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CURRENT STATE OF SERVOSYSTEM COMPONENTS

Shigefumi Kurita
Hiroyuki Imoto

1. FOREWORD

Automation and labor-saving technology, represented by FA and FMS, is advancing steadily and demands are becoming more diverse. The demand for higher quality and more diverse specifications for servosystem components components which form its base is one step stronger.

Fuji Electric took the opportunity of the sale of the DC servomotor in 1983 and the sale of AC servosystems in 1985 to meet the many demands for automation and labor-saving of these. In recent years, market needs have become more diverse and complex. Fuji Electric expanded and arranged its models by diversification of the shape of the servomotor, commercialization of multiaxis correspondence positioning system, development of general purpose programmable controller (PC) MICREX-F correspondence positioning system, etc.

The development aims, specifications or features, etc. of various servosystem components for suitable selection of servosystem components are outlined.

2. COMPOSITION OF SERVOSYSTEM COMPONENTS

Figure 1 shows the overall composition of servosystem components. These components are mainly for application to systems and can be easily combined with a general-purpose PC. For example, various motion data and information (command position data, current position data, etc.)

Fig. 1 Composition of servosystem components

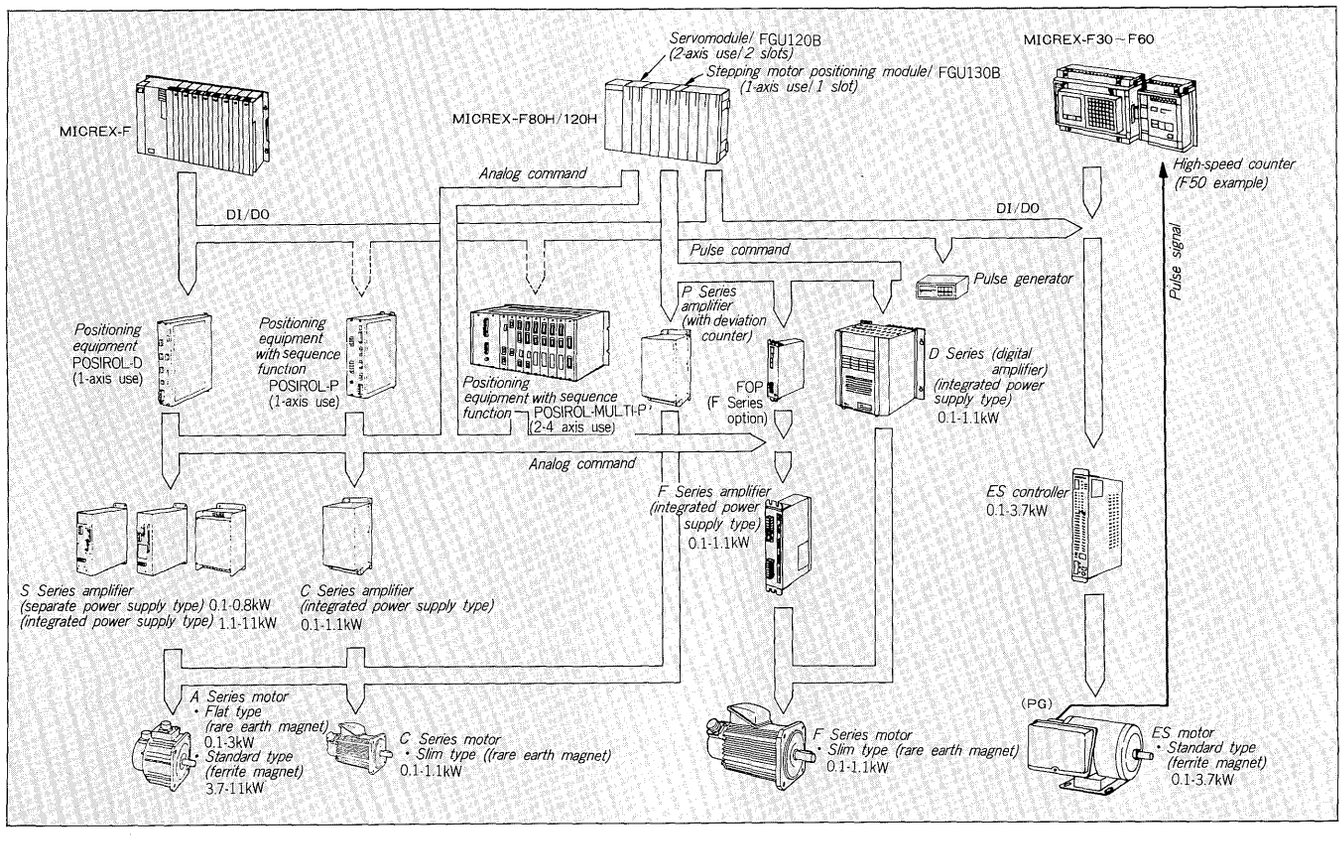
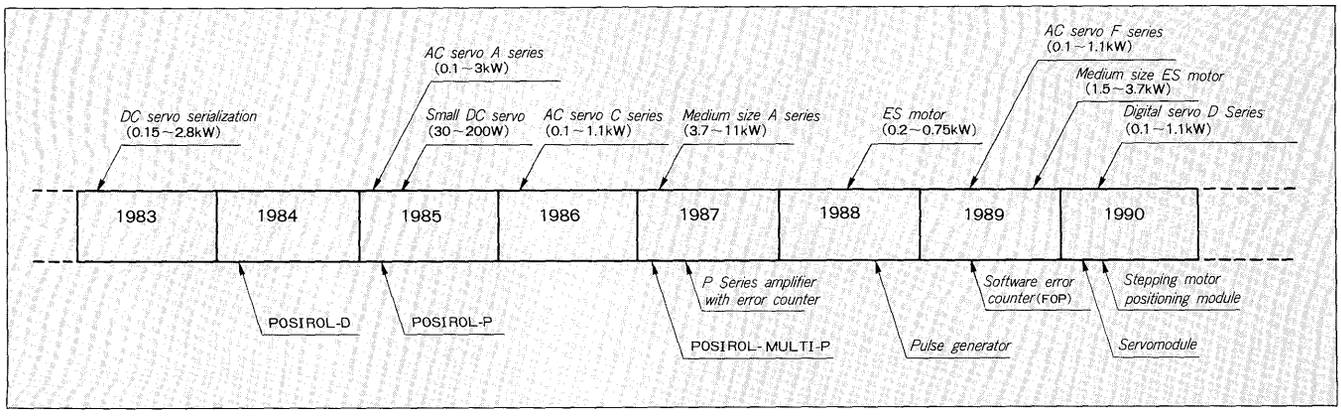


