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LOW CAPACITY INVERTER FOR GENERAL USE FVR-G7S

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1. FOREWORD

The inverter for general use has advanced considerably up to here. In 1985 the Fuji Electric FVR-G5 Series was placed on sale and the age of the all-digital, multifunction inverter for general use was entered. In the five years since its introduction, numerous new demands have been raised by users. The main demands are for upgrading of functions centered about system correspondence, simple operation, fast response, high precision, and trip-free operation except when trouble occurs.

To meet these demands, the standard type inverter for general use FVR-G7S, which introduced much new hardware and software technology, including a specially designed 32-bit DSP (Digital Signal Processor), was developed and is outlined here. The FVR-K7S Series introduced in a separate article is a sister product developed, as a simple type inverter with limited functions.

2. BASIC FEATURES OF NEW MODEL

To meet the type of industry, equipment, operator experience, and other different demands and to maintain economy, the numerous new technologies accumulated up to here were introduced and inverter development was promoted. Its basic features are:

(1) High accuracy and multiple functions

The number of functions was about tripled and many new functions were installed. A high resolution of 0.002Hz and high accuracy of 0.01% are also obtained.

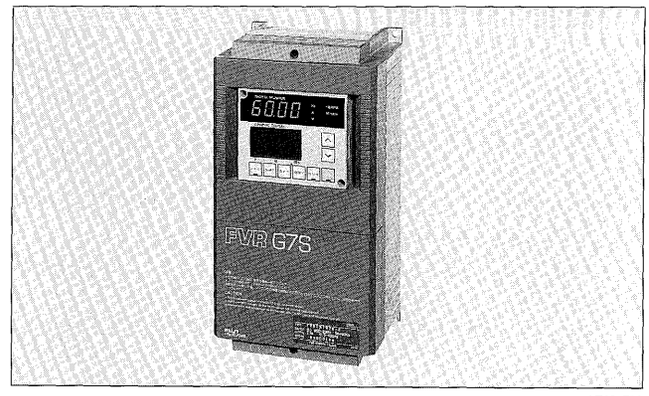
(2) High-speed control

To achieve multiple functions, there are such problems as the software is generally long and as a result, the time to cycle it is long and the response time is long.

To solve these problems, the processing time was shortened tremendously by using an ultra high-speed operation 32-bit DSP and reading of analog signals by A/D converter, etc. As a result, the effect of the increased number of functions was canceled and a processing speed of several times that in the past couled be achieved.

The result is realization of trip-free operation in impact lead and motor direct-on-line starting, and other severe operation. Improvement of positioning accuracy in conveying equipment can also be expected.

Fig. 1 FVR-G7S



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(3) Small size and high reliability

The inverter is shown in *Fig. 1*. The following development was performend with emphasis an smaller size than old products, same dimensions for 200V and 400V class, environmental correspondence by totally enclosed construction, improvement of workability at manufacture and maintenance.

For the control circuit, a DSP as the operation element and an ultra LSI corresponding to the peripheral circuit were newly developed and the printed circuit board was miniaturized by housing most of the control circuit functions in these two elements.

For the main circuit section, in the low capacity range of 3.7kW or less, a compound power module housing the main circuit parts, except the electrolytic capacitor, was developed and a reduction of the occupied area and elimination of wiring were realized. For models of 5.5 kW and greater, productivity was improved and maintenance was simplified by using a wiring board with the main circuit wiring copper bar integrated on an insulated board.

Regarding cooling design, since the generation of internal heat was suppressed by a construction which dissipates the heat of all the heat generating parts, up to the base drive circuit and control power supply circuit, besides the main circuit elements, to the main cooling body, a totally-enclosed construction of all models was realized.

(4) Easy-to-understand operation

Many innovations were made against such disadvan-

tages as "We want the advantages of multiple functions, but troublesome operation is a problem", "It is a nuisance to those which use basic functions only", etc.

