6

Basic Operation

This chapter explains the basic settings required to operate and stop the VG5. The user constants described here will be sufficient for simple Inverter.

Even when your application requires special functions, such as torque control or PID Control, make these basic settings first and then go to the explanations of those special functions in *Chapter 7 Advance Operation*.

6.1 Common Settings

This section describes the constants that are used with all of the control methods.

6.1.1 Setting the Access Level and Control Method: A1-01, A1-02

■ Constant Access Level: A1-01

- Select the constant access level. This level determines which constants can be accessed and changed.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
A1-01	Constant access level	❍	0 to 4	—	2 (Q)	Q	Q	Q	Q

- Access Level Settings

Setting	Name	Function
0	Operation Only	Allows the operation mode and initialize mode to be displayed or changed. Use this setting to prevent constant settings from being changed.
1	User Program	Allows only the user-selected constants (up to 32) to be displayed or changed. Set the desired constants as “User Parameters” in constants A2-01 through A2-32.
2	Quick-Start	Allows the constants required to start the Inverter (about 25) to be displayed or changed.
3	Basic	Allows the commonly used constants to be displayed or changed.
4	Advanced	Allows the constants to be displayed or changed.

- The control method setting also affects which constants can be displayed and changed. Refer to *Chapter 8 User Constant Lists*.
- The constants required for basic operation could be displayed and changed in the Basic Level, but this section also describes constants that can set only in the Advanced Level, so set the access level to Advanced.

Changing the Access Level

The following procedure shows how to change from Quick-Start to Advanced.

Step	Key Sequence	Digital Operator Display	Remarks
1	MENU	Main Menu ✳ Operation	Displays Operation mode.
2	^	Main Menu ✳ Initialize	Displays Initialize mode.
3	DATA ENTER	Select Language English	Puts the unit in Initialize mode. (Select Language display.)
4	^	Access Level Quick-Start	Displays the Access Level (A1-01).
5	DATA ENTER	A1-01 = 2 ✳ ✳ ✳ Quick-Start	Displays the constant setting for A1-01.
6	^ Press 2 times.	A1-01 = 4 Advanced	Displays Advanced.
7	DATA ENTER	Entry Accepted	Writes the new setting.
		Access Level Advanced	Returns to the Access Level display.

Control Method: A1-02

- Select one of the four control methods.
- This constant is not initialized by the initialize operation.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
A1-02	Control method selection	X	0 to 3	—	2 Open-Loop Vector	Q	Q	Q	Q

- Control Method Settings

Setting	Name	Function
0	V/f Control	Normal V/f Control
1	V/f Control with PG Feedback	V/f Control using a PG Speed Option Card
2	Open-Loop Vector Control	Vector Control using the Inverter's internal speed information
3	Flux Vector Control	Vector Control using a PG Speed Option Card

- The characteristics of each control method are shown in *Table 6.1*.

Table 6.1 Control Method Characteristics

Characteristic	V/f Control	V/f Control w/ PG Feedback	Open-Loop Vector	Flux Vector
Basic control method	Voltage/frequency control (Open-Loop)	Voltage/frequency control with speed compensation	Current Vector Control without PG	Current Vector Control with PG
Speed detector	Not required	Required (pulse generator)	Not required	Required (pulse generator)
Optional speed detectors	Not required	PG-A2 or PG-D2	Not required	PG-B2 or PG-X2
Speed control range	1:40	1:40	1:100	1:1000
Starting torque	150%/3 Hz	150%/3 Hz	150%/1 Hz	150%/o r/min
Speed control accuracy	±2 to 3%	±0.03%	±0.2%	±0.02%
Torque limit	Not possible	Not possible	Possible	Possible
Torque limit	Not possible	Not possible	Not possible	Possible
Example applications	• Multiple motor drives. • Replacing existing motor for which motor constants are not known. • When Auto-Tuning is not possible.	• Simple speed feedback control. • When a PG is attached to the machine axis.	• Variable speed drives applications.	• Simple servo drives. • Precision speed control. • Torque control.

- Vector Control has a greater starting torque and more precise speed control than V/f Control, so use of Vector Control is recommended whenever possible.

  Use V/f Control in the following types of applications:

  - When several motors are being operated.
  - When special motors, such as submersible motors or spindle motors, are being used (situations in which Auto-Tuning cannot be used).
  - When operation is being coordinated with an older V/f Control inverter control system.

6.1.2 Frequency Reference Settings: b1-01, H3-01, H3-08, H3-09

These settings are required when inputting analog voltage or current signals from the control circuit terminals.

■ Frequency Reference Selection: b1-01

- Constant b1-01 is used to select the reference source.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
b1-01	Reference selection	X	0 to 3	—	1	Q	Q	Q	Q

- Settings

Setting	Reference Source
0	Digital Operator
1	Control circuit terminals (external terminals)
2	Transmission
3	Option Card

- The frequency reference is input from the control circuit terminals (external terminals), so set b1-01 to 1.

■ Frequency Reference (Voltage), Terminal 13 Signal Level: H3-01

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
H3-01	Signal level selection (Terminal 13)	X	0, 1	—	0	B	B	B	B

- The frequency reference (voltage) is valid when constant b1-01 has been set at 1.
- Set the voltage range for the frequency reference (voltage) signal.
- Settings

Setting	Function
0	0 to 10 VDC input
1	-10 to 10 VDC input (A negative voltage is a reference for reverse rotation.)

■ Frequency Reference (Current), Terminal 14 Signal Level: H3-09, H3-08

- Set Terminal 14 to a frequency reference with constant H3-09 to use Terminal 14 as the frequency reference terminal.
- The frequency reference setting is 1F.

Function Selection: H3-09

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
H3-09	Multi-function analog input (terminal 14)	X	1 to 1F	—	1F	A	A	A	A

- After setting constant H3-09, set Terminal 14 signal level with H3-08.

Signal Level: H3-09

- The frequency reference (current) is valid when constant b1-01 has been set to 1.
- Set the signal level for the frequency reference (current).

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
H3-08	Signal level selection (Terminal 14)	X	0 ~ 2	—	2	A	A	A	A

- Settings

Setting	Function
0	0 TO 10 VDC input
1	-10 to 10 VDC input (A negative voltage is a reference for reverse rotation.)
2	4 to 20 mA input

- When the terminal is being used as a voltage input terminal (setting 0 or 1), jumper J1 must be disconnected on the control board. (See *Figure 6.1*). The terminal's input resistor will be destroyed if the terminal is used for voltage input with jumper J1 connected.
- When frequency references are being input simultaneously from both the voltage Terminal 13 and the current Terminal 14, the final reference value will be the sum of the two references that are input.
- To switch the frequency reference input between the voltage Terminal 13 and the current Terminal 1, set a value of 1F in any one of the multi-function inputs (H1-01 through H1-06). The voltage Terminal 13 will be used when this multi-function input is OFF and the current Terminal 14 will be used when this multi-function input is ON.
- If a 0 to ±10 VDC input is set, H3-01 must also be set to a 0 to ±10 VDC input.

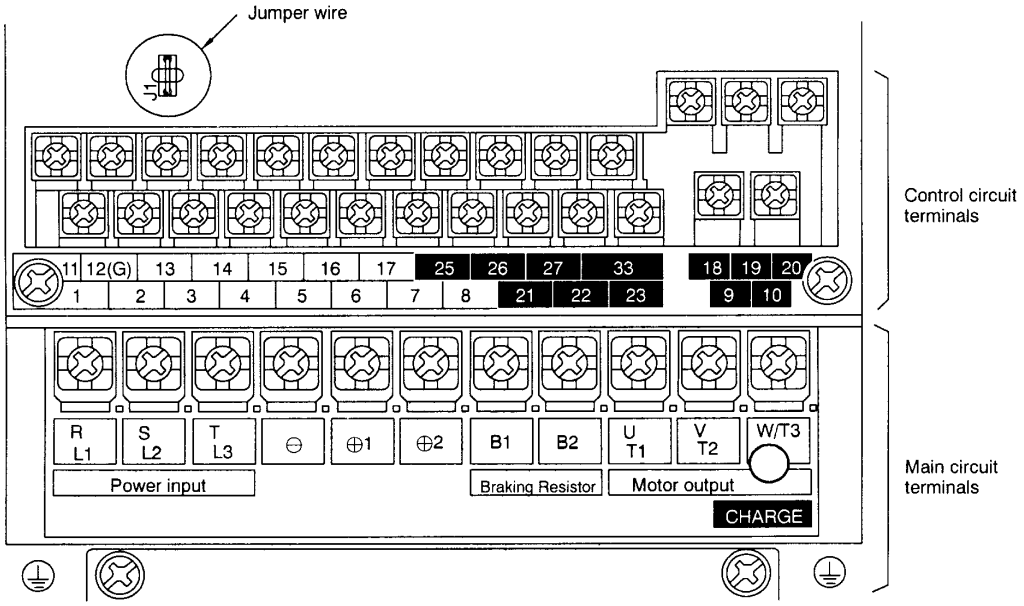


Figure 6.1 Terminal Arrangement of a 200 V Class Inverter of 0.4 kW

■ Function and Signal Level for Multi-Function Analog Input (Terminal 16): H3-04, H3-05

- This function is useful when switching between two analog inputs. The input is from Terminal 16.
- When using the multi-function input (Terminal 16) as the frequency reference terminal, first set the multi-function analog input function to "Auxiliary Reference" by setting constant H3-05 to 0.

Function for Multi-Function Analog Input, Terminal 16: H3-05

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
H3-05	Multi-function analog input (Terminal 16)	X	0 to 1F	—	0	B	B	B	B

- The auxiliary reference is factory-preset to 0.
- After setting H3-05 to 0, set any one of the multi-function inputs (H1-01 through H1-06) to a value of 3 (multi-step speed reference 1).
- When a multi-function analog input has been set to "Auxiliary Reference", it is treated as frequency reference 2 during multi-step speed operation, so it cannot be used unless the multi-step speed reference 1 has been set.

Signal Level for Multi-Function Analog Input, Terminal 16: H3-04

- Set the signal level for the multi-function analog input.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
H3-04	Signal level selection (Terminal 16)	X	0, 1	—	0	B	B	B	B

- Settings

Setting	Function
0	0 TO 10 VDC input
1	-10 to 10 VDC input (A negative voltage is a reference for reverse rotation.)

■ Adjusting Analog Inputs: H3-02, H3-03, H3-06, H3-07, H3-10, H3-11, H3-12

- There are three constants used to adjust the analog inputs; the gain, bias (both set separately for each input), and filter time constant (a single value for all of the inputs).

- The gain and bias can be adjusted separately for each analog input (Terminals 13, 14, and 16).
  Gain: Set the frequency corresponding to a 10 V (20 mA) input as a percentage of the maximum frequency. (The maximum output frequency set in E1-04 is 100%.)
  Bias: Set the frequency corresponding to a 0 V (4 mA) input as a percentage of the maximum frequency. (The maximum output frequency set in E1-04 is 100%.)

- Set the gains and biases for Terminals 13, 14, and 16 as follows:

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
H3-02	Gain for Terminal 13	❍	0.0 to 1000.0	%	100.0	B	B	B	B
H3-03	Bias for Terminal 13	❍	-100.0 to 100.0	%	0.0	B	B	B	B
H3-10	Gain for Terminal 14	❍	0.0 to 1000.0	%	100.0	A	A	A	A
H3-11	Bias for Terminal 14	❍	-100.0 to 100.0	%	0.0	A	A	A	A
H3-06	Gain for Terminal 16*	❍	0.0 to 1000.0	%	100.0	B	B	B	B
H3-07	Bias for Terminal 16*	❍	-100.0 to 100.0	%	0.0	B	B	B	B

- The setting for Terminal 16 is valid only when the multi-function analog input has been selected. The gain and bias set here will be disregarded if a frequency reference is selected and the values set for Terminal 13 will be used.

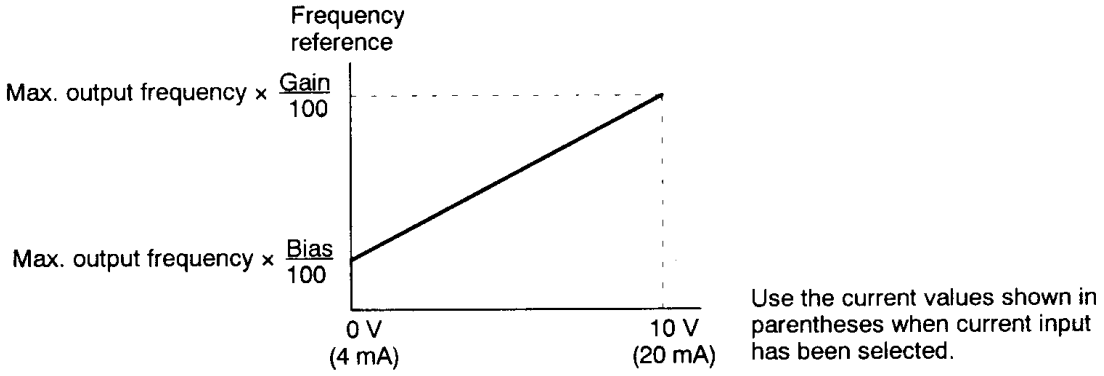


Figure 6.2 Gain and Bias Chart

Analog Input Filter Time Constant: H3-12

- A primary delay digital filter can be set for all three analog inputs (frequency reference (voltage), frequency reference (current), and multi-function analog input).

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
H3-12	Analog input filter time constant	X	0.00 to 2.00	s	0.00	A	A	A	A

- This setting is effective when there are sudden changes or noise in the analog input signal.
- Responsiveness decreases as the setting increases.

6.1.3 Frequency Reference from Digital Operator: b1-01, o1-03, d1-01 to d1-09

■ Frequency Reference Source: b1-01

- Select the reference source.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
b1-01	Reference selection	X	0 to 3	—	1	Q	Q	Q	Q

- Settings

Setting	Reference Source
0	Digital Operator
1	Control circuit terminals (analog inputs)
2	Transmission
3	Optional Card

- The frequency reference is input from the Digital Operator, so set b1-01 to 0.

■ Frequency Unit for Reference Setting and Monitoring: o1-03

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
o1-03	Frequency unit for reference setting and monitor	X	0 to 39999	—	0	B	B	B	B

- Settings

Setting	Function
0	0.01 Hz units
1	0.01% units (The maximum frequency is 100%.)
2 to 39	r/min units (Set the number of poles.)
40 to 39999	Sets a specific value for the maximum frequency. ❑ ❑❑❑❑ The 4-digit setting without the decimal point. The location of the decimal point. (Number of digits after the decimal point.) For example, set o1-03 to “12000” to display “200.0” as the maximum output frequency.

- When the 40 to 39,999 range is used, any unit can be set for the reference frequency. For example, the frequency reference can be displayed or set in units such as mm/s or m/min to coincide with the linear operating speed of the machine.

