AC Servo Amplifier "SANMOTION R" Series ADVANCED MODEL with Built-in EtherCAT Interface

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1. Introduction

In the FA industry, there are many competing standards that were developed in order to improve the performance of the manufacturing line. Among these standards, EtherCAT is expected to spread as a next-generation high-speed motion network, not just in Europe, but also in Asia and North America. Therefore, we developed an AC servo amplifier with built-in EtherCAT interface.

This document introduces an overview of EtherCAT and an overview of the features of the AC servo amplifier with built-in EtherCAT.

2. About EtherCAT

EtherCAT stands for "Ethernet for Control Automation Technology". It was developed as a standard by the German company Beckhoff, and the development and growth is currently being promoted by ETG (EtherCAT Technology Group).

This standard was developed late as an industrial open network, but it has been praised for its high speed and flexibility, and an increasing number of device manufacturers have adopted it. EtherCAT has the following features.

(1) High-speed open network interface (Standard Ethernet system with an Ethernet physical layer and IEEE802.3 standard)

(2) Wide variety of data protocols (uses profile compliant with file transfer, CANopen, SERCOS)

(3) Freely settable transfer data length and mapping

(4) Broad band (the command and the status can be grouped or separated, and empty band can be used effectively in asynchronous transfer)

(5) Various sync functions (in addition to sync with the clock master-slave axis and sync with the reception frame, it also supports asynchronous)

(6) Development of master controller is easy relatively (I/F card with a built-in dedicated LSI not required)

In 2007, EtherCAT had been integrated into the international fieldbus standards IEC 61158 Type 12 elements as well as into the drive profile standard IEC 61800-7.

3. Background of the Development

At Sanyo Denki, we have created an AC servo amplifier product with built-in original serial communications and open network. The current product lineup could not meet the recent demands for faster communication period, increased real-time variable parameters, and more accurate sync due to limitations on the communication rate (max. 16 Mbps) and the transfer data length (max. 20 bytes). An urgent need to develop new production and find a new communication method began.

In order to meet these market needs, we adopted EtherCAT for its superior performance, which includes an Ethernet base, customizable mapping for real-time parameters, accurate sync, and broadband communications.

Table 1 shows a list of the major communication standards

Table 1: List of major communication standards adopted by our products

Product (LSI)	Communication standard	Physical layer	Baud rate	Data length
GA1022	Sanyo Denki original	RS422/485	2.5Mbps	6Byte
GA1045	Sanyo Denki original	RS422/485	4Mbps	10Byte
GA1060	Sanyo Denki original	RS422/485	10Mbps	20Byte
DeviceNet	DeviceNet	ISO11898	500kbps	8Byte
SERCOS	IEC61491	Optical	4Mbps	12Byte
SERCOS II	IEC61491	Optical	16Mbps	20Byte
CANopen	CiA 301	ISO11898	1Mbps	8Byte
EtherCAT	IEC61800-7	IEC61158	100Mbps	64byte

adopted by our products, while Fig. 1 shows the change in communication rates for these products.
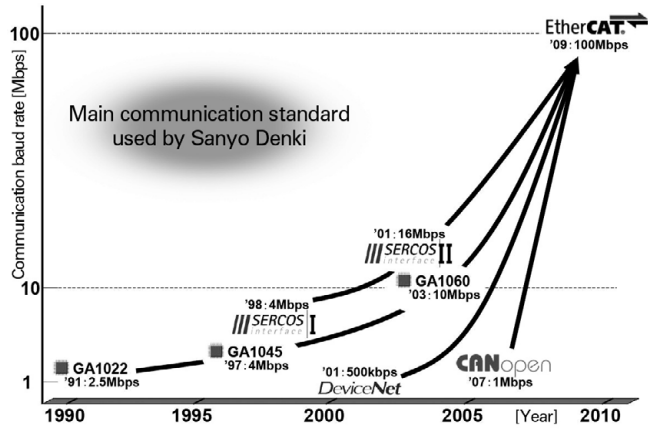

Fig. 1: Changes in communication rates

4. Product Overview

Fig. 2 shows a photograph of the developed model.

Fig. 2: External view of the servo amplifier with built-in EtherCAT interface

4.1 Specifications

The developed product is a model that inherited the properties of the "SANMOTION R" series ADVANCED MODEL, but replaced the analog/pulse interface with an EtherCAT interface. Applicable motors include "SANMOTION R" series, "SANMOTION Q" series motors, and "SANMOTION P" series rotary motors, as well as linear motors. Applicable encoders include start-stop synchronization serial encoders, and they can be operated with either absolute or incremental systems. Table 2 outlines specifications of the product.