First, a method by which the setting functions are grouped into basic functions, standard functions, and advanced functions and reduces them to range of the basic functions only in the factory setting state and range modification setting is performed by the customer when desiring to advance to the range of standard functions, etc.

Next, an LCD screen display is added as shown at the screen operation section of *Fig. 1* and the function items are selected in conversation form and the data uses a very detailed real number display and units display and erroneous setting is prevented.

3. OVERVIEW OF CIRCUIT CONFIGURATION AND SPECIFICATIONS

The circuit configuration (3.7kW or less) is outlined in *Fig. 2.*

(1) Simple current detection

A dedicated main circuit module was developed and 3-phase current by one current detectioon resistor and microcomputer operation.

(2) High-speed operation current limiting and voltage adjuster

The load current and DC intermediate circuit voltage are read continuously at high-speed by using an A/D converter. Overall, high-speed operation of 1ms or less was achieved. This allows stable control relative to load and power supply variative to load and power supply variations.

(3) Abundate input and output signals

Multistep speed operation up to 8 steps by the 3 bit signals X1 to X3, acceleration and deceleration time switching up to 4 steps by the 2 bits signals RT1 and RT2, various monitor signals, and other convenient signals were provided. The function of some terminals can be switched by setting modification from the keypad panel.

Table 1 shows the specifications centered about the FVR-G7S power circuit. The following improvements were made as compared to the old FVR-5S Series.

(4) Detailed capacity and review of current ratings

The low capacity range capacity series was broken down in detail and economical cpaacity selection was made possible. Moreover, 380V, 4-pole motor is applied at standard capacity and the overall current rating is reviewed.

4. OPERATING CHARACTERISTICS AND APPLICATION TECHNOLOGY

4.1 Current limiting control

The most severe operation condition is direct-on-line starting of the motor while the inverter is running. *Figure 3*

Fig. 2 FVR-G7S circuit configuration (3.7kW or less)

