

Motoman NX100 Controller

Form Cut Function Manual

Part Number: 149648-19CD
Revision: 1



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Chapter 1

Introduction

1.1 About This Document

This manual provides information for the Form Cut option and contains the following sections:

SECTION 1 - INTRODUCTION

Provides general information about the structure of this manual, a list of reference documents, and customer service information.

SECTION 2 - SAFETY

This section provides information regarding the safe use and operation of Motoman products.

SECTION 3 - FORM CUT INSTRUCTIONS

Provides detailed instructions for Form Cut option.

1.2 Reference to Other Documentation

For additional information refer to the following:

- NX100 Controller Manual (P/N 149201-1)
- Concurrent I/O Manual (P/N 149230-1)
- Operator's Manual for your application
- Vendor manuals for system components not manufactured by Motoman

1.3 Customer Service Information

If you are in need of technical assistance, contact the Motoman service staff at (937) 847-3200. Please have the following information ready before you call:

- Robot Type (Form Cut)
- Application Type (arcwelding, spot welding, handling)
- Robot Serial Number (located on back side of robot arm)
- Robot Sales Order Number (located on back of controller)

Chapter 2

Safety

2.1 Introduction

It is the purchaser's responsibility to ensure that all local, county, state, and national codes, regulations, rules, or laws relating to safety and safe operating conditions for each installation are met and followed.

We suggest that you obtain and review a copy of the ANSI/RIA National Safety Standard for Industrial Robots and Robot Systems. This information can be obtained from the Robotic Industries Association by requesting ANSI/RIA R15.06-1999. The address is as follows:

Robotic Industries Association
900 Victors Way
P.O. Box 3724
Ann Arbor, Michigan 48106
TEL: (734) 994-6088
FAX: (734) 994-3338
INTERNET: www.roboticsonline.com

Ultimately, the best safeguard is trained personnel. The user is responsible for providing personnel who are adequately trained to operate, program, and maintain the robot cell. **The robot must not be operated by personnel who have not been trained!**

We recommend that all personnel who intend to operate, program, repair, or use the robot system be trained in an approved Motoman training course and become familiar with the proper operation of the system.

This safety section addresses the following:

- Standard Conventions (Section 2.2)
- General Safeguarding Tips (Section 2.3)
- Mechanical Safety Devices (Section 2.4)
- Installation Safety (Section 2.5)
- Programming, Operation, and Maintenance Safety (Section 2.6)

2.2 Standard Conventions

This manual includes the following alerts – in descending order of severity – that are essential to the safety of personnel and equipment. As you read this manual, pay close attention to these alerts to insure safety when installing, operating, programming, and maintaining this equipment.



DANGER!

Information appearing in a **DANGER** concerns the protection of personnel from the immediate and imminent hazards that, if not avoided, will result in immediate, serious personal injury or loss of life in addition to equipment damage.



WARNING!

Information appearing in a **WARNING** concerns the protection of personnel and equipment from potential hazards that can result in personal injury or loss of life in addition to equipment damage.



CAUTION!

Information appearing in a **CAUTION** concerns the protection of personnel and equipment, software, and data from hazards that can result in minor personal injury or equipment damage.



Note: Information appearing in a Note provides additional information which is helpful in understanding the item being explained.

2.3 General Safeguarding Tips

All operators, programmers, plant and tooling engineers, maintenance personnel, supervisors, and anyone working near the robot must become familiar with the operation of this equipment. All personnel involved with the operation of the equipment must understand potential dangers of operation. General safeguarding tips are as follows:

- Improper operation can result in personal injury and/or damage to the equipment. Only trained personnel familiar with the operation of this robot, the operator's manuals, the system equipment, and options and accessories should be permitted to operate this robot system.
- Do not enter the robot cell while it is in automatic operation. Programmers must have the teach pendant when they enter the robot cell.
- Improper connections can damage the robot. All connections must be made within the standard voltage and current ratings of the robot I/O (Inputs and Outputs).
- The robot must be placed in Emergency Stop (E-STOP) mode whenever it is not in use.
- In accordance with ANSI/RIA R15.06-1999, section 4.2.5, Sources of Energy, use lockout/tagout procedures during equipment maintenance. Refer also to Section 1910.147 (29CFR, Part 1910), Occupational Safety and Health Standards for General Industry (OSHA).

2.4 Mechanical Safety Devices

The safe operation of the robot, positioner, auxiliary equipment, and system is ultimately the user's responsibility. The conditions under which the equipment will be operated safely should be reviewed by the user. The user must be aware of the various national codes, ANSI/RIA R15.06-1999 safety standards, and other local codes that may pertain to the installation and use of industrial equipment. Additional safety measures for personnel and equipment may be required depending on system installation, operation, and/or location. The following safety equipment is provided as standard:

- Safety fences and barriers
- Light curtains and/or safety mats
- Door interlocks
- Emergency stop palm buttons located on operator station, robot controller, and programming pendant

Check all safety equipment frequently for proper operation. Repair or replace any non-functioning safety equipment immediately.

