

# HIGH-ACCURACY TRANSISTOR INVERTER (FRENIC 5000T) FOR SYNTHETIC FIBER INDUSTRIES

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## 1 FOREWORD

Recently, as the power transistor performance made a giant leap forward innovation and has become highly resistant to high voltage and compatible with larger current, realization of transistor inverters with higher economicity is made possible and its application field also is rapidly expanding. As Fuji Electric has developed a new transistor inverter FRENIC 5000T whose chief aim is to apply to synthetic fiber industries, we like to introduce their features.

As the outstanding features of 5000T, we can cite:

- (1) High efficiency and high power factor operation through sinusoidal PWM control.
- (2) Adoption of a new protective system from short-circuit (Patent pending).
- (3) Possibility of coping with automatic systems.
- (4) High-precision frequency ( $\pm 0.01\%$ ).
- (5) Compactness in size and lightness in weight.

In the following, the outline of 5000T is described.

Fig. 1 shows its outer view.

Fig. 1 FRENIC 5000T



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## 2 OUTLINES

### 2.1 Circuit composition

Fig. 2 shows 5000T circuit composition. The main circuit consists of diode rectifier, DC intermediate circuit and transistor PWM inverter. Optionally, application of common DC bus system connecting several inverters to DC bus, regenerative braking and generating braking systems are possible. For inverter main circuit, insulating type large-capacity power transistor modules easy to compose hardwares are adopted.

### 2.2 Control system

For control system of 5000T, synchronous type sinusoidal wave PWM control is adopted. By the adoption of this system, the inverter output current is made into sinusoidal wave approximately, motor efficiency is much improved in comparison with PAM control 6-step inverters. Fig. 3 shows the waveforms of output voltage and current under load of 5000T.

In due consideration of the fact that the inverter precision determines directly the quality of fiber products, the output frequency precision is set as high as  $\pm 0.01\%$ . The characteristics of the control circuit is, in contrast that the conventional thyristor inverter FRENIC 1000 used to be analogic, that the digital system has been adopted in large scale.

### 2.3 Protective system

- (1) Protection from instantaneous power supply interruption

In the fiber industry, it is necessary to keep operating the machinery without stopping the work when there occurs a voltage drop or instantaneous power supply interruption. In order to compensate this continuous operation of the plant, 5000T adopted the following operating system:

First, when an instantaneous power supply interruption takes place, the motor will run by inertia and during this period, the inverter will continue operating in