■ Preset Frequency Reference Values: d1-01 through d1-09

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
d1-01	Frequency reference 1	❍	0 to 400.00	Hz	0.00 Hz	Q	Q	Q	Q
d1-02	Frequency reference 2	❍	0 to 400.00	Hz	0.00 Hz	Q	Q	Q	Q
d1-03	Frequency reference 3	❍	0 to 400.00	Hz	0.00 Hz	Q	Q	Q	Q
d1-04	Frequency reference 4	❍	0 to 400.00	Hz	0.00 Hz	Q	Q	Q	Q
d1-05	Frequency reference 5	❍	0 to 400.00	Hz	0.00 Hz	B	B	B	B
d1-06	Frequency reference 6	❍	0 to 400.00	Hz	0.00 Hz	B	B	B	B
d1-07	Frequency reference 7	❍	0 to 400.00	Hz	0.00 Hz	B	B	B	B
d1-08	Frequency reference 8	❍	0 to 400.00	Hz	0.00 Hz	B	B	B	B
d1-09	Jog frequency reference	❍	0 to 400.00	Hz	6.00 Hz	Q	Q	Q	Q

- The units for these values are set in o1-03.
- The frequency reference default value and set value will change when o1-03 is changed. For example, if preset reference 1 is set to 6.00 Hz and o1-03 is changed to 1 (0.01% units), the setting for preset reference 1 will become 10.00%.
- When using preset references 2 through 8, be sure to set multi-step speed references 1, 2 and 3 in the multi-function inputs (H1-01 through H1-06) as required.
- When using the jog function, set the job frequency reference in constant d1-09. When jogging from an external terminal, set the multi-function inputs (H1-01 through H1-06) to “Jog Frequency Reference”, “Forward Jog”, or “Reverse Jog” as required.
- The multi-function input setting is unnecessary when jogging from the Operator.

6.1.4 Run Source and Sequence Input Responsiveness: b1-02, b1-06, b1-07

■ Run Source: b1-02

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
b1-02	Operation method selection	X	0 to 3	—	1	Q	Q	Q	Q

- Constant b1-02 is used to select the source of the run command.
- When a control circuit terminal (external terminal) is set, the unit operates with 2-wire forward RUN/STOP and reverse RUN/STOP control. (When the unit has been initialized for a 3-wire control or multi-function input is set to 0 (3-wire sequence); the unit operates with 3-wire run, stop and forward/reverse controls.)
- Settings

Setting	Run Source
0	Digital Operator
1	Control circuit terminals (external terminals)
2	Transmission
3	Option Card

■ Sequence Input Responsiveness (Reading Twice): b1-06

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
b1-06	Read sequence input twice	x	0, 1	—	1	A	A	A	A

- Set the responsiveness of the control inputs (forward/reverse RUN and multi-function inputs).
- Settings

Setting	Function
0	Two scans every 2 ms (Use when connecting transistor outputs.)
1	Two scans every 5 ms (Use when connecting contact outputs or switches.)

- Set the responsiveness to match the type of control inputs being used. Use a setting of 1 if there is one or more contact inputs.

■ Operation after Switching to Remote Mode: b1-07

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
b1-07	Operation selection after switching to remote mode	X	0, 1	—	0	A	A	A	A

- Set the interlock operation to be used after switching from local mode (operation from Digital Operator) to remote mode (operation according to control circuit terminal).
- Settings

Setting	Function
0	No operation even if RUN signal is ON after switching to remote mode. (Operation will start if the RUN signal turns OFF and then back ON after switching to remote mode.)
1	Operate according to the RUN signal after switching to remote mode.

6.1.5 Acceleration/Deceleration Times: C1-01 through C1-08, C1-09, C1-10, C1-11

This section describes setting the acceleration times, deceleration times, and emergency stop times.

■ Acceleration/Deceleration Time Unit: C1-10

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
C1-10	Accel/decel time setting unit	X	0, 1	—	1	A	A	A	A

- Settings

Setting	Function
0	Sets the acceleration/deceleration time unit to 0.01 seconds.
1	Sets the acceleration/deceleration time unit to 0.1 seconds.

- Set “0” to set more precise acceleration and deceleration times. (This will reduce the setting range.)

■ Acceleration/Deceleration Time Unit: C1-01 through C1-08

- Set individual acceleration and deceleration times.
  - An acceleration time is the time required to go from 0% to 100% of the maximum output frequency.
  - A deceleration time is the time required to go from 100% to 0% of the maximum output frequency.
- Four acceleration times and four deceleration times can be set. When using acceleration/deceleration times 2 through 4, set multi-function inputs (H1-01 through H1-06) to the acceleration/deceleration time selectors 1 and 2.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
C1-01	Acceleration time 1	❍	0.0 to 6000.0	s	10.0	Q	Q	Q	Q
C1-02	Deceleration time 1	❍	0.0 to 6000.0	s	10.0	Q	Q	Q	Q
C1-03	Acceleration time 2	❍	0.0 to 6000.0	s	10.0	B	B	B	B
C1-04	Deceleration time 2	❍	0.0 to 6000.0	s	10.0	B	B	B	B
C1-05	Acceleration time 3	X	0.0 to 6000.0	s	10.0	A	A	A	A
C1-06	Deceleration time 3	X	0.0 to 6000.0	s	10.0	A	A	A	A
C1-07	Acceleration time 4	X	0.0 to 6000.0	s	10.0	A	A	A	A
C1-08	Deceleration time 4	X	0.0 to 6000.0	s	10.0	A	A	A	A

- The setting range for the acceleration /deceleration times depends on the setting in C1-10 (acceleration/deceleration time unit). The table shows the setting range when the factory setting is used for C1-10.
- If C1-10 is set to “0” (0.01 seconds) the setting range will be 0.00 to 600.00 seconds.

■ Emergency Stop Time: C1-09

- Sets the deceleration time that will be used when an emergency stop signal is input or a fault is detected. The deceleration time is the time required to go from 100% to 0% of the maximum output frequency.
- When using an emergency stop input, set multi-function input (H1-01 through H1-06) for an emergency stop.
- The emergency stop time is effective for the following faults. Set a stopping method for each.
  - Inverter overheating (OH) pre-alarm: Set in L8-03.
  - PG faults: Set in F1-02 through F1-04.

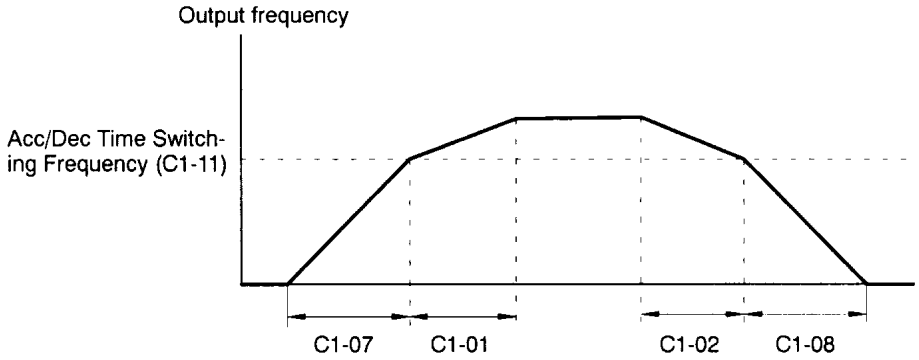
User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
C1-09	Emergency stop time	❍	0.0 to 6000.0	s	10.0	B	B	B	B

- The setting range for the emergency stop deceleration time depends upon the setting in C1-10 (acceleration/deceleration time unit). The table shows the setting range when the factory setting is used for C1-10.
- If C1-10 is set to "0" (0.01 seconds) the setting range will be 0.00 to 600.00 seconds.

■ Acceleration/Deceleration Time Switching Frequency: C1-11

- When an acceleration/deceleration time switching frequency is set, the acceleration and deceleration times will be changed automatically as the frequency passes the set level.
- If the acceleration/deceleration time selectors 1 and 2 are input via the multi-function inputs, they will have priority.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
C1-11	Accel/decel time switching frequency	X	0.0 to 400.0	Hz	0.0	A	A	A	A



Acceleration/Deceleration Times 1 (C1-01 and C1 -02) are used when the output frequency ≥ C1 -11
Acceleration/Deceleration Times 4 (C1-07 and C1 -08) are used when the output frequency < C1 -11

Fig 6.3 Acceleration/Deceleration Time Switching Frequency

6.1.6 Prohibiting Reverse Operation: b1-04

- Set whether or not to operate the motor in reverse when a reverse reference is input.
- Set this constant to "1" to disable reverse operation when necessary.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
b1-04	Prohibition of reverse operation	X	0, 1	—	0	B	B	B	B

- Settings

Setting	Function
0	Allows reverse operation.
1	Prohibits reverse operation.

6.1.7 Selecting the Stopping Method: b1-03

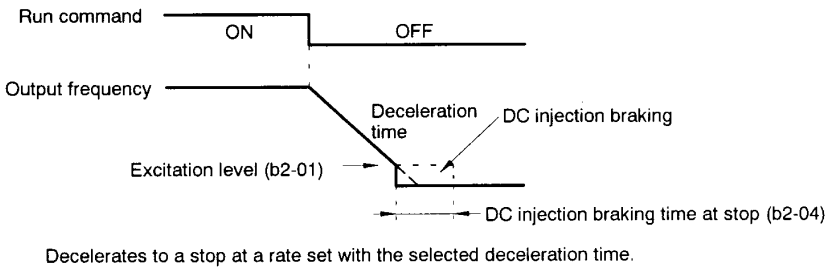
- Set the stopping method used when a stop command is input.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
b1-03	Stopping method selection	X	0 to 3	—	0	Q	Q	Q	Q

- Only settings 0 and 1 can be used with Flux Vector Control.
- Settings

Setting	Function
0	Deceleration to stop.
1	Coast to stop.
2	DC braking stop. Stops faster than coast to stop, without regenerative operation.
3	Coast to stop with timer. Run commands are disregarded during deceleration time.

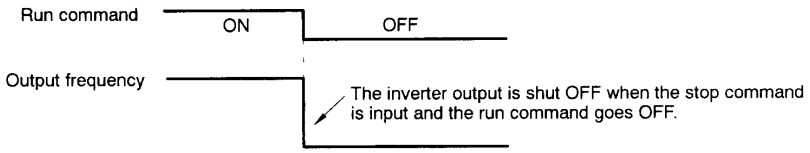
- The following diagrams show the operation of each stopping method.
  - Deceleration to Stop (b1-03 = 0)



Decelerates to a stop at a rate set with the selected deceleration time.

Figure 6.4 Deceleration to Stop

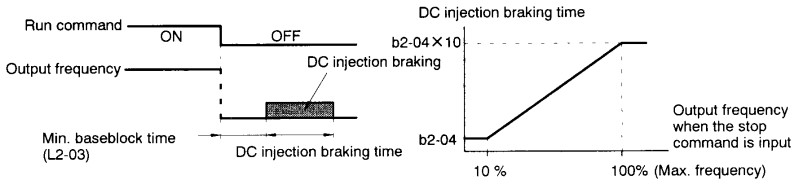
  - Coast to Stop (b1-03 = 1)



After the stop command is input, run commands are disregarded until the minimum baseblock time (L2-03) has elapsed.

Figure 6.5 Coast to Stop

  - DC Injection Braking Stop (b1-03=2)

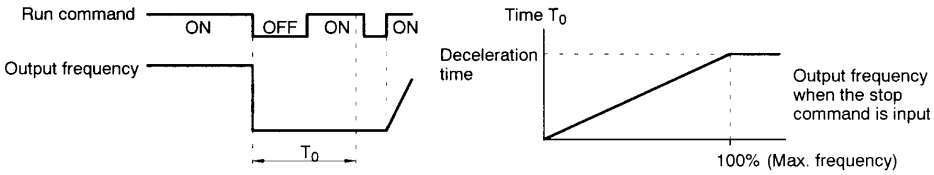


After the stop command is input and the minimum baseblock time (L2-03) has elapsed, DC injection braking is applied and the motor stopped.
The DC injection braking time depends upon the output frequency when the stop command is input and the "DC injection braking time at stop" setting in b2-04, as shown in *Figure 6.6*.

Figure 6.6 DC Injection Braking Stop

NOTE: Lengthen the minimum baseblock time (L2-03) when an overcurrent (OC) occurs during stopping. When the power to an induction motor is turned OFF, the counter-electromotive force generated by the residual magnetic field in the motor can cause an overcurrent to be detected when DC injection braking is applied.

- Coast to Stop with Timer (b1-03 = 3)



After the stop command is input, run commands are disregarded until the time T_0 has elapsed. The time T_0 depends upon the output frequency when the stop command is input and the deceleration time.

Figure 6.7 Coast to Stop with Timer

6.1.8 Multi-Function Input Settings: H1-01 through H106

- Set the functions for Terminals 3 to 8. Set the functions of the multi-function inputs according to the application.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
H1-01	Multi-function input 1 (Terminal 3)	X	0 to 77	—	24	B	B	B	B
H1-02	Multi-function input 2 (Terminal 4)	X	0 to 77	—	14	B	B	B	B
H1-03	Multi-function input 3 (Terminal 5)	X	0 to 77	—	3 (0)	B	B	B	B
H1-04	Multi-function input 4 (Terminal 6)	X	0 to 77	—	4 (3)	B	B	B	B
H1-05	Multi-function input 5 (Terminal 7)	X	0 to 77	—	6 (4)	B	B	B	B
H1-06	Multi-function input 6 (Terminal 8)	X	0 to 77	—	8 (6)	B	B	B	B

- The default settings in parentheses are the default values when the unit is initialized for 3-wire sequence control.
- The constant settings that are used most often are explained below. Refer to *Chapter 7 Advanced Operation* or the constant tables for details on the other settings.
  - 3-wire sequence (forward/reverse run command): Set “0”
  - Multi-step speed references 1 to 3 and jog command: Set “3” to “6”
  - Acceleration/Deceleration Time Selectors 1 and 2: Set “7” and “1A”
  - Emergency Stop: Set “15”
  - Forward and Reverse Jog References: Set “12” and “13”
  - Terminal 13/14 Switch: Set “1F”

3-Wire Sequence (Forward/Reverse Run Commands): "0"

- When a value of "0" is set for any one of the multi-function inputs (H1-01 through H1-06), 3-wire sequence control is used and the multi-function input terminal for which "0" was set becomes the forward/reverse run command terminal.
- When the unit is initialized for 3-wire sequence control with A1-03, multi-function input 3 (Terminal 5) becomes the input terminal for the forward/reverse run command.

