# FALDIC Series Position Control Servo System

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## 1. Introduction

Servo system components used as automated, labor saving devices are expected to provide a wide variety of functions. In particular, demands are increasing for a simpler implementation of PTP (point to point) motion control.

Further, the popularization of personal computers and programmable controller (PLC) has increased needs for powerful communication functions with such upper-level controllers.

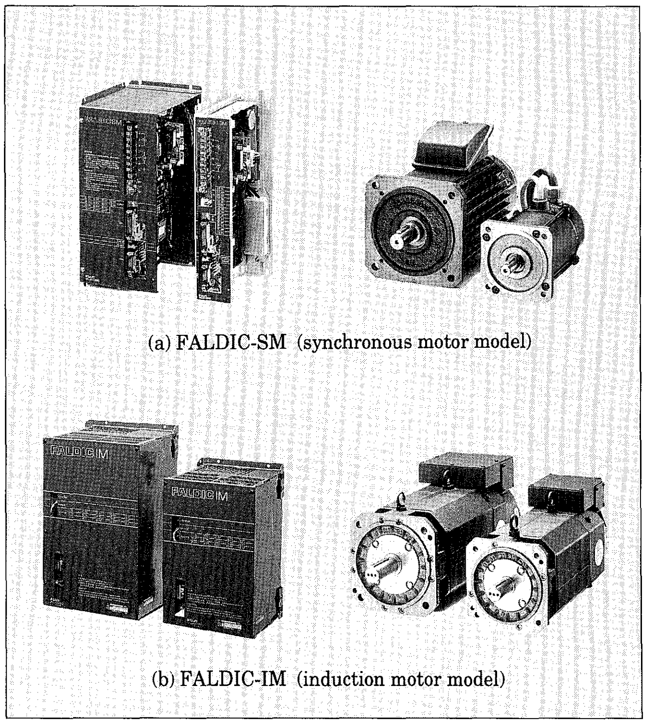
The general-purpose servo FALDIC series is introduced below. This series meets the above needs by employing fully-digital controls, integrating the positioning control block and a one-CPU design.

## 2. Outline and Characteristics

The FALDIC series is comprised of two types of motors, the SM (synchronous motor) and IM (induction motor). The series for both types has a wide capacity ranging from 0.05 to 37kW.

Figure 1 shows the appearance of FALDIC-SM/IM. Those compact units are equipped with a “position reference (command) calculator”, “servo controller”, and “power amplifier”.

Fig. 1 FALDIC-SM/IM



(a) FALDIC-SM (synchronous motor model)

(b) FALDIC-IM (induction motor model)

Figure 2 shows the system configuration of the FALDIC series. Despite its small size, wide variety of positioning operations listed below can be performed.

(1) Positioning by either address specification or numeric data specification using the code-switch
(2) Positioning by pulse-train input
(3) Positioning through serial communication (T-link) with a PLC
(4) Positioning through serial communication (RS-232C) with a personal computer

The serial communications indicated in methods (3) and (4) above are capable of increasing flexibility and reducing wiring in the system. In the basic positioning function, the target position, feed speed and dwell timer value are set as position data (for up to 99 locations) in the FALDIC’s non volatile memory unit. When activated from an external system one-axis linear positioning can be performed.

Auxiliary functions are also included, such as the continuous activation of multiple position data, sequential activation starting from a desired address, and other activation methods that are best suited for each of the various applications. When these functions are used simultaneously with origin return, manual feed, sequence supporting functions, etc., a broad range of tasks are possible, from complicated positioning in combination with the PLC to simple positioning.

Available variations of the series include: (a) an absolute encoder (ABS) version, (b) a rotation indexing (ROR) version, and (c) a velocity servo (VEL) version.

The ABS version uses an absolute encoder to store the motor rotation positions (absolute positions) over a range of ±16,383 rotations. Therefore, the system can be configured so as not to require a return to the origin.