2.5 Installation Safety

Safe installation is essential for protection of people and equipment. The following suggestions are intended to supplement, but not replace, existing federal, local, and state laws and regulations. Additional safety measures for personnel and equipment may be required depending on system installation, operation, and/or location. Installation tips are as follows:

- Be sure that only qualified personnel familiar with national codes, local codes, and ANSI/RIA R15.06-1999 safety standards are permitted to install the equipment.
- Identify the work envelope of each robot with floor markings, signs, and barriers.
- Position all controllers outside the robot work envelope.
- Whenever possible, install safety fences to protect against unauthorized entry into the work envelope.
- Eliminate areas where personnel might get trapped between a moving robot and other equipment (pinch points).
- Provide sufficient room inside the workcell to permit safe teaching and maintenance procedures.

2.6 Programming, Operation, and Maintenance Safety

All operators, programmers, plant and tooling engineers, maintenance personnel, supervisors, and anyone working near the robot must become familiar with the operation of this equipment. Improper operation can result in personal injury and/or damage to the equipment. Only trained personnel familiar with the operation, manuals, electrical design, and equipment interconnections of this robot should be permitted to program, operate, and maintain the system. All personnel involved with the operation of the equipment must understand potential dangers of operation.

- Inspect the robot and work envelope to be sure no potentially hazardous conditions exist. Be sure the area is clean and free of water, oil, debris, etc.
- Be sure that all safeguards are in place. Check all safety equipment for proper operation. Repair or replace any non-functioning safety equipment immediately.
- Do not enter the robot cell while it is in automatic operation. Be sure that only the person holding the programming pendant enters the workcell.
- Check the E-STOP button on the programming pendant for proper operation before programming. The robot must be placed in Emergency Stop (E-STOP) mode whenever it is not in use.
- Back up all programs and jobs onto suitable media before program changes are made. To avoid loss of information, programs, or jobs, a backup must always be made before any service procedures are done and before any changes are made to options, accessories, or equipment.

- Any modifications to PART 1, System Section, of the robot controller concurrent I/O program can cause severe personal injury or death, as well as damage to the robot! Do not make any modifications to PART 1, System Section. Making any changes without the written permission of Motoman will VOID YOUR WARRANTY!
- Some operations require standard passwords and some require special passwords. Special passwords are for Motoman use only. YOUR WARRANTY WILL BE VOID if you use these special passwords.
- The robot controller allows modifications of PART 2, User Section, of the concurrent I/O program and modifications to controller parameters for maximum robot performance. Great care must be taken when making these modifications. All modifications made to the controller will change the way the robot operates and can cause severe personal injury or death, as well as damage the robot and other parts of the system. Double-check all modifications under every mode of robot operation to ensure that you have not created hazards or dangerous situations.
- Check and test any new or modified program at low speed for at least one full cycle.
- This equipment has multiple sources of electrical supply. Electrical interconnections are made between the controller and other equipment. Disconnect and lockout/tagout all electrical circuits before making any modifications or connections.
- Do not perform any maintenance procedures before reading and understanding the proper procedures in the appropriate manual.
- Use proper replacement parts.
- Improper connections can damage the robot. All connections must be made within the standard voltage and current ratings of the robot I/O (Inputs and Outputs).

NOTES

NX100 OPTIONS INSTRUCTIONS

FORM CUTTING FUNCTION

Upon receipt of the product and prior to initial operation, read these instructions thoroughly, and retain for future reference.

MOTOMAN INSTRUCTIONS

MOTOMAN-□□□ INSTRUCTIONS
NX100 INSTRUCTIONS
NX100 OPERATOR'S MANUAL
NX100 MAINTENANCE MANUAL

The NX100 operator's manuals above correspond to specific usage.
Be sure to use the appropriate manual.





MANDATORY

- **This manual explains the form cutting function of the NX100. Read this manual carefully and be sure to understand its contents before handling the NX100.**
- **General items related to safety are listed in Section 1: Safety of the NX100 Instructions. To ensure correct and safe operation, carefully read the NX100 instructions before reading this manual.**



CAUTION

- **Some drawings in this manual are shown with the protective covers or shields removed for clarity. Be sure all covers and shields are replaced before operating this product.**
- **The drawings and photos in this manual are representative examples and differences may exist between them and the delivered product.**
- **YASKAWA may modify this model without notice when necessary due to product improvements, modifications, or changes in specifications. If such modification is made, the manual number will also be revised.**
- **If your copy of the manual is damaged or lost, contact a YASKAWA representative to order a new copy. The representatives are listed on the back cover. Be sure to tell the representative the manual number listed on the front cover.**
- **YASKAWA is not responsible for incidents arising from unauthorized modification of its products. Unauthorized modification voids your product's warranty.**

Notes for Safe Operation

Read this manual carefully before installation, operation, maintenance, or inspection of the NX100.

In this manual, the Notes for Safe Operation are classified as “WARNING”, “CAUTION”, “MANDATORY”, or “PROHIBITED”.



WARNING

Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury to personnel.



CAUTION

Indicates a potentially hazardous situation which, if not avoided, could result in minor or moderate injury to personnel and damage to equipment. It may also be used to alert against unsafe practices.



