**Rotary Knife**

**[System Configuration]**

- 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.
[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]
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.

<table>
<thead>
<tr>
<th>Setting Item (Buffer Mem.)</th>
<th>Setting Content</th>
<th>Setting Range</th>
<th>Example Settings</th>
</tr>
</thead>
</table>
| 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.
Sheet Synchronization Width (10.0mm)
Synchronization Starting Point (95.0mm)
Sheet Length (200.0mm)
Cam Axis Current Value per Cycle
Sheet Synchronous Width (10.0mm)
Cutter Axis (Cam Axis)
Synchronous Axis Length
Cutter Axis cycle length
Sheet Feed
Sheet Length (200.0mm)
Cam Axis Current Value per Cycle
Sheet Synchronous Width (10.0mm)
Cutter Axis (Cam Axis) Speed
Synchronous Speed (Sheet Feed Speed)
Cam Stroke Ratio (Generated Cam Data) 100%
0° 180° 360°
Synchronous Section Acceleration Ratio
(When 0% it is as fast as Synchronous Speed)
[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]

<table>
<thead>
<tr>
<th>File name</th>
<th>Description</th>
<th>Model</th>
<th>Programming tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vol2_R_Cutter_PL.C.gxw</td>
<td>Ladder program</td>
<td>Q06UDEHCPU</td>
<td>MELSOFT GX Works2</td>
</tr>
<tr>
<td>Vol2_R_Cutter_Motion.pcw</td>
<td>Motion setting file</td>
<td>QD77MS4</td>
<td></td>
</tr>
<tr>
<td>Vol2_R_Cutter_GOT.GTW</td>
<td>GOT monitoring data</td>
<td>GT165*-V (640x480)</td>
<td>MELSOFT GT Works3</td>
</tr>
</tbody>
</table>

(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.
[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]

**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

---

**Blue:** Default Value

**Black:** Settings Made

---

**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)
(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)

Axis 2: Conveyor axis automatic operation

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

Axis 4 Virtual servo amplifier: Mark detection compensation

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.

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

<table>
<thead>
<tr>
<th>Item</th>
<th>Setting value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cam Resolution</td>
<td>206</td>
</tr>
<tr>
<td>Sheet Length</td>
<td>2000</td>
</tr>
<tr>
<td>Sheet Synchronization Width</td>
<td>100</td>
</tr>
<tr>
<td>Synchronous Axis Length</td>
<td>6500</td>
</tr>
<tr>
<td>Synchronization Starting Point</td>
<td>950</td>
</tr>
<tr>
<td>Synchronous Section Acceleration Ratio</td>
<td>0</td>
</tr>
</tbody>
</table>

Auto Generation

Cam pattern

The conveyor axis (Main Shaft) sends the sheet length, and the cutter axis turns for one rotation (360 degrees), so that the sheet is cut at the set sheet length.
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.

- **Linear cam:** The command coming from the output of the speed change gear is directly outputted as it is.
- 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).
[Sample ladder program configuration]

[MAIN: Scan Execution]

START

Initial data processing

QD77MS Simple Motion startup processing
JOG operation processing
Home positioning return processing
Automatic operation processing 1: Automatic rotary cutter cam generation setting
Automatic operation processing 2: Cutter axis synchronous control start processing
Automatic operation processing 3: Conveyor axis start processing
Automatic operation processing 4: Mark detection compensation processing
Automatic operation processing 5: Stop processing
Positioning start signals processing
GOT monitor signal used processing
Error reset processing

END

[Mark_Sim: 0.5ms fixed cycle] Mark detection simulation

START

Virtual sheet feed generation axis synchronous control start
Initial data setting process during automatic start processing
Virtual sheet cut measurement detection processing
Virtual mark position detection processing

END

[Devices used in this program]

<table>
<thead>
<tr>
<th>Device No.</th>
<th>Content</th>
<th>Device No.</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>B0</td>
<td>Automatic Operation Start (GOT)</td>
<td>M1</td>
<td>Cutter Axis HPR Start</td>
</tr>
<tr>
<td>B1</td>
<td>Home Position Return (GOT)</td>
<td>M2</td>
<td>Conveyor Axis HPR Start</td>
</tr>
<tr>
<td>B2</td>
<td>Error Reset (GOT)</td>
<td>M5</td>
<td>Automatic Conveyor Axis Start</td>
</tr>
<tr>
<td>B4</td>
<td>Mark Detection compensation ON/OFF (GOT)</td>
<td>M11</td>
<td>Cutter Axis in Synchronous Control</td>
</tr>
<tr>
<td>B5</td>
<td>Home Position Return Completion (GOT)</td>
<td>M20</td>
<td>Mark Compensation Start Possible</td>
</tr>
<tr>
<td>B6</td>
<td>Error Lamp (GOT)</td>
<td>M21</td>
<td>Mark Compensation Start</td>
</tr>
<tr>
<td>B11</td>
<td>Cutter Axis JOG forward (GOT)</td>
<td>D0</td>
<td>Last Mark Detection Counter Value</td>
</tr>
<tr>
<td>B12</td>
<td>Cutter Axis JOG reverse (GOT)</td>
<td>D1</td>
<td></td>
</tr>
<tr>
<td>B21</td>
<td>Conveyor Axis JOG forward (GOT)</td>
<td>D2</td>
<td>Last (Recent) Mark Detection Value</td>
</tr>
<tr>
<td>B22</td>
<td>Conveyor Axis JOG reverse (GOT)</td>
<td>D3</td>
<td></td>
</tr>
<tr>
<td>W0</td>
<td>Cutter Axis JOG Speed setting (GOT): x 0.001 [degree/min]</td>
<td>D4</td>
<td>Distance between two mark detection x0.1 [μm]</td>
</tr>
<tr>
<td>W1</td>
<td></td>
<td>D5</td>
<td></td>
</tr>
<tr>
<td>W2</td>
<td>Conveyor Axis JOG Speed Setting (GOT): x 0.01 [mm/min]</td>
<td>D6</td>
<td>Mark Detection Compensation Amount x0.1 [μm]</td>
</tr>
<tr>
<td>W3</td>
<td></td>
<td>D7</td>
<td></td>
</tr>
<tr>
<td>W10</td>
<td>Sheet Length Setting (GOT): x 0.1 [mm]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W12</td>
<td>Conveyor Speed Setting</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Initial Settings: Initialization of the input devices in GOT

- Cutter Axis JOG Speed: 3600.000deg/min (10r/min)
- Conveyor Axis JOG Speed: 600mm/min (10mm/sec)
- Sheet Length: 200.0mm
- Conveyor Speed: 20.0m/min

For simulation purposes amplifier-less mode is selected.

Fixed Cycle Program (Mark Sim) is enabled.

QD77MS Simple module Motion module start-up

- All Axis Servo ON Command
**JOG operation**

*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**

*Return to origin*

**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

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

  - Mark Detection Counter Value
    - Current Value $\rightarrow$ Last Value
  - Mark Detection Data
    - Current Value $\rightarrow$ 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 $\rightarrow$ 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**

- **Error reset**

---

BCN-B62005-666-A
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

Virtual Mark Position detection processing

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

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