FALDIC-W Series Servo Systems

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1. Introduction

The range of applications for servo systems has recently been expanding to include the field of general industrial machinery, such as conveyance machinery, printing machinery, textile machinery, injection molding machinery, and to the field of semiconductor manufacturing equipment, to achieve better mechanical performance and thereby improve productivity in these fields. In addition to the prior requirements for high performance and high precision, availability for severe operating environments and easy setup and maintenance are also required.

Responding to these marketplace requests, Fuji Electric has newly developed FALDIC-W series (hereafter referred to as "W series"), as a continuation of its FALDIC-α series and FALDIC-β series high-performance servo systems. W series servo system is equipped with vibration suppression control to improve performance and precision, and International Protection Code IP67 motor to support use in severe operating environments. Moreover, easy-tuning function and centralized parameter management function are provided to increase user's easy-of-use and to simplify setup and maintenance work.

Specifications and features of this new servo system are described below.

2. Basic Specifications

Figure 1 shows external appearance of W series.

W series consists of three model types: a low inertia model having 3,000 r/min rated speed, and two middle inertia models having 2,000 r/min and 1,500 r/min rated speeds. Basic specifications of these

Fig.1 Appearance of FALDIC-W series

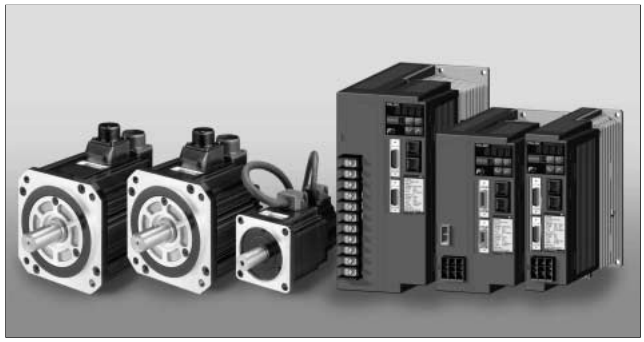


Table 1 Servomotor specifications

Item \ Model	GYS□□□DC2-T2△					GYG□□□CC2-T2△					GYG□□□BC2-T2△		
	500	101	201	401	751	501	751	102	152	202	501	851	132
Rated output (kW)	0.05	0.1	0.2	0.4	0.75	0.5	0.75	1.0	1.5	2.0	0.5	0.85	1.3
Rated torque (N·m)	0.159	0.318	0.637	1.27	2.39	2.39	3.58	4.77	7.16	9.55	3.18	5.41	8.28
Max. torque (N·m)	0.478	0.955	1.91	3.82	7.17	7.2	10.7	14.3	21.5	28.6	9.50	16.2	24.8
Rated speed (r/min)	3,000					2,000					1,500		
Max. speed (r/min)	5,000					3,000							
Moment of inertia $\times 10^{-4}$ (kg·m^2)	0.0192	0.0371	0.135	0.246	0.853	7.96	11.55	15.14	22.33	29.51	11.55	15.15	22.33
Rated current (A)	0.85	0.85	1.5	2.7	4.8	3.5	5.2	6.4	10.0	12.3	4.7	7.3	11.5
Max. current (A)	2.55	2.55	4.5	8.1	14.4	10.5	15.6	19.2	30.0	36.9	14.1	21.9	34.5
Altitude at location of installation	Indoor: 1,000 m or less												
Ambient temperature, humidity	–10 to +40°C, 90 % RH or less (no condensation)												
Resistance to vibration (m/s^2)	49					24.5							
Mass (kg)	0.45	0.55	1.2	1.8	3.4	5.3	6.4	7.5	9.8	12.0	6.4	7.5	9.8

Table 2 Servo amplifier specifications

Item \ Model			RYC□□□D3-VVT2					RYC□□□C3-VVT2					RYC□□□B3-VVT2		
			500	101	201	401	751	501	751	102	152	202	501	851	132
Applicable motor rated speed (r/min)			3,000					2,000					1,500		
Applicable motor output (kW)			0.05	0.1	0.2	0.4	0.75	0.5	0.75	1.0	1.5	2.0	0.5	0.85	1.3
Input	Main power	No. of phases	Single phase				Single phase, 3-phase	3-phase					Single phase, 3-phase	3-phase	
		Voltage	200 to 230 V AC −10 to +10 % (single phase)												
			200 to 230 V AC −15 to +10 % (3-phase)												
		Frequency	50/60 Hz												
	Control power	No. of phases	Single phase												
		Voltage	200 to 230 V AC −10 to +10 %												
		Frequency	50/60 Hz												
Output	Control method		IGBT PWM sine wave operation												
	Carrier frequency		10 kHz												
	Overload capability		300 % / 3 s												
	Control method		Regenerative braking applied to intermediate DC circuitry, regenerative resistor installed externally												
Feedback			Incremental 17-bit encoder (17-bit resolution per revolution)												
Control function	Control function		Position control, speed control, torque control												
	Max. frequency of input pulse string		1.0MHz (differential input), 200 kHz (open collector)												
	Frequency response		600 Hz (at $J_L = J_M$)												
	Position analysis function		2^{17} (= 131,072) / revolution												
Environment	Location of installation		To be installed indoors, an altitude of 1,000 m or less, at a location free from dust, corrosive gas or direct sunlight. To conform with European standards: pollution degree = 2, overvoltage category Ⅲ												
	Ambient temperature		−10 to +55°C												
	Ambient humidity		10 to 90 % RH (no condensation)												
	Resistance to vibration (m/s^2)		4.9												
	Resistance to impact (m/s^2)		19.6												
Applicable standards			Conforms to UL/cUL (UL508c), CE marking (low voltage directive EN50178)												
Mass (kg)			1.0					1.5			2.5		1.5		2.5

