MITSUBISHI TRANSISTORIZED INVERTER Instruction Manual

AUTOMATIC CONTROL COMPATIBLE UNIT TYPE FR-APD

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- PI Control
- Programmed Operation Battery Backup

Thank you for choosing the option unit for the Mitsubishi FREQROL transistorized frequency inverters. Please read this manual carefully to use the option unit to its optimum.

Automatic Control Compatible Unit (FR-APD)

This option unit is a multi-function unit designed for use in automatic control operation and has the following functions:

- · PI control
- · Programmed operation battery backup

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1. STRUCTURE

NOTALLATEMES



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2. INSTALLATION

Remove the inverter cover and install the option unit in the following procedure.

2.1 Pre-Installation Checks

(1) Check the inverter type.

This option unit may only be used with the FREQROL-A series inverters and must not be used with any other series (such as the Z and F series).

(2) Make sure that the inverter input power is off.

The inverter may become faulty if the option unit is installed with the input power on.

- (3) Check that the following accessories are supplied with the option unit.
 - 1 Instruction manual
 - 2 Mounting screws M3 x 14

2.2 Installation Procedure

- Snugly insert the connector of the option unit far into the connector of the inverter.
- (2) Securely fix the option unit to the inverter at the top and bottom with the accessory mounting screws. If the screw holes in the option unit do not match those in the inverter, check that the connectors have been fitted snugly.

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(3) For the proper installation diagram, see page 3.



3. PI CONTROL

This function allows the inverter to carry out process control, e.g. flow or pressure control.

3.1 Wiring Example



Note 1: The power supply should be selected in accordance with the power specifications of the detector used.

3.2 Terminals

Symbol	Terminal	Description		
PIS	PI control select input terminal	Connect with terminal SD to enable Pl operation.		
FBS	Feedback signal select terminal	Connect with terminal SD to input a 4- 20mA signal from the detector as a pro- cess value signal.		
SD	Input signal common terminal	Common terminal for PIS and FBS. Common to terminal SD of the inverter.		
FUP	• Upper limit output terminal	Gives output if the process value ex- ceeds the upper limit set value. Open collector output.		
FDN	• Lower limit output terminal	Gives output if the process value falls below the lower limit set value. Open collector output.		
RLF	Forward output terminal	Gives output when the display of the pa- rameter unit is forward (FWD). Open collector output.		
RLR	Reverse output terminal	Gives output when the display of the pa- rameter unit is reverse (REV). Open collector output.		
SE2	Output signal common terminal	Common terminal for FUP, FDN, RLF and RLR. Isolated from the inverter ter- minal SE.		

Note: Allowable load of open collector output: 24VDC 0.1A

• Made valid when PI control is selected (terminals PIS-SD are connected).

PI CONTROL

3.3 Operation

(1) PI control system configuration



Kp: Proportional constant Ti: Integral time S: Differentiator

- (2) Features of PI control
 - 1) PI control

A combination of proportional control (P) and integral control (I) for providing a manipulated variable in response to deviation and changes with time.

(Response for stepped changes of the controlled variable)





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2) Reverse action Increases the manipulated value (output frequency) if deviation X is positive and decreases the manipulated value if deviation is negative.



3) Forward action Increases the manipulated value (output frequency) if deviation X is negative and decreases the manipulated value if deviation is positive.

(Cooling)



Relationship between Deviation and Manipulated Variable (Output Frequency)

	Deviation			
	Positive	Negative		
Reverse action	/	$\mathbf{\mathbf{x}}$		
Forward action	/	~		

