7

Advanced Operation

This chapter describes the user constants used for specific control methods in VG5 application.

7.1 Open-Loop Vector Control

The functions that can be used with Open-Loop Vector Control are listed in *Table 7.1*. Details on functions that are specific to Open-Loop Vector Control (i.e. those marked with a ★) are provided in the following table.

Table 7.1 Open-Loop Vector Control Functions

Group		Function		Comments	Control Method			
					V/f	V/f with PG	Open-Loop Vector	Flux Vector
b	Application	b1	Sequence	Settings such as the reference input method	❍	❍	❍	❍
		b2	Dc Injection Braking	DC Injection Braking function settings	❍	❍	❍	❍
		b3	Speed Search	Speed search function settings	❍	❍	❍	❍
		b4	Delay Timers	Timer function settings	❍	❍	❍	❍
		b5	PID Control	PID Control settings	❍	❍	❍	❍
		b6	Dwell Functions	Acceleration/deceleration time dwell function settings	❍	❍	❍	❍
		b7	Droop Control	Not used. (Cannot be set.)	X	X	X	❍
		b8	Energy Saving	Not used. (Cannot be set.)	❍	❍	X	X
		b9	Zero Servo	Not used. (Cannot be set.)	X	X	X	❍
C	Tuning	C1	Accel/Decl	Acceleration/deceleration time settings	❍	❍	❍	❍
		C2	S-Curve Acc/Dec	S-curve characteristics for acceleration/deceleration times	❍	❍	❍	❍
		C3	Motor-Slip Compensation	Slip compensation functions settings	❍	❍	❍	❍
		C4	Torque Compensation	Torque compensation function settings	❍	❍	❍	X
		C5	Speed Controls	Not used. (Cannot be set.)	X	❍	X	❍
		C6	Carrier Frequency	Carrier frequency settings	❍	❍	❍	❍
		C7	Hunting Prevention	Not used. (Cannot be set.)	❍	❍	X	X
		C8	Factory Tuning	★ Adjustment for Open-Loop Vector Control	X	X	★	X
d	Reference	d1	Preset Reference	Frequency reference settings (when using Operator)	❍	❍	❍	❍
		d2	Reference Limits	Frequency upper and lower limit settings	❍	❍	❍	❍
		d3	Jump Frequencies	Prohibited frequency settings	❍	❍	❍	❍
		d4	Reference Frequency Hold Function	Up/Down, Accel/Decel stop hold frequency setting	❍	❍	❍	❍
		d5	Torque Control	Not used. (Cannot be set.)	X	X	X	❍
E	Motor	E1	V/f Pattern	★ Motor constant settings	❍	❍	❍	❍
		E2	Motor Setup	(Motor constants are set by the Auto-Tuning function.)	❍	❍	❍	❍
		E3	Motor 2 Control Methods	Control method settings for motor 2	❍	❍	❍	❍
		E4	Motor 2 V/f Characteristics	V/f characteristics settings for motor 2	❍	❍	❍	❍
		E5	Motor 2 Motor Constants	Motor constant settings for motor 2	❍	❍	❍	❍
F	Options	F1	PG Speed Option Card settings	User constant settings for a PG Card	X	❍	X	❍
		F2	Analog Reference Card AI	User constant settings for an Analog Reference Card	❍	❍	❍	❍
		F3	Digital Reference Card DI	User constant settings for a Digital Reference Card	❍	❍	❍	❍
		F4	Analog Monitor Card AO	User constant settings for an Analog Monitor Card	❍	❍	❍	❍
		F5	Digital Output Card DO	User constant settings for a Digital Output Card	❍	❍	❍	❍
		F6	Digital Output Card DO	User constant settings for a Digital Output Card	❍	❍	❍	❍
		F7	Pulse Monitor Card PO	User constant settings for a Pulse Monitor Card	❍	❍	❍	❍
		F8	SI-F/SI-G Transmission Card	User constant settings for a Transmission Card	❍	❍	❍	❍
		F9	CP-916B Transmission Card	User constant settings for a Transmission Card	❍	❍	❍	❍

Group		Function		Comments	Control Method			
					V/f	V/f with PG	Open-Loop Vector	Flux Vector
H	Terminal	H1	Multi-Function Inputs	Function selection for multi-function inputs	❍	❍	❍	❍
		H2	Multi-Function Outputs	Function selection for multi-function outputs	❍	❍	❍	❍
		H3	Analog Inputs	Function selection for analog inputs	❍	❍	❍	❍
		H4	Multi-Function Analog Outputs	Function selection for analog outputs	❍	❍	❍	❍
		H5	MEMOBUS Communications	MEMOBUS communications settings	❍	❍	❍	❍
L	Protection	L1	Motor Protection Functions	Sets thermal functions that protect the motor	❍	❍	❍	❍
		L2	Power Loss Ridethru	Selects the power-loss processing method	❍	❍	❍	❍
		L3	Stall Prevention	Accel/Decl Stall Prevention and selection	❍	❍	❍	❍
		L4	Reference Detection	Frequency detection settings and selection	❍	❍	❍	❍
		L5	Fault Restart	Fault restart function settings	❍	❍	❍	❍
		L6	Torque Detection	Sets overtorque detection functions 1 and 2 (by torque)	❍	❍	❍	❍
		L7	Torque Limit	★ Four-quadrant individual torque limit settings	X	X	❍	❍
		L8	Hardware Protection	Hardware overheating and open-phase protection settings	❍	❍	❍	❍
o	Operator	o1	Monitor Select	Selects the Operator's display and setting methods	❍	❍	❍	❍
		o2	Key Selections	Operator's key function selection and other constants	❍	❍	❍	❍

7.1.1 Torque Limit Function

With Open-Loop Vector Control, torque limits can be applied at an arbitrary value because the torque output by the motor is calculated internally.

The torque limit function is useful when the load cannot sustain a torque above a certain level or to maintain the regenerative torque above a certain level. The two ways to apply torque limits are listed below. (The lower torque limit will be used if both of these methods are set.)

- Settings a torque limit with the constants
- Limiting torque with the analog inputs

The accuracy of the torque is ±5% for output frequencies above 10 Hz, but the accuracy is lower for output frequencies below 10 Hz. Use Flux Vector Control if you want to apply a torque limit at low-speed (below 10 Hz).

■ Torque Limits: L7-01 through L7-04

Torque limits can be set separately for the four ways that torque can be applied: forward torque, reverse torque, forward regenerative torque, and reverse regenerative torque.

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
L7-01	Forward torque limit	X	0 to 300	%	200	X	X	B	B
L7-02	Reverse torque limit	X	0 to 300	%	200	X	X	B	B
L7-03	Forward regenerative torque limit	X	0 to 300	%	200	X	X	B	B
L7-04	Reverse regenerative torque limit	X	0 to 300	%	200	X	X	B	B

Figure 7.1 shows the relationship between each constant and the output torque.

When the torque limit function is used, the torque limits have priority and motor speed control and compensation will be disregarded, so the acceleration/deceleration times might be lengthened and motor speed might be reduced.

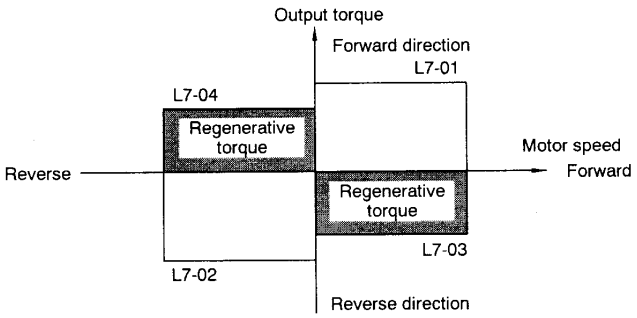


Figure 7.1 Torque Limit Function

■ Limiting Torque with Analog Inputs: H3-05, H3-09

The following two analog inputs that can be used to limit torque.
Multi-function analog input, Terminal 16
Frequency reference (current), Terminal 14

Use either or both of these inputs as needed with constants H3-05 and 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
H3-05	Multi-function analog input (Terminal 16)	X	0 to 1F	—	0	B	B	B	B
H3-09	Multi-function analog input (Terminal 14)	X	1 to 1F	—	1F	A	A	A	A

- Settings

Setting	Name
10	Forward Torque Limit
11	Reverse Torque Limit
12	Regenerative Torque Limit
15	Forward/Reverse Torque Limit

- The above table shows only those settings related to the torque limit function.
- Set the analog input terminal's signal level, gain, and bias to match actual input signal.
- The factory settings for the input terminal's signal level are as follows:
  - Terminal 16: 0 to 10 V (A 10 V input limits the torque to 100% of the motor's rated torque.)
  - Terminal 14: 4 to 20 mA (A 20 mA input limits the torque to 100% of the motor's rated torque.)

  Figure 7.2 shows the relationship between the output torque and each torque limit.

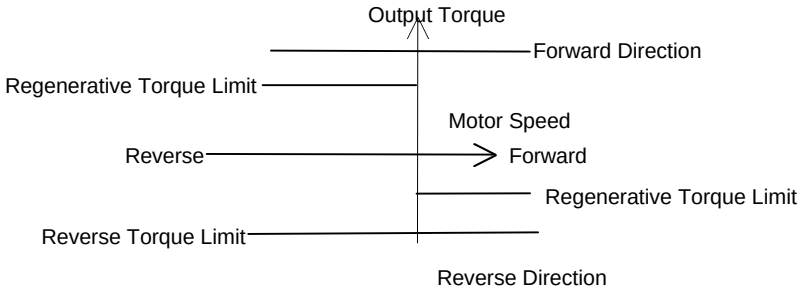


Figure 7.2 Limiting Torque with Analog Inputs

- When the forward torque limit has been set, the analog input signal acts as the limit value for torque generated in the forward direction. The torque limit input is effective when torque is generated in the forward direction even if the motor is operating in reverse (regenerative torque).

- The torque limit is 100% of the motor's rated torque when the analog input is at its maximum value (10 V or 20 mA). To increase the torque limit above 100%, set the input terminal's gain above 100%. For example, a gain of 150.0% would result in a torque limit of 150% of the motor's rated torque with a 10 V or 20 mA analog input.
  - Gain for multi-function analog input, Terminal 16: H3-06
  - Gain for frequency reference (current), Terminal 14: H3-10

7.1.2 Adjusting Speed Feedback

With Open-Loop Vector Control, internal Inverter data is used to calculate the feedback value. The gain of this Automatic Frequency Regulator (AFR) operation can be fine-tuned according to motor response. (Normally it is not necessary to change the default setting.)

■ Speed Feedback Detection Control (AFR) Gain: C8-08

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
C8-08	AFR gain	X	0.00 to 10.00	Multiple	1.00	X	X	A	X

- Normally it is not necessary to change this setting.
- Fine-tune the gain when motor operation is unstable causing hunting to occur or torque/speed responsiveness is low.
  - When hunting occurs, increase the gain by 0.05 increments while checking the motor responsiveness.
  - When responsiveness is low, decrease the gain by 0.05 increments while checking the motor responsiveness.

7.1.3 Setting/Adjusting Motor Constants

■ Adjusting the V/f Pattern: E1-04 through E1-10, E1-13

Normally it is not necessary to adjust the V/f pattern with Open-Loop Vector Control. Adjust the V/f pattern when you want to change the maximum output frequency setting or decrease the Inverter's output voltage or when stalls are occurring during no-load operation.

To increase the motor's rated speed, increase the maximum output frequency in E1-04 in programming mode after Auto-Tuning.

It is possible to make user-defined V/f pattern settings (E1-04 through E1-10) in Open-Loop Vector Control mode. (The preset V/f patterns cannot be selected.)

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	Max. output frequency	X	40.0 to 400.0	Hz	60.0	Q	Q	Q	Q
E1-05	Max. voltage	X	0.0 to 255.0 *1	VAC	200.0*1	Q	Q	Q	Q
E1-06	Base frequency	X	0.0 to 400.0	Hz	60.0	Q	Q	Q	Q
E1-07	Mid. output frequency	X	0.0 to 400.0	Hz	3.0*2	Q	Q	A	X
E1-08	Mid. output frequency voltage	X	0.0 to 255.0*1	VAC	11.0 *1, *2	Q	Q	A	X
E1-09	Min. output frequency	X	0.0 to 400.0	Hz	0.5	Q	Q	Q	A
E1-10	Min. output frequency voltage	X	0.0 to 255.0*1	VAC	2.0 *1, *2	Q	Q	A	X
E1-13	Base voltage	X	0.0 to 255.0	VAC	0.0	A	A	Q	Q

*1 These voltages are for 200 V class Inverter; double the voltage for 400 V class Inverters.

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

NOTE:

1. The default settings for E1-07 through E1-10 depend on the control method. The default settings shown in the table are for Open-Loop Vector Control. (See Page 257)
2. The four frequency settings must satisfy the following formula:

   E1-04 (F_{MAX}) ≥ E1-06 (F_A) > E1-07 (F_B) ≥ E1-09 (F_{MIN})
3. 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.
4. If E1-13 is set to 0.0, the same value as in E1-13 will be set for E1-05. It does not normally need to be set separately.

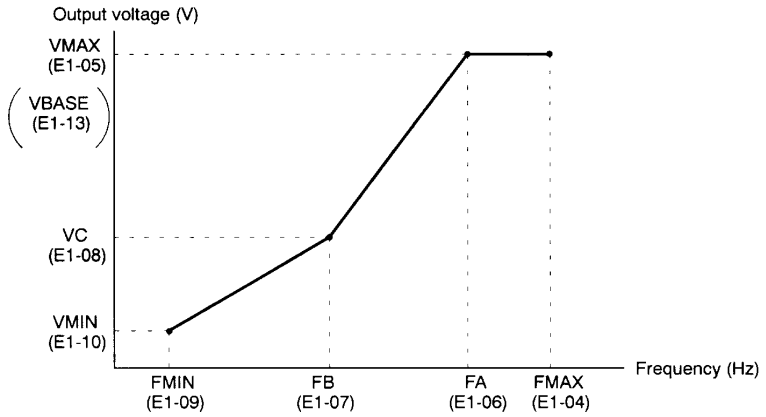


Figure 7.3 User-Defined V/f Pattern

Adjusting Output Voltage: VC (E1-08), VMIN (E1-10)

Adjust the output voltage when you want to output more torque at low speed, such as in an elevator, or when torque is not really necessary and you want to reduce the output voltage to save energy.
Adjustment range: 200 V class Inverters: Initial value ±0 to 2 V
400 V class Inverters: Initial value ±0 to 4 V

- When generating more torque, gradually increase the voltage but do not exceed 100% of the motor's rated current.
- When saving energy, decrease the voltage but do not cause stalling.

