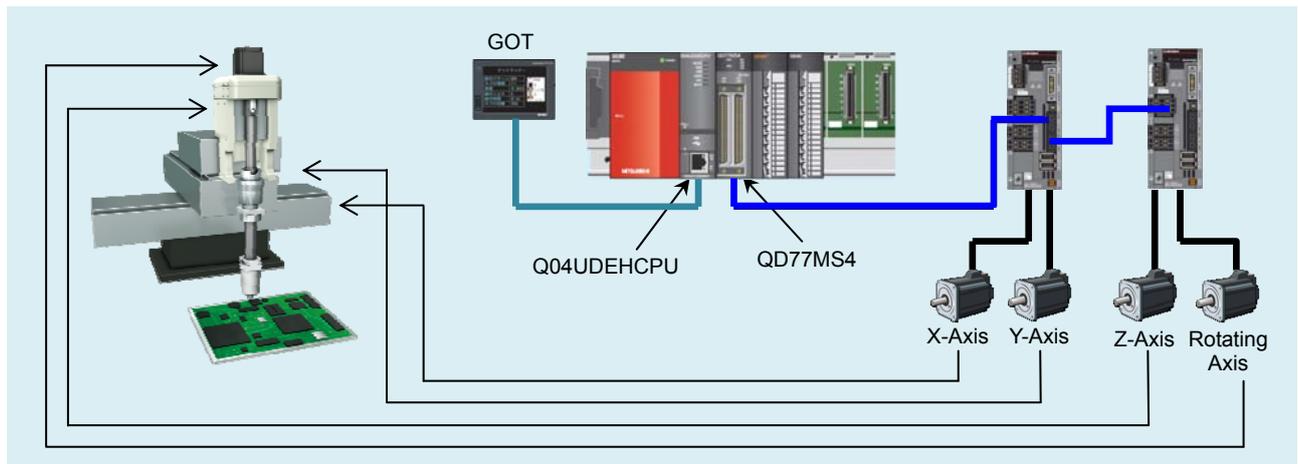


Screw Tightening Machine

[System Configuration]

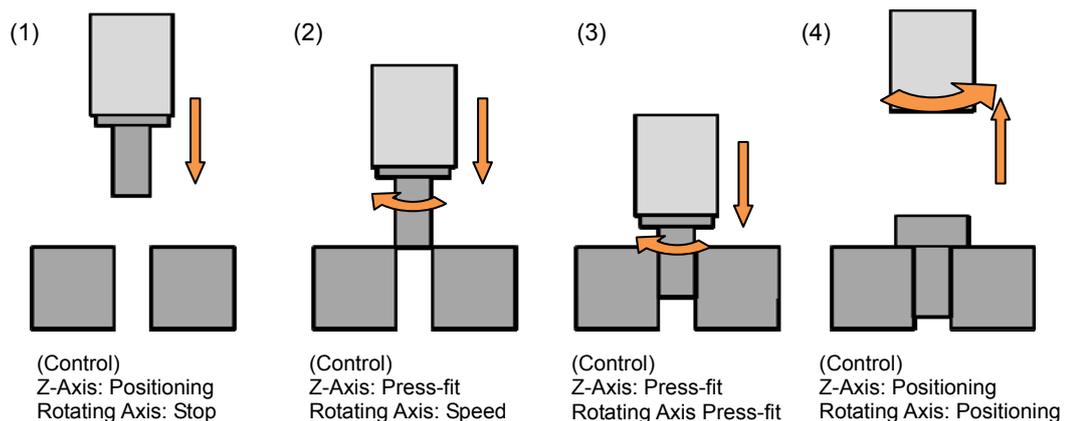


[Mitsubishi solution]

PLC CPU	: Q04UDEHCPU	Simple Motion module	: QD77MS4	GOT: GT27**-V
Main base	: Q35B	Servo amplifier	: MR-J4W2-B	
Power supply	: Q62P	Servo motor	: HG-KR	
Engineering environment: MELSOFT GX Works2 (PLC), MELSOFT GT Works3 (GOT)				

[Operation Description]

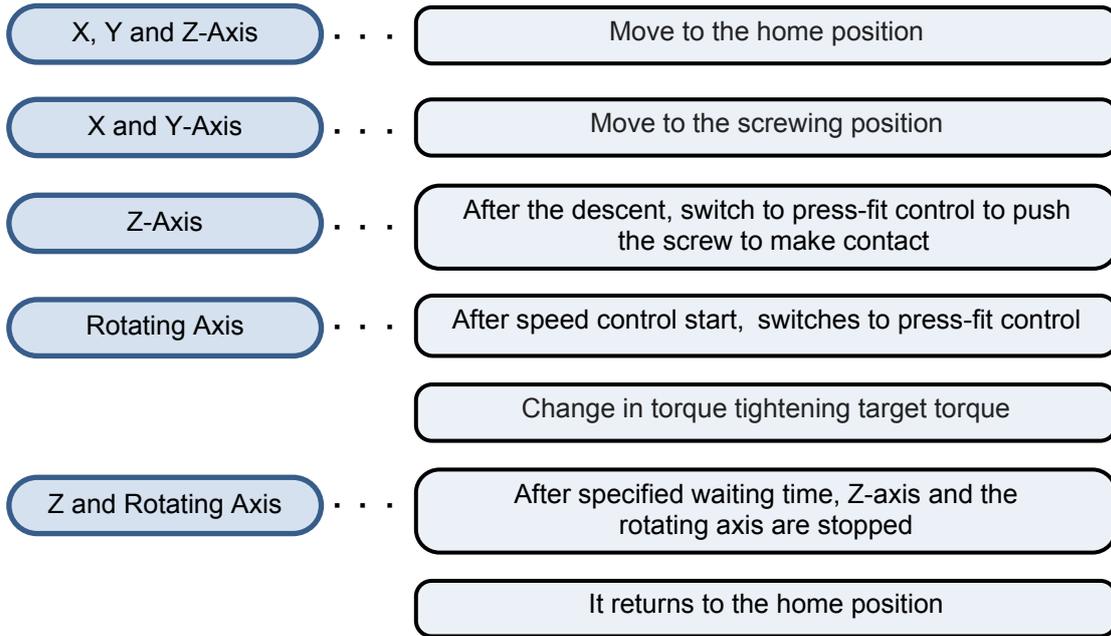
- (1) After the tool is positioned in the screw tightening respect with X and Y-axis, Z-axis is lowered with the positioning control.
- (2) When a screw comes in contact with a work, the Z-axis pushes it and it is switched from positioning control to press-fit control, and the rotating axis is driven with speed control.
- (3) When the Z-axis reaches a predetermined value or less, even rotating axis also switches to press-fit control. When the speed of the tightened screw is equal to or less than a certain value, the torque of rotating axis will change to the tightening torque of the screw.
- (4) After a certain period of tightening time with tightening torque, Z-axis and rotating axis return in positioning control mode to the retracted position.



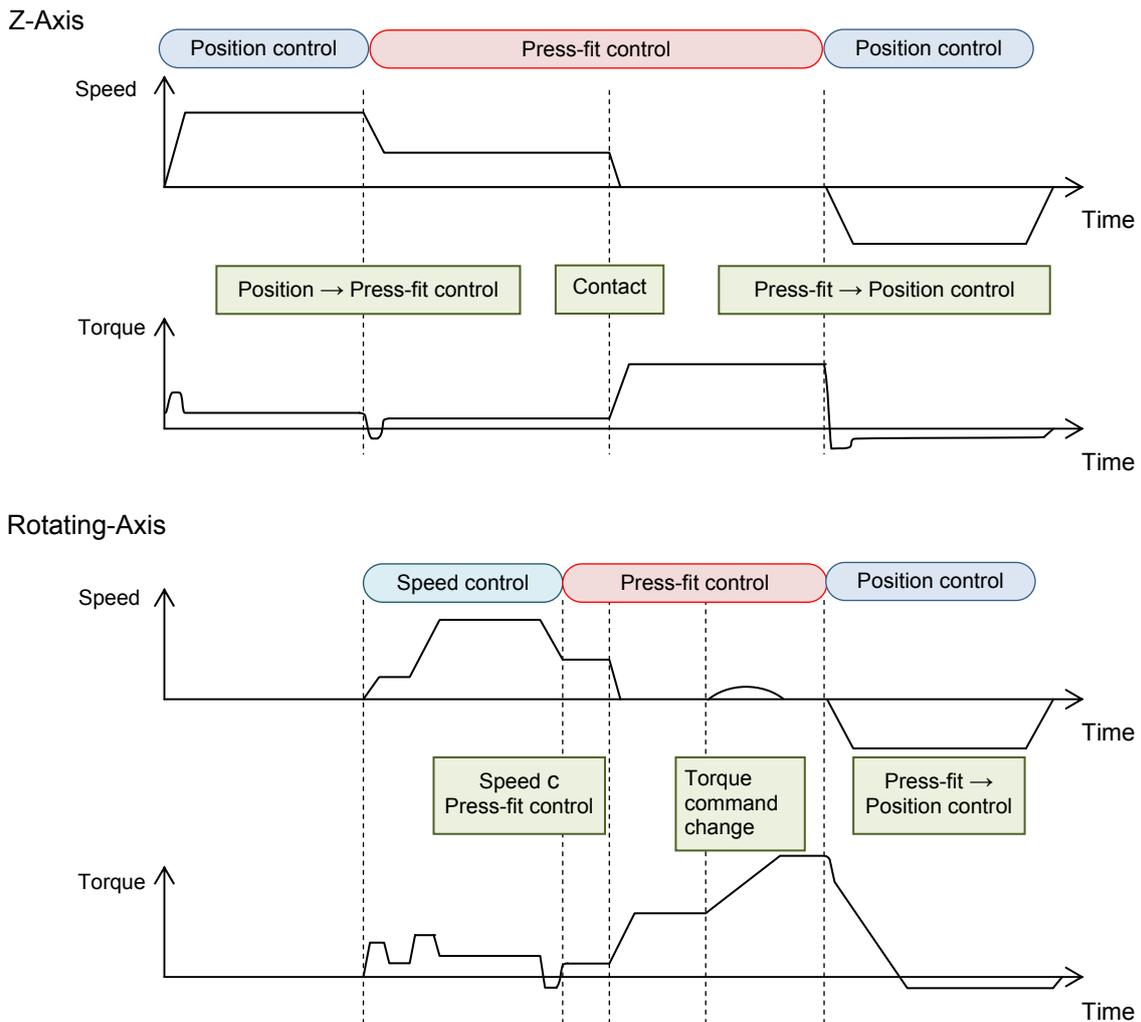
[Control Points]

- Point1: The torque sensor is not used, and the screw tightening becomes possible by additionally controlling the speed and the torque of the rotating axis in the process in open loop.
- Point2: By the press-fit control, torque is not suddenly changed when switching to torque control from position control, smooth operation is possible.
- Point3: The ladder program such as the control mode switching of the rotating axis and Z-axis can be described by the function block.

[Operation Flowchart]



[Operation Time Chart]



[Using the sample program]

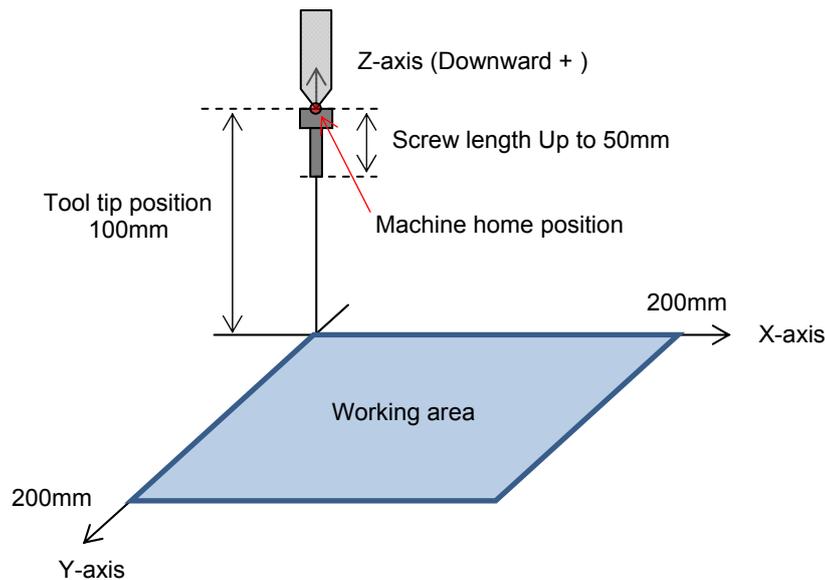
[Sample program configuration]

File name	Description	Model	Programming tool
Vol10_Screw_PLC.gxw	Ladder program	Q04UDEHCPU	MELSOFT GX Works2
Vol10_Screw_Motion.pcw	Simple Motion setting file	QD77MS4	
Vol10_Screw_GOT.GTX	GOT monitoring data	GT27**-V (640x480)	MELSOFT GT Works3

[Typical machinery configuration]

It is necessary to connect the servo amplifier and the servo motor with the third axis (Z-axis) and the fourth axis (rotating axis) to operate the sample program (A virtual servo cannot be used).