Fig. 2 Circuit composition of FRENIC 5000T

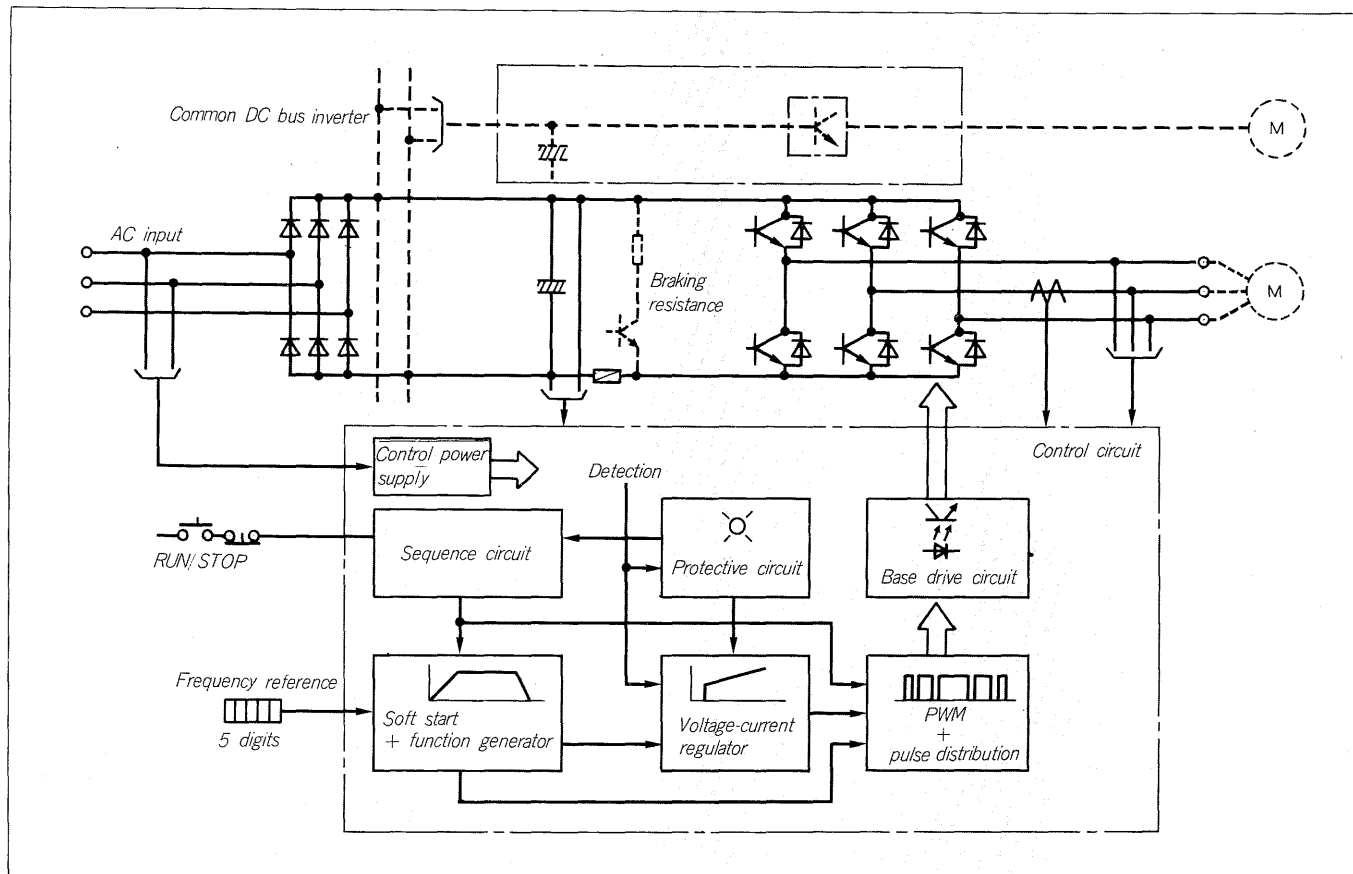


Fig. 3 Output voltage and current waveform of FRENIC 5000T

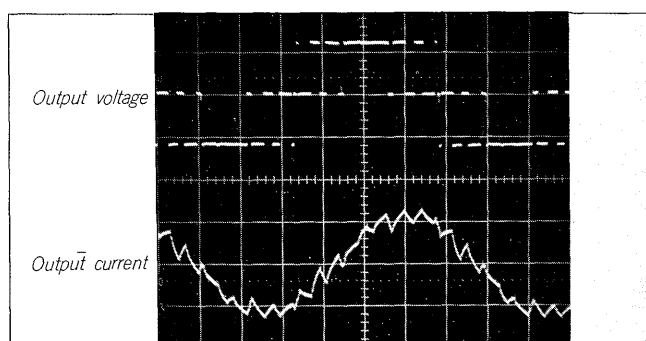
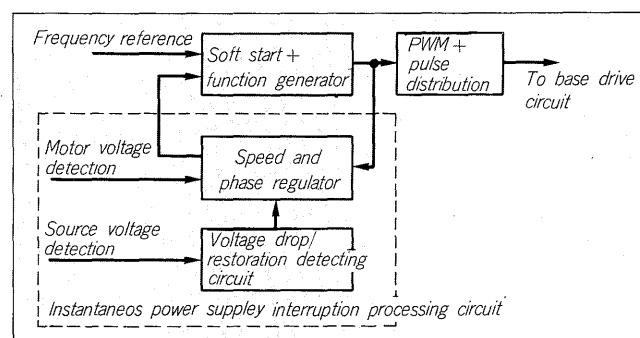


Fig. 4 Block diagram of instantaneous power supply interruption processing circuit



synchronization with the motor rotating speed. Then, when the power supply is restored, the control equipment frequency will act as accelerating signal and motor will gradually be accelerated and regain its original speed. This operation can be attained by adding the instantaneous power supply interruption device up to 100% for one second of voltage drop. Also, in this inverter, the standard practice is to cope with the voltage drop down to 50% for one second. Fig. 4 shows the control block diagram.

## (2) Protection from overcurrent

By whatever the cause an overcurrent and/or short-circuit current are produced during the inverter operation, it is necessary that prompt protective action should take place in order to prevent the machine from breakdown.