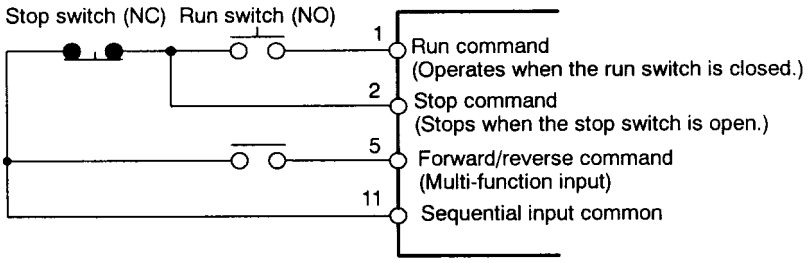


Figure 6.8 3-Wire Sequence Wiring Example

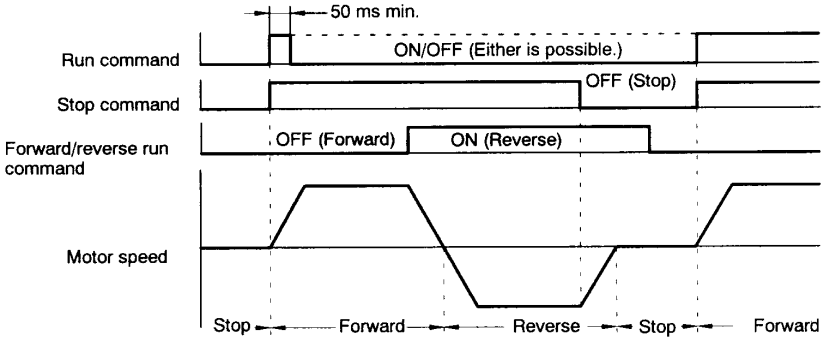


Figure 6.9 Timing Chart for 3-Wire Sequence

Multi-Step Speed References 1 through 3 and Jog Reference: "3" to "6"

- Eight frequency references and one jog frequency reference can be used.
- Set the multi-step speed references 1, 2 and 3 to the Jog reference for the multi-function inputs, and change the status of these inputs to switch between the 9 frequency references.

Terminal	Constant	Setting	Function
5	H1-03	3	Multi-step speed reference 1 (Also used for master-speed/auxiliary-speed switching when an auxiliary reference is set for the multi-function analog input in H3-05.)
6	H1-04	4	Multi-step speed reference 2
7	H1-05	5	Multi-step speed reference 3
8	H1-06	6	Jog reference (This setting has higher priority than the multi-step speed reference.)

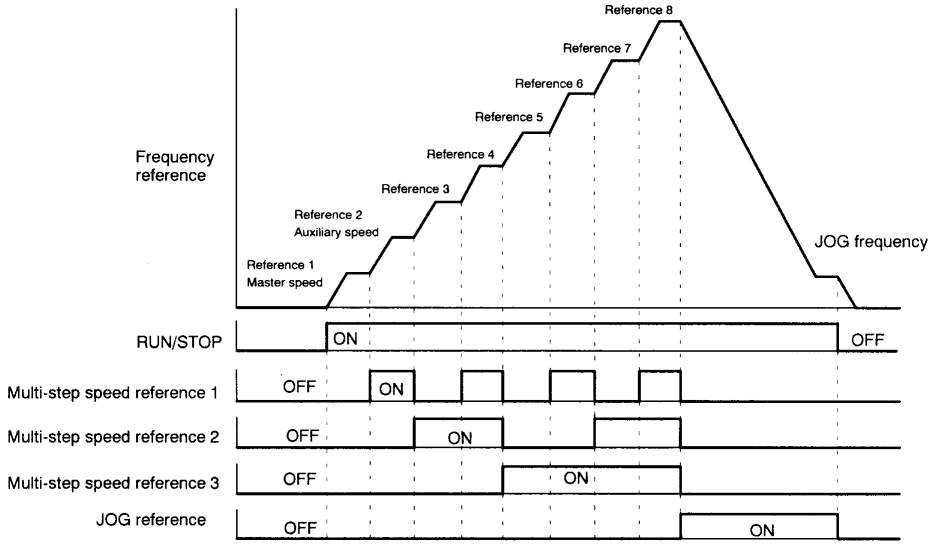
- The following table shows which frequency is selected by each possible combination of multi-step speed and Jog reference settings.

Terminal 5	Terminal 6	Terminal 7	Terminal 8	Selected Frequency
Multi-Step Speed Reference 1	Multi-Step Speed Reference 2	Multi-Step Speed Reference 3	Jog Reference	
OFF	OFF	OFF	OFF	Reference 1: d1-01 (master speed frequency)
ON	OFF	OFF	OFF	Reference 2: d1-02 (auxiliary speed frequency)
OFF	**ON**	OFF	OFF	Reference 3: d1-03
ON	**ON**	OFF	OFF	Reference 4: d1-04
OFF	OFF	**ON**	OFF	Reference 5: d1-05
ON	OFF	**ON**	OFF	Reference 6: d1-06
OFF	**ON**	**ON**	OFF	Reference 7: d1-07
ON	**ON**	**ON**	OFF	Reference 8: d1-08
—	—	—	**ON**	Jog frequency: d1-09

Selecting 1-Step and 2-Step Frequency References

- To use the master frequency (analog Terminal 13 or 14), set b1-01 to 1.
- To use frequency reference 1 (d1-01), set b1-01 to 0.
- To use the auxiliary frequency reference (analog Terminal 16), use the factory setting.
- To use frequency reference 2 (d1-02), set H3-05 to 1F.

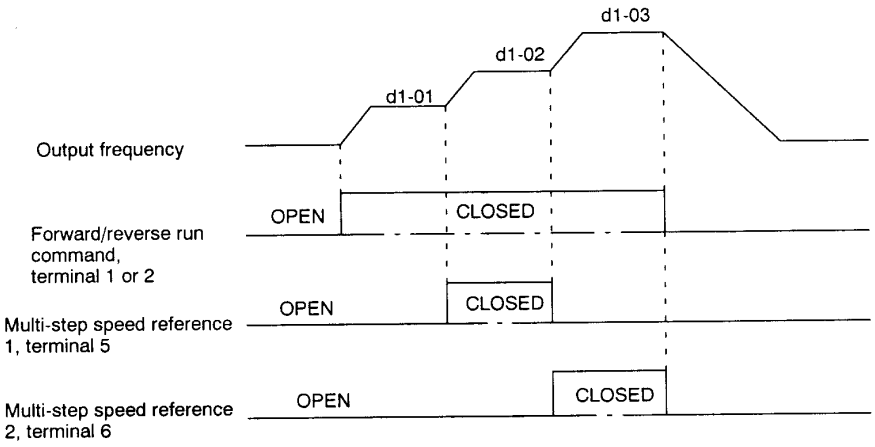
Figure 6.10 Timing Chart for Multi-Step Speed and Jog References



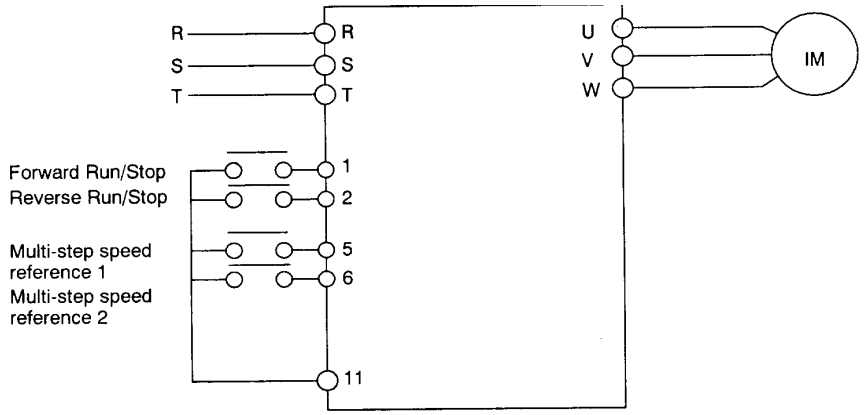
3-Step Speed Operation Example

The following example shows 3-step speed operation with frequencies set at Inverter constants.

- Sequence



- Connections



- User Constant Settings

Constant No.	Name	Setting
A1-01	Constant access level	3: Basic (B)
b1-01	Reference selection	0: Operator
d1-01	Frequency reference 1	✻✻ Hz (frequency setting)
d1-02	Frequency reference 2	✻✻ Hz (frequency setting)
d1-03	Frequency reference 3	✻✻ Hz (frequency setting)
H1-03	Multi-function input (Terminal 5)	3: Multi-step speed reference 1 (factory setting)
H1-04	Multi-function input (Terminal 6)	4: Multi-step speed reference 2 (factory setting)
H3-05	Multi-function input (Terminal 16)	1F: Not used

Terminal 6 would not be needed if 2-step speed operation were required.

Acceleration/Deceleration Time Selectors 1 and 2: "7" and "1A"

- Four acceleration times and four deceleration times can be set. The multi-function inputs can be set as acceleration/deceleration time selectors 1 and 2 to switch between these acceleration and deceleration times.

Setting	Function
7	Acceleration/Deceleration time selector 1
1A	Acceleration/Deceleration time selector 2

- The following table shows which acceleration and deceleration times are selected by each possible combination of acceleration/deceleration time selectors 1 and 2. The acceleration and deceleration times can be changed while the Inverter is operating.

Accel/Decel Time Selector 1	Accel/Decel Time Selector 2	Acceleration Time	Deceleration Time
OFF or not set	OFF or not set	Acceleration time 1 (C1-01)	Deceleration time 1 (C1-02)
ON	OFF or not set	Acceleration time 2 (C1-02)	Deceleration time 2 (C1-04)
OFF or not set	ON	Acceleration time 3 (C1-05)	Deceleration time 3 (C1-06)
ON	ON	Acceleration time 4 (C1-07)	Deceleration time 4 (C1-08)

Emergency Stop: "15"

- When the multi-function input that is set as an emergency stop is turned ON, the motor will decelerate to a stop at the rate set with the deceleration time in C1-09 (emergency stop time).
- To clear the emergency stop, turn OFF the run command, turn OFF the emergency stop input, and then turn ON the run command again.

Forward and Reverse Jog Commands: "12" and "13"

The jogging can be performed in forward or reverse.

Setting	Function
12	Forward jog command: Runs forward at the jog frequency (d1-09).
13	Reverse jog command: Runs in reverse at the jog frequency (d1-09).

- The forward jog and reverse jog commands have priority over other frequency reference commands.
- The inverter will stop operation with the stopping method set in b1-03 if the forward jog and reverse jog commands are both ON for more than 500 ms.
- Turn ON either the forward jog command or the reverse jog command, not both.
- These jog commands can operate the Inverter independently. It is not necessary for a forward/reverse run command to be input.

Terminal 13/14 Switch: "1F"

- When this function is set for multi-function input, that input terminal can be used to switch between Terminal 13 and Terminal 14.

OFF	The analog input from Terminal 13 is used as the master-speed frequency reference.
ON	The analog input from Terminal 14 is used as the master-speed frequency reference.

- When Terminal 14 is used as the frequency reference, set "1F" (frequency reference) in constant H3-09; this constant is the function selector for frequency reference (current) Terminal 14. A setting fault (OPE03) will occur if this function is selected without setting "1F" in H3-09.
- When H3-09 is set to "1F" (frequency reference) but none of the multi-function inputs is set to "1F" Terminal 13/14 switch), the sum of the inputs from Terminals 13 and 14 will be used as the master-speed frequency reference.

6.2 Open-Loop Vector Control

Open-Loop Vector Control is Vector Control without PG input. Auto-Tuning is the only setting for basic operation with Open-Loop Vector Control.

To operate with the greatest speed precision near the rated speed, select a motor with a rated voltage that is at least 20 V below the Inverter's input power supply voltage for 200 V class Inverters and 40 V below for 400 V class Inverters. When the input voltage is the same as the rated voltage, the voltage limit may be applied and Vector Control won't be established.

6.2.1 Auto-Tuning

⚠ CAUTION

- Do not connect a load to the motor when performing Auto-Tuning. Doing so may result in personal injury or equipment damage.

■ Precautions Before Auto-Tuning

- The Inverter's Auto-Tuning function automatically determines the motor constants while a servo system's Auto-Tuning function determines the size of a load, so these Auto-Tuning functions are fundamentally different.
- If a load is connected when Auto-Tuning is performed, not only will incorrect motor constants be recorded, but the motor may operate erratically or unexpectedly.
- The motor shaft will rotate when Auto-Tuning is performed. Confirm safety before starting Auto-Tuning.

■ Inverter Input Voltage Setting: E1-01

- Set the Inverter input voltage (E1-01) to match the power supply voltage.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
E1-01	Input voltage setting	X	155 to 255 (310 to 510)	VAC	200 (400)	Q	Q	Q	Q

- The voltage settings shown in parentheses are the values for the 400 V class. This setting is used as the reference value for functions such as the protection functions.

■ Required Constant Settings

1. Enter Auto-Tuning mode and make the following constant settings:
   - Rated Voltage – Set the rated voltage VAC shown on the motor nameplate.
   - Rated Current – Set the rated current (A) shown on the motor nameplate.
   - Rated Frequency – Set the rated frequency (Hz) sown on the motor nameplate.
   - Rated Speed – Set the rated speed (RPM) shown on the motor nameplate.
   - Number of Poles – Set the number of poles.
   - Motor Selection – Select motor 1 or motor 2. (Normally select motor 1.)
2. The following message will appear when the constants have been set:

Tuning Ready? Press RUN key

   The "Press RUN key" message will blink.
3. At this point, it is still possible to change the constant settings by pressing the Increment and Decrement keys to display the desired constant.
4. Press the STOP key to cancel Auto-Tuning, and then press the MENU key and DATA/ENTER key. The operation mode display will appear.

■ Performing Auto-Tuning

- Auto-Tuning will start is the RUN key is pressed when the “Tuning Ready?” message is being displayed.
- The motor will operate during Auto-Tuning, so be sure that it is safe for the motor to operate before pressing the RUN key.
- The following message will be displayed when the RUN key is pressed:

  Tune Proceeding
  ❑ Hz ❑❑❑❑ A

  The “Tune Proceeding” message will blink.
- Auto-Tuning takes up to 1.5 minutes. The message “Tune Successful” will be displayed when Auto-Tuning has been completed.
- If Auto-Tuning has been completed successfully, press the MENU key and proceed to the next operation.
- If a fault occurred during Auto-Tuning, refer to *6.2.2 Auto-Tuning Faults* for details on correcting the cause of the fault and perform Auto-Tuning again.

6.2.2 Auto-Tuning Faults

- One of the fault messages in the following table will be displayed if a fault occurs during Auto-Tuning and the motor will stop. In this case, determine the cause of the fault, correct it, and perform Auto-Tuning again.
- The fault display can be cleared by pressing the MENU key.
- The motor constants will revert to their default settings if a fault occurs. Set these constants again before starting Auto-Tuning again.