Table 2: Specifications

Power voltage	200 VAC (15 A and 30 A models can also use 100 VAC)
Amplifier capacity	15 A, 30 A, 50 A
Applicable motor capacity	30 W to 1.5 kW (R Series)
Applicable encoders	2048 to 1048576 P/R (Serial) 500 to 65535 × 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
Frequency characteristic	Same as R ADVANCED MODEL Type S
Sequence signal	Input 2 ch., output 2 ch.
Built-in functions	Same as R ADVANCED MODEL Type S
I/O signal	EtherCAT interface specifications
Communication PC I/F	Same as R ADVANCED MODEL Type S
Operating ambient temperature	0 to 55°C
Structure	Tray type
Applicable standards	UL, CE, and RoHS directive

4.2 Functions and performance

The functions and performance are the same as the "SANMOTION R" series ADVANCED MODEL Type S. Also, in order to advance maintainability, the "R ADVANCED MODEL setup software" can be used. In addition, a safety function is included standard in order to improve the safety of the applicable machinery. Table 3 shows the main control functions.

Table 3: Built-in functions

High response	High-power torque control, model following control
High precision	Position command movement average filter, friction compensation function
Damping control	Model following damping control (compatible with feed-forward damping control)
Improved usability	Setup software (multiple windows, operation trace, system analysis, etc.), motor auto-identification function
Safety	Hardware gate-off function
Maintainability	Alarm state display, alarm history time stamp, multiple alarm monitor

4.3 Exterior and structure

The servo amplifier's control circuit and EtherCAT interface circuit are collected on a single board and all of the software processes can be handled by a single control

CPU, which helps the product achieve small size and low cost. Fig. 3 shows a comparison of the size for our servo amplifiers with built-in networks.
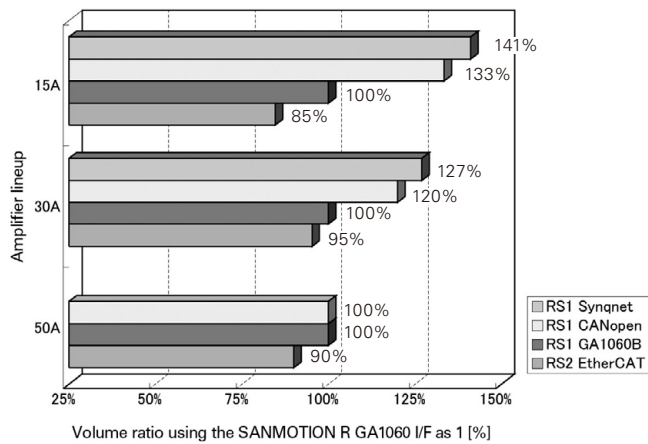

Fig. 3: Servo amplifier volume ratio

Furthermore, this product has the same size as the analog/pulse interface model, making the mounting compatible.

4.4 EtherCAT interface specifications
Table 4 shows EtherCAT interface specifications.

Table 4: EtherCAT interface specifications

Physical layer	IEC61158-2 IEEE802.3u (100BASE-TX)
Data link layer	IEC61158-3, -4 Type12
Application layer	IEC61158-5, -6 Type12
Device profile	IEC61800-7 Profile type 1 (CiA 402) • CoE (CANopen over EtherCAT) • FoE (File access over EtherCAT)
Communication port	RJ45 connector (2 ports)
Baud rate	2 × 100 Mbaud (full duplex)
Max. No. of nodes	65535 slaves
Transmission distance	Max. 100 m (between nodes)
Frame data	Max. 1484 bytes
Cable	Twisted-pair CAT5e (straight or cross)
Data processing	Processing on the fly

PDO Transmission mode	• Synchronous with
	  SYNC0 Event (DC Mode)
	• Synchronous with
	  SYNC1 Event (DC Mode)
	• Synchronous with SM2 Event
	• Asynchronous FreeRun Mode

Communication object	• SDO (Service Data Object) • PDO (Process Data Object)
PDO length	Output : Max.64Byte, Input : Max.64Byte (Total: Max. 128 Bytes)
LED indicator	Port 0/1 link display, RUN display, error display

This product complies with IEC61800-7 for power drive systems (PDS), while the device profile uses CoE (CANopen over EtherCAT), the same as CiA402.

The control mode has a positioning function (Profile Position Mode) and homing function (Homing Mode) in addition to the synchronous mode recommended by ETG so that it can easily replace a CANopen system. Furthermore, all of the control modes can be switched during motor excitation. Table 5 shows the applicable operation modes.