MANDATORY

Always be sure to follow explicitly the items listed under this heading.



PROHIBITED

Must never be performed.

Even items described as “CAUTION” may result in a serious accident in some situations. At any rate, be sure to follow these important items



To ensure safe and efficient operation at all times, be sure to follow all instructions, even if not designated as “CAUTION” and “WARNING”.



WARNING

- **Before operating the manipulator, check that servo power is turned OFF when the emergency stop buttons on the front door of the NX100 and programming pendant are pressed. When the servo power is turned OFF, the SERVO ON LED on the programming pendant is turned OFF.**

Injury or damage to machinery may result if the emergency stop circuit cannot stop the manipulator during an emergency. The manipulator should not be used if the emergency stop buttons do not function.



Emergency Stop Button

- **Once the emergency stop button is released, clear the cell of all items which could interfere with the operation of the manipulator. Then turn the servo power ON.**

Injury may result from unintentional or unexpected manipulator motion.



Release of Emergency Stop

- **Observe the following precautions when performing teaching operations within the P-point maximum envelope of the manipulator :**
 - **View the manipulator from the front whenever possible.**
 - **Always follow the predetermined operating procedure.**
 - **Ensure that you have a safe place to retreat in case of emergency.**

Improper or unintended manipulator operation may result in injury.

- **Confirm that no persons are present in the P-point maximum envelope of the manipulator and that you are in a safe location before:**
 - **Turning ON the NX100 power**
 - **Moving the manipulator with the programming pendant**
 - **Running the system in the check mode**
 - **Performing automatic operations**

Injury may result if anyone enters the P-point maximum envelope of the manipulator during operation. Always press an emergency stop button immediately if there are problems. The emergency stop buttons are located on the right of the front door of the NX100 and the programming pendant.



CAUTION

- **Perform the following inspection procedures prior to conducting manipulator teaching. If problems are found, repair them immediately, and be sure that all other necessary processing has been performed.**
 - Check for problems in manipulator movement.**
 - Check for damage to insulation and sheathing of external wires.**
- **Always return the programming pendant to the hook on the NX100 cabinet after use.**

The programming pendant can be damaged if it is left in the P-point maximum envelope of the manipulator's work area, on the floor, or near fixtures.

- **Read and understand the Explanation of the Warning Labels before operating the manipulator.**

Definition of Terms Used Often in This Manual


The MOTOMAN manipulator is the YASKAWA industrial robot product.

The manipulator usually consists of the controller, the programming pendant, and supply cables.

In this manual, the equipment is designated as follows.

Equipment	Manual Designation
NX100 Controller	NX100
NX100 Programming Pendant	Programming Pendant
Cable between the manipulator and the controller	Manipulator cable

Descriptions of the programming pendant, buttons, and displays are shown as follows:

Equipment		Manual Designation
Programming Pendant	Character Keys	The keys which have characters printed on them are denoted with []. ex. [ENTER]
	Symbol Keys	The keys which have a symbol printed on them are not denoted with [] but depicted with a small picture. ex. page key  The cursor key is an exception, and a picture is not shown.
	Axis Keys Number Keys	“Axis Keys” and “Number Keys” are generic names for the keys for axis operation and number input.
	Keys pressed simultaneously	When two keys are to be pressed simultaneously, the keys are shown with a “+” sign between them, ex. [SHIFT]+[COORD]
	Displays	The menu displayed in the programming pendant is denoted with { }. ex. {JOB}

Description of the Operation Procedure

In the explanation of the operation procedure, the expression "Select •••" means that the cursor is moved to the object item and the SELECT key is pressed, or that the item is directly selected by touching the screen.

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2 Patterns for Cutting

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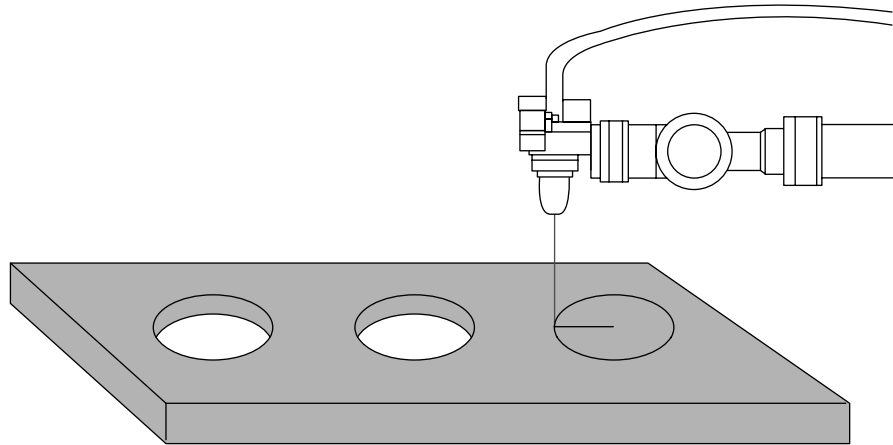
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7 Alarm Message List

1 Form Cutting Motion

The form cutting motion cuts workpieces according to a pattern with a tool such as a laser cutting machine handled by a manipulator.



