Expansion of FALDIC-α Series AC Servo Systems

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1. Introduction

With the aim of achieving a smaller size, higher precision, faster response and less wiring, it is recently popular for AC servo systems to be equipped with a serial encoder and to be connected to various interfaces to upper level systems. Moreover, by simplifying the adjustment work required for each installed machine, providing various control functions to suppress mechanical vibration while keeping high-speed response capability, and implementing full-closed control to achieve even higher precision, daily progress is being made toward the realization of high precision, easy to use equipment.

In consideration of these trends, Fuji Electric brought to market the FALDIC Series high-performance AC servo systems, and the marketplace reception has been favorable. In order to broaden the range of market applications and to address demands for applications such as printing machines, molding machines and large conveying equipment, Fuji Electric has newly introduced a medium capacity FALDIC-α Series (hereafter, the medium capacity series) that is provided with vibration suppressing control and a notch filter as standard functions, in addition to the various types of interfaces supported by prior models.

An overview, specifications and features of this medium capacity series are presented below.

2. Features of the Medium Capacity Series

Figure 1 shows a model map of the FALDIC Series and Fig. 2 shows an external view of the FALDIC-α Series.

Because the medium capacity series keeps the features of the FALDIC-α Series, it realizes a dramatic improvement in functionality and performance compared to the FALDIC-IM Series, the former medium capacity series.

Main features are described below.

2.1 Damping control function with a 2-mass model

The damping control function of the FALDIC-α Series and FALDIC-β Series has been well-accepted in the marketplace, and Fuji Electric also provides this independently developed technology as standard function for this medium capacity series. The damping control function achieves a dramatic reduction in

Fig.1 Map of FALDIC Series models

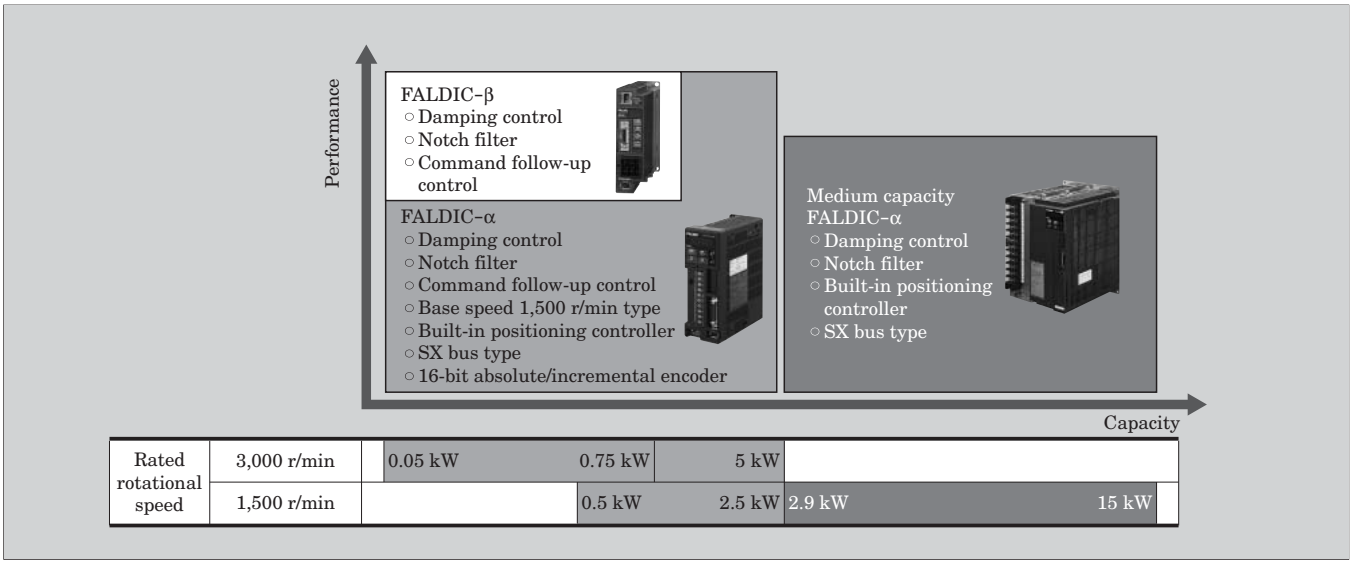


Fig.2 Appearance of FALDIC-α Series

position setting time and suppresses vibration of the mechanical system.

2.2 Notch filter function to suppress resonance of the machine

As in the case of the damping control function, a notch filter function that has been well-accepted with the FALDIC Series is also provided as a standard function. By presetting the servo amp with resonance point data as a parameter to prevent the inherent resonance of the machinery, the notch filter function can be used to decrease mechanical resonance.

2.3 Expanded user interface

This medium capacity series may be connected to the same PC loader (option) as for the FALDIC-α Series. This is useful in retaining the same ease of use, while reducing setup time and improving maintainability.