model types are presented below.

2.1 Servomotor specifications

Table 1 lists basic specifications of servomotor. W series consists of total 26 models, configured from 3 different types of rated speeds and output capacities, and either with or without a brake.

In order to support wide range of applications, motor (except for shaft area and connector area) in all models has dustproof and waterproof construction that conforms to International Protection Code IP67.

New middle inertia models, achieves 2.5 to 3.5 times inertia moment as same rated speed prior models. The result is improved suitability for applications involving machinery which have relatively large ratio of load inertia moment or have low rigidity, and thus broader range of applications is available for the servo system.

2.2 Servo amplifier specifications

Table 2 lists basic features of servo amplifier. W series is provided with a control function that allows switching among following three types of control: position control, speed control and torque control.

Since all wiring connectors are arranged on the front and bottom panels of the amplifier to enable side-by-side installation, it realizes 400 W in compact size of 45 mm (W) × 160 mm (H). Moreover, control power source is provided to backup sensor position in case main power is cut off during emergency, and thereby it eliminates return to origin action.

3. High Performance

3.1 Vibration suppression control

Shorter takt times are increasingly demanded in order to improve productivity. W series uses Fuji Electric's proprietary vibration suppression control function, inherited from FALDIC-β series, to achieve a takt time reduction. The vibration suppression control function can reduce vibrations of machinery having low rigidity, such as tip of robotic arm using multi-inertia machine model housed in the servo amplifier. In recent years, applicable range of vibration suppression

control is increasing due to demand of shorter takt times by suppressing mechanical vibration in applications such as LCD glass panel conveyor lines, for example.

Prior to using the vibration suppression control function, mechanical vibration frequency is set as a parameter. Up to four different frequencies can be set to support machinery in which vibration frequency changes due to operation or object being conveyed. Servo analysis function that analyzes specific vibrating frequencies of the machine is also provided to simplify user's task of setting the frequency. To simplify the user's operation, PC loader tool can be used to instruct the servo amplifier to perform automated analysis operation and then to display the analysis results on PC screen. The parameters may then be set directly from the display screen.

3.2 Improved response with model torque computation function

In response to requests for shorter takt time machine operation, W series is equipped with a model torque computation function. Model torque computation calculates amount of torque needed for particular command, thereby it increases tracking performance and reducing settling time for that command. As a result, W series is suitable for application such as die bonder, that is one of the semiconductor-manufacturing equipment in which high performance is required.

3.3 17-bit serial encoder

The motor of W series is equipped with a newly developed serial encoder to provide stable rotation at slow speeds. This encoder has a resolution of 17 bits (corresponding to 131,072 pulses), and sends data to the amplifier through high-speed serial interface. Reduction of rotational speed fluctuation realized smooth mechanical operation and high-speed response.

4. Simplified Setup

4.1 Centralized parameters management

When using a servo system, various parameters must be set in accordance with machinery characteristics. Setting of parameters is accomplished via serial communication interface, which previously has been implemented as point-to-point communication between upper-level controller and the servo system. When using multi-axis servo system for mass-produced machinery, manual setting becomes time consuming because communication cables must be changed for each servo system. Moreover, mistakes tend to occur, such as the incorrect parameter setting.

With W series, node numbers are used to identify a servo system for communication. W series is also equipped with two RS-485 interface ports to support multi-drop communication with multiple servo systems. Figure 2 shows a conceptual drawing of multi-drop connection. A maximum 31 servo systems can be connected to one upper-level controller, and communication with any servo system is possible by specifying the appropriate node number, without having to replace any communication cable. As a result, during system setup, setting of parameters can be carried out automatically from the upper-level controller, thereby it reduces required setup time and prevents setting mistake.

4.2 Pattern operation

When setting up the total system, even if a servo system is installed to a machine, the system will not operate unless upper-level controller such as programmable controller issues the appropriate command. Therefore, no operation will occur until the upper-level controller completes such preparatory tasks as verifying the load factor of the servo system in accordance with the operating pattern, and adjusting operation-related parameters.