In the form cutting function, there may be some differences between the set design and the actual cutting motion path, depending on the calibration, ambient temperature, and load applied to the manipulator.

In order to minimize the above explained differences, be sure to calibrate your tools before using this function.

2 Patterns for Cutting

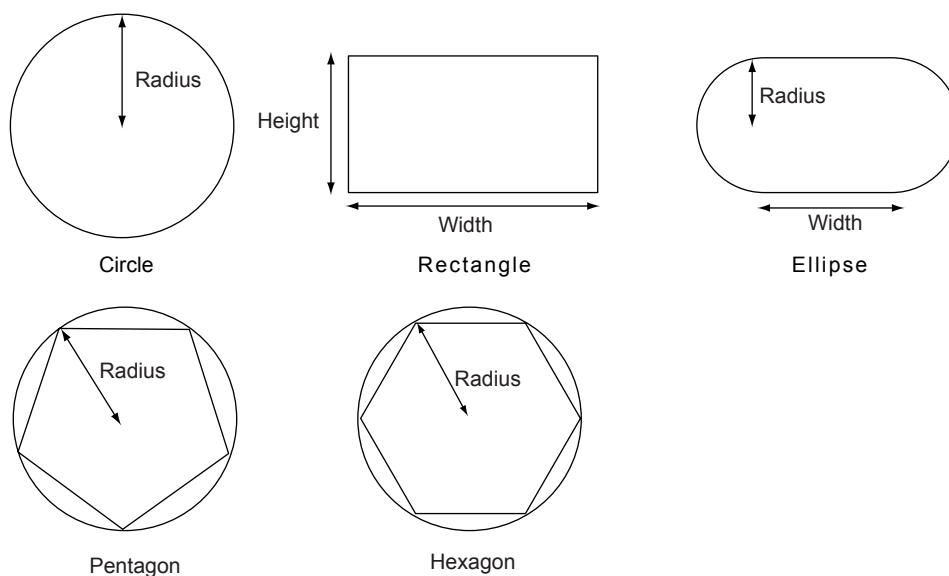
Five patterns, circle, rectangle (including square), ellipse, pentagon, and hexagon are available.

The minimum and maximum set values of a pattern can be set at the following parameters.

Parameter	Contents	Initial Value
S1C □G63	Minimum set value	1,000 μm
S1C □G64	Maximum set value	1,000,000 μm

The minimum and maximum values of data required for a pattern are set as follows.

Pattern	Item	Minimum Value	Maximum Value
Circle	Radius	$S1C□G63 / 2$	$S1C□G64 / 2$
Rectangle	Width	1	$\sqrt{(S1C□G64)^2 - (Height)^2}$
	Height	$S1C□G63 / 2$	$\sqrt{(S1C□G64)^2 - (Width)^2}$
Ellipse	Radius	$S1C□G63 / 2$	$(S1C□G64 / 2) - (Width / 2)$
	Width	0	$S1C□G64 - (2 * Radius)$
Pentagon	Radius	$S1C□G63 / 2$	$S1C□G64 / 2$
Hexagon	Radius	$S1C□G63 / 2$	$S1C□G64 / 2$



3 Teaching

Follow the example of teaching shown below to teach a motion instruction for cutting a form. The items to be set in the form cut setting file are shown in " " .

3.1 How to Teach a Pattern

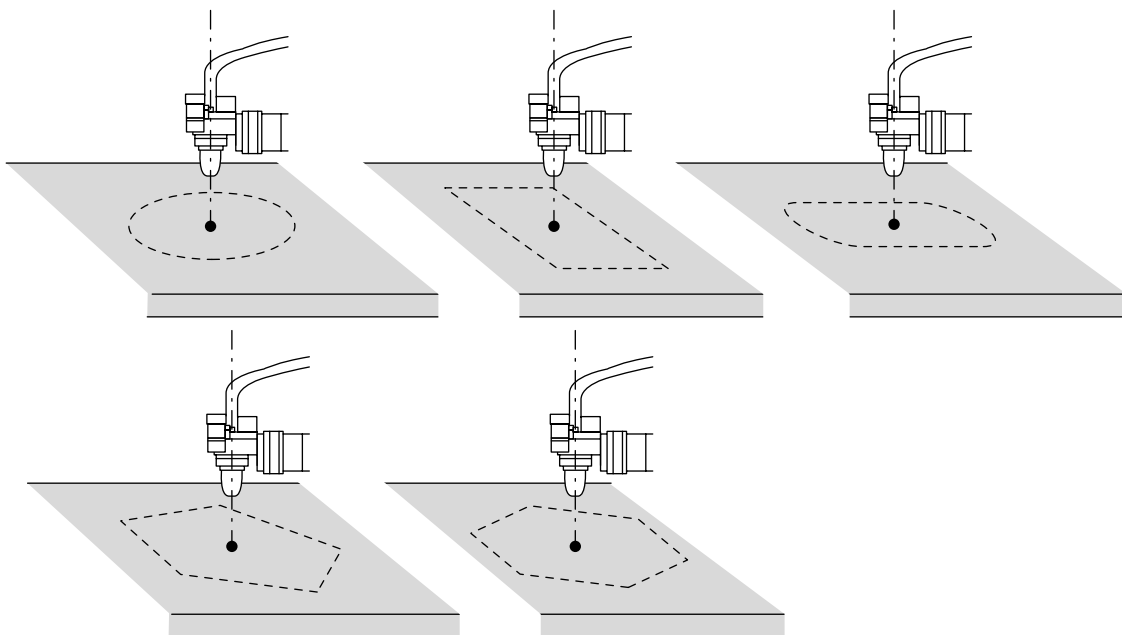
With the form cutting function, teaching can be done by registering the FORMAPR and FORMCUT instructions.