3. Product Specifications of Medium Capacity Series

3.1 Capacity range of the series

The series has capacities ranging from 2.9 to 15 kW (rated speed: 1,500 r/min) and may be applied to large torque loads.

3.2 Basic specifications of servo amp

Table 1 lists the basic specifications of the medium capacity series. There are four varieties of servo amp models according to their different control functions and interfaces to upper level systems.

(1) VVK type

The VVK servo amp is able to perform positioning control by means of pulse train input and can perform speed control and torque control by means of analog voltage input. The interface to an upper level controller is I/O based.

(2) VSK type

Table 1 Servo amp specifications

Servo amp model (RYS○○○M3-□□□)			VVK	VSK	LPK	LSK
Main uses			Speed control		Linear positioning	
Input power supply	Voltage		200 to 230 V, +10 % / –15 %			
	Frequency		50 / 60 Hz			
Control specifications	Control method		Sinusoidal wave PWM control (all digital)			
	Carrier frequency		5 kHz			
	Feedback		16-bit serial encoder			
	Speed range		1 : 3,000			
	Frequency response		300 Hz			
	Overload capability		236 to 250 % / 3 s (according to capacity)			
	Positioning resolution		16-bit (16,384 pulse equiv.) / rev			
	Position management		Absolute / incremental selectable			
Control function	Speed control		○	○	–	–
	Torque control		○	○	–	–
	Pulse train		○	○	○	○
	PTP positioning		–	–	○	○
	Origin return		○	○	○	○
	Interrupt positioning		○	○	○	○
Interface specifications	Input	Digital	8 points	5 points	21 points	5 points
		Analog	2 points	–	1 point	–
		Pulse	1 channel (can be either open collector or differential input)			
	Output	Digital	5 points	2 points	10 points	2 points
		Analog	2 channels			
		Pulse	1 channel (differential output)			
Environment	Temperature, humidity		–10 to +55°C, 10 to 90 %RH (no condensation)			
	Usage site, elevation		Indoors, 1,000 m or below (no dust, corrosive gas, flammable gas or direct sunlight)			

Similar to the VVK type, the VSK servo amp is able to perform positioning control by means of pulse train input and can perform speed control and torque control in accordance with commands received from an upper level controller. Fuji Electric's MICREX-SX programmable controller is used as the upper level controller to realize various types of motion control. Fuji Electric has prepared a large library of software function blocks (FBs) that are optimal for motion control use, making it easy to configure applications according to customer needs.

(3) LPK type

A positioning control function is built into the servo amp, and positioning can be implemented by receiving on and off signals from the upper level controller. The interface to the upper level controller

Table 2 Servo motor specifications

Servo motor model (GYM□□□BC1-○C)	292	402	552	752	113	153
Rated output (kW)	2.9	4.0	5.5	7.5	11	15
Rated torque (Nm)	18.6	25.5	35.0	48.0	70.0	95.4
Rated rotational speed (r/min)	1,500					
Max. rotational speed (r/min)	3,000				2,000	
Max. torque (Nm)	45.1	63.4	87.6	119	175	221
Moment of inertia (kgm^2)	0.0046	0.0068	0.0089	0.0125	0.0281	0.0315
Rated current (A)	23.8	30.0	42.1	54.7	58.6	78.0
Max. current (A)	56.0	76.0	110.0	130.0	140.0	170.0
Insulation class	F type					
Rating	Continuous rating					
Protection ventilation	Fully enclosed, self-cooling IP67 (except for penetrating portion of shaft)					
Terminal (motor)	Canon connector					
Terminal (detector)	Canon connector					
Overheat protection	None (electronic thermal detection by servo amp)					
Attachment method	Flange attachment					
Shaft extension	Cylindrical shaft, with key					
Color of coating	N1.5 (semi-gloss)					
Detector	16-bit incremental serial encoder (standard) 16-bit absolute serial encoder (option)					
Vibration	V15					
Site of usage, elevation	Indoors, 1,000 m or below					
Ambient temperature, humidity	0 to 40°C, 20 to 90 % RH (no condensation)					
Vibration resistance	24.5 m/s^2					
Total mass (kg)	18	23	30	40	57.5	86

is I/O based, and a system can be configured without requiring a motion control module in the upper level system.

(4) LSK type

Similar to the LPK type, a positioning control function is built into the servo amp. The upper level controller is the abovementioned MICREX-SX, and point-to-point (PTP) positioning can be performed via the SX bus without use of a motion control module,

3.3 Basic specifications of servo motor

Table 2 lists the basic specifications of the medium capacity servo motor. The medium capacity servo motor uses a synchronous motor and achieves a large reduction in size and inertia compared to the former FALDIC-IM Series.

The built-in encoder is a 16-bit serial encoder, similar to the FALDIC-α Series, and a reduction in wiring, higher response and higher precision are realized.

Moreover, requested features such as the provision of an absolute encoder, gears, brake, shaft key, etc. are available as options.