- 1) The working range and the machine starting point are set as shown in figure.



- 2) Each axis has been set as shown in the table below.

Axis No.	Connecting Axis	Servo motor	Machinery configuration
1	X-Axis	HG-KR43	Ball screw (pitch 10mm), Reduction ratio1/2
2	Y-Axis	HG-KR43	Ball screw (pitch 10mm), Reduction ratio1/2
3	Z-Axis	HG-KR43B	Ball screw (pitch 10mm), Reduction ratio1/2
4	Rotating Axis	HG-KR43	Connected to a tool

- 3) The home position return for all axes has been set in as data set method in the initial state. Set it to be an appropriate starting point return method to each axis when actually start a machine.

[Start-up]

1. Decompress the downloaded files to any folder in your PC.
2. Double clicking decompressed files to open the corresponding engineering tool.
3. Ladder program and GOT monitoring data as default are set for English environment. When using Japanese environment, it's possible to switch to Japanese for ladder program in GX Works2 [Tool] -> [Select Language] menu and for GOT monitoring data in GT Works3 Language change the preview column from [2] to [1].
4. Change the model settings according to models to be used.
5. Write the sample program data to PLC CPU, Simple Motion and GOT.
6. After writing all the programs, reset the PLC CPU.

[Operating method]

Start operation by using the GOT touch button.

If you do not have GOT, operate the device with the appropriate touch button in GT Works3's simulator function^(Note) or GX Works2's device test function.

(Note): When using GT Works3's simulator function, click on the "communication setup" tab of "Simulator setup" and select "USB" or "CPU(RS-232)" from the pull-down menu of "connection".



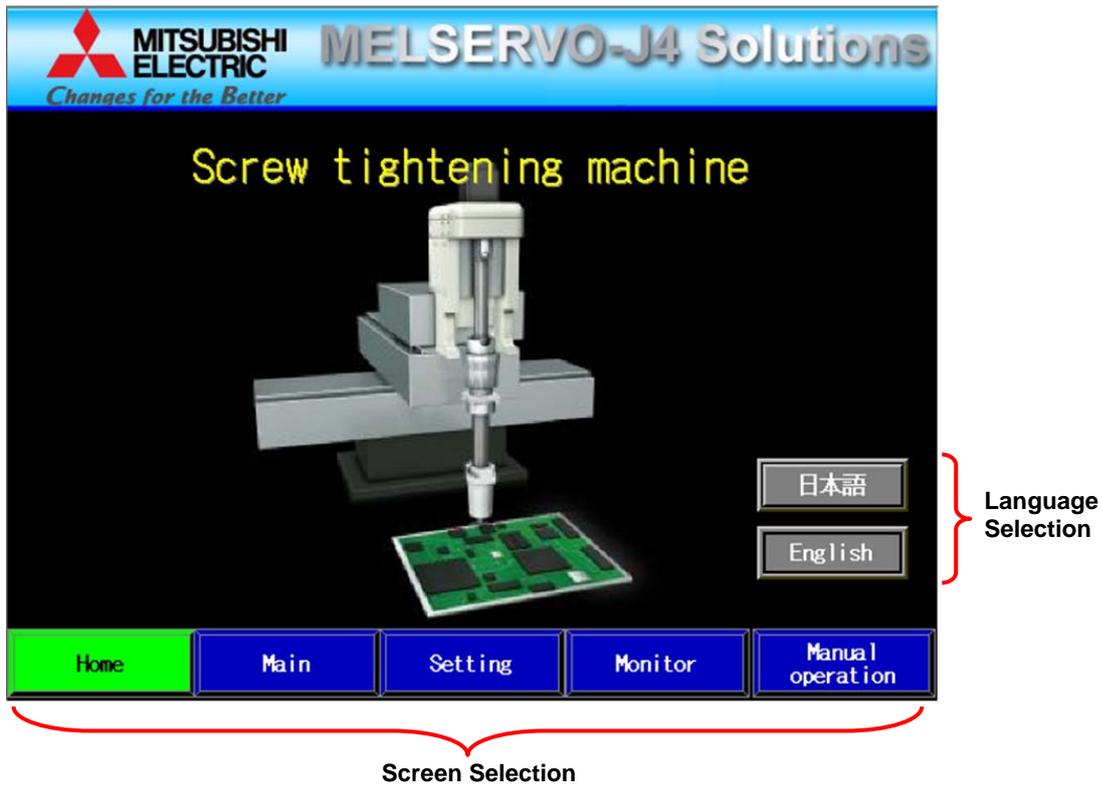
1. When you start-up the system, touch "Reset system" button on the GOT Main screen to perform machine home position return operation. Home position return complete HPR lamp and auto operation enable lamp turn on when operation is completed normally.
2. After home position return completion, set the length and size of the screw tightening, tightening torque, tightening time and the position of the screw holes on [Setting screen]. After setting, it will start automatic operation when you touch the operation start switch on [main screen]. If you touch the STOP switch during automatic operation, automatic operation will be stopped.
3. Each axis can be operated independently by using the JOG touch buttons.

	Operation	GOT touch key	Device No.
1	Machine HPR	[Main] Home position set	B02
	High speed HPR	[Main] Return to Home position	B03
2	Automatic operation start	[Main] RUN	B00
	Automatic operation stop	[Main] STOP	B01
	Screw hole position setting (X-coordinate)	[Setting] X-coordinate value	D110
	Screw hole position setting (Y-coordinate)	[Setting] Y-coordinate value	D120
	Screw size setting	[Setting] M2 to M5, Manual Setting	B06 to B0A B0B
	Screw length setting	[Setting] Screw length	D150
	Tightening torque	[Setting] Tightening torque value	D107
	Tightening time	[Setting] Tightening time	D104
	(Note) Tightening torque	[Setting] Tightening torque value	D100
	(Note) Screw pitch	[Setting] Screw pitch value	D101
3	Each axis JOG operation (forward)	[Manual operation] FWD for each axis	B10,B12,B14,B16
	Each axis JOG operation (reverse)	[Manual operation] REV of each axis	B11,B13,B15,B17
	Each axis JOG speed	[Manual operation] Speed value of each axis	D200,D202,D204,D206

(Note): When [Manual Setting] is selected in the screw size setting, it is possible to input the tightening torque and screw pitch manually. When M2 to M5 is selected, the numerical value is automatically set.

[GOT Sample screen]

[GOT Home Screen]



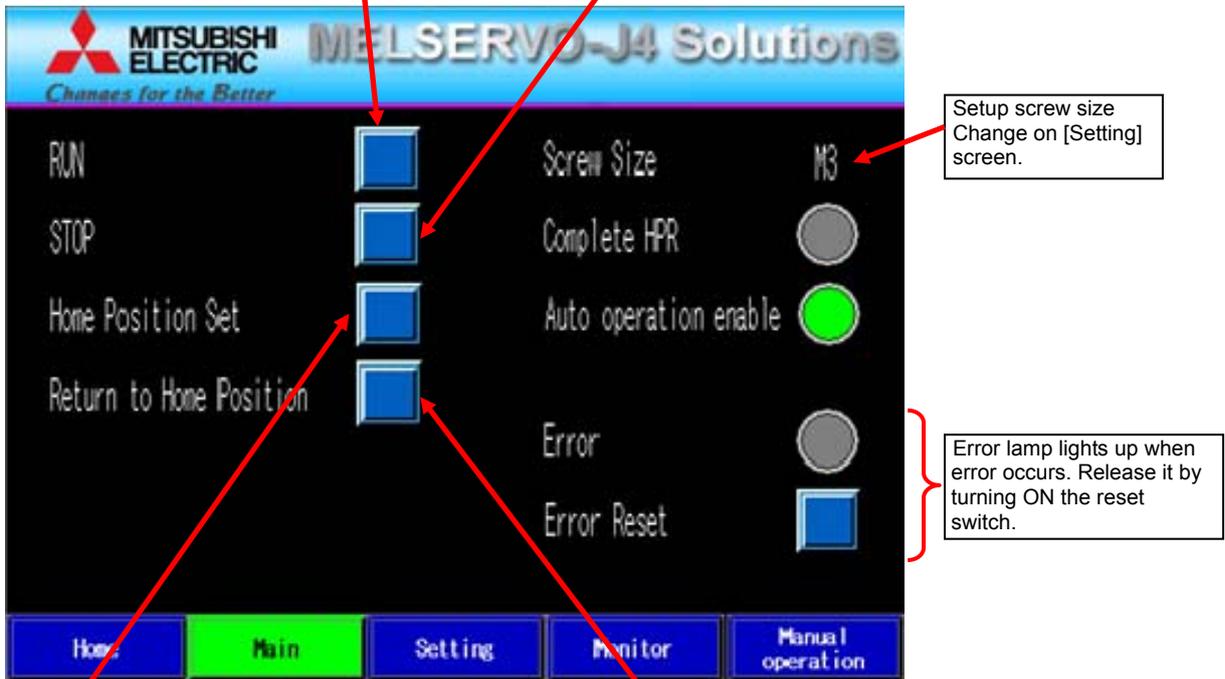
[GOT Main Screen]

Operation start switch

When this switch is turned ON while automatic operation lamp is ON, automatic operations will start.

Operation stop switch

Automatic operation will stop with ON during automatic operation.



Machine HPR switch

Turn ON for the mechanical zero return. Completion of homing lamp lights up when is successfully completed.

High speed HPR switch

Turn ON for high speed HPR. All axes will return to the retracted position.

[GOT Setting Screen]



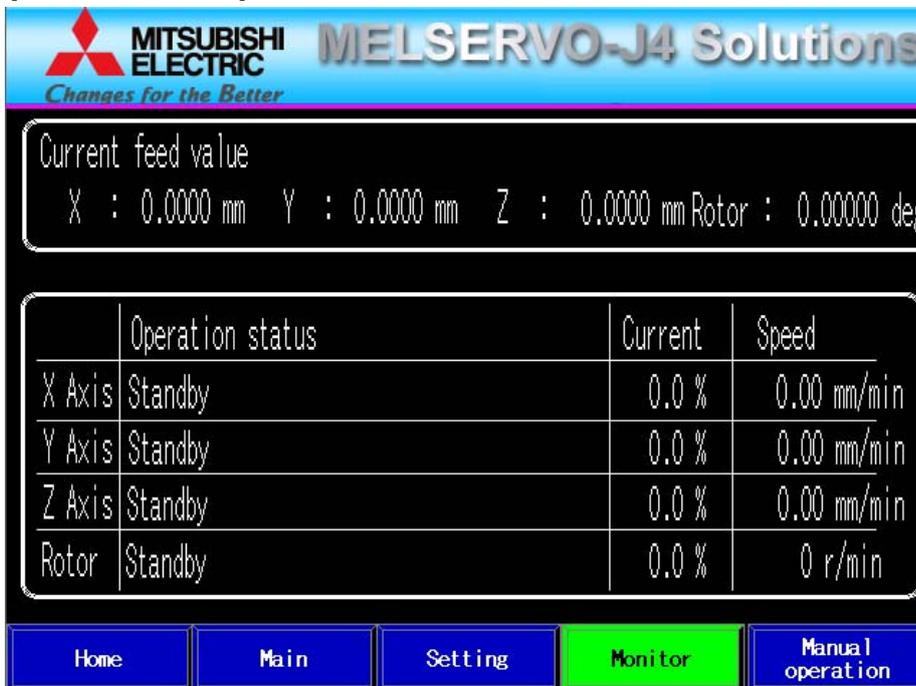
Select the screw type. Screw pitch and tightening torque corresponding to the screw size will be set automatically (refer to the following table). If you select Manual Setting, you can manually set the screw pitch and tightening torque.

Tightening torque (D100) and screw pitch (D101) are entered using the GOT recipe function.

	M2	M2.5	M3	M4	M5
Tightening torque (D100) ^(Note)	134 (0.174Nm)	274 (0.356Nm)	488 (0.634Nm)	1139 (1.48Nm)	2292 (2.98Nm)
Screw pitch (D101)	400 (400μm)	450 (450μm)	500 (500μm)	700 (700μm)	750 (750μm)

(Note): The value of D100 is set in a ratio (0.1% unit) for the rated torque (1.3Nm) of the servo motor HG-KR43.

[GOT Monitor Screen]



Feed current position X, Y, Z-axis and rotating axis are displayed.

The operating state, current value, and speed for each axis are displayed.

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JOG

X Axis Y Axis Z Axis Rotor

FWD REV FWD REV FWD REV FWD REV

1000.00 mm/min 1000.00 mm/min 1000.00 mm/min 100 r/min

Current feed value
X : 0.0000 mm Y : 0.0000 mm Z : 0.0000 mm Rotor : 0.00000 deg

Home Main Setting Monitor Manual operation

JOG operation of each axis.

Set JOG speed.

Feed current position of each axis is displayed.