The FORMAPR instruction is a move instruction to move to the cutting motion's starting point, and the FORMCUT instruction is a cutting motion instruction.

Move the manipulator axis in the step where the manipulator moves to the cutting motion's starting point and use the FORMAPR instruction to register the position which is the center of the form's pattern to be set.

Register the FORMCUT instruction in the step where the cutting motion starts (the next step after the FORMAPR instruction).

Teaching Position of the FORMAPR Instruction



CONTROL GROUP : R1		TOOL : 00
0003	MOVJ VJ=100.00	
0004	MOVJ VJ=100.00	
0005	MOVJ VJ=100.0	●
0006	FORMAPR FCF#(1) V=50.0	●
0007	FORMCUT FCF#(1)	●
0008	MOVL V=50.0	●
0009	END	

● Move to the shelter point
 ● Move to the starting point of the pattern
 ● Cutting
 ● Move to the shelter point

3.1 How to Teach a Pattern



Do not register any move instruction (MOVJ, MOVL, etc.) between the FORMAPR and FORMCUT instructions.
If any move instruction is registered, normal operation is disabled or an alarm occurs.



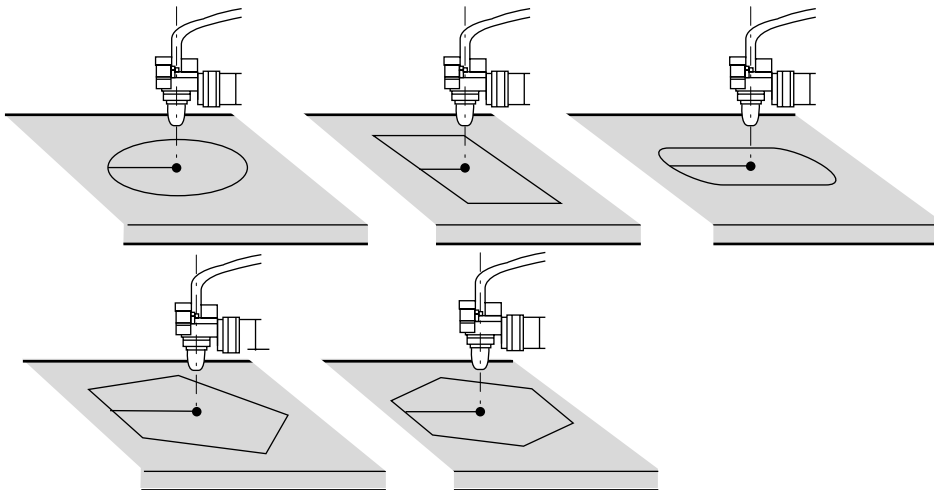
Set the same value for both the FORMAPR and FORMCUT instruction tag values (form cut setting file No., etc.) except for "SPEED". If the values are different, the FORMAPR instruction tag value is validated.
The speed in the FORMAPR instruction is for the speed when moving to the starting point, and the FORMCUT instruction is for the speed when cutting.

By setting the "START POINT" of the form cut setting file to the center or the specified point, the FORMCUT instruction can start a cutting motion from the center of the pattern or any point near the pattern.

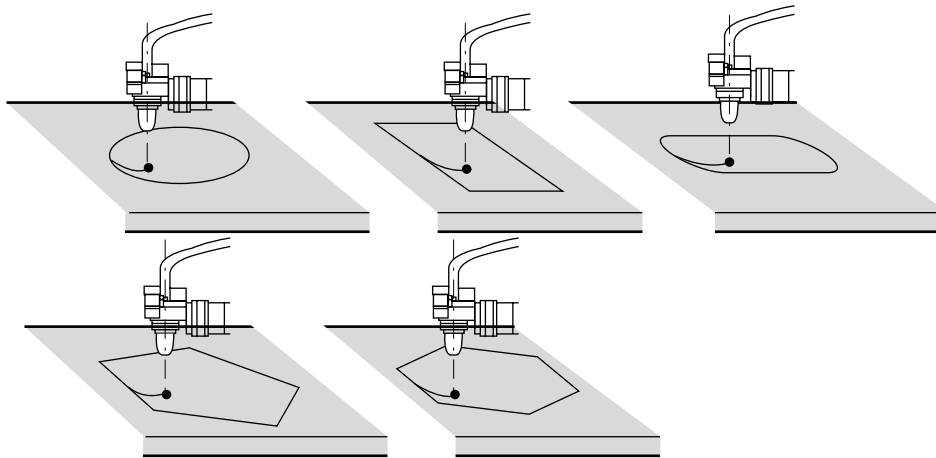
By pressing PLAYBACK, TEST RUN, or INTERLOCK and NEXT at the same time, the FORMAPR instruction is carried out and the manipulator moves to the center of the pattern when the center is set as the "START POINT"; or it moves to the specified point near the pattern when a specific point is set as the "START POINT".