Table 6.2 Troubleshooting Auto-Tuning Faults for Open-Loop Vector Control

Fault Display	Probable Cause		Remedy
Data Invalid (Motor data fault)	There was a fault in the data set during Auto-Tuning.	There was a fault in the relationship between the rated frequency, rated speed, and number of poles.	Change the settings to conform to the following equation: Rated speed < 120 x Motor frequency/number of poles
ALARM: Over Load (Excessive tuning load)	The effective load factor exceeded 20% during Auto-Tuning.	A load is connected to the motor.	Remove the load.
		There was a setting fault during Auto-Tuning.	Check the rated current setting. Change if necessary.
		There is a motor bearing problem.	Turn the Inverter OFF and rotate the motor by hand. Replace the motor if it does not turn smoothly.
Motor Speed (Motor speed fault)	The torque reference value exceeded 100% during Auto-Tuning.	There is a broken/disconnected motor power wire.	Check and replace wiring components if necessary.
		A load is connected to the motor.	Remove the load.
Accelerate (Acceleration fault)	The motor does not accelerate within the prescribed time.	The torque limit function is operating.	Initialize the torque limit constants (H7-01 to H7-04).
		The acceleration time is too short.	Increase acceleration time 1 (C1-01).
		A load is connected to the motor.	Remove the load.
Rated Slip (Rated slip fault)	The rated slip setting cannot be tuned within the prescribed time.	A load is connected to the motor.	Remove the load.
Saturation –1 (Iron core saturation coefficient 1 fault)	The core-saturation coefficients cannot be turned within the prescribed time.	The rated current setting is not correct.	Check and change the setting if necessary.
Saturation –2 (Iron core saturation coefficient 2 fault)		There is a broken/disconnected motor power wire.	Check and replace wiring components if necessary.
Resistance (Line-to-line resistance fault)	The motor terminal resistance or no-load current setting cannot be turned within the prescribed time.	The rated current setting is not correct.	Check and change the setting if necessary.
No-Load Current (No-load current fault)		There is a broken/disconnected motor power wire.	Check and replace wiring components if necessary.
Tune Aborted Minor Fault: ❑❑❑	—	A minor Inverter fault occurred.	Check the minor fault indicated in the boxes in the display shown at the left.

6.3 V/f Control

With V/f control, the user must set the Inverter input voltage, motor selection, rated current, and V/f pattern.

6.3.1 Setting the Motor Constants: E1-01, E1-02, E2-01

■ Inverter Input Voltage: E1-01

- Set the Inverter input voltage (E1-01) to match the power supply voltage.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
E1-01	Input voltage setting	X	155 to 255 (310 to 510)	VAC	200 (400)	Q	Q	Q	Q

- The voltage settings shown in parentheses are for 400 V class Inverters.
- This setting is used as a reference value for functions such as the protection functions.

■ Motor Selection and Rated Current: E1-02, E2-01

Motor Selection (Motor Overheating Protection): E1-02

- Set the type of motor being used. This setting is a reference for overheating protection functions.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
E1-02	Motor selection (motor overheating protection)	X	0,1	—	0	Q	Q	Q	Q

- Settings

Setting	Function
0	Standard motor (general-purpose motor)
1	Special motor (inverter-exclusive motor)

Motor Rated Current (Electronic Thermal Reference Current): E2-01

- Set the rated current (A) shown on the motor nameplate.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
E2-01	Motor rated current (electronic thermal reference current)	x	10% to 200% (of rated current)*1	A	*2	Q	Q	Q	Q

*1 The setting range is 10% to 200% of the Inverter rated output current.

*2 The factory setting depends upon the Inverter capacity. Refer to Pages 258 and 259.

6.3.2 V/f Pattern Selection: E1-03

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
E1-03	V/f pattern selection	X	0 to F	—	F	Q	Q	X	X

- The V/f pattern can be set to any of the following:
  - One of 15 preset patterns (settings 0 through E)
  - A custom user-set pattern (setting F)
- The factory setting for E1-02 is “F” (user-defined V/f pattern), but the default contents of this setting are the same as setting “1”.

■ Selecting a Preset V/f Pattern: E1-03 = “0” through “E”

- Refer to the following table to set one of the 15 preset patterns.

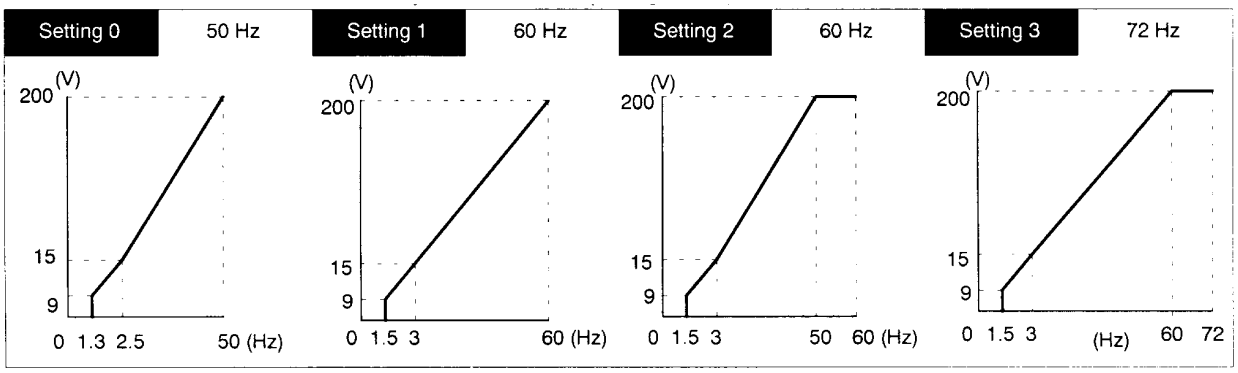
Characteristics	Applications	Setting	Specifications
Constant Torque	These patterns are for general-purpose applications. Use these patterns when the load torque is to remain constant for any rotational speed, such as in straight-line conveyors.	0	50 Hz
		1	60 Hz
		2	60 Hz, voltage saturation at 50 Hz
		3	72 Hz, voltage saturation at 60 Hz
Variable Torque	Use these patterns when there is a quadratic or cubic relationship between the rotational speed and load, such as in fans or pumps	4	50 Hz, cubic, variable torque 1
		5	50 Hz, quadratic, variable torque 2
		6	60 Hz, cubic, variable torque 1
		7	60 Hz, quadratic, variable torque 2
High Starting Torque*	Select a high starting torque V/f pattern only in the following cases: • The wiring distance between the Inverter and motor is relatively large (greater than 150 meters). • A large torque is required at startup (such as for heavy axis loads). • An AC or DC Reactor is connected to the Inverter’s input or output. • A motor less than the maximum applicable motor is being used.	8	50 Hz, low starting torque
		9	50 Hz, high starting torque
		A	60 Hz, low starting torque
		B	60 Hz, high starting torque
High-Speed Operation	These patterns are for applications that must rotate at frequencies greater than 60 Hz. A fixed voltage is applied at frequencies greater than 60 Hz.	C	90 Hz, voltage saturation at 60 Hz
		D	120 Hz, voltage saturation at 60 Hz
		E	180 Hz, voltage saturation at 60 Hz

* Normally it is not necessary to use these patterns because starting torque is ensured by automatic torque boost functions.

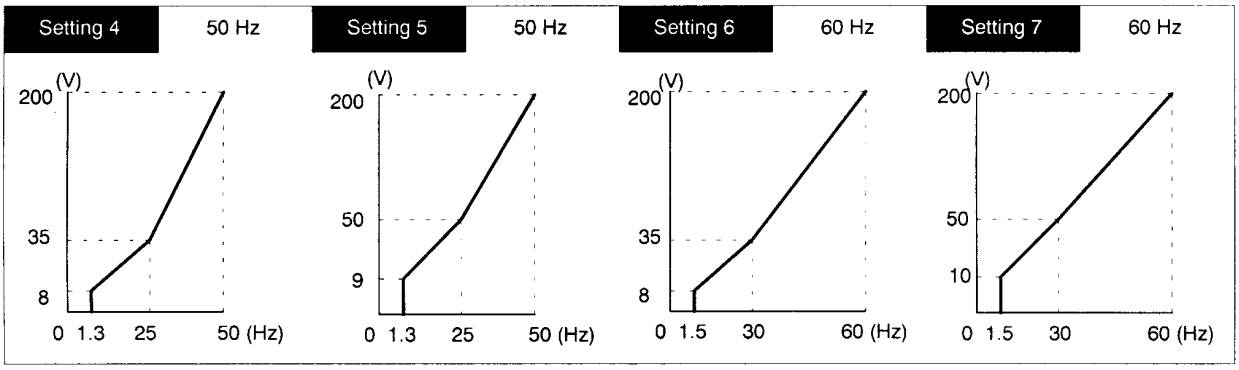
- The constant settings for E1-04 through E1-10 will be changed automatically when one of these patterns is selected. There are three possible settings for these constants depending on the Inverter’s capacity:
  - A 0.4 to 1.5 kW V/f pattern
  - A 2.2 to 45 kW V/f pattern
  - A 55 to 300 kW V/f pattern
- The characteristics for these patterns are shown in the diagrams on the following pages.

V/f Patterns: 0.4 to 1.5kW

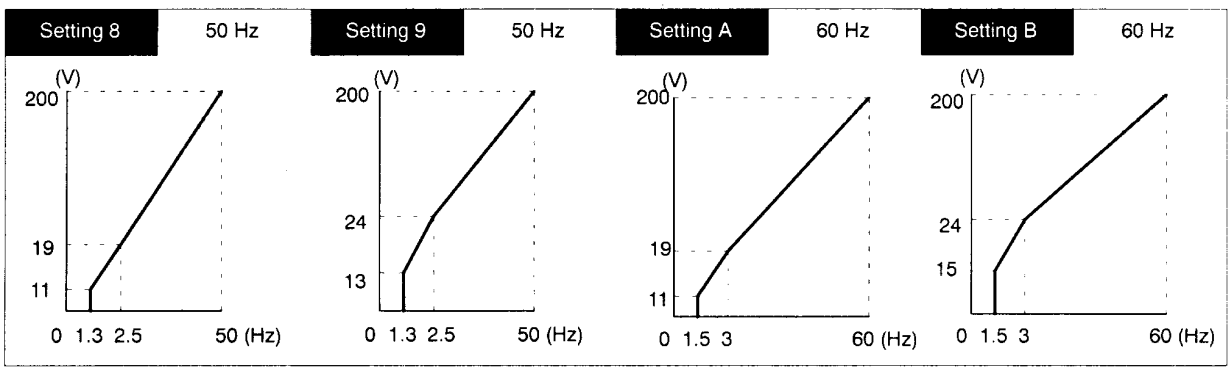
- Fixed Torque Characteristics (Settings 0 to 3)



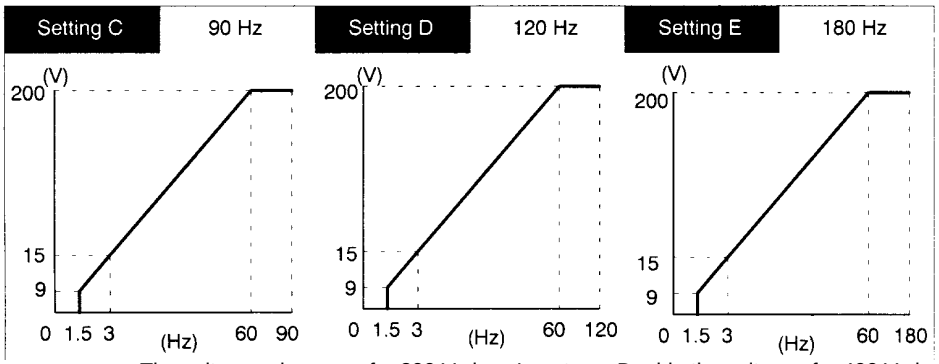
- Variable Torque Characteristics (Settings 4 to 7)



- High Starting Torque Characteristics (Settings 8 to b)



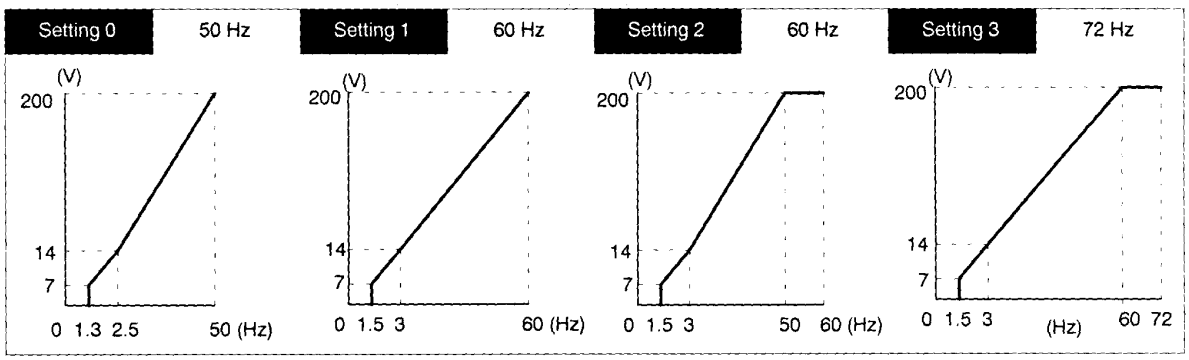
- High Speed Operation (Settings C to E)



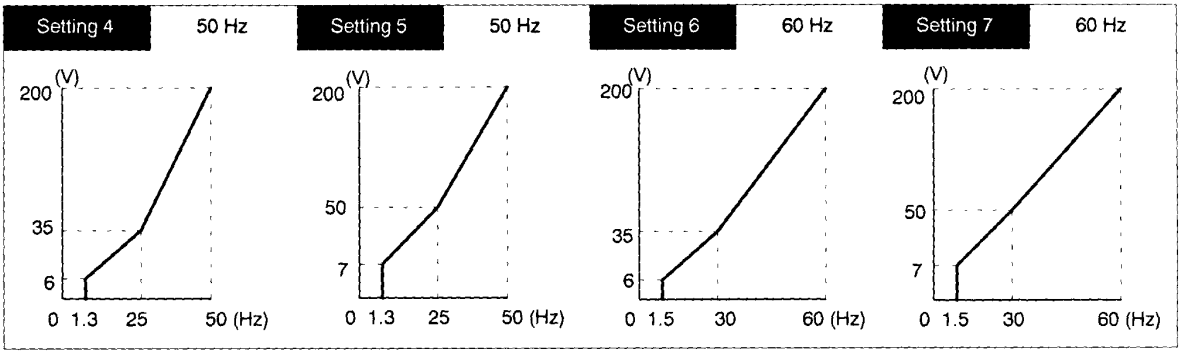
The voltages above are for 200 V class Inverters. Double the voltages for 400 V class Inverters.