[Operation check method]

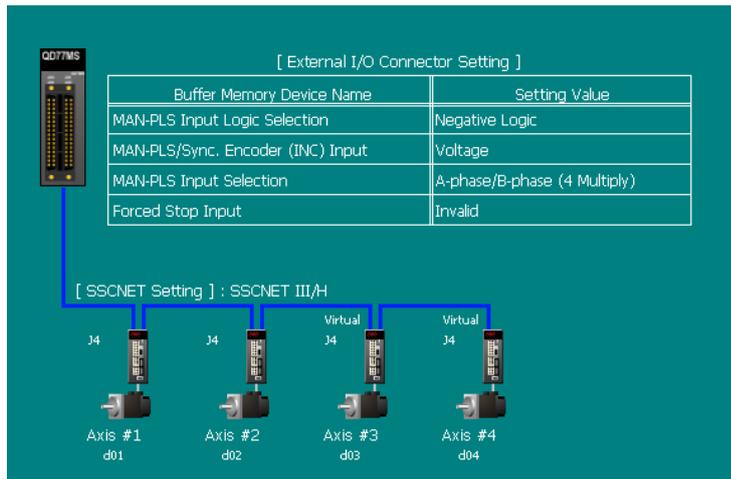
1. Start the digital oscilloscope function of Simple Motion module setting tool.
2. A trigger condition is automatic operation start (B0). During automatic operation, speed waveform of each axis is registered.
3. Check collected waveforms with operation pattern.

⚠ Cautions

- When diverting the sample program to the actual system, be sure to verify that there are no problems with control in the system.
- Add interlock conditions in the target system where considered necessary.

[Simple Motion Settings]

[System Settings]



- Axis1: X- Axis (MR-J4-B)
- Axis2: Y- Axis (MR-J4-B)
- Axis3: Z- Axis (MR-J4-B)
- Axis4: Rotating Axis (MR-J4-B)

[Parameters]

The table below lists the items that changed from the default value.

Items	Axis 1	Axis 2	Axis 3	Axis 4
Pr.1 Unit setting	0: mm	0: mm	0: mm	2: degree
Pr.2 Number of pulses per rotation (AP)	4194304PLS	4194304PLS	4194304PLS	4194304PLS
Pr.3 Movement amount per rotation (AL)	5000.0μm	5000.0μm	5000.0μm	360.00000degree
Pr.8 Speed limit value	2000.00mm/min	2000.00mm/min	2000.00mm/min	720000.000degree/min
Pr.12 Software stroke limit upper limit value	220000.0μm	220000.0μm	110000.0μm	0.00000degree
Pr.13 Software stroke limit lower limit value	-20000.0μm	-20000.0μm	-20000.0μm	0.00000degree
Pr.15 Software stroke limit valid/invalid setting	Valid	Valid	Valid	Invalid
Pr.21 Current feed value during speed control	0: Do not update current feed value	0: Do not update current feed value	0: Do not update current feed value	1: Update current feed value
Pr.22 Input signal logic selection lower limit	1: Positive logic	1: Positive logic	1: Positive logic	1: Positive logic
Pr.22 Input signal logic selection upper limit	1: Positive logic	1: Positive logic	1: Positive logic	1: Positive logic
Pr.80 External input signal selection	2: Buffer memory of QD77MS	2: Buffer memory of QD77MS	2: Buffer memory of QD77MS	2: Buffer memory of QD77MS
Pr.82 Forced stop valid/invalid selection	1: Invalid			
Pr.31 JOG speed limit value	1000.00mm/min	1000.00mm/min	1000.00mm/min	360000.000degree/min
Pr.43 OPR method	6: Data set method	6: Data set method	6: Data set method	6: Data set method
Pr.46 OPR speed	1000.00mm/min	1000.00mm/min	1000.00mm/min	360000.000degree/min

Blue: Default value
Black: Set point

Reset according to the actual device for the setting of stroke limit and home position return.

[Positioning Data]

Changed by ladder program.

Axis-1: X-axis automatic operation

No.	Operation pattern	Control system	Axis to be interpolated	Acceleration time No.	Deceleration time No.	Positioning address	Arc address	Command speed	Dwell time	M code
1	0:END <Positioning Comment>	01h:ABS Linear 1	-	0:1000	0:1000	100000.0 μm	0.0 μm	1500.00 mm/min	0 ms	0

Set the screw hole position in GOT.
Default value: 100000.0μm

Axis-2: Y-axis automatic operation

No.	Operation pattern	Control system	Axis to be interpolated	Acceleration time No.	Deceleration time No.	Positioning address	Arc address	Command speed	Dwell time	M code
1	0:END <Positioning Comment>	01h:ABS Linear 1	-	0:1000	0:1000	100000.0 μm	0.0 μm	1500.00 mm/min	0 ms	0

Axis-3: Z-axis automatic operation:

No.	Operation pattern	Control system	Axis to be interpolated	Acceleration time No.	Deceleration time No.	Positioning address	Arc address	Command speed	Dwell time	M code
1	0:END <Positioning Comment>	01h:ABS Linear 1	-	0:1000	0:1000	100000.0 μm	0.0 μm	1000.00 mm/min	0 ms	0

Set the distance from the home position to the work. The control mode is switched to press-fit control along the descending.

Speed during press-fit control is set automatically according to the pitch of screw.

Axis-4: Rotating axis

No.	Operation pattern	Control system	Axis to be interpolated	Acceleration time No.	Deceleration time No.	Positioning address	Arc address	Command speed	Dwell time	M code
1	0:END <Positioning Comment>	04h:FWD V1	-	0:1000	0:1000	0.00000 degree	0.00000 degree	43200.000 degree/min	0 ms	0

120r/min (2 revolutions per second)

[Sample Ladder Program Configuration]

START
QD77MS Simple Motion Module Start-up
Data Initialization
JOG Operation
Machine Home Position Return
High Speed Home Position Return
Automatic Operation 1): X-Axis, Y-Axis Operation Start
Automatic Operation 2): Z-Axis Operation Start
Automatic Operation 3): Z-Axis press-fit control switching, Rotating axis operation start
Automatic Operation 4): Rotating axis press-fit control switching
Automatic Operation 5): Z-axis torque change, During tightening
Automatic Operation 6): After completion of tightening, Z-axis and rotating axis high speed home position return
Automatic Operation 7): Operation stop
Error Reset
Monitor Signal used in GOT
END

[Used Devices in this program]

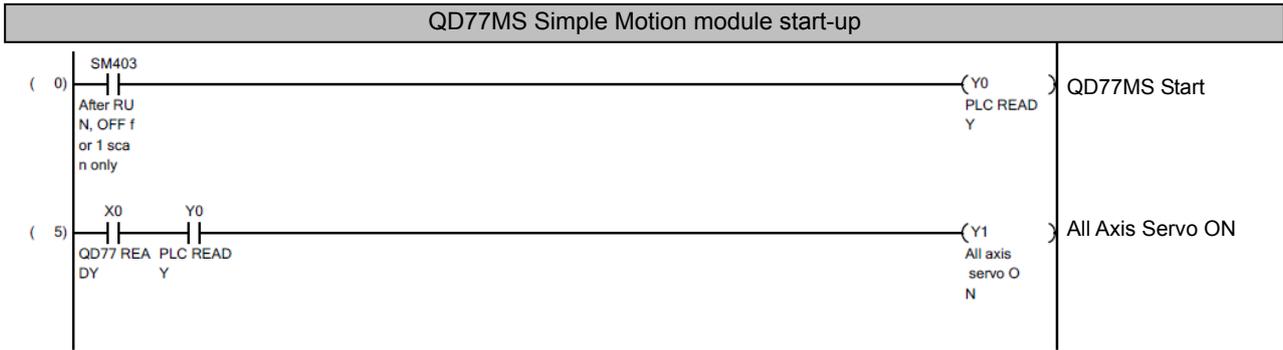
[User devices]

Device No.	Content	Device No.	Content
B00	Operation start	D100	Tightening torque (%)
B01	Operation stop	D101	Screw pitch (μm)
B02	Machine HPR	D102	Speed limit value of the Z-axis press-fit control
B03	High speed HPR	D104	Tightening time
B04	Error reset	D107	Target torque during press-fit control of the Z-axis
B06	Screw setting (M2)	D110	Screw hole position (X-coordinate)
B07	Screw setting (M2.5)	D111	
B08	Screw setting (M3)	D120	Screw hole position (Y-coordinate)
B09	Screw setting (M4)	D121	
B0A	Screw setting (M5)	D140	Screw size setting
B0B	Screw setting (Manual)	D150	Screw length
B0D	Home position return complete lamp	D152	Switching position in the Z-axis press-fit control
B0E	Error lamp	D200	X-axis JOG speed
B10	X-axis JOG operation (forward)	D201	
B11	X-axis JOG operation (reverse)	D202	Y-axis JOG speed
B12	Y-axis JOG operation (forward)	D203	
B13	Y-axis JOG operation (reverse)	D204	Z-axis JOG speed
B14	Z-axis JOG operation (forward)	D205	
B15	Z-axis JOG operation (reverse)	D206	Rotating axis JOG speed (r/min)
B16	Rotating axis JOG operation (forward)	D207	
B17	Rotating axis JOG operation (reverse)	D208	Rotating axis JOG speed (degree/min)
B20	Automatic operation permission lamp	D209	

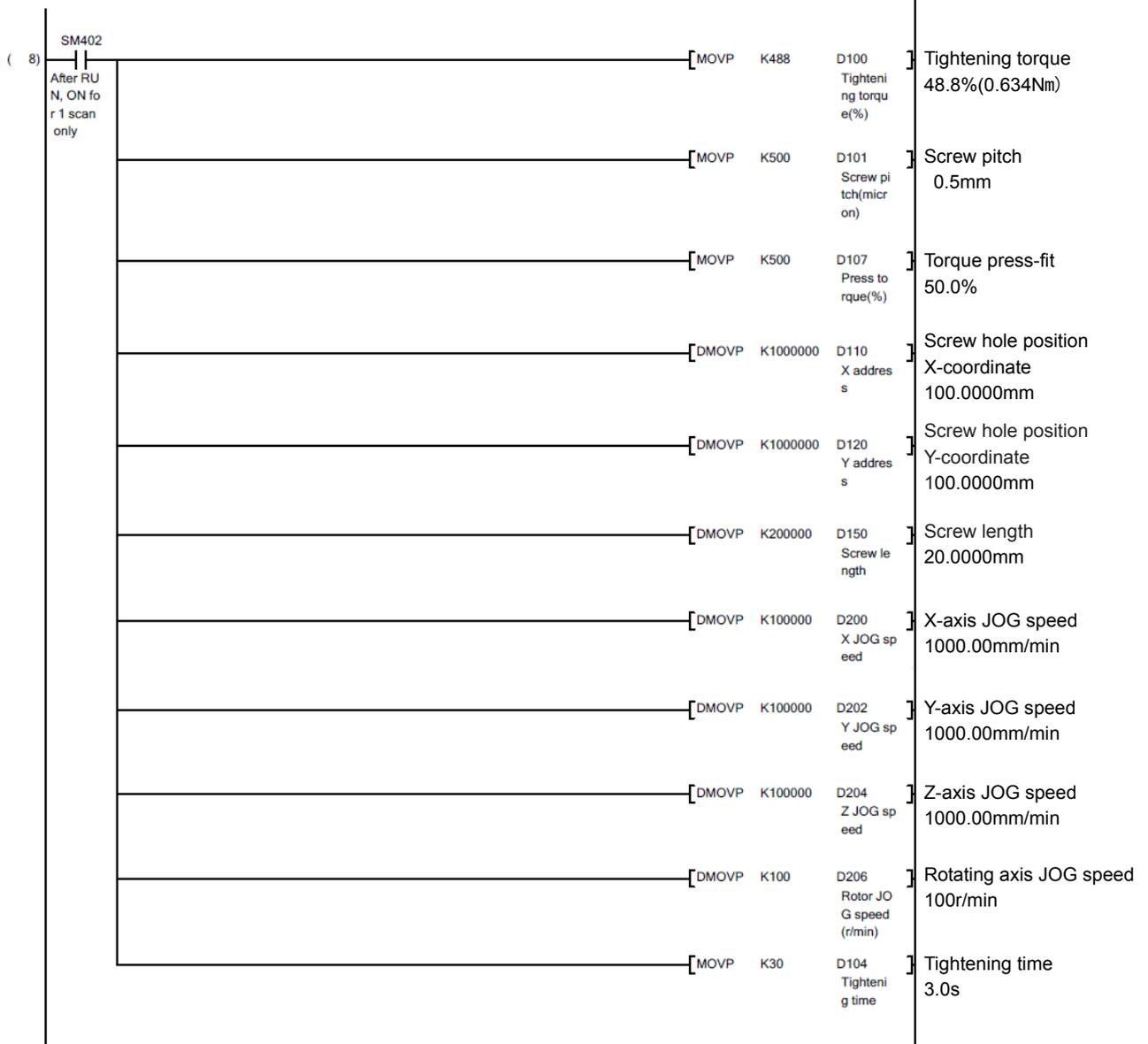
[QD77MS dedicated devices]

