronization accuracy	1 μ sec or less
Control mode switching	Able to switch to the various control modes shown in Table 6.

Table 5: Built-in functions

High response	High output torque control, model following control
High accuracy	Friction compensation function, command synchronization/feedback synchronization
Vibration suppression control	Model following vibration suppression control (compatible with feed-forward vibration suppression control)
Safety	Hardware gate-off function
Maintainability	Status display at alarm occurrence, multiple alarm occurrence monitor, power consumption monitoring
Motion profile	Linear lamp profile, Jerk limited lamp profile, S-curve profile (position control/speed control)

Table 6: Supported control modes

Pp	Profile position mode
Pv	Profile velocity mode (2 types)
Tq	Profile torque mode
Hm	Homing mode
Csp	Cyclic sync position mode
Csv	Cyclic sync velocity mode
Cst	Cyclic sync torque mode

3.4 Exterior and structure

As Fig. 4 shows, the new product is a branched module configuration comprising of a control unit which governs 4-axes EtherCAT communication and servo control, an amplifier unit which switches power devices using PWM control and a power unit which supplies power to each amplifier unit.

Moreover, an open frame style is adopted assuming that power units below 16 kW and amplifier units below 300 A will be built into the control panel, making it possible to increase user system cost advantage and compatibility.

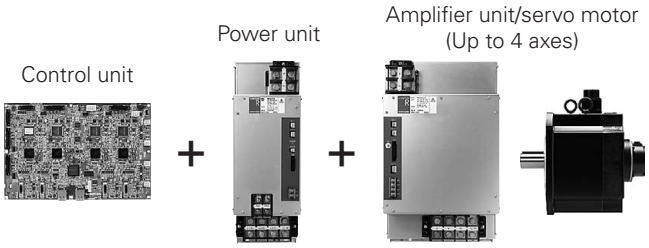


Fig. 4: Unit configuration conceptual diagram

4. Features

The features of the new product developed under the concept of “FAST” , “FLEXIBILITY” and “FUSION” are shown below.

4.1 High-speed field bus with EtherCAT interface

EtherCAT is a field bus capable of high-speed (100 Mbps) and highly-reliable communication. On the single-axis RS2 EtherCAT model, EtherCAT communication was achieved by using ASIC for EtherCAT slaves (Note 1), however in the case of the new model, 4-axes communication FPGA (Note 2) was newly developed with the configuration shown in Fig. 5 as Sanyo Denki’s original design.

Note 1: ASIC: Application Specific Integrated Circuit
An integrated circuit combining circuits with complex functions into one.
Note 2: FPGA: Field Programmable Gate Array
A programmable integrated circuit.

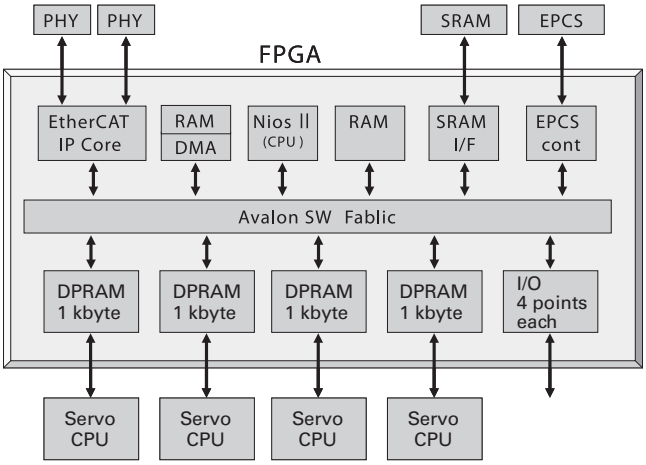


Fig. 5: FPGA configuration for 4-axes communication

By distributing software processing load appropriately between the CPU deployed within the FPGA and the CPU for servo control, high speed communication with a shortest communication cycle of 125 μ sec was achieved.

4.2 Space-saving, flexible system configuration

The new model is a unit-type multi-axis servo amp able to control up to 4 axes, and as shown in Fig. 4, it is possible to select the control unit, power unit and amplifier unit suitable for the capacity of the motor being used. This allows for a flexible arrangement suiting the equipment and saving space.

4.3 Energy saving

Regenerative power can be used as power for other motors, therefore the equipment can be expected to contribute to energy saving efforts.

Moreover, as a support function to monitor the servo system's power consumption by a higher-level device, a power consumption monitoring function is implemented to notify the amount of power being used by the servo motor.

Fig. 6 shows an image of monitored power consumption output if the motor output is constant at 30 kW. A higher-level device can use this monitored value to calculate the power consumption per unit of time for each servo motor.

