VIGOR PROGRAMMABLE CONTROLLER

Positioning Control Module User Manual

VB-1PG

VIGOR ELECTRIC CORP.

豐煒科技

Foreword

- This manual contains text, diagrams and explanations which will guide the reader in the correct installation, safe use and operation of the VB-1PG pulse generator module. It should be read and understood before attempting to install or use the unit.
- Further information can be found in the VIGOR M, VB and VH series PLC PROGRAMMING MANUAL.
- If in doubt at any stage during the installation of the VB-1PG pulse generator module always consult a professional electrical engineer who is qualified and trained to the local and national standards.
- If in doubt about the operation or use of the VB-1PG pulse generator module please consult the nearest VIGOR ELECTRIC CORP. distributor.
- This manual is subject to change without notice.

Contents:

1. Introduction

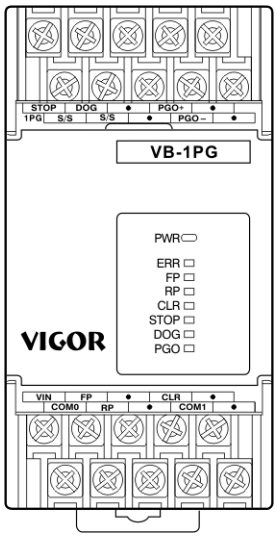
- The VB-1PG pulse generator module is attached as an extension to the VB series Programmable Logical Controller (hereinafter referred to as "PLC"), and the VB-1PG is attached as an extension to the VB series PLC Main Unit. Each VB-1PG functions as a special module which transfers data with the PLC using the FROM/TO instructions, and would not occupy any input or output point. Up to 8 VB-1PG modules can be connected to single VB2 series PLC so operation for independent 8 axes can be realized. (A single VB0 series PLC can connect with two VB-1PG modules.)

- The VB-1PG pulse generator module performs simple positioning of an independent axis (not interpolation control between multiple axes) by supplying a prescribed quantity of pulses (100 kHz maximum) to drive an amplifier for servo or stepper motor.

- This module not only provides connection terminals for positioning operations that require High-Speed responses as well as those used for pulse train outputs, but also it provides DOG (Near Point Signal), PGO (Zero Point Signal) and STOP connection terminals. The JOG+, JOG-, Home Position Return, Error Reset and Various Operation Mode triggers are assigned by the input points of PLC Main Unit (or expansion nodule/unit).

- The VB-1PG has 7 Operation Modes available:
  1. Jog+, Jog- operation
  2. Home position return start
  3. Single-speed positioning
  4. Interrupt single- speed positioning
  5. Two-speed positioning
  6. External command positioning
  7. Variable speed operation

2. Terminal Arrangement and LED Indication



<< Terminal Layout Instruction >>

Point	Function
STOP	DECELERATION STOP input terminal. Can function as STOP command input in external command operation mode.
DOG	Offers following different functions depending on operation mode. ◎ Machine home position return operation: NEAR POINT SIGNAL input ◎ Interrupt single-speed operation: INTERRUPT input ◎ External command operation: DECELERATION START input
S/S	The COM terminal of 24V DC power terminal for "STOP" input and "DOG" input. (V+ of a NPN sensor ; V- of a PNP sensor) Connected to sensor power supply of PLC or external power supply.
PGO+	Power terminal for zero point signal. Connected to servo amplifier or external power supply. (5~24V DC, ≤ 20 mA)
PGO-	Input terminal for zero point signal from drive unit or servo amplifier. Response pulse width: ≥ 4 μs
CLR	Output terminal for clearing deviation counter. 5~24V DC, ≤ 20 mA Output pulse width: 20 ms (Outputs when return to home position is completed or LIMIT SWITCH input is triggered.)
COM1	Common terminal for CLR output.
FP	Terminal which outputs forward pulse or pulses. 100 kHz, ≤ 20 mA (5~24V DC)
RP	Terminal which outputs reverse pulse or direction. 100 kHz, ≤ 20 mA (5~24V DC)
VIN	Power terminal for pulse output. (supplied from servo amplifier or external unit) 5~24V DC, ≤ 5 mA
COM0	Common terminal for pulse output.
●	Spare terminal. Shall not be used a relay terminal.

<< LED Indicator Instruction >>

LED	Explanation
PWR	Indicates power status of the VB-1PG. Lighted when 5 V is supplied from PLC.
ERR	Flashes when error has been occurred. The START command is not acceptable when this LED is ON.
FP	Flashes when forward pulse or pulses is outputting.
RP	Flashes when reverse pulse or direction is outputting.
CLR	Lighted when CLR signal is outputting.
STOP	Lighted when STOP command is triggered. Lighted by the trigger of either STOP terminal or BFM #25 b1=1.
DOG	Lighted when DOG input is triggered.
PGO	Lighted when zero point signal is triggered.

3. Specifications

<< Performance Specifications >>

Item	Specifications
Power Requirement	● +24V (for input signals) : 24V DC ±10%, Current consumption: ≤ 50 mA , Supplied from external power supply or 24V DC output of PLC. ● +5V (for internal control) : 5V DC, 50 mA, Supplied from PLC Main Unit (or Expansion Unit) via its extension cable. ● For pulse signal output : 5~24V DC, current consumption: ≤ 5 mA, Supplied from the servo amplifier or external power supply.
Number of I/O points occupied	None of I/O point from PLC Main Unit for the VB-1PG.
Number of control axes	A VB-1PG unit controls one axis, a single VB2 series PLC can control independent 8 axes maximum. (VB0 series PLC controls up to 2 axes)
Command speed	● Operations are enabled at pulse speed of 10 PPS to 100 kPPS. ● Command unit can be selected among PLS/s, cm/min, 10 deg/min or inch/min.
Setting pulse	● 0 to ±999,999,999 ● Absolute position specification or relative travel specification can be selected. ● Command unit can be selected among pulse (PLS), μm, mdeg or 10^{-4} inch. ● Multiplication of 10^0, 10^1, 10^2 or 10^3 can be set for position data.
Pulse output format	● Forward (FP) / Reverse (RP) pulse or pulse (PLS) + direction (DIR) can be selected. ● Open collector and transistor output. 5~24V DC, ≤ 20 mA
External I/O	● Photocoupler insulation and LED operation indication are offered for every point. ● 3 input points: (STOP/DOG) 24V DC, 7 mA and (PGO*❶) 24V DC, 20 mA ● 3 output points (FP/RP/CLR): 5~24V DC, ≤ 20 mA
Communication with PLC	16-bit RAM (without battery backup default values) buffer memories (BFMs) #0 to #31 are built in a VB-1PG. Data communication with PLC is performed using the FROM/TO instructions. 32-bit data is processed by combining two BFMs (using the DFROM/DTO instructions).

*❶ The zero point signal PGO is entered by the trigger from the PGO+ and PGO- terminals.

4. Buffer Memory (BFM)

4-1 BFM List:

BFM No.		Item	Range	Default Value *❹ (When power is turned ON)	R: Readable W: Writable
Higher 16 bits	Lower 16 bits				
-	#0	Pulse rate A	1 ~ 32,767 PLS/REV (Pulse/Revolution)	2,000	R / W
#2	#1	Feed rate B	1~999,999 *❶	1,000	R / W
-	#3	Parameter	b0 ~ b15	H0000	R / W
#5	#4	Maximum speed, Vmax	10 PPS ~ 100 kPPS	100 kPPS	R / W
-	#6	Bias speed, Vbia	0 PPS ~ 10 kPPS	0 PPS	R / W
#8	#7	JOG speed, Vjog	10 PPS ~ 100 kPPS	10 kPPS	R / W
#10	#9	Home position return speed (high speed), Vrt	10 PPS ~ 100 kPPS	50 kPPS	R / W
-	#11	Home position return speed (creep speed), Vcr	10 PPS ~ 10 kPPS	1 kPPS	R / W
-	#12	Number of zero point signals for home position return, N	0 ~ 32,767 PLS	10 PLS	R / W
#14	#13	Home position, HP	0 ~ ±999,999 *❷	0	R / W
-	#15	Acceleration/Deceleration time, Ta	50 ~ 5,000 ms	100 ms	R / W
-	#16	Reserved			
#18	#17	Set position (I), P(I)	0 ~ ±999,999,999 *❷	0	R / W
#20	#19	Operating speed (I), V(I)	10 PPS ~ 100 kPPS	10 PPS	R / W
#22	#21	Set position (II), P(II)	0 ~ ±999,999,999 *❷	0	R / W
#24	#23	Operating speed (II), V(II)	10 PPS ~ 100 kPPS	10 PPS	R / W
#25 *❸		Operating command	b0 ~ b12	H0000	R / W
#27	#26	Current position CP, Automatic writing	-2,147,483,648 ~ +2,147,483,647		R / W
-	#28	VB-1PG status information	b0 ~ b8 display operating status		R
-	#29	Error code	See Section 4-6		R
-	#30	Model code	VB-1PG : 105		R
-	#31	Version code			R

*❶ Command unit can be selected: μm/R, mdeg/R or 10^{-4} inch/R.

*❷ Unit is PLS, μm, mdeg or 10^{-4} inch, depending on the unit setting in the BFM #3 b1 and b0.

*❸ Only one bit among the BFM #25 b6 ~ b4 or b12 ~ b8 can be turned ON. If two or more bits among them are turned ON, no operation is performed.

*❹ When the power of the VB-1PG is turned OFF, the data in BFM will be cleared. When the power of the VB-1PG is turned ON, the default values are entered to the BFMs.

*❺ When each BFM is read or written, 16-bit data shall be read/written in the unit of 16 bits FROM/TO instruction; 32-bit data shall be read/written in the unit of 32 bits DFROM/DTO instruction.

4-2 System of Units, Parameter Setting and Speed, Position Data

[BFM #0] Pulse rate

A= 1 ~ 32,767 PLS/R
This is the number of input pulses required by the amplifier to rotate the motor by one revolution. It is not the number of encoder pulses per revolution of the motor. (The pulse rate becomes a different value in accordance with the electronic gear ratio.)
The BFM#0 is not required to be set when the system of units described later is selected to motor system (BFM#3 b1=0, b2=0).

[BFMs #2 and #1] Feed rate

B1 (distance specification) = 1 ~ 999,999 μm/R
B2 (angle specification) = 1 ~ 999,999 mdeg/R
B3 (distance specification) = 1 ~ 999,999 $\times 10^{-4}$ inch/R
This is the machine travel B while the motor rotates by one revolution. Set either one among B1, B2 and B3 in accordance with the unit among μm/R, mdeg/R and 10^{-4} inch/R suitable to the application.
The BFMs #2 and #1 are not required to be set when the motor system of units described later is selected to motor system (BFM#3 b1=0, b2=0).