Device No.	Content	Device No.	Content
X00	QD77 ready	Y00	PLC ready
X08	Axis 1 error detection	Y01	All axis servo ON
X09	Axis 2 error detection		
X0A	Axis 3 error detection		
X0B	Axis 4 error detection		
X14	Axis 1 positioning completion		
X15	Axis 2 positioning completion		
U0\G800	X-axis current position (GOT)	U0\G1502	X-axis error reset
U0\G809	X-axis operation state (GOT)	U0\G1602	Y-axis error reset
U0\G812	X-axis speed (GOT)	U0\G1702	Z-axis error reset
U0\G817	X-axis status	U0\G1802	Rotating axis error reset
U0\G856	X-axis current value (GOT)	U0\G1890	Rotating axis press-fit mode target torque
U0\G900	Y-axis current position (GOT)	U0\G2006	X-axis positioning address
U0\G909	Y-axis operation state (GOT)	U0\G8006	Y-axis positioning address
U0\G912	Y-axis speed (GOT)		
U0\G917	Y-axis status		
U0\G956	Y-axis current value (GOT)		
U0\G1000	Z-axis current position (GOT)		
U0\G1009	Z-axis operation state (GOT)		
U0\G1012	Z-axis speed (GOT)		
U0\G1017	Z-axis status		
U0\G1054	Z-axis motor rotation speed		
U0\G1056	Z-axis current value (GOT)		
U0\G1100	Rotating axis current position (GOT)		
U0\G1109	Rotating axis operation state (GOT)		
U0\G1112	Rotating axis speed (GOT)		
U0\G1117	Rotating axis status		
U0\G1154	Rotating axis motor rotation speed		
U0\G1156	Rotating axis current value (GOT)		

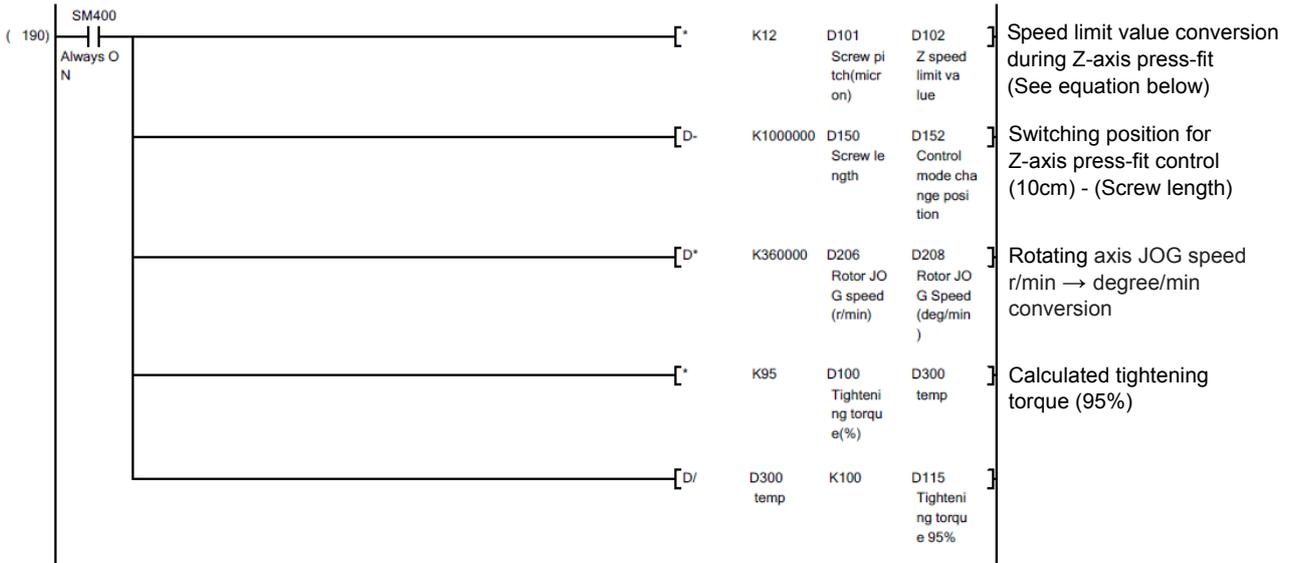
[Ladder program]



Data Initialization: Initialization of the input devices in GOT



Data Initialization: Numerical value conversion



Speed limit during Z-axis press-fit control

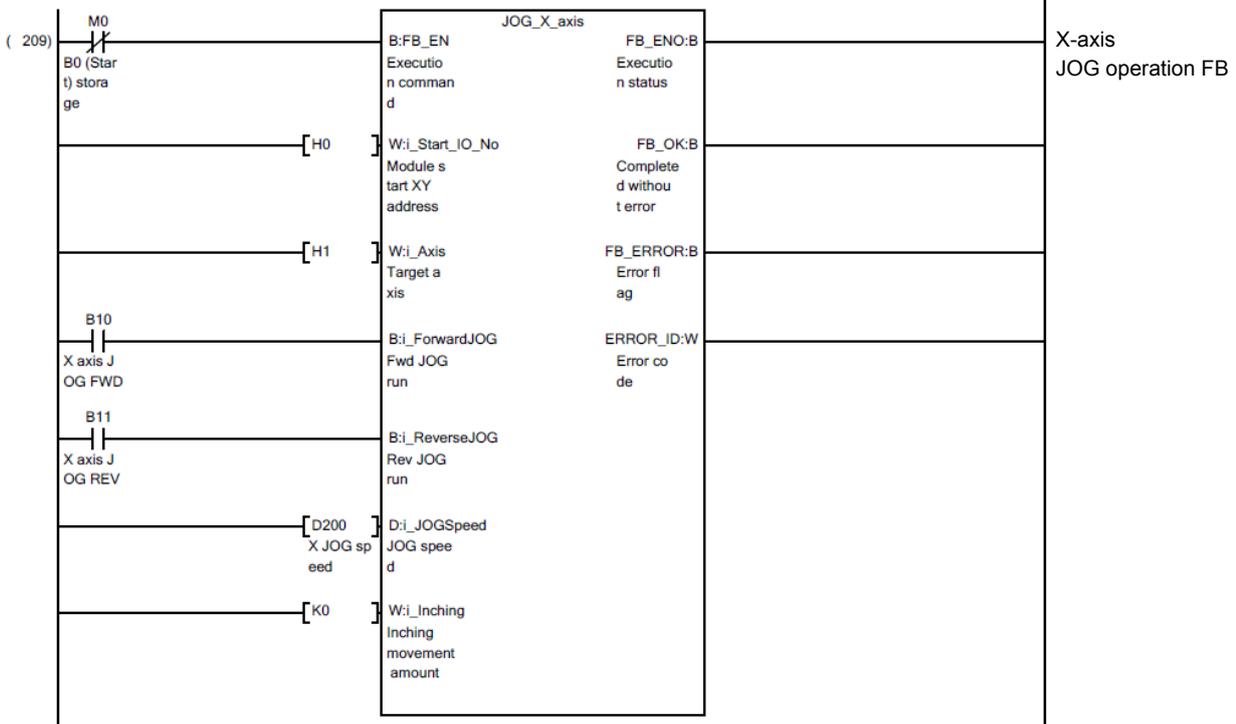
In this sample program, the axis rotates at 120 [r/min] during press-fit control, that is, two revolutions per second, for screw tightening. At this time, Z-axis is lowered by 2 revolution per second, then the screw is advanced by the thread pitch (D101) × 2 [mm] per second.

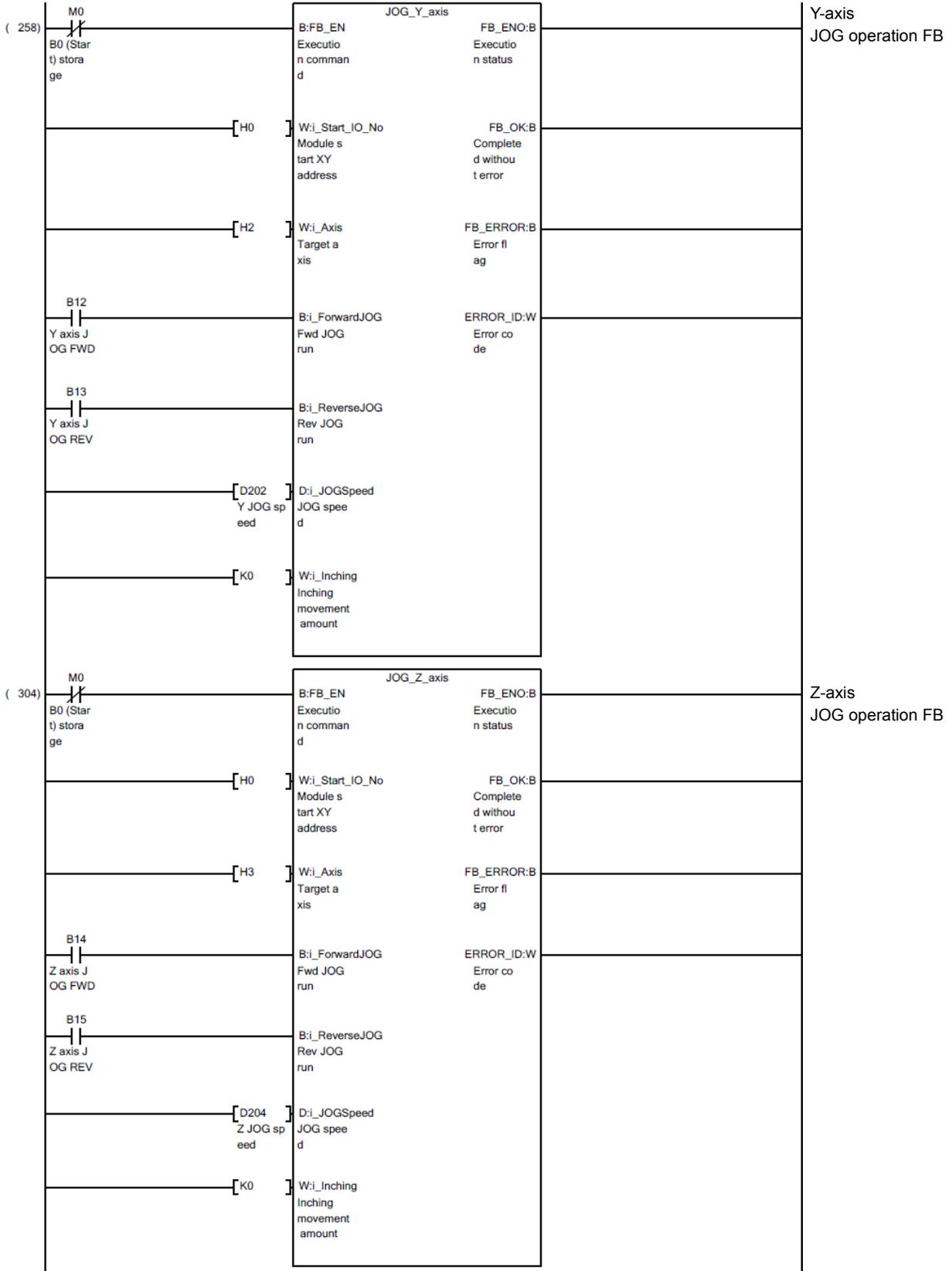
Therefore, the speed limit value (D102) is calculated by the following formula:

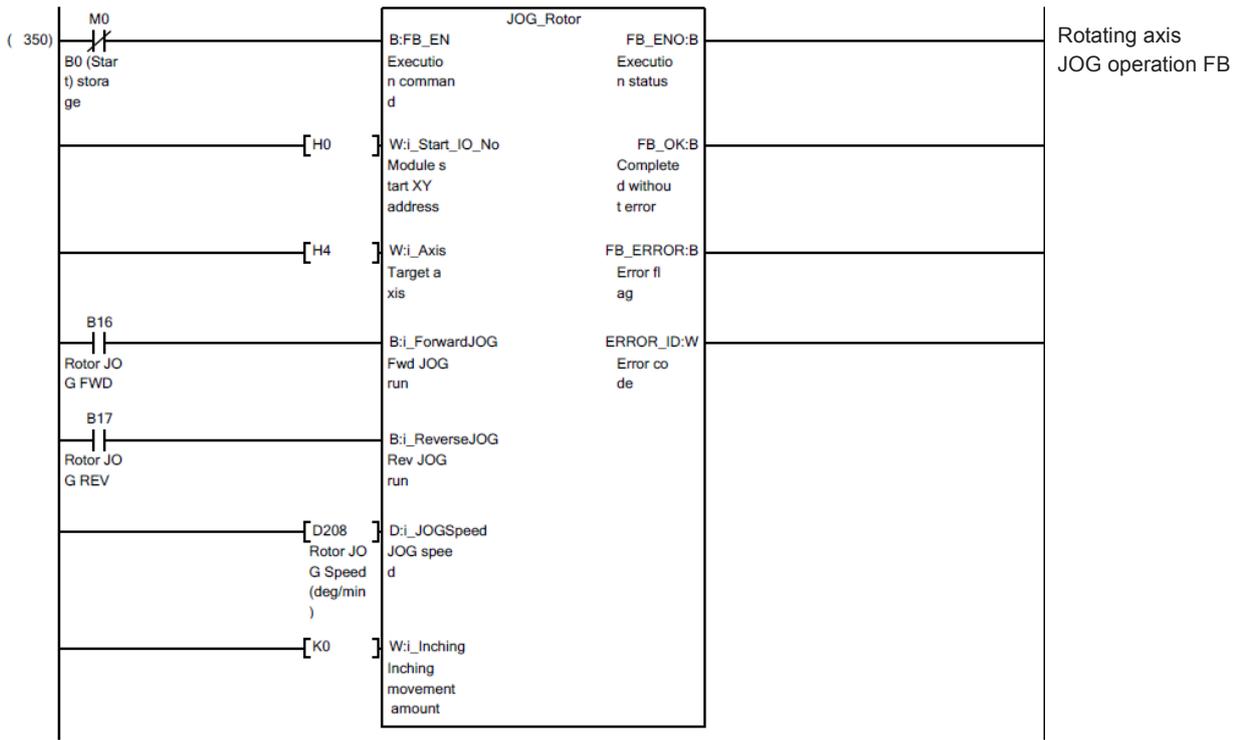
$$\text{Speed limit value during Z-axis press-fit control (D102) } [\times 10^{-2} \text{mm/min}] = \text{Screw pitch(D101)} [\times 10^{-3} \text{mm}] \times \frac{60[\text{s}]}{1[\text{min}]} \times \frac{2[\text{rev}]}{1[\text{s}]}$$

$$\therefore \text{Z-axis speed limit value (D102)} = \text{Screw pitch (D101)} \times 12$$