The ROR version is used exclusively for indexing rotational bodies such as an ATC (Auto Tool Changer) or a turntable. Positioning at a specified station can be

Fig. 2 FALDIC series system configuration

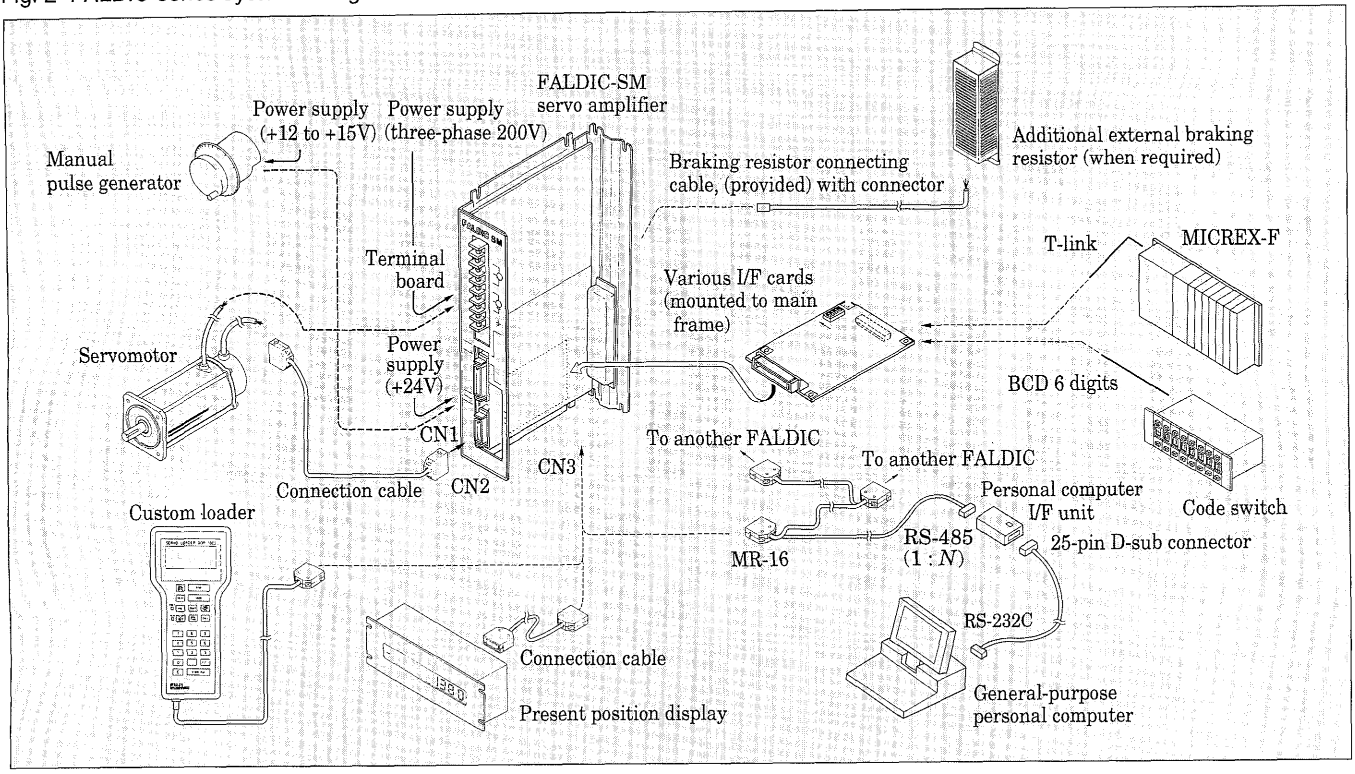
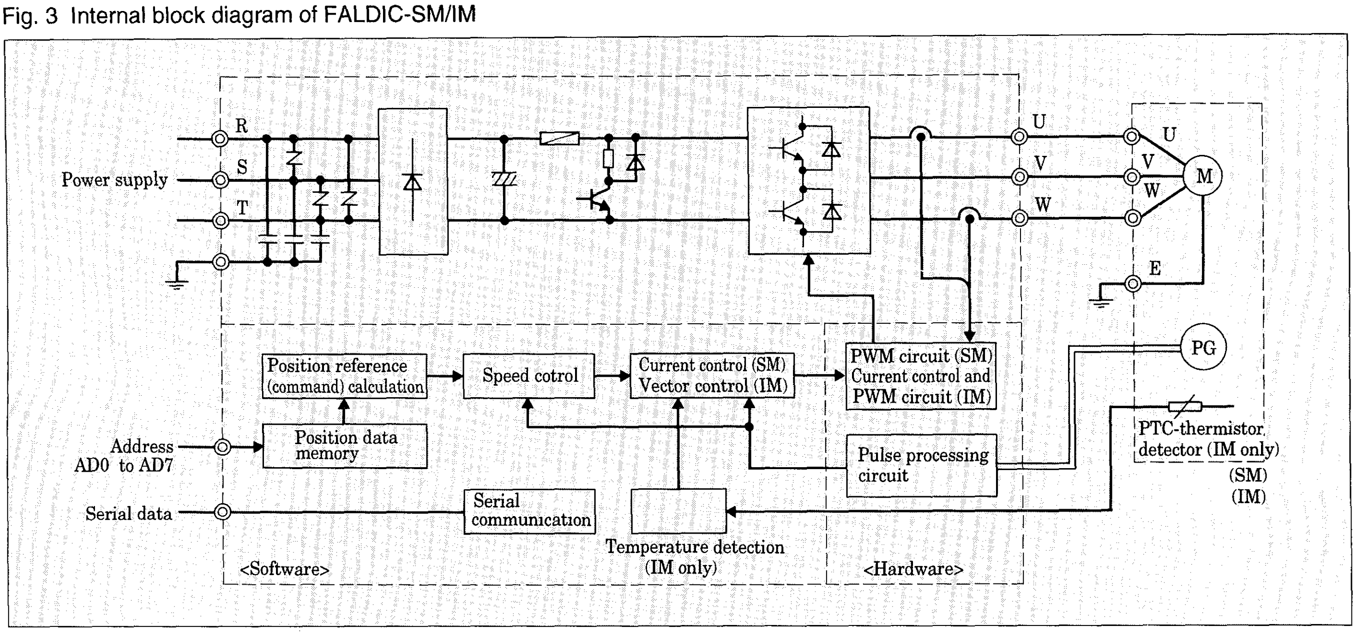