Setting the Maximum Output Frequency

The maximum output frequency can be set from 40.0 to 400.0 Hz. Set this constant in accordance with the motor's maximum rotational speed.

■ Setting Motor Constants: E2-01 through E2-03 (E5-01 through E5-03), E2-05 through E2-08 (E5-05, E5-06)

- The motor constants (Function E2) will all be set automatically when Auto-Tuning is performed, so it normally is not necessary to set them manually. Set these constants manually if Auto-Tuning cannot be completed properly.
- User constant numbers for motor 2 are given in parentheses.

Motor Rated Current: E2-01

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
E2-01 (E5-01)	Motor rated current	X	0.32 to 6.40	A	1.90	Q	Q	Q	Q

- The setting range is 10% to 200% of the Inverter rated output current. The default setting depends upon the Inverter capacity. (The table shows the default setting for 200 V class, 0.4 kW Inverters.) (See Page 258)
- Set the rated current (A) shown on the motor nameplate.

- **Motor Rated Slip: E2-02**

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
E2-02 (E5-02)	Motor rated slip	X	0.00 to 20.00	Hz	2.90	A	A	Q	Q

- The default setting depends upon the Inverter capacity. (The table shows the default settings for 200 V class, 0.4 kW Inverters.)
- Calculate the rated slip (E2-02) from the value shown on the motor nameplate with the following equation and set this value.

  Rated slip = rated frequency (Hz) – rated speed (r/min) x number of poles/120

Motor No-Load Current: E2-03

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
E2-03 (E5-03)	Motor no-load current	X	0.00 to 1500.0	A	1.20	A	A	Q	Q

- The default setting depends upon the Inverter capacity. (The table shows the default settings for 200 V class, 0.4 kW Inverters.)
- Set the no-load current (E2-03) at the rated voltage and rated frequency. Normally this value is not shown on the motor nameplate, so it might be necessary to contact the motor manufacturer.

Motor Line-to-Line Resistance: E2-05

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
E2-05 (E5-05)	Motor line-to-line resistance	X	0.000 to 65.000	Ω	9.842	A	A	A	A

- The default setting depends upon the Inverter capacity. (The table shows the default settings for 200 V class, 0.4 kW Inverters.)
- Set the motor terminal resistance (U-V, V-W, and W-U) in constants E2-05. Normally this value is not shown on the motor nameplate, so it might be necessary to contact the motor manufacturer for the terminal resistance at the insulation class temperature. Use the following equations to calculate the resistance value from the terminal resistance of a test report.
  - E-class insulation: Terminal resistance at 75°C in the test report (Ω) x 0.92.
  - B-class insulation: Terminal resistance at 75°C in the test report (Ω) x 0.92.
  - F-class insulation: Terminal resistance at 115°C in the test report (Ω) x 0.87.

Motor Leakage Inductance: E2-06

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
E2-06 (E5-06)	Motor leak inductance	X	0.0 to 30.0	%	18.2	X	X	A	A

- The default setting depends upon the Inverter capacity. (The table shows the default settings for 200 V class, 0.4 kW Inverters.)
- Set the voltage drop (caused by the motor's leakage inductance) as a percentage of the motor's rated voltage in constant E2-06.
- This constant does not normally require setting because the Inverter automatically compensates during operation.
- Normally this value is not shown on the motor nameplate, so it might be necessary to contact the motor manufacturer. It is also acceptable to set the loss (caused by the motor's leakage inductance) as a percentage.

Motor Iron-Core Saturation Coefficients 1, 2: E2-07, E2-08

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
E2-07	Motor iron-core saturation coefficient 1	X	0.00 to 0.50	—	0.50	X	X	A	A
E2-08	Motor iron-core saturation coefficient 2	X	0.00 to 0.75	—	0.75	X	X	A	A

- Constants E2-07 and E2-08 are not required when using the motor at or below the rated frequency.
- Set these constants when operating at a frequency higher than the motor's rated frequency. Set the following values:
  - Motor iron-core saturation coefficient 1: Core-saturation coefficient when magnetic flux is 50%.
  - Motor iron-core saturation coefficient 2: Core-saturation coefficient when magnetic flux is 75%.
- Normally these values are not shown on the motor nameplate, so it might be necessary to contact the motor manufacturer. Operation will be possible with the factory-preset values.

7.2 Normal V/f Control

The functions that can be used with normal Vector Control are listed in *Table 7.2*. Details on functions that are specific to normal Vector Control (i.e. those marked with a ★) are provided in the following table.

Table 7.2 Normal V/f Control Functions

Group		Function		Comments	Control Method			
					V/f	V/f with PG	Open-Loop Vector	Flux Vector
b	Application	b1	Sequence	Settings such as the reference input method	❍	❍	❍	❍
		b2	Dc Injection Braking	DC Injection Braking function settings	❍	❍	❍	❍
		b3	Speed Search	Speed search function settings	❍	❍	❍	❍
		b4	Delay Timers	Timer function settings	❍	❍	❍	❍
		b5	PID Control	PID Control settings	❍	❍	❍	❍
		b6	Dwell Functions	Acceleration/deceleration time dwell function settings	❍	❍	❍	❍
		b7	Droop Control	Not used. (Cannot be set.)	X	X	X	❍
		b8	Energy Saving	★ Multi-function input: Energy Saving Control settings	❍	❍	X	X
		b9	Zero Servo	Not used. (Cannot be set.)	X	X	X	❍
C	Tuning	C1	Accel/Decl	Acceleration/deceleration time settings	❍	❍	❍	❍
		C2	S-Curve Acc/Dec	S-curve characteristics for acceleration/deceleration times	❍	❍	❍	❍
		C3	Motor-Slip Compensation	Slip compensation functions settings	❍	❍	❍	❍
		C4	Torque Compensation	Torque compensation function settings	❍	❍	❍	X
		C5	Speed Controls	Not used. (Cannot be set.)	X	❍	X	❍
		C6	Carrier Frequency	Carrier frequency settings	❍	❍	❍	❍
		C7	Hunting Prevention	★ Hunting Prevention function settings	❍	❍	X	X
		C8	Factory Tuning	Not used. (Cannot be set.)	X	X	★	X
d	Reference	d1	Preset Reference	Frequency reference settings (when using Operator)	❍	❍	❍	❍
		d2	Reference Limits	Frequency upper and lower limit settings	❍	❍	❍	❍
		d3	Jump Frequencies	Prohibited frequency settings	❍	❍	❍	❍
		d4	Reference Frequency Hold Function	Up/Down, Accel/Decel stop hold frequency setting	❍	❍	❍	❍
		d5	Torque Control	Not used. (Cannot be set.)	X	X	X	❍
E	Motor	E1	V/f Pattern	★ Motor constant settings	❍	❍	❍	❍
		E2	Motor Setup	(Motor constants are set manually.)	❍	❍	❍	❍
		E3	Motor 2 Control Methods	Control method settings for motor 2	❍	❍	❍	❍
		E4	Motor 2 V/f Characteristics	V/f characteristics settings for motor 2	❍	❍	❍	❍
		E5	Motor 2 Motor Constants	Motor constant settings for motor 2	❍	❍	❍	❍

Group		Function		Comments	Control Method			
					V/f	V/f with PG	Open-Loop Vector	Flux Vector
F	Options	F1	PG Speed Option Card settings	User constant settings for a PG Card	X	❍	X	❍
		F2	Analog Reference Card AI	User constant settings for an Analog Reference Card	❍	❍	❍	❍
		F3	Digital Reference Card DI	User constant settings for a Digital Reference Card	❍	❍	❍	❍
		F4	Analog Monitor Card AO	User constant settings for an Analog Monitor Card	❍	❍	❍	❍
		F5	Digital Output Card DO	User constant settings for a Digital Output Card	❍	❍	❍	❍
		F6	Digital Output Card DO	User constant settings for a Digital Output Card	❍	❍	❍	❍
		F7	Pulse Monitor Card PO	User constant settings for a Pulse Monitor Card	❍	❍	❍	❍
		F8	SI-F/SI-G Transmission Card	User constant settings for a Transmission Card	❍	❍	❍	❍
		F9	CP-916B Transmission Card	User constant settings for a Transmission Card	❍	❍	❍	❍
H	Terminal	H1	Multi-Function Inputs	Function selection for multi-function inputs	❍	❍	❍	❍
		H2	Multi-Function Outputs	Function selection for multi-function outputs	❍	❍	❍	❍
		H3	Analog Inputs	Function selection for analog inputs	❍	❍	❍	❍
		H4	Multi-Function Analog Outputs	Function selection for analog outputs	❍	❍	❍	❍
		H5	MEMOBUS Communications	MEMOBUS communications settings	—	—	—	—
L	Protection	L1	Motor Protection Functions	Sets electrical/thermal functions that protect the motor	❍	❍	❍	❍
		L2	Power Loss Ridethru	Selects the power-loss processing method	❍	❍	❍	❍
		L3	Stall Prevention	Accel/Decl Stall Prevention and selection	❍	❍	❍	❍
		L4	Reference Detection	Frequency detection settings	❍	❍	❍	❍
		L5	Fault Restart	Fault restart function settings	❍	❍	❍	❍
		L6	Torque Detection	Sets overtorque detection functions 1 and 2 (by current)	❍	❍	❍	❍
		L7	Torque Limit	Not used. (Cannot be set.)	X	X	❍	❍
		L8	Hardware Protection	Hardware overheating and open-phase protection settings	❍	❍	❍	❍
o	Operator	o1	Monitor Select	Selects the Operator's display and setting methods	❍	❍	❍	❍
		o2	Key Selections	Operator's key function selection and other constants	❍	❍	❍	❍

7.2.1 Energy Saving Control Function

The Energy Saving Control function is enabled when the Energy Saving command (Setting 63) has been set in a multi-function input (H1-01 through H1-06). Inputting the Energy Saving command while there is a light load causes the Inverter's output voltage to be reduced and saves energy. Turn OFF the Energy Saving command when a normal load is added.

■ Energy Saving Gain: b8-01

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
b8-01	Energy Saving gain	X	0 to 100	%	80	A	A	X	X

- Constant b8-01 determines the Inverter's output voltage when the Energy Saving command is input. Set this value as a percentage of the V/f pattern's voltage.
- Constant L2-04 (the voltage recovery time) determines the rate at which the output voltage is changed when the Energy Saving command is turned ON or OFF.

■ Energy Saving Frequency: b8-02

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
b8-02	Energy Saving frequency	X	0.0 to 400.0	Hz	0.0	A	A	X	X

- Constant b8-02 determines the lower limit frequency for the Energy Saving function.
- The Energy Saving command is enabled only when the frequency reference is above the Energy Saving frequency and the motor speed is within the "speed agree" range.
  A time chart for Energy Saving operation is shown below.

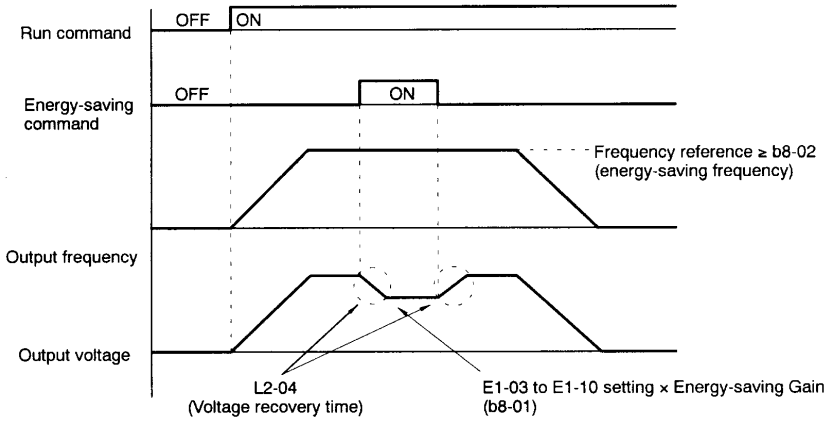


Figure 7.4 Time Chart for Energy Saving Operation

7.2.2 Hunting Prevention Function

The Hunting Prevention function suppresses hunting when the motor is operating with a light load. This function is valid with V/f Control and V/f with PG Feedback control.

■ Hunting Prevention Selection: C7-01

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
C7-01	Hunting Prevention selection	X	0, 1	—	1	A	A	X	X

- Settings

Setting	Function
0	Disables the Hunting Prevention function.
1	Enables the Hunting Prevention function.

■ Hunting Prevention Gain: C7-02

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
C7-02	Hunting Prevention gain	X	0.00 to 2.50	Multiple	1.00	A	A	X	X

Normally it is not necessary to change these constants. Adjust these constants as follows if hunting occurs with a light load.

- Increase the setting in C7-02 if oscillation occurs when operating with a light load. (If the setting is increased too much, the current can fall to the point where stalling occurs.)
- Decrease the setting in C7-02 if stalling occurs.
- Disable the Hunting Prevention function (C7-01 = 0) if high responsiveness is more important than suppressing oscillation.

7.2.3 Setting Motor Constants

■ Motor Rated Slip: E2-02

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
E2-02	Motor rated slip	X	0.00 to 20.00	Hz	2.90	A	A	Q	Q

- This setting is used as a reference value for the torque compensation function.
- The default setting depends upon the Inverter capacity. (The table shows the default settings for 200 V class, 0.4 kW Inverters.) (See Page 258)
- Calculate the rated slip (E2-02) from the value shown on the motor nameplate with the following equation and set this value.

  Rated slip = rated frequency (Hz) – rated speed (r/min) x number of poles/120

■ Motor No-Load Current: E2-03

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
E2-03	Motor no-load current	X	0.00 to 1500.0	A	1.20	A	A	Q	Q

- This setting is used as a reference value for the torque compensation function.
- The default setting depends upon the Inverter capacity. (The table shows the default settings for 200 V class, 0.4 kW Inverters.) (See Page 258)
- Set the no-load current (E2-03) at the rated voltage and rated frequency. Normally this value is not shown on the motor nameplate, so it might be necessary to contact the motor manufacturer.

