

Development of the *SANMOTION R 3E Model* EtherCAT Servo Amplifier

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1. Introduction

In recent years, industries such as semiconductor manufacturing equipment, machine tools, industrial robots, and general industrial machinery have seen a rapid adoption of Ethernet for industrial applications and its market share is expanding. Propelled along by factors such as Industry 4.0 and the shift towards IoT, industrial Ethernet is predicted to expand on a global scale.

In 2009, SANYO DENKI released the EtherCAT-equipped *SANMOTION R ADVANCED MODEL AC* servo amplifier which is currently being used by a variety of customers. In 2014, we released the new series *SANMOTION R 3E Model AC* servo amplifier with improved usability and evolved performance. In 2017, we developed *SANMOTION R 3E Model* as an EtherCAT servo amplifier with further improved usability and scalability.

This article briefly introduces the performance and functions of this newly developed EtherCAT servo amplifier added to the *SANMOTION R 3E Model* series.

2. Product Overview

2.1 The new model and our product lineup

Figure 1 shows the history of SANYO DENKI's EtherCAT servo amplifier to date. Since developing the *SANMOTION R ADVANCED MODEL* EtherCAT servo amplifier in 2009, we have expanded the lineup and improved performance by releasing a high-speed communication type in 2012 that has a minimum communication cycle of 125 μ s, and a low-voltage input

multi-axis type in 2014. The new model has improved its basic performance for communication and servo control as a product of the *SANMOTION R 3E Model* series.

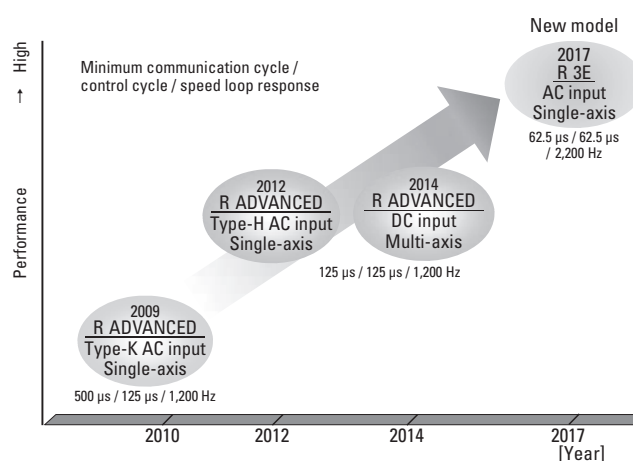


Fig. 1: History of the EtherCAT servo amplifier and positioning of the new model

2.2 Appearance and dimensions

Figure 2 shows an external view of the 200 VAC, 10 A models as typical examples. The standard model is shown on the left, and the safety function-equipped model (Safety) is shown on the right. Figure 3 gives a dimensional drawing of the 200 VAC, 10 A standard model as a typical example. All the new amplifiers have the same dimensions as the *SANMOTION R 3E Model* analog/pulse input amplifiers corresponding in terms of the input power and amplifier capacity.



Fig. 2: Appearance of the new model (200 VAC/10 A)

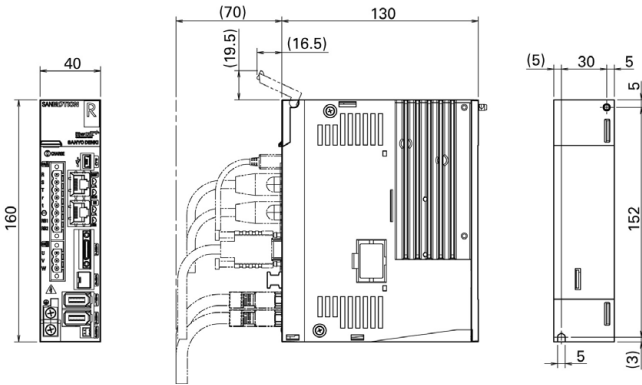


Fig. 3: Dimensions (200 VAC, 10 A model)

2.3 Main specifications

Table 1 shows the main specifications of the newly developed *SANMOTION R 3E Model* EtherCAT servo amplifiers.

Regarding input power and amplifier capacity, the new models added to the lineup include nine 200 VAC models, three 100 VAC models, and three 400 VAC models with amplifier capacity variations.

These amplifiers can drive various servo motors: the *SANMOTION R* series rotary servo motors, linear motors, and direct drive motors.

These are compatible with our battery-less and battery-backup absolute encoders and wire-saving pulse encoders. Also, for use in linear systems or fully-closed loop control systems, encoders supporting EnDat2.2 (manufactured by HEIDENHAIN) can be combined.