Table 5: Operation modes

Symbol	Operation mode
Pp	Profile Position Mode
Pv	Profile Velocity Mode
Tq	Torque Profile Mode
Hm	Homing Mode
Csp	Cycle Sync Position Mode
Csv	Cycle Sync Velocity Mode
Cst	Cycle Sync Torque Mode

5. Features
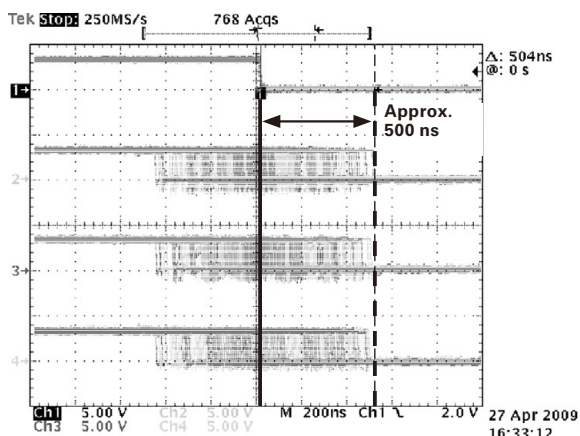
5.1 Expansion of homing mode
Until recently, there was no Z pulse output in the incremental system using a one rotation absolute sensor, so Homing Mode could not be performed. This product supports Homing Mode with "current position", "HOME switch", and "HOME switch and one rotation absolute data zero".
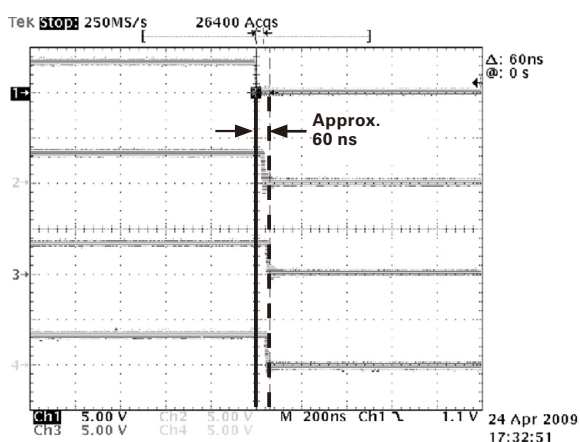
5.2 Touch probe function
Two channels of the Touch Probe Function were included to meet high user needs. With this function, we hope to strengthen sales for measurement instrument applications. Furthermore, one of these channels can perform probing on the current position by using the index pulse.

5.3 Improvement of sync accuracy
With the "Distributed Clocks" method, all of the slaves can be synchronized to the sync timing of the servo amplifier on the lead node with jitters of 1 μs or less. With this method, this product achieves a synchronization accuracy that is 1/8 or less compared to the conventional model (GA1060). Fig. 4 shows the sync signal jitter waveform for GA1060 and EtherCAT.

6. Conclusion

This document introduced an overview of the AC servo amplifier with built-in EtherCAT interface.

This product inherits the same functions and performance as the "SANMOTION R" series ADVANCED MODEL Type S while achieving the same size. Therefore, the forming die and molded plastic can be shared. Furthermore, by eliminating the dedicated CPU for communication processing to master controller, this model realizes the same cost performance as models with built-in GA1060 network. Therefore, we feel that we developed a very competitive product, whether it is compared to other network products developed by Sanyo Denki, or compared to competing products from within Japan or around the world.

In the future, we will expand on the EtherCAT interface into all types of power specifications, multiple axes, and stepping systems in order to support customer needs.

GA1060   sync signal (4 axis)

Jitters due to EtherCAT DC sync (4 axis)

Fig. 4: Jitter waveform for the sync signal

5.4 Online firmware overwrite

Until recently, firmware updates required a flash writer, dedicated writing tool, and the dedicated application software. EtherCAT comes with FoE (File access over EtherCAT) that transfers data in ASCII code. With this function, the firmware can be updated from the EtherCAT master device. This product can quickly support additional specification demands.

5.5 Built-in safety function

This product is compliant with a safety function. This function is defined by "IEC61800-5-2: Safe torque off" and "IEC60204-1: Stop category 0". Furthermore, this product has obtained certification in the safety standards "IEC61508/IEC62061, SILCL2" and "ISO13849-1:Cat3, PL=d". With this function, we hope to strengthen sales in Europe.

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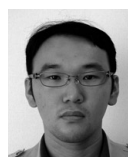Worked on the development and design of servo amplifiers.
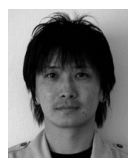
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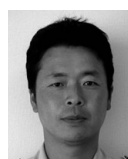
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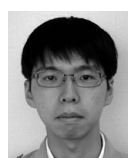Worked on the development and design of servo amplifiers.

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