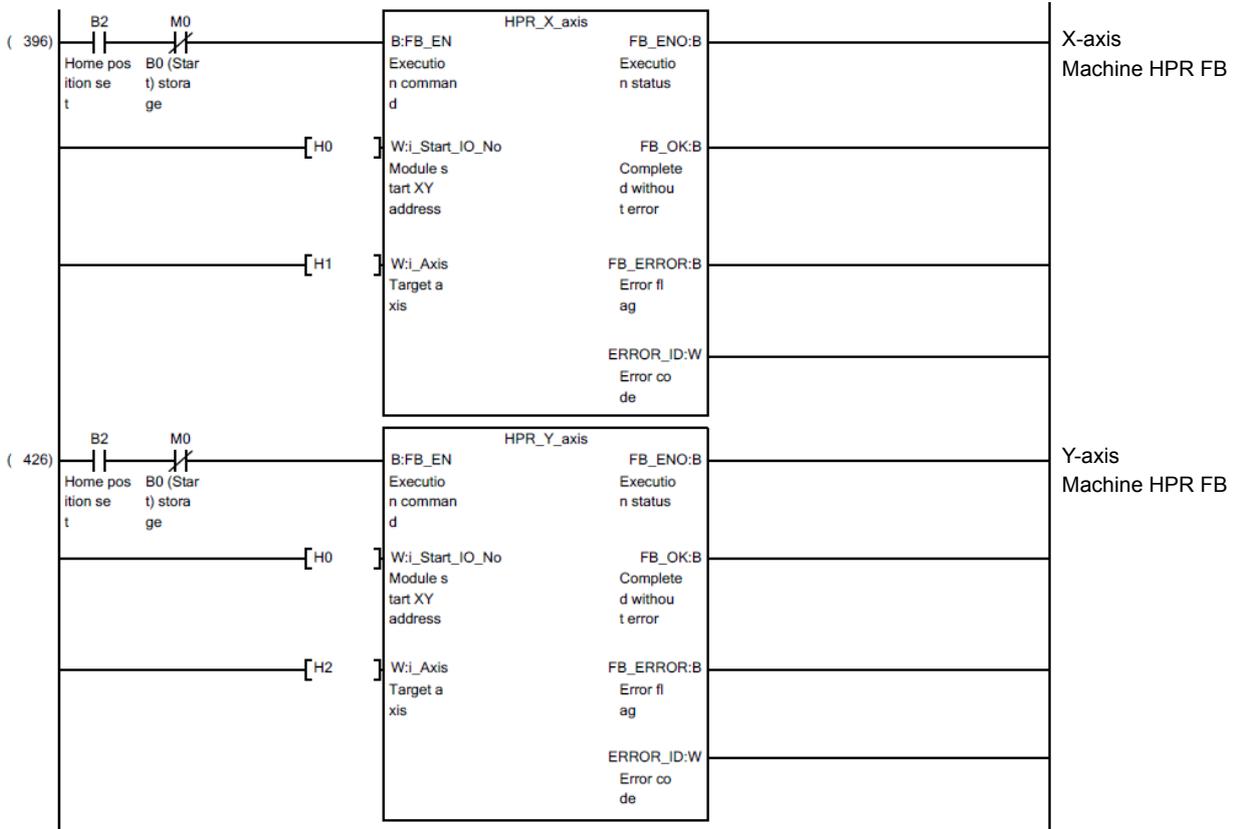
JOG Operation

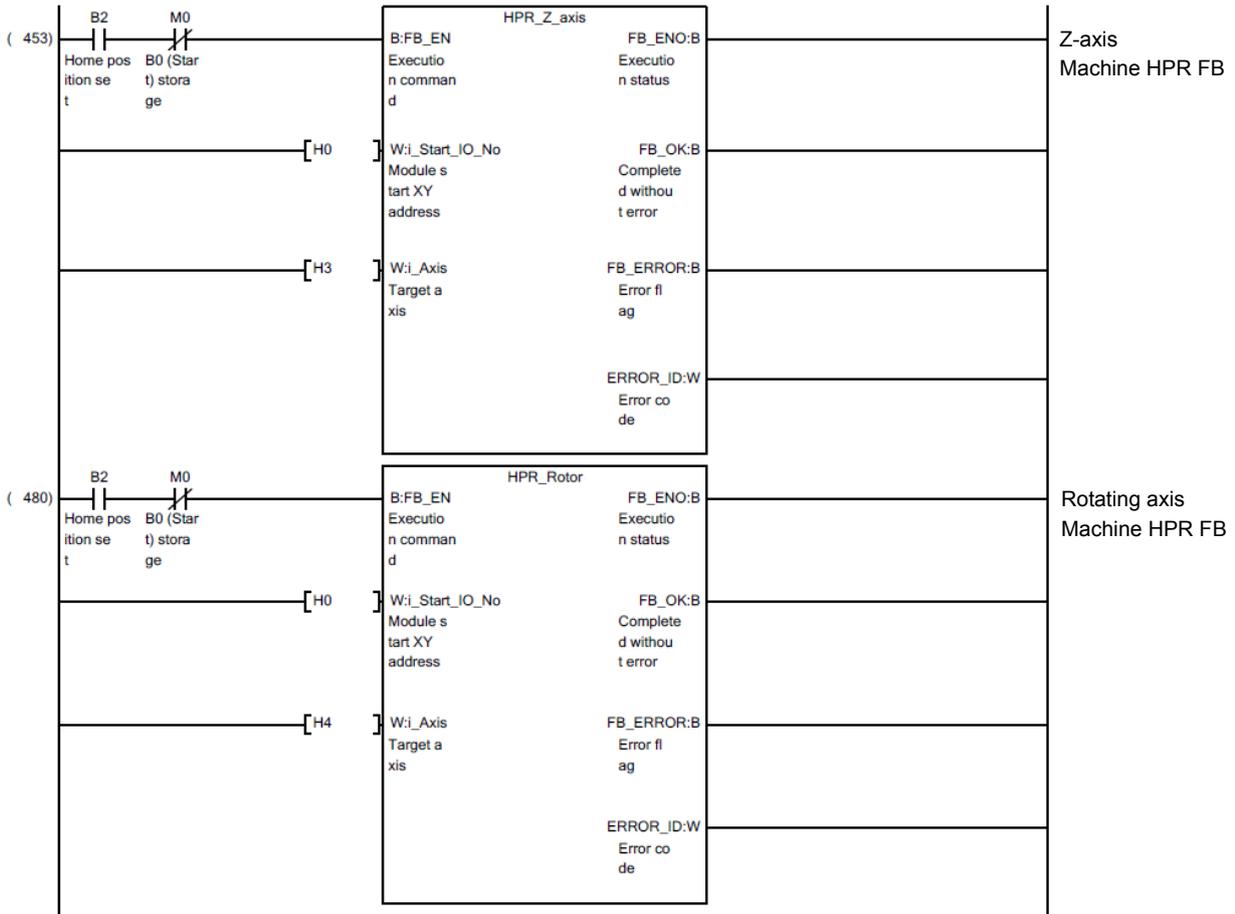




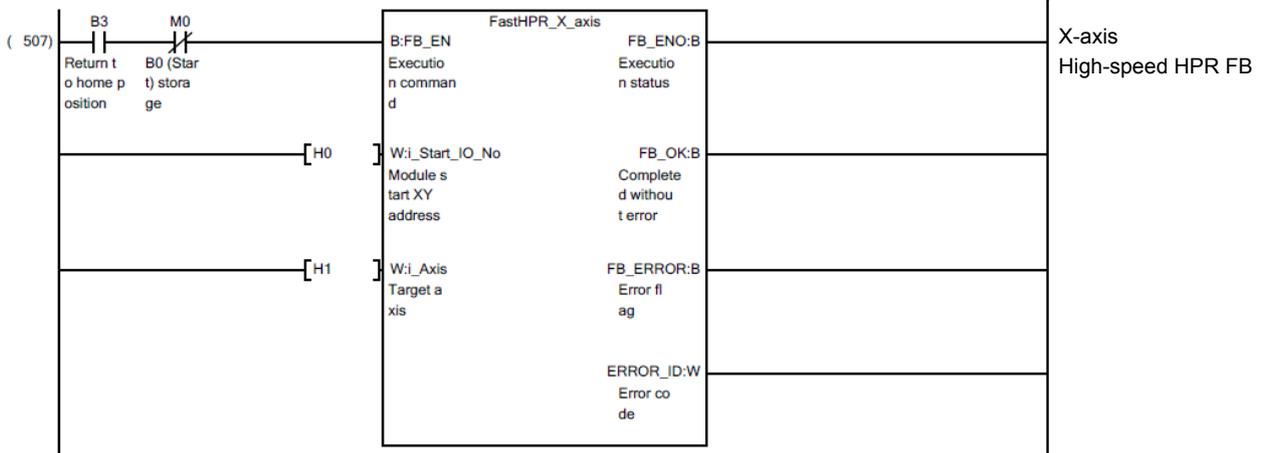


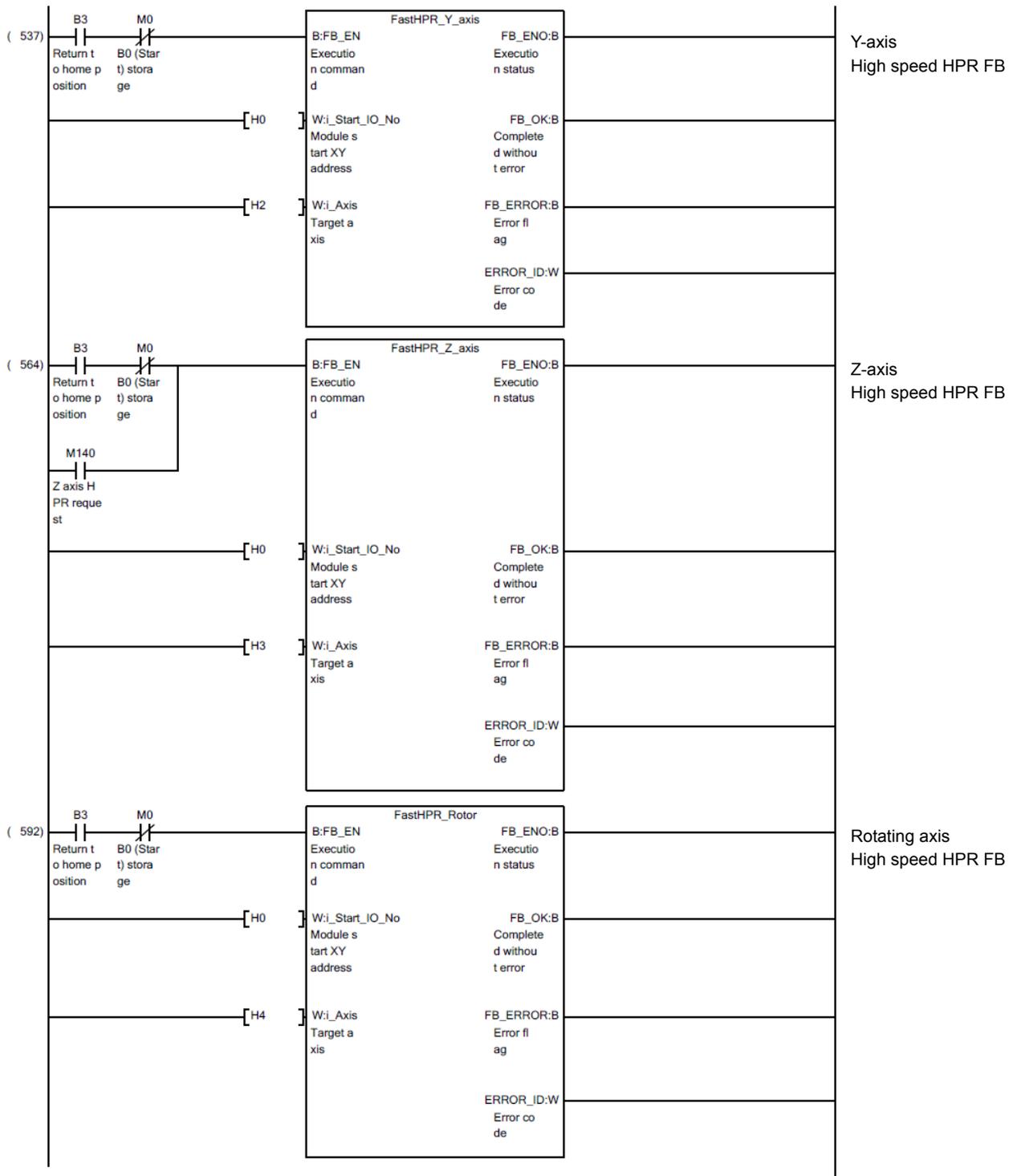
Machine Home Position Return



