

AC SPINDLE DRIVE SYSTEM FOR SMALL-SIZED MACHINE TOOL FRENIC 5000M

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1 FOREWORD

For driving spindles of small-sized lathes or milling machine, the standard cage rotor type induction motors have been used conventionally, and speed change was effectuated by changing the pulley ratio or through gradual change by pole-number changing cage rotor type induction motor as the case may be. But with a view of miniaturizing of machines and improving the functionality, electric variable speed spindle drive system has come to be desired. For coping with such demands, Fuji Electric has developed and is now mass producing high performance and maintenance free AC Spindle Drive System FRENIC 5000M.

This AC Spindle Drive System consists of exclusively designed cage rotor type induction motor and PWM (pulse-width modulation) inverter, but different from general-purpose AC variable-speed motor, in order to improve accelerating/decelerating performance and making speed higher of shortening the working cycles, it is designed and constructed as an optimum product for small-sized machine tools. *Fig. 1* shows its outer view.

In the following, features, specifications and performance of FRENIC 5000M are described.

2 FEATURES

The features of FRENIC 5000M AC Spindle Drive System are the following.

1) Short accelerating/decelerating time

In a wide range of constant torque and constant output, by enlarging overcurrent capacity of the drive unit and control giving accelerating/decelerating command by a curve suitable for the torque generated by a motor, shortening of accelerating/decelerating time is attained.

This contributes greatly to the improvement of work efficiency of small-sized machine tools as automatic lathe.

2) Wide adjusting speed control

By means of a specially designed motor and inverter, a speed control range as wide as 150 to 4,500 rpm (constant torque + constant output range) can be obtained for the operation.

3) Smooth reversible operation and stopping

As shockless progressive/reverse operation switchover system is adopted, a smooth reversible operation of the spindle can be attained. Also, for stopping, a DC braking under 0.5 Hz will be applied for obtaining sure and quick stopping operation.

4) Interface and option for NC machine tool

As an interface in full consideration of NC equipment, important functions as detection of designed speed attained, speed zero detection and override setting are equipped as standard equipment.

As an option, a frequency meter, D/A converter for coping with the digital speed command, and simplified orientation system for stopping at fixed point with a precision of 2 to 3° of the spindle are available.

3 SPECIFICATION

3.1 Standard specifications

Table 1 shows the standard specifications.

1) Rated output

Five models ranging from 1.5 to 7.5 kW are made as standard equipment, but upon a special request, construction up to 11 kW is possible.