5000T machines are provided with the following three-step protective measures.

### (a) Protection from overload

The protective means consist of an electronic circuit having time limiting characteristics and protect the machine from an overload of 150% for more than one minute.

### (b) Protection from overcurrent

By the action of control equipment, current limiting control is made.

### (c) Protecting from short circuit

Usually, the inverter is securely protected from overload and overcurrent by the current limiting control of the control equipment. However when there

is any failure due to the arm short-circuit or troubles, or misoperation of the control equipment, in extreme cases, the transistor may break down. For 5000T, even in case of these short-circuits, protective measures are duly protected for preventing the momentaneous transistor breakdown.

For (c) above, the protective measures are two-folded.

One is, by taking advantage fully of short-circuit withstanding capability that power transistors have, to interrupt the base current by detecting the short-circuit current within the withstanding capability. The other is, by taking advantage of transistor output characteristics, to inteerrupt automatically the base current by detecting the short-circuit current with the transistor base circuit by itself apart from the control equipment. (Patent pending).

Fig. 5 Short-circuit protection circuit

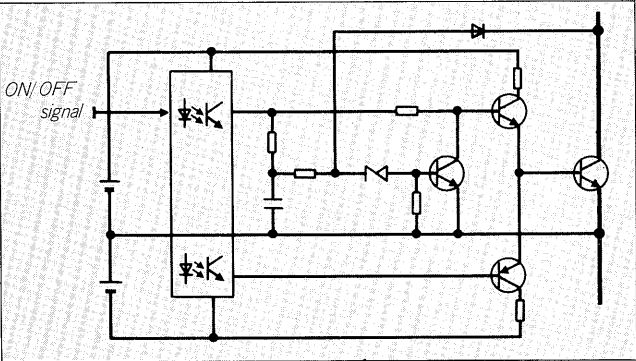


Table 1 Standard specifications of FRENIC 5000T

Item		Specifications						
Rating	Capacity (kVA)	15	30	60	90	120	150	200
	Current (A)	22	43	87	130	173	216	288
	Short-term capacity	150% overload, 1 minute						
Input	Main circuit voltage	Three-phase AC 440/400 V±10%						
	Frequency	50/60 Hz ±5%						
	Voltage drop	50% drop within 1 second, inverter can be operated.						
Environment	Installing place	Indoors						
	Altitude	1,000 m or less						
	Humidity	90% RH or less (no condensation allowed)						
Control specification	Output voltage	Three-phase AC 400 V						
	Output frequency	5 ~ 300 Hz						
	Control system	Sinusoidal-wave PWM control						
	Frequency control range	1 : 10						
	Output frequency precision	0.01%						
	V/f characteristics	V/f constant control						
	Accelerating/decelerating time	6 ~ 60 seconds/60 ~ 600 seconds, switchable						
	Speed control signal	BCD 5 digits						
Color of paint		Surface and interior Munsell 5Y7/1						

Fig. 5 shows the short-circuit protecting circuit.