[BFM #3] Parameters (b0 ~ b15)

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Stop input mode	Stop input polarity	Count start point	Polarity of the DOG input	0	Home position return direction	Rotation direction	Pulse format	0	0	Multi-plication of position data		0	0	Unit system	

Write hexadecimal H0000 in BFM #3 in accordance with the 0 and 1 status of each bit.

Set bits 0 ~ 15 as follows: (Please set the b2, b3, b6, b7 and b11 to 0.)

(1) System of units (b1, b0)

b1	b0	System of units	Remarks
0	0	Motor system	For positions and speeds their units are based on pulses.
0	1	Machine system	For positions and speeds their units are based on lengths and angles.
1	0	Combined system	For positions their units are based on lengths and angles; For speeds their units are based on pulses.
1	1		

The table below shows the units for position and speed (B1, B2, and B3) in accordance with the setting of the BFMs #2 and #1 (feed rate).

	Selection of feed rate	Motor system	Combined system	Machine system
Position data *❶	B1	PLS	μm	
	B2	PLS	mdeg	
	B3	PLS	10^{-4} inch	
Speed data *❷	B1	PLS / sec.		cm / min.
	B2	PLS / sec.		10deg / min.
	B3	PLS / sec.		inch / min.

*❶ Position data is related to: HP, P(I), P(II), CP
*❷ Speed data is related to: Vmax, Vbia, Vjog, Vrt, Vcr, V(I), V(II)

(2) Multiplication of position data (b5, b4)

b5	b4	Multiplication
0	0	10^0
0	1	10^1
1	0	10^2
1	1	10^3

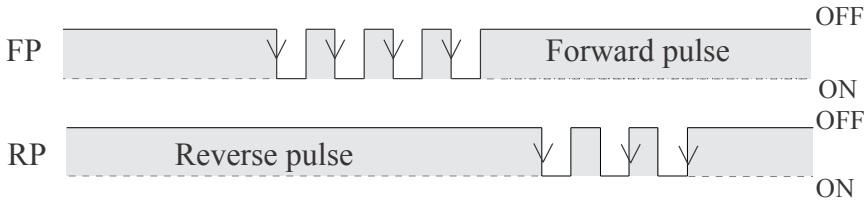
The position data HP, P(I), P(II) and CP will be multiplied by the value shown in the table on the left.

Example: When the value of the set position P(I) (BFMs #18 and #17) is 123 and the BFM#3 (b5, b4) is (1, 1), the actual position (or travel) becomes as follows:

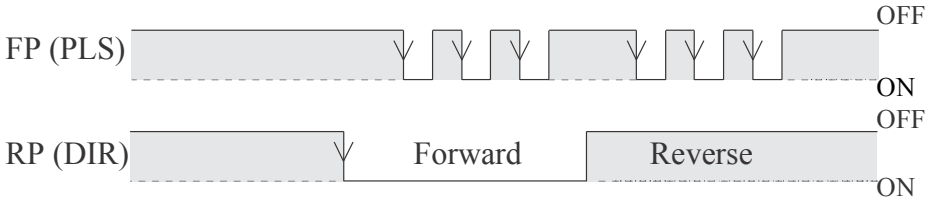
Motor system of units	123×10^3 = 123,000 (pulses)
Machine system of units Combined system of units	123×10^3 = 123,000 (μm, mdeg, 10^{-4}inch) = 123 (mm,deg, 10^{-1} inch)

(3) Pulse output format (b8)

When b8 = 0 : Forward pulse (FP) and reverse pulse(RP)



When b8 = 1 : Pulse (PLS) with direction (DIR)



(4) Rotation direction (b9)

When b9 = 0: The current position (CP) value increases with a forward pulse (FP).
When b9 = 1: The current position (CP) value decreases with a forward pulse (FP).

(5) Home position return direction (b10)

When b10 = 0: The current position (CP) value decreases during return to the home position.
When b10 = 1: The current position (CP) value increases during return to the home position.

(6) DOG input polarity (b12)

When b12 = 0: The DOG (near point signal) input is turned ON when the workpiece is coming near the home position.
When b12 = 1: The DOG (near point signal) input is turned OFF when the workpiece is coming near the home position.

(7) Count start point (b13)

This bit specifies the point at which counting of zero point signals is started.
When b13 = 0: Counting of zero point signals is started when the DOG input is given (when DOG input is turned ON if b12 = 0; otherwise when DOG input is turned OFF if b12 = 1).
When b13 = 1: Counting of zero point signals is started when the DOG input is given once, then stopped.

(8) STOP input polarity (b14)

When b14 = 0: The operation is stopped when the input is turned ON (OFF during operation).
When b14 = 1: The operation is stopped when the input is turned OFF (ON during operation).

(9) STOP input mode (b15)

When b15 = 0: The operation is interrupted when the STOP command is given (from the VB-1PG or the PLC) during operation, then the operation for the remaining distance is restarted when the restart command is given.
The JOG drive begins again when the STOP command is turned OFF from turning ON when the JOG command has been turned ON.

* However, if any BFM (except #25) is rewritten while operation is interrupted by the stop command, the operation for the remaining distance will not be performed. Write the BFMs by pulse operation (except the BFM #25).

When b15 = 1: The operation for the remaining distance is not performed, but the next positioning is performed.
The JOG drive begins again when the STOP command is turned OFF from turning ON when the JOG command has been turned ON.

[BFMs #5 and #4] Maximum speed Vmax

Motor system and combined system: 10 PPS ~ 100 kPPS ; Machine system: 1 ~ 153,000
This is the maximum speed. Make sure that the bias speed Vbia (BFM #6), the JOG speed Vjog (BFMs #7 and #8), the home position return speed Vrt (BFMs #9 and #10), the creep speed Vcr (BFM #11), the operating speed V(I) (BFMs #19 and #20) and the operating speed V(II) (BFMs #23 and #24) are set respectively to a value equivalent to or less than the maximum speed.
The degree of acceleration/deceleration is determined by this maximum speed, the bias speed Vbia (BFM #6) and the acceleration/deceleration time Ta (BFM #15).

[BFM #6] Bias speed Vbia

Motor system and combined system: 0 ~ 10 kPPS ; Machine system: 0 ~ 15,300
This is the bias speed at time of start.
When the VB-1PG and the stepper motor are used together, set a value while taking the resonance area and the self-start frequency of the stepper motor into account.

[BFMs #8 and #7] JOG speed Vjog

Motor system and combined system: 0 ~ 100 kPPS ; Machine system: 1 ~ 153,000
This is the speed for manual forward/reverse (JOG+/JOG-).
Set a value between the bias speed Vbia and the maximum speed Vmax.

[BFMs #10 and #9] Home position return speed (high speed) Vrt

Motor system and combined system: 0 ~ 100 kPPS ; Machine system: 1 ~ 153,000
This is the speed (high speed) for returning to the machine home position.
Set a value between the bias speed Vbia and the maximum speed Vmax.

[BFM #11] Home position return speed (creep) Vcr

Motor system and combined system: 0 ~ 10 kPPS ; Machine system: 1 ~ 15,300
This is the speed (extremely slow speed) after the near point signal (DOG) for returning to the machine home position.
It is the speed immediately before stopping in the machine home position. It is recommended to set it as slow as possible so that the precision of the home position becomes better.

[BFM #12] Number of zero point signals for home position return N

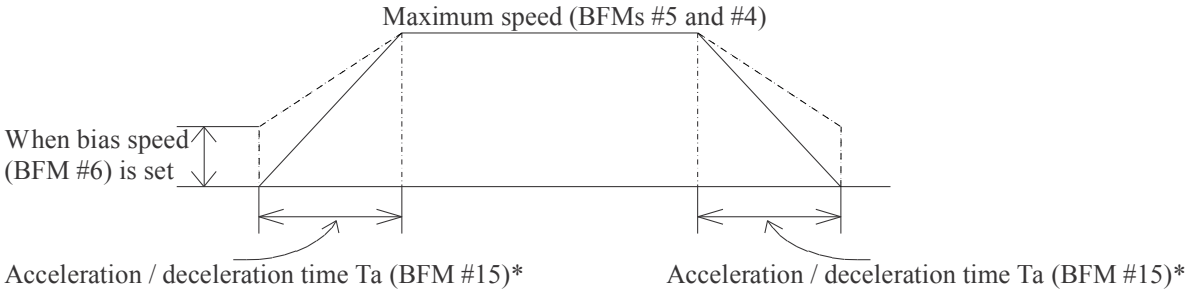
0 ~ 32,767 PLS
This is the number of zero point signals counted for returning to the machine home position.
When the zero point signal is not used and the machine should be stopped immediately by only the DOG input, set the BFM #12 to 0. However, pay rigid attention so that the machine is not damaged when it is immediately stopped from high-speed operation.

[BFMs #14 and #13] Home position HP

Motor system: 0 ~ 999,999 PLS ; Machine system and combined system: 0 ~ 999,999
This is the home position used for returning to the machine home position.
When the home position return operation is completed, the value set here is written to the current position (BFMs #26 and #27).

[BFM #15] Acceleration/deceleration time Ta

50 ~ 5,000 ms
This is the time between the bias speed (BFM #6) and the maximum speed (BFMs #5 and #4).
The degree of acceleration/deceleration is determined by the maximum speed, the bias speed and the acceleration/deceleration time.



* They can not be set separately. Same value is used.

[BFMs #18 and #17] Set position (I) P(I)

Motor system: 0 ~ ±999,999,999 PLS ;
Machine system and combined system: 0 ~ ± 999,999,999
This is the target position or the travel distance for operation.
When the absolute position is used, the rotation direction is determined in accordance with the absolute value of the set position based on the current position (BFMs #26 and #27).
When the relative position is used, the rotation direction is determined by the sign of the set position.

[BFMs #20 and #19] Operating speed (I) V(I)

Motor system and combined system: 10 ~ 100 kPPS ; Machine system: 1 ~ 153,000
This is the actual operating speed within the range between the bias speed Vbia and the maximum speed Vmax.
In variable speed operation and external command positioning operation, forward rotation or reverse rotation is performed in accordance with the sign (positive or negative) of this set speed.