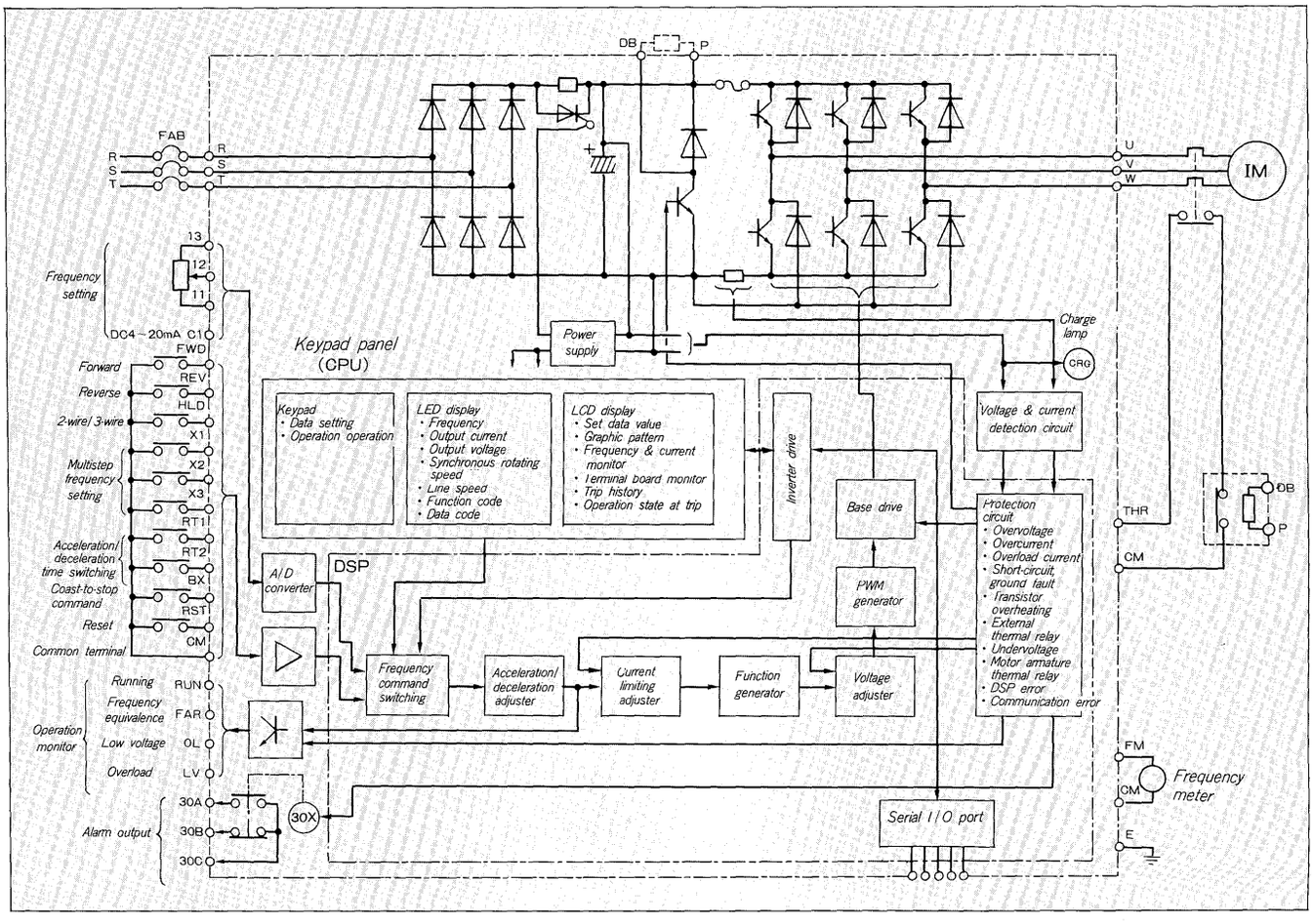


Table 1 FVR-G7S outline specifications

(a) 200V series

Item \ Model			FVR004 G7S-2	FVR008 G7S-2	FVR015 G7S-2	FVR022 G7S-2	FVR037 G7S-2	FVR055 G7S-2	FVR075 G7S-2	FVR110 G7S-2	FVR150 G7S-2	FVR185 G7S-2	FVR220 G7S-2
Standard applicable motors (kW)			0.4	0.75	1.5	2.2	3.7	5.5	7.5	11	15	18.5	22
Output	Rated capacity (kVA)		1.2	2	3	4	6	9	13	17	22	28	33
	Rated output voltage		3-phase, 3-wire system, 200 to 230V										
	Rated output frequency		50 ~ 400Hz										
	Rated output current (A)		3	5	8	11	17	25	33	46	59	74	87
	Overload current rating		150% for 1 minute (inverse time characteristic)										
Braking torque	Standard equipment	Regenerative braking	150% min.			100% min.		40% min.		Condenser regenerative braking: 20% min.			
		DC braking	Braking start frequency 0.5 to 60Hz, braking time 0.01 to 30 sec, braking voltage 0 to 15%										
	When option used	Type	Braking resistor							Braking resistor and control unit			
		Torque	150% min.			100% min.				100% min.			
Power	Rated input AC voltage		3-phase, 3-wire 200 to 230V, 50/60Hz										
	Allowable fluctuation		Voltage: $^{+10\%}_{-15\%}$, voltage unbalance ratio: within 3%, frequency: ±5%										
Cooling method			Fully enclosed self cooling type (IP40)		Fully enclosed forced cooling type (IP40...,except cooling fan)								
Approx. weight (kg)			2.7	2.8	4.9	5.0	5.0	9.0	9.2	13.0	13.4	16.8	17.0

