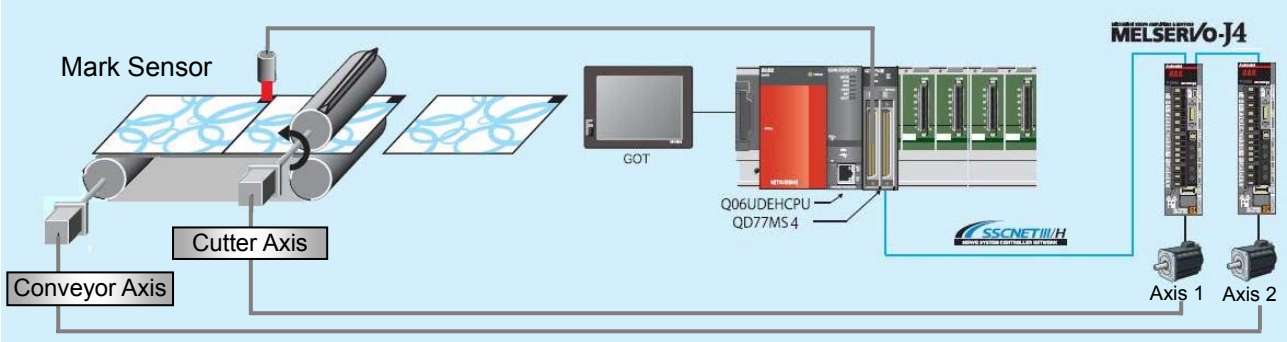
Rotary Knife

[System Configuration]



[Mitsubishi solution]

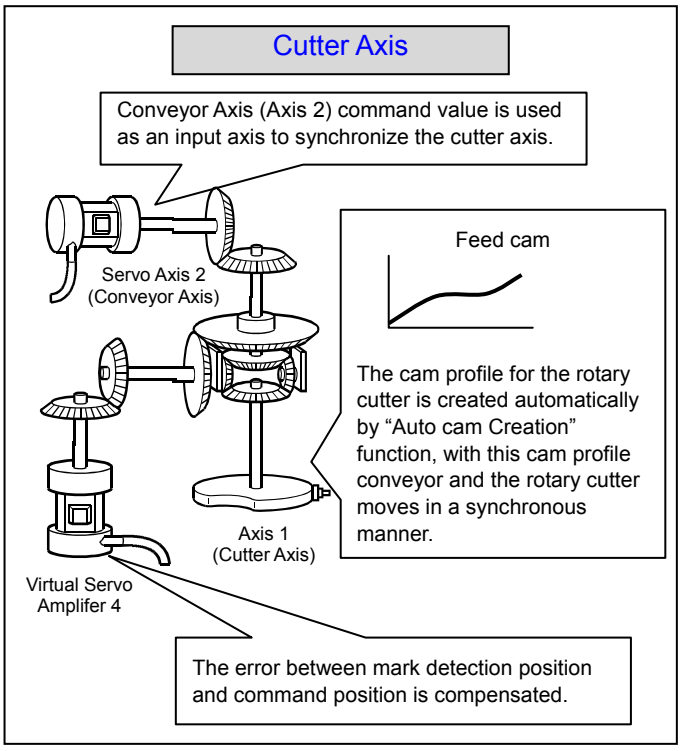
PLC CPU: Q06UDEHCPU **Simple Motion module: QD77MS4** **GOT: GT165*-V**
Main base: Q35DB **Servo amplifier: MR-J4-B** **Servo motor: HG-SR**
Engineering environment: MELSOFT GX Works2 (PLC), MELSOFT GT Works3 (GOT)

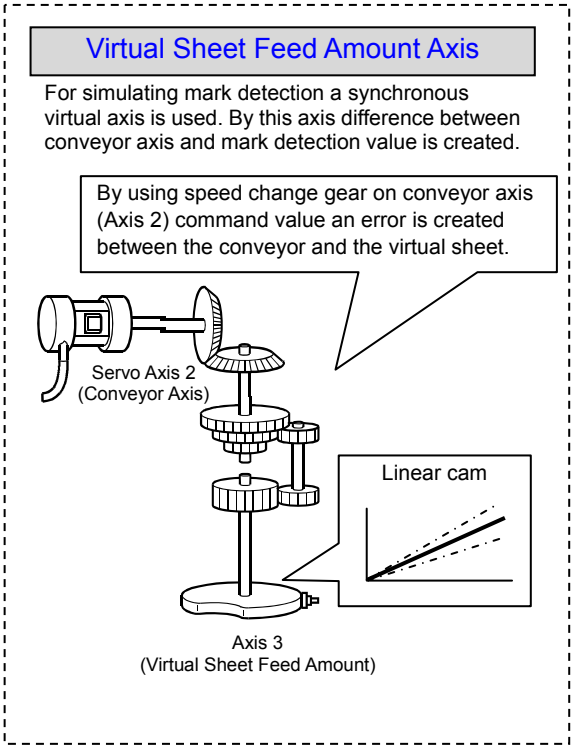
[Operation Overview]

- The rotary knife cuts the sheet that is fed at constant speed with the conveyor to the desired length. When the sheet is being cut the cutter speed and the conveyor speed are synchronized and the cutting is performed.
- To overcome the variations in sheet length and the error caused by slippage of the sheet the registration mark is read and cutting position is compensated.

[Points of Control]

Point1: The cam profile for the rotary cutter is created automatically by “Auto cam Creation” function, with this cam profile conveyor and the rotary cutter moves in a synchronous manner.
Point2: The error (slippage) is detected from the registration mark just as Mark Detection function then the amount error is compensated.