3.4 Setting Method

(1) Terminal setting

- Before starting the PI control, connect the FR-APD terminals PIS and SD. When these terminals remain disconnected, the inverter performs ordinary operation without carrying out the PI control.
- 2) Input the desired value across the inverter terminals 2-5 or into parameter number 133 and input the feedback signal across the inverter terminals 4-5. In this case, the FR-APD terminals FBS-SD should be connected.
- 3) The deviation signal calculated outside the inverter should be input across terminals 1-5 after disconnecting terminals FBS and SD.
- 4) Setting method

ltem	Input Method	Description			
	Across inverter terminals 2-5	Define	0V as 0% 5V as 100%	When the set value of Pr. 73 (voltage selection) is 1, 3, 5, 11, 13 or 15 (5V is selected for terminal 2)	
Desired value		Define	0V as 0% 10V as 100%	When the set value of Pr. 73 (voltage selection) is 0, 2, 4, 10, 12 or 14 (10V is selected for terminal 2)	
	Parameter number 133	Set the desired value (%) in Pr. 133.			
Deviation	Deviation Across inverter signal terminals 1-5	Define	-5V as -100% 0V as 0% +5V as +100%	When the set value of Pr. 73 (voltage selection) is 2, 3, 5, 12, 13 or 15 (5V is selected for terminal 1)	
signal		Define	–10V as –100% 0V as 0% +10V as +100%	When the set value of Pr. 73 (voltage selection) is 0, 1, 4, 10, 11 or 14 (10V is selected for terminal 1)	
Feedback signal	Across inverter terminals 4-5	The feedback signal of 4mA correspond to 0% and 20mA to 100%.			

(2) Parameter List

Parameter No.	Description	Range	Minimum Input Increment	Factory Setting	Remarks
128	PI control selection	0, 1		0	0: PI reverse action 1: PI forward action
129*	Pi propor- tional band	0.1 to 1000% 9999	0.1%	100%	Set to 9999 to use integral control only.
130*	Integral time	0.1 to 3600 seconds 9999	0.1 seconds	1 second	Set to 9999 to use proportional control only.
131	Upper limit	Upper limit 0 to 100% 9999		9999	FUP is output if the feedback value ex- ceeds the upper limit value setting.
132	Lower limit	0 to 100% 9999	0.1%	9999	FDN is output if the feedback value falls below the lower limit value setting.
133	PI control desired value for PU operation	0 to 100%	0.01%	0%	Only valid during PU or combined PU/ex- ternal operation.

Note: *The set values of parameter numbers 129 and 130 may be changed during operation.

(3) Parameter setting

1) Pl control selection (Pr. 128)

Set the reverse or forward action in Pr. 128 in accordance with the system controlled,

e.g. Reverse action (Pr. 128 = 0)......For heating, pressure control, etc. Forward action (Pr. 128 = 1)......For cooling, etc.

- 2) PI proportional band (Pr. 129)
 - 1/(PI proportional band value) = gain Kp.

If Pr.129 is small, the manipulated value varies greatly with a slight change of the controlled variable.

Hence, as Pr.129 is small, the response sensitivity improves but the stability deteriorates, e.g. hunting occurs.

3) Integral time (Pr. 130) Integral time = Ti.

(I/Ti) is closely related to the gain of the integration term of the PI equation.

As Pr. 130 is small, the controlled variable is reached to the desired value earlier but hunting occurs more easily.

4) Upper limit, lower limit (Pr. 131) (Pr. 132) Alarm can be output if the feedback signal comes out of the setting range.

Set the upper limit value in Pr. 131 and the lower limit value in Pr. 132. The feedback signal of 4mA corresponds to 0% and 20mA to 100%.

5) PI control desired value for PU operation (Pr. 133)

Set the desired value (%) in parameter number 133. It is valid for the PU operation only.

For the external operation, the desired value is the voltage across the inverter terminals 2-5.

3.5 Adjustment Example

In the following example, a detector of 4mA at 0°C and 20mA at 50°C is used to adjust room temperature to 25°C by PI control. The desired value is given across the inverter terminals 2 and 5 (0-5V).