[BFMs #22 and #21] Set position (II) P(II)

Motor system: 0 ~ ±999,999,999 PLS ;
Machine system and combined system: 0 ~ ± 999,999,999
This is the set position for the second speed in two-speed positioning operation.

[BFMs #24 and #23] Operating speed (II) V(II)

Motor system and combined system: 10 ~ 100 kPPS ; Machine system: 1 ~ 153,000
This is the second operating speed in two-speed positioning operation within the range between the bias speed Vbia and the maximum speed Vmax.

[BFMs #27 and #26] Current position CP

Motor system: -2,147,483,648 ~ +2,147,483,647 PPS ;
Machine system and combined system: -2,147,483,648 ~ +2,147,483,647
The current position data is automatically written here. When the value set here is read by the PLC for monitoring, make sure to read it in the unit of 32 bits.

<< Conversion of system of units >>

The following relationship is present between the motor system of units and the machine system of units. They are automatically converted each other.

$$\boxed{\begin{array}{l}\text{Speed command}\\ \text{cm/min, 10deg/min, inch/min}\end{array}} \times \frac{A \times 10^4}{B1,\ B2 \text{ or } B3} = \text{Speed command (PPS) x 60}$$

A indicates the pulse rate. B1 to B3 indicate the feed rate. PPS indicates the pulses per second. When setting the speed data using the machine system of units, make sure that the value converted into pulses is within the range determined for the motor system and the combined system (PPS).

<< Stepwise speed command value >>

The frequency f of the pulse generated in the VB-1PG is stepwise as follows.

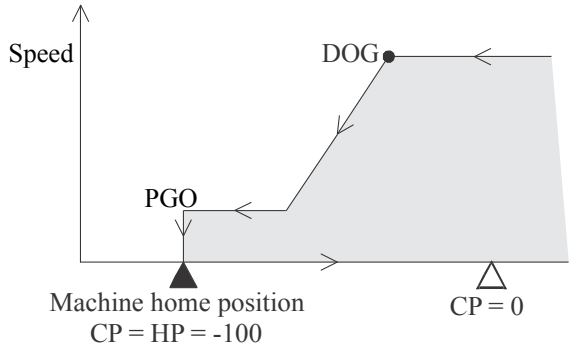
$$f = \frac{1}{0.25\ n} \times 10^6 = 10 \sim 100{,}000 \text{ PPS}$$

Where, n: Integer in range of 40 ~ 400,000
For example, in the case of n = 40, f = 100,000 PPS;
in the case of n = 41, f = 97,560 PPS
Any pulse whose frequency is between the two values above cannot be generated.

4-3 Position Data, Home Position and Current Position

- The position data includes the following:
  HP: Home position; P(I): Set position (I); P(II): Set position (II); CP: Current position

- When the operation of returning to the machine home position is completed, the home position HP (BFMs #14 and #13) value is automatically written to the current position CP (BFMs #27 and #26). The figure below shows the CP value when the home position HP is -100.



  - The current position (CP) value increases or decreases in accordance with the forward/reverse pulse.
  - When the CP = 0, this position is the Machine home position.
  - If the CP = HP = 0, the Machine home position and Electrical Origin position are equal.

- The set positions P(I) and P(II) can be treated as absolute positions (distance from the current position CP = 0) or relative positions (travel from the current stop position) as described later.

<< Error in command between the machine system of units and the combined system of units>>

1. When the pulse rate of the BFM #0 (#2, #1) is supposed the pulse rate as A, the feed rate as B and the relative travel distance as C, then the value "C × (A/B)" indicates the pulse quantity which should be generated by the VB-1PG.
2. Even if the value "(A/B)" is not an integer, error is not generated in the command if the value "C × (A/B)" is an integer.
3. However, if the value "C × (A/B)" is not an integer, accumulated error is generated in the current position when relative movement is repeated.
   When the absolute position is used for operation, an error less than 1 pulse may be generated by counting fractions over 1/2 as one and disregarding the rest, but accumulated error is not generated.
4. When the motor system of units is used, such an accumulated error is not generated.

4-4 Operation Command [BFM #25]

Operation command is in the BFM #25 b0 ~ b12. (total 13 bits parameters)
After data is written to the BFMs #0 ~ #24, write the BFM #25 (b0 ~ b12) as follows.

[b0] When b0 = 1: Error reset
The error flag (BFM #28 b7) described later is reset. When the error occurs, the positioning completion signal (BFM #28 b8) is reset.

[b1] When b1 = 0 → 1: Stop
This bit functions in the same way with the STOP input in the VB-1PG, but the stop operation can be performed from the sequence program in the PLC.
However, if this bit is changed from 0 to 1 before the STOP input is given in the VB-1PG in the external command positioning mode, the machine is decelerated and stopped.

[b2] When b2 = 1: Forward pulse stop
The forward pulse is immediate stopped in the forward limit position.

[b3] When b3 = 1: Reverse pulse stop
The reverse pulse is immediate stopped in the reverse limit position.

[b4] When b4 = 1: JOG+ operation
When b4 continues to be 1 for < 300 ms, one forward/reverse pulse is generated.
When b4 continues to be 1 for ≥ 300 ms, continuous forward/reverse pulses are generated.
(BFM #3 b9=0: forward pulses; BFM #3 b9=1: reverse pulses)

[b5] When b5 = 1: JOG- operation
When b5 continues to be 1 for < 300 ms, one reverse/forward pulse is generated.
When b5 continues to be 1 for ≥ 300 ms, continuous reverse/forward pulses are generated.
(BFM #3 b9=0: reverse pulses; BFM #3 b9=1: forward pulses)

[b6] When b6 = 0 → 1: Home position return start
The machine starts to return to the home position, and is stopped at the machine home position when the DOG input (near point signal)or the PGO (zero point signal) is given.

[b7] When b7 = 0: Absolute position / When b7 = 1: Relative position
The relative or absolute position is specified in accordance with the b7 status (1 or 0).
(This bit is valid while operation is performed using b8, b9 or b10.)

[b8] When b8 = 0 → 1: Single-speed positioning operation start
Single-speed positioning operation is performed. For the details, see Section 5-3.

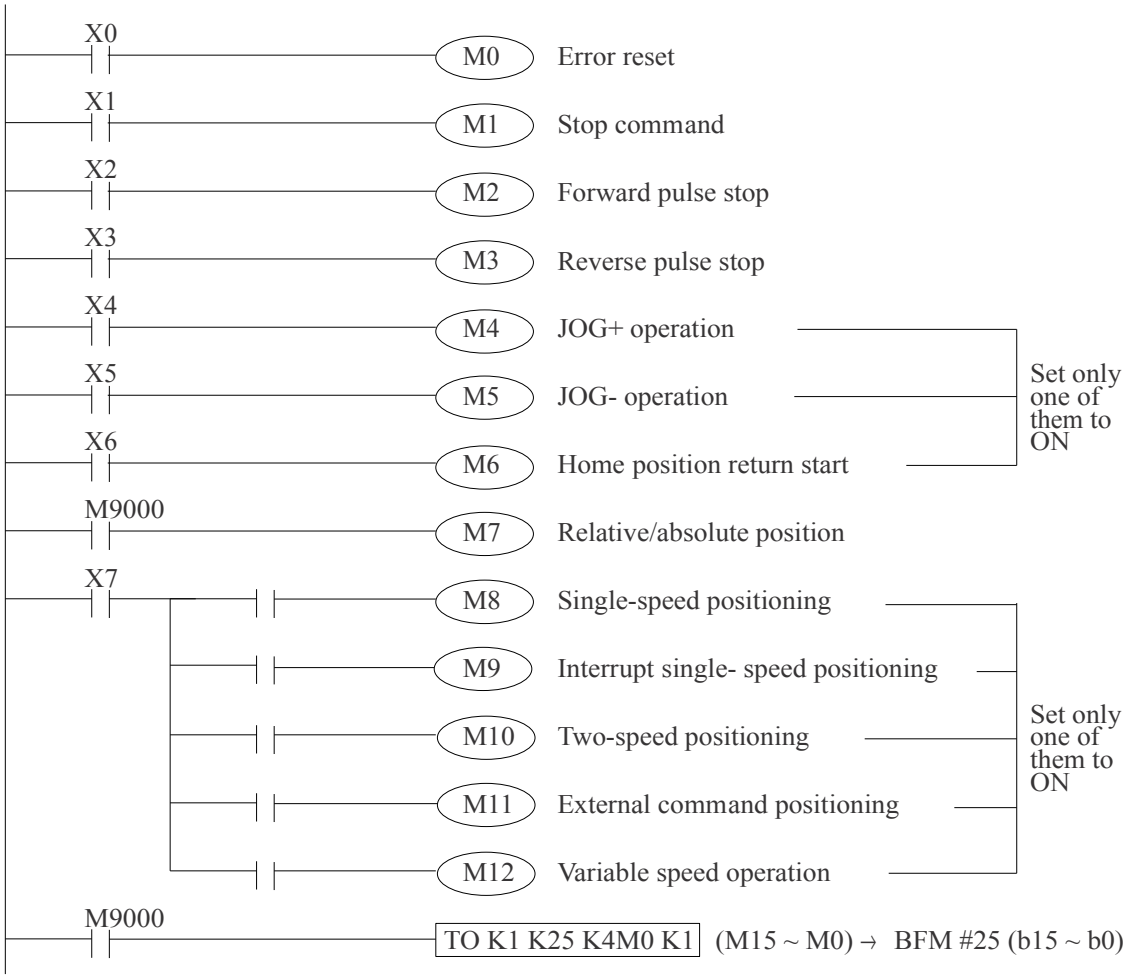
[b9] When b9 = 0 → 1: Interrupt single-speed positioning operation start
Interrupt single-speed positioning operation is performed. For the details, see Section 5-3.

[b10] When b10 = 0 → 1: Two-speed positioning operation start
Two-speed positioning operation is performed. For the details, see Section 5-5.

[b11] When b11 = 0 → 1: External command positioning operation start
External command positioning operation is performed. The rotation direction is determined by the sign of the speed command. For the details, see Section 5-6.

[b12] When b12 = 1: Variable speed operation
Variable speed operation is performed. For the details, see Section 5-7.