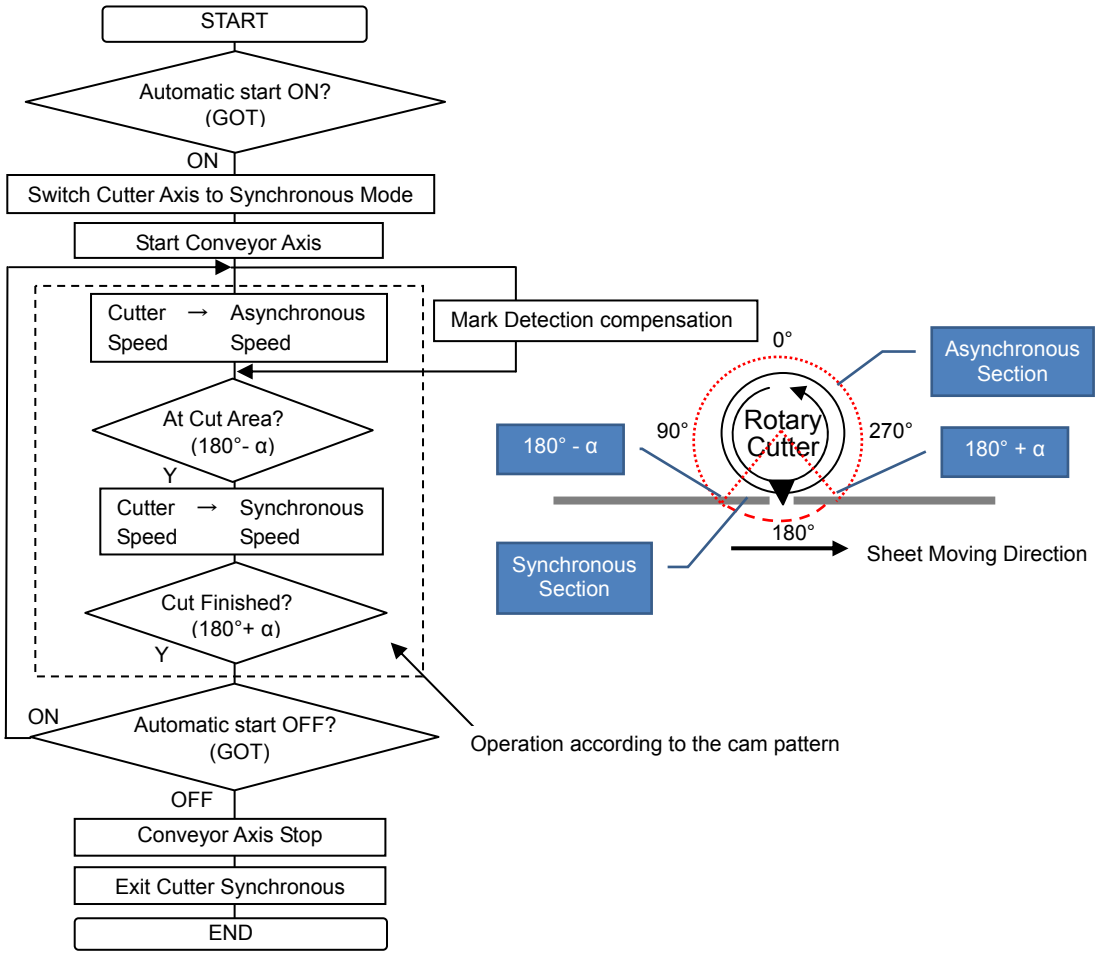


BCN-B62005-666-A

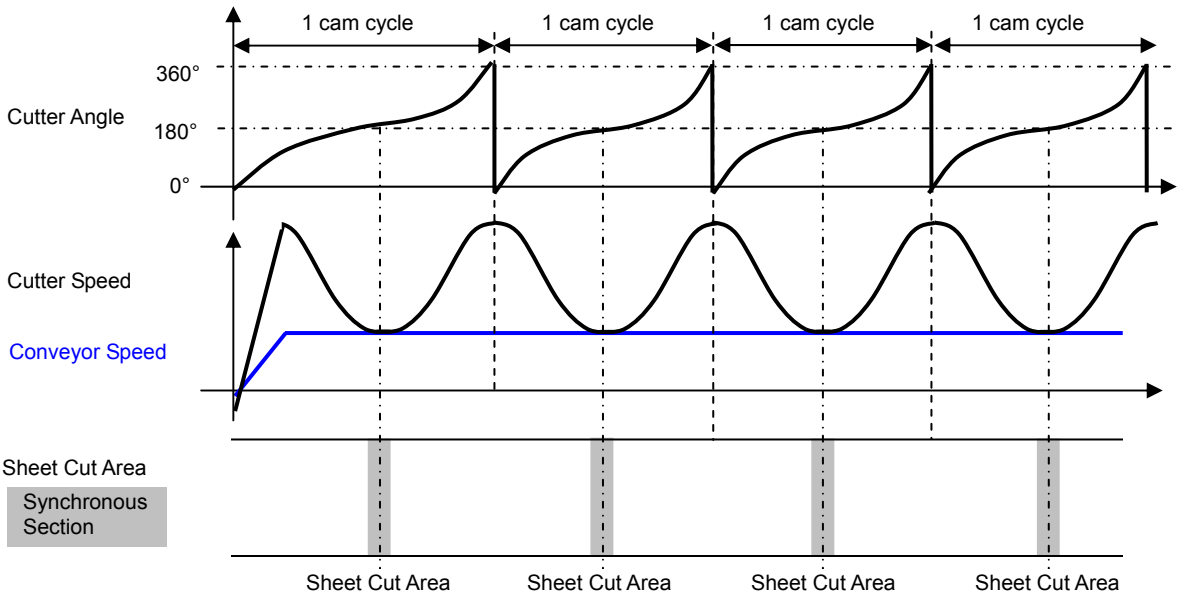
[Each Axis Control Detail]

- Conveyor Axis: Speed control at constant speed
- Cutter Axis: Synchronized with the conveyor axis following a cam pattern (one direction movement)

[Operation Flowchart]



[Operation Time Chart]



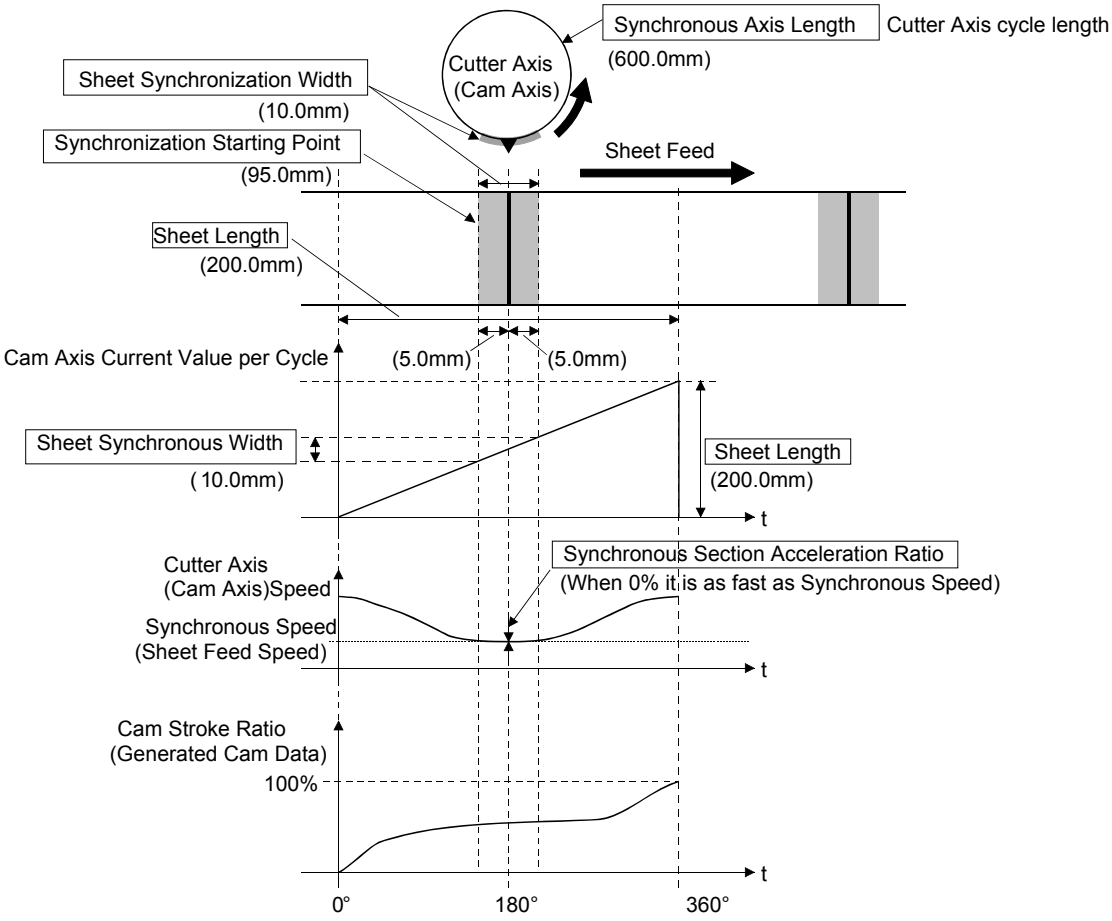
[Cam Pattern Automatic Generation for Rotary Knife]

In ladder program the parameter below set then Automatic Cam Generation is requested. The rotary cutter cam pattern is generated and saved inside the cam number set in the parameters.

Setting Item (Buffer Mem.)	Setting Content	Setting Range	Example Settings
Cam auto-generation request (53200)	- Set the request for cam auto-generation. - The Simple Motion module resets the value to "0" automatically after completion of the cam auto generation.	1:Cam auto-generation request	-
Cam auto-generation cam No. (53201)	- Set the No. of the cam to be generated automatically.	1~256	1
Cam auto-generation type (53202)	- Set the type of cam auto-generation.	1:Cam for rotary cutter	1
Cam resolution (53204)	- Set the cam resolution for generating the cam.	256/512/1024/2048/4096/ 8192/16384/32768	256
Sheet Length (53206, 53207)	- Set the sheet length. - Set this value in the cam axis length per cycle.	1~2147483647	2000 (Note-1) [x 0.1mm]
Sheet synchronization width (53208, 53209)	- Set the sheet length of the synchronous section.	1~2147483647	100 [x 0.1mm]
Synchronous axis length (53210, 53211)	- Set the cycle length of the rotary cutter shaft.	1~2147483647	6000 [x 0.1mm]
Synchronization starting point (53212, 53213)	- Set the length from the beginning of the sheet to the start of the synchronous section.	0~2147483647	950 (Note-2) [x 0.1mm]
Synchronous section acceleration ratio (53214)	- Set when the synchronous speed in the synchronous section needs to be adjusted. The speed is "Synchronous speed (100% + Acceleration ratio)" in the synchronous section.	-5000~5000[0.01%]	0 [%]

(Note-1): 200.0mm (Sheet Length) is the initial setting in the sample program.

(Note-2): 95.0mm (Synchronization starting point) is the initial setting in the sample program.
The ±5mm area from the middle of the sheet length is selected as the synchronous section.