By adopting these circuits, 5000T is promised to have

Table 2 Option

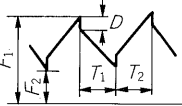
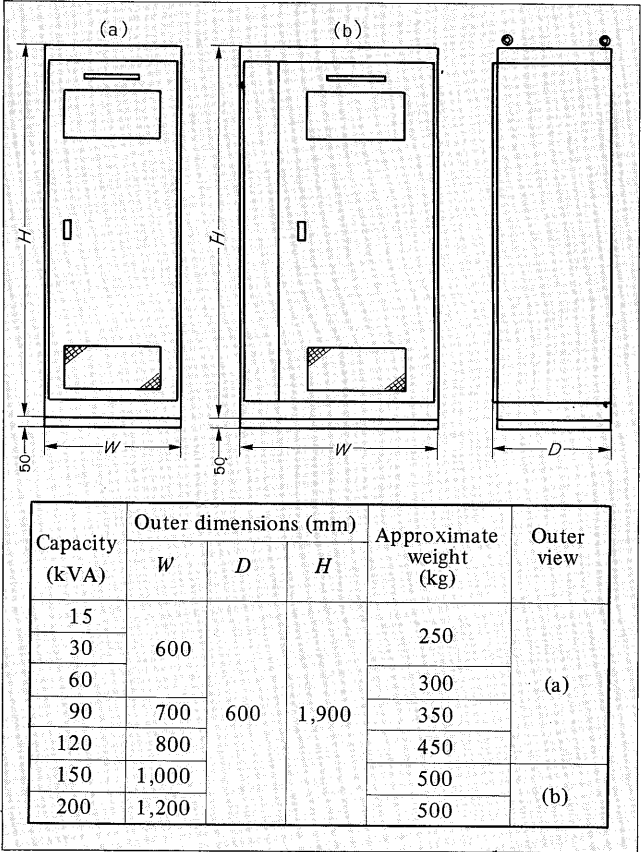
Item	Specifications
Traverse	 $F_1, F_2 = 30.0 \sim 300.0 \text{ Hz}$ $D = 0.0 \sim 9.9 \text{ Hz}$ $T_1, T_2 = 0.1 \sim 99.9 \text{ s}$
Ratio operation	$B \text{ (Hz)} = A \text{ (Hz)} \times K \text{ (\%)}$ $A = 30.00 \sim 300.00 \text{ Hz}$ $K = 80 \sim 120\%$
Instantaneous power supply interruption device	Operation compensation after 1 second when 100% drop occurs.
Braking system	(1) Generating braking (2) Common DC bus (3) Power source regeneration
Synchronism switching	(1) Switching between inverters (2) Switching between inverter and commercial power source
Others	(1) Input power factor improving reactor (2) Input/output transformer

Fig. 6 Outer dimensions of FRENIC 5000T



an extremely stable protective operation.

2.4 Standard series

Table 1 shows the standard specifications of 5000T. The capacity series are available in 7 models. Also, on the basis of technological experience with FRENIC 1000, a full line of options (Table 2) that can be applied for all purposes are available. Fig. 6 shows the outer dimensions of 5000T. The outer dimensions are made smaller and lighter in weight in comparison with the conventional thyristor type machines.

3 APPLICATION TO SYNTHETIC FIBER INDUSTRY PLANTS

3.1 Application to take-up machines

Fig. 7 shows an example of typical application to take-up machines which are the representative installation in the synthetic fiber industries. Also, Fig. 8 shows an outer view of a permosyn motor (permanent magnet synchronous

Fig. 7 An example of application to take-up machine

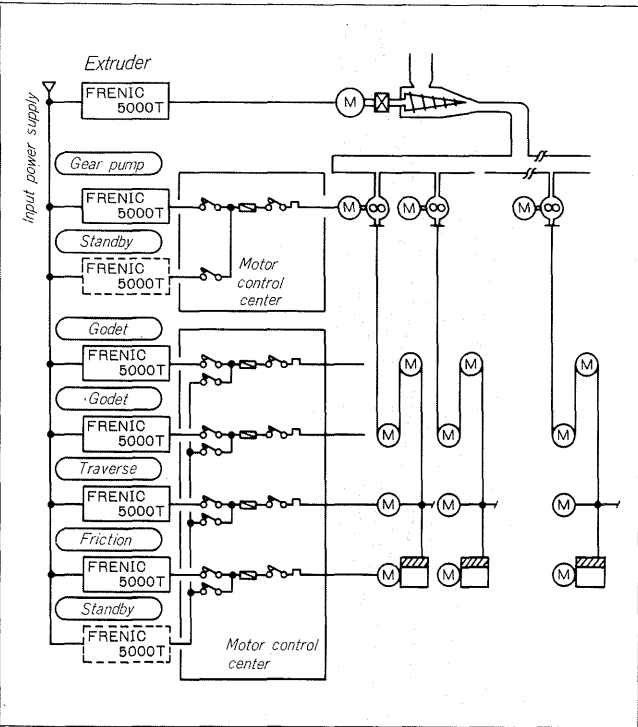
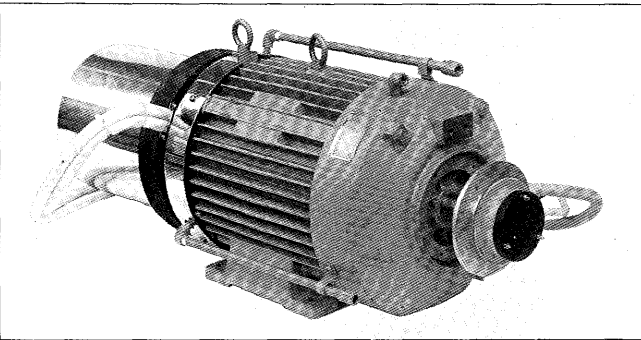