<< Operation command data transfer method example >>



- Error can be reset (M0) by forcedly turning ON/OFF the peripheral unit. The input X0 does not have to be used.
  When the data on absence/presence of error and the error code should be saved even after power interrupt, use the latched auxiliary relays or latched data registers to back up the code.
- The STOP command is generally provided in the VB-1PG, and is also output from the sequence program in the PLC. In such a case, the input X1 is not required.
- In operation which does not require returning to the home position such as inching operation with a constant feed rate, the input X6 is not required.
- When which one between the relative and absolute positions should be used is always determined, drive the M7 using the M9000 to always ON or the M9001 to always OFF.
- Drive one and only one of the M8 ~ M12 using the M9000. If two or more of them are turned ON, operation is disabled and the ERR indicator will flash.
- As the general start command, create an appropriate sequence using the input X7 to drive the M8 ~ M12. (See Section 7-2)
- The time after the VB-1PG receives the start command until it generates a pulse is approximately 10 mS usually. However, 500 mS maximum is required for the first operation after the PLC starts running or for the first operation after the BFM #0, #1, #2, #3, #4, #5, #6 or #15 is written.
- In the example above, the TO instruction is a write instruction from the PLC to the BFM. The VB-1PG is connected as a special module in the nearest position (K1) to the Main Unit. Picks up the status of M0 ~ M15 (K4M0) and writes into the BFM #25 of VB-1PG. The number of transfer sets is in the last (K1 means there is only one set data will be process).
- The start bit for the operation mode cannot be set to OFF inside the VB-1PG, so operation from the second time and later cannot be performed.

4-5 Status [BFM #28]

The status information to notify the PLC of the VB-1PG status is automatically saved in the BFM #28. Read it into the PLC using the FROM instruction.

[BFM #28] Status information (b0 to b8)

[b0] When b0 = 0: BUSY;
When b0 = 1: READY
This bit is set to BUSY while the VB-1PG is generating pulses.

[b1] When b1 = 0: Reverse rotation;
When b1 = 1: Forward rotation
This bit is set to 1 when operation is started with forward pulse.

[b2] When b2 = 0: Home position return unexecuted;
When b2 = 1: Home position return completed
When returning to the home position is completed, b2 is set to 1, and continues to be 1 until the power is turned OFF. To reset b2, use the program. Connect b2 in series to the start command.

[b3] When b3 = 0: STOP input OFF;
When b3 = 1: STOP input ON

[b4] When b4 = 0: DOG input OFF;
When b4 = 1: DOG input ON

[b5] When b5 = 0: PGO input OFF;
When b5 = 1: PGO input ON
Any of them represents the ON/OFF status of the VB-1PG input as it is.

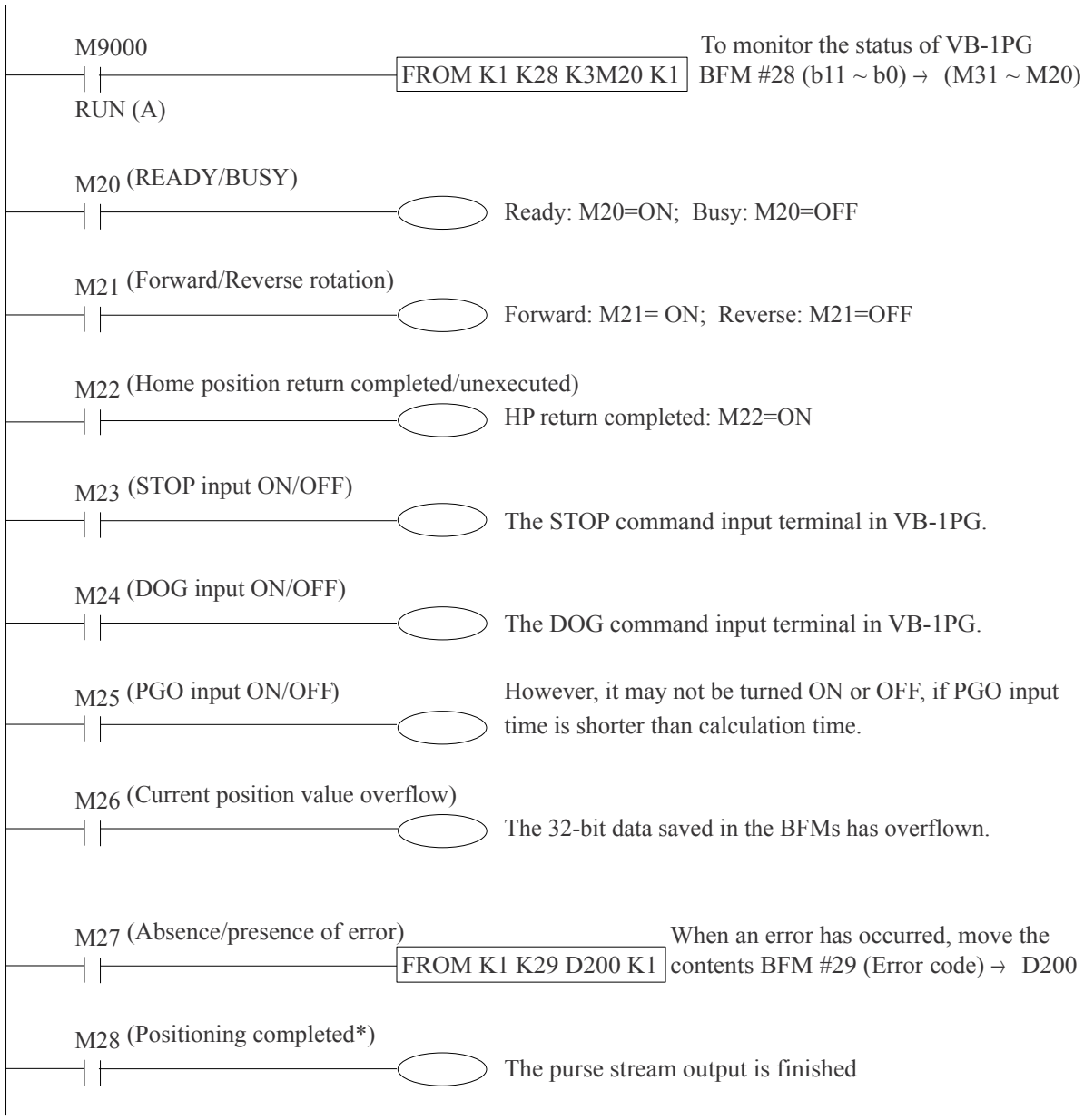
[b6] When b6 = 1: Current position value overflow
The 32-bit data saved in the BFMs (#27 and #26) has overflown. This bit is reset when returning to the home position is completed or the power is turned Off.

[b7] When b7 = 1: Error flag
b7 becomes 1 when an error has occurred in the VB-1PG, and the contents of the error are saved in the BFM #29.
This error flag is reset when the BFM #25 b0 becomes 1 or the power is turned OFF.

[b8] When b8 = 0: Positioning started;
When b8 = 1: Positioning completed
b8 is cleared when positioning is started home position return start, or error reset (only when error occurs), and set when positioning is completed. b8 is also set when returning to the home position is completed.

- Various start commands are accepted exclusively while the BFM #28 b0 is set to 1 (READY).
- Various data is also accepted exclusively while the BFM #28 b0 is set to 1 (READY). However, the BFM #25 b1 (stop command), the BFM #25 b2 (forward pulse stop) and the BFM #25 b3 (reverse pulse stop) are accepted even while the BFM #28 b0 is set to 0 (BUSY).
- The data can be read from the VB-1PG to the PLC without regard to the setting of the BFM #28 b0.
- The current position is changed accompanied by generation of pulses even while the BFM #28 b0 is set to 0 (BUSY).

<< Reading of status information >>



* When a drive amplifier for a stepper motor without the positioning completed output is used, this signal can be used for recognition of positioning completed and the next operation can be started.

4-6 Error Code [BFM #29]

The following error code numbers are saved in the BFM #29. Read and check it when the BFM #28 b7 is set to 1 (Error present).

OO1: Large/small relationship is incorrect. (Vmax < Vbia or Vrt < Vcr)
(OO indicates the lower word No. of the related BFM.)

OO2: Setting is not performed yet. (V(I), P(I), V(II) or P(II))
However, V(II) and P(II) should be set exclusively in two-speed operation or external command operation.
(OO indicates the corresponding BFM No. For example, "172" indicates that the BFMs #18 and #17 are set to 0.)

OO3: Setting range is incorrect.
(OO indicates the corresponding BFM No. For example, "043" indicates that the BFMs #5 and #4 are set to a value outside the range of 10 PPS~ 100 kPPS.)

OO4: Illegal operation mode.
(OO indicates the lower word No. of the related BFM. For example, "254" indicates that the status of operation command BFM #25 is incorrect.)

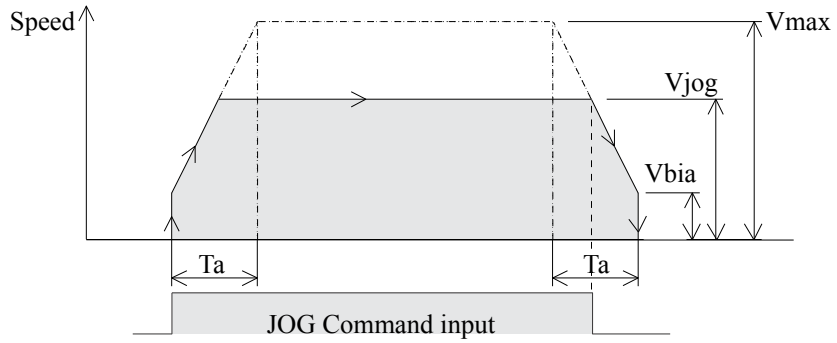
- When a speed command specifies a value equivalent to or more than Vmax or a value equivalent to or less than Vbia, error does not occur. Vmax or Vbia is used for operation.
- Though the ready status can be specified even while an error is present, the start command is not accepted.

5. Outline of Operation Modes

Seven operation modes are available in the VB-1PG in accordance with the start command type. The data on speed and position should be transferred preliminarily from the PLC to the buffer memories (BFMs) of the VB-1PG. The transfer data addresses are BFMs #0 to #25 which are allocated as described in Chapter 4.

5-1 JOG Operation

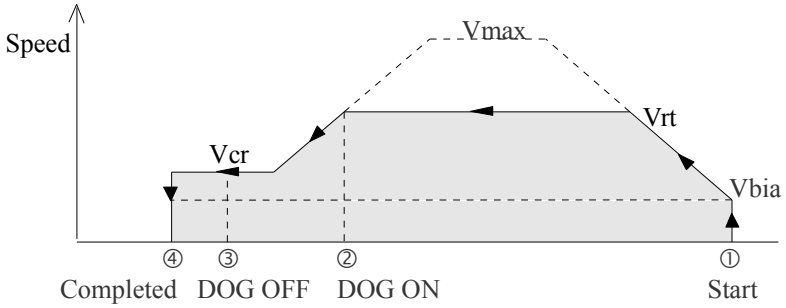
While the forward or reverse button is pressed and held, the motor is driven forward or in reverse.