By pressing the NEXT or BACK, the FORMAPR instruction is carried out and the manipulator disregards the "START POINT" setting and moves to the center of the pattern.

When the center is set as the "START POINT"



When a specified point is set to as the "START POINT"



When a specified point is set as the "START POINT", the position is set with "CUT IN LENGTH" and "CUT IN ANGLE" of the form cut setting file for the starting point (a point near the pattern). Refer to Section " 6.2.2 Specifying the CUT IN LENGTH and the CUT IN ANGLE ".

Only when the center is set as the "START POINT", the starting point position (the center of the pattern) can be set by a move instruction (MOVJ, MOVJ, etc.) other than FORMAPR instruction. If so, the FORMCUT instruction can be carried out with the registered position as the center.

A job including a conventional FORMCUT instruction can be used by setting the center as the "START POINT". The following shows an example of a job.

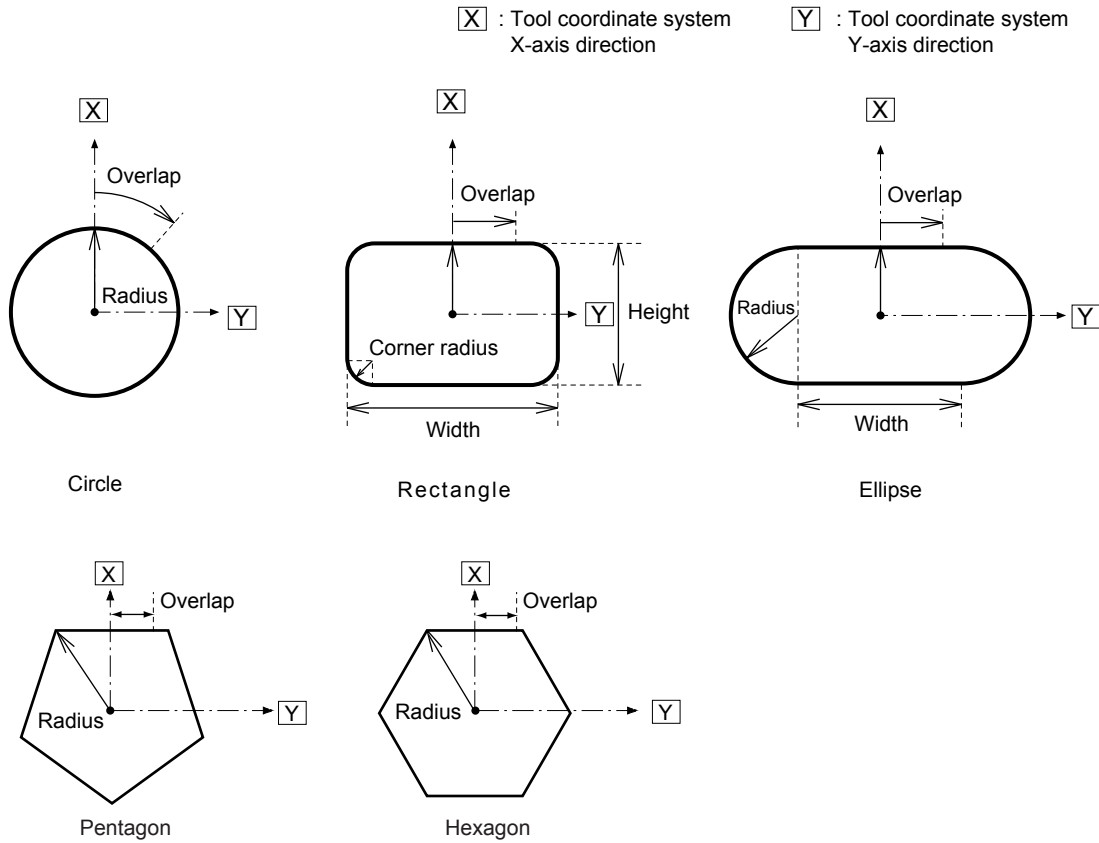
CONTROL GROUP : R1		TOOL : 00	
0004	MOVJ VJ=100.00		
0005	MOVJ VJ=100.00	●	Move to the shelter point
0006	MOVL V=50.0	●	Move to the starting point (center) of the pattern
0007	FORMCUT FCF#(1)	●	Cutting
0008	MOVL V=50.0	●	Move to the shelter point
0009	END		



To carry out a FORMCUT instruction, in which PLACEMENT is set as the "START POINT", by pressing PLAYBACK, TEST RUN, or INTERLOCK and NEXT at the same time after a NEXT or BACK operation, be sure to carry out the NEXT or BACK operation several steps before the FORMCUT instruction. All the instructions between the instruction carried out by pressing the NEXT or BACK and the FORMCUT instruction must be carried out by pressing PLAYBACK, TEST RUN, or INTERLOCK and NEXT at the same time.