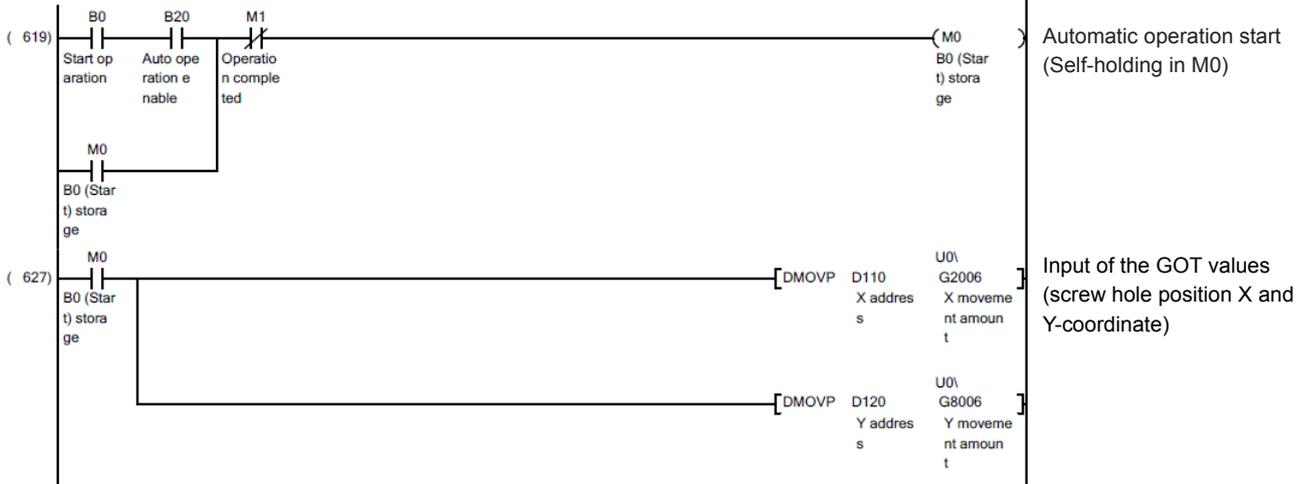


High Speed Home Position Return

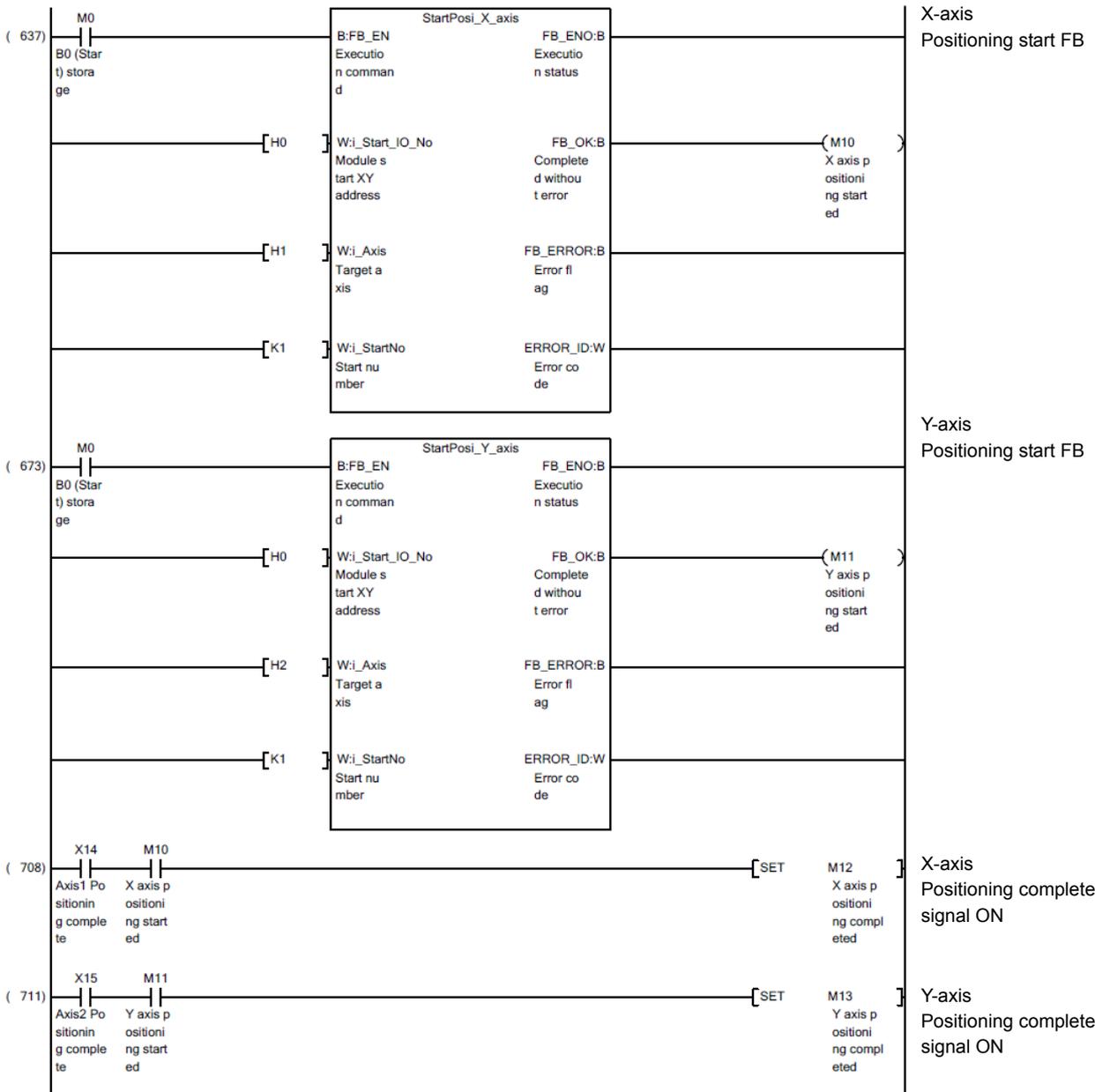


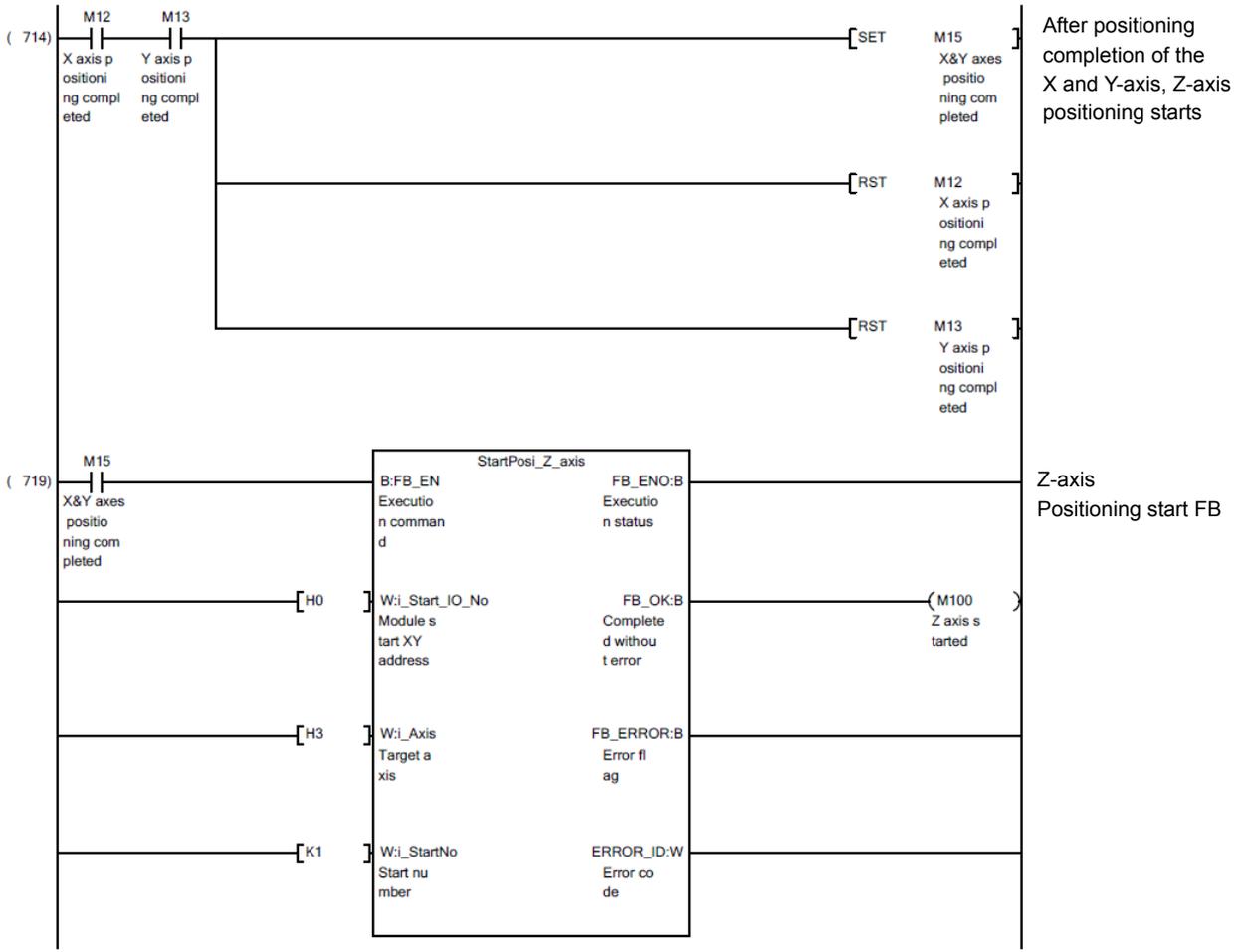


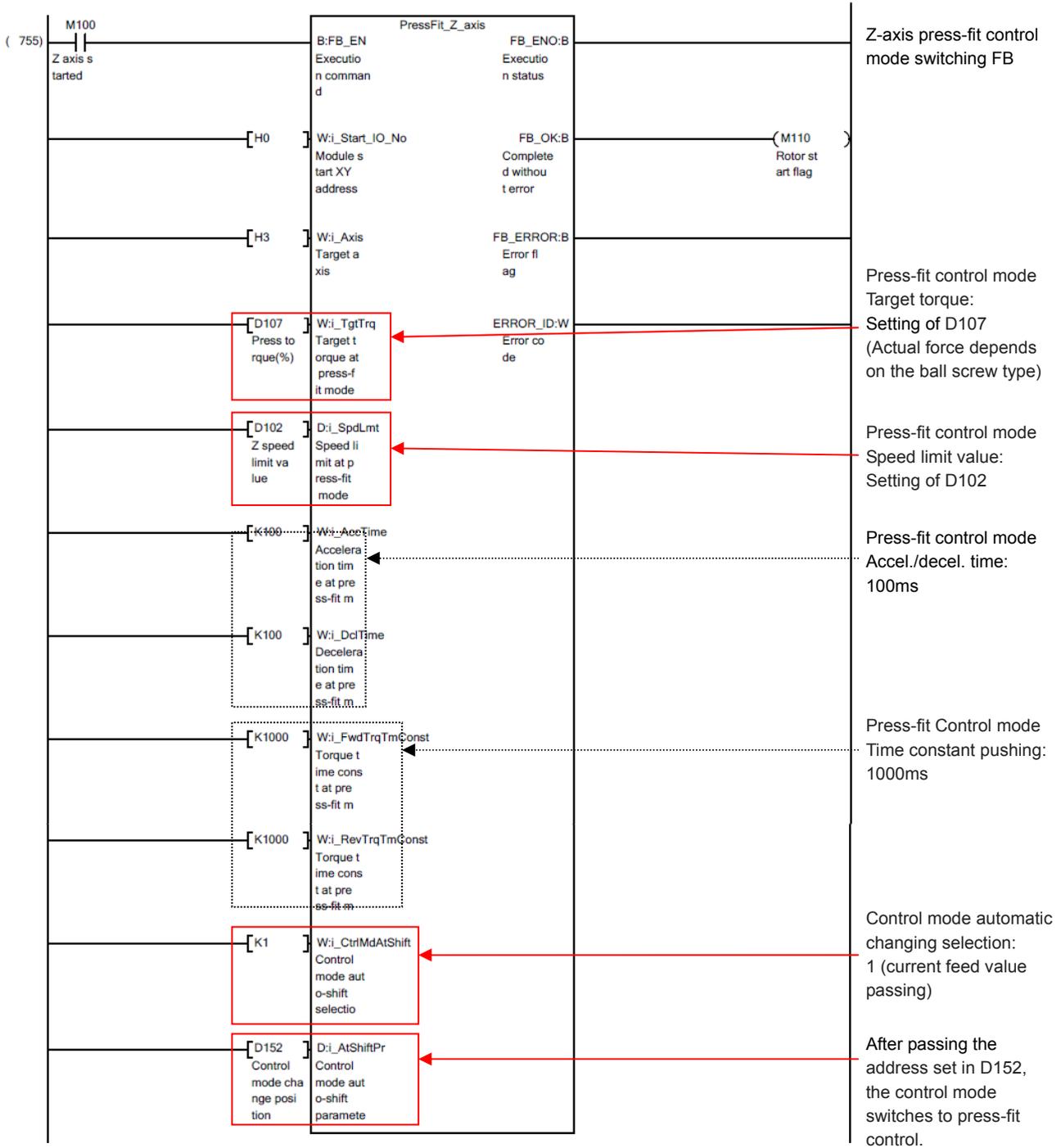