■ Motor Line-to-Line Resistance: E2-05

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
E2-05	Motor line-to-line resistance	X	0.000 to 65.000	Ω	9.842	A	A	A	A

- This setting is used as a reference value for the torque compensation function.
- The default setting depends upon the Inverter capacity. (The table shows the default settings for 200 V class, 0.4 kW Inverters.) (See Page 258)
- Set the motor's terminal resistance (U-V, V-W, and W-U). Normally this value is not shown on the motor nameplate, so it might be necessary to contact the motor manufacturer.

7.3 Flux Vector Control

The functions that can be used with Flux Vector Control are listed in *Table 7.3*. Details on functions that are specific to Flux Vector Control (i.e. those marked with a ★) are provided in the following table.

Table 7.3 Flux Vector Control Functions

Group		Function		Comments	Control Method			
					V/f	V/f with PG	Open-Loop Vector	Flux Vector
b	Application	b1	Sequence	Settings such as the reference input method	❍	❍	❍	❍
		b2	Dc Injection Braking	DC Injection Braking function settings	❍	❍	❍	❍
		b3	Speed Search	Speed search function settings	❍	❍	❍	❍
		b4	Delay Timers	Timer function settings	❍	❍	❍	❍
		b5	PID Control	PID Control settings	❍	❍	❍	❍
		b6	Dwell Functions	Acceleration/deceleration time dwell function settings	❍	❍	❍	❍
		B7	Droop Control	★ Droop Control function settings.	X	X	X	❍
		b8	Energy Saving	Not used. (Cannot be set.)	❍	❍	X	X
		b9	Zero Servo	Not used. (Cannot be set.)	X	X	X	❍
C	Tuning	C1	Accel/Decl	Acceleration/deceleration time settings	❍	❍	❍	❍
		C2	S-Curve Acc/Dec	S-curve characteristics for acceleration/deceleration times	❍	❍	❍	❍
		C3	Motor-Slip Compensation	★ Motor temperature compensation function adjustment	❍	❍	❍	❍
		C4	Torque Compensation	Not used. (Cannot be set.)	❍	❍	❍	X
		C5	Speed Controls	Speed Control loop adjustment	X	❍	X	❍
		C6	Carrier Frequency	Carrier frequency settings	❍	❍	❍	❍
		C7	Hunting Prevention	Not used. (Cannot be set.)	❍	❍	X	X
		C8	Factory Tuning	Not used. (Cannot be set.)	X	X	★	X
d	Reference	d1	Preset Reference	Frequency reference settings (when using Operator)	❍	❍	❍	❍
		d2	Reference Limits	Frequency upper and lower limit settings	❍	❍	❍	❍
		d3	Jump Frequencies	Prohibited frequency settings	❍	❍	❍	❍
		d4	Reference Frequency Hold Function	Up/Down, Accel/Decel stop hold frequency setting	❍	❍	❍	❍
		d5	Torque Control	★ Torque Control settings and adjustment	X	X	X	❍
E	Motor	E1	V/f Pattern	★ Motor constant settings	❍	❍	❍	❍
		E2	Motor Setup	★ Motor constant settings (Motor constants set automatically with Auto-Tuning	❍	❍	❍	❍
		E3	Motor 2 Control Methods	Control method settings for motor 2	❍	❍	❍	❍
		E4	Motor 2 V/f Characteristics	V/f characteristics settings for motor 2	❍	❍	❍	❍
		E5	Motor 2 Motor Constants	Motor constant settings for motor 2	❍	❍	❍	❍
F	Options	F1	PG Speed Option Card settings	Constant settings for a PG Speed Option Card	X	❍	X	❍
		F2	Analog Reference Card AI	User constant settings for an Analog Reference Card	❍	❍	❍	❍
		F3	Digital Reference Card DI	User constant settings for a Digital Reference Card	❍	❍	❍	❍
		F4	Analog Monitor Card AO	User constant settings for an Analog Monitor Card	❍	❍	❍	❍
		F5	Digital Output Card DO	User constant settings for a Digital Output Card	❍	❍	❍	❍
		F6	Digital Output Card DO	User constant settings for a Digital Output Card	❍	❍	❍	❍
		F7	Pulse Monitor Card PO	User constant settings for a Pulse Monitor Card	❍	❍	❍	❍
		F8	SI-F/SI-G Transmission Card	User constant settings for a Transmission Card	❍	❍	❍	❍
		F9	CP-916B Transmission Card	User constant settings for a Transmission Card	❍	❍	❍	❍

Group		Function		Comments	Control Method			
					V/f	V/f with PG	Open-Loop Vector	Flux Vector
H	Terminal	H1	Multi-Function Inputs	Function selection for multi-function inputs	❍	❍	❍	❍
		H2	Multi-Function Outputs	Function selection for multi-function outputs	❍	❍	❍	❍
		H3	Analog Inputs	Function selection for analog inputs	❍	❍	❍	❍
		H4	Multi-Function Analog Outputs	Function selection for analog outputs	❍	❍	❍	❍
		H5	MEMOBUS Communications	MEMOBUS communications settings	❍	❍	❍	❍
L	Protection	L1	Motor Protection Functions	Sets electrical/thermal functions that protect the motor	❍	❍	❍	❍
		L2	Power Loss Ridethru	Selects the power-loss processing method	❍	❍	❍	❍
		L3	Stall Prevention	Accel/Decl Stall Prevention and selection	❍	❍	❍	❍
		L4	Reference Detection	Frequency detection settings and selection	❍	❍	❍	❍
		L5	Fault Restart	Fault restart function settings	❍	❍	❍	❍
		L6	Torque Detection	Sets overtorque detection functions 1 and 2 (by current)	❍	❍	❍	❍
		L7	Torque Limit	★ Torque limit function settings	X	X	❍	❍
		L8	Hardware Protection	Hardware overheating and open-phase protection settings	❍	❍	❍	❍
o	Operator	o1	Monitor Select	Selects the Operator's display and setting methods	❍	❍	❍	❍
		o2	Key Selections	Operator's key function selection and other constants	❍	❍	❍	❍

7.3.1 Droop Control Function

Droop Control is a function that allows the user to set the amount of motor slip. When single load is operated with two motors (such as in a crane conveyor), a high-resistance motor is normally used, as shown in *Figure 7.5*.

If Droop Control is used, a high-resistance motor characteristics can be set for a general-purpose motor. Also, it is easy to make adjustments while watching the load balance because the amount of slip can be set arbitrarily.

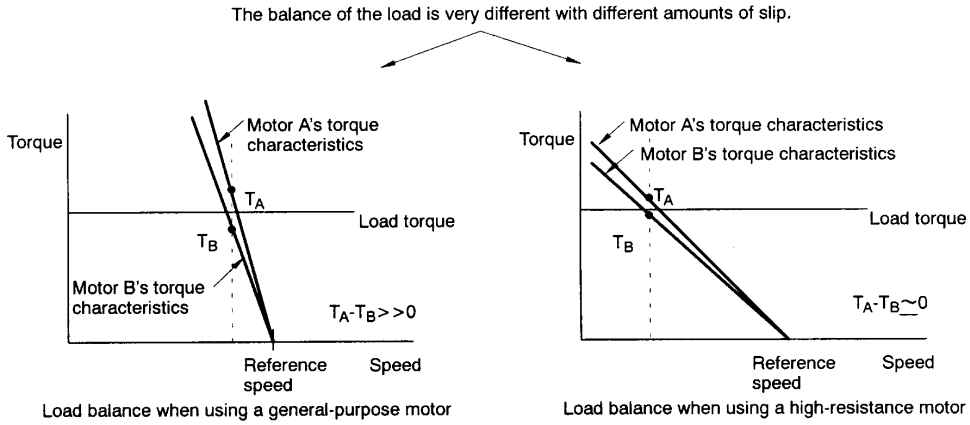


Figure 7.5 Droop Control Function

■ Droop Control Gain: b7-01

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
b7-01	Droop control gain	❍	0.0 to 100.0	%	0.0	X	X	X	A

- Set the amount of slip as the percentage of slip when the maximum output frequency is input and the rated torque is generated.
- Droop control is disabled if b7-01 is set to 0.0.

■ Droop Control Gain: b7-01

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
b7-02	Droop control delay time	❍	0.03 to 2.00	s	0.05	X	X	X	A

- Constant b7-02 is used to adjust the responsiveness of Droop Control.
- Increase this setting if oscillation or hunting occur.

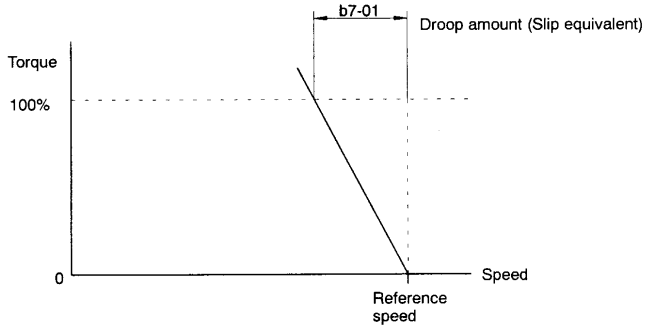


Figure 7.6 Droop Control Gain

7.3.2 Zero Servo Function

The Zero Servo Function is enabled when one of the multi-function inputs (H1-01) is set to 72 (Zero Servo command). If the Zero Servo command is ON when the frequency (speed) reference falls below the Zero Speed level (b2-01), a position control loop is formed and the motor is stopped. (The motor will not rotate even if there is an offset in the analog command input.)

■ Zero Servo Settings: b9-01, b9-02

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
b9-01	Zero Servo gain	X	0 to 100	—	5	X	X	X	A
b9-02	Zero Servo completion width	X	0 to 16383	Pulses	10	X	X	X	A

A time chart for the Zero Servo function is given in *Figure 7.7*.

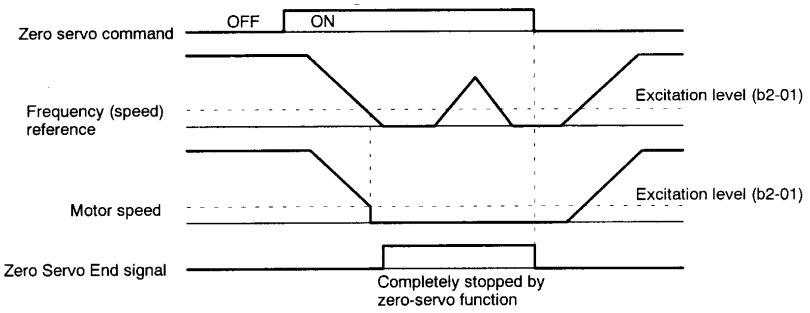


Figure 7.7 Time Chart for Zero Servo

- Assign the Zero Servo command (Setting 72) to one of the multi-function inputs (H1-01 to H1-06).
- The Zero Servo status is entered when the frequency (speed) reference falls below the Zero Speed level (b2-01).
- Be sure to leave the run command input ON. If the run command is turned OFF, the output will be interrupted and the Zero Servo function will become ineffective.
- Adjust the holding strength of the Zero Servo with constant b9-01 (Zero Servo Gain). Increasing this setting increases the holding strength, although oscillation will occur if the setting is too high. (Adjust the holding strength after adjusting the ASR gain.)

- To output the Zero Servo status externally, assign the Zero Servo End signal (Setting 33) to one of the multi-function outputs (H2-01 to H2-03). The setting in b9-02 (Zero Servo Completion Width) is enabled when one of the multi-function outputs has been set to 33.
- The Zero Servo End signal remains ON as long as the position is within this range (starting position ± Zero Servo Completion Width).
- Set the Zero Servo Completion Width to four times the number of pulses from the PG, as shown in *Figure 7.8*.

  For example, when a 600 p/r encoder is being used, the number of pulses would be 2,400 p/r after multiplying by 4.
- The Zero Servo End signal will go OFF when the Zero Servo command is turned OFF.
- Do not lock the Servo for extended periods of time at 100% when using the Zero Servo Function. Extended periods of Servo Lock can be achieved by ensuring that the current during the Servo Lock is 50% or less or by increasing the Inverter capacity.

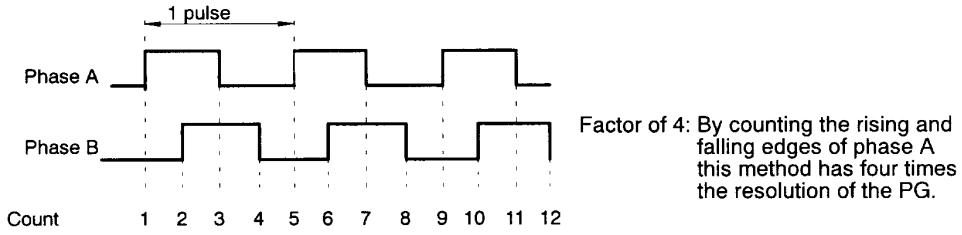


Figure 7.8 Pulse Count Factored by 4

7.3.3 Torque Control

■ Torque Control Function Settings: d5-01

With Flux Vector Control, the motor's output torque can be controlled by a torque reference from an 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
d5-01	Torque control selection	X	0, 1	—	0	X	X	X	A

- Settings

Setting	Function
0	Speed Control (controlled by C5-01 to C5-07)
1	Torque Control

- Set constant d5-01 to "1" to select Torque Control.
- *Figure 7.9* shows the operation of Torque Control.

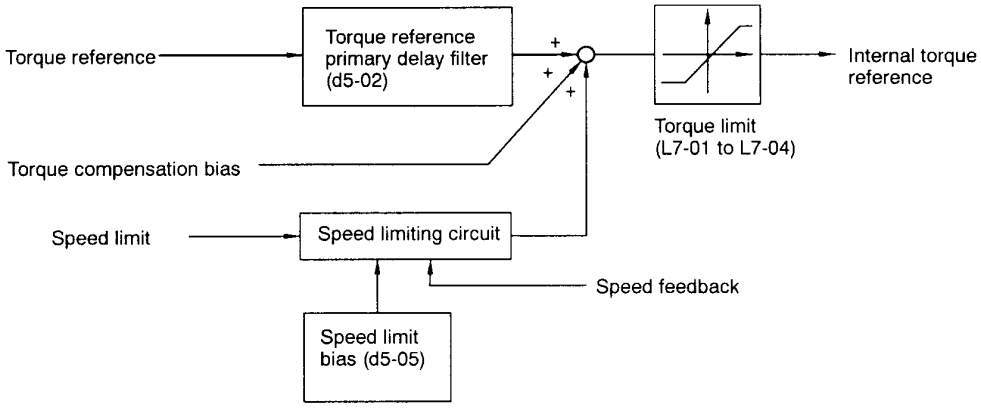


Figure 7.9 Torque Control Block Diagram

■ Torque Reference Settings: H3-04, H3-05, H3-08, H3-09

- Set the multi-function analog input Terminal 16 (H3-05) or 14 (H4-09) to torque reference (a setting of 13). The torque reference value cannot be set with the Digital Operator.