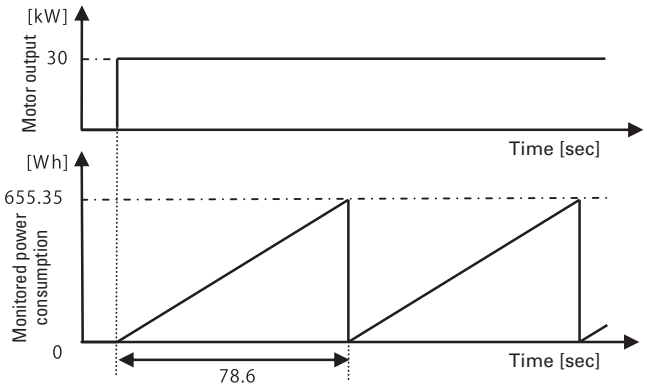


Fig. 6: Image of monitored power consumption output

4.4 Enhancement of synchronization function through feedback synchronization

EtherCAT uses the accurate "Distributed Clocks" method to synchronize all slaves at a jitter of 1 μ s or less against the synchronization timing of the 1st node servo amplifier. In addition to this, the new model also enables feedback synchronization control which reduces the position error between axes, as shown in Fig. 7.

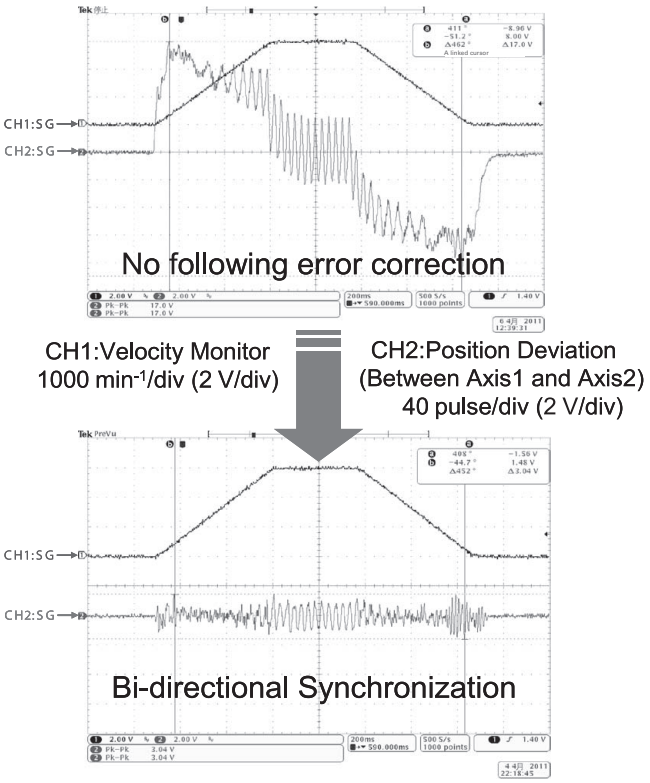


Fig. 7: Feedback synchronization benefits

4.5 Enhancement of motion profile

The single-axis RS2 EtherCAT model was only able to support a linear lamp (trapezoidal) motion profile, however the new model also supports the jerk limited lamp and S-curve motion profiles of position control added to the "SANMOTION R ADVANCED MODEL" with PROFINET interface model. Moreover, an S-curve motion profile was added as a new profile within velocity control. Fig. 8 shows sample operating pattern of the added profile speed mode.

By adding this profile, velocity control choice increased and higher-level device load is reduced and use in a diversity of applications becomes possible.

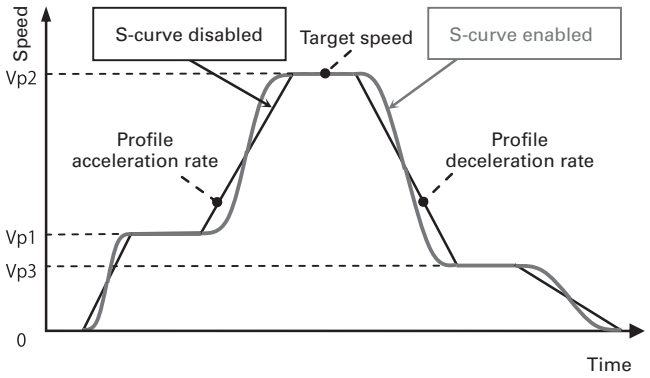
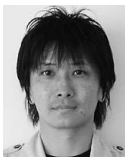


Fig. 8: S-curve motion profile in velocity control

5. Conclusion

This paper provided an overview of the Multi-axis AC Servo Amplifier with EtherCAT Interface specifications and introduced its features. As well as achieving functions and performance exceeding that of the single-axis RS2 EtherCAT model, a multi-axis system creating advantages for user equipment overall was realized. This product is believed to be highly competitive even compared with Sanyo Denki’s conventional multi-axis products and those of other Japanese and overseas manufacturers.

No doubt in the future there will be a need for servo amplifiers with customized capacity and number of axes to better match system configuration as multi-axis systems. Sanyo Denki wishes to propose systems even more user-friendly which can create even more advantages for users in the future.



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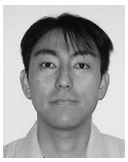

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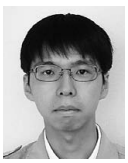

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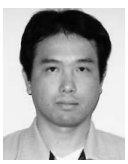

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