V/f Patterns: 2.2 to 45kW

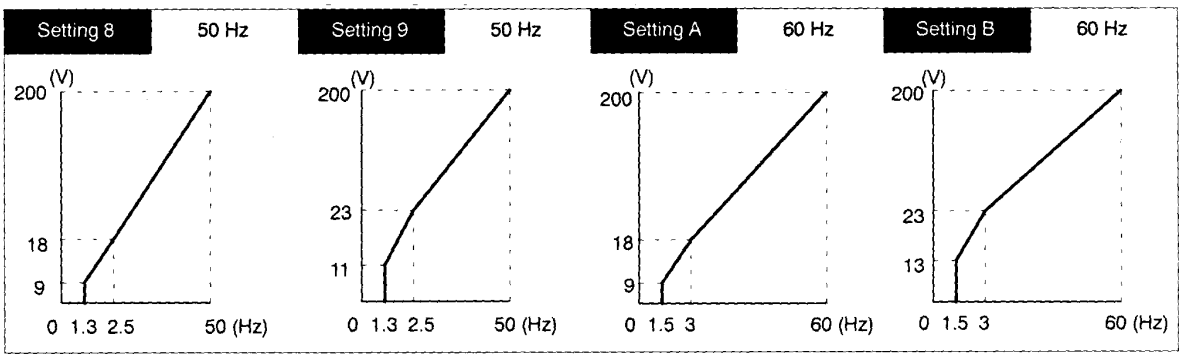
- Fixed Torque Characteristics (Settings 0 to 3)



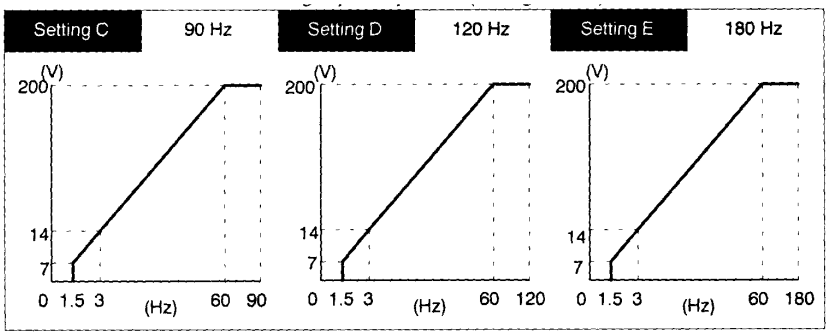
- Variable Torque Characteristics (Settings 4 to 7)



- High Starting Torque Characteristics (Settings 8 to b)



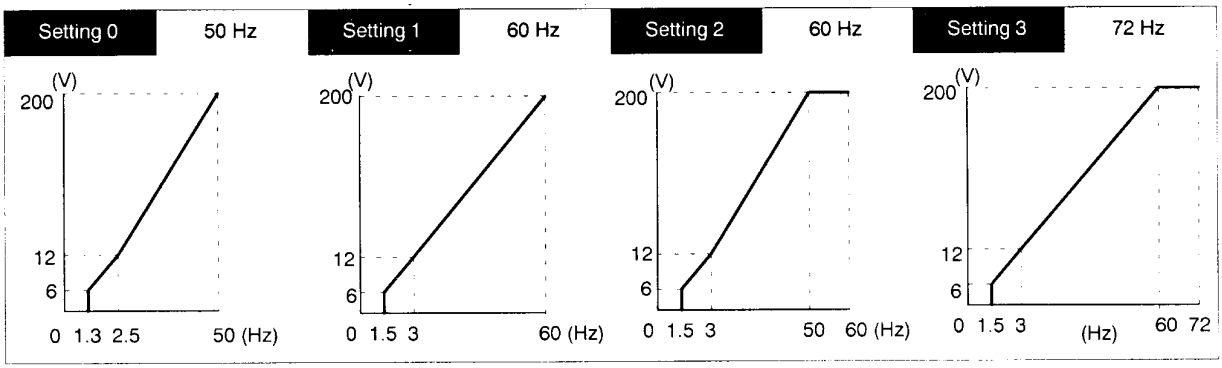
- High Speed Operation (Settings C to E)



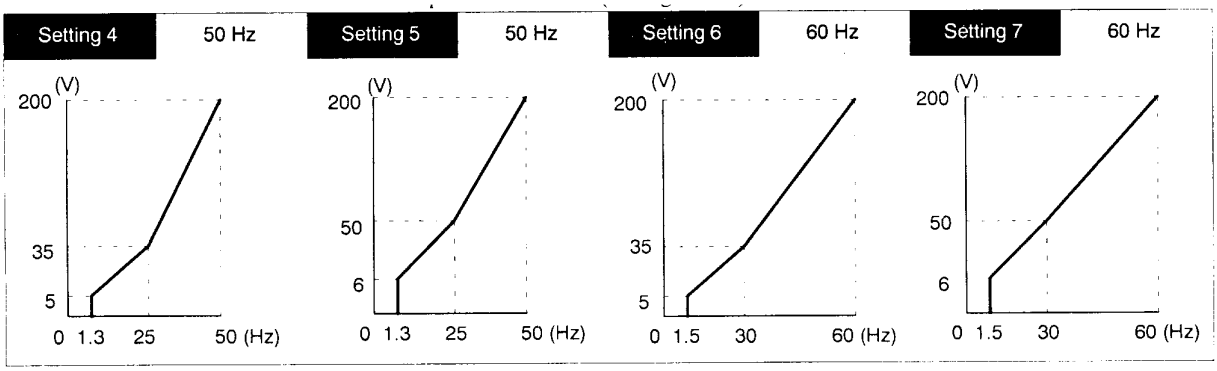
The voltages above are for 200 V class Inverters. Double the voltages for 400 V class Inverters.

V/f Patterns: 55 to 300kW

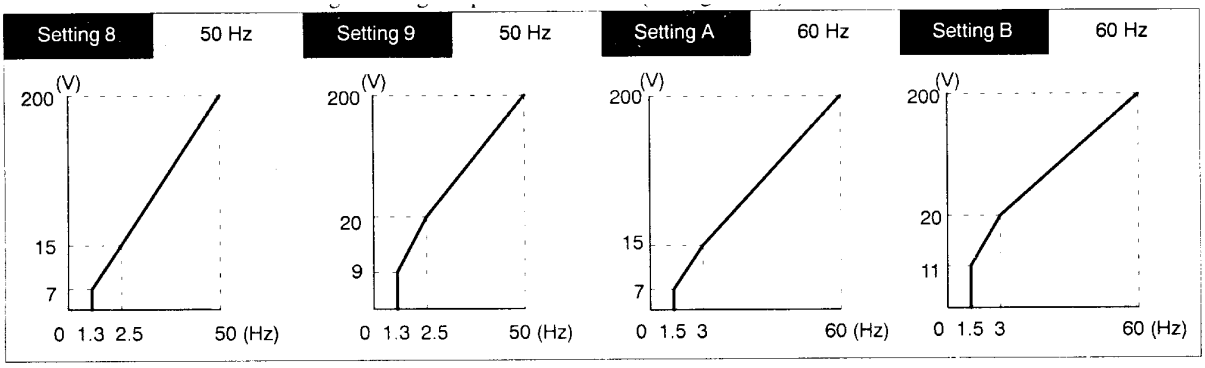
- Fixed Torque Characteristics (Settings 0 to 3)



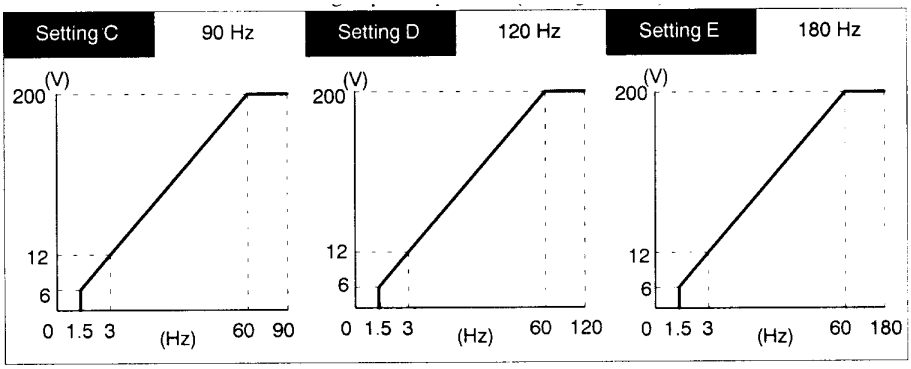
- Variable Torque Characteristics (Settings 4 to 7)



- High Starting Torque Characteristics (Settings 8 to b)



- High Speed Operation (Settings C to E)



The voltages above are for 200 V class Inverters. Double the voltages for 400 V class Inverters.

Setting a User-Defined V/f Pattern: E1-03 = "F"

- Constants E1-04 through E1-10 can be set by the user when E1-03 has been set to "F". These constants are read-only when E1-03 is not set to "F".
- When making the V/f characteristics a straight line, set the same value in E1-07 (middle output frequency) and E1-09 (minimum output frequency). In this case, constant E1-08 (middle output frequency voltage) will be disregarded.
- The user constant numbers for motor 2 are given in parentheses.

Settings for E1-04 to E1-10 (E4-01 to E4-07) and E1-13

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
E1-04 (E4-01)	Max. output frequency (FMAX)	X	40.0 to 400.0	Hz	60.0	Q	Q	Q	Q
E1-05 (E4-02)	Max. voltage (VMAX)	X	0.0 to 255.0*1	VAC	200.0 *1	Q	Q	Q	Q
E1-06 (E4-03)	Base frequency (FA)	X	0.0 to 400.0	Hz	60.0	Q	Q	Q	Q
E1-07 (E4-04)	Mid. Output frequency voltage (VC)	X	0.0 to 400.0	Hz	3.0 *2	Q	Q	A	X
E1-08 (E4-05)	Mid. output frequency voltage (VC)	X	0 to 255.0*1	VAC	15.0*1, *2	Q	Q	A	X
E1-09 (E4-06)	Min. output frequency (FMIN)	X	0.0 to 400.0	Hz	1.5 *2	Q	Q	Q	A
E1-10 (E4-07)	Min. output frequency voltage (VMIN)	X	0.0 to 255.0*1	VAC	9.0*1, *2	Q	Q	A	X
E1-13	Base voltage (VBASE)	X	0.0 to 255.0	VAC	0.0 *3	A	A	Q	Q

*1 These values are for the 200 V class; double the values for 400 V class Inverters.

*2 The factory setting depends on the Inverter capacity. The factory settings shown in the table are for 200 V class, 0.4 to 1.5 kW Inverters. (See Page 258)

*3 If E1-13 is set to 0.0, E1-13 will be set to the same value as E1-05 following Auto-Tuning and does not need to be set.

- The factory settings for E1-07 through E1-10 will be set according to the control method whenever the control method is changed. The factory settings shown in the table are for V/f Control. (See Page 257)
- The four frequency settings must satisfy the following formula:
  E1-04 (F_{MAX}) ¾ E1-06 (F_A) > E`-07 (F_B) ¾ E1-09 (F_{MIN})

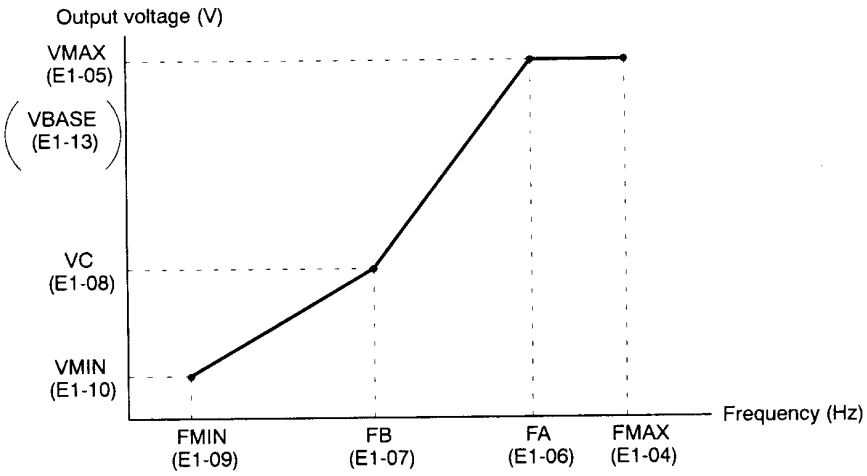


Figure 6.11 User-Defined V/f Pattern

6.4 Flux Vector Control

With Flux Vector Control (Vector Control with PG), make the settings for the PG Speed Option Card, select the Zero Speed operation method, set the various Auto-Tuning constants, and then adjust the gain of the speed control loop.

To ensure high-accuracy torque/speed control, use a motor specifically designed for Vector Control with an integrated PG.

When setting up a PG, connect it directly to the motor shaft. If the PG is connected to the motor via gearing or belts, responses can be delayed by backlash or torsion; the delayed responses can generate oscillation and make control impossible.

6.4.1 PG Speed Option Card Settings

■ Available PG Speed Option Cards

- There are four models of PG Speed Option Cards, but only two models can be used with Vector Control.
  - PG-B2: Phase-A/Phase-B pulse inputs, complementary output PG-X2: Phase-A/Phase-B/Phase-Z pulse inputs, line drivers
- Select the card according to the application and install it in the Inverter as described in *3.7 Installing and Wiring PG Speed Option Cards*.

■ PG Constant: F1-01

- Set the PG constant in pulses/revolution.
- Set the number of Phase-A or Phase-B pulses in one motor revolution.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
F1-01	PG constant	X	0 to 60000	p/r	600	X	Q	X	Q

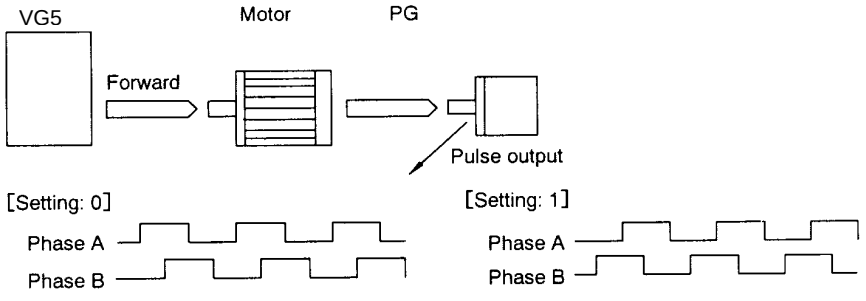
■ PG Rotation Direction: F1-05

- This constant is used to coordinate the PG's rotation direction with the motor's rotation direction. The setting for the standard applicable Saftronics PG (made by Thermtac) is an advanced Phase-A for forward rotation.
- Generally, Phase-A leads when the PG rotates in the clockwise direction (looking from the input axis). When a forward reference is output, the motor rotates in the counterclockwise direction (looking from the output axis).
- Set whether Phase-A or Phase-B leads when the motor operates in the forward direction.

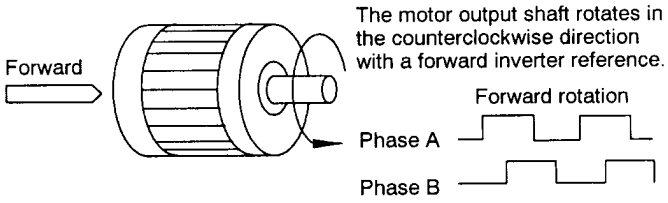
User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
F1-05	PG rotation	X	0, 1	—	0	X	B	X	B

- Settings

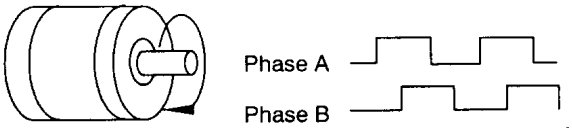
Setting	Function
0	Phase-A leads with forward rotation. (Phase-B leads with reverse rotation.)
1	Phase-B leads with forward rotation. (Phase-A leads with reverse rotation.)