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
H3-09	Multi-function analog input (Terminal 14)	X	1 to 1F	—	1F	A	A	A	A

- Next, set the signal level for the analog input terminal that was set to torque reference.

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
H3-08	Signal level selection (Terminal 14)	X	0 to 2	—	2	A	A	A	A

- Signal Level Settings

Setting	Function
0	0 to +10 V input (When H3-08 is being set, be sure to disconnect the jumper wire J1.)
1	0 to ±10 V input (When H3-08 is being set, be sure to disconnect the jumper wire J1.)
2	4 to 20 mA input (H3-08 only)

- Set the proper signal level for the torque reference that you want to input.
- The direction of the torque that is output is determined by the sign (polarity) of the signal that was input. It is not determined by the direction of the run command (forward/reverse).
  - +Voltage (or current): Forward torque reference (generally counterclockwise; axis side)
  - -Voltage: Reverse torque reference (generally clockwise; axis side)

  Since the polarity of the voltage input determines the direction, only forward torque references can be input when the "0 to +10V" or "4 to 20mA" signal level has been selected. If you want to input reverse torque references, be sure to select the "0 to ±10 V" signal level.
- When supplying a voltage input to the frequency reference current input (Terminal 14) (a setting of 0 or 1), be sure to disconnect jumper wire J1 on the control board. (See *Figure 7.10*.) If the jumper wire is not disconnected, the input resistor will be destroyed.

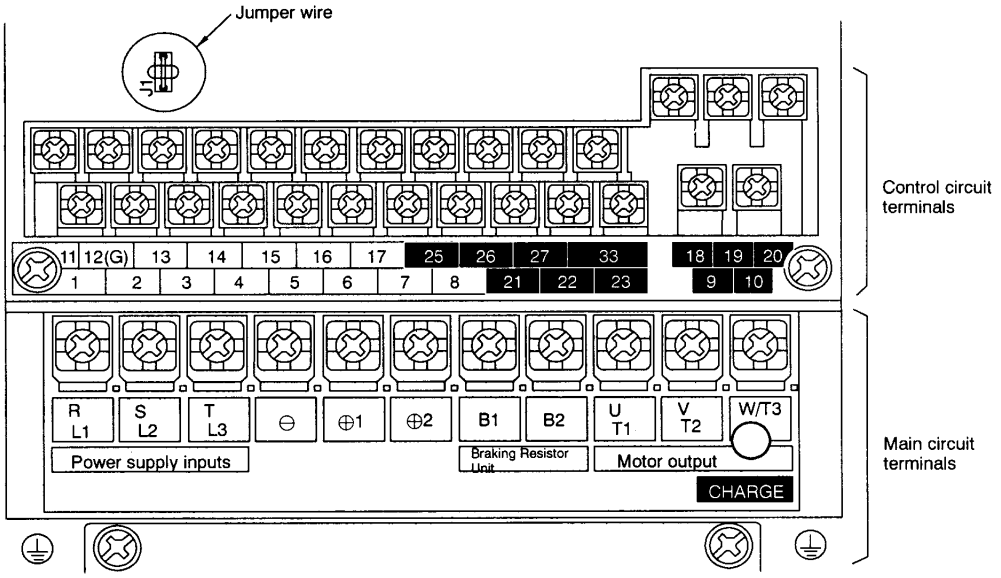


Figure 7.10 Jumper Wire Location for 200 V Class Inverter of 0.4 kW

Speed Limit Function Settings: d5-03, H3-01, d5-04, d5-05

- This setting selects the speed limit function used when Torque Control is performed. With Torque Control, the motor sometimes rotates a high speed with no load or a light load. The speed limit function keeps the motor speed from exceeding the specified limit in these cases.
- If the speed limit is exceeded during Torque Control operation, a suppressing torque (proportional to the divergence from the speed limit) is added to the torque reference. (The suppressing torque is applied opposite to the motor rotation.)
- There are two ways to set the motor speed limit: a constant setting or an analog input value.

Speed Limit Selection: d5-03

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
d5-03	Speed limit selection	X	1, 2	—	1	X	X	X	A

- Signal Level Settings

Setting	Function
0	The speed limit is set from one of the analog frequency reference terminals (13 or 14).
1	The speed limit is set to the value in constant d5-04.

Speed Limit Selection Settings: d5-03, H3-01, d5-04

- Limit with Analog input (d5-03 = 1).
- The speed limit value is set by the input voltage (H3-01) to frequency reference (voltage) Terminal 13.
- When frequency reference (current) Terminal 14 has been set to frequency reference by setting constant H3-09 to 1F, this terminal is also used as an input terminal for the speed limit. In this case, the actual speed limit value is the sum of the voltage input value at Terminal 13 and the current input value at Terminal 14.
- The polarity of the speed limit signal and the direction of the run command determine the direction in which the speed is limited.
  - +Voltage input: Forward rotation; speed is limited in the forward direction.
Reverse rotation; speed is limited in the reverse direction.
  - -Voltage input: Forward rotation; speed is limited in the reverse direction.
Reverse rotation; speed is limited in the forward direction.
- The speed limit value is zero for rotation opposite to the speed limit direction. For example, when a +voltage is being input and the forward rotation command is ON, the effective range of the torque control is from zero to the speed limit value in the forward direction (when constant d5-05, the speed limit bias, is set to 0).

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

- Setting (See Page 98)

Setting	Function
0	0 to 10 VDC input
1	-10 to 10 VDC input (A negative voltage is a command for rotation in the opposite direction.)

- Set the signal level to match the speed limit voltage being input.
- Limit with Constant Setting (d5-03 = 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
d5-04	Speed limit	X	-120 to +120	%	0	X	X	X	A

- Set the speed limit as a percentage of the maximum frequency. (The maximum frequency is 100%.) The sign of the constant setting and the direction of the run command determine the direction in which the speed is limited.

- Setting +: Forward rotation; speed is limited in the forward direction.
  Reverse rotation; speed is limited in the reverse direction.
- Setting -: Forward rotation; speed is limited in the reverse direction.
  Reverse rotation; speed is limited in the forward direction.

- The speed limit value is 0 for rotation opposite to the speed limit direction. For example, when a positive value is set in d5-04 and the forward rotation command is ON, the effective range of the torque control is from 0 to the speed limit value in the forward direction (when constant d5-05, the speed limit bias, is set at 0).

Speed Limit Bias Setting: d5-05

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
d5-05	Speed limit bias	X	0 to 120	%	10	X	X	X	A

- The speed limit bias can be used to add margins to the speed limit.
- When the speed limit bias is used, it is possible to set the same limit value in both the forward and reverse directions.
- Set the speed limit bias as a percentage of the maximum output frequency. (The maximum frequency is 100%.) For example, the following settings establish speed limits of 50% of the maximum output frequency in both the forward and reverse directions.
  - Speed limit setting: 0 (with d5-04 as the speed limit: d5-03 = 2, d5-04 = 0)
  - Speed limit bias setting: 50% (d5-05 = 50)
- When a forward speed limit and a speed limit bias have been set, the speed range of the Torque Control is from the "-speed limit bias setting" to the "speed limit setting + speed limit bias setting". In effect, the speed limit range is extended by the speed limit bias in both the forward and reverse directions.

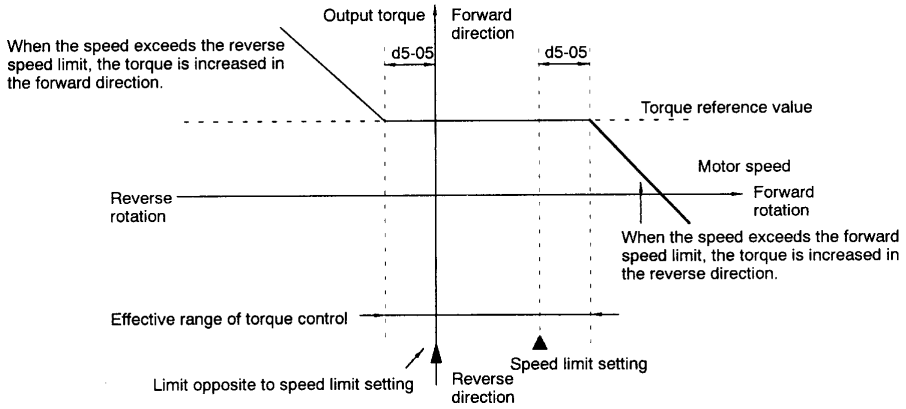


Figure 7.11 Speed Limit Bias Settings

Operation

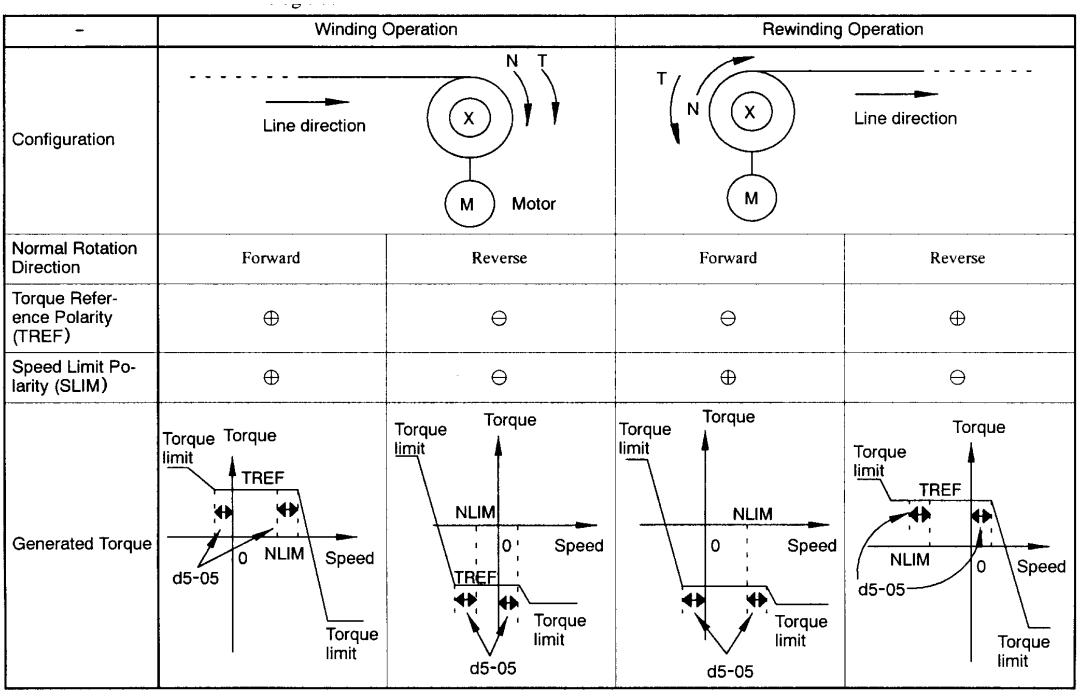
The following operation will be performed if the torque reference is greater than 0 and the speed limit is greater than 0 (winder operation).

- If (-1 x speed limit bias (d5-05)) < motor speed < (speed limit + d5-05), the torque will be controlled according to the set torque reference.
- If the motor speed > (speed limit + d5-05), the speed limit circuit will output a negative torque reference to prevent the motor speed from increasing.
- If the motor speed < (-1 x d5-05), the speed limit circuit will output a positive torque reference to prevent the speed from increasing in the reverse direction.

  Thus, if the torque reference is greater than 0 and the speed limit is greater than 0, the torque will be controlled within the following limits:

  (-1 x d5-05) < motor speed < (speed limit + d5-05)

The relationships between the torque reference, speed limits, and motor speed are shown in the following diagram.



Torque Reference Adjustment: d5-02, H3-02 to H3-11

Primary Delay Time Constant for Torque Reference Filter: d5-02

- The time constant of the primary filter in the torque reference section can be adjusted.
- This constant is used to eliminate noise in the torque reference signal and adjust the responsiveness to the host controller.

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
d5-02	Torque reference delay time	X	0 to 1000	ms	0	X	X	X	A

- Set the torque reference filter primary delay time constant in ms units.
- Increase the time constant setting if oscillation occurs during torque control operation.

Setting the Torque Compensation Bias: H3-05, H3-04, H3-08, H3-09

- Set multi-function analog input (Terminal 16) or frequency reference current input (Terminal 14) to torque compensation (Setting 14). When the amount of torque loss at the load is input to one of these terminals, it is added to the torque reference to compensate for the loss.

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
H3-09	Multi-function analog input (Terminal 14)	X	1 to 1F	—	1F	A	A	A	A

- The functions of H3-05 and H3-09 are listed in *Table 7.12*.
- Set torque compensation (Setting 14) for the input terminal that is not set to torque reference (Setting 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
H3-04	Signal level selection (Terminal 16)	X	0, 1	—	0	B	B	B	B
H3-08	Signal level selection (Terminal 14)	X	0 to 2	—	2	A	A	A	A

- Settings

Setting	Function
0	0 to +10 V input (When H3-08 is being set, be sure to disconnect jumper wire J1.)
1	0 to ±10 V input (When H3-08 is being set, be sure to disconnect jumper wire J1.)
2	4 to 20 mA input (H3-08 only)

- Set the proper signal level for the torque compensation bias that you want to input.
- The direction of the torque compensation bias is determined by the sign (polarity) of the signal that is input. It is not determined by the direction of the run command (forward/reverse).
  - +Voltage (or current) Forward torque compensation (generally counterclockwise; axis side).
  - -Voltage: Reverse torque compensation (generally clockwise; axis side).