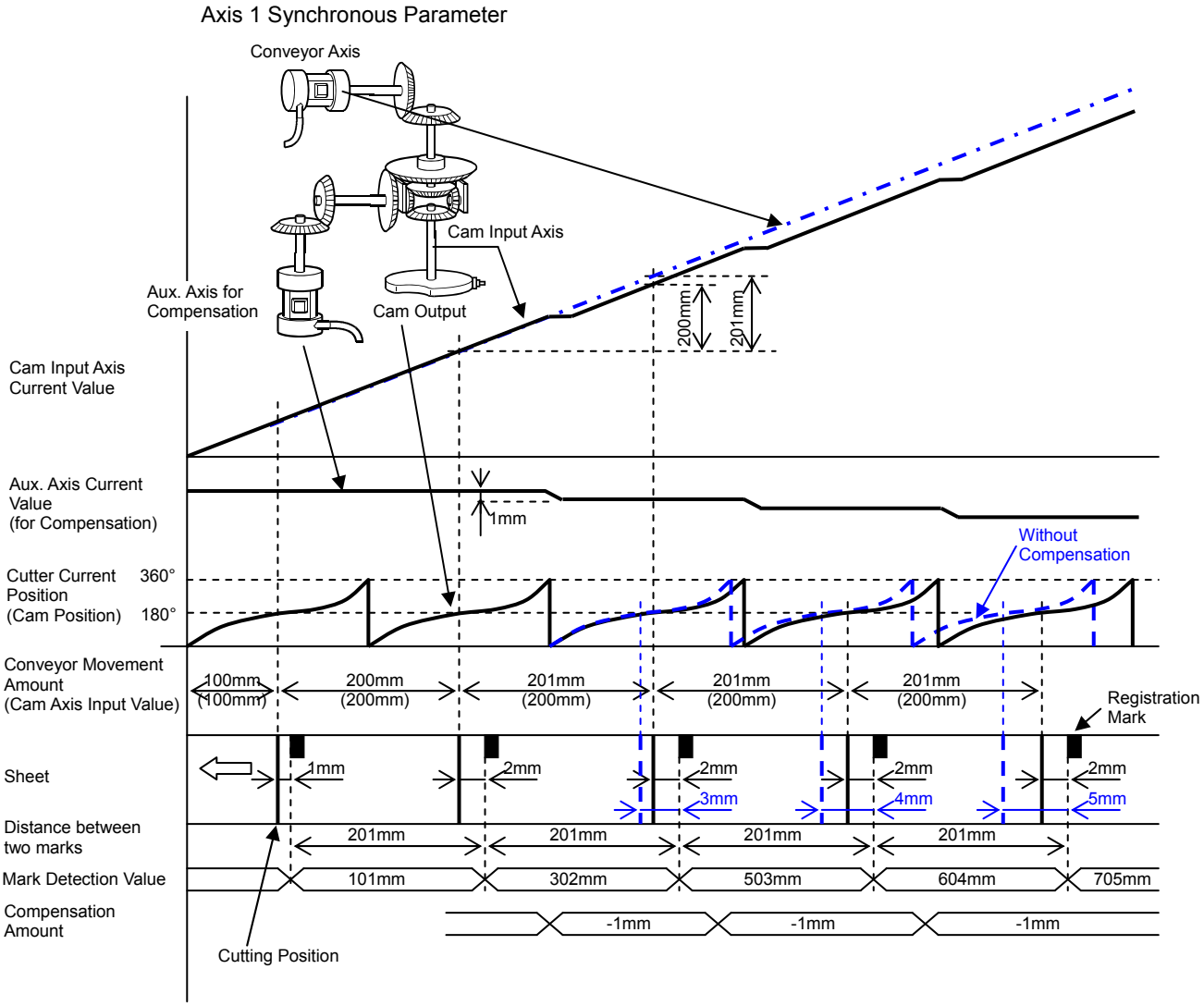

Synchronous Axis Length
Cutter Axis cycle length
(600.0mm)
Cutter Axis
(Cam Axis)
Sheet Synchronization Width
(10.0mm)
Synchronization Starting Point
(95.0mm)
Sheet Feed
Sheet Length
(200.0mm)
Cam Axis Current Value per Cycle
(5.0mm)
(5.0mm)
Sheet Synchronous Width
(10.0mm)
Sheet Length
(200.0mm)
t
Cutter Axis
(Cam Axis)Speed
Synchronous Section Acceleration Ratio
(When 0% it is as fast as Synchronous Speed)
Synchronous Speed
(Sheet Feed Speed)
t
Cam Stroke Ratio
(Generated Cam Data)
100%
t
0°
180°
360°

[Mark Detection Compensation]

The registration marks that are printed equal distances apart (Product length) are detected and the distance between marks are measured.
The difference between measured distance and the set cutting length is compensated so that the cutter axis and the conveyor moves synchronously.

[Sample Program Control Example]

When the sheet length setting is 200mm, and due to stretch, mark is not detected unless conveyor feeds 201mm of sheet.



For Mark Compensation Ladder program and Simple Motion setting example, refer to the contents of the following pages. (Ladder Program: Page 16, Mark Detection Settings: Page 9, Synchronous Control Parameters: Page 10, 11)

[Using the sample program]

[Sample program configuration]

File name	Description	Model	Programming tool
Vol2_R_Cutter_PLC.gxw	Ladder program	Q06UDEHCPU	MELSOFT GX Works2
Vol2_R_Cutter _Motion.pcw	Motion setting file	QD77MS4	
Vol2_R_Cutter _GOT.GTW	GOT monitoring data	GT165*-V (640x480)	MELSOFT GT Works3

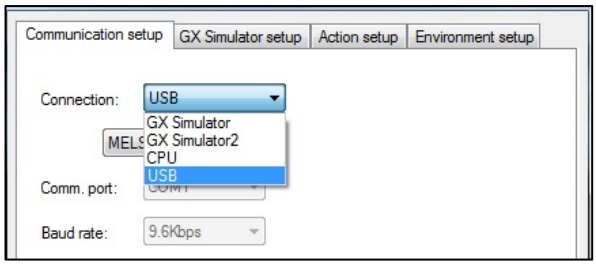
(Note): Equipment other than the servo amplifiers and servo motor in the system configuration (page 1) are required to operate sample program. Remove the circuit of amplifier-less operation function when connecting a servo amplifier to check the operation (page 13).

[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 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. When writing all programs was completed, reset the PLC program.

[Operating method]

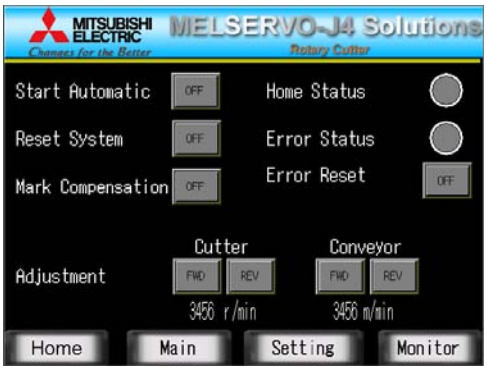
Start operation by using the GOT touch button.
When you do not have GOT, operate the device with the appropriate touch button in GT Works3's simulator function (Note) or GX Works2's device test function.
(Note): When using GX Works3's simulator function, click on the "communication setup" tab of "Simulator setup" and select "USB" or "CPU(RS-232)" from the pull-down menu of "connection".



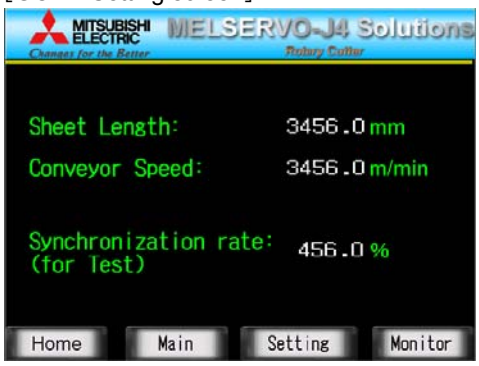
1. When you start-up the system, on the GOT screen press "Reset system" button to perform home position return operation. Home position return complete lamp turns on when operation is completed.
2. After home position return operation is completed, press "Start Automatic" button, then automatic operation is started. Automatic operation is also stopped by pressing "Start Automatic" button.
3. When Synchronization Rate Setting is changed from the screen during automatic operation, the cut length becomes "Sheet Length" x "Synchronization Rate" and with that an error occurs between the sheet length setting and cut length (Monitor Screen: Cutting Error) during this situation if the "Mark Compensation" button is pressed on the main screen this Cutting Error is compensated.
4. Each axis can be operated independently by using the JOG touch buttons.

[GOT : Home screen]

[GOT : Main screen]



[GOT : Setting screen]



[GOT : Monitor screen]

[Operation check method]

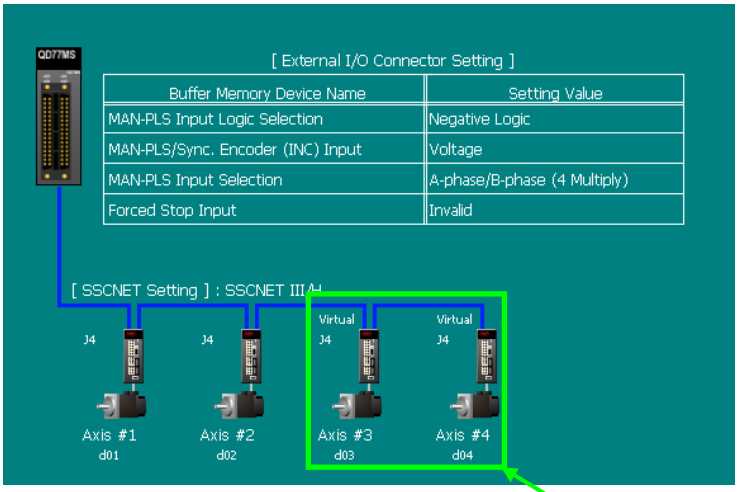
1. Start the digital oscilloscope function of Simple Motion module setting tool.
2. A trigger condition is automatic operation start (B0). During automatic operation, speed waveform of each axis is registered.
3. Check collected waveforms with operation pattern.

⚠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]



Virtual servo amplifier

- Axis1: Cutter Axis (MR-J4-B)
- Axis2: Conveyor Axis (MR-J4-B)
- Axis3: For creating Virtual Sheet Feed Amount (creating Synchronous Error) (Virtual Servo Amplifier)
- Axis4: Mark Detection Compensation (Virtual Servo Amplifier)

[Parameters]

- Movement amount per motor rotation
  - Cutter axis : 90degree/rev
  - Conveyor axis, Virtual servo amplifier axis : 200mm/rev
- Speed limit settings
  - Cutter axis : 90degree/rev × 3000r/min = 270000degree/min (750 sheets/min)
  - Conveyor axis, Virtual servo amplifier axis : 200mm/rev × 3000r/min = 600000mm/min