- Forward rotation in a typical motor.



- Phase-A leading in a typical PG:



■ PG Pulse Output Monitor Division Rate: F1-06

- This constant is effective only when a PG-B2 PG Option Card is used.
- It sets the division ratio used when the pulse monitor output is connected to a pulse input device.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
F1-06	PG division rate (PG pulse monitor)	X	1 to 132	—	1	X	B	X	B

- The first digit in the setting (0 or 1) is n and the second two digits (01 to 32) are m. The division ratio is calculated from n and m with the following equation:

  Division ratio = (1+n)/m Setting Ranges n: 0,1 m: 1 to 32
  F1-06 = ❑ ❑❑
  n m

- Possible division rate settings are as follows: 1/32 ≦ F1-06 ≦ 1. For example, if the division rate is half (a setting of "2"), the monitor output will be half of the number of pulses output from the PG.

■ Fault Detection Functions: F1-02 to F1-04, F1-08 to F1-11, F1-14

PG Disconnection Stopping Method: F1-02, F1-14

- Sets the PG open-circuit detection time and stopping method that is used when a break is detected in the PG cable (PGO).

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
F1-02	Operation selection at PG open circuit	X	0 to 3	—	1	X	B	X	B
F1-14	PG open-circuit detection time	X	0.0 to 10.0	s	2.0	X	A	X	A

- Settings

Setting	Function
0	Deceleration to stop using deceleration time 1 (C1-02).
1	Coast to stop.
2	Emergency stop using the emergency-stop time (C1-09).
3	Continue operation. (This setting cannot be made with Flux Vector Control.)

Overspeed Settings: F1-03, F1-08, F1-09

- Overspeed refers to an excessive motor speed.
- Set the conditions (level and time) for detecting overspeed and the stopping method that is used when an overspeed is detected.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
F1-03	Operation selection at overspeed	X	0 to 3	—	1	X	B	X	B
F1-08	Overspeed detection level	X	0 to 120	%	115	X	A	X	A
F1-09	Overspeed detection delay time	X	0.0 to 2.0	s	0.0	X	A	X	A

- Settings

Setting	Function
0	Deceleration to stop using deceleration time 1 (C1-02).
1	Coast to stop.
2	Emergency stop using the emergency-stop time (C1-09).
3	Continue operation. (This setting can't be made with Flux Vector Control.)

- F1-08 and F1-09 Settings
  Constant F1-08 sets the overspeed detection level as a percentage of the maximum output frequency.
  Constant F1-09 sets the length of time in seconds that the motor speed must exceed the overspeed detection level in order to generate an overspeed fault.

PG Speed Deviation Settings: F1-04, F1-10, F1-11

- PG Speed Deviation refers to the difference between the actual motor speed and the reference speed.
- These constants set the conditions (level and time) for detecting PG speed deviation and the stopping method that is used when a PG Speed Deviation is detected.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
F1-04	Operation selection at deviation	X	0 to 3	—	3	X	B	X	B
F1-10	Excessive Speed Deviation detection level	X	0 to 50	%	10	X	A	X	A
F1-11	Excessive Speed Deviation detection delay time	X	0.0 to 10.0	s	0.5	X	A	X	A

- Settings

Setting	Function
0	Deceleration to stop using deceleration time 1 (C1-02).
1	Coast to stop.
2	Emergency stop using the emergency-stop time (C1-09).
3	Continue operation. (Displays "DEV" and continues control.)

- F1-10 and F1-11 Settings
  Constant F1-10 sets the PG Speed Deviation detection level as a percentage of the maximum output frequency. Constant F1-11 sets the length of time in seconds that the difference between the motor speed and reference speed must exceed the PG Speed Deviation detection level in order to detect a PG Speed Deviation.

6.4.2 Setting the Zero Speed Operation Constants

- With Flux Vector Control, operation is possible even when the frequency reference is zero (below the minimum output frequency).
- Set the operation methods for the minimum output frequency.

■ Stopping Method Selection: b1-03

- Set the stopping method used when a stop command is input.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
b1-03	Stopping method selection	X	0 to 3	—	0	Q	Q	Q	Q

- Settings

Setting	Function
0	Deceleration to stop.
1	Coast to stop.
2	DC Injection Braking stop. (This setting cannot be made with Flux Vector Control.)
3	Coast to stop with time. (This setting cannot be made with Flux Vector Control.)

■ Zero Speed Operation: b1-05 and Minimum Output Frequency: E1-09

- Set the operation method used when the frequency reference is below the minimum output frequency.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
b1-05	Operation selection for setting of E1-09 or less	X	0 to 3	—	0	X	X	X	X

- Settings

Setting	Function
0	Operate according to the frequency reference. (E1-09 is invalid.)
1	Interrupt the output. (Coast when the frequency reference is below E1-09.)
2	Operate at E1-09 frequency. (Output the frequency set in E1-09.)
3	Zero Speed operation. (Zero reference value when the frequency reference is below E1-09.)

Minimum Output frequency (FMIN): E1-09

- Set the minimum output frequency according to the requirements of the application.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
E1-09	Minimum output frequency	X	0.0 to 400.0	Hz	0.0	Q	Q	Q	A

Initial Excitation Settings: b2-01, b2-03, b2-04

- Set the Zero Speed level, DC Injection Braking time at startup, and the DC Injection Braking time when stopping.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
b2-01	Zero speed level (DC Injection Braking starting frequency)	X	0.0 to 10.0	Hz	0.5	B	B	B	B
b2-03	DC Injection Braking	X	0.00 to 10.00	s	0.00	B	B	B	B
b2-04	DC Injection Braking time at stop	X	0.00 to 10.00	s	0.50	B	B	B	B

- With Flux Vector Control, the DC Injection Braking function is replaced by the initial excitation function and Zero Speed function.
- The timing of the initial excitation function depends on the Zero Speed operation method selected in b1-05 (Zero Speed operation), as shown in *Figure 6.13*.
- The initial excitation function stops a motor that is rotating because of inertia.

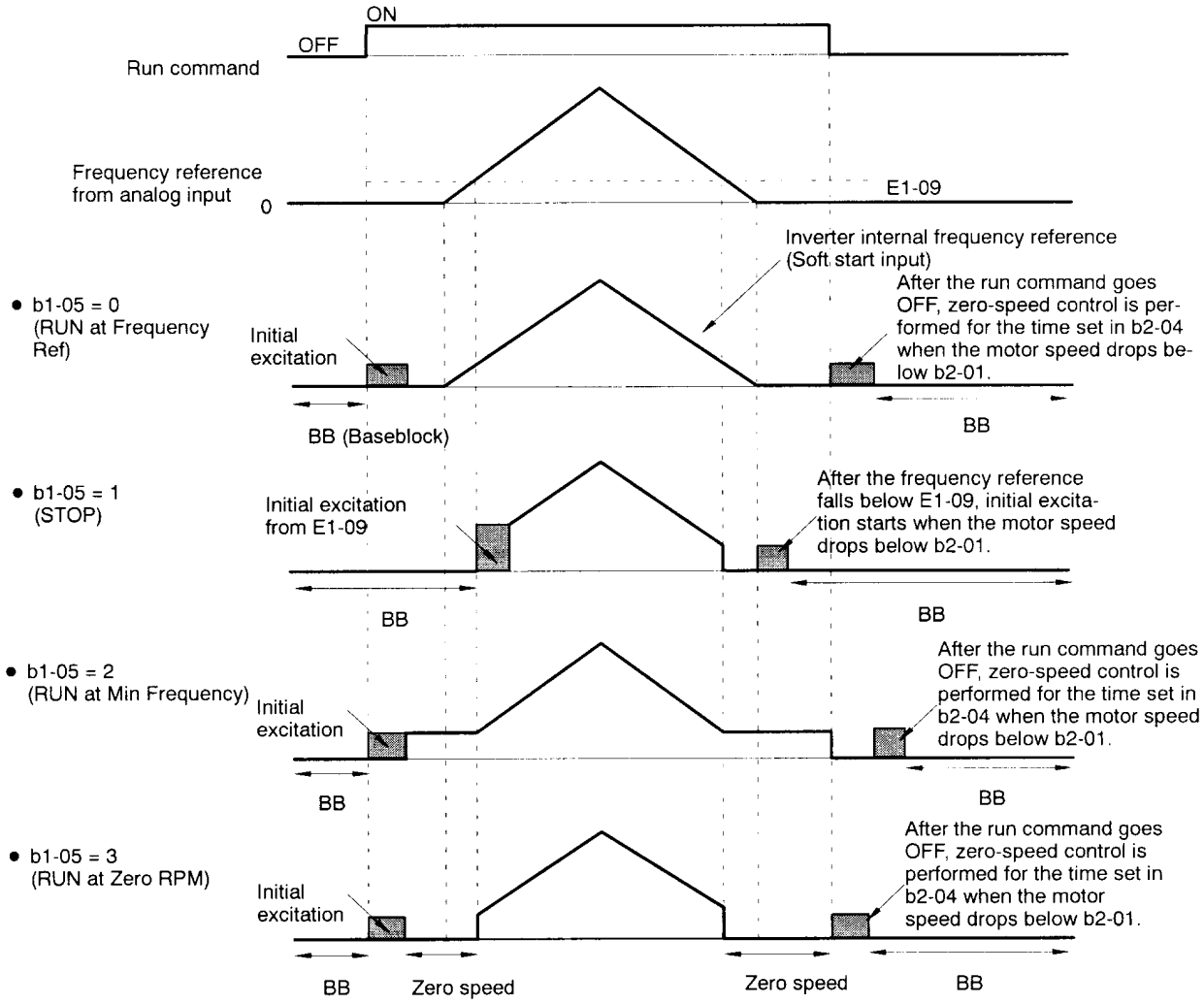


Figure 6.13 Zero Speed Operation Method

- Initial excitation is started from b2-01 (Zero Speed level) when decelerating. A setting of b2-01<E1-09 is valid only with Flux Vector Control.
- The current level of the initial excitation function is set in E2-03 (motor no-load current).
- The DC Injection Braking current (b2-02) is not used with Flux Vector Control and cannot be set.

6.4.3 Auto-Tuning

CAUTION

- Do not connect a load to the motor when performing Auto-Tuning. Doing so may result in personal injury or equipment damage.

■ Precautions Before Auto-Tuning

- The Inverter's Auto-Tuning function automatically determines the motor constants while a servo system's Auto-Tuning function determines the size of a load, so these Auto-Tuning functions are fundamentally different.
- If a load is connected when Auto-Tuning is performed, not only will incorrect motor constants be recorded, but the motor may operate erratically or unexpectedly.
- The motor shaft will rotate when Auto-Tuning is performed. Confirm safety before starting Auto-Tuning.

■ Inverter Input Voltage Setting: E1-01

- Set the Inverter input voltage to match the power supply voltage.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
E1-01	Input voltage setting	X	155 to 255 (310 to 510)	VAC	200 (400)	Q	Q	Q	Q

- The voltage settings shown in parentheses are for 400 V class Inverters.
- This setting is used as the reference value for functions such as the protection functions.

■ Required Constant Settings

1. Enter Auto-Tuning mode and make the following constant settings:
   - Rated Voltage - Set the rated voltage (VAC) shown on the motor nameplate.
   - Rated Current – Set the rated current (A) shown on the motor nameplate.
   - Rated Frequency – Set the rated frequency (Hz) shown on the motor nameplate.
   - Rated Speed – Set the rated speed (RPM) shown on the motor nameplate.
   - Number of Poles – Set the number of poles.
   - Motor Selection – Select motor 1 or motor 2. (Normally select motor 1.)
   - PG Pulses/Rev – Set the number of A-Phase or B-Phase pulses per revolution.
2. The following message will appear when the constants have been set:

   Tuning Ready?
   Press RUN key

   The "Press RUN key" message will blink.
3. At this point, it is still possible to change the constant settings by pressing the Increment and Decrement keys to display the desired constant.
4. Press the STOP key to cancel Auto-Tuning, and then press the MENU key and DATA/ENTER key. The operation mode display will appear.

■ Performing Auto-Tuning

- Auto-Tuning will start if the RUN key is pressed when the "Tuning Ready?" message is being displayed.
- The motor will operate during Auto-Tuning, so be sure that it is safe for the motor to operate before pressing the RUN key.

- The following message will be displayed when the RUN key is pressed:

  Tune Proceeding
  ❑ Hz ❑❑❑❑ A

  The "Tune Proceeding" message will blink.

- Auto-Tuning takes up to 1.5 minutes. The message "Tune Successful" will be displayed when Auto-Tuning is completed.
- If Auto-Tuning has been completed successfully, press the MENU key and proceed to the next operation.
- If a fault occurred during Auto-Tuning, refer to *Table 6.3 Auto-Tuning Faults* for details on correcting the cause of the fault and perform Auto-Tuning again.

■ Auto-Tuning Faults

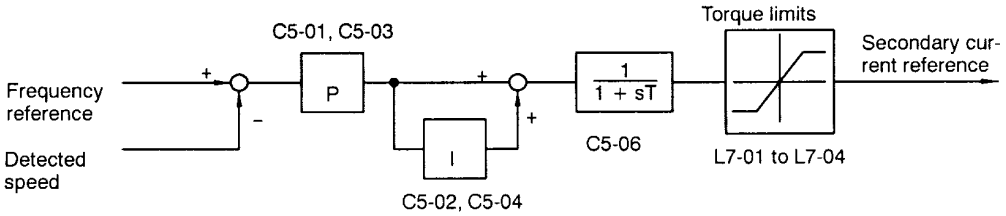
- One of the fault messages in the following table will be displayed if a fault occurs during Auto-Tuning and the motor will stop. In this case, determine the cause of the fault, correct it, and perform Auto-Tuning again.
- The fault display can be cleared by pressing the MENU key.
- The motor constants will revert to their default settings if a fault occurs. Set these constants again before starting Auto-Tuning again.