3.2 Tool Position and Cutting Pattern

The following figures show the relation between the tool position each the cutting pattern.



3.3 Cutting Width Correction Function

The cutting width correction function shifts the scale of the cutting width of the laser for the cutting path when cutting the form according to the pattern. The following parameter is used for the setting.

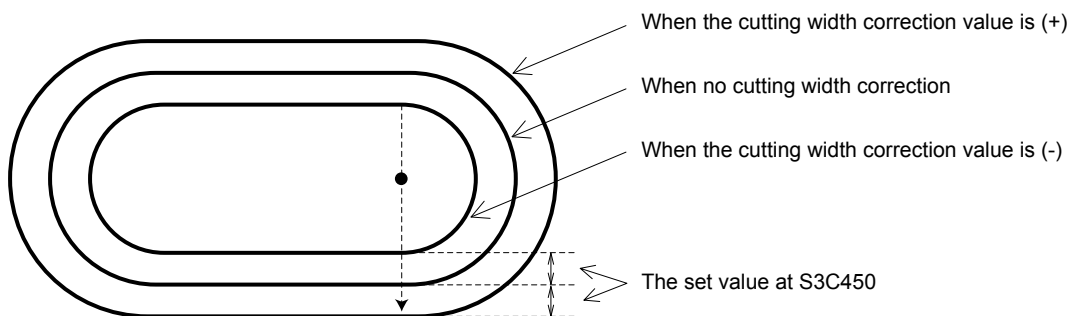
Parameter	Contents	Initial Value
S3C450	Cutting width correction (in units of 0.001 mm)	0 mm

Set the cutting width of the laser to 1/2 of its value. When cutting, the path is corrected by the parameter set values.

The following illustration is an example of the path correction when cutting the ellipse pattern.

The correction for the motion path is similar when using the other patterns.

The center of the circle does not change before and after the cutting width correction.

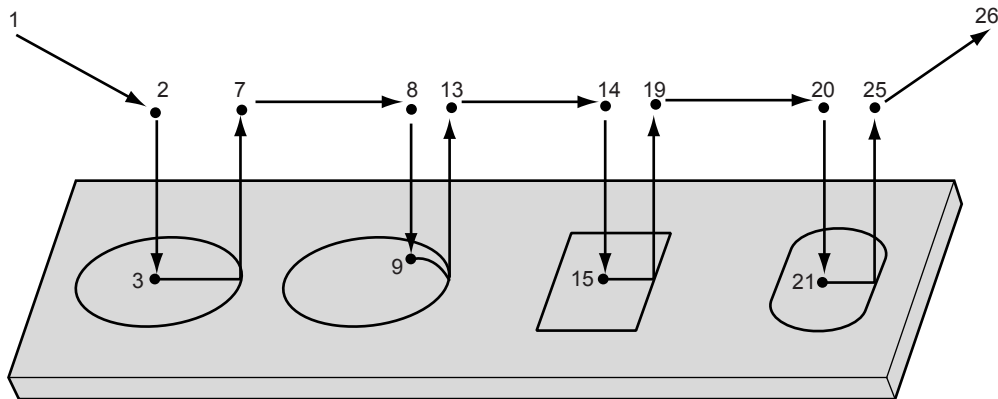


3.4 Example of Form Cutting Function

3.4 Example of Form Cutting Function

3.4.1 Example of a Job

An example of a job for cutting the following pattern is shown.



```

0000 NOP
0001 MOVJ VJ=100.00
0002 MOVJ VJ=100.00
0003 FORMAPR FCF#(1)····Move to the starting point (center)
0004 CALL LASERON····Instruction to a laser, etc. to start motion
0005 FORMCUT FCF#(1)····Cutting motion (circle)
0006 CALL LASEROFF····Instruction to a laser, etc. to end motion
0007 MOVL V=50
0008 MOVJ VJ=100.00
0009 FORMAPR FCF#(2) R=10.000····Move to the starting
                                point (specified point)
0010 CALL LASERON····Instruction to a laser, etc. to start motion
0011 FORMCUT FCF#(2) R=10.000····Cutting motion (circle)
0012 CALL LASEROFF····Instruction to a laser, etc. to end motion
0013 MOVL V=50
0014 MOVJ VJ=100.00
0015 MOVL V=50····Move to the starting point (center)
0016 CALL LASERON····Instruction to a laser, etc. to start motion
0017 FORMCUT FCF#(3)····Cutting motion (rectangle)
0018 CALL LASEROFF····Instruction to a laser, etc. to end motion
0019 MOVL V=50
0020 MOVJ VJ=100.00
0021 MOVL V=50····Move to the starting point (center)
0022 CALL LASERON····Instruction to a laser, etc. to start motion
0023 FORMCUT FCF#(4)····Cutting motion (ellipse)
0024 CALL LASEROFF····Instruction to a laser, etc. to end motion
0025 MOVL V=50
0026 MOVJ VJ=100.00
0027 END