Item	Axis #1	Axis #2	Axis #3	Axis #4
Basic parameters 1	**Set according to the machine and applicable motor when system is started up. (This parameter become valid when the PLC READY signal [Y0] turns from OFF to ON.)**			
Pr.1:Unit setting	2:degree	0:mm	0:mm	0:mm
Pr.2:No. of pulses per rotation	4194304 PLS	4194304 PLS	4194304 PLS	4194304 PLS
Pr.3:Movement amount per rotation	90.00000 degree	200000.0 µm	200000.0 µm	200000.0 µm
Pr.4:Unit magnification	1:x1 Times	1:x1 Times	1:x1 Times	1:x1 Times
Pr.7:Bias speed at start	0.000 degree/min	0.00 mm/min	0.00 mm/min	0.00 mm/min
Basic parameters 2	**Set according to the machine and applicable motor when system is started up.**			
Pr.8:Speed limit value	270000.000 degree/min	600000.00 mm/min	600000.00 mm/min	600000.00 mm/min
Pr.9:Acceleration time 0	500 ms	1000 ms	1000 ms	100 ms
Pr.10:Deceleration time 0	500 ms	1000 ms	1000 ms	100 ms
Detailed parameters 1	**Set according to the system configuration when the system is started up. (This parameter become valid when the PLC READY signal [Y0] turns from OFF to ON)**			
Detailed parameters 2	**Set according to the system configuration when the system is started up. (Set as required.)**			
Pr.25:Acceleration time 1	1000 ms	1000 ms	1000 ms	1000 ms
Pr.26:Acceleration time 2	1000 ms	1000 ms	1000 ms	1000 ms
Pr.27:Acceleration time 3	1000 ms	1000 ms	1000 ms	1000 ms
Pr.28:Deceleration time 1	1000 ms	1000 ms	1000 ms	1000 ms
Pr.29:Deceleration time 2	1000 ms	1000 ms	1000 ms	1000 ms
Pr.30:Deceleration time 3	1000 ms	1000 ms	1000 ms	1000 ms
Pr.31:JOG speed limit value	270000.000 degree/min	600000.00 mm/min	200.00 mm/min	200.00 mm/min
Pr.32:JOG operation acceleration time selection	0:500	0:1000	0:1000	0:100
Pr.33:JOG operation deceleration time selection	0:500	0:1000	0:1000	0:100
Pr.34:Acceleration/deceleration process selection	0:Trapezoidal Acceleration/Deceleration Process	0:Trapezoidal Acceleration/Deceleration Process	0:Trapezoidal Acceleration/Deceleration Process	0:Trapezoidal Acceleration/Deceleration Process
Pr.35:S-curve ratio	100 %	100 %	100 %	100 %
Pr.36:Sudden stop deceleration time	1000 ms	1000 ms	1000 ms	1000 ms
Pr.37:Stop group 1 sudden stop selection	0:Normal Deceleration Stop	0:Normal Deceleration Stop	0:Normal Deceleration Stop	0:Normal Deceleration Stop
Pr.38:Stop group 2 sudden stop selection	0:Normal Deceleration Stop	0:Normal Deceleration Stop	0:Normal Deceleration Stop	0:Normal Deceleration Stop
Pr.39:Stop group 3 sudden stop selection	0:Normal Deceleration Stop	0:Normal Deceleration Stop	0:Normal Deceleration Stop	0:Normal Deceleration Stop
Pr.40:Positioning complete signal output time	300 ms	300 ms	300 ms	300 ms
Pr.41:Allowable circular interpolation error width	0.00100 degree	10.0 µm	10.0 µm	10.0 µm
Pr.42:External command function selection	4:High Speed Input Request	0:External Positioning Start	0:External Positioning Start	0:External Positioning Start

Blue: Defualt Value
Black: Settings Made

[Mark detection settings]

Item	Setting 1	Setting 2	Setting 3	Setting 4
Mark detection setting				
Pr.800:Mark detection signal setting	1	0	0	0
Pr.801:Mark detection signal compensation time	0 μs	0 μs	0 μs	0 μs
Mark detection data setting				
Pr.802:Type	2:Real Current Value	0:Current Feed Value	0:Current Feed Value	0:Current Feed Value
Pr.803:Axis No.	2	0	0	0
Pr.804:Buffer memory No.	0	0	0	0
Pr.805:Latch data range upper limit value	0 x(10^-1)μm	0	0	0
Pr.806:Latch data range lower limit value	0 x(10^-1)μm	0	0	0
Mark detection mode setting				
Pr.807:Mark detection mode	Continuous Detection Mode	Continuous Detection Mode	Continuous Detection Mode	Continuous Detection Mode
Pr.807:Number of detections	0	0	0	0

Axis2: When the Mark Sensor ON it latches the Conveyor Axis current position.

(Note): There is no Mark Detection signal connected to the input for this sample program simulation. For simulation purposes an artificial mark signal is generated inside the PLC program. That's why only these Mark Detection settings are made.

[Positioning data]

Value that could be changed by PLC ladder program

Axis 1: Cutter axis home position return (Main point return)

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	01h:ABS Linear 1	-	0:500	0:500	0.00000 degree	0.00000 degree	3600.000 degree/min	0 ms	0
	<Positioning Comment>									

Axis 2: Conveyor 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	04h:FWD V1	-	0:1000	0:1000	0.0 μm	0.0 μm	20000.00 mm/min	0 ms	0
	<Positioning Comment>									

During Automatic Operation Speed Control is done at conveyor speed (GOT setting)

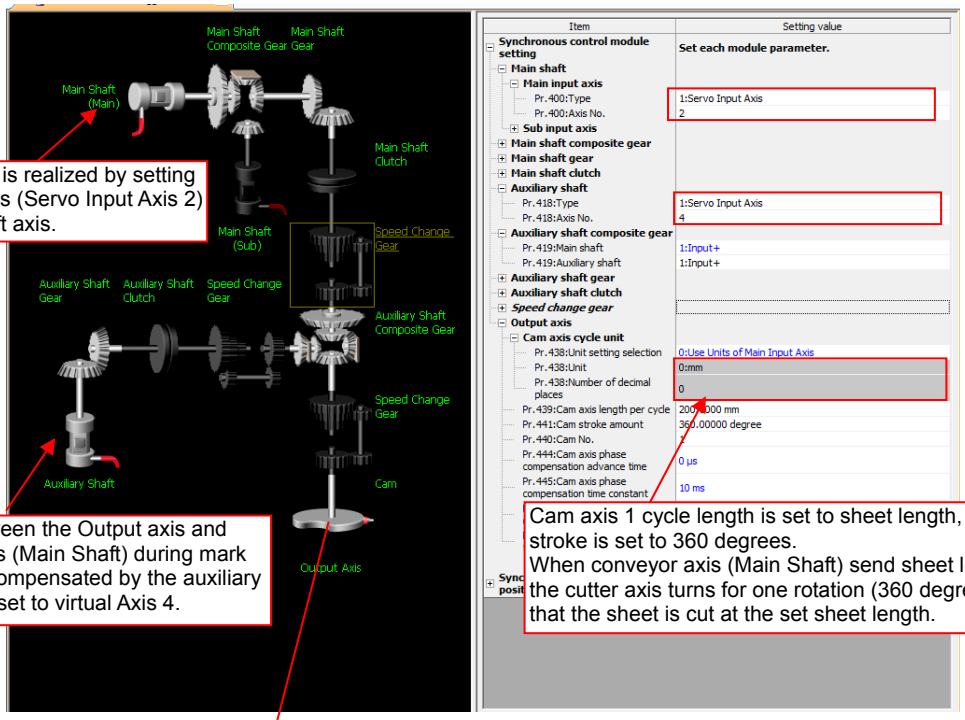
Axis 4 Virtual servo amplifier: Mark detection compensation

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	02h:INC Linear 1	-	0:100	0:100	200.0 μm	0.0 μm	600000.00 mm/min	0 ms	0
	<Positioning Comment>									

By using Mark Detection the real sheet length (Distance between marks) and Sheet length setting difference is calculated. Then by this value the set cutting length is compensated.

[Synchronous control parameter]

Axis 1 : Cutter Axis

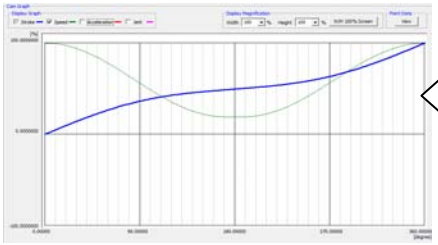


Synchronization is realized by setting the conveyor axis (Servo Input Axis 2) as the main shaft axis.

The gap between the Output axis and Conveyor axis (Main Shaft) during mark detection is compensated by the auxiliary axis which is set to virtual Axis 4.

Cam axis 1 cycle length is set to sheet length, and cam stroke is set to 360 degrees.
When conveyor axis (Main Shaft) send sheet length, the cutter axis turns for one rotation (360 degrees), so that the sheet is cut at the set sheet length.

Cam pattern

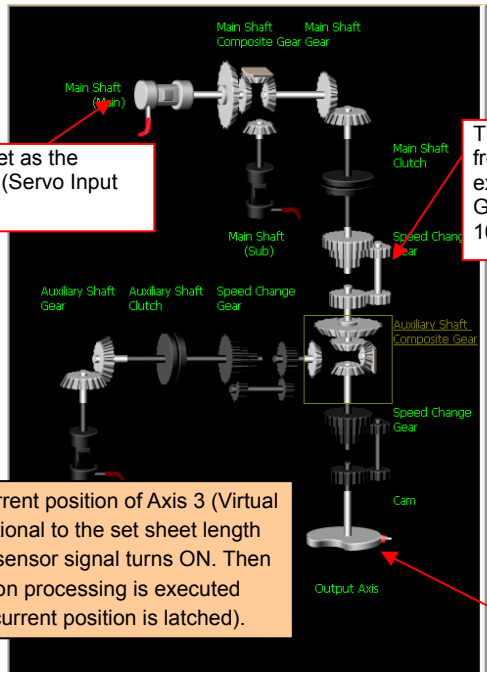


Auto Generation

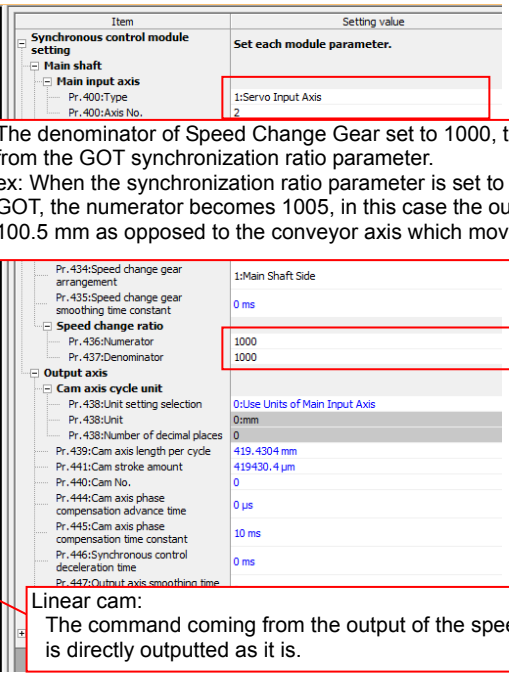
The settings below are made from ladder program. The cam used for Rotary Cutter is generated automatically.