Any value between the bias speed Vbia (BFM #6) and the maximum speed Vmax (BFMs #5 and #4) is valid as the command speed Vjog (BFMs #8 and #7). The acceleration / deceleration time Ta (BFM #15) is the time between Vbia and Vmax.
Vmax, Vbia and Ta are equivalent in the operation modes described later.

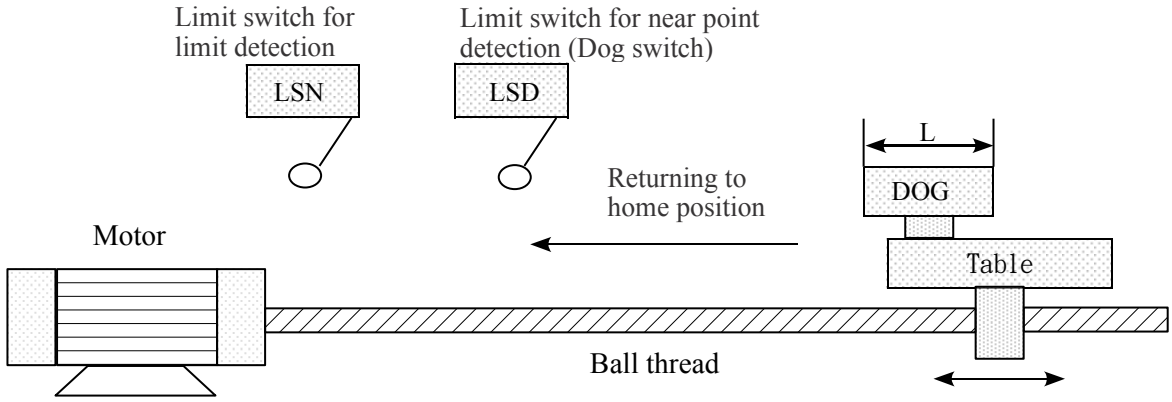
5-2 Machine Home Position Return Operation

When the home position start command is received, the motor makes the machine return to the home position.
When returning to the home position is completed, the home position HP (BFMs #14 and #13) value is written to the current position CP (BFMs #27 and #26).
Position ④ in the figure below indicates the machine home position.

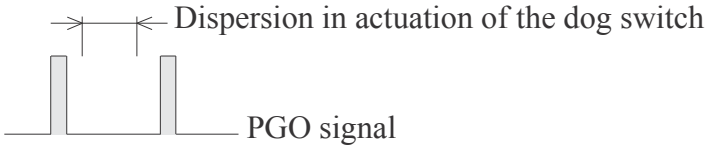


① When the home position return start command is changed from OFF to ON, the home position return operation is started at the speed VRT (BFMs #10 and #9).
② When the near point signal DOG input is turned ON, the motor decelerates to the creep speed Vcr (BFM #11).
③ When the near point signal DOG input is changed from ON to OFF and the motor zero point signal PGO is received (There is setting by BFM #3 b13), the motor is immediately stopped in the position. The value of the home position address is written in the home position value by generating a clear signal.

< <DOG switch for returning to home position >>

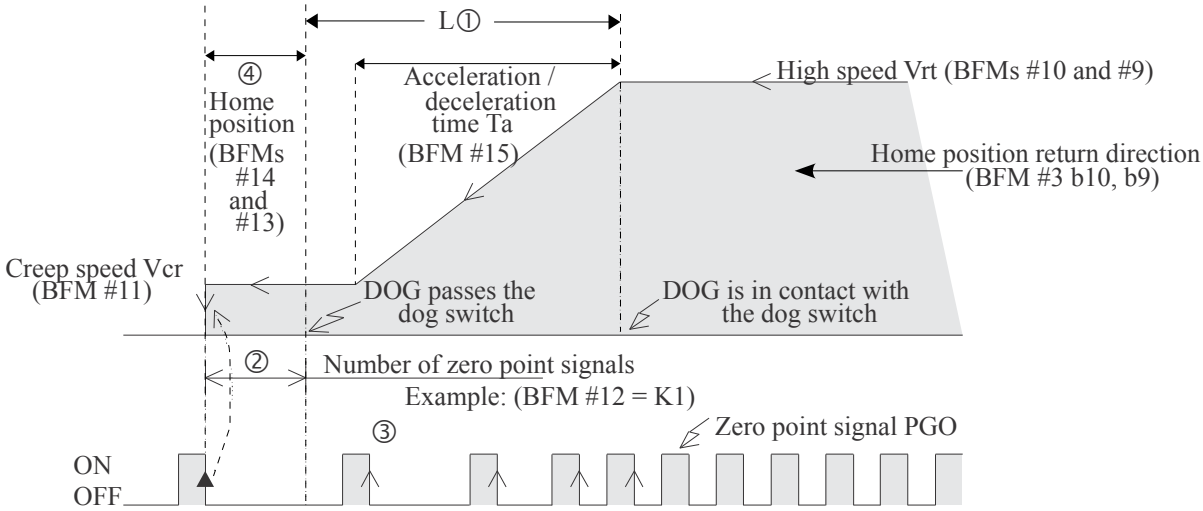


- A dog whose length is L is fixed to a table driven in the left and right direction by a servo motor via a ball thread.
- When the table moves in the home position return direction, the dog is in contact with the limit switch (LSD) for near point detection, and the LSD is actuated.
- The LSD is turned ON from OFF when the BFM #3 b12 is set to 0, and turned OFF from ON when the BFM #3 b12 is set to 1.
- The home position return direction is determined by the BFM #3 b9 (rotation direction) and b10 (home position return direction).
- The limit switch LSD is often referred to as dog switch. The actuation point of the dog switch is rather dispersed.
- It is not always actuated at one same point, which will affect the repeatability of the home position return operation.
  On the other hand, the servo amplifier outputs one zero point signal PGO (Z phase signal 0P) for each revolution of the servo motor.
  For example, if the table is moved by 1 mm per revolution of the servo motor, one PGO signal is output for every 1 mm movement of the table.
- If the dog switch is adjusted so that it is actuated within the interval between two PGO signals and the PGO signal is used for returning to the home position, dispersion in actuation of the dog switch can be neglected. The repeatability of the home position return operation is assured.



<< Overshoot detection home return positioning method >>

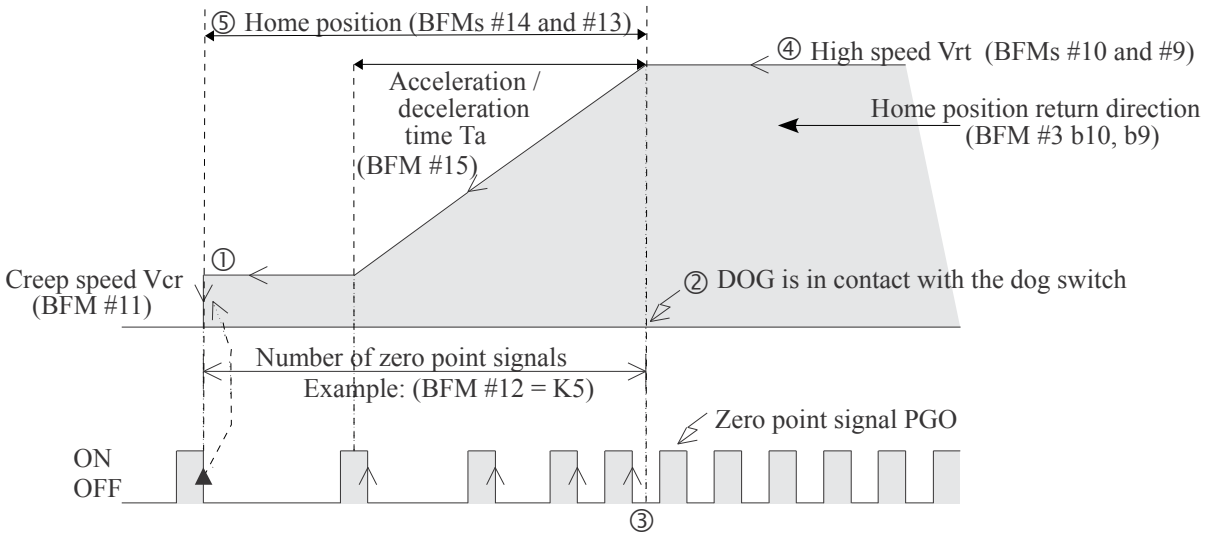
- With this method, the motor starts deceleration when the dog is in contact with the dog switch, and the motor is stopped immediately when one (or several) zero point signal PGO is received after the dog has passed the dog switch. (BFM #3 b13 = 1)



① With this method, the length L of the dog is required to be determined so that deceleration is completed until the dog has passed the dog switch.
② Dispersion in the point at which the dog switch becomes unactuated while the dog is passing the dog switch is required to be adjusted so that the dog switch is actuated within the interval between two PGO signals at any time.
(The actuation start point is not required to be adjusted.)
③ BFM #12 determines how many zero point signals PGO should be counted after the dog has passed the dog switch. With this method, set the BFM #12 always to 1 so that the motor is stopped at the first zero point signal PGO.
④ When the operation is stopped, the deviation counter clear signal CLR of the servo amplifier is output. The home position (BFMs #14 and #13) value is transferred to the current position (BFMs #27 and #26), and the home position return completed flag (BFM #28 b2) is set to 1.

- It may be required to perform a home return operation after the dog has passed the dog switch. In such a case, the dog should be preliminarily moved back to a position before the dog switch by the jog operation before the home position return operation is performed again.
This procedure may be automatically performed when the limit switches for detecting the forward and reverse limits are connected to the PLC.