Fig. 2 Servosystem components development process



for position control can be transferred at high speed by the following techniques:

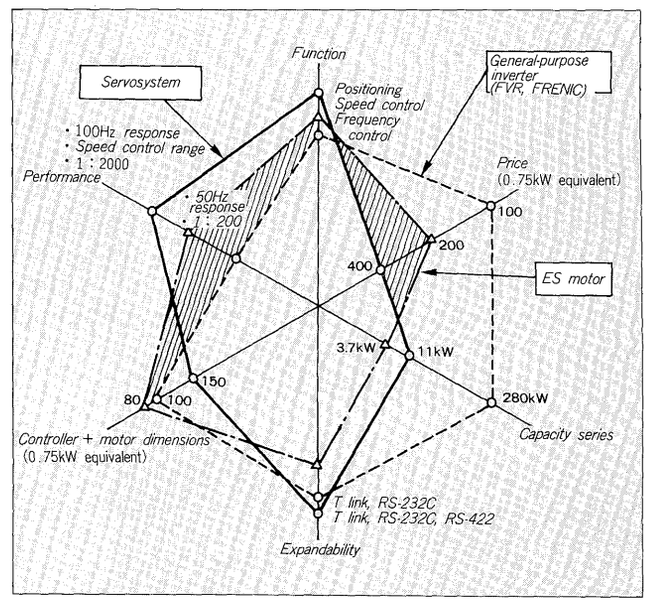
(1) Parallel transfer by general-purpose I/O.
(2) Serial transfer by RS-232C, RS-422, etc.
(3) High-speed transfer by baseboard integration
(4) Serial transfer by T-link, etc.