Item	Setting Value
Cam Resolution	256
Sheet Length	2000
Sheet Synchronization Width	100
Synchronous Axis Length	6000
Synchronization Starting Point	950
Synchronous Section Acceleration Ratio	0

Axis 3 (Virtual Servo): Used for generating Virtual Sheet amount.
Conveyor axis difference is created by using a speed change gear regarding to the conveyor axis.
Then this value is used for mark detection compensation simulation purpose.



Shaft axis is set as the conveyor axis (Servo Input Axis 2)



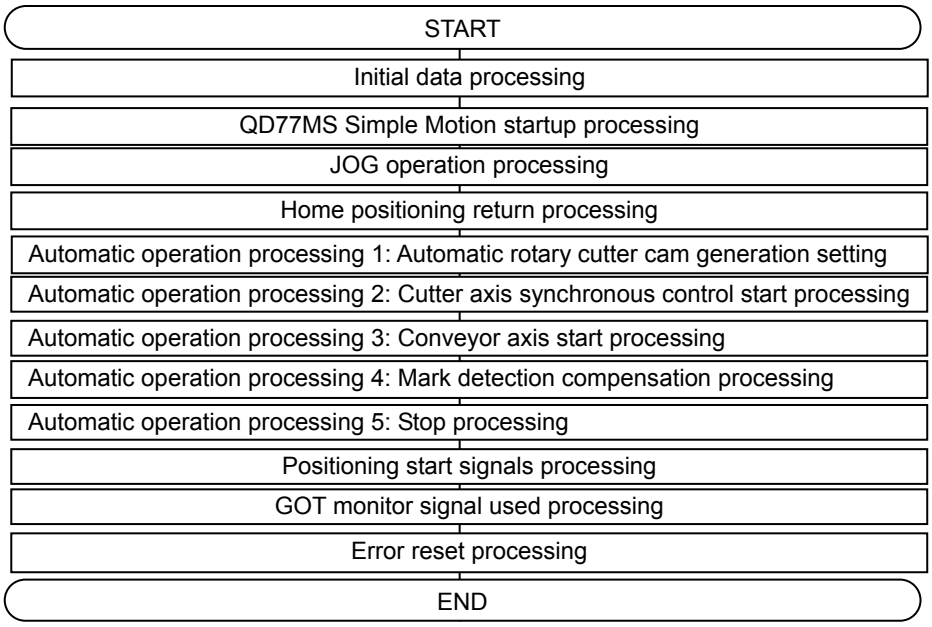
The denominator of Speed Change Gear set to 1000, the numerator is set from the GOT synchronization ratio parameter.
ex: When the synchronization ratio parameter is set to 100.5[%] from the GOT, the numerator becomes 1005, in this case the output axis moves for 100.5 mm as opposed to the conveyor axis which moves 100 mm.

At every time current position of Axis 3 (Virtual Sheet) is proportional to the set sheet length the virtual mark sensor signal turns ON. Then the mark detection processing is executed (Conveyor axis current position is latched).

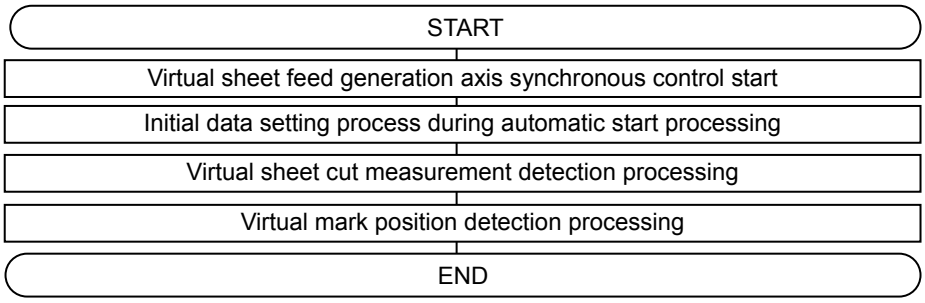
Linear cam:
The command coming from the output of the speed change gear is directly outputted as it is.

[Sample ladder program configuration]

[MAIN: Scan Execution]



[Mark_Sim: 0.5ms fixed cycle] Mark detection simulation

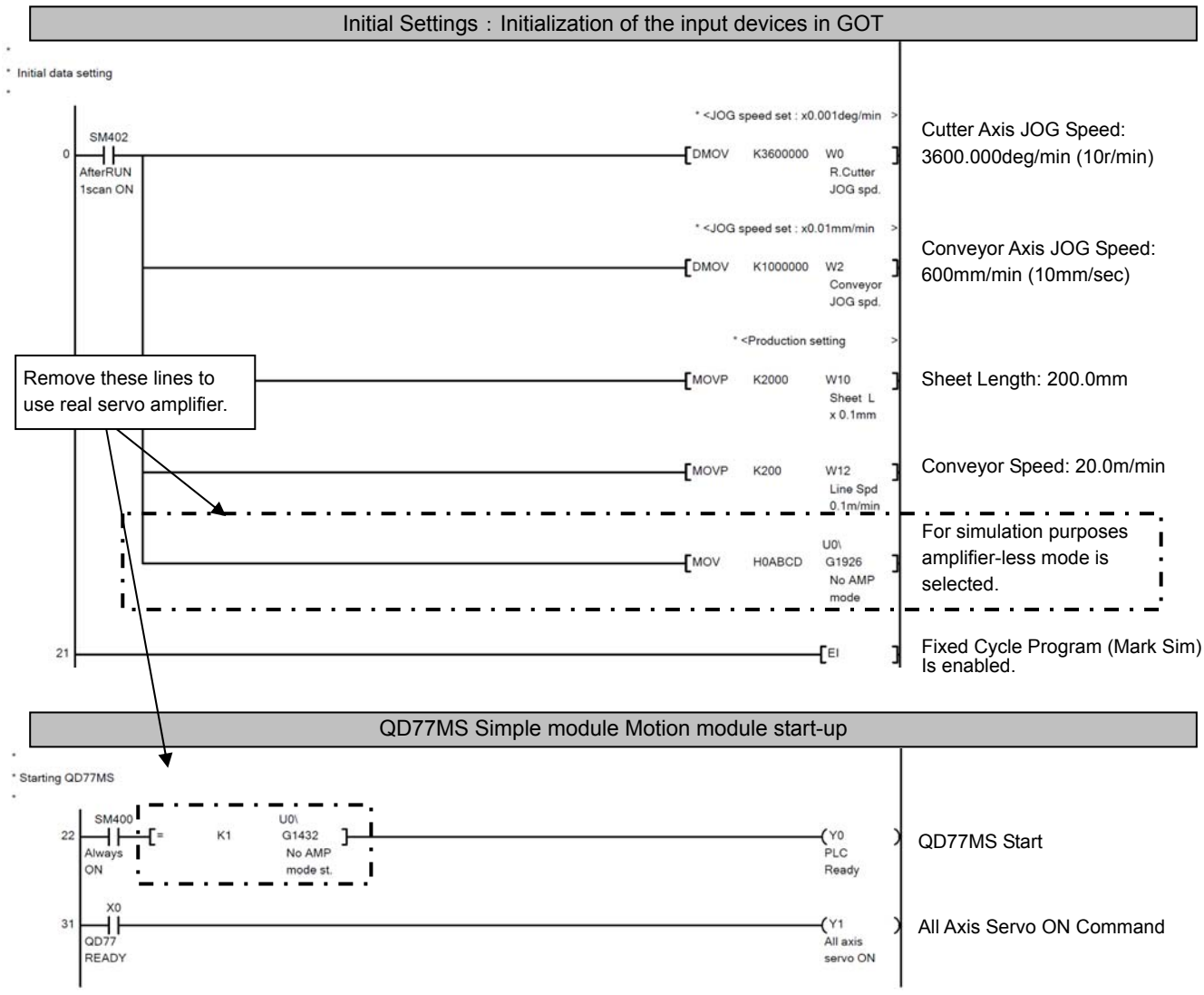


[Devices used in this program]