  Since the polarity of the voltage input determines the direction, only forward torque compensation can be input when the "0 to +10 V" or "4 to 20 mA" signal level has been selected. If you want to input reverse torque compensation, be sure to select the "0 to ±10 V" signal level.
- When supplying a voltage input to a frequency reference current input (Terminal 14), be sure to disconnect jumper wire J1 on the control board. If the jumper wire is not disconnected, the input resistor will be destroyed. Refer to *Figure 7.10* for a diagram of the control board.

Adjusting the Gain/Bias of the Analog Inputs: H3-02, H3-03, H3-06, H3-07, H3-10, H3-11

- Adjust the gain and bias for the frequency reference (voltage), frequency reference (current), and multi-function analog inputs according to the input specifications for each 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
H3-02	Gain (Terminal 13)	❍	0.0 to 1000.0	%	100.0	B	B	B	B
H3-03	Bias (Terminal 13)	❍	-100.0 to +100.0	%	0.0	B	B	B	B
H3-06	Gain (Terminal 16)	❍	0.0 to 1000.0	%	100.0	B	B	B	B
H3-07	Bias (Terminal 16)	❍	-100.0 to +100.0	%	0.0	B	B	B	B
H3-10	Gain (Terminal 14)	❍	0.0 to 1000.0	%	100.0	A	A	A	A
H3-11	Bias (Terminal 14)	❍	-100.0 to +100.0	%	0.0	A	A	A	A

- Adjust the gain so that the maximum signal level corresponds to the maximum frequency or the motor's rated torque, as follows:
  - When the input terminal is used for frequency reference:
    A 10 V (20 mA) input indicates a frequency reference that is 100% of the maximum output frequency.
  - When the input terminal is used for torque reference:
    A 10 V (20 mA) input indicates a torque reference that is 100% of the motor's rated torque.
  - When the input terminal is used for torque compensation:
    A 10 V (20 mA) input indicates a torque compensation that is 100% of the motor's rated torque.
- Adjust the bias so that the minimum signal level corresponds to the maximum frequency or the motor's rated torque, as follows:
  - When the input terminal is used for frequency reference:
    A 0 V (4 mA) input indicates a frequency reference that is 100% of the maximum output frequency.
  - When the input terminal is used for torque reference:
    A 0 V (4 mA) input indicates a torque reference that is 100% of the motor's rated torque.
  - When the input terminal is used for torque compensation:
    A 0 V (4 mA) input indicates a torque compensation that is 100% of the motor's rated torque.

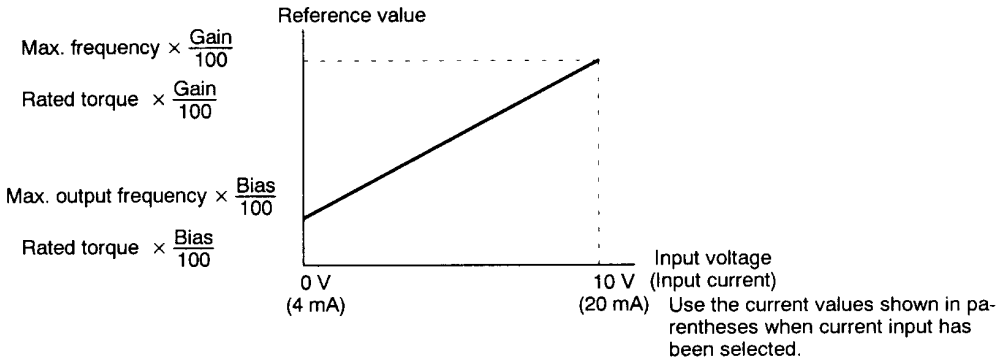


Figure 7.12 Analog Input Gain and Bias Settings

7.3.4 Speed/Torque Control Switching Function

It is possible to switch between speed control and Torque Control when one of the multi-function inputs (H1-01 to H1-06) is set to 71 (Speed/Torque Control Change). Speed Control is performed when the input is OFF and Torque Control is performed when the input is ON.

■ Torque Control Function Settings: d5-01

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
d5-01	Torque control selection	X	0, 1	—	0	X	X	X	A

- Settings

Setting	Function
0	Speed Control (controlled by C5-01 to C5-07)
1	Torque Control

- Set constant d5-01 to 0 (Speed Control) when using the Speed/Torque Control switching function.

■ Setting the Speed/Torque Control Switching Timer: d5-06

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
d5-06	Speed/Torque Control switching timer	X	0 to 1000	ms	0	X	X	X	A

- This setting specifies the delay (0 to 1,000 ms) between a change in the multi-function input (ON➡OFF or OFF➡ON) and the corresponding change in the control mode. The timer setting is effective only when 71 (Speed/Torque Control Change) has been set in one of the multi-function inputs (H1-01 to H1-06).
- During the timer delay, the value of the three analog inputs will retain the values they had when the ON/OFF status of Speed/Torque Control switching signal was changed. Use this delay to make any preparations for change in the control mode.

■ Frequency Reference and Speed Limit

The frequency reference (during Speed Control) is set with b1-01 (Reference Selection). The speed limit (during Torque Control) is set with d5-03 (Speed Limit Selection). It is possible to assign the frequency reference and speed limit functions to the same analog input terminal (13 or 14).

■ Torque Reference and Torque Limit

If the torque reference has been assigned to a multi-function analog input or the frequency reference (current) terminal, the input function changes when the control mode is switched between Torque Control and Speed Control.

- During Speed Control, the analog input terminal is used as the torque limit input.
- During Torque Control, the analog input terminal is used as the torque reference input.

Either the absolute value of the torque limit input or the torque limit constant setting (L7-01 to L7-04), whichever is smaller, will be used for the torque limit. Refer to *7.3.5 Toque Limit Function*.

■ Stopping Method

- When the run command is turned OFF during Speed Control, the motor is decelerated to a stop. When the run command is turned OFF during Torque Control, the control mode is automatically switched to Speed Control and the motor is decelerated to a stop.
- When A1-02 is set to 3 (Flux Vector Control), the speed/torque change command can be set for a multi-function input (a setting of 71) to switch between speed and Torque Control during operation. An example is shown below.
- Settings

Terminal No.	User Constant No.	Factor Setting	Setting	Function
8	H1-06	8	71	Speed/Torque Control change
13	b1-01	1	1	Frequency source (Terminals 13, 14)
	d5-03	1	1	Speed limit (Terminals 13, 14)
16	H3-05	1	13	Torque reference/torque limit

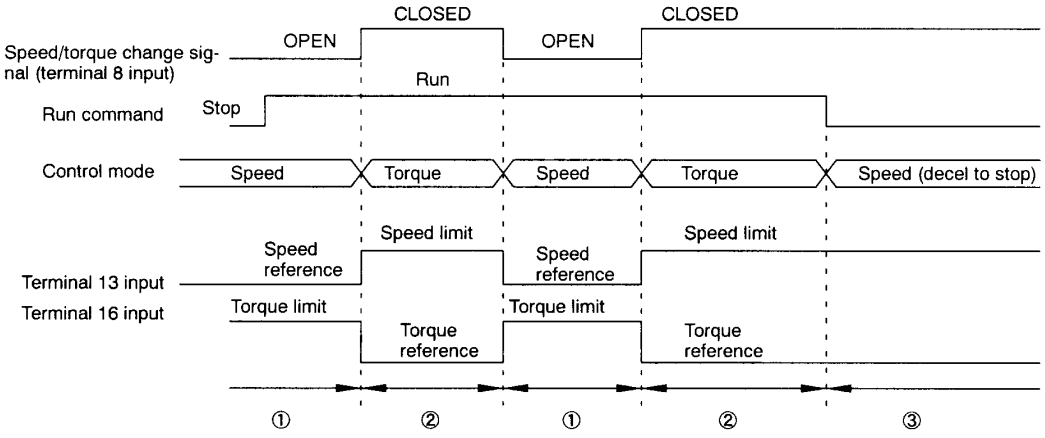


Figure 7.13 Switching between Speed and Torque Control

7.3.5 Torque Limit Function

With Flux Vector Control, the torque limit can be applied at an arbitrary value because the torque output by the motor is calculated internally. The torque limit function is useful when the load cannot sustain a torque above a certain level or regenerative torque above a certain level.

The two ways to apply a torque limit are listed below.

- Setting torque limits with the constants
- Limiting torque with the analog inputs

The lower torque limit will be used if both of these methods are set. The accuracy of the torque limit is ±5% at all frequencies.

■ Setting a Torque Limit with Constants: L7-01 to L7-04

- Torque limits can be set separately for the four ways that torque can be applied: forward torque, reverse torque, forward regenerative torque, and reverse forward regenerative torque.

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
L7-01	Forward torque limit	X	0 to 300	%	200	X	X	B	B
L7-02	Reverse torque limit	X	0 to 300	%	200	X	X	B	B
L7-03	Forward regenerative torque limit	X	0 to 300	%	200	X	X	B	B
L7-04	Reverse regenerative torque limit	X	0 to 300	%	200	X	X	B	B

- *Figure 7.14* shows the relationship between each constant and the output torque.

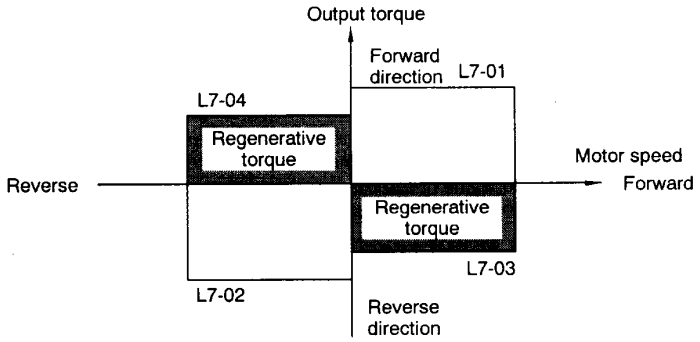


Figure 7.14 Torque Limit Function

- When the torque limit function is used, the Torque Control has priority and motor Speed Control and compensation will be disregarded, so the acceleration/deceleration times might be lengthened and motor speed might be reduced.

■ Limiting Torque with Analog Inputs: H3-05, H3-09

The following two analog inputs that can be used to limit torque. Use either or both of these inputs as needed with constants H3-05 and H3-09.

- Multi-function analog input Terminal 16.
- Frequency reference (current) Terminal 14.

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	—	B	B	B	B	B
H3-09	Multi-function analog input (Terminal 14)	X	1 to 1F	—	1F	A	A	A	A

- Settings

Setting	Name
10	Forward Torque Limit
11	Reverse Torque Limit
12	Regenerative Torque Limit
13	Torque Reference (The input limits torque in both the forward and reverse directions during Speed Control.)
15	Forward/Reverse Torque Limit (Limits torque in both the forward and reverse directions.)

- The above table shows only those settings related to the torque limit function.
- Set the analog input terminal's signal level, gain, and bias to match the actual input signal.
- The factory default settings for the input terminal's signal level are as follows:
  - Terminal 16: 0 to +10 V (A 10 V input limits the torque to 100% of the motor's rated torque.)
  - Terminal 14: 4 to 20 mA (A 20 mA input limits the torque to 100% of the motor's rated torque.)

Figure 7.15 shows the relationship between the output torque and each torque limit.

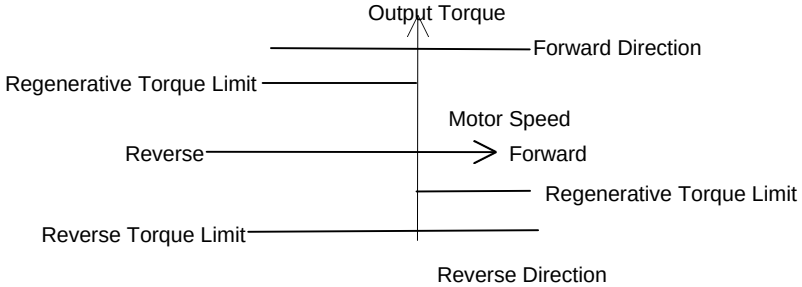


Figure 7.15 Limiting Torque via Analog Inputs

- When the forward torque limit has been set, the analog input signal acts as the limit value for torque generated in the forward direction. The torque limit input is effective when torque is generated in the forward direction even if the motor is operating in reverse (regenerative torque).
- The torque limit is 100% of the motor's rated torque when the analog input is at its maximum value (10 V or 20 mA). To increase the torque limit above 100%, set the input terminal's gain above 100%. For example, a gain of 150.0% would result in a torque limit of 150% of the motor's rated torque with a 10 V or 20 mA analog input.

7.3.6 Setting/Adjusting Motor Constants

■ Adjusting the V/f Pattern: E1-04 to E1-07, E1-13

- Normally it is not necessary to adjust the V/f pattern with Flux Vector Control. Adjust the V/f pattern when you want to change the maximum output frequency, maximum voltage, base frequency, or minimum output frequency settings.

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	Maximum output frequency	X	40.0 to 400.0	Hz	60.0	Q	Q	Q	Q
E1-05	Maximum voltage	X	0.0 to 255.0 *1	VAC	200.0*1	Q	Q	Q	Q
E1-06	Base frequency	X	0.0 to 400.0	Hz	60.0	Q	Q	Q	Q
E1-09	Minimum output frequency	X	0.0 to 400.0	Hz	0.0	Q	Q	Q	A
E1-13	Base voltage	X	0.0 to 255.0	VAC	0.0 *2	A	A	Q	Q

*1 These voltages are for the 200 V class. Double the voltage for 400 V class Inverters.
*2 If E1-13 is set to 0.0, the same value as in E1-13 will be set for E1-05. It does not normally need to be set separately.