<< Undershoot detection home return positioning method >>

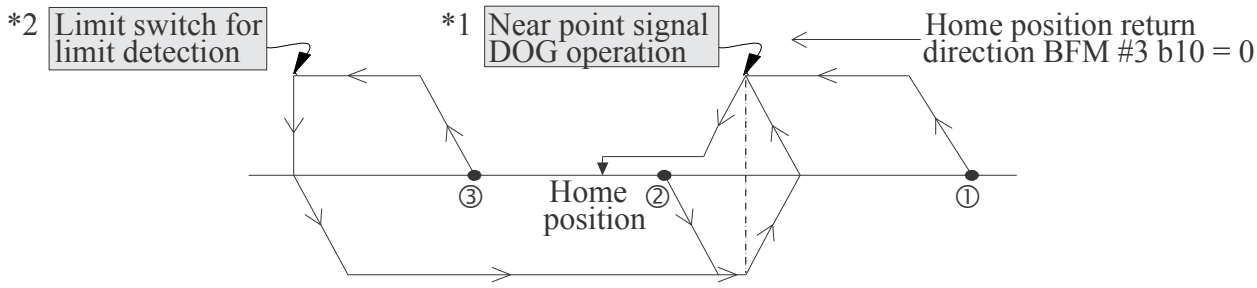


- With this method, the motor starts deceleration when the dog is in contact with the dog switch, and the motor is stopped immediately when the specified number of zero point signals PGO are received and the speed becomes sufficiently slow. (BFM #3 b13 = 0)

① With this method, the number of zero point signals is required to be set so that deceleration is completed before the stop point.
② Set the length L of the dog long enough so that the dog switch continues to be actuated even when the dog is at the stop point. This allows the dog automatically go back and reproach the dog switch before the home position return operation is performed again consecutively.
But even if the dog is short, when the limit switches for detecting the forward and reverse limits are connected to the PLC, the dog switch can automatically go back using these limit switches.
③ Dispersion in the point at which the dog starts to be in contact with the dog switch is required to be adjusted so that the dog switch is actuated within the interval between two PGO signals at any time.
④ Set the home position return speed Vrt as small a value as possible because there may be a response lag with the dog switch.
It is recommended to set a Vcr value small enough compared with the Vrt value so that the stop precision is improved.
⑤ When the operation is stopped, the error counter clear signal CLR of the servo amplifier is output. The home position (BFMs #14 and #13) value is transferred to the current position (BFMs #27 and #26), and the home position return completed flag (BFM #28 b2) is set to 1.

<< Home position return operation >>

- The home position return operation varies depending on the start position.



① The near point signal is turned OFF (before the DOG passes).
② The near point signal is turned ON.
③ The near point signal is turned OFF (after the DOG has passed).

For this operation, the limit switches for detecting the forward limit and the reverse limit should be provided on the PLC.
When the limit switch for limit detection is actuated, the home position return operation is not performed even if the home position return operation is started. Move the dog by performing the JOG operation so that the limit switch for limit detection is not actuated, then start the home position return operation.

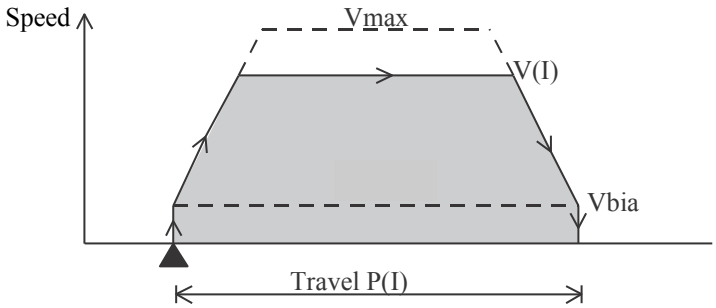
*1 The example above shows the case where the BFM #3 b12 is set to 0 (DOG input polarity OFF → ON).
*2 When the limit switch for limit detection is turned ON, the pulse output is immediately stopped (BFM #25 b3: ON). At this time, the clear signal is also output.

<< When the stepper motor is used >>

When the stepper motor is used, rigid attention should be paid to the following items.
① If the motor capacity is not sufficient compared with the load torque, the motor may stall. In such a case, even if the specified quantity of pulses are supplied t the motor, the expected drive quantity may not be obtained.
② Start and stop the motor slowly enough (by setting a long acceleration/deceleration time to the BFM #15) so that the acceleration/deceleration torque does not become excessive.
③ A resonance point is present in low speed operation. It is recommended to avoid this point. Set the bias speed (BFM #6), and do not perform operation at a speed slower than that.
④ An external power supply may be required for signal communication with the drive amplifier.

5-3 Single-speed Positioning Operation

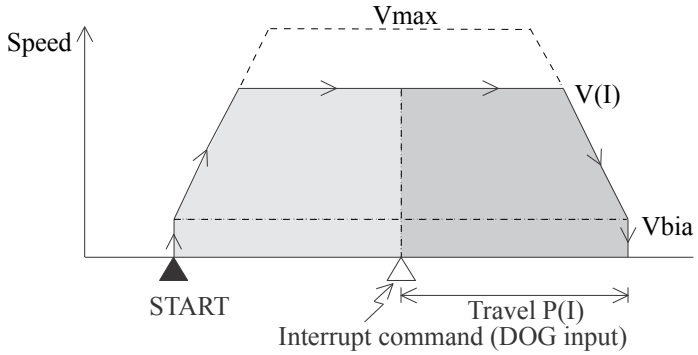
When the single-speed positioning operation command is received, the motor performs the following operation.



- When the start command is given, the motor accelerates up to the operating speed V(I) (BFMs #20 and #19), then decelerates and stops in the set position P(I) (BFMs #18 and #17).
- The absolute position from the point at which the current position CP becomes 0 (electric home position) or the relative position from the start position can be specified as the set position.
- When a servo motor is used, Vbia is generally set to 0.

5-4 Interrupt Single-speed Positioning Operation

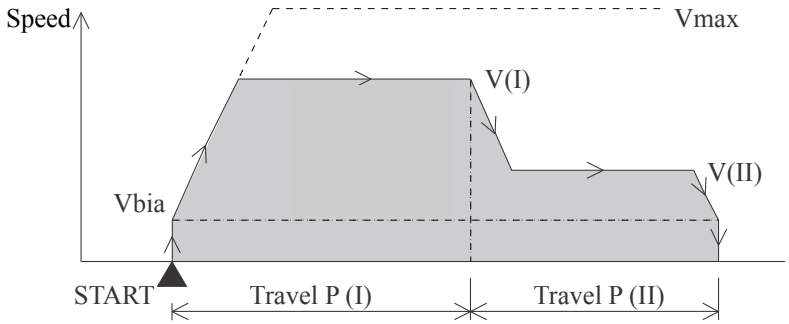
When the interrupt single-speed positioning operation command is received, the motor performs the following operation.



- The interrupt command is connected to the DOG input in the VB-1PG.
- When the START command is received, the motor starts operation. When the INTERRUPT input is received, the motor moves by the specified distance, then stops (The relative travel exclusively can be specified.)
- The current value is cleared by the start command. The current value starts to change by the INTERRUPT input, and becomes equivalent to the set position when the operation is completed.
- Rigid attention should be paid when operations using absolute position specification are performed also.
- The Interrupt command detects change in the input signal. (OFF→ON, ON→OFF)

5-5 Two-speed Positioning Operation

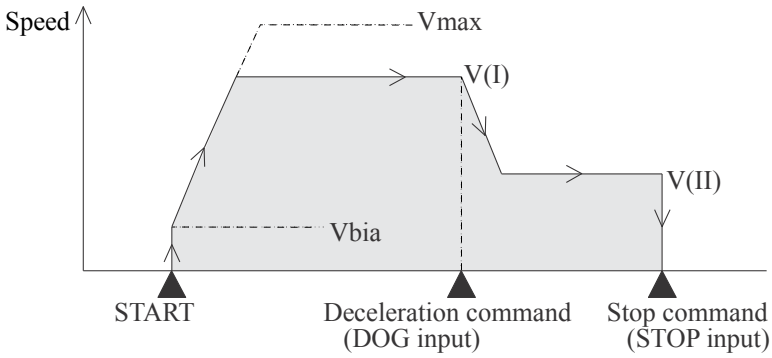
The motor performs the following operation by the two-speed positioning operation command. Approach at high speed as well as processing and moving forward at low speed can be performed.



- When the START command is received, the motor performs positioning at the operating speed V(I) (BFMs #20 and #19) until the set position P(I) (BFMs #18 and #17), then at the operating speed V(II) (BFMs #24 and #23) until the set position P(II) (BFMs #22 and #21) (two-step speed).

5-6 External Command Positioning Operation

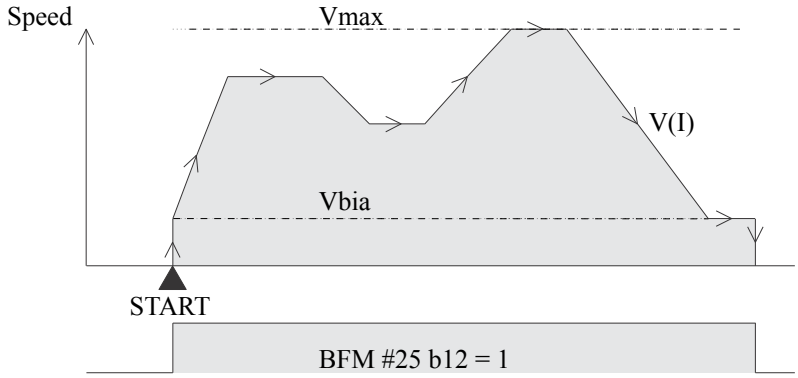
Commands for determining the deceleration start point and the stop point are given from the external limit switches. The VB-1PG does not control the pulse quantity, and positioning is performed by the two-step speed technique.



- When the start command is received, the motor performs positioning at the operating at the operating at the operating speed V(I) (BFMs #20 and #19) until the deceleration command is received. At that time, the motor decelerates to the operating speed V(II) (BFMs #24 and #23). When the stop command is received, pulse generation is stopped immediately.
- The rotation direction is determined by the sign (positive or negative) of the operating speed V(I).
- The deceleration command detects the change in the input signal. (OFF→ON, ON→OFF)
- The STOP command reads the state of the input signal level. (OFF or ON)
- The sign of operating speed V(II) is disregarded.

5-7 Variable Speed Operation

- When the operation command BFM #25 b12 is set to 1, the speed pulses specified in the BFMs (#20 and #19) are generated.
- This operating speed can be freely changed even while pulses are generated. However, because there is no cushion start/stop function, acceleration and deceleration must be controlled by the PLC.
- Only b0 (error reset) and b12 (variable speed operation) of the operation command BFM #25 are valid in this mode. Set b1 to b11 to 0.
  When b12 is set to 1, variable speed operation is performed.
  When b12 is set to 0, pulse output is stopped. (The pulse output does not stop even if "0" is written in BFM #20, #19.)
- As for the parameter BFM #3, only b1 and b0 (system of units) and b8 (pulse output format) are valid.
- The rotation direction (forward or reverse) can be specified by the sign (positive or negative) of the speed command (BFMs #20 and #19).