(b) 400V series

Item \ Model			FVR008 G7S-4	FVR015 G7S-4	FVR022 G7S-4	FVR037 G7S-4	FVR055 G7S-4	FVR075 G7S-4	FVR110 G7S-4	FVR150 G7S-4	FVR185 G7S-4	FVR220 G7S-4
Standard applicable motors (kW)			0.4~0.75	1.5	2.2	3.7	5.5	7.5	11	15	18.5	22
Output	Rated capacity (kVA)		2	3	4	6	9	13	17	22	28	33
	Rated output voltage		3-phase, 3-wire system, 380 to 460V									
	Rated output frequency		50 ~ 400Hz									
	Rated output current (A)		2.5	3.7	5.5	9.0	13	18	24	30	39	45
	Overload current rating		150% for 1 minute (inverse time characteristic)									
Braking torque	Standard equipment	Regenerative braking	150% min.	65% min.	45% min.	40% min.	35% min.		Condenser regenerative braking: 20% min.			
		DC braking	Braking start frequency 0.5 to 60Hz, braking time 0.01 to 30 secs, braking voltage 0 to 15%									
	When option used	Type	Braking resistor						Braking resistor and control unit			
		Torque	150% min.		100% min.				100% min.			
Power	Rated input AC voltage		3-phase, 3-wire 380 to 460V, 50/60Hz									
	Allowable fluctuation		Voltage: $^{+10\%}_{-15\%}$, voltage unbalance ratio: within 3%, frequency: ±5%									
Cooling method			Fully enclosed self cooling type (IP40)		Fully enclosed forced cooling type (IP40... , except cooling fan)							
Approx. weight (kg)			3.6	4.9	5.0	5.0	9.3	9.5	12.9	13.0	16.6	16.9

is an example of its operating characteristics, the overcurrent which flows at closing of the motor is limited to 150% and the frequency is lowered and speed search is performed during this time. Since the current is lowered when the frequency matches the speed, this is judged and the motor is accelerated up to the set frequency.

For impact loads, persistent operation is possible by controlling the frequency in the constant torque state shown in *Fig. 4*.

4.2 Slip compensation control

Figure 5 is an example of the slip compensation control characteristic. The speed torque and current curves with and without slip compensation are compared. If slip compensation control is selected, a stable speed relative to load torque changes is obtained. Since the optimum slip compensation amount for the 4-pole standard applicable motor is selected, there is a slight difference when the capacity application is different.

4.3 Pattern operation

An example of program operation is shown in *Fig. 6*. Speed (frequency) up to 7 steps, direction of rotation, time of each step, etc. can be preselected and pattern operation can be performed.

The processing method after the end of T7 of the last zone can be selected from among (1) stop, (2) return to speed 1 and cycle operation, and (3) continuous operation at speed 7. The "time-up signal" or "cycle end signal" shown in *Fig. 6* is output as the program advance monitor signal.

Fig. 3 Example of direct-on-line starting characteristic

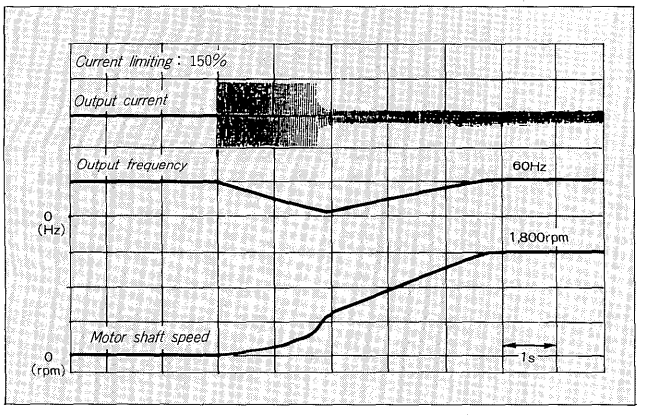
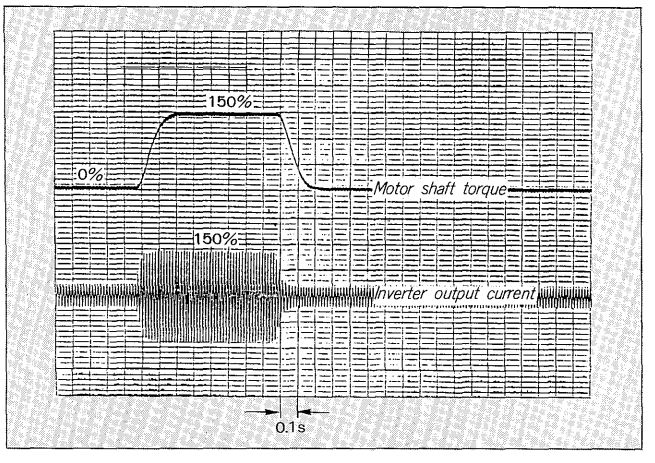