PI CONTROL

- [•] When calibration is required → Calibrate the detector output and the desired value setting input using calibration parameters 902 to 905. Make calibration in the PU mode when the inverter is at a stop.
 - (1) The desired value input calibration
 - 1) Input a voltage for the desired value setting of 0% (e.g. 0V) across terminals 2-5.
 - Make calibration using Pr. 902 (frequency setting voltage bias). At this time, input the frequency which should be output by the Inverter at the deviation of 0% (e.g. 0Hz).
 - 3) Input a voltage for the desired value setting of 100% (e.g. 5V) across terminals 2-5.
 - 4) Make calibration using Pr. 903 (frequency setting voltage gain). At this time, input the frequency which should be output by the inverter at the deviation of 100% (e.g. 60Hz).
 - (2) Detector output calibration
 - 1) Input an output current for the detector setting of 0% (e.g. 4mA) across terminals 4-5.
 - 2) Make calibration using Pr. 904 (frequency setting current bias).
 - input an output current for the detector setting of 100% (e.g. 20mA) across terminals 4-5.
 - 4) Make calibration using Pr. 905 (frequency setting current gain).
 - The frequencies set in 904 and 905 should be identical those set in 902 and 903, respectively.

(But the frequencies set in 904 and 905 are independent of the PI control.)

The results of the above calibrations are as shown below:





3.6 Instructions

- (1) With terminals PIS and SD connected, input the multi-speed (terminals RH, RM, RL) or jog operation (terminal JOG) signal to stop the PI control and start multi-speed or jog operation.
- (2) When terminals FBS and SD are connected, note that the input signal across the inverter terminals 1-5 is added to the desired value across terminals 2-5.
- (3) Set 5 (programmed operation mode) in parameter number 79 to disable PI control operation and enable programmed operation.

3.7 Specifications

(1) PI setting ranges

Proportional band (P) : 0.1 to 1000%

- Integral time (I) : 0.1 to 3600 seconds
- (2) Input signals
 - (a) Desired value, feedback signal and deviation

Input Spec	lfications	Input Terminal, Input Method	Input Signal	
	Desired value	Inverter terminal 2	0 to 5V, 0 to 10V (DC)	
Feedback signal of 4 to 20mA		Parameter unit	Digital setting	
	Feedback signal	Inverter terminal 4	4 to 20mA (DC)	
Direct input of deviation	Deviation	Inverter terminal 1 *	0 to ±5V or 0 to ±10V (DC)	

*: If a deviation value has been calculated outside the inverter, enter that value into the inverter terminal 1 ($\pm 10V$ or $\pm 5V$).

Also, the FR-APD terminals FBS and SD must be disconnected.

- (b) Select signals (Contact input)
 - Pl control selection
 - Feedback signal (4 to 20mA) selection
- (3) Output signals (Open collector output)
 - Upper limit
 - Lower limit
 - Rotation direction (forward, reverse)

(4) Functions (by using parameter unit)

- · Upper limit value
- · Lower limit value
- PI proportional band
- Integral time
- Reverse/Forward action selection
- PI control desired value setting at PU operation

(5) Detector power supply

Use the appropriate power supply in accordance with the detector's power supply specifications. The detector power cannot be supplied from the inverter and option unit.

4. PROGRAMMED OPERATION BATTERY BACKUP

This function allows the internal timer of the inverter to be battery-backed so that programmed operation, i.e. automatic operation performed under the control of the internal timer in accordance with the preset operation time of day, frequency and rotation direction, can be resumed at power restoration if the inverter power is switched off.

Programmed operation can be performed by the inverter without the FR-APD option fitted. During such programmed operation, however, its program will be cleared when the power is switched off.



4.1 Wiring Example

Note 1:If 5 (programmed operation mode) is set in parameter number 79, fitting the FR-APD option to the inverter returns the inverter terminals STF, RH, RM, RL and STR to their ordinary functions (STF: forward rotation, STR: reverse rotation, RH: high speed, RM: middle speed, RL: low speed).

4.2 Terminals

Symbol	Terminal	Description
TG1, TG2, TG3	Group select signals	Used to select the group for programmed operation.
TRS	Timer reset signal	Input to reset the reference time of day to zero.
тэт	Programmed operation start signal	Input to start programmed operation.
TU1, TU2, TU3	Group time-out signals	Output when the operation of the corre- sponding group is completed. Switched off when the other group starts operating or the timer is reset.

4.3 Settings

The programmed operation function is standard-equipped for the inverter. For full information on the settings, see the inverter instruction manual.