Automatic Operation

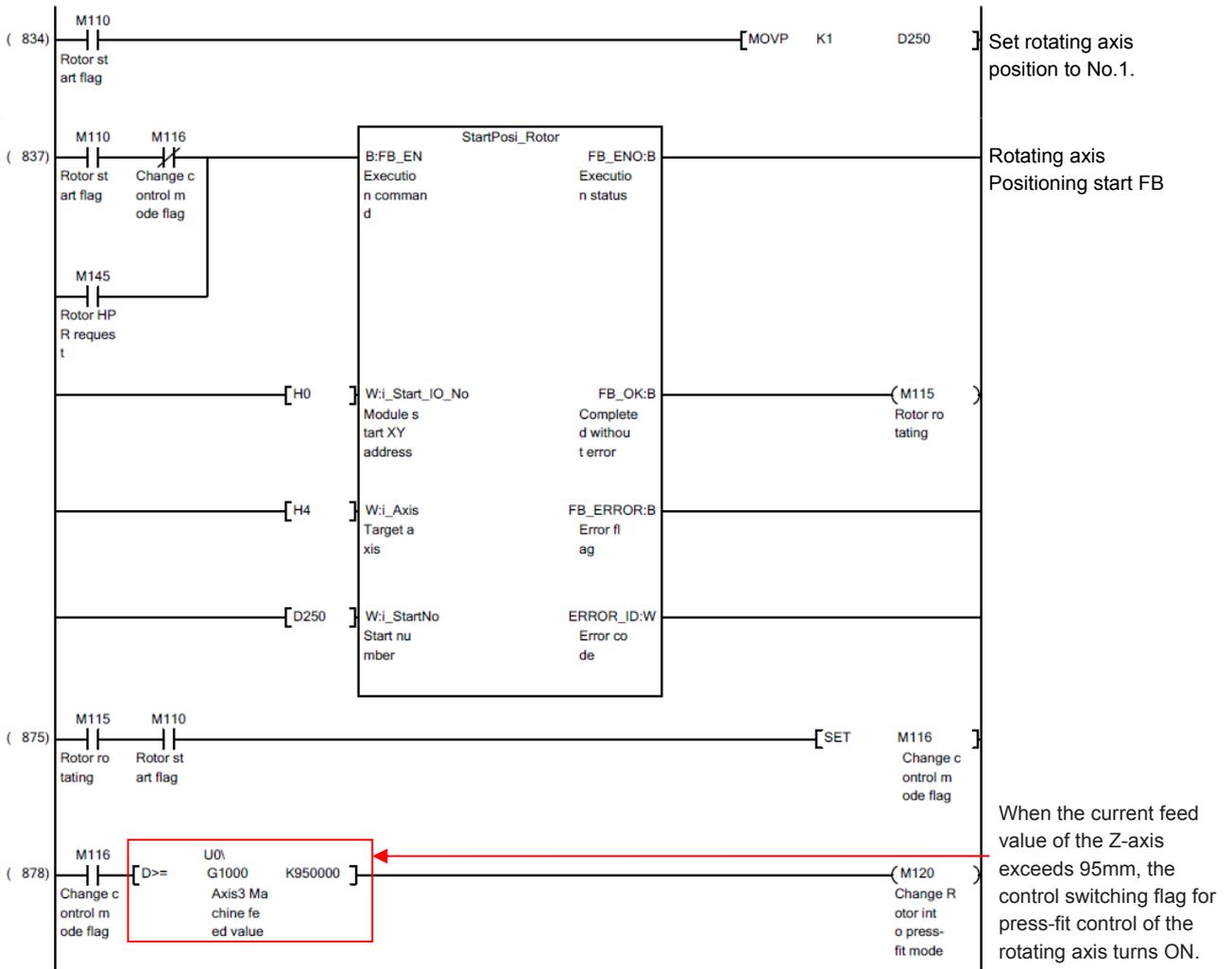


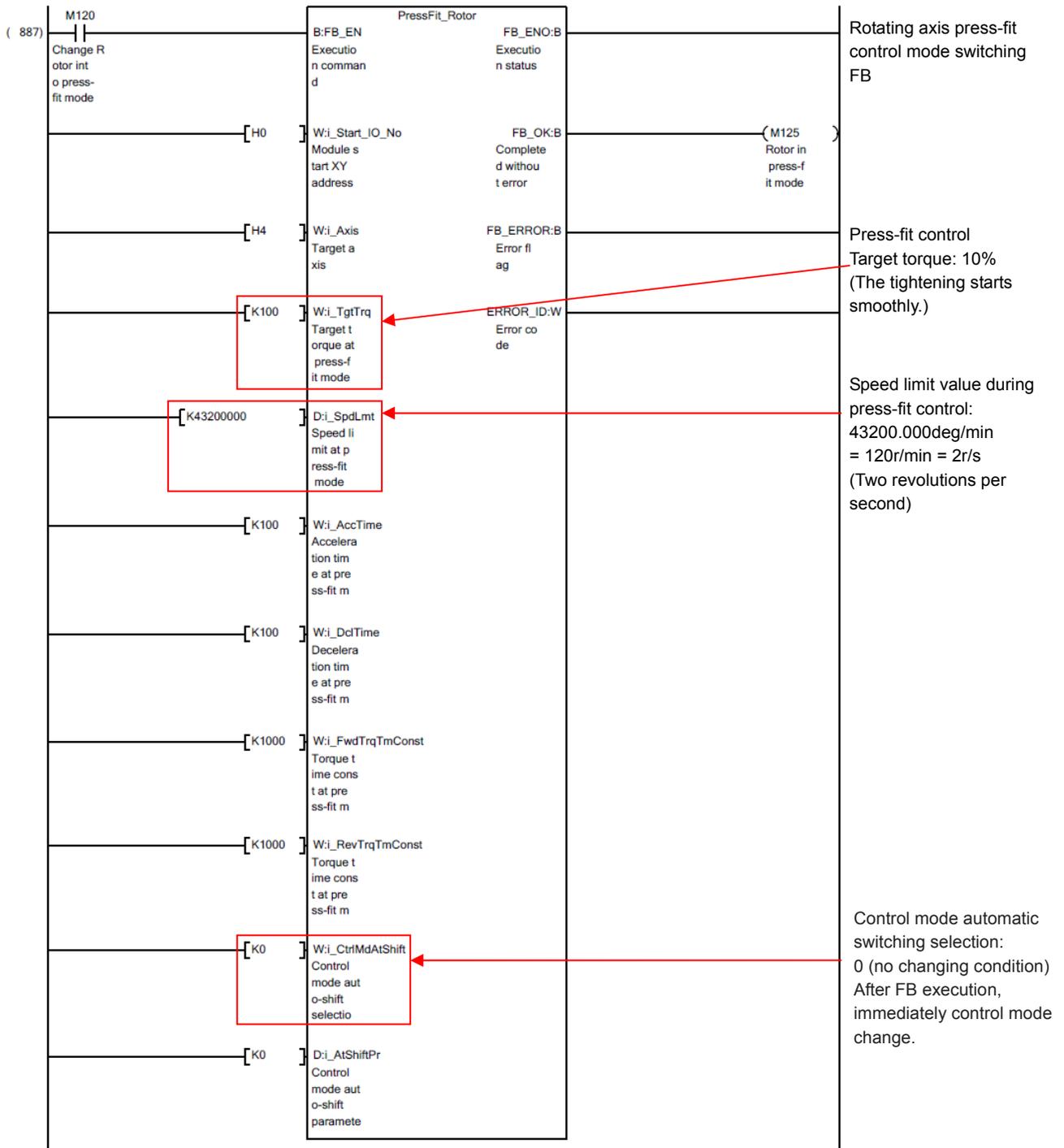
Before X and Y-axis positioning start FB execution, set the positioning data of both axis set in GOT screen.