3.4 Main standard functions

(1) Damping control

The damping control function is a control technology developed independently by Fuji Electric to dramatically reduce both sustained vibration at the edges of mechanical parts, and vibration and shock to the machinery. In the implementation of this damping control function, a 2-mass mechanical model is provided within the control block, and the model is internally controlled so to eliminate vibration at its edges. By applying this control amount to compensate motor positioning and speed control, the vibration at the edges of mechanical parts can be suppressed

This damping function enables faster operating speed of the machinery itself as well as a reduction in tact time and positioning stabilization time.

(2) Notch filter

The phenomenon of mechanical resonance occurs

Fig.3 Effect of notch filter

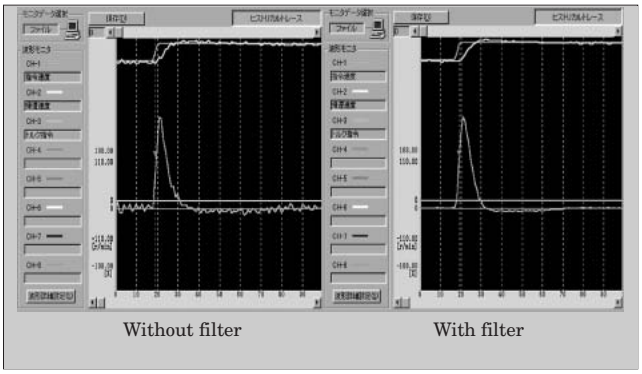
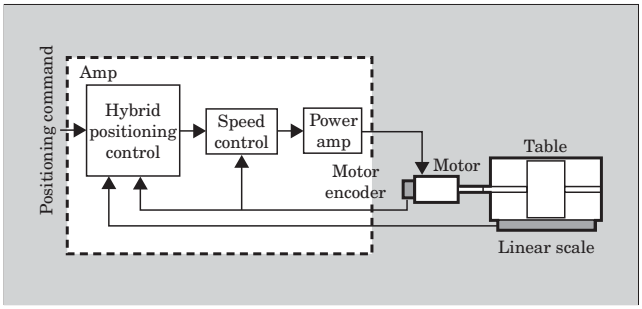


Fig.4 Block diagram of full-closed control



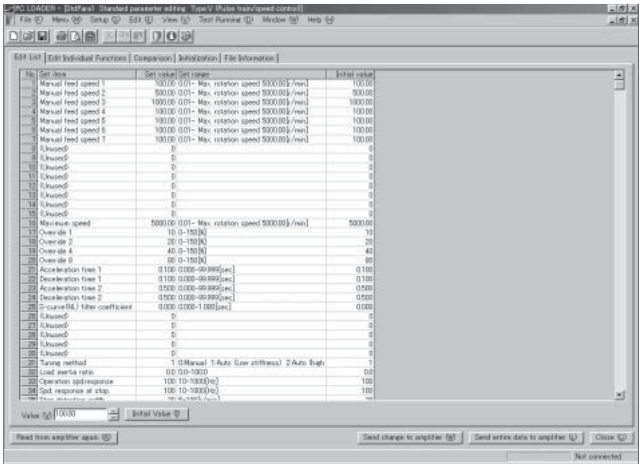
at different points (frequencies) for each machine. The notch filter function acts to attenuate only the resonance frequency components of amp torque commands, and therefore the overall gain remains high. In other words, this function suppresses the phenomenon of mechanical resonance without degrading the overall response.

Figure 3 shows examples of torque command waveforms, both with and without using a notch filter. By presetting the servo amp with the parameters of resonance frequency and the amount of attenuation, the vibration-inducing components in a torque command can be suppressed to a large extent.

(3) Full-closed control

Full-closed control is a control method to achieve higher precision and is applied to systems in which positioning precision is affected by mechanical vibration. Full-closed control is available as an option with the medium capacity series. Figure 4 shows a block diagram of an implementation of the full-closed control method. Here, the position of a table or task to be controlled is detected as feedback from a linear scale (or external encoder), and hybrid position control is performed according to feedback from the servo motor's internal encoder (also known as the motor encoder). Since dynamic control is performed with feedback from the motor encoder and static control is performed with

Fig.5 PC loader screenshot



feedback from the linear scale, there is less positional deviation than in the case of conventional control methods, and the high-speed response performance is kept.

(4) PC loader

The same PC loader software of the FALDIC-α Series is also available with the medium capacity series as an option. The software is simple to operate and allows easy editing and copying of each parameter, real-time and historical tracing of various data, etc. Figure 3 shows example trace screenshots and Fig. 5 shows the parameter editing screen.

4. Conclusion

Features, specifications and an overview of the medium capacity FALDIC-α Series have been presented. This series was developed to provide a large improvement in control functionality and performance and to be applicable to a wide range of uses. We at Fuji Electric will continue our efforts to provide solutions that satisfy user needs.