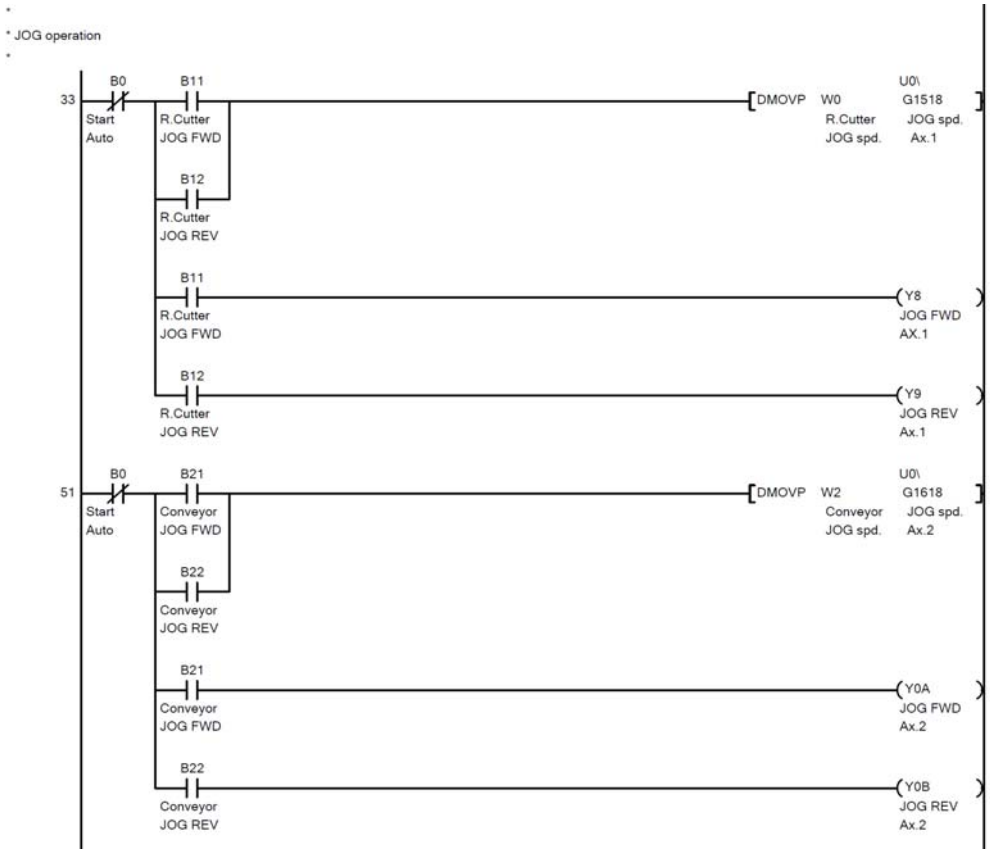
Device No.	Content	Device No.	Content
B0	Automatic Operation Start (GOT)	M1	Cutter Axis HPR Start
B1	Home Position Return (GOT)	M2	Conveyor Axis HPR Start
B2	Error Reset (GOT)	M5	Automatic Conveor Axis Start
B4	Mark Detection compensation ON/OFF (GOT)	M11	Cutter Axis in Synchronous Control
B5	Home Position Return Completion (GOT)	M20	Mark Compensation Start Possible
B6	Error Lamp (GOT)	M21	Mark Compensation Start
B11	Cutter Axis JOG forward (GOT)	D0	Last Mark Detection Counter Value
B12	Cutter Axis JOG reverse (GOT)	D1	
B21	Conveyor Axis JOG forward (GOT)	D2	Last (Recent) Mark Detection Value
B22	Conveyor Axis JOG reverse (GOT)	D3	
W0	Cutter Axis JOG Speed setting (GOT): x 0.001 [degree/min]	D4	Distance between two mark detection x0.1 [µm]
W1		D5	
W2	Conveyor Axis JOG Speed Setting (GOT): x 0.01 [mm/min]	D6	Mark Detection Compensation Amount x0.1 [µm]
W3		D7	
WA	Current Production Monitor (GOT): [sheet]	D1050	Temporary calculation
W10	Sheet Length Setting (GOT): x 0.1 [mm]		
W12	Conveyor Speed Setting		

[Ladder program]

1. MAIN



JOG operation



Cutter Axis

JOG Speed Setting

Axis 1 Forward JOG Command ON

Axis 1 Reverse JOG Command ON

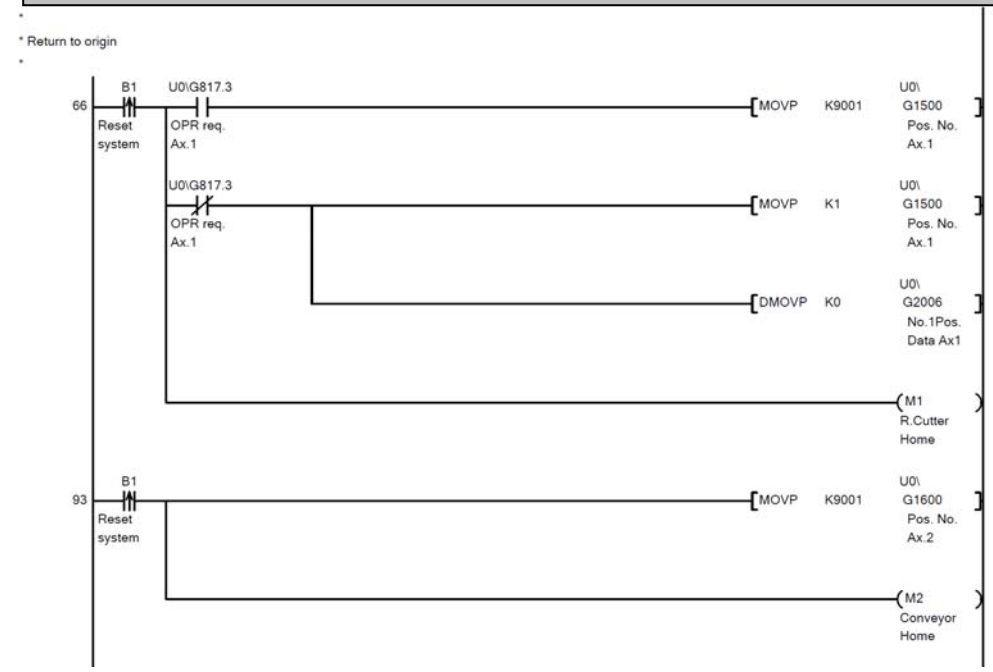
Conveyor Axis

JOG Speed Setting

Axis 2 Forward JOG Command ON

Axis 2 Reverse JOG Command ON

Home Position Return



Cutter Axis

When HPR is not completed
Positioning No.9001 (HPR) is set.

When HPR is completed
Positioning No.1 (Move to 0 degree) is set.

Positioning Point:
0 degree is set.

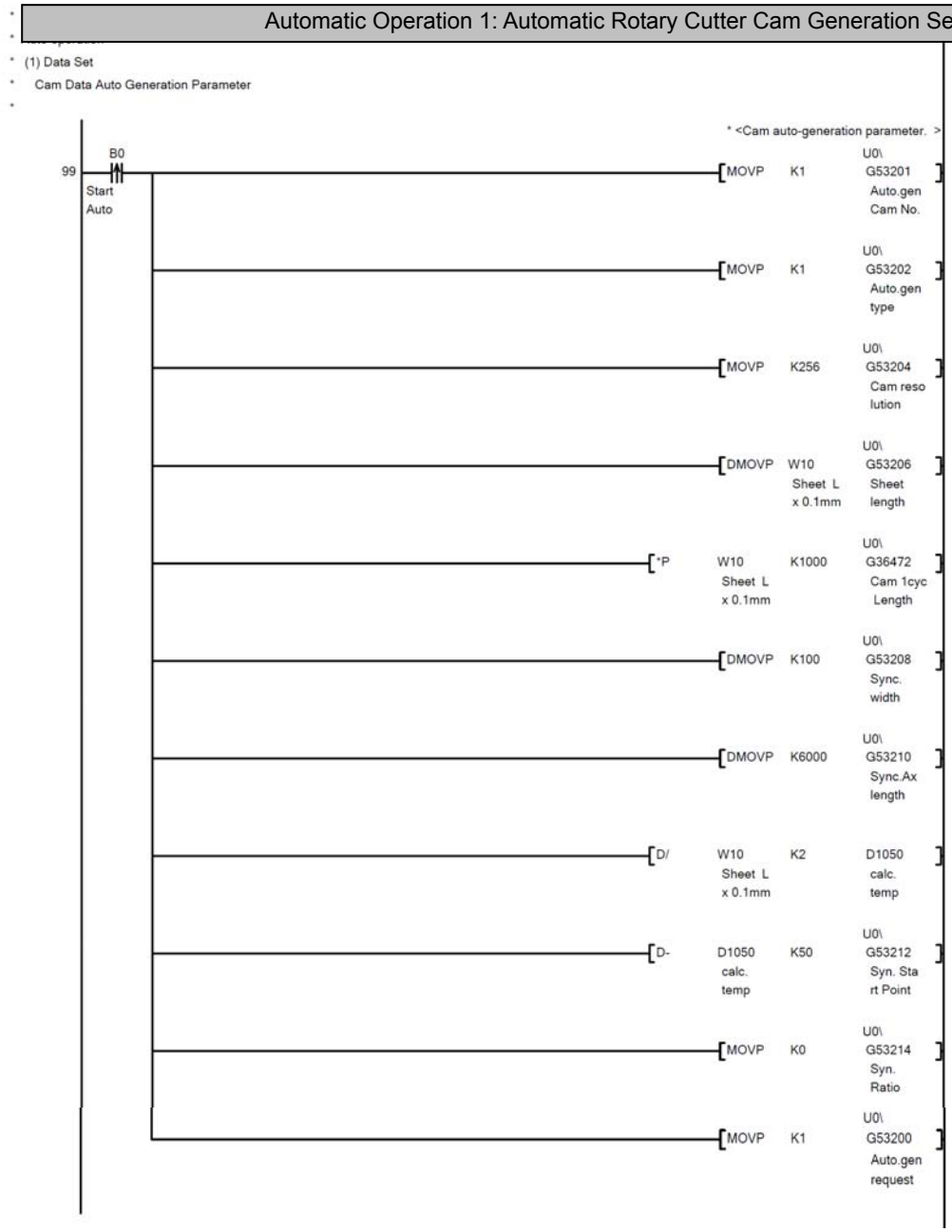
Positioning Start Flag ON

Conveyor Axis

Positioning No.9001 (HPR) is set.