Table 2 shows the functions and communication specifications. While basic EtherCAT functions remain compatible with existing products, the communication performance has been improved with the shortened minimum communication cycle and expanded amount of data transfer for data processing. Moreover, the new models are equipped with a scaling function enabling command input not only in the conventional encoder pulse unit but also in linear and rotational units. In addition, the new models have passed the latest conformance test, “EtherCAT Conformance Test Tool Version 2.0” which is the standard for interoperability of EtherCAT communication.

Table 1: Main specifications

Power supply voltage range	200 VAC	200 to 240 VAC
	100 VAC	100 to 120 VAC
	400 VAC	380 to 480 VAC
Amplifier output capacity	200 VAC	10, 20, 30, 50, 75, 100, 150, 300, 600 A
	100 VAC	10, 20, 30 A
	400 VAC	25, 50, 100 A
Compatible motor		SANMOTION R series motors
Compatible encoder		<ul style="list-style-type: none"> Absolute encoder (Battery backup, Battery-less) Wire-saving pulse encoder EnDat2.2 encoder*
Safety function	Amplifier	STO (Safe Torque Off)
	Safety module	STO, SS1, SS2, SLS, SOS, SSM, SBC
Function	Control function	<ul style="list-style-type: none"> Dual position feedback control Tandem operation control
	Mechanical vibration/resonance suppression	<ul style="list-style-type: none"> FF vibration control (2 levels) Vibration control for track control Adaptive notch filter
	Servo tuning	<ul style="list-style-type: none"> Auto tuning response 40 levels Servo tuning support function
	Start-up, monitoring, diagnosis	<ul style="list-style-type: none"> Virtual motor operation Encoder/amplifier temperature monitoring Power consumption monitoring Drive recorder
Safety standards	UL/cUL	UL 61800-5-1
	Low-voltage directive	EN 61800-5-1
	EMC directive	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

* Not compatible with the safety function-equipped model (Safety)

Table 2: Communication specifications and functions

Interface	EtherCAT	
Device profile	CoE: CANopen over EtherCAT	
	FoE: Fileaccess over EtherCAT	
Synchronization mode	DC sync (Sync0, Sync1)	
	SM2 event synchronization	
Communication cycle	Minimum communication cycle: Position control: 125 μ s Velocity/torque control: 62.5 μ s (1/2 of current model but with PDO mapping limitations)	
Communication parameter	SDO: Service Data Object	
	PDO: Process Data Object	
Amount of data transfer	Maximum mapping number Transmitting PDO: 31 objects Receiving PDO: 31 objects	
Authentication test version	Conformance test (CTT) Ver 2.0	
Operation mode	PP	Profile Position mode
	PV	Profile Velocity mode
	TQ	Torque Profile mode
	IP	Interpolated Position mode
	HM	Homing mode
	CSP	Cyclic Sync. Position mode
	CSV	Cyclic Sync. Velocity mode
	CST	Cyclic Sync. Torque mode
Function	FT	Touch Probe function
	Scaling function (Pulse, mm, degree)	

3. Performance and Main Functions

3.1 Servo performance and functions

The basic servo performance and functions are the same as the regular *SANMOTION R 3E Model* series amplifiers. The main features are as follows.

3.1.1 High-response position speed control

Feedback response can be improved with a function to improve the phase delay within position control and speed control systems, as well as a function to increase integral gain. Moreover, with both speed and torque feed-forward compensation, an improvement in command responsiveness can be expected as well.

3.1.2 Power consumption monitoring function

The new models feature a power consumption monitoring function which estimates the power consumption of the servo motor and amplifier based on the speed and current of

the motor. This makes it possible to easily monitor a device's power consumption.

3.1.3 Virtual motor operation function

As a user assist function aimed at enhancing usability, the new model is equipped with a virtual motor operation function which simulates operations of the servo motor and servo amplifier based on commands from a host device, without actually operating the motor. This function makes it possible to start up a device safely and swiftly.

3.1.4 Drive recorder function

To improve troubleshooting, the new model features a drive recorder function to record the operational data of the servo motor and amplifier for a set period of time. Such data recorded during fault occurrences includes motor rotational speed, torque, and main circuit DC line voltage. As a result, troubleshooting is made easy as fault cause can be identified and appropriate countermeasures can be performed swiftly. This helps to improve the reliability of the system.

3.2 EtherCAT-related functions

The new and current models share the same main communication functions and parameters, making it easier for customers to upgrade to a new model. The following functions were expanded to better leverage the advantages of EtherCAT communication.