Fig. 4 Example of current limiting control characteristic



4.4 Operation between inverters

The linked operation configuration and signal flow are shown in *Fig. 7*. In a facility which uses multiple inverters, if the inverters are interconnected with a special link cable, all the inverters can be controlled from the terminals of a representative inverter (master). Therefore, the wiring

Fig. 5 Example of slip compensation control (3.7kW, 4-pole)

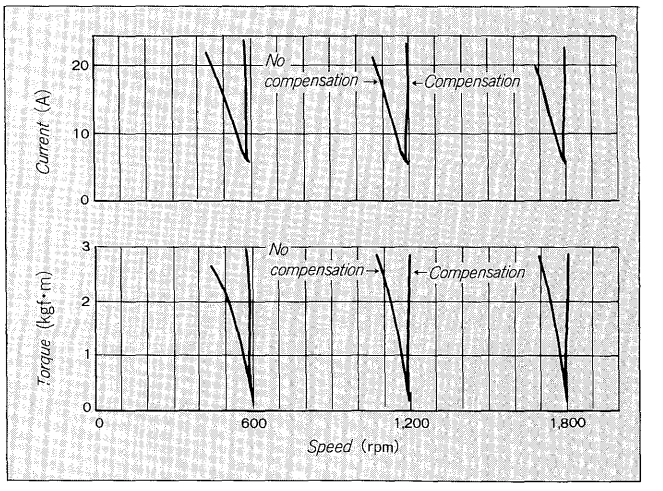


Fig. 6 Inverter operation example

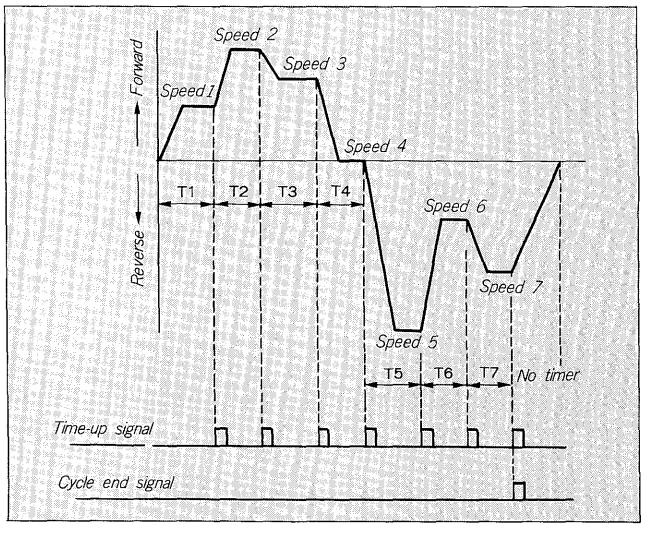
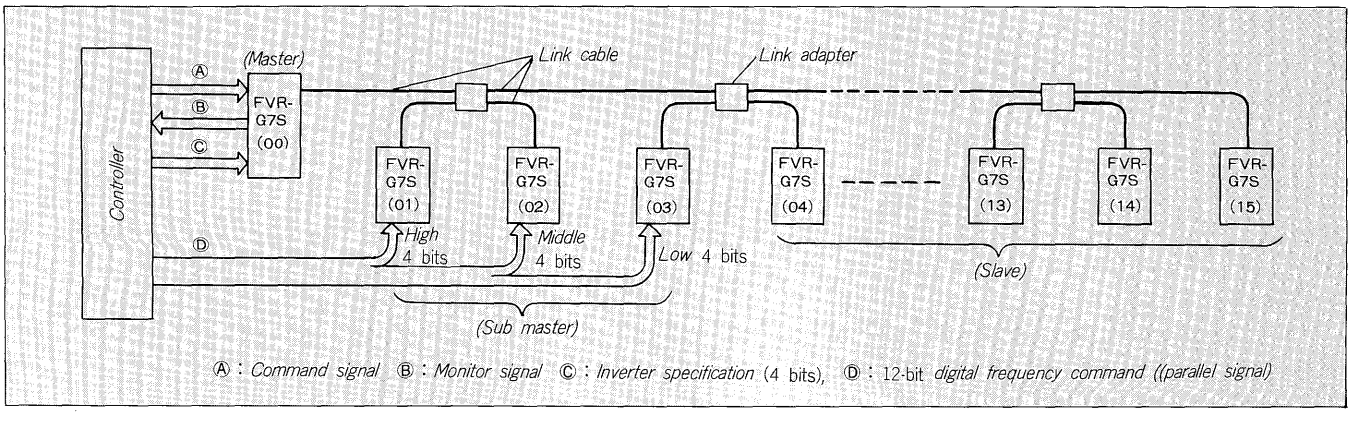