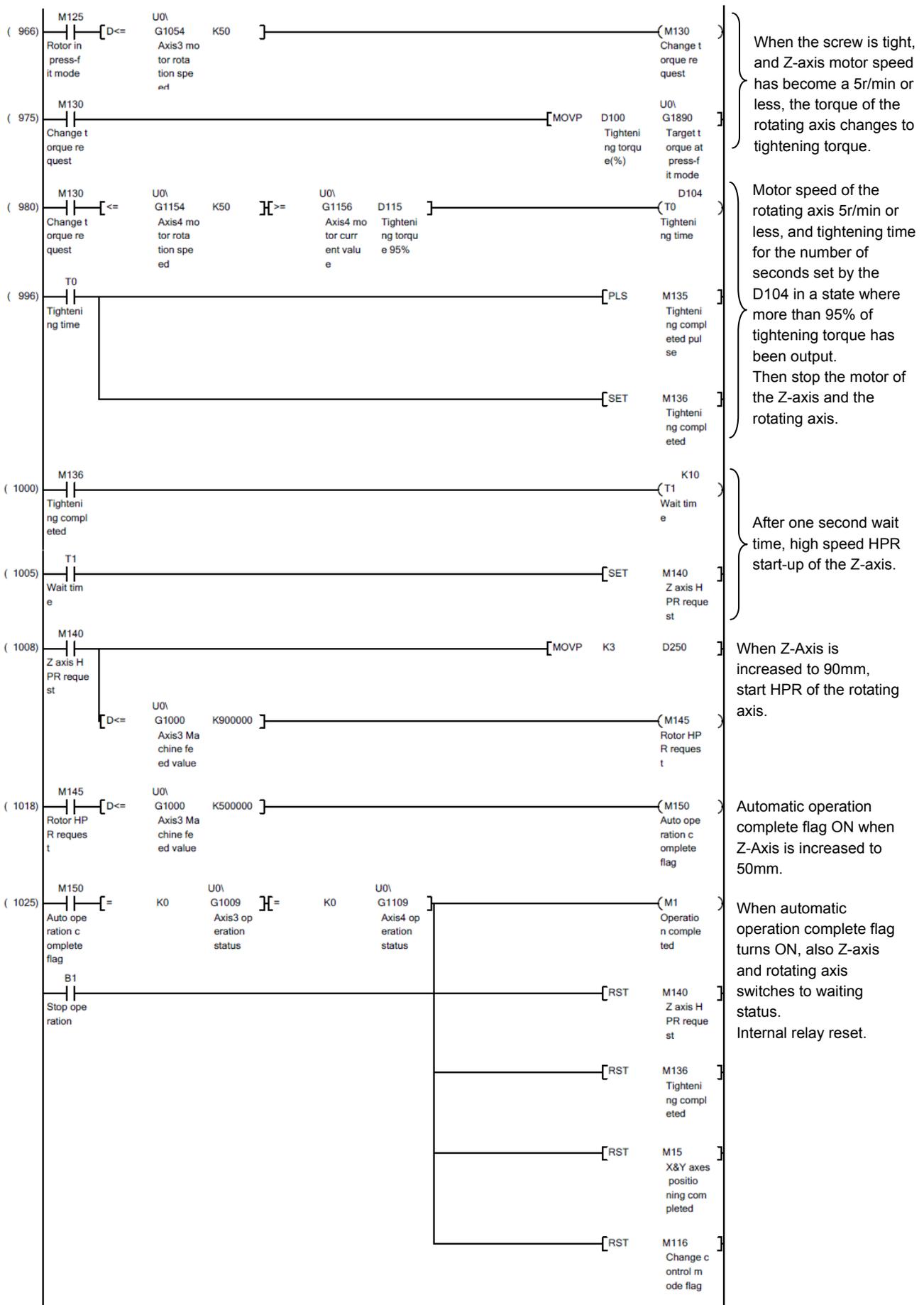




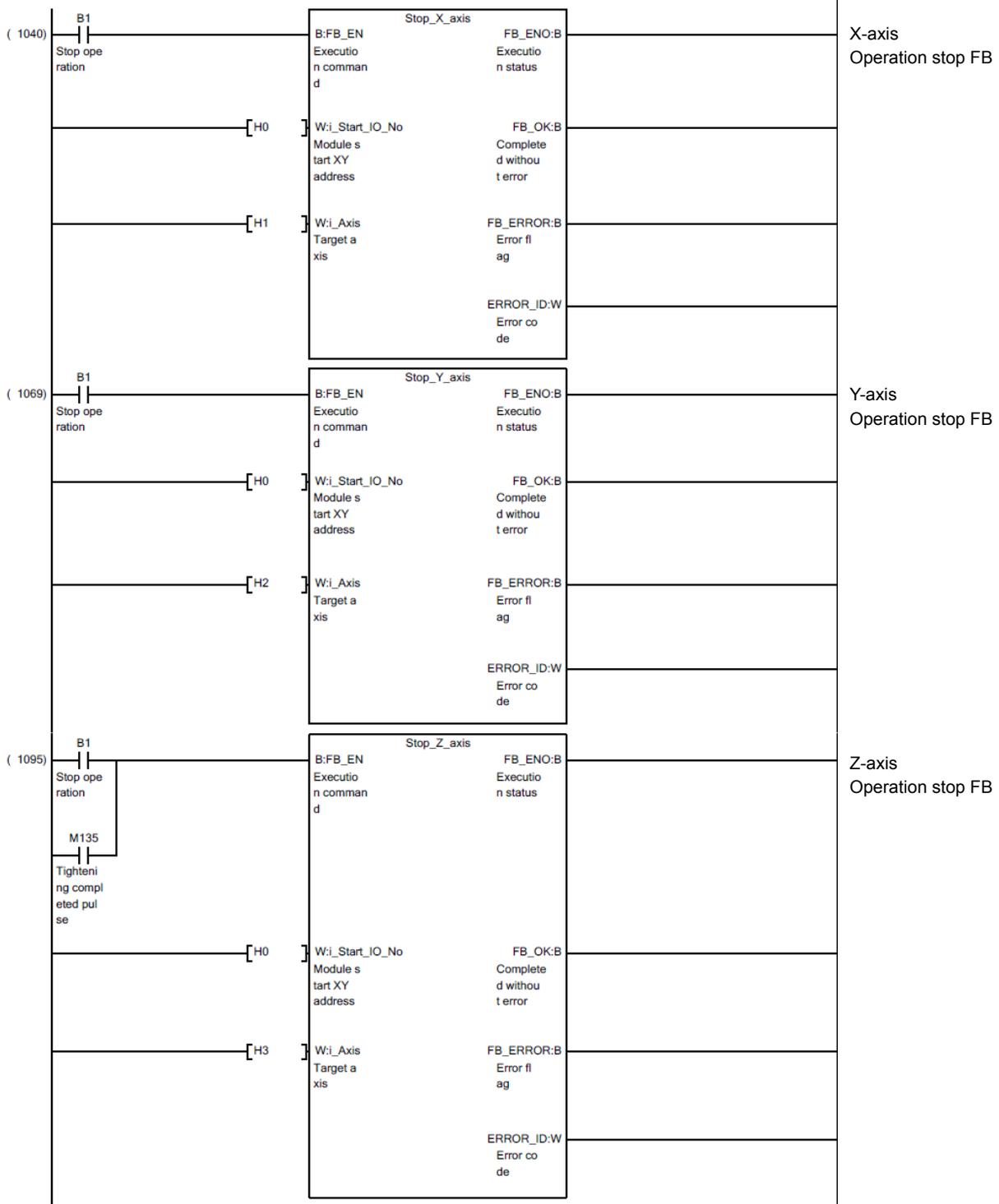


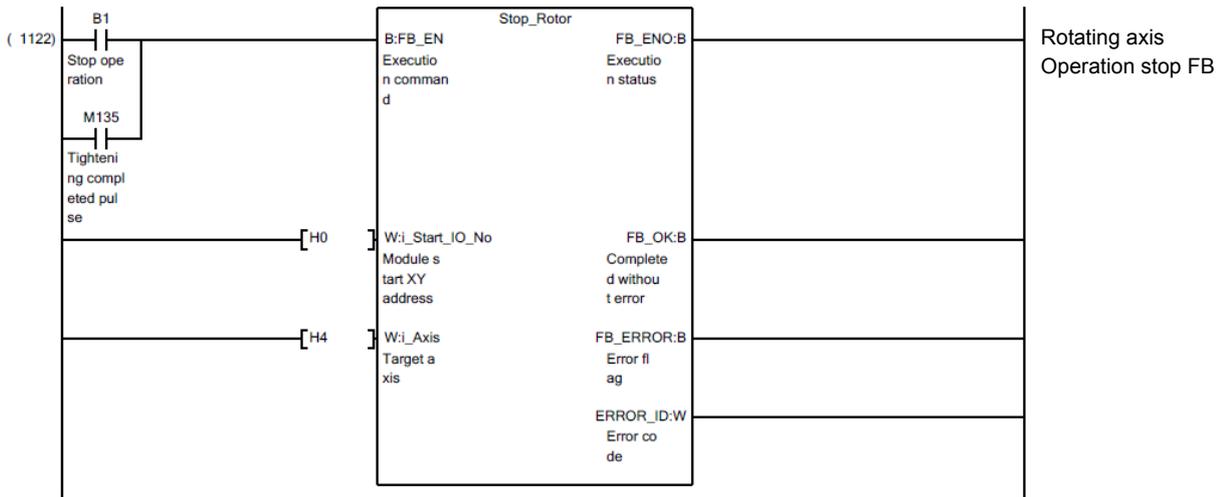






Automatic Operation Stop Processing

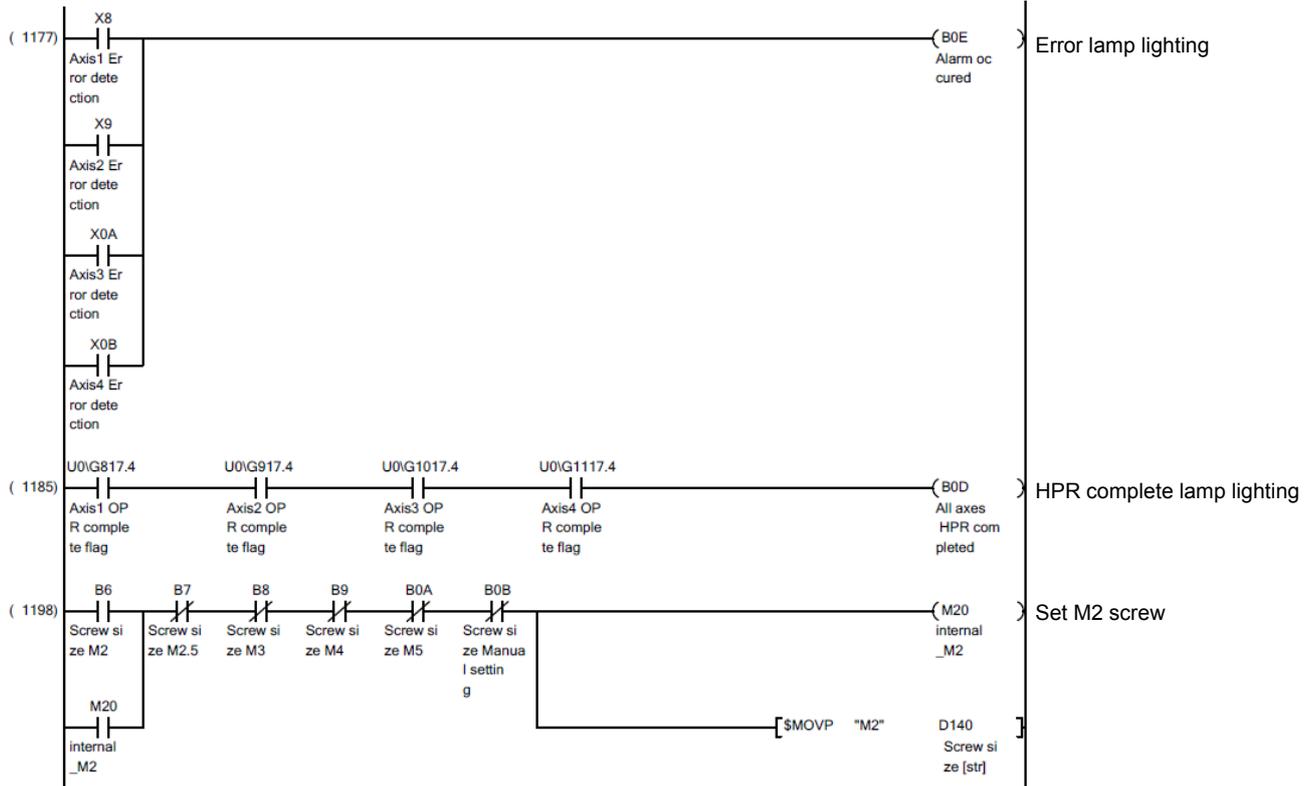


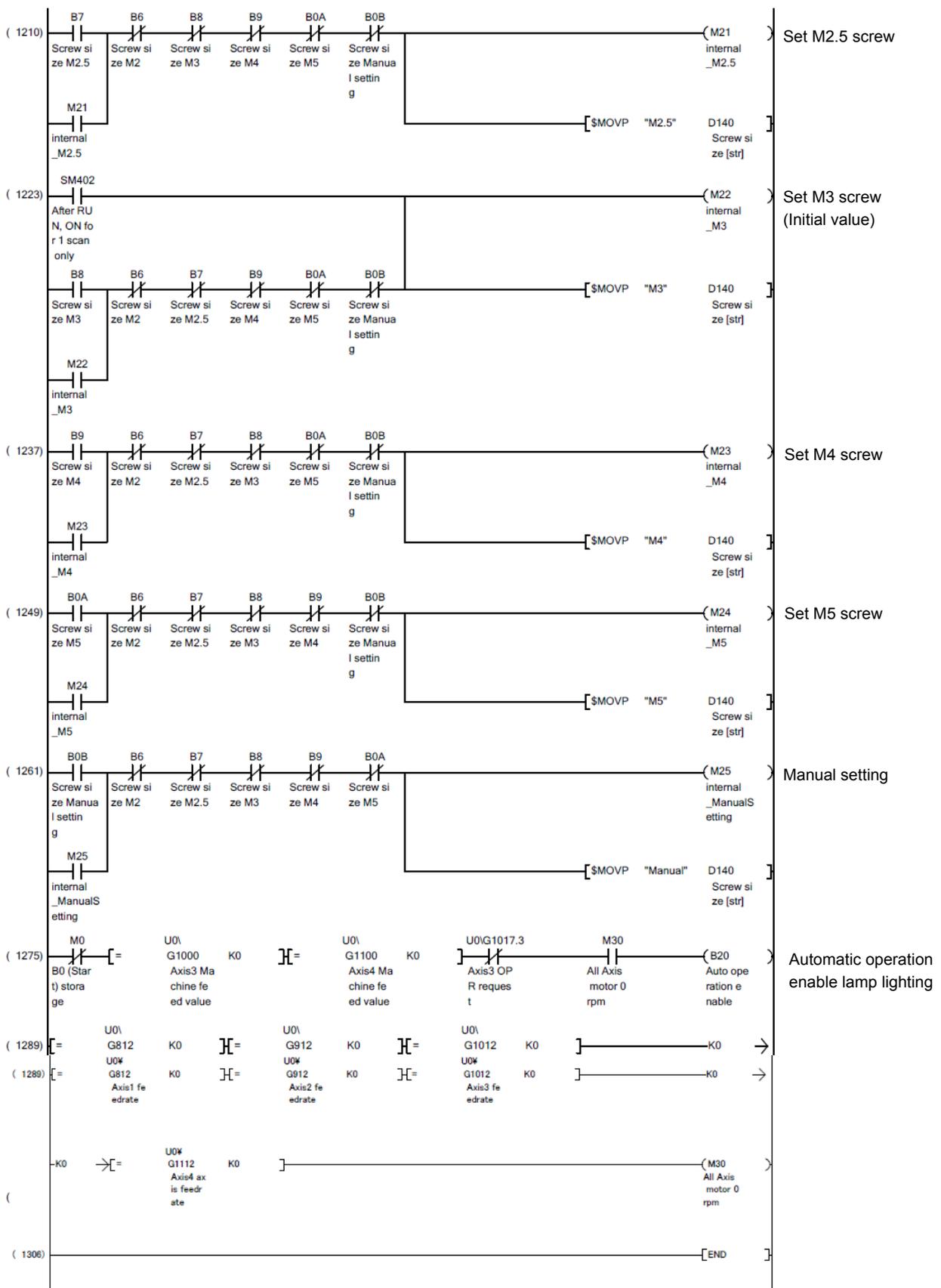


Error Reset



GOT Monitoring Signals





END

BCN-B62005-680-A