Figure 2 shows the servosystem components development process. Since the DC servomotor was placed on sale in 1983, precision positioning equipment in general industrial application have become more advanced and diversified and AC servomotors have been commercialized and their capacity series expanded and the need for maintenance-free operation can be met. Especially, the ES servomotors commercialized in 1990 are new type motor developed by reducing the specifications exhaustively with high performance and low price as the development topics while smashing the AC servomotor principle and construction. In the past, the inverter for general use or AC servomotor was used in application which required a comparatively high performance used by DC variable speed equipment. However, both are unsatisfactory from the standpoint of performance or prices and high cost-performance application has become possible by selecting this ES motor.

For servosystems, the "medium capacity servo (FRS type)" and "digital servo (FRD type)" were sequentially developed and serialized to meet market demands. On the other hand, for precision positioning applications, a positioning controller with sequence function was developed and flexibility was improved. The demand for advanced functions and diversification could also be met by serializing its multiaxis position control equipment.

The need for layering and dispersion of various functions has increased in accordance with the expansion of general-purpose PC applications. Under these conditions, the addition of various kinds of positioning modules to the PC baseboard was made possible and system components were made more compact.

Fig. 3 Comparison of features of servomotor and ES motor



3. SERVOSYSTEM COMPONENTS SPECIFICATIONS AND FEATURES

3.1 Servomotor

Figure 3 is an active comparison of the typical specifications of the servomotor and ES motor with the general-purpose inverter as the standard. As fan be seen from this figure, the general-purpose inverter is superior in price, capacity series, and expandability and the servosystem wins by performance, functions, and overall dimensions, including the motor.

The development topic of the ES motor was the high prices which is the disadvantage of the servosystem and high performance which is not satisfied by the general-purpose inverter. The ES motor was developed and exhaustively tightening the development specifications and extracting and arranging the cost-cutting items. Therefore, it has superior features relative to the general-purpose inverter and the servomotor in the hatched line region

Table 1 Comparison of specifications and characteristics of typical variable speed drive equipment

Item \ Type	General-purpose inverter FVR-G7	Vector inverter FRENIC 5000VG	ES motor	AC servo
Output range (kW)	0.4~22 (3.7~280*[1])	3.7~800	0.2~3.7	0.1~11
Applicable motor	Induction motor	Same as at left	Synchronous motor w/permanent magnet	Same as left
Rated/max. (rpm)	1,800/12,000 (4-pole motor)	1,500/3,600	2,000/2,500	2,000/3,000 (1,500/2,000*[2])
Speed control range	–	1:100 (240*[3])	1:200	1:2000
Maximum acceleration/ deceleration torque (%) (vs rated torque)	100~150	150 min.	150 min.	300 min.
Minimum acceleration/ deceleration time*[4] (s)	0.2	0.15	0.1	0.01
Speed fluctuation (0 ⇄ 100% load) (%)	– (0.5~1.5)	±0.2	±0.5	±0.01
Frequency response *[5] (Hz)	–	5~10	50	100
Motor efficiency (%)	40~90	60~90	80~90	85~95
Controllable torque when motor stopped (%) (vs rated torque)	Not controllable	150	150	300
Variable speed operation system	No-voltage contacts switching	−10V ~ 0 ~ +10V (reverse) (forward)	Same as left.	Same as left.
Detector	Unnecessary	Encoder (512p/rev)	Encoder (1,000p/rev)	Resolver, encoder (2,000p/rev)

*[1] : FRENIC 5000G7 output range, *[2] : Specifications at 2.2-11kW, *[3] : Weak magnetic field area considered,
*[4] : Motor alone and 0 ⇄ 2000 (rpm) condition, *[5] : Motor alone condition

shown in *Fig. 3*. Put in other words, the general-purpose inverter is lacking in performance, but the optimum system can be built by using the ES motor where performance up to that of the servomotor is unnecessary. A comparison of the specifications and characteristics of typical variable speed drive equipment is shown in *Table 1*. There are large differences in speed control range, maximum acceleration and deceleration torque, minimum acceleration and deceleration torque, and frequency response and amply consideration is necessary from the standpoint of application.