Fig. 3 Internal block diagram of FALDIC-SM/IM




performed by first setting the number of divisions (1,000 divisions max.) of a rotational body and the total reduction ratio, next, the stop position (station number) is specified and the system started.

The VEL version is constructed from a control loop for speed control, and can respond to a speed reference (command) such as analog voltage (analog input card), serial digital data (T-link I/F card) or parallel digital data (parallel I/F card) depending on which option card is used. A custom loader has been developed for enhancing the operability of the above functions. This loader has a wide liquid crystal display of 16 characters × 4 lines as well as numeric keys. With this loader, the monitoring of various operations, parameter settings, position data settings, all types of resets, test run and sequence checks can be performed.

## 3. Circuit Configuration and Specifications

The internal block diagram of the FALDIC-SM/IM is shown in Fig. 3 and its specifications are listed in Table 1. As can be seen in both the figure and table, SM

Table 1 FALDIC-SM/IM specifications

(a) FALDIC-SM

| Item | Amplifier model | FRV050A | FRV100A | FRV300A | FRV500A | FRV101A | FRV151A | FRV181A | FRV271A |
|---|---|---|---|---|---|---|---|---|---|
| Motor specs. | Applicable motor type | GRY2050 | GRY2100 | GRH1300 | GRH1500 | GRH1111 | GRH1151 | GRH1181 | GRH1271 |
| | Output, cont. (kW) | 0.05 | 0.1 | 0.3 | 0.5 | 1.1 | 1.5 | 1.8 | 2.7 |
| | Torque, rated (N · m) | 0.15 | 0.29 | 0.96 | 1.59 | 3.50 | 4.77 | 6.88 | 10.3 |
| | Torque, max. (N · m) | 0.44 | 0.86 | 2.86 | 5.73 | 11.5 | 15.7 | 18.0 | 26.3 |
| | Speed (r/min) | 3,000/3,000 (rated/max.) | | | | | | 2,500/2,500 (rated/max.) | |
| Basic specs. | Power input supply | Three-phase, 200/200−230 (V) ± 10% 50/60 (Hz) ± 5%, Supply voltage unbalance: 3% max. | | | | | | | |
| | Output current, rated (A) | 0.5 | 0.8 | 1.9 | 2.7 | 5.4 | 7.0 | 8.3 | 13.0 |
| | Output current, max. (A) | 1.5 | 2.4 | 5.7 | 8.1 | 16.2 | 21.0 | 20.8 | 32.5 |
| | Carrier frequency (kHz) | 10 | | | | | | 2.5 | |
| | Speed detector (feedback) | Encoder 2,000 pulse/revolution (internal quadrupling: 8,000 pulse/rev.) | | | | | | | |
| | Frequency response | DC to above 100Hz AC (when $J_L = J_M$) | | | | | | | |
| | Moment of inertia, load (max.) | 5 times max. of motor rotor inertia | | | | | | | |
| | Position control/No. of position data | Point to point/99 locations set internally | | | | | | | |
| Input/ output | Pulse train input | Open collector (+12V), max. frequency 100kHz | | | | | | | |
| | Control input | Run command, Forces top, Manual forward, Manual reverse, Auto start, Return to origin, Origin LS, ± direction overtravel, Alarm reset, Address 0 to 7, Multi-purpose control (input) 0 to 3 | | | | | | | |
| | Control output | Ready/alarm, Positioning end, Major fault, Dynamic braking, Multi-purpose control out 1 to 3 | | | | | | | |

(b) FALDIC-IM

| Item | Amplifier model | FLD002A −21 | FLD003A −21 | FLD005A −21 | FLD007A −21 | FLD011A −21 | FLD015A −21 | FLD018A −21 | FLD022A −21 | FLD030A −21 | FLD037A −21 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Motor specs. | Applicable motor type | MPF002US −21G | MPF003US −21G | MPF005US −21G | MPF007US −21G | MPF011US −21G | MPF015US −21G | MPF018US −21G | MPF022US −21G | MPF030US −21G | MPF037US −21G |
| | Output, cont. (kW) | 2.2 | 3.7 | 5.5 | 7.5 | 11 | 15 | 18.5 | 22 | 30 | 37 |
| | Torque, rated (N · m) | 14.0 | 23.5 | 35.0 | 47.6 | 70.0 | 95.5 | 118 | 140 | 191 | 236 |
| | Torque, max. (N · m) | 42.1 | 70.6 | 70.6 | 95.1 | 140 | 191 | 235 | 280 | 382 | 400 |
| | Speed (r/min) | 1,500/2,000 (rated/max.) | | | | | | | | | |
| Basic specs. | Power input supply | Three-phase, 200/200−230 (V) ± 10% 50/60 (Hz) ± 5%, Supply voltage unbalance: 3% max. | | | | | | | | | |
| | Output current, rated (A) | 14 | 21 | 29 | 39 | 55 | 76 | 91 | 110 | 145 | 175 |
| | Output current, max. (A) | 34 | 52 | 52 | 72 | 103 | 140 | 170 | 200 | 265 | 280 |
| | Carrier frequency (kHz) | 3 | | | | | | | | | |
| | Speed detector (feedback) | Encoder 2,000 pulse/revolution (internal quadrupling: 8,000 pulse/rev.) | | | | | | | | | |
| | Frequency response | DC to above 100Hz AC (when $J_L = J_M$) | | | | | | | | | |
| | Moment of inertia, load (max.) | 5 times max. of motor rotor inertia | | | | | | | | | |
| | Position control/ No. of position data | Point to point/99 locations set internally | | | | | | | | | |
| Input/ output | Pulse train input | Open collector (+12V), max. frequency 100kHz | | | | | | | | | |
| | Control input | Run command, Forces top, Manual forward, Manual reverse, Auto start, Return to origin, Origin LS, ± direction overtravel, Alarm reset, Address 0 to 7, Multi-purpose control (input) 0 to 3 | | | | | | | | | |
| | Control output | Ready/alarm, Positioning end, Major fault, Dynamic braking, Multi-purpose control out 1 to 3 | | | | | | | | | |