Table 6.3 Troubleshooting Auto-Tuning Faults for Open-Loop Vector Control

Fault Display	Probable Cause		Remedy
Data Invalid (Motor data fault)	There was a fault in the data set during Auto-Tuning.	There was a fault in the relationship between the rated frequency, rated speed, and number of poles.	Change the settings to conform to the following equation: Rated speed < 120 x Motor Frequency/Number of Poles
ALARM: Over Load (Excessive tuning load)	The effective load factor exceeded 20% during Auto-Tuning.	A load is connected to the motor shaft.	Remove the load.
		There was a setting fault during Auto-Tuning.	Check the rated current setting. Change if necessary.
		There is a motor bearing problem.	Turn the Inverter off and rotate the motor by hand. Replace the motor if it does not turn smoothly.
Motor Speed (Motor speed fault)	The torque reference value exceeded 100% during Auto-Tuning.	There is a broken/disconnected motor power wire.	Check and replace wiring components if necessary.
		A load is connected to the motor shaft.	Remove the load.
Accelerate (Acceleration fault)	The motor does not accelerate within the prescribed time.	The torque limit function is operating.	Initialize the torque limit constants (H7-01 to H7-04).
		The acceleration time is too short.	Increase acceleration time 1 (C1-01).
		A load is connected to the motor shaft.	Remove the load.
Rated slip (Rated slip fault)	The rated slip setting cannot be tuned within the prescribed time.	A load is connected to the motor shaft.	Remove the load.
Saturation –1 (Iron core saturation coefficient 1 fault)	The core-saturation coefficients cannot be tuned within the prescribed time.	The rated current setting is not correct.	Check and change the setting is necessary.
Saturation –2 (Iron core saturation coefficient 1 fault)		There is a broken/disconnected motor power wire.	Check and replace wiring components if necessary.
Resistance (Line-to-line resistance fault)	The motor terminal resistance or no-load current setting cannot be tuned within the prescribed time.	The rated current setting is not correct.	Check and change the setting if necessary.
No-Load Current (No-load current fault)		There is a broken/disconnected motor power wire.	Check and replace wiring components if necessary
Motor Direction Fault (Motor direction fault)	—	There is a faulty connection between the Inverter and PC (A or B-Phase) or the Inverter and Motor (U, V, or W-Phase).	• Check the PG wiring. • Check the motor wiring. • Check the PG rotation direction and constant F1-05.
PG Circuit Fault (PGO: PG break detected)	Pulses are not being input from the PG even though a rotation output is being sent to the motor.	• The cable to the PG is broken/ disconnected. • The PG's power supply is broken/ disconnected.	Check the wiring and correct any problems.
Turn Aborted (Minor Fault: ❑❑❑)	—	A minor Inverter fault occurred.	Check the minor fault indicated in the boxes in the display shown at the left.

6.4.4 Speed Control (ASR) Structure

- The following block diagram shows the structure of the speed control (ASR).



■ Gain Settings: C5-01, C5-02

- Set the proportional gain and the integral time of the ASR.

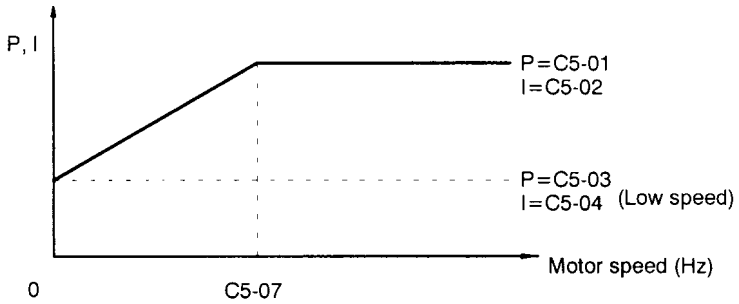
User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
C5-01	ASR proportional (P) gain 1	❍	0.00 to 300.00	Multiple	20.00	X	B	X	B
C5-02	ASR integral (I) time 1	❍	0.000 to 10.000	s	0.500	X	B	X	B

■ **Low-Speed Gain Settings: C5-03, C5-04, C5-07**

- Use these constants to set different proportional gain and integral time settings for low-speed operation. Constant C5-03 sets the low-speed proportional gain of the ASR, and C5-04 sets the low-speed integral time.
- Set constant C5-07 to the frequency at which to switch to the low-speed ASR proportional gain and integral time.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
C5-03	ASR proportional (P) gain 2	❍	0.00 to 300.00	Multiple	20.00	X	B	X	B
C5-04	ASR integral (I) time 2	❍	0.000 to 10.000	s	0.500	X	B	X	B
C5-07	ASR switching frequency	X	0.0 to 400.0	Hz	0.0	X	X	X	A

- *Figure 6.15* shows how the proportional gain and integral time approach the ASR proportional gain 2 and ASR integral time 2 linearly.



If C5-07 is set to 0.0, ASR proportional gain 1 and ASR integral time 1 are used for the proportional gain and integral time at all frequencies.

Figure 6.15 Gain Settings at Low Frequencies

- Multi-Function Input Settings: H1-01 (Terminal 3) to H1-06 (Terminal 8)

ASR Integral Reset Setting: "E"

- When one of the multi-function inputs is set to "E", the input can be used to switch the speed control loop between P Control and PI Control.
- P Control (integral reset) is used when the multi-function input is ON.

ASR Proportional Gain Switch Setting: "77"

- When one of the multi-function inputs is set to "77", the input can be used to switch between proportional gain 1 and proportional gain 2.
- Proportional gain 2 (C5-03) is used when the multi-function input is ON. This input has higher priority than the ASR switching frequency set in C5-07.

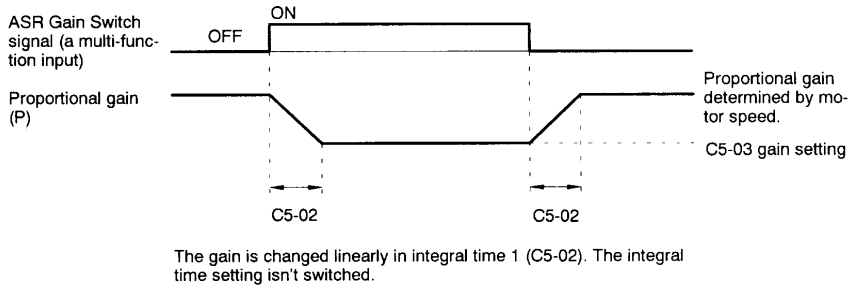


Figure 6.16 ASR Proportional Gain Switch

ASR Responsiveness: C5-06

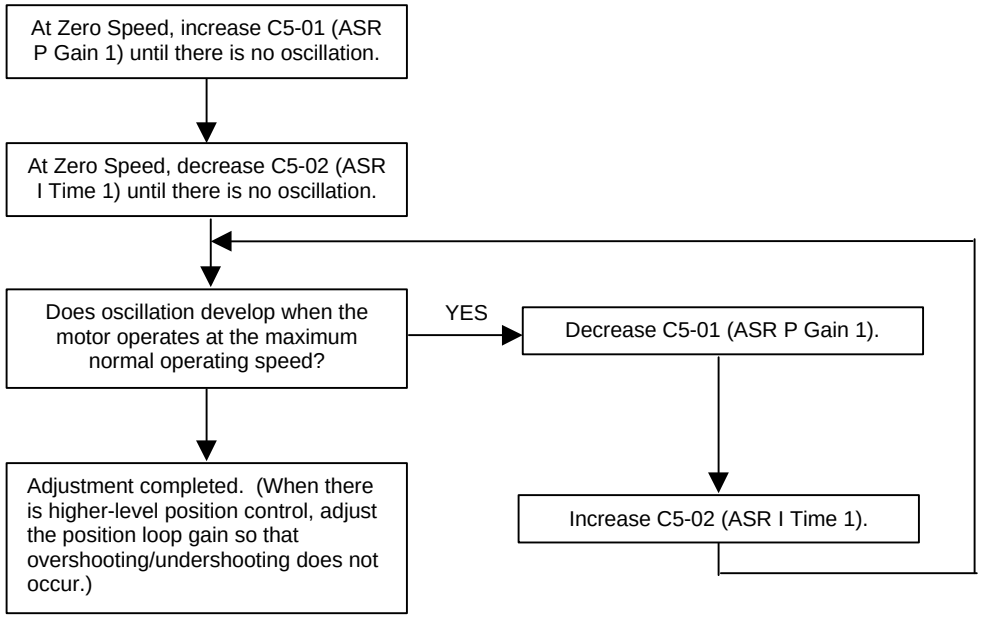
User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
C5-06	ASR primary delay time	X	0.000 to 0.500	s	0.004	X	X	X	A

- Normally it is not necessary to make this adjustment.
- Constant C5-06 can be used when adjusting the gain does not remove motor oscillation, or adjusting the gain removes oscillation but results in poor responsiveness.
- A high C5-06 setting lowers the responsiveness of the speed control, but makes it difficult for oscillation to occur.

6.4.5 ASR Gain

■ Gain Adjustment Procedure

Use the following procedure to adjust the gain with the mechanical system and actual load connected.



■ Fine Adjustments

- When you want even finer gain adjustment, adjust the gain while observing the speed waveform.
- Constant settings like those shown in the following table will be necessary to monitor the speed waveform.

Constant	Setting	Explanation
H4-01 Analog output selection (Terminal 21)	2	Settings that allow multi-function analog output 1 to be used to monitor the output frequency.
H4-02 Analog output gain (Terminal 21)	1.00	
H4-03 Analog output bias (Terminal 21)	0.0	
H4-04 Analog output selection (Terminal 23)	5	Settings that allow multi-function analog output 2 to be used to monitor the motor speed.
H4-05 Analog output gain (Terminal 23)	1.00	
H4-06 Analog output bias (Terminal 23)	0.0	
H4-07 Analog output level selection	1	This setting allows a 0 to ±10 V signal range to be monitored.

- The multi-function analog outputs have the following functions with these constant settings.
  - Multi-function analog output 1 Terminal 21): Outputs Inverter's output frequency (0 to ±10 V).
  - Multi-function analog output 2 (Terminal 23): Output actual motor speed (0 to ±10 V).

    Terminal 22 is the multi-function analog output common.
- We recommend monitoring both the output frequency and the motor speed to monitor the response delay or deviations from the reference value, as shown in the following diagram.

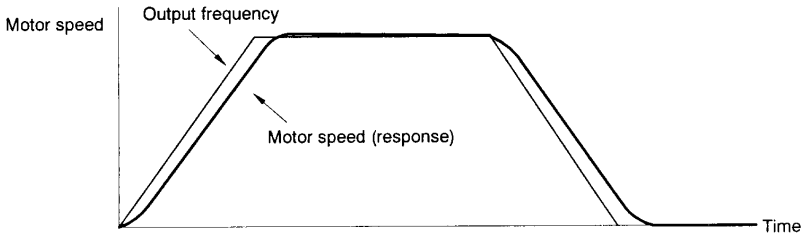


Figure 6.18 Example Monitor Waveforms

Adjusting ASR Proportional Gain 1 (C5-01)

- This gain setting adjusts the responsiveness of the ASR.
- The responsiveness is increased when this setting is increased. Usually this setting is higher for larger loads. Oscillation will occur if this setting is increased too much.
- The following diagram shows the type of changes that can occur in the response when the ASR proportional gain is changed.

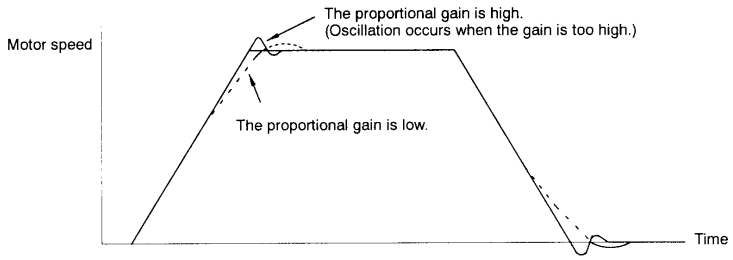


Figure 6.19 Responsiveness for Integral Time

Adjusting ASR Integral Time 1 (C5-02)

- This constant sets the ASR integral time.
- Lengthening the integral time lowers the responsiveness and weakens the resistance to external influences. Oscillation will occur if this setting is too short.
- The following diagram shows the type of changes that can occur in the response when the ASR integral time is changed.

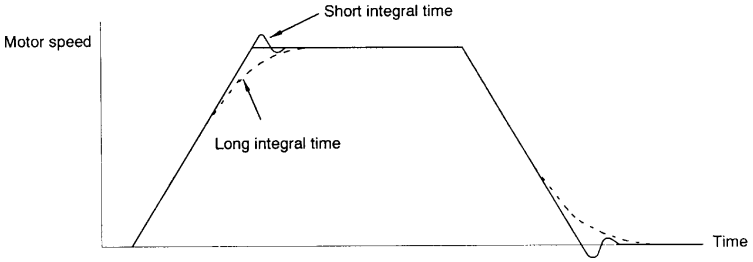


Figure 6.20 Responsiveness for Integral Time

Different Gain Settings for Low-Speed and High-Speed

Switch between low-speed and high-speed gain when oscillation occurs because of resonance with the mechanical system at low-speed or high-speed.

Setting the Gain Switching Frequency (C5-07)

- Set the switching frequency to about 80% of the motor operating frequency or the frequency at which oscillation occurs.

Low-Speed Gain Adjustments (C5-03, C5-04)

- Connect the actual load and adjust these constants at Zero Speed. Increase ASR proportional gain 2 (C5-03) until there is no oscillation.
- Decrease ASR integral time 2 (C5-04) until there is no oscillation.

High-Speed Gain Adjustments (C5-01, C5-02)

- Adjust these constants at normal operating speed. Increase ASR proportional gain 1 (C5-01) until there is no oscillation.
- Decrease ASR integral time 1 (C5-02) until there is not oscillation.
- Refer to *Fine Adjustments* on Page 130 for details on making fine adjustments of high-speed operation.

6.5 V/f Control with PG

With V/f Control with a PG, the user must set the motor constants, V/f pattern, and PG Control Card settings, and then adjust the Speed Control gain.

6.5.1 Motor Constants: E1-01, E1-02, E2-01, E2-04

■ Inverter Input Voltage Setting: E1-01

- Set the Inverter's input voltage to match the power supply voltage.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
E1-01	Input voltage setting	X	155 to 255 (350 to 510)	VAC	200 (400)	Q	Q	Q	Q

- The voltage settings shown in parentheses are the values for the 400 V class.
- This setting is used as the reference value for functions such as the protection functions.

■ Motor Selection: E1-02, E2-01, E2-04

Motor Selection (Motor Overheating Protection): E1-02

- Set the type of motor being used with the motor selection constant (E1-02). This setting is a reference for overheating protection functions.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
E1-02	Motor selection (motor overheating protection)	X	0, 1	—	0	Q	Q	Q	Q

- Settings

Setting	Function
0	Standard motor (general-purpose motor)
1	Special motor (inverter-exclusive motor)

Motor Rated Current (Electronic Thermal Reference Current): E2-01

- Set the rated current (A) shown on the motor nameplate.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
E2-01	Motor rated current (electronic thermal reference current)	X	10% to 200% (of rated current)*1	A	*2	Q	Q	Q	Q

*1 The setting range is 10% to 200% of the Inverter rated output current.

*2 The factory setting depends upon the type of Inverter. Refer to Pages 258 and 259.

Number of Motor of Poles: E2-04

- Set constant (E2-04) to the number of poles shown on the motor nameplate.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
E2-04	Number of motor poles	X	2 to 48	—	4	X	Q	X	Q

6.5.2 V/f Pattern Selection: E1-03

- The V/f pattern can be set to any of the following:
  - One of 15 preset patterns (settings 0 through E).
  - A custom user-set pattern (setting F).
- The factory setting for E1-03 is "F" (user-defined V/f pattern), but the default contents of this setting are the same as setting "1".