Fig. 1 FRENIC 5000M series AC spindle drive system

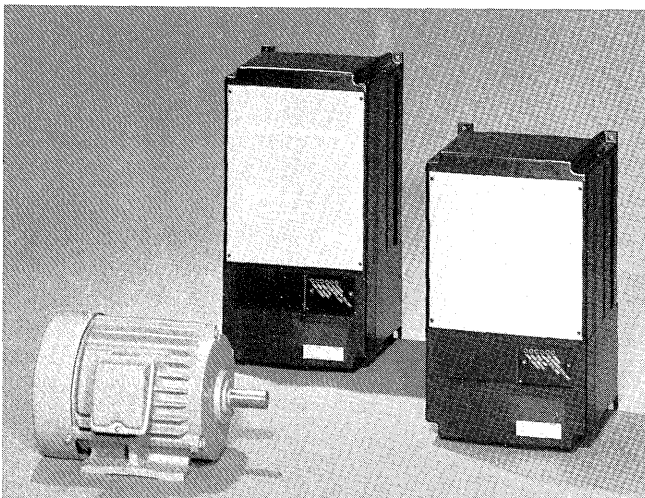


Table 1 List of standard specifications

Series name		FRENIC 5000M				
System name FMD-		1A	2A	3A	5A	7A
Spindle motor	Continuous rating output (kW)	1.5	2.2	3.7	5.5	7.5
	Based speed (rpm)	1,500 (Synchronous speed)				
	Maximum speed (rpm)	4,500 (Synchronous speed)				
	Model MPF	2097	2107	2115	2133	2135
	Continuous fan capacity (kg · m)	0.97	1.43	2.40	3.57	4.87
	GD ² (kg · m ²)	0.022	0.028	0.064	0.11	0.14
	Approximate weight (kg)	22	26	46	60	74
	Cooling fan capacity	— 1 φ, 50 W				
	Vibration	V 10 or less				
	Noise	75 dB (A) or less				
	Overload resistance	150%, one minute				
	Mounting system	Foot mounting type (F11) Flange type (LS1, LS2)				
	Color of paint	Munsell N5				
	Accessories	Forced cooling fan (3.7 kW or more only) PTC thermistor				
	Installing place	Indoors, altitude: 1,000 m or lower				
	Ambient temperature and humidity	-10~+40°C, 20~90% RH (no condensation allowed)				
Drive unit	Model FMD-	1AN-21	2AN-21	3AN-21	5AN-21	7AN-21
	Power supply capacity (kVA)	3	4	7	9	13
	Power supply	3 φ, 200/220·230 V±10%, 50/60 Hz ±5%				
	Generated heat value (W)	120	150	220	300	400
	Approximate weight (kg)	10	12	15		
	Main circuit system	Transistor type sinusoidal wave PWM type VVVF inverter				
	Control system	V/F control				
	Operating system	Reversible operation (selected by contact signal)				
	Braking system	Dynamic braking (10% ED rating) and DC braking (0.5 Hz or less)				
	Frequency control range	0.5~150 Hz (200 Hz also possible)				
	Frequency precision	±0.5% (25±10 °C)				
	Frequency setting voltage	+10V or -10V/maximum frequency				
	Accelerating/decelerating system	Soft start/soft stop (1~10 sec. 16 item setting)				
	Color of paint	Munsell 1.2 semi-gloss (Cover: Munsell 1PB5/1.3)				
	Option	D/A converter, simplified orientation system				
	Installing place	Indoors, altitude: 1,000 m or less				
	Ambient temperature and humidity	0~+50 °C, 20~90% RH (No condensation allowed).				

2) Maximum speed

As the standard practice for all models, 4,500 rpm is the maximum speed, but upon a special request, construction up to 6,000-rpm equipment is possible.

3) Input power supply

As the input voltage of 200 to 230 V±10% is tolerable, the equipment can be used simply by switching an internal selector switch even for the areas where 230 V power supply is used as in the United States.

4) Braking

In order to shorten the decelerating time, regenerative discharge circuit will be equipped as standard practice and discharge resistance equivalent of 10% ED is supplied as accessories outside of the inverter unit.

3.2 Option

1) D/A converter

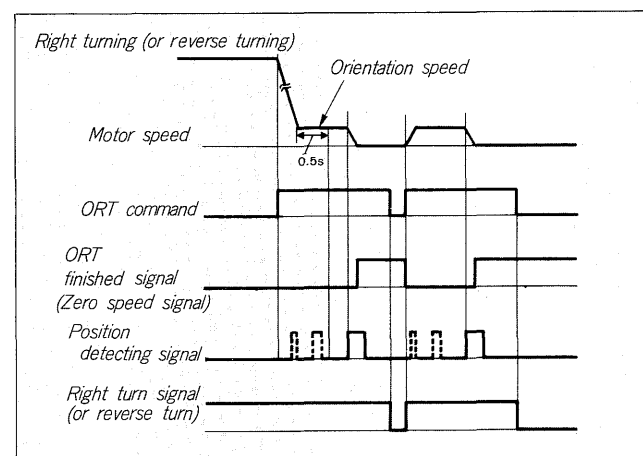
Two types of printed-circuit boards are available for coping with 12-bit binary and BCD 2-digit signals as digital signal of speed command.

2) Simplified orientation

In due consideration of cases in which the work replacement of small-sized machine tools is carried out by robots, it is designed to carry out fixed point stopping with a precision of ±2 to 3° as for the spindle angular position.

The operation is explained by referring to the time chart given in Fig. 2. When an ORT command signal is inputted during an operation with optional speed, the spindle motor will be decelerated to preset ORT speed (1 to 1.5 Hz). Also, when ORT command signal is received during a machine stop, it will be accelerated once to ORT speed, then stops at a designed position.

Fig. 2 Simplified orientation operating time chart



4 CIRCUIT COMPOSITION

Fig. 3 shows the circuit composition. Main points of the composition are explained in the following.