and IM functions and operations are the same in regard to applications. However, their control methods and capacities are somewhat different. For this reason, the software has been designed with a hierarchical structure so that software modules are common for both types, with the exception of current control and vector control. Because the same modules are used, future functional upgrading can be easily achieved. Although both FALDIC-SM and IM share the basic functions explained above, each type also incorporates unique innovations as listed below.

(1) SM (synchronous motor) type
  (a) Compact design due to fully-digital controls
  (b) Reduced noise due to the PWM's high carrier frequency by using MOSFETs and IGBTs
  (c) Suppresses uneven rotation due to automatic offset compensation in the current detection block
(2) IM (induction motor)
  (a) Obtains high control response and high-performance vector control through use of an analog current control block
  (b) Suppresses uneven rotation due to automatic offset compensation in the current control block
  (c) Employs a power-regenerative braking system for 18.5 kW or more, which contributes to energy saving

Both FALDIC-SM and IM optimize the allocation of processing between the software and hardware. The combination of a 16-bit CPU and a custom LSI make quick and highly-responsive servo control possible.

## 4. Operational Characteristics

Figures 4 and 5 show the frequency response of the speed control loop in FALDIC-SM and IM. At the –3db point, the frequency exceeds 100Hz for the FALDIC-SM and 80Hz for the FALDIC-IM. Therefore both types are suitable for quick and highly responsive positioning.

Figures 6 and 7 show the response waveforms for the linear and smooth acceleration/deceleration modes. In the smooth acceleration/deceleration mode, the change of torque is smooth, and the shock is dampened.

Figure 8 shows an example of the operational waveform during continuous activation of the positioning data. The upper and lower curves represent the speed waveform and the positioning end waveform, respectively. At the data changeover point, the speed is slowed down to the feed speed of the next data, so oper-

Fig. 4 FALDIC-SM (0.5kW) frequency response ($J_L = J_M$ condition)

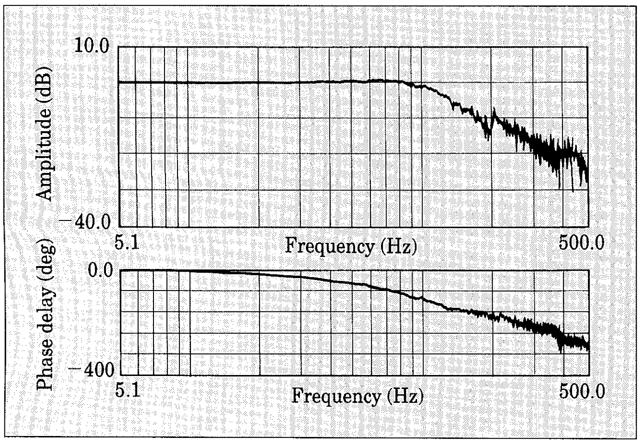



Fig. 5 FALDIC-IM (11kW) frequency response ($J_L = J_M$ condition)