Positioning Start Flag ON

Automatic Operation 1: Automatic Rotary Cutter Cam Generation Setting



[Cd.609] Auto cam Generation No. Setting
1: No.1

[Cd.610] Auto cam Generation Type
1: Rotary Cutter cam

[Cd.611] Auto cam Generation parameter
cam Resolution: 256

[Cd.611] Auto cam Generation parameter
Sheet Length: Setting from GOT (W10)

[Pr.439] cam Axis 1 Length per cycle
1 Cycle Length: Sheet Length

[Cd.611] Auto cam Generation parameter
Sheet Synchronization Width: 10.0mm

[Cd.611] Auto cam Generation parameter
Synchronous Axis Length: 600.0mm

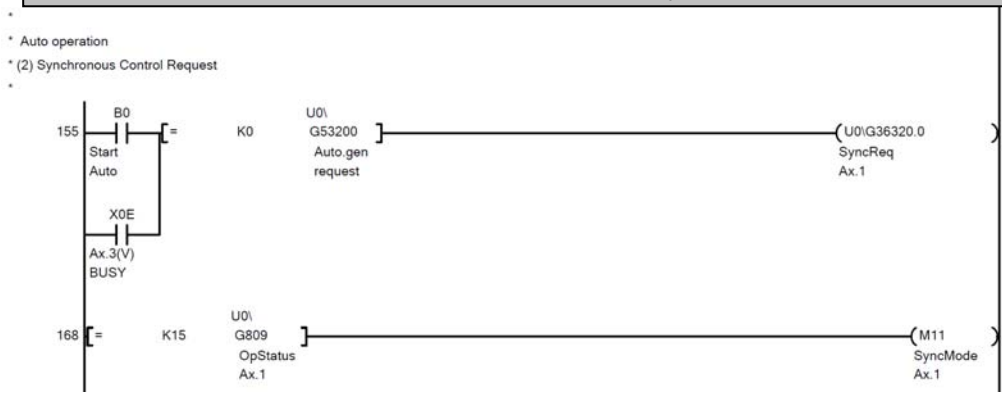
[Cd.611] Auto cam Generation parameter
Synch Start Pos: (Sheet Length/2)-5.0mm

*A center position of the length of a set seat is set as the cutting position and cutting position ±5.0mm is taken as synchronous width.

[Cd.611] Auto cam Generation parameter
Acc. Ratio in Synchronous section: 0.00%

[Cd.608] Auto cam generation request

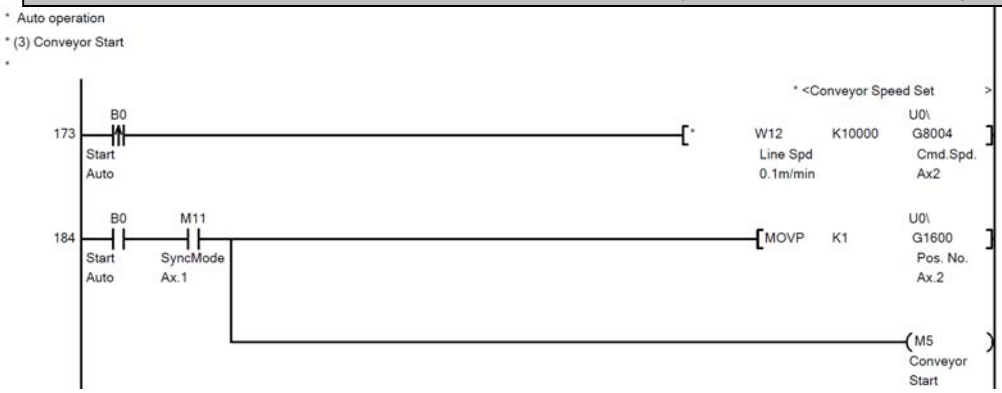
Automatic Operation 2: Cutter Axis Synchronous Control start processing



Cutter Axis Synchronization Request

Cutter Axis In Synchronization Status

Automatic Operation 3: Conveyor Axis Startup processing

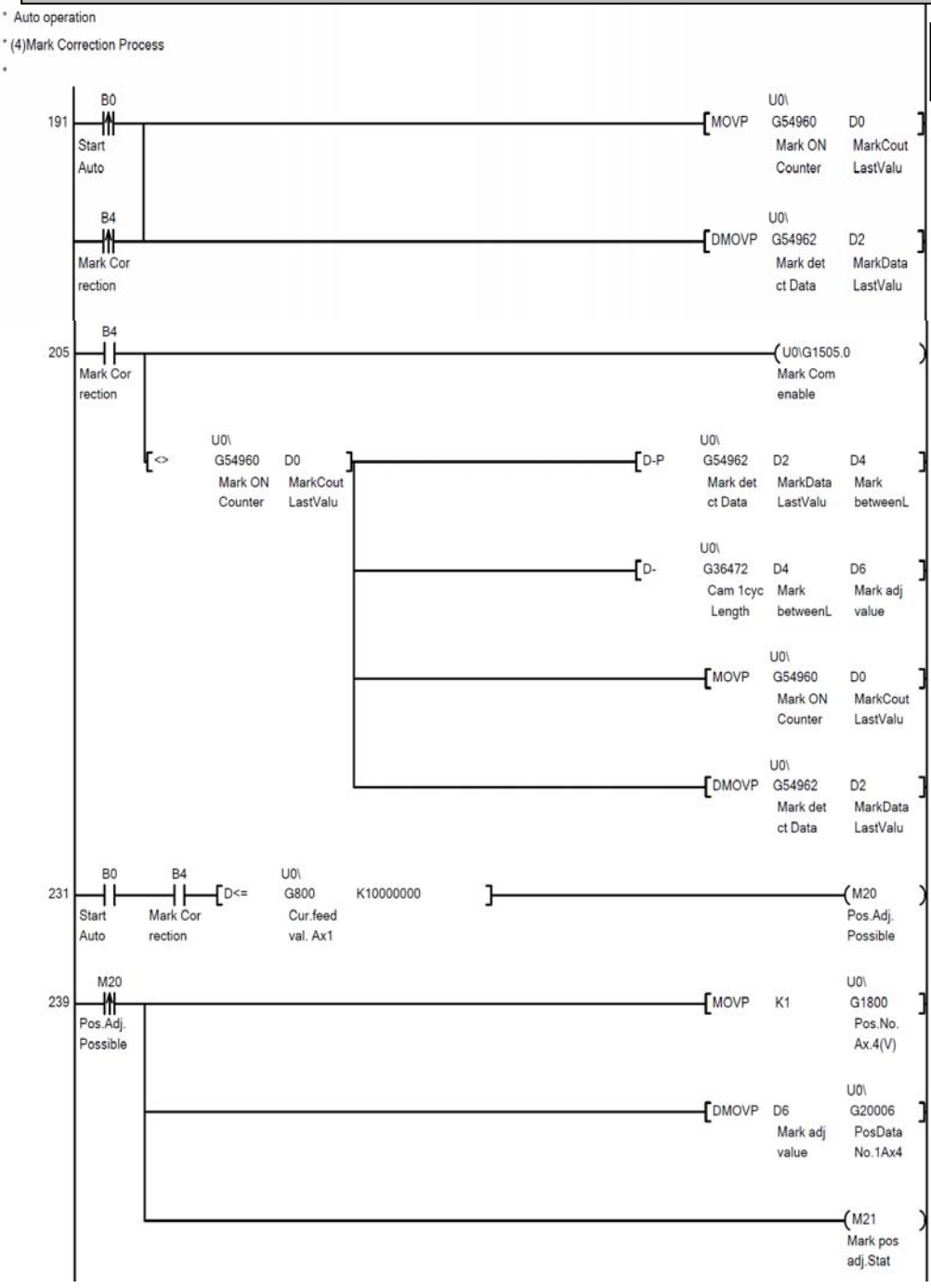


[Conveyor Axis Speed]
Screen Speed Setting -> Command Speed

Axis 2 Position No.1 is set

Axis 2 Positioning Start Flag ON

Automatic Operation 4: Mark Detection compensation processing



When Automatic Operation Starts or Mark Compensation is started the values are initialized as the last values.

Mark Detection Counter Value
Current Value → Last Value

Mark Detection Data
Current Value → Last Value

External Command Enable

When the Mark Detection Counter Value changes
The difference of Distance Between Marks (Detection Value: Current Value - Last Value) and Standard Value (Set sheet length) is calculated.

Distance between marks (Real Sheet Length) Calculation
Mark Detection Value: Current- Last Value

Compensation Amount Calculation
Set Sheet Length - Real Sheet Length

Mark Detection Counter Value
Last Value Update

Mark Detection Data
Last Value Update

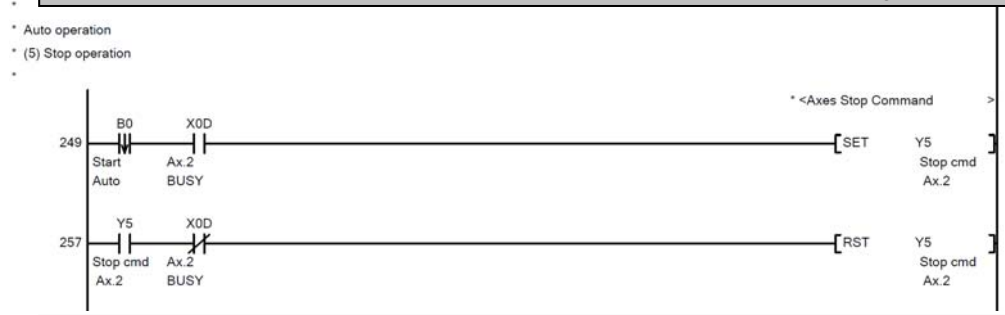
While Cutter Angle is between 0 to 100° start positioning for compensation.