Fig. 3 Circuit composition

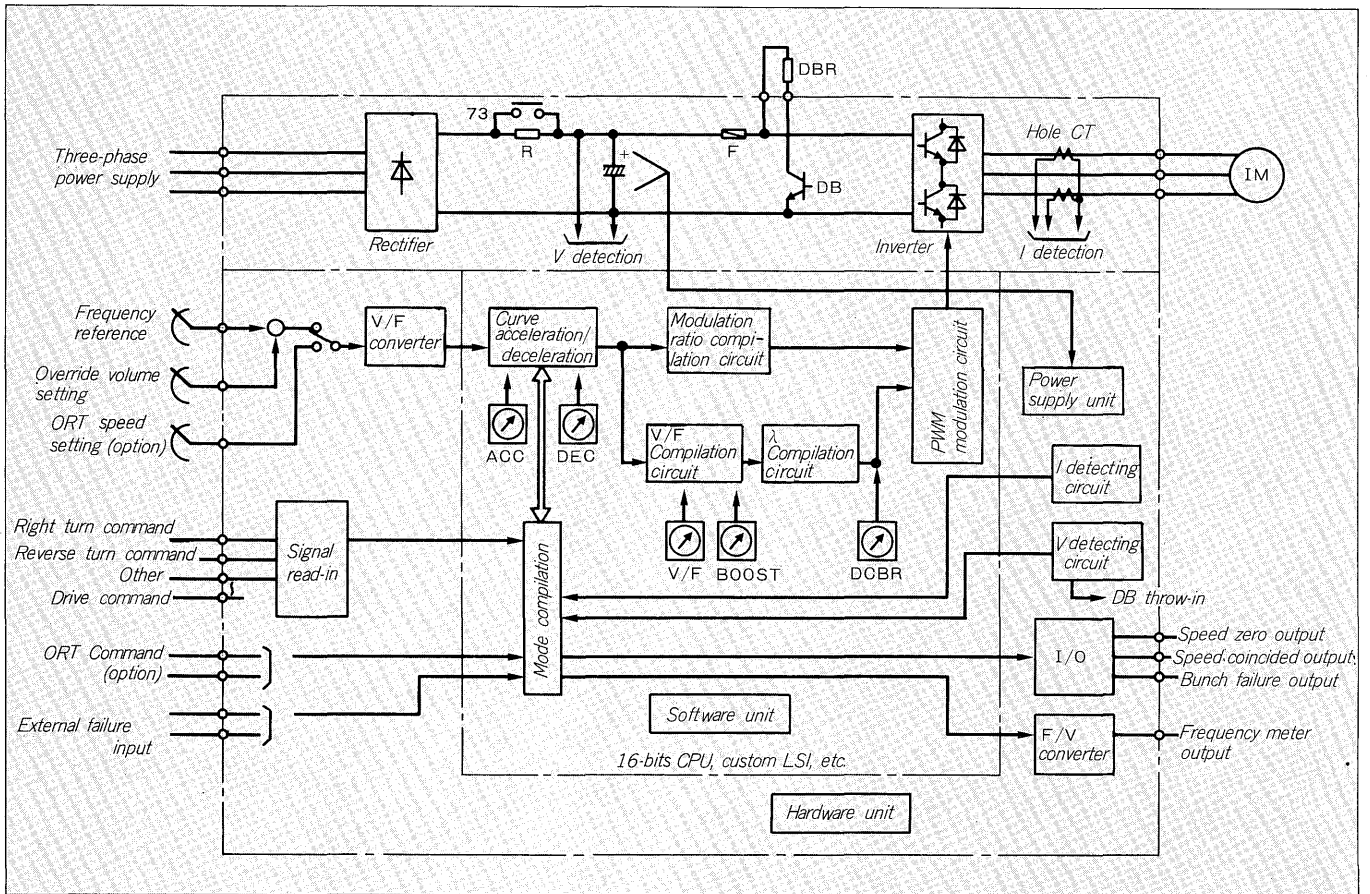


Fig. 4 Acceleration/deceleration characteristics (Motor only)