NOTE:
1. The default setting for E1-09 depends on the control method. The default settings shown in the table are for Flux Vector Control.
2. The three frequency settings must satisfy the following equation:
E1-04 (F_{MAX}) ≥ E1-06 (F_A) > E1-09 (F_{MIN})

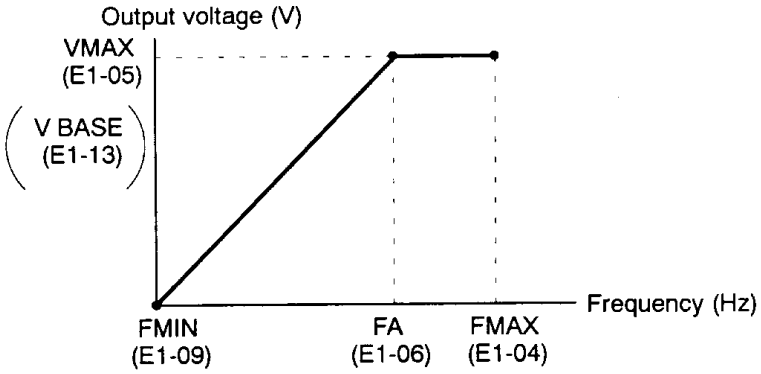


Figure 7.16 V/f Pattern Adjustment

Units for V/f Pattern Settings: o1-04

The units used for V/f pattern frequency settings can be changed when Flux Vector Control has been selected.

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
o1-04	Frequency units of constant setting	X	0, 1	—	0	X	X	X	B

- Display Unit Settings

Setting	Function
0	Units: Hz
1	Units: RPM

- The setting units for constants E1-04, and E1-09 can be changed.
- The unit for other frequencies will not change.
- Constant o1-04 is specific to Flux Vector Control.

■ Setting Motor Constants: E2-01 to E2-09

The motor constants (Function E2) will all be set automatically when Auto-Tuning is performed.

Set these constants manually if Auto-Tuning cannot be completed properly.

Motor Rated Current: E2-01

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
E2-01	Motor rated current	X	0.32 to 6.40	A	1.90	Q	Q	Q	Q

- The setting range is 10% to 200% of the Inverter rated output current. The default setting depends upon the Inverter capacity. (The table shows the default setting for 200 V class, 0.4 kW Inverters.) (See Page 258)
- Set the rated current (A) shown on the motor nameplate.

Motor Rated Slip: E2-02

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
E2-02	Motor rated slip	X	0.00 to 20.00	Hz	2.90	A	A	Q	Q

- The default setting depends upon the Inverter capacity. (The table shows the default settings for 200 V class, 0.4 kW Inverters.) (See Page 258)
- Calculate the rated slip (E2-02) from the value shown on the motor nameplate with the following equation and set this value.

  Rated slip = rated frequency (Hz) – rated speed (RPM) x number of poles/120

Motor No-Load Current: E2-03

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
E2-03	Motor no-load current	X	0.00 to 1500.0	A	1.20	A	A	Q	Q

- The default setting depends upon the Inverter capacity. (The table shows the default settings for 200 V class, 0.4 kW Inverters.) (See Page 258)
- Set the no-load current (E2-03) at the rated voltage and rated frequency. Normally this value is not shown on the motor nameplate, so it might be necessary to contact the motor nameplate, so it be necessary to contact the motor manufacturer.

Number of Motor Poles: E2-04

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
E2-04	Number of motor poles	X	2 to 48	—	4	X	Q	X	Q

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

Motor Line-to-Line Resistance: E2-05

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
E2-05	Motor line-to-line resistance	X	0.000 to 65.000	Ω	9.842	A	A	A	A

- The default setting depends upon the Inverter capacity. (The table shows the default settings for 200 V class, 0.4 kW Inverters.) (See Page 258)
- Set the motor terminal resistance (U-V, V-W, and W-U) in constant E2-05.
- Normally this value is not shown on the motor nameplate, so it might be necessary to contact the motor manufacturer for the terminal resistance at the insulation class temperature. Use the following equations to calculate the resistance value from the terminal resistance of a test report.
  - E-class insulation: Terminal resistance at 75°C in the test report (Ω) x 0.92.
  - B-class insulation: Terminal resistance at 75°C in the test report (Ω) x 0.92.
  - F-class insulation: Terminal resistance at 115°C in the test report (Ω) x 0.87.

Motor Leak Inductance: E2-06

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
E2-06	Motor leak inductance	X	0.0 to 30.0	%	18.2	X	X	A	A

- The default setting depends upon the Inverter capacity. (The table shows the default settings for 200 V class, 0.4 kW Inverters.) (See Page 258)
- Set the voltage drop (caused by the motor's leakage inductance) as a percentage of the motor's rated voltage in constant E2-06.
- This constant does not normally require setting because the Inverter automatically compensates during operation.
- Normally this value is not shown on the motor nameplate, so it might be necessary to contact the motor manufacturer. It is also acceptable to set the loss (caused by the motor's leakage inductance) as a percentage.

Motor Iron-Core Saturation Coefficients 1, 2: E2-07, E2-08

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
E2-07	Motor iron-core saturation coefficient 1	X	0.00 to 0.50	—	0.50	X	X	A	A
E2-08	Motor iron-core saturation coefficient 2	X	0.00 to 0.75	—	0.75	X	X	A	A

- Constants E2-07 and E2-08 are not required when using the motor at or below the rated frequency.
- Set these constants when operating at a frequency higher that the motor's rated frequency. Set the following values:
  - Motor iron-core saturation coefficient 1: Iron-core saturation coefficient when magnetic flux is 50%.
  - Motor iron-core saturation coefficient 2: Iron-core saturation coefficient when magnetic flux is 75%.
- Normally these values are not shown on the motor nameplate, so it might be necessary to contact the motor manufacturer. Operation will be possible with the factory-preset values.

Motor Mechanical Loss: E2-09

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
E2-09	Motor mechanical loss	X	0.0 to 10.0	%	0.0	X	X	X	A

- Normally it is not necessary to change this setting in the following cases:
  - There is a large torque loss to the motor's bearings.
  - There is a large torque loss to a fan or pump.
- Set the mechanical loss as a percentage of the motor's rated output power (W). Constant E2-09 is used to compensate for torque lost mechanically in the motor.

■ Setting the Slip Compensation Gain: C3-01

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
C3-01	Slip compensation gain	❍	0.0 to 2.5	Multiple	1.0	B	X	B	B

- Normally it is not necessary to change this setting.
- With Flux Vector Control, constant C3-01 sets the motor's temperature compensation gain. Adjust the setting when a torque limit or Torque Control is being used and the output torque varies with the ambient temperature.
- This constant can be adjusted when the motor's output torque changes at higher temperatures when Torque Control or limits are used. The larger the setting, the larger the compensation will be.

7.4 V/f Control with PG Feedback

The functions that can be used with V/f Control with PG Feedback are listed in *Table 7.4*. Details on functions that are specific to V/f Control with PG Feedback (i.e. those marked with a ★) are provided in the following table.

Table 7.4 V/f Control with PG Feedback

Group		Function		Comments	Control Method			
					V/f	V/f with PG	Open-Loop Vector	Flux Vector
b	Application	b1	Sequence	Settings such as the reference input method	❍	❍	❍	❍
		b2	Dc Injection Braking	DC Injection Braking function settings	❍	❍	❍	❍
		b3	Speed Search	Speed search function settings	❍	❍	❍	❍
		b4	Delay Timers	Timer function settings	❍	❍	❍	❍
		b5	PID Control	PID Control settings	❍	❍	❍	❍
		b6	Dwell Functions	Acceleration/deceleration time dwell function settings	❍	❍	❍	❍
		B7	Droop Control	Not used. (Cannot be set.)	X	X	X	❍
		b8	Energy Saving	★ Multi-function input: Sets Energy Saving Control by energy saving reference.	❍	❍	X	X
		b9	Zero Servo	Not used. (Cannot be set.)	X	X	X	❍
C	Tuning	C1	Accel/Decl	Acceleration/deceleration time settings	❍	❍	❍	❍
		C2	S-Curve Acc/Dec	S-curve characteristics for acceleration/deceleration times	❍	❍	❍	❍
		C3	Motor-Slip Compensation	Slip compensation function settings	❍	❍	❍	❍
		C4	Torque Compensation	Torque compensation function settings	❍	❍	❍	X
		C5	Speed Controls	Speed control loop adjustment	X	❍	X	❍
		C6	Carrier Frequency	Carrier frequency settings	❍	❍	❍	❍
		C7	Hunting Prevention	★ Hunting Prevention settings	❍	❍	X	X
		C8	Factory Tuning	Not used. (Cannot be set.)	X	X	★	X

Group		Function		Comments	Control Method			
					V/f	V/f with PG	Open-Loop Vector	Flux Vector
d	Reference	d1	Preset Reference	Frequency reference settings (when using Operator)	❍	❍	❍	❍
		d2	Reference Limits	Frequency upper and lower limit settings	❍	❍	❍	❍
		d3	Jump Frequencies	Prohibited frequency settings	❍	❍	❍	❍
		d4	Reference Frequency Hold Function	Up/Down, Accel/Decel stop hold frequency setting	❍	❍	❍	❍
		d5	Torque Control	Not used. (Cannot be set.)	X	X	X	❍
E	Motor	E1	V/f Pattern	★ Motor constant settings	❍	❍	❍	❍
		E2	Motor Setup	★ Motor constant settings (Motor constants are set manually	❍	❍	❍	❍
		E3	Motor 2 Control Methods	Control method settings for motor 2	❍	❍	❍	❍
		E4	Motor 2 V/f Characteristics	V/f characteristics settings for motor 2	❍	❍	❍	❍
		E5	Motor 2 Motor Constants	Motor constant settings for motor 2	❍	❍	❍	❍
F	Options	F1	PG Speed Option Card settings	Constant settings for a PG Speed Option Card	X	❍	X	❍
		F2	Analog Reference Card AI	User constant settings for an Analog Reference Card	❍	❍	❍	❍
		F3	Digital Reference Card DI	User constant settings for a Digital Reference Card	❍	❍	❍	❍
		F4	Analog Monitor Card AO	User constant settings for an Analog Monitor Card	❍	❍	❍	❍
		F5	Digital Output Card DO	User constant settings for a Digital Output Card	❍	❍	❍	❍
		F6	Digital Output Card DO	User constant settings for a Digital Output Card	❍	❍	❍	❍
		F7	Pulse Monitor Card PO	User constant settings for a Pulse Monitor Card	❍	❍	❍	❍
		F8	SI-F/SI-G Transmission Card	User constant settings for a Transmission Card	❍	❍	❍	❍
		F9	CP-916B Transmission Card	User constant settings for a Transmission Card	❍	❍	❍	❍
H	Terminal	H1	Multi-Function Inputs	Function selection for multi-function inputs	❍	❍	❍	❍
		H2	Multi-Function Outputs	Function selection for multi-function outputs	❍	❍	❍	❍
		H3	Analog Inputs	Function selection for analog inputs	❍	❍	❍	❍
		H4	Multi-Function Analog Outputs	Function selection for analog outputs	❍	❍	❍	❍
		H5	MEMOBUS Communications	MEMOBUS communications settings	❍	❍	❍	❍
L	Protection	L1	Motor Protection Functions	Sets electrical/thermal functions that protect the motor	❍	❍	❍	❍
		L2	Power Loss Ridethru	Selects the power-loss processing method	❍	❍	❍	❍
		L3	Stall Prevention	Accel/Decl stall prevention and selection	❍	❍	❍	❍
		L4	Reference Detection	Frequency detection settings and selection	❍	❍	❍	❍
		L5	Fault Restart	Fault restart function settings	❍	❍	❍	❍
		L6	Torque Detection	Sets overtorque detection functions 1 and 2	❍	❍	❍	❍
		L7	Torque Limit	Not used. (Cannot be set.)	X	X	❍	❍
		L8	Hardware Protection	Hardware overheating and open-phase protection settings	❍	❍	❍	❍
o	Operator	o1	Monitor Select	Selects the Operator's display and setting methods	❍	❍	❍	❍
		o2	Key Selections	Operator's key function selection and other constants	❍	❍	❍	❍

7.4.1 Energy Saving Control Function

The Energy Saving Control function is enabled when the energy saving command (Setting 63) has been set in a multi-function input (H1-01 through H1-06). Inputting the energy saving command while there is a light load causes the Inverter's output voltage to be reduced and saves energy. Turn OFF the energy saving command when a normal load is added.

■ Energy Saving Gain: b8-01

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
b8-01	Energy Saving gain	X	0 to 100	%	80	A	A	X	X

- Constant b8-02 determines the lower limit frequency for the energy saving function.
- The energy saving command is enabled only when the frequency reference is above the energy saving frequency and the motor speed is within the "speed agree" range. A time chart for energy saving operation is shown below.

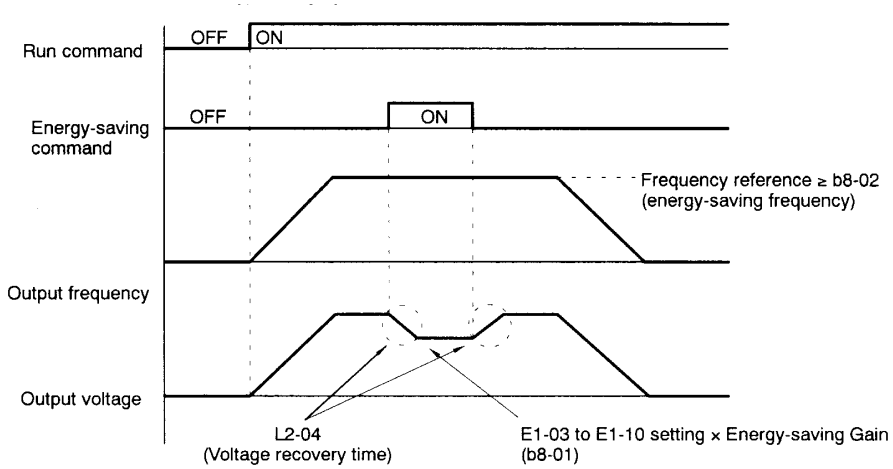


Figure 7.17 Time Chart for Energy Saving Operation

7.4.2 Hunting Prevention Function

The Hunting Prevention function suppresses hunting when the motor is operating with a light load. This function is valid with V/f Control and V/f with PG Feedback Control.

■ Hunting Prevention Selection: C7-01

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
C7-01	Hunting Prevention selection	X	0, 1	—	1	A	A	X	X

- Settings

Setting	Function
0	Disables the Hunting Prevention function.
1	Enables the Hunting Prevention function.

■ Hunting Prevention Gain: C7-02

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
C7-02	Motor rated slip	X	0.00 to 20.00	Hz	2.90	A	A	Q	Q

- Normally it is not necessary to change these constants. Adjust these constants as follows if hunting occurs with a light load.
  - Increase the setting in C7-02 if oscillation occurs when operating with a light load. (If the setting is increased too much, the current can fall to the point where stalling occurs.)
  - Decrease the setting C7-02 if stalling occurs.
  - Disable the Hunting Prevention function (C7-01 = 0) if high responsiveness is more important than suppressing oscillation.