Virtual servo amplifier axis 4
Positioning No.1 is set.

Virtual servo amplifier axis 4
Compensation Amount -> Positioning Amount

Virtual servo amplifier axis 4
Positioning Start Flag ON

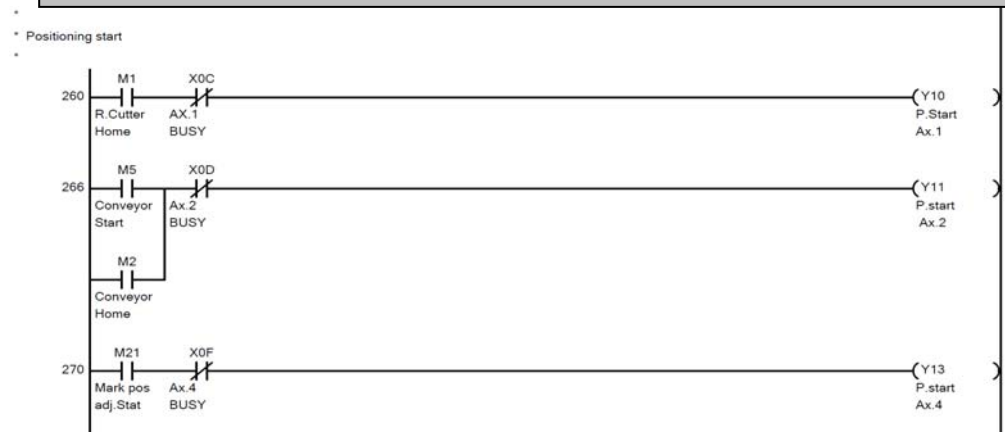
Automatic Operation 5: Stop processing



[Conveyor Axis]
When auto operation is OFF, stop command is set.

When the BUSY signal is OFF, stop command is reset.

Positioning Start Signal processing

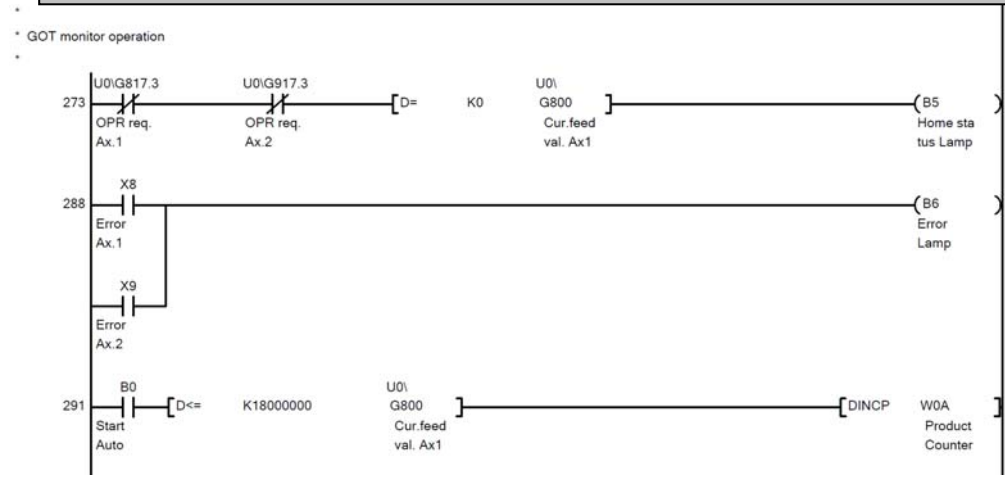


[Cutter Axis]
During HPR, axis 1 starts.

[Conveyor Axis]
During auto start or HPR, axis 2 starts.

[Cutter Axis Synchronous Aux. Axis]
During mark detection compensation, virtual axis 4 starts.

Monitor Signal used in GOT processing



Home Position Return Complete Flag
When all axes HPR request are OFF and cutter axis's current angle is 0°, this flag turns ON.

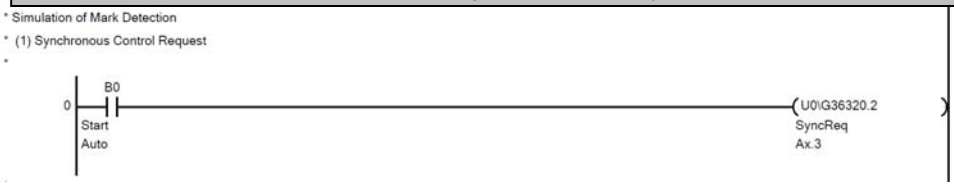
Error Flag
Turns on when error is detected in an axis.

Count up when an angle of cutter passes 180° during automatic operation.

Error Reset processing

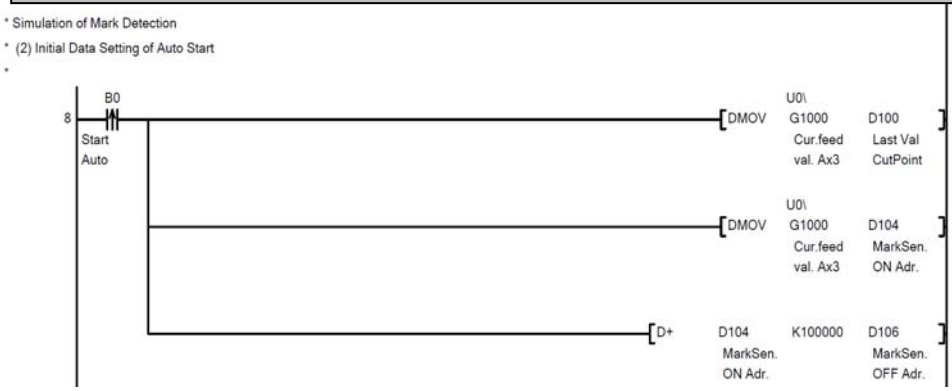
2. Mark_Sim (For Mark Detection Simulation:0.5ms fixed cycle program)

Virtual sheet feed generation axis synchronous control start processing



During automatic operation starts, synchronous control of Virtual Servo Amplifier Axis 3 starts.

Initial data setting process during Auto Start processing

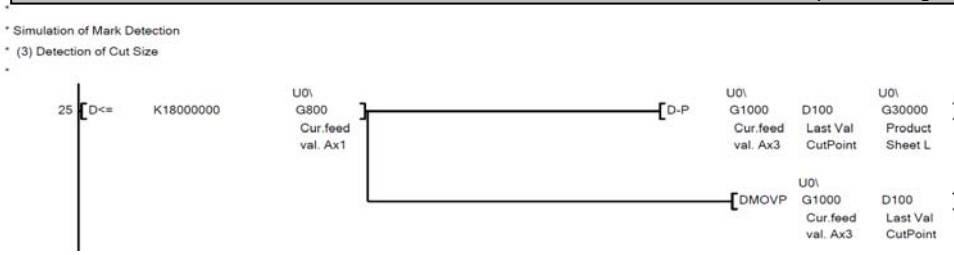


Mark Detection Counter
Axis 3 Current Value → Last Value

Mark ON Address
Axis 3 Current Value → ON Address

Mark OFF Address
ON Address+10mm → OFF Address

Virtual sheet cut measurement detection processing

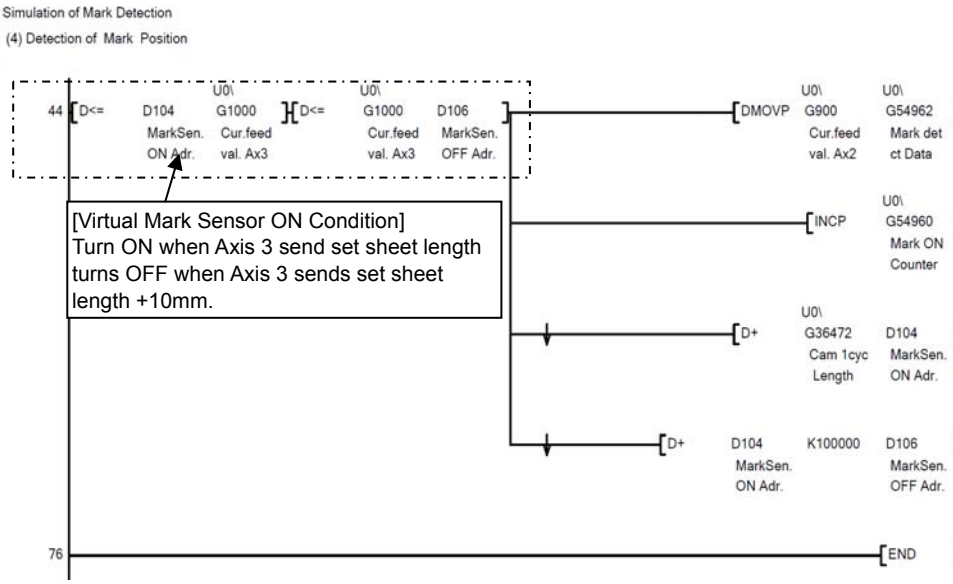


During Cutting (When cutter passes 180°)

Axis 3 Current Value
Current Value- Last Value → Cut Measurement

Axis 3 Current Value
Current Value → Last Value

Virtual Mark Position detection processing



[Virtual Mark Sensor ON Condition]
Turn ON when Axis 3 send set sheet length turns OFF when Axis 3 sends set sheet length +10mm.

Virtual Mark Sensor ON Processing

Axis 2 (Conveyor Axis) Current Value latch
→ Mark Detection Data

Mark Detection Counter
Count Up

Virtual Mark Sensor OFF Processing

Mark ON Address
Current ON address + Sheet length
→ Next ON Address

Mark OFF Address
Next ON address + 10mm
→ Next OFF address

END