3.2.1 Shortening minimum communication cycle

By leveraging the strengths of high-speed communication, we have maximized servo performance and enabled smooth motion, thus shortening minimum communication cycle from 125 μ s on the current models to 62.5 μ s on the new models. (During speed control and torque control mode)

3.2.2 Expanding the maximum amount of data transfer

As Figure 4 shows, the maximum amount of data transfer in one communication cycle has increased from 20 objects on current models to 31 objects on the new models, which is an increase of around 1.6 times. This has made it possible to monitor the customer's device data managed by the servo amplifier with greater speed and in more detail, thus contributing to the IoT trend by providing predictive maintenance diagnostics of the device and servo equipment.

■ R ADVANCED MODEL Type-H		■ R 3E Model	
Sub-Index	Data	Sub-Index	Data
0x00	20	0x00	31
0x01	PDO Object 1	0x01	PDO Object 1
0x02	PDO Object 2	0x02	PDO Object 2
0x03	PDO Object 3	0x03	PDO Object 3
0x04	PDO Object 4	0x04	PDO Object 4
0x05	PDO Object 5	0x05	PDO Object 5
0x06	PDO Object 6	0x06	PDO Object 6
0x07	PDO Object 7	0x07	PDO Object 7
0x08	PDO Object 8	0x08	PDO Object 8
0x09	PDO Object 9	0x09	PDO Object 9
0x0A	PDO Object 10	0x0A	PDO Object 10
0x0B	PDO Object 11	0x0B	PDO Object 11
0x0C	PDO Object 12	0x0C	PDO Object 12
0x0D	PDO Object 13	0x0D	PDO Object 13
0x0E	PDO Object 14	0x0E	PDO Object 14
0x0F	PDO Object 15	0x0F	PDO Object 15
0x10	PDO Object 16	0x10	PDO Object 16
0x11	PDO Object 17	0x11	PDO Object 17
0x12	PDO Object 18	0x12	PDO Object 18
0x13	PDO Object 19	0x13	PDO Object 19
0x14	PDO Object 20	0x14	PDO Object 20
		0x15	PDO Object 21
		0x16	PDO Object 22
		0x17	PDO Object 23
		0x18	PDO Object 24
		0x19	PDO Object 25
		0x1A	PDO Object 26
		0x1B	PDO Object 27
		0x1C	PDO Object 28
		0x1D	PDO Object 29
		0x1E	PDO Object 30
		0x1F	PDO Object 31

x 1.6

Fig. 4: Comparison of maximum PDO mapping number

3.2.3 Scaling function

The new models feature a scaling function enabling users to select the unit of measurement used for commands and feedback data to suit the particular piece of equipment. Figure 5 illustrates the concept of the scaling function. Conventionally, host controller would operate by first converting position commands to encoder pulse units. However, thanks to the scaling function, it is possible to give position commands for linear motion in mm and for rotational motion in degrees, thus alleviating the burden on the controller and improving convenience.

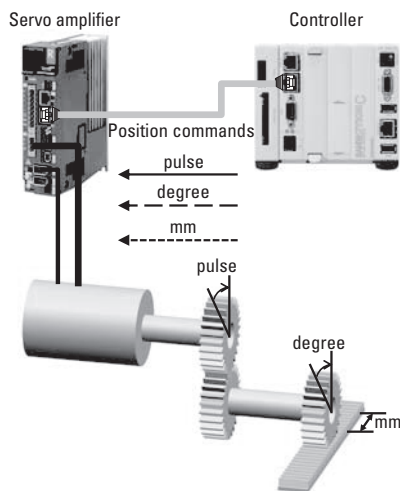


Fig. 5: Concept of scaling function

4. Conclusion

This article has presented an overview of the performance, functions, and features of the EtherCAT servo amplifier that has been newly added to the AC servo amplifier *SANMOTION R 3E Model* series lineup.

The new models add a high-speed network type to the high-performance, highly-functional *SANMOTION R 3E Model* series which pursues safety and usability. We believe it will greatly contribute to further improving the reliability and safety of our customers' devices and help shift towards IoT.

Moving forward, we plan to enhance functions to further promote the IoT transition. Moreover, SANYO DENKI intends to enhance our lineups for DC input, multi-axis specifications and other network products in order to propose products which better satisfy customer needs and contribute to our customers' value creation.



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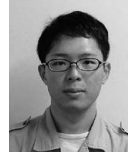
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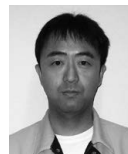
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