- Do according to the undermentioned procedure when you change the direction of the rotation.
  ① Turn OFF b12 of BFM #25.
  ② Change the value at drive speed (BFM #20, BFM #19).
  (The direction of the rotation is decided according to the sign)
  ③ Again, turn ON b12 of BFM #25.

5-8 Common Matter for Operation Modes

<< Handling the STOP command >>

In all operation modes, the stop command is valid at any time during operation. However, if a STOP command is received during a positioning operation, the motor decelerates and stops. And after restarting, the motor normally travels by the remaining distance and then stops. (The motor can be stopped and the operation can be completed without traveling the remaining distance. Refer to 4-2)

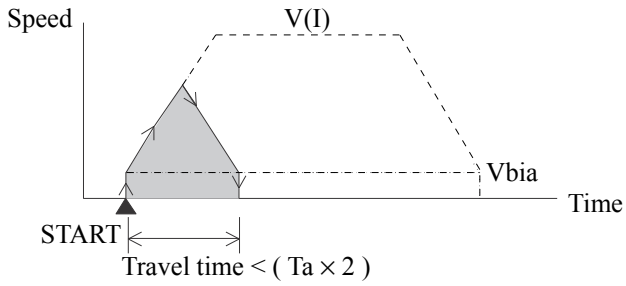
<< Duplicated specifications for various operation modes >>

When the bits which determine operation modes such as b4 ~ b6 and b8 ~ b12 are turned ON simultaneously in the operation command BFM #25, any operation is not executed.
If an other mode input is turned ON while operation is being performed in any mode, such an input is neglected.

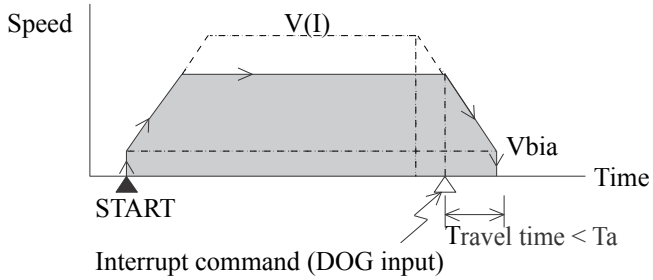
<< When travel time is small >>

When the travel time is small compared to the acceleration/deceleration time (Ta), the motor cannot realize specified speed.

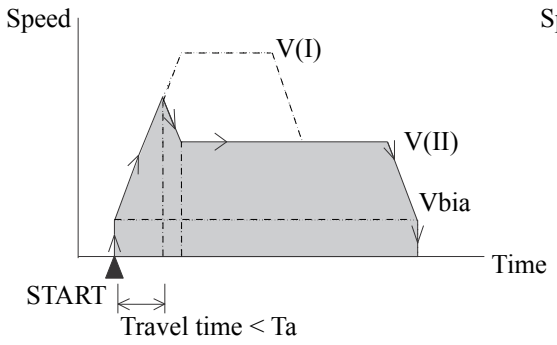
- Single-speed positioning operation

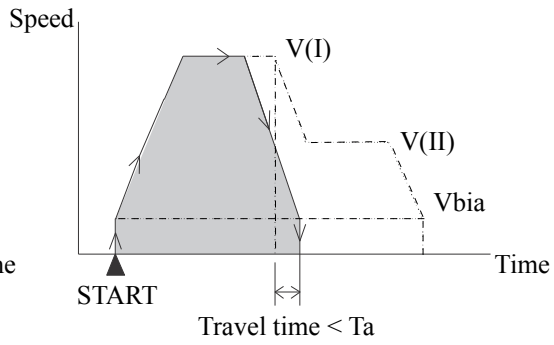


- Interrupt single operation

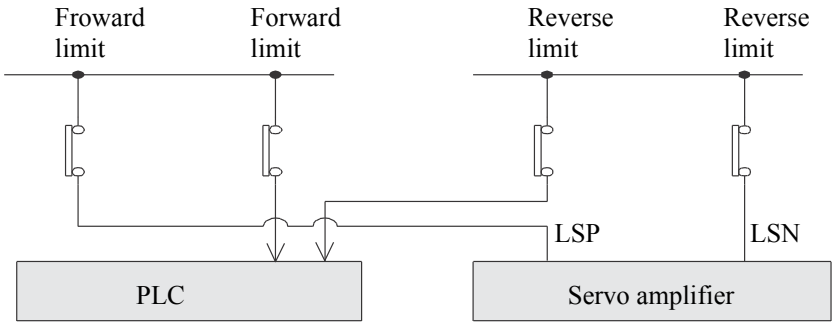


- Two-speed positioning operation





<<Connection of Limit Switches for Limit Detection>>



- To assure safety, provide limit switches for detecting the forward and reverse limits on the servo amplifier also.
  Make sure so that the limit switches on the PLC are actuated simultaneously with or a little earlier than the limit switches on the servo amplifier.
- Because a drive amplifier for a stepper motor does not have these terminals, make sure to provide limit switches on the PLC.
- When b2 and b3 of the BFM #25 are driven by these signals, pulse output is immediate stopped and the counter clear output CLR is generated.
- Evade from the state of the pulse output stop by Jog in the opposite direction when forward pulse stop (BFM #25 b2) or reverse pulse stop (BFM #25 b3) is turned ON.
- Because the counter clear output CLR is generated, the forward pulse stop and the reverse pulse stop cannot be used as a stop and home position.

5-9 Various Operation Modes and Buffer Memory Setting

O indicates the item required to be set.

BFM No.		Name	JOG	Home position return	Single -speed positioning	Interrupt single-speed positioning	Two -speed positioning	External command positioning	Variable
Higher bits	Lower bits								
—	#0	Pulse rate	Not required to be set for motor system of units (PLS and Hz). Required to be set for machine and combined systems of units.						
#2	#1	Feed rate							
—	#3	Parameter	O	O	O	O	O	O	O
#5	#4	Maximum speed	O	O	O	O	O	O	O
—	#6	Bias speed *1	O	O	O	O	O	O	O
#8	#7	JOG speed	O	—	—	—	—	—	—
#10	#9	Home position return speed (high speed)	—	O	—	—	—	—	—
—	#11	Hime position return speed (creep speed)	—	O	—	—	—	—	—
—	#12	Number of zero point signals for home position return	—	O	—	—	—	—	—
#14	#13	Home position	—	O	—	—	—	—	—
—	#15	Acceleration/deceleration time	O	O	O	O	O	O	—
—	#16	Reserved	—	—	—	—	—	—	—
#18	#17	Set position (I)	—	—	O	O	O	—	—
#20	#19	Operating position (I)	—	—	O	O	O	*3	*3
#22	#21	Set position (II)	—	—	—	—	O	—	—
#24	#23	Operating velocity (II)	—	—	—	—	O	O	—
—	#25	Operation command	O	O	O	O	O	O	O
#27	#26	Current position	*2	—	*2	*2	*2	—	—
—	#28	Status information	*2	*2	*2	*2	*2	*2	*2
—	#29	Error code	*2	*2	*2	*2	*2	*2	*2
—	#30	Model code	*2	*2	*2	*2	*2	*2	*2
—	#31	Reserved	*2	*2	*2	*2	*2	*2	*2

*1 When a servo motor is used, the initial value 0 can be used.
*2 Valid information
*3 FP/RP output is generated by a positive/negative speed command. The absolute value shall be a value within the range between the bias speed (BFM #6) and the maximum speed (BFMs #5 and #4).

6. Outline of FROM/TO Instruction

D	FNC 78 FROM	P	DFROMP (m1) (m2) (D) (n)	Read special module BFM

Device																
	X	Y	M	S	KnX	KnY	KnM	KnS	T	C	D	SD	P	V,Z	K,H	VZ index
m1															○	
m2															○	
D						○	○	○	○	○	○					○
n															○	

● m1 = 1~8 ● m2 = 0~32767 ● n = 1~32767

```
X0          (m1) (m2) (D) (n)
 ┤ ├──FROM  K1   K28  D0   K2
```

(m1) : The position number of the specified special module
(m2) : Initial serial number of the BFM to be read
(D) : The initial device of storages for collect the picked up data
(n) : Number of data groups to be read

- The Main Unit of VB Series PLC use the instruction to read BFM data of the special module.
- When X0=”ON”, 2 groups (they will be BFM #28~BFM #29 because (n) = K2 and (m2) = K28) data in the specified special module (which is installed in the (m1) = K1 = 1st position) will be read and stored in D0~D1.
- To assign the (m1) in VB Series, each special module is consecutively assigned from k1 to k8, it begins with the closest one to the Main Unit.
- When X0=”OFF”, the instruction will not be performed but the data (which was read previously) will still remain.

D	FNC 79 TO	P	DTOP (m1) (m2) (S) (n)	Special module BFM write in

Device																
	X	Y	M	S	KnX	KnY	KnM	KnS	T	C	D	SD	P	V,Z	K,H	VZ index
m1															○	
m2															○	
D					○	○	○	○	○	○	○				○	○
n															○	

● m1 = 1~8 ● m2 = 0~32767 ● n = 1~32767

```
X0          (m1) (m2) (S)  (n)
 ┤ ├──TO    K1   K15  K1000 K4
```

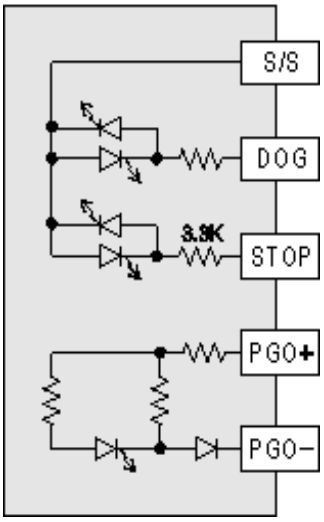
(m1) : The position number of the specified special module
(m2) : Initial serial number of the BFMs, which will be written
(S) : The initial source device, which stores the data is for the BFM
(n) : Number of data groups to be write

- The Main Unit of VB series PLC use this instruction to write data to the special module BFM.
- When X0=”ON”, the content value of (S) (K1000) will be written into the BMFs which are started form BFM #15 ((m2) = K15) in the special module and it is installed in the 1st ((m1) = K1) position. Since (n) =K4, there are 4 BFMs will be written in sequentially.
- To assign the (m1) in VB Series, each special module is consecutively assigned from K1 to K8, it begins with the closest one to the Main Unit.
- When X0=”OFF”, the instruction will not be performed but the data (which was written previously) will still remain.