Since the servomotor is used in position feedback control by rotary encoder, etc., system closed loop position control, the following specifications and characteristics are demanded:

(1) Frequency response: 100Hz min.
(2) Speed control range: 1:1,000 min.
(3) Maximum acceleration/deceleration torque: 300% or rated torque
(4) Rotary encoder for closed loop control can be added.

3.2 Positioning equipment

To meet the need for more advanced functions and deversification in automation and labor-saving, precision positioning equipment from single-axis single function type to built-in sequence function type, multiaxis type with interpolation function, and built-in general-purpose PC type multiaxis function positioning modules were sequentially developed and serialization was advanced. The basic specifications and functions are compared in *Table 2*.

The development aims and features are given below.

3.2.1 Pulse generator (RP100)

The number of control axes is and smaller size and lighter weight were planned by mounting a loader with ten keys to input the positioning data or parameters. It is a pulse output type and is used by combining it with a servoamp with error counter (P Series, D Series or FOP+F Series). It is a positioning controller by positioning address specification (100 points) and can be used in applications which perform positioning by registered data. For example, it can be used with indexing machines, point-to-point conveying equipment, etc.

3.2.2 Stepping motor positioning module (FGU130B)

The number of control axes is 1 axis. This module is used by connecting it to an ordinary stepping motor driver. Since it has a pulse output, precision positioning control by pulse feedback control (open loop type for position data) by combining it with a servoamp with error counter, the same as the RP100 previously described. A general-purpose PC is connected on the baseboard, and high-speed transfer of position data, present position data, and other motion information is possible. Besides positioning control by immediate position data, step advance type positioning control by start address specification and positioning control by multistage data continuation are possible. A 1,000 steps position data capacity is provided,

Table 2 Comparison of positioning equipment specifications and characteristics

Item \ Type	Pulse generator (RP100)	Stepping motor positioning module for MICREX-F (FGU130B)	POSIROL-D	POSIROL-P	POSIROL-MULTI-P	Servo module for MICREX-F (FGU120B)
Number of control axes	1 axis	1 axis	1 axis	1 axis	2~4 axes	2~8 axes
Program function	–	○	–	○	○	○
Programming language	–	Dedicated command code	–	Mnemonic PC language	Same as at left.	Dedicated command code
Program capacity	–	By F80H, F120H	–	1,000 steps	5,000 steps	By F80H, F120H
Positioning operation system	Positioning by positioning address specification (8 bits)	Step advance type positioning by start address specification	Immediate positioning by I/O data (CD 6 digi digits)	Positioning by arbitrary positioning data by sequence program	Same as at left.	Step advance type positioning by start address specification
Positioning data capacity	100 points	1,000 points	15 points	480 points	480 points/axis	500 points/axis
Output mode	Pulse output	Pulse output	±10V analog output	±10V analog output	±10V analog output	±10V analog output
Allowable pulse frequency	100kHz	166kHz	100kHz	500kHz	500kHz	500kHz
Acceleration/deceleration characteristic	Exponent	Straight line	Exponent, Straight line	Same as at left.	Same as at left.	Index, straight line, S
Interpolation function	–	–	–	–	• 3-axis linear interpolation • 2-axis arc interpolation	• 2-axis linear interpolation • 2-axis arc interpolation
Loader	Built into body	Separate dedicated loader	–	Separate dedicated loader	Same as at left	Same as at left
Teaching function	–	○	–	○	○	○
Communication function (RS-232C)	–	○ (by PC)	–	○ (option)	○ (option)	○ (by PC)
Present position display	○ (display by loader)	○ (option)	Same as at left	Same as at left	Same as at left	Same as at left
Output of present position data to general-purpose I/O	–	○	–	○	○	○
Special functions	• Rotation index control	• Multistep data continuous operation	• Synchronization with external pulse and positioning operation mode switching	• Multistage data continuous operation • Position control by external marker	• Multistage data continuous operation with interpolation • Data operation functions • Sequence data display function	• Feed forward control • Multistage data continuous operation with interpolation • External interrupt positioning control • Synchronous operation
Application examples	• Indexer • Conveyer • Cutter	• Feeder • Traverser • Cutter	• Cutter • Synchronous conveyer • Press feeder	• Traverser • Printer • Knitting machine, weaving machine	• X-Y table • Precision winder	• X-Y table • Auto loader • Conveyer