W series is equipped with a pattern operation function that automatically performs reciprocal operations. Figure 3 shows a conceptual drawing of pattern operation. Pattern operation accepts the stroke and speed parameters according to a pattern to enable combination action with mechanical system by means of repeated reciprocal operation, even in cases where

Fig.2 Multi-drop connection

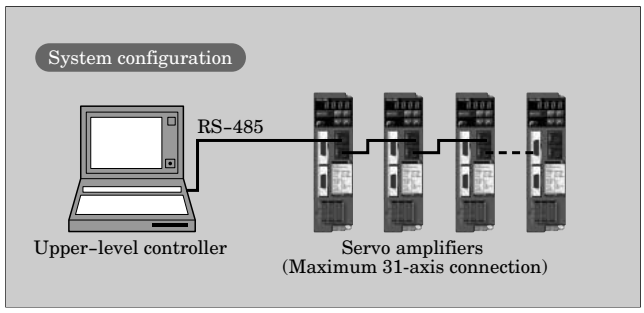
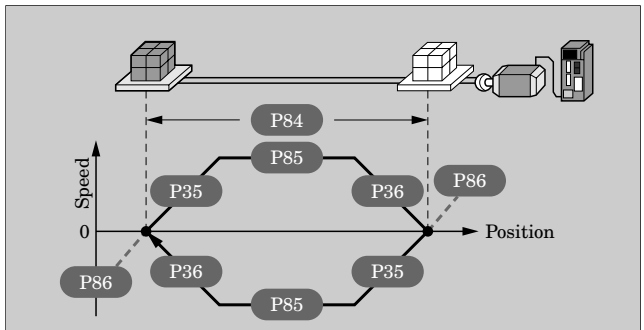


Fig.3 Pattern operation



<Description of pattern operation>
○ In the figure, P□□ indicates the parameter number.
○ Accelerates at acceleration time (P35), moves by stroke setting (P84) amount at speed setting (P85), decelerates at deceleration time (P36), stops for duration of timer setting (P86), and then similarly returns to the start position.
○ This reciprocating operation is repeated.

there is no upper-level controller. By monitoring each motor during operation, overload level, motor suitability, operation pattern suitability and the like can be assessed early on, without affecting by completion degree of upper-level controller. Moreover, use of the easy tuning function to perform adjustments and operational verification reduces required setup time.

4.3 Easy tuning

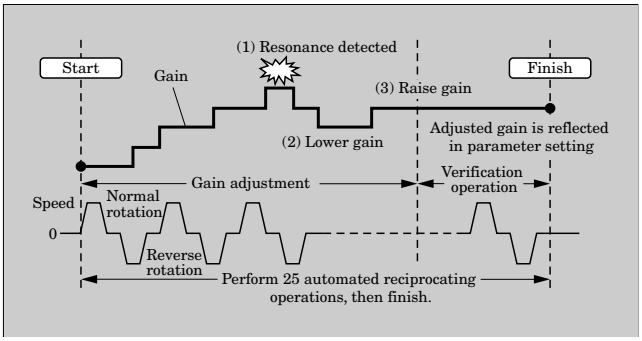
With conventional auto-tuning, relevant parameters are computed automatically according to gain and ratio of load inertia. Ratio of load inertia is estimated automatically, and user sets the gain itself. Machine's response is determined by the gain adjustment, and in cases where machine vibrates at its resonance frequency, adjustment-related expertise and experience are needed to reduce the gain and adjust various parameters.

In W series, instead of requiring the user to make such adjustments, easy tuning function is provided for gain adjustment. Figure 4 shows the operation of the easy tuning function. The easy tuning function operates automatically to increase the gain according to servo system operation pattern suited for tuning. If resonant vibration is detected, the easy tuning function automatically decreases the gain, sets a notch filter, and then increases the gain again. When the easy tuning operation is completed, gain value is reflected on the parameter setting, and subsequent normal operation is performed using this gain setting. This gain adjustment is extremely easy to implement, the user simply presses a button to activate the easy tuning function and the adjustment is performed entirely by the servo system.

4.4 Z-phase offset

During setup, origin sensor attached to the machine have to set machine's origin position. Therefore this origin position and the Z-phase servomotor reference position require position matching. Normally, such positional adjustment is implemented by mechanical coupling between the machine's shaft and the

Fig.4 Easy tuning operation



servomotor's output shaft. However in recent years, the range for this adjustment has become extremely narrow due to the smaller sizing of machines, and the man-hour cost for adjustment work which is the burden on the user have been increasing.

W series, however, is equipped with Z-phase offset function that electronically adjusts Z-phase output position. With Z-phase offset function, electrical Z-phase position is set by simply moving the machine to a location where a Z-phase signal is desired and then activating an automated adjustment function. As a result, the task of Z-phase positional adjustment can be eliminated.

5. Conclusion

Features and specifications of FALDIC-W series have been presented. W series was designed to support a wide range of applications with increased variety of motors, and dramatically improved performance.

In the future, Fuji Electric intends to advance conformance with EU's RoHS directive*1 that regulates the use of chemical substances, and to strive to satisfy user expectations.

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*1: RoHS directive is restriction on the use of certain hazardous substances in electric and electronic devices.