7.4.3 Setting Motor Constants

■ Motor Rated Slip: E2-02

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
E2-02	Motor rated slip	X	0.00 to 20.00	Hz	2.90	A	A	Q	Q

- These settings are used as reference values for the motor slip compensation function.
- The default setting depends upon the Inverter capacity. (The table shows the default settings for 200 V class, 0.4 kW Inverters.) (See Page 258)
- Calculate the rated slip (E2-02) from the value shown on the motor nameplate with the following equation and set this value.

  Rated slip = rated frequency (Hz) – rated speed (r/min) x number of poles/120

■ Motor No-Load Current: E2-03

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
E2-03	Motor no-load current	X	0.00 to 1500.0	A	1.20	A	A	Q	Q

- These settings are used as reference values for the motor slip compensation function.
- The default setting depends upon the Inverter capacity. (The table shows the default settings for 200 V class, 0.4 kW Inverters.) (See Page 258)
- Set the no-load current (E2-03) at the rated voltage and rated frequency. Normally this value is not shown on the motor nameplate, so it might be necessary to contact the motor manufacturer.

■ Motor Line-to-Line Resistance: E2-05

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
E2-05	Motor line-to-line resistance	X	0.000 to 65.000	Ω	9.842	A	A	A	A

- This setting is used as a reference value for the torque compensation function.
- The default setting depends upon the Inverter capacity. (The table shows the default settings for 200 V class, 0.4 kW Inverters.) (See Page 258)
- Set the motor's terminal resistance (U-V, V-W, and W-U). Normally this value is not shown on the motor nameplate, so it might be necessary to contact the motor manufacturer.

7.5 Common Functions

The functions that can be used for all control methods are listed in *Table 7.5*. Details on functions marked with a ★ are provided in the following table.

Table 7.5 Functions Used with All Control Methods

Group		Function		Comments	Control Method			
					V/f	V/f with PG	Open-Loop Vector	Flux Vector
b	Application	b1	Sequence	Settings such as the reference input method	❍	❍	❍	❍
		b2	Dc Injection Braking	★ DC Injection Braking function settings	❍	❍	❍	❍
		b3	Speed Search	★ Speed search function settings	❍	❍	❍	❍
		b4	Delay Timers	★ Timer function settings	❍	❍	❍	❍
		b5	PID Control	★ PID Control settings	❍	❍	❍	❍
		b6	Dwell Functions	★ Acceleration/deceleration time dwell function settings	❍	❍	❍	❍
		B7	Droop Control	Droop Control settings	X	X	X	❍
		b8	Energy Saving	Multi-function input: Sets Energy Saving Control by energy saving reference.	❍	❍	X	X
		b9	Zero Servo	Zero Servo settings	X	X	X	❍
C	Tuning	C1	Accel/Decl	Acceleration/deceleration time settings	❍	❍	❍	❍
		C2	S-Curve Acc/Dec	★ S-curve characteristics for acceleration/deceleration times	❍	❍	❍	❍
		C3	Motor-Slip Compensation	★ Slip compensation function settings	❍	❍	❍	❍
		C4	Torque Compensation	★ Torque compensation function settings	❍	❍	❍	X
		C5	Speed Controls	Speed Control tuning	X	❍	X	❍
		C6	Carrier Frequency	★ Carrier frequency settings	❍	❍	❍	❍
		C7	Hunting Prevention	Hunting Prevention settings	❍	❍	X	X
		C8	Factory Tuning	Adjustment for Open-Loop Vector Control	X	X	★	X
d	Reference	d1	Preset Reference	Frequency reference settings (when using Operator)	❍	❍	❍	❍
		d2	Reference Limits	★ Frequency upper and lower limit settings	❍	❍	❍	❍
		d3	Jump Frequencies	★ Prohibited frequency settings	❍	❍	❍	❍
		d4	Reference Frequency Hold Function	★ Up/Down, Accel/Decel stop hold frequency setting	❍	❍	❍	❍
		d5	Torque Control	Torque Control settings and tuning	X	X	X	❍
E	Motor	E1	V/f Pattern	Motor constant settings	❍	❍	❍	❍
		E2	Motor Setup		❍	❍	❍	❍
		E3	Motor 2 Control Methods	Control method settings for motor 2	❍	❍	❍	❍
		E4	Motor 2 V/f Characteristics	V/f characteristics settings for motor 2	❍	❍	❍	❍
		E5	Motor 2 Motor Constants	Motor constant settings for motor 2	❍	❍	❍	❍
F	Options	F1	PG Speed Option Card settings	Constant settings for a PG Speed Option Card	X	❍	X	❍
		F2	Analog Reference Card AI	★ User constant settings for an Analog Reference Card	❍	❍	❍	❍
		F3	Digital Reference Card DI	★ User constant settings for a Digital Reference Card	❍	❍	❍	❍
		F4	Analog Monitor Card AO	★ User constant settings for an Analog Monitor Card	❍	❍	❍	❍
		F5	Digital Output Card DO	User constant settings for a Digital Output Card	❍	❍	❍	❍
		F6	Digital Output Card DO	User constant settings for a Digital Output Card	❍	❍	❍	❍
		F7	Pulse Monitor Card PO	★ User constant settings for a Pulse Monitor Card	❍	❍	❍	❍
		F8	SI-F/SI-G Transmission Card	User constant settings for a Transmission Card	❍	❍	❍	❍
		F9	CP-916B Transmission Card	User constant settings for a Transmission Card	❍	❍	❍	❍

Group		Function		Comments	Control Method			
					V/f	V/f with PG	Open-Loop Vector	Flux Vector
H	Terminal	H1	Multi-Function Inputs	★ Function selection for multi-function inputs	❍	❍	❍	❍
		H2	Multi-Function Outputs	★ Function selection for multi-function outputs	❍	❍	❍	❍
		H3	Analog Inputs	★ Function selection for analog inputs	❍	❍	❍	❍
		H4	Multi-Function Analog Outputs	★ Function selection for analog outputs	❍	❍	❍	❍
		H5	MEMOBUS Communications	MEMOBUS communications settings	—	—	—	—
L	Protection	L1	Motor Protection Functions	★ Sets electrical/thermal functions that protect the motor	❍	❍	❍	❍
		L2	Power Loss Ridethru	★ Selects the power-loss processing method	❍	❍	❍	❍
		L3	Stall Prevention	★ Accel/Decl Stall Prevention and selection	❍	❍	❍	❍
		L4	Reference Detection	★ Frequency detection settings and selection	❍	❍	❍	❍
		L5	Fault Restart	★ Fault restart function settings	❍	❍	❍	❍
		L6	Torque Detection	★ Sets overtorque detection functions 1 and 2	❍	❍	❍	❍
		L7	Torque Limit	Torque limit settings	X	X	❍	❍
		L8	Hardware Protection	★ Hardware overheating and open-phase protection settings	❍	❍	❍	❍
o	Operator	o1	Monitor Select	★ Selects the Operator's display and setting methods	❍	❍	❍	❍
		o2	Key Selections	★ Operator's key function selection and other constants	❍	❍	❍	❍

7.5.1 Application Constants: b

■ DC Injection Braking: b2-01 to b2-04

- The DC Injection Braking function deceleration by applying a DC current to the motor. This happens in the following two cases:
  - DC Injection Braking Time at Start: Effective for temporarily stopping and then restarting, without regenerative processing, a motor coasting by inertia.
  - DC Injection Braking Time at Stop: Used to prevent coasting by inertia when the motor is not completely stopped by normal deceleration when there is a large load. The stopping time can be shortened by lengthening the DC Injection Braking time or increasing the DC Injection Braking 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
b2-01	Zero speed level (DC Injection Braking starting frequency)	X	0.0 to 10.0	Hz	0.5	B	B	B	B
b2-02	DC Injection Braking current	X	0 to 100	%	50	B	B	B	X
b2-03	DC Injection Braking time at start	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

- For the Zero Speed level (b2-01), set the frequency for beginning DC Injection Braking for deceleration. If the excitation level is lower than the minimum output frequency (E1-09), the DC Injection Braking will begin from the minimum output frequency.
- In Flux Vector Control mode, DC Injection Braking becomes the initial excitation starting frequency at the time of deceleration. In that case, braking starts from the excitation level regardless of the minimum output frequency setting.
- The excitation level is also used as the operating frequency for the Zero Servo function (for Flux Vector Control only).
- For the DC Injection Braking current (b2-02), set the value for the current that is output at the time of DC Injection Braking. DC Injection Braking current is set at a percentage of Inverter rated output current, with the Inverter rated output current taken as 100%.

- For the DC Injection Braking time at start (b2-03), set the DC Injection Braking operating time for when the motor is started.
- For the DC Injection Braking time at stop (b2-04), set the DC Injection Braking operating time for when the motor is started.
- *Figure 7.18* provides a timing chart of DC Injection Braking (initial excitation).

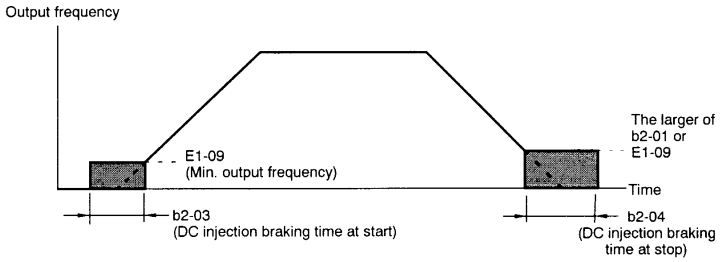


Figure 7.18 DC Injection Braking Timing Chart

■ Speed Search: b3-01 to b3-03

The speed search function finds the speed of a coasting motor and starts up smoothly from that speed. It is effective in situations such as switching from a commercial power supply.

Speed Search Selection at Start: b3-01

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
b3-01	Speed search selection at start	X	0, 1	—	0*	A	A	A	A

* When the control method is switched, the factory setting changes as follows:
V/f Control: 0; V/f with PG: 1; Open-Loop Vector 0; Flux Vector: 1

- Settings

Setting	Contents	
0	Speed search disabled:	Motor starts from minimum output frequency
1	Speed search enabled:	Speed search is performed from maximum output frequency and motor is started. (In control methods with PG, i.e., V/f with PG Feedback and Flux Vector, motor starts from the motor speed.)

- Set "1" to use the speed search function. A speed is performed each time the run command is input.
- To use speed search freely in control methods without PG, i.e., V/f Control and Open-Loop Vector Control, set the multi-function contact input selection (H1-01 to H1-06) to 61 or 62 (external search command). (See *7.5.5 External Terminal Functions: H*.)

Speed Search Operating Current, Speed Search Deceleration Time, and Minimum Baseblock Time: b3-02, b3-03, L2-03

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
b3-02	Speed search operating current	X	0~200	%	100 (150)*1	A	X	A	X
b3-03	Speed search deceleration time	X	0.1~10.0	S	2.0	A	X	A	X
L2-03	Minimum baseblock time	X	0.0~0.5	S	0.5*2	B	B	B	B

*1 The factory setting for V/f Control is 150%.
*2 The factory setting varies depending on the Inverter capacity. The values shown in the table are for the 200 V class Inverters of 0.4 kW.

- For the speed search operating current (b3-02), set the operating current for the speed search. If restarting is not possible with the setting, then lower the setting.
- Set the speed search operating current as a percentage of the Inverter's rated output current, with the Inverter's rated output current taken as 100%.
- For the speed search deceleration time (b3-03), set the output frequency deceleration time for while the speed search is being performed. Set the time required to decelerate from the maximum output frequency to 0 Hz.
- When the speed search and DC Injection Braking are set, set the minimum baseblock time (L2-03). For the minimum baseblock time, set the time to wait for the motor's residual voltage to dissipate. If an overcurrent is detected when starting a speed search or DC Injection Braking, raise the setting to prevent a fault from occurring.

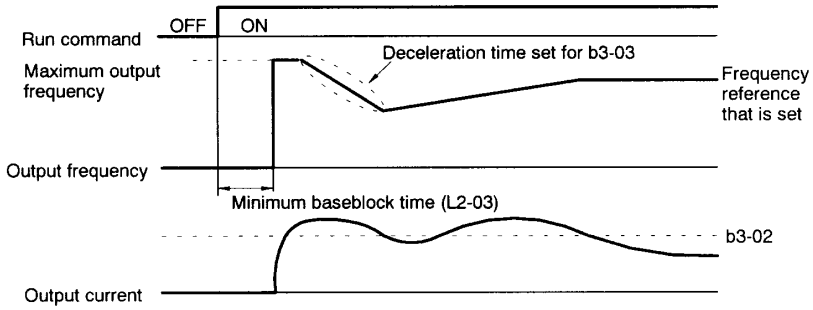


Figure 7.19 Speed Search Timing Chart

Timer Functions: b4-01, b4-02

- The timer functions are enabled when the timer function input (Setting 18) and the timer function output (Setting 12) are set for the multi-function input and multi-function output respectively.
- These inputs and outputs serve as general-purpose I/O. Chattering of sensors, switches, and so on, can be prevented by setting a delay 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
b4-01	Timer function ON–delay time	X	0.0 to 300.0	s	0.0	A	A	A	A
b4-02	Timer function OFF–delay time	X	0.0 to 300.0	s	0.0	A	A	A	A

- When the timer function input ON time is longer than the value set for b4-01 (timer function ON-delay time), the timer function output turns ON.
- When the timer function input OFF time is longer than the value set for b4-02 (timer function OFF-delay time), the timer function output turns OFF. An operation example of the timer function is shown in *Figure 7.20*.

Figure 7.20 Operation Example of Timer Function

PID Control Settings: b5-01 to b5-08

The PID Control function is a control system that matches a feedback value (i.e., a detected value) to the set target value. Combining Proportional (P), Integral (I), and Derivative (D) control makes control possible even for a mechanical system with dead time.

This section explains the PID Control applications and operations, along with the constant settings and tuning procedure.

PID Control Applications

Table 7.6 shows examples of PID Control applications using the Inverter.