Fig. 7 Linked operation configuration and signal flow



and wiring check work related to running operation can be omitted. This also allows work at maintenance, besides solving the problem of induced noise in the control panel.

The linked operation functions are outlined below.

(1) The representative inverter is called "master" and the other inverters are generally called "slave". When some of the terminals of a slave are used, it is classified as "sub master".

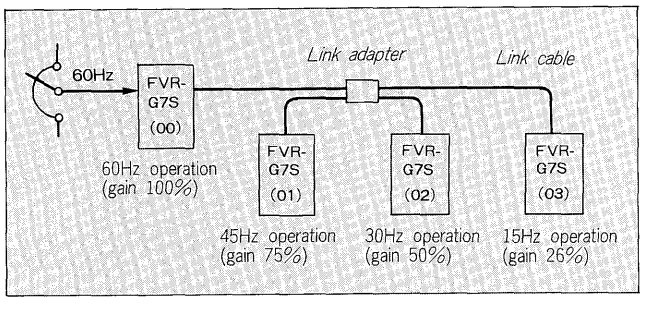
(2) The inverter number is specified by 4-bit specification signal (C) and the start/stop, frequency setting, and other command signals (A) are commanded at each inverter. Setting of batch commands for all the inverters instead of the specification signal (C) is also possible.

(3) The operation monitor signal (frequency equivalence signal, running signal, etc.) matched to the condition of specification signal (C) can be called at the master unit terminals (B),

(4) If the terminals of the sub master are used, frequency setting can be performed by 4 to 12 bits digital signal (D).

(5) The various parameters of the inverter selected by signals (C) can be set from the master keypad panel.

Fig. 8 Example of frequency ratio operation



4.5 Speed (frequency) ratio operation

Figure 8 shows the connections for ratio operation using the link function. Frequency ratio operation can be performed at a high accuracy of 1% step by setting all the inverters for batch command operation and setting the gain of each inverter. An example of connection of four inverters is shown here, but ratio operation of up to 16 inverters is possible by link cable and adapter.

5. CONCLUSION

Some of the functions and operating characteristics of the new series of inverters were introduced above. The capabilities of the inverter for general use could be strengthened further from the standpoints of accuracy, response, persistence, and many other areas by high-speed control by DSP.

The inverter linked operation function is a unique function which open a new age. We will put our efforts into further development together with those concerned.