(1) Parameters

Parameter No.	Description	Range	Minimum Input Increment	initiai Setting	Remarks
Pr. 200	Programmed op- eration minute/second selection	0 to 3	1	0	 minute/second unit, voltage monitoring hour/minute unit, volt- age monitoring minute/second unit, ref- erence time of day monitoring hour/minute unit, refer- ence time of day moni- toring
Pr. 201 to 230	Programmed op- eration program setting	0 to 2 0 to 400Hz 0 to 99:59	1 0.1Hz Minute or second	9999	Rotation direction: 0-stop, 1-forward rotation, 2- reverse rotation Set frequency (9999 : Time of day (no setting)
Pr. 231	Timer setting	0 to 99.59		0	Set the current time of day. (RAM)

*Rewriting the set value of Pr. 200 independently changes the units set in Pr. 231 and Pr. 201 to 230.

The numerals remain unchanged.

*When 2 or 3 is set in Pr. 200, voltage monitoring is replaced by reference time of day monitoring.

) Setting the operation time of day, frequency and rotation direction		Set point	Rotation direction, fre- quency, start time of day	
The above three items make	(No.1	Pr.201	
up one point and form up to	Group 1 Group 2	2	Pr.202	
three groups of 10 points.		3	Pr.203	
Lise parameters Pr 200 to		4	Pr.204	
Br 232 for this setting		:	:	
FI. 252 for this setting.		10	Pr.210	
		No.11	Pr.211	
		1	:	
	Group 3	<u> </u>	Pr.220	
		No.21	Pr.221	
		:		
		(30	Pr.230	

PROGRAMMED OPERATION BATTERY BACKUP

(3) Reference time of day

Programmed operation is performed in reference to the internal timer (RAM) of the inverter.

When the power is switched off, the timer (RAM) is battery-backed.

The reference time of day is reset by switching on the timer reset signal (across terminals TRS-SD).

4.4 Operation

(1) After the setting is completed in accordance with Section 4.3, switch on the required group select signal (for example, connect TG1 and SD to select group 1), then connect the start signal (TST). This automatically resets the internal timer (reference time of day) and the operation of the group selected is performed in accordance with the setting. After the operation of that group ends, the time-out signal is switched on at the corresponding time-out output terminal (e.g. in case of group 1, the open collector across TU1 and SE2 is switched on).



- (2) Perform operation in the external operation mode. Programmed operation is not performed if any group select signal is switched on during the PU or data link operation.
- (3) Selection of two groups at the same time causes operation to be performed in order of group 1, group 2 and group 3. For example, when groups 1 and 2 have been selected, group 1 operation is started, the reference time of day is reset on completion of group 1 operation, group 2 operation is started, and the TU2 time-out signal of group 2 is output on completion of group 2 operation.



PROGRAMMED OPERATION BATTERY BACKUP

(4) To repeat the operation of the same group(s), reset the timer using the

- time-out signal as shown below. 1) To repeat group 1 only FR-APD TGI TG2 TG3 TRS SD TU1 TU2 TUS SE2 2) To repeat groups 1 and 2 FR-APD TG1 TG2 TG3 TRS SD TU1 TU2 тиз SE2 (5) Operation at occurrence of power failure
- If a power failure occurs, operation is continued with the setting ignored during the power failure period as shown below.



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4.5 Instructions

(1) The battery check LED on the front panel of the option unit is lit to indicate that the battery life has expired.

Change the battery together with the option unit. The replacement of only the battery cannot be made.

When the battery check LED is lit, first check the connector for a contact fault.

- (2) If the group selected has been changed during a power failure, the operation of the new group selected is started after power restoration.
- (3) Operation is not performed if a power failure lasts until the time-out signal (terminals TU1 to TU3) is output.
- (4) When a power failure lasts for a long time, programmed operation is not resumed if the power is restored. Hence, group selection and time of day setting should be made again.

Permissible power failure time to continue programmed operation depends on the set value of parameter 200:

- Max. 18 hours when Pr. 200 = 0.
- Max. 30 days when Pr. 200 = 1.

4.6 SPECIFICATIONS

(1) Battery

Life: 10 years beginning on the date of manufacture

- Type: Lithium battery
- (2) Timer accuracy

Error of max. 0.9 seconds per day