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
E1-03	V/f pattern selection	X	0 to F	—	F	Q	Q	X	X

■ Selecting a Preset V/f Pattern: E1-03 = "0" through "E"

- Refer to the following table when selecting one of the 15 preset patterns.

Characteristics	Applications	Setting	Specification
Constant Torque	These patterns are for general-purpose applications. Use these patterns when the load torque is to remain constant for any rotational speed, such as in straight-line conveyors.	0	50 Hz
		1	60 Hz
		2	60 Hz, voltage saturation at 50 Hz
		3	72 Hz, voltage saturation at 60 Hz
Variable Torque	Use these patterns when there is a quadratic or cubic relationship between the rotational speed and load, such as in fans or pumps.	4	50 Hz, cubic, variable torque 1
		5	50 Hz, quadratic, variable torque 2
		6	60 Hz, cubic, variable torque 1
		7	60Hz, quadratic, variable torque 2
High Starting Torque*	Select a high starting torque V/f pattern only in the following cases: • The wiring distance between the Inverter and motor is relatively large (greater than 150 meters). • A large torque is required at startup (such as heavy axis loads). • An AC or DC reactor is connected to the Inverter's input or output. • A motor less than the maximum applicable motor is being used.	8	50 Hz, low starting torque
		9	50 Hz, high starting torque
		A	60 Hz, low starting torque
		B	60 Hz, high starting torque
High-Speed Operations	These patterns are for applications that must rotate at frequencies greater than 60 Hz. A fixed voltage is applied at frequencies greater than 60 Hz.	C	90 Hz, voltage saturation at 60 Hz
		D	120 Hz, voltage saturation at 60 Hz
		E	180 Hz, voltage saturation at 60 Hz

* Normally it is not necessary to use these patterns because starting torque is ensured by automatic torque boost functions.

- The constant settings for E1-04 through E1-10 will be changed automatically when one of these patterns is selected. There are three possible settings for these constants depending on the Inverter's capacity:
  - A 0.4 to 1.5 kW V/f pattern
  - A 2.2 to 45 kW V/f pattern
  - A 55 to 300 kW V/f pattern
- The characteristics for these patterns are shown in the diagrams on Pages 116 through 118.

■ Setting a User-Defined V/f Pattern: E1-03 = "F"

- Constants E1-04 through E1-10 can be set by the user when E1-03 has been set to "F".
- Refer to Page 119 for details on setting these constants.

6.5.3 PG Speed Option Card Settings

■ Available PG Speed Option Cards

- There are four models of PG Speed Option Cards, but only two models can be used with Vector Control.
  - PG-A2: Phase-A/Phase-B pulse inputs, complementary output.
  - PG-D2: Phase-A/Phase-B/Phase-Z pulse inputs, line drivers.
- Select the card according to the application and install it in the Inverter as described in *3.7 Installing and Wiring PG Speed Option Cards*.

■ Setting the PG Pulse Number: F1-01

- Set the PG pulse number in pulses/revolutions.
- Set the number of Phase-A or Phase-B pulses in one motor revolution.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
F1-01	PG constant	X	0 to 60000	P/r	600	X	Q	X	Q

■ Setting the Number of PG Gear Teeth: F1-12, F1-13

- When V/f Control with PG Feedback is used, the motor can be operated even if there are gears between the motor and PG because the responsiveness is lower than it is with vector control.
- Set the number of teeth on the gears if there are gears between the motor and PG.
- The motor speed will be calculated within the Inverter using the following equation:

$$\text{Motor speed (RPM)} = \frac{\text{Number of pulses input from the PG X 60}}{\text{Number of PG pulses (F1-01)}} \times \frac{\text{Number of gear teeth 2 (F1-13)}}{\text{Number of gear teeth 1 (F1-12)}}$$

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
F1-12	Number of PG gear teeth 1	X	0 to 1000	—	0	X	A	X	X
F1-13	Number of PG gear teeth 2	X	0 to 1000	—	0	X	A	X	X

- A gear ratio of 1 (F1-12 = F1-13 = 1) will be used if either of these constants is set to 0.

■ Selecting Integral Operation During Acceleration/Deceleration: F1-07

- When V/f Control with PG Feedback is used, integral control during acceleration and deceleration can be enabled or disabled with F1-07.
- Set F1-07 to “1” (integral control enabled) if you want to keep the motor speed as close to the frequency reference as possible during acceleration and deceleration. Set F1-07 to “0” (integral control disabled) if you want to prevent the occurrence of overshooting/undershooting.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
F1-07	Integral value during accel/decel enable/disable	X	0, 1	—	0	X	B	X	X

- Settings

Setting	Function
0	Disabled (The integral function is not used while accelerating or decelerating; it is used at constant speeds.)
1	Enabled (The integral function is used at all times.)

Setting and Adjusting the Fault Detection Functions

PG Disconnection Stopping Method: F1-02, F1-14

- This constant sets the stopping method that is used when the signal from the PG is lost.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
F1-02	Operation selection at PG open circuit	X	0 to 3	—	1	X	B	X	B
F1-14	PG open-circuit detection time	X	0.0 to 10.0	s	2.0	X	A	X	A

- Settings

Setting	Function
0	Deceleration to stop using deceleration time 1 (C1-02).
1	Coast to stop.
2	Emergency stop using the emergency stop time (C1-09).
3	Continue operation. (Display “PGO” and continue operation with V/f Control.)

Overspeed Settings: F1-03, F1-08, F1-09

- Overspeed refers to an excessive motor speed.
- Set the conditions (level and time) for detecting overspeed and the stopping method that is used when an overspeed is detected.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
F1-03	Operation selection at overspeed	X	0 to 3	—	1	X	B	X	B
F1-08	Overspeed detection level	X	0 to 120	%	115	X	A	X	A
F1-09	Overspeed detection delay time	X	0.0 to 2.0	s	1.0	X	A	X	A

- Settings

Setting	Function
0	Deceleration to stop using deceleration time 1 (C1-02).
1	Coast to stop.
2	Emergency stop using the emergency stop time (C1-09).
3	Continue operation. (Display “OS” and continue control.)

- F1-08 and F1-09 Settings
  Constant F1-08 sets the overspeed detection level as a percentage of the maximum output frequency. Constant F1-09 sets the length of time in seconds that the motor speed must exceed the overspeed detection level in order to generate an overspeed fault.

PG Speed Deviation Settings: F1-04, F1-10, F1-11

- PG Speed Deviation refers to the difference between the actual motor speed and the reference speed.
- These constants set the conditions (level and time) for detecting PG Speed Deviation and the stopping method that is used when a PG Speed Deviation is detected.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
F1-04	Operation selection at deviation	X	0 to 3	—	3	X	B	X	B
F1-10	Excessive Speed Deviation detection level	X	0 to 50	%	10	X	A	X	A
F1-11	Excessive Speed Deviation detection delay time	X	0.0 to 2.0	s	1.0	X	A	X	A

- Settings

Setting	Function
0	Deceleration to stop using deceleration time 1 (C1-02).
1	Coast to stop.
2	Emergency stop using the emergency stop time (C1-09).
3	Continue operation. (Display "DEV" and continue control.)

- F1-10 and F1-11 Settings
  Constant F1-10 sets the PG Speed Deviation detection level as a percentage of the maximum output frequency. Constant F1-11 sets the length of time in seconds that the difference between the motor speed and reference speed must exceed the PG Speed Deviation detection level in order to detect a PG Speed Deviation.

6.5.4 ASR Structure

- The following block diagram shows the structure of the speed control.

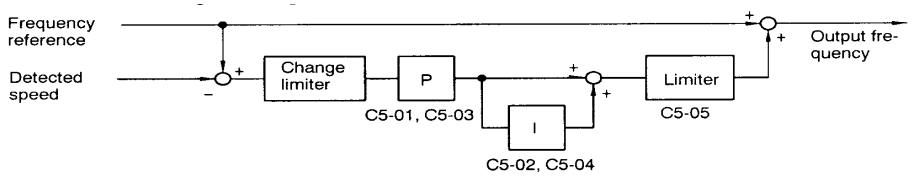


Figure 6.21 Speed Control Structure

■ Gain Settings

- When using V/f Control with PG Feedback, set the gain at the minimum output frequency and maximum output frequency.

Maximum Output Frequency Gain Settings: C5-01, C5-02

- Set the proportional gain (C5-01) and the integral time (C5-02) of the ASR.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
C5-01	ASR proportional (P) gain 1	❍	0.00 to 300.00	Multiple	0.20	X	B	X	B
C5-02	ASR integral (I) time 1	❍	0.000 to 10.000	s	0.200	X	B	X	B

Minimum Output Frequency Gain Settings: C5-03, C5-04

- Set ASR proportional gain 2 (C5-03) and ASR integral time 2 (C5-04) for the minimum output frequency.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
C5-03	ASR proportional (P) gain 2	❍	0.00 to 300.00	Multiple	0.20	X	B	X	B
C5-04	ASR integral (I) time 1	❍	0.000 to 10.000	s	0.050	X	B	X	B

- *Figure 6.22* shows how the proportional gain and integral time are calculated from constants C5-01 through C5-04.

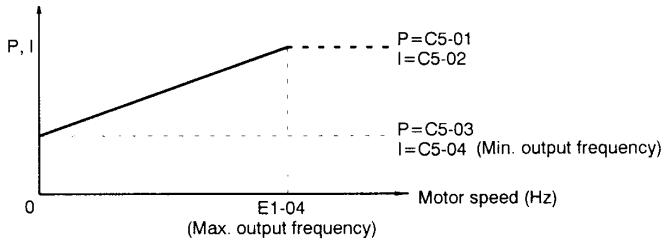


Figure 6.22 Minimum Output Frequency Gain Settings

■ Multi-Function Input Settings: H1-01 (Terminal 3) to H1-06 (Terminal 8)

V/f Mode Select Setting: "D'

- When one of the multi-function inputs is set to "D", the input can be used to enable and disable the Speed Control.
- The Speed Control is disabled (normal V/f Control) when the multi-function input is ON.

ASR Integral Reset Setting: "E"

- When one of the multi-function inputs is set to "E", the input can be used to switch the Speed Control between P Control and PI Control.
- P Control (integral reset) is used when the multi-function input is ON.

6.5.5 Adjusting ASR Gain

Use the following procedure to adjust the gain with the mechanical system and actual load connected.

■ Gain Adjustments at Minimum Output Frequency

1. Operate the motor at the minimum output frequency.
2. Increase C5-03 (ASR proportional gain 2) to a level where there is no oscillation.
3. Decrease C5-04 (ASR integral time 2) to a level where there is no oscillation.
4. Monitor the Inverter's output current and verify that it is less than 50% of the Inverter rated current. If the output current exceeds 50% of the Inverter's rated current, decrease C5-03 and increase C5-04.

■ Gain Adjustments at Maximum Output Frequency

1. Operate the motor at the maximum output frequency.
2. Increase C5-01 (ASR proportional gain 1) to a level where there is no oscillation.
3. Decrease C5-02 (ASR integral time 1) to a level where there is no oscillation.

■ Gain Adjustments for Integral Control During Acceleration/Deceleration

- Enable integral operation during acceleration and deceleration (with F1-07) when you want the motor speed to closely follow the frequency reference during acceleration and deceleration. Integral operation causes the speed to reach the target speed as fast as possible, but may result in overshooting or undershooting.

1. Set F1-07 to "1" to enable integral operation at all times.
2. Make the constant settings shown below in order to observe the speed waveform while making fine adjustments to the gain.

Constant	Setting	Explanation
H4-01 Analog output selection (Terminal 21)	2	Settings that allow multi-function analog output 1 to be used to monitor the output frequency.
H4-02 Analog output gain (Terminal 21)	1.00	
H4-03 Analog output bias (Terminal 21)	0.0	
H4-04 Analog output selection (Terminal 23)	5	Settings that allow multi-function analog output 2 to be used to monitor motor speed.
H4-05 Analog output gain (Terminal 23)	1.00	
H4-06 Analog output bias (Terminal 23)	0.0	
H4-07 Analog output level selection	1	This setting allows a 0 to ±10 V signal range to be monitored.

- The multi-function analog outputs have the following functions with these constant settings.
  - Multi-function analog output 1 (Terminal 21): Outputs Inverter's output frequency (0 to ±10 V).
  - Multi-function analog output 2 (Terminal 23): Outputs the actual motor speed (0 to ±10 V).
- Terminal 22 is the multi-function analog output common.
- We recommend monitoring both the output frequency and the motor speed to monitor the response delay or deviations from the reference value, as shown in the following diagram.

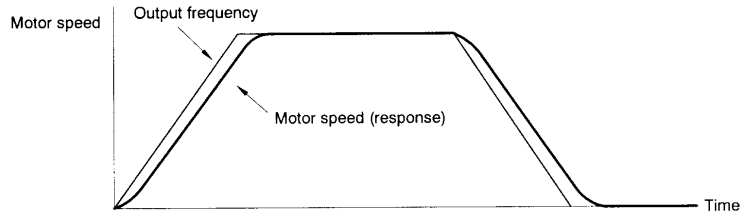


Figure 6.23 Example Monitor Waveforms

3. Give acceleration/deceleration commands and adjust the gain while observing the waveform.

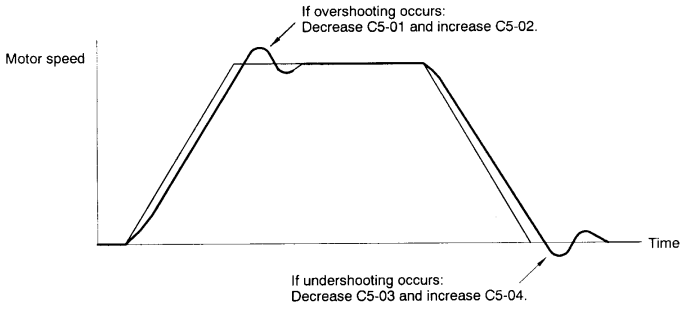


Figure 6.24 Gain Adjustments

4. If the overshooting or undershooting cannot be eliminated by adjusting the gain, decrease the ASR limit (C5-05) to lower the frequency reference compensation limit.

User Constant Number	Name	Change During Operation	Setting Range	Unit	Factory Setting	Valid Access Levels			
						V/f Control	V/f with PG	Open-Loop Vector	Flux Vector
C5-05	ASR limit	X	0.0 to 20.0	%	5.0	X	A	X	X

- Since C5-05 cannot be changed during operation, stop the Inverter's operation and then decrease the ASR limit by 0.5%.
- Perform Step 3 again after the setting has been changed.
- The ASR limit is the frequency limit for compensation by speed control. Set this frequency limit as a percentage of the maximum output frequency.
- If the frequency limit is lowered too much, the motor speed might not reach the target speed. Verify that the target speed is reached during normal operation.