Table 7.6 PID Control Applications

Applications	Control Contents	Sensors Used (Example)
Speed Control	• Speeds are matched to target values as speed information in a mechanical system. • Speed information for another mechanical system is input as target values, and synchronized control is executed by feeding back actual speeds.	Tach Generator
Pressure Control	Pressure information is returned as feedback for stable pressure control.	Pressure Sensor
Flow Control	Flow information is returned as feedback for accurate flow control.	Flow Sensor
Temperature Control	Temperature information is returned as feedback to control temperature by turning a fan.	• Thermocouple • Thermistor

PID Control Operations

In order to distinguish the separate PID Control operations (i.e., proportional, integral, and derivative), *Figure 7.21* shows the changes in the control input (i.e., the output frequency) when the deviation between the target value and the feedback is held constant.

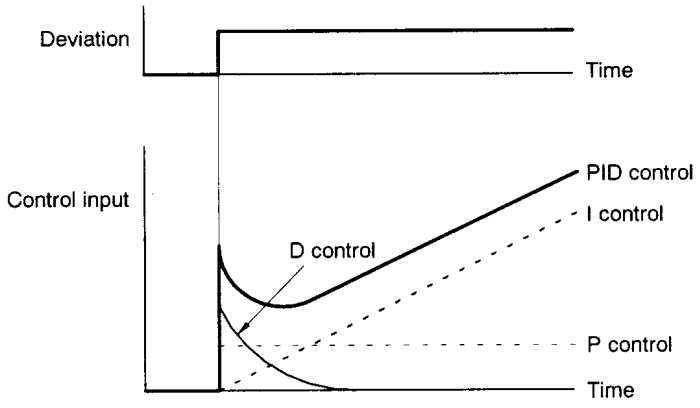


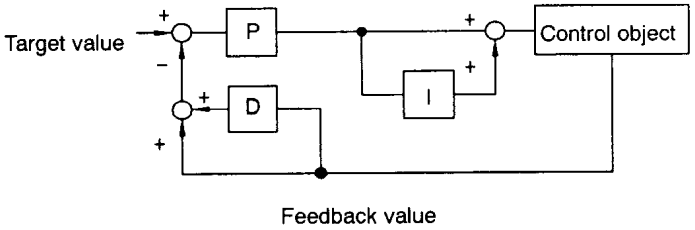
Figure 7.21 PID Control Operations

- P Control: A control input proportional to the deviation is output. The deviation cannot be zeroed by P Control alone.
- I Control: A control input which is an integral of the deviation is output. This is effective for matching the feedback to the target value. Sudden changes, however, cannot be followed.
- D Control: A control input which is an integral of the deviation is output. Quick response to sudden changes is possible.
- PID Control: Optimum control is achieved by combining the best features of P, I, and D Control.

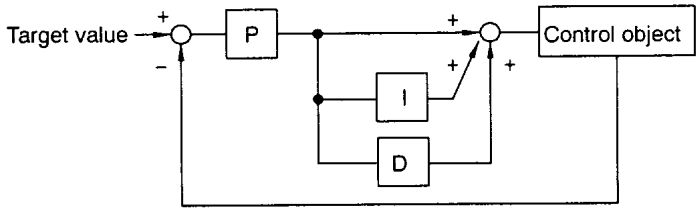
Types of PID Control

Two types of PID Control are possible with the Inverter: measured-value derivative PID Control and basic PID Control. The type that is normally used is measured-value derivative PID Control.

- Measured-value derivative PID Control: With measured-value derivative PID Control, the feedback value is differentiated for PID Control. Response is possible with respect to changes both in target values and the control object.



- Basic PID Control: This is the basic form of PID Control. When the D Control response is adjusted to follow changes in the control object, overshooting and undershooting can occur with changes in the target value.



Inverter's PID Control Function

Figure 7.22 is a block diagram of the Inverter's internal PID Control.

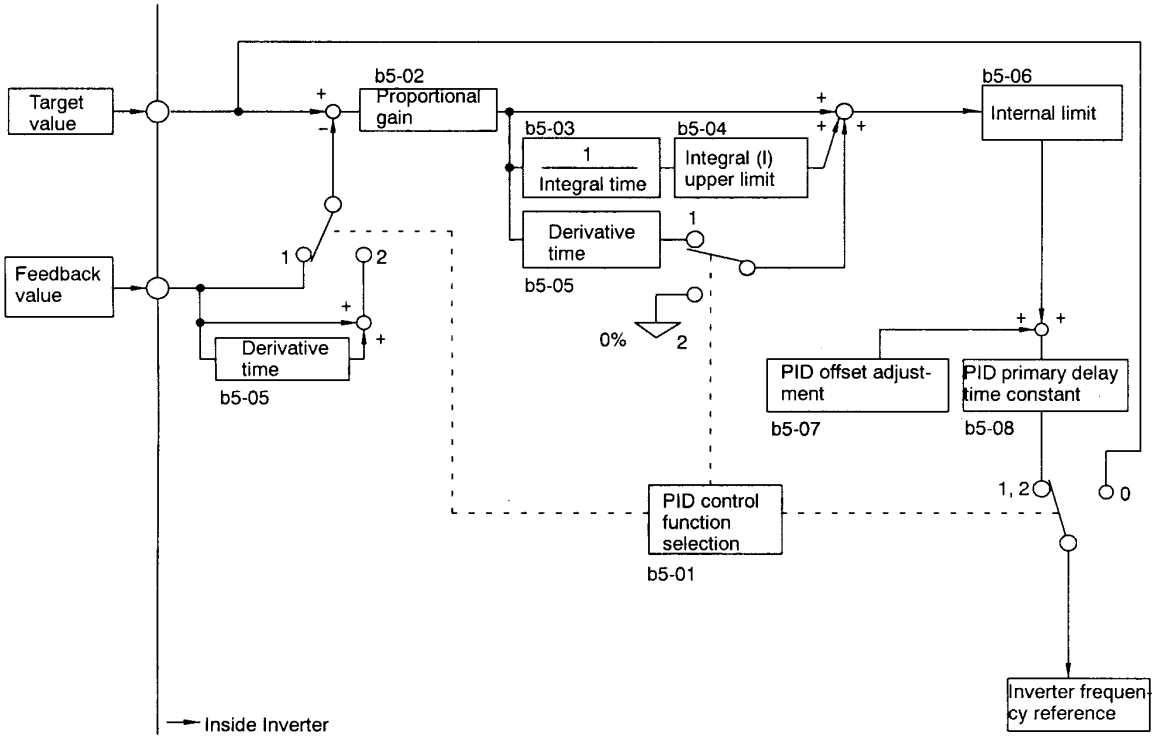


Figure 7.22 Block Diagram for PID Control in Inverter

PID Control Settings

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
b5-01	PID Control mode selection	X	0 to 2	—	0	A	A	A	A

- Settings

Setting	Contents
0	PID Control disabled.
1	PID Control enabled, deviation signal is subject to derivative control.
2	PID Control enabled, feedback signal is subject to derivative control.

- To enable PID Control, set either “1” or “2”, (normally “2” is used, for measured-value derivative PID Control).
- When PID Control is enabled, the target value input is determined by constant b1-01 (reference selection).
- The feedback value is input from a multi-function analog input terminal or frequency reference (current) terminal. Set PID feedback (Setting B) for either the constant H3-05 (multi-function analog input, Terminal 16), or constant H3-09 (multi-function analog input, Terminal 14) function selection. (See *Table 7.11*.) Adjust the amount of feedback by setting the gain and bias of the analog input that are used.
- Proportional gain (P), Integral (I) Time, and Differential (D) Time: b5-02, b5-03, b5-05
- Adjust the responsiveness of the PID control by means of the Proportional Gain (P), Integral Time (I), and Derivative Time (D).

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
b5-02	Proportional Gain (P)	❍	0.00 to 25.00	Multiple	1.00	A	A	A	A
b5-03	Integral (I) Time	❍	0.0 to 360.0	S	1.0	A	A	A	A
b5-05	Derivative (D) Time	❍	0.00 to 10.00	S	0.00	A	A	A	A

- Optimize the responsiveness by adjusting it while operating an actual load (mechanical system). (Refer to *Adjusting PID Control* on Page 176.) Any control (P, I, or D) that is set to zero (0.0, 0.00) will not operate.

- Integral (I) Limit: b5-04

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
b5-04	Integral (I) Limit	❍	0.0 to 100.0	%	100.0	A	A	A	A

- This constant prevents the calculated value of the integral control in the PID Control from exceeding the fixed amount.
- There is normally no need to change the setting.
- Reduce the setting if there is a risk of load damage, or if the motor is going out of step, by the Inverter’s response when the load suddenly changes. If the setting is reduced too much, the target value and the feedback value will not match.
- Set this constant as a percentage of the maximum output frequency, with the maximum frequency taken as 100%.

- PID Limit: b5-06

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
b5-06	PID Limit	❍	0.0 to 200.0	%	100.0	A	A	A	A

- Constant b5-06 prevents the frequency reference after PID Control from exceeding the fixed amount.
- Set this constant as a percentage of the maximum output frequency, with the maximum frequency taken as 100%.

- PID Offset Adjustment: b5-07

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
b5-07	PID offset adjustment	❍	100.0 to 100.0	%	0.0	A	A	A	A

- Constant b5-07 adjusts the PID Control offset.
- If both the target value and the feedback value are set to zero, adjust the Inverter's output frequency to zero.

- PID Primary Delay Time Constant: b5-08

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
b5-08	PID primary delay time constant	❍	0.00 to 10.00	s	0.00	A	A	A	A

- Constant b5-08 is the low-pass filter setting for PID Control outputs.
- There is normally no need to change the setting.
- If the viscious friction of the mechanical system is high, or if the rigidity is low, causing the mechanical system to oscillate, increase the setting so that it is higher than the oscillation frequency period. This will decrease the responsiveness, but it will prevent the oscillation.

Adjusting PID Control

Use the following procedure to activate PID Control and then adjust it while monitoring the response.

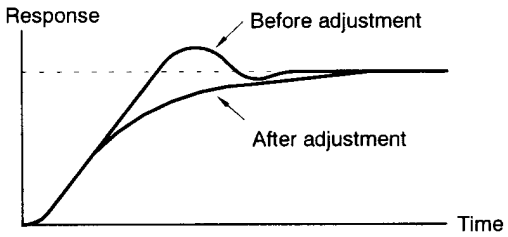
1. Enable PID Control (set b5-01 to 2 or 1).
2. Increase the proportional gain P in b5-02 as far as possible without creating oscillation.
3. Reduce the integral time I in b5-03 as far as possible without creating oscillation.
4. Increase the differential time (D) in b5-05 as far as possible without creating oscillation.

Making Fine Adjustments

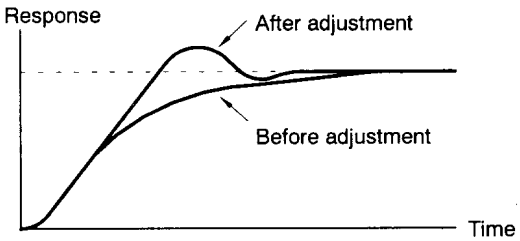
First set the individual PID Control constants, and then make fine adjustments.

- Reducing Overshooting

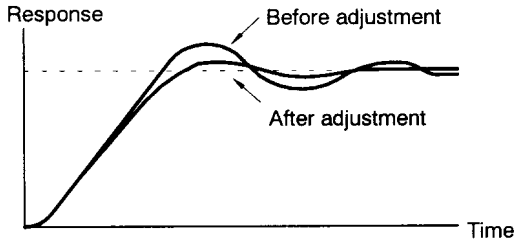
  If overshooting occurs, shorten the derivative time (D) and lengthen the integral time (I).



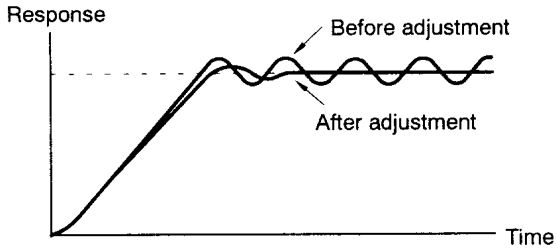
- Rapidly Stabilizing Control Status
  To rapidly stabilize the control conditions even when overshooting occurs, shorten the Integral Time (I) and lengthen the Derivative Time (D).



- Reducing Long-Cycle Oscillation
  If oscillation occurs with a longer cycle than the Integral Time (I) setting, it means that integral operation is strong. The oscillation will be reduced as the Integral Time (I) is lengthened.



- Reducing Short-cycle Oscillation
  If the oscillation cycle is short and oscillation occurs with a cycle approximately the same as the Derivative Time (D) setting, it means that the derivative operation is strong. The oscillation will be reduced as the Derivative Time (D) is shortened. If oscillation cannot be reduced even by setting the Derivative Time (D) to "0.00" (no derivative control), then either lower the Proportional Gain (P) or raise the PID primary delay time constant.



■ Dwell Functions: b6-01 to b6-04

- The dwell functions are used to temporarily hold the output frequency when starting or stopping a motor with a heavy load. This helps to prevent stalling.

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
b6-01	Dwell frequency at start	X	0.0 to 400.0	Hz	0.0	A	A	A	A
b6-02	Dwell time at start	X	0.0 to 10.0	s	0.0	A	A	A	A
b6-03	Dwell frequency at stop	X	0.0 to 400.0	Hz	0.0	A	A	A	A
b6-04	Dwell time at stop	X	0.0 to 10.0	s	0.0	A	A	A	A

- The relation between these constants is shown in *Figure 7.23,* below.

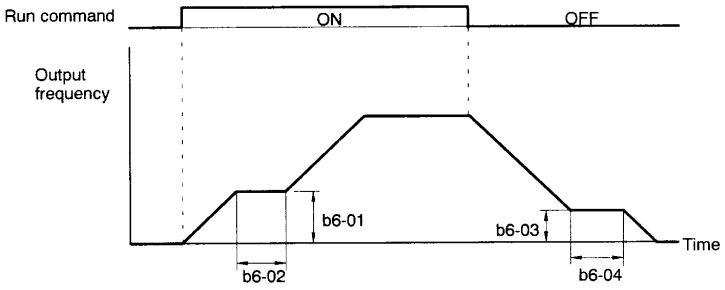


Figure 7.23 Timing Chart for Dwell Functions