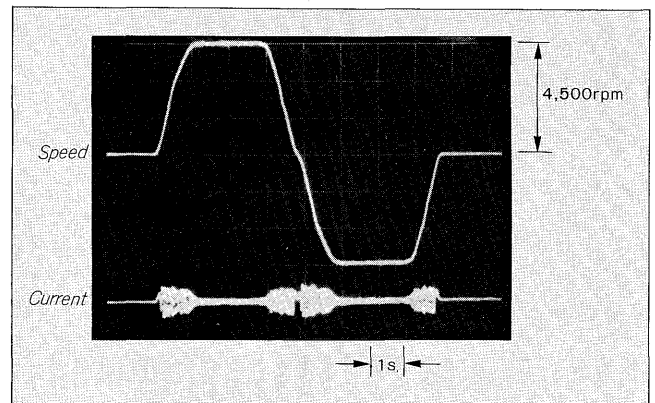
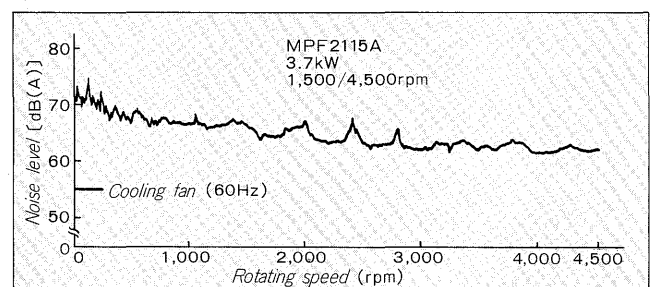


Fig. 5 Spindle motor noise characteristics



4.1 Main circuit

The circuit is structured with the same design concept as that of FUJI ELECTRIC's general-purpose inverters. That is, it is designed to have a larger overcurrent capacity (200%), and it is equipped with a regenerative discharge circuit for intensifying the braking torque as standard equipment.

4.2 Control circuit

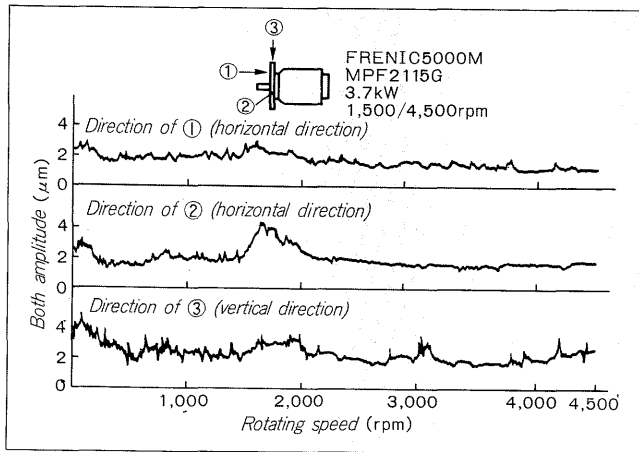
The main control circuits except for interface circuit, base drive circuit and protective circuit are covered with software by high-performance 16-bit micro-computer. So that number of parts is reduced and reliability is much improved.

The power supply for the control circuit is obtained from DC intermediate circuit of the main circuit, and it has a performance of allowable momentaneous interruption time of more than 100 ms.

5 OPERATING CHARACTERISTICS

Fig. 4 shows an oscillogram of accelerating/decelerating operation consisting of Acceleration-Reverse Operation - Stop. The speed for both way operations (progressive/reverse) is 4,500 rpm, but current-limiting acceleration is

Fig. 6 Spindle motor vibration characteristics



carried out even for constant output range more than 1,500 rpm. Switching over between progressive/reverse rotations is carried out by 0.5 Hz, so that smooth and natural changeover operations can be attained from the

point of view of current waveform.

Fig. 5 shows the results of noise measurement. In the high-speed operation range, which is the most frequently used region, particularly quiet operating characteristics are obtained.

Fig. 6 shows the results of vibration measurement in the whole operating range measured in three directions. An amplitude of 5 μm is attained in all-over range.

6 SUMMARY

We have in this report introduced newly developed FRENIC 5000M excellent in cost performance as the spindle drive system for small-sized machine tools.

The newly developed system enjoys a big popularity since it expanded a range of machine type selection as machine tool spindle driving system, used in combination with high-performance superior-order series 5000V2/VH2.

We intend to improve and expand the manufacture of this type of machine so that we ask for kind suggestions and instructions from the users.