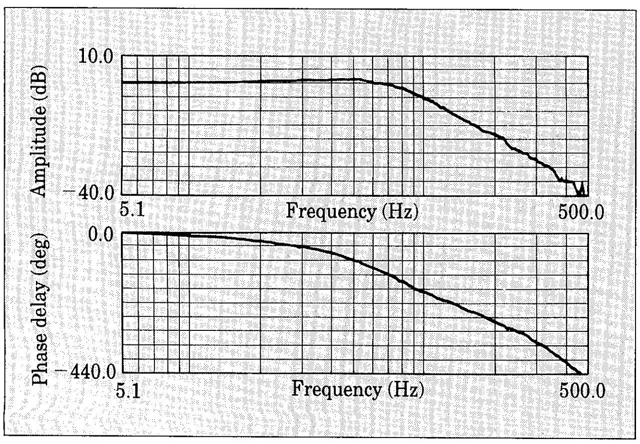



Fig. 6 Response waveform during linear acceleration/deceleration

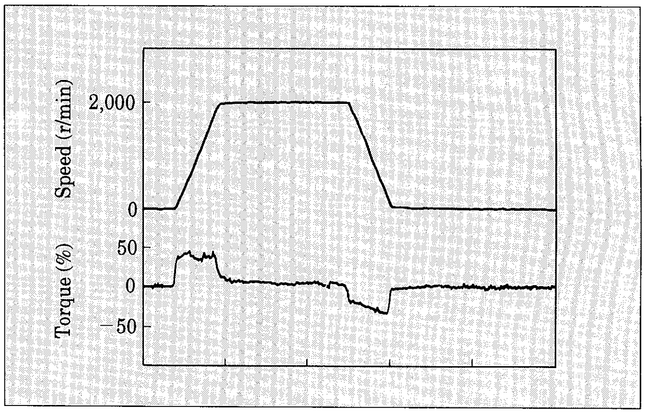



Fig. 7 Response waveform during smooth acceleration/deceleration

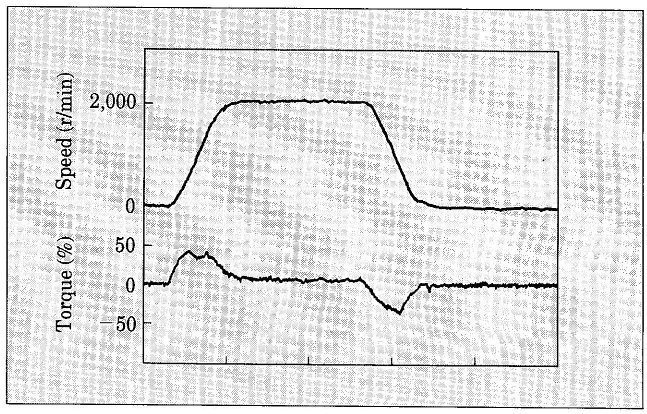
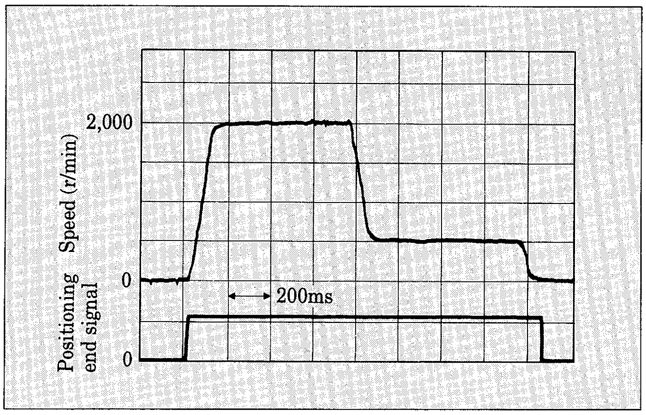


Fig. 8 Operational waveform during continuous activation of positioning data




ation may continue smoothly.

## 5. Conclusion

The FALDIC series satisfies demands for quicker and higher accuracy, allows transmission of detailed motion information to an upper-level controller, and substantially reduces space and wiring requirements.