Fig. 8 Permosyn motor



10090-3

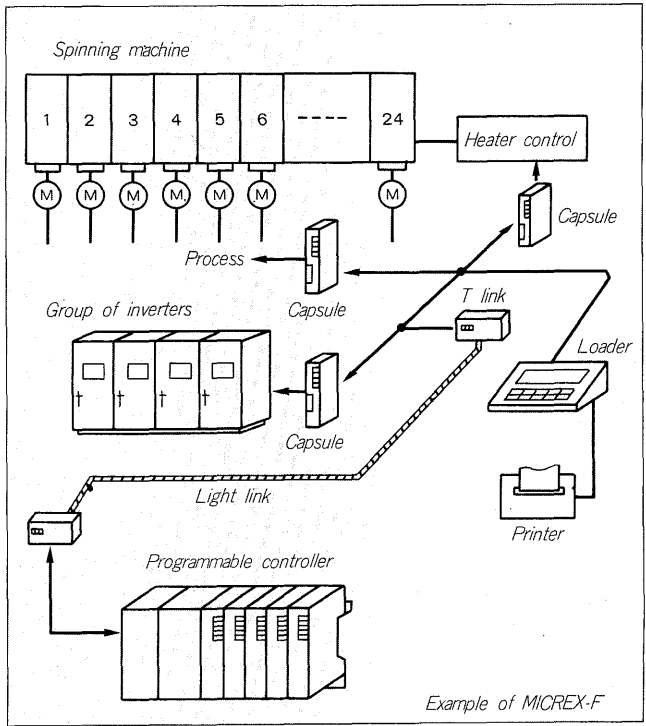
motor) driven by the inverter. In this example of application, a high-precision inverter is adopted for all sections and carries out high speed-precision group control even for the open loop. A standby inverter is provided so that the operation can be carried out without interruption even when the inverter fails, adopting a system that can carry out backup on-line, instead of failed inverter. As it is clear from the above description, an optimization of the system is complete from a pursuit of higher reliability of inverter itself to the means of back-up for the entire system. Together with the progress of adoption of high-speed spinning machines for the entire plant, the improvement of winding machine performance has come to play more and more important role. The new series of inverters are designed and constructed in due consideration of the improvement in performance of machineries to which inverters are applied.

3.2 Applications to automatic systems

Fig. 9 shows an example of application to an automatized take-up machine.

Demands for operational speed increase and degree of automatization are more and more increasing. Here, in this system, an inverter control is being made by using Fuji Electric's general-purpose programmable controller. The inverter sends and receives data at each 10 ms through T link transfer line, so that it can obtain speedy responses. Between the inverter and remote capsule, serial or parallel bilateral transmission system is adopted and used for each plant, so that a flexibility larger than the conventional system can be obtained. Also, a loader is directly connected to the T link, so that specific data of the inverter can be effectuated, being the construction extremely advantageous

Fig. 9 An example of automatization in synthetic fiber industry



Example of MICREX-F

for maintenance. The contents of inverter control are, as we can cite among others, setting of automatic spinning speed in each section, transfer to optimum pattern with the change in operating speed, collection of operating data, collection of failure contents, etc. When remote capsules are installed in the inverter room, as the connection between central controllers can be effectuated with a pair of cables, reduction in the costs and the term of the construction work can be obtained.

#### **[4] SUMMARY**

Fuji Electric has a record of manufacturing and delivering a multitude of thyristor type inverters for synthetic fiber industries. We ascertain that the new type of transistor inverter FRENIC 5000T that we have introduced in this

report is easier to use and higher performance and higher economicity products developed on the basis of power electronic technology represented by power transistors and technological know-hows accumulated up to now in the field of synthetic industries.

The progress of power electronic technology knows no boundaries. This technological progress will further, so it seems, realize newer still synthetic fiber inverters in the very near future. Fuji Electric is determined to utilize to the full the technique that it has cultivated in the sector of fiber industries on the basis of the technological capacity mentioned above, and by watching closely the tendency of the movement of the industry, for developing and improving still easier-to-use products. We request generous support and cooperations from our clients.