7. I/O Specifications and External Connection Examples

7-1 I/O Specifications

<<Input Specifications>>



Connected to 24V DC Service power supply of PLC
The COM terminal of the DOG and STOP.
[For a NPN sensor : connect to 24+
For a PNP sensor : connect to 24-]

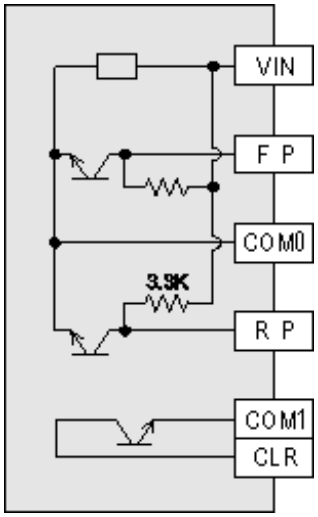
24V DC, 7 mA Response lag: 1 ms
Input ON current : ≥ 4.5 mA, Input OFF current: ≤ 1.5 mA

24V DC, 7 mA Response lag: 4 ms
Input ON current : ≥ 4.5 mA, Input OFF current: ≤ 1.5 mA

Connected to servo amplifier or external power supply
Input ON current : ≥ 4 mA, Input OFF current: ≤ 0.5 mA

Response pulse width: 4 μs

<<Output Specifications>>



(From servo amplifier or external power supply)
5 ~ 24V DC, Current consumption : ≤ 35 mA

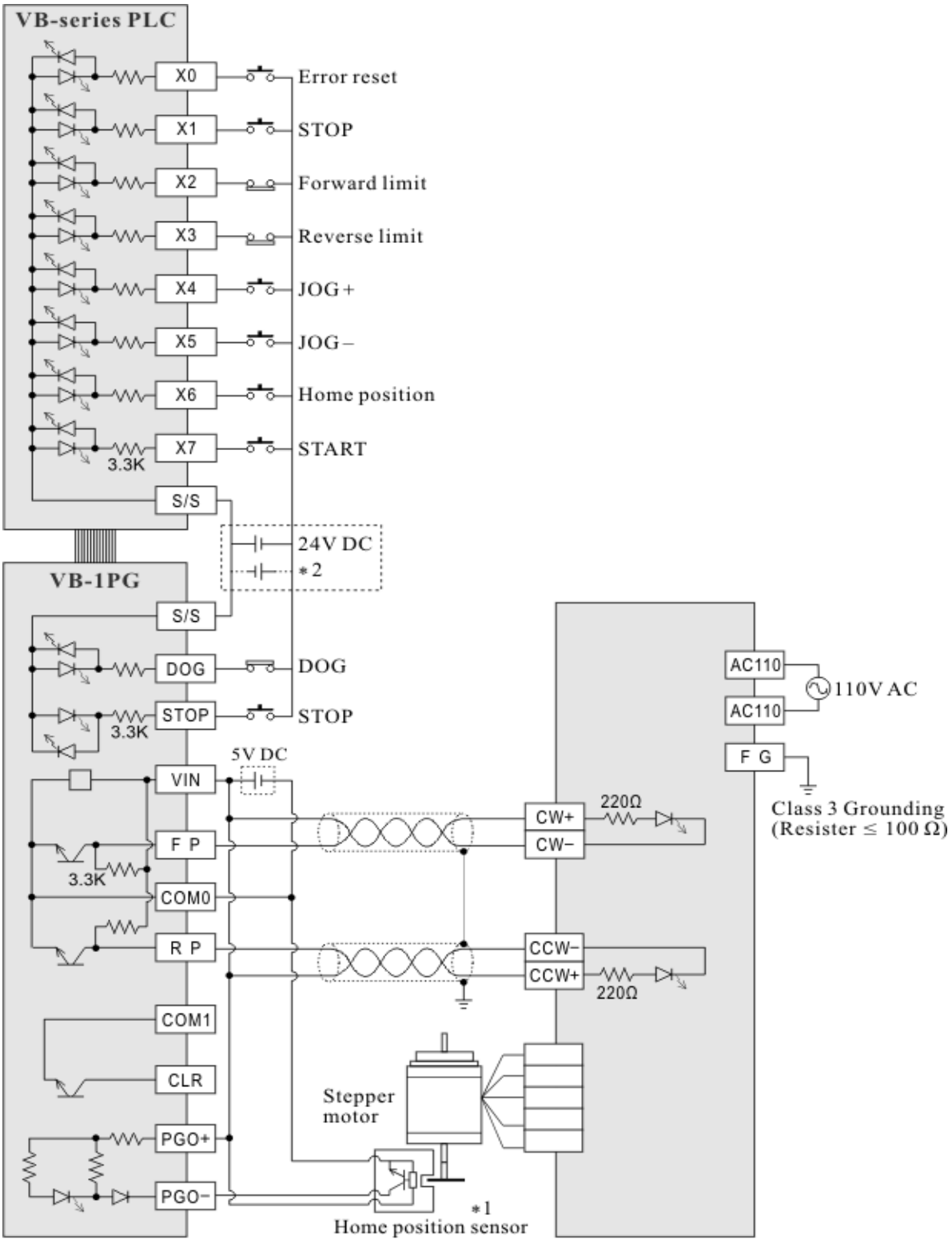
100 kPPS pulse out, 5 ~ 24 V DC, ≤ 20 mA

The COM terminal of FP and RP (VIN-)

100 kPPS pulse out, 5 ~ 24 V DC, ≤ 20 mA

Output for clearing deviation counter: 5 ~ 24V DC, ≤ 20 mA;
Output pulse with : 20 ms
(When home position return is completed or limit switch is input.)

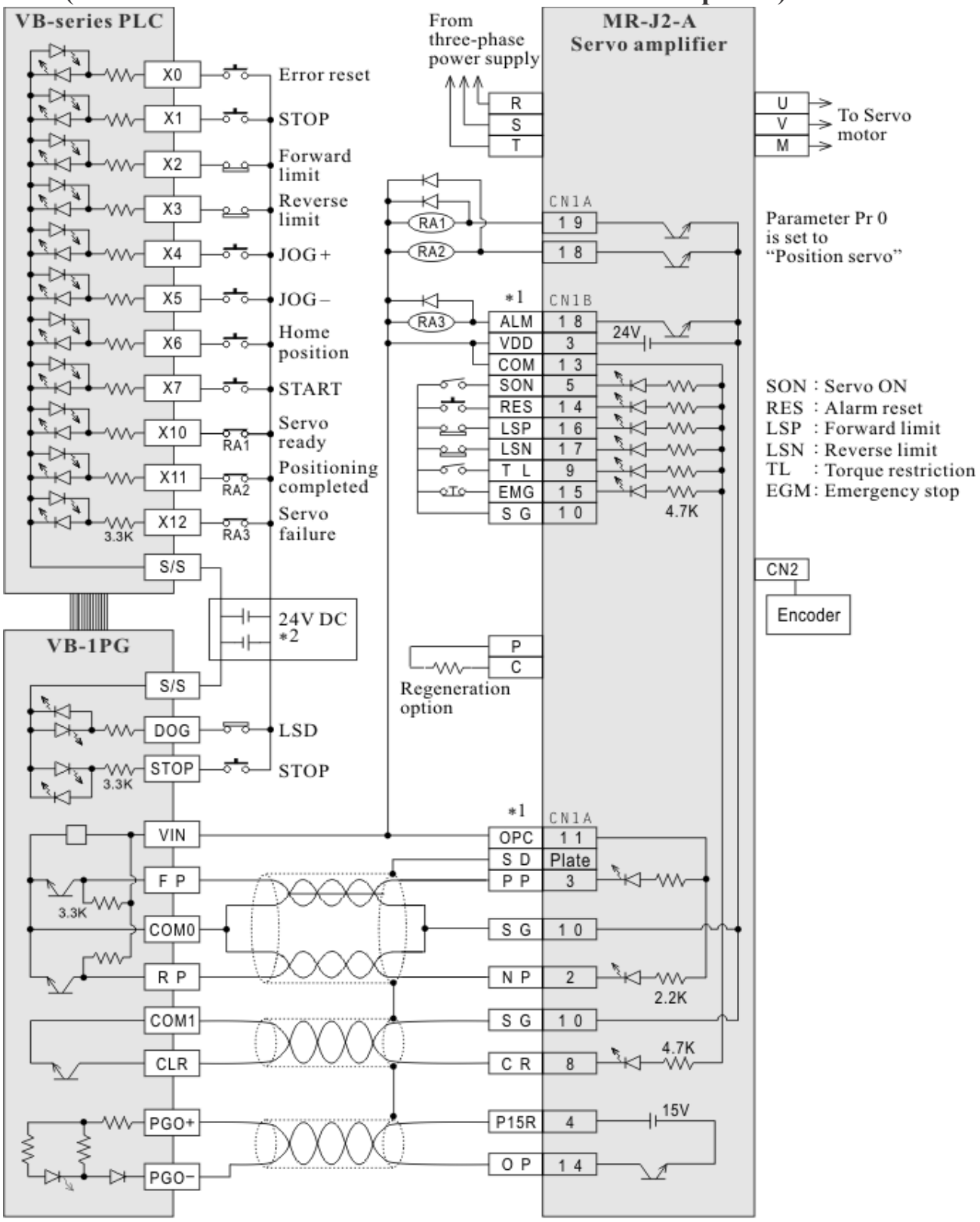
7-2 Example of Connection Between VB-1PG and Stepper Motor



*1 The number of counts of zero signals is adjusted to 0 (BFM #12, N= 0) when there is no home position sensor.
At this time, when the DOG input operates, the motor stops at once.
Make the home position return speed (creep) Vcr (BFM #11) as slow as possible because it does not destroy the machine.

*2 Connect either one in accordance with the external supply voltage. (See Section 7-1 Input Specifications.)

7-3 Example of External Connection (Between VB-1PG and Mitsubishi MR-J2 Servo Amplifier)



*1 PIN No. can be modified using the extension parameter. (The example above shows the case where the initial value is set.)

*2 Connect either one in accordance with the external supply voltage. (See Section 7-1 Input Specifications.)

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