the allowable pulse frequency is a high 166kHz, and comparatively fast, high precision positioning control is possible.

3.2.3 POSIROL-D

This is single-function type positioning equipment without sequence or program functions. Positioning control by immediate data (sign, speed, BDC 6 digits position) given from a high-level controller or a digital switch or precision synchronization, ratio operation by pulse command is performed. Since it is a single-function type, its operation method is comparatively simple. As a special application method, it can be used by function switching and mixing an operation mode which performs synchronization and ratio operation with external pulses and ordinary position control by immediate data mode. Effective application to fling cutter, etc. or conveyer and table synchronization and positioning operation are possible by means of this function.

3.2.4 POSIROL-P

This is programmable positioning equipment with built-in sequence function (1k words). It has a 480 steps position data area. Positioning control by arbitrary data

is possible. Various motion control information can be transferred with a high-level controller by using a general-purpose I/O. The allowable pulse frequency is 500kHz, and high-speed, high precision positioning control is possible. For example, when the resolution per pulse is 0.001mm, 30m/mi. high-speed feed can be achieved. A multistage data continuation function is provided. Position data, speed data, or parameter rewriting is also possible, and it can be used flexibility.

3.2.5 POSIROL-MULTI-P

This equipment can handle 2 to 4 control axes and a 480 (total 1,920) steps/axis position data area. A PC with 5k words program area which supports numeric operation, etc. is built in. General-purpose I/O of up to 256 channels can be expanded on the same slot. Three-axes linear interpolation, 2-axes arc interpolation, and other functions are provided and application which requires multiple servo axes, for example, effective application for X-Y table positioning control, spindle, traverse axis and other multi-axis configuration winder or autoloader, etc. is planned. The composite speed between axes can be controlled uniformly even for complex tracking control by multi-stage data continuation function in the interpolation control mode. For example, it can be used advantageously even with an adhesive coater, etc. Data transfer with a high-level controller can be achieved by serial communication by RS-232C (option), in addition to general-purpose I/O.

3.2.6 Servomodule (FGU120B)

A MICREX-F is connected on the base board and highspeed transfer of position data, present position data, and various other motion information, in addition to automatic, manual, zero return, override, or single operation, and other commands, is possible.

Besides various interpolation functions, "synchronous operation of servomotors of up to 8 axes" is possible, in addition to "S acceleration/deceleration" for shockless starting, "feed forward control" for slow response improvement, "interrupt positioning by external signal" which performs precision positioning after external marker detection, and other functions. Abundant control function unavailable up to now can be added. Application can be expanded to application which were formerly difficult by menas of these functions.

(1) Very small shock and vibration conveying equipment
(2) Multicolor printer mark positioning
(3) High-speed press feeder or punch press
(4) Synchronous and ratio operation of machines on machining and assembly line

4. CONCLUSION

Servosystem components were outlined. For the detailed specifications, functions, and characteristics of each component, see the other articles. In the marketplace, the pursuit of automation and labor-saving technology will be the mission of manufactures in the future. We plant advanced functions and diversification suitable for servosystem components. Especially, greater effort will be put into expansion and equipping of various positioning modules which are built into a general-purpose PC and completion of various system component groups.