```

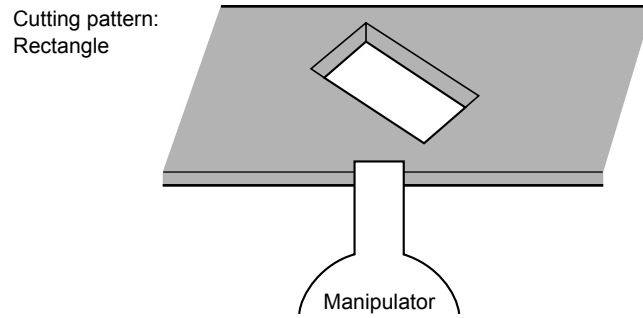
Set the same file No.

Set the same file No. and radius.

3.4.2 Example of a Motion Path

By setting the "END POINT" to PATH or to PLACEMENT in the form cut setting file, the FORMCUT instruction can be used to cut in on the pattern path or inwards from the path to complete a cutting motion.

Also, the "ROTATION DIRECTION", and the "ROTATION ANGLE", etc. of the pattern can be set in the form cut setting file. (Refer to Section " 6 Form Cut Setting File ".)



3.4 Example of Form Cutting Function

■ Motion Example 1

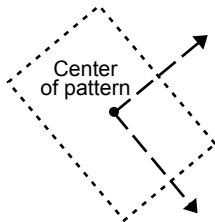
Conditions are as follows.

FIGURE: RECTANGLE

START POINT: CENTER

END POINT: PATH

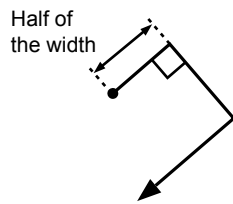
ROTATION DIRECTION: CW



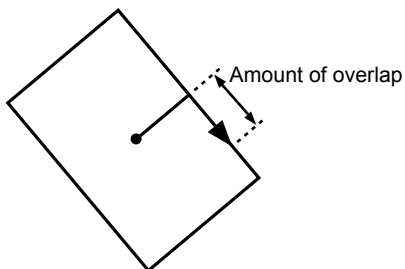
1. The starting point is the center of pattern.



2. The manipulator moves in the direction of the X-axis on the tool coordinate system in the positive direction.



3. After proceeding the half of the width, the manipulator changes the cutting direction by 90° to start drawing the rectangle.



4. Performs overlapping for the length specified in "AMOUNT OF OVERLAP".

■ Motion Example 2

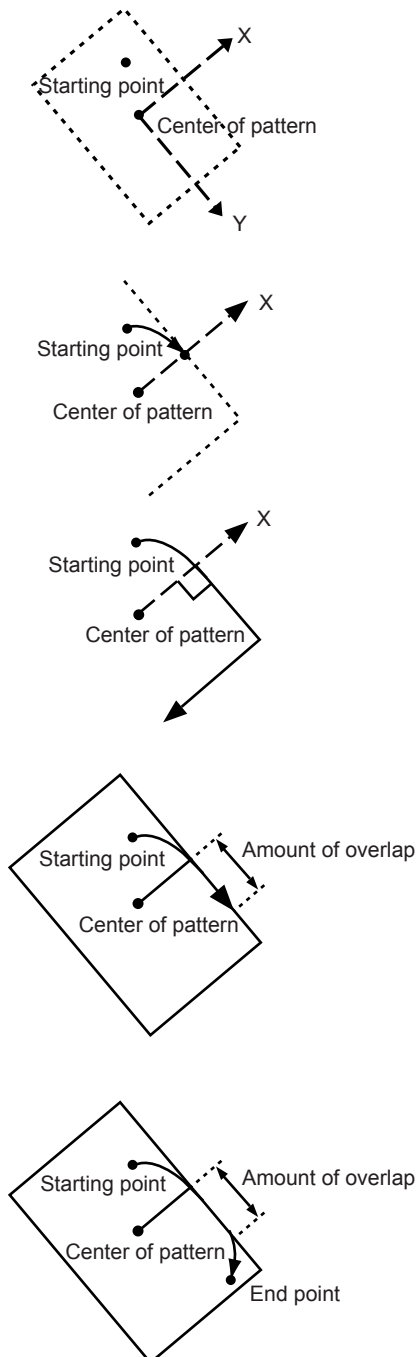
Conditions are as follows.

FIGURE: RECTANGLE

START POINT: PLACEMENT

END POINT: PLACEMENT

ROTATION DIRECTION: CW



1. The starting point is the point near the form cutting pattern.
2. The manipulator moves to the intersection of the cutting pattern and the X-axis direction on the tool coordinate system in the positive direction.
3. After proceeding up to the edge of the form cutting pattern, the manipulator starts drawing the specified rectangle.
4. Performs overlapping for the length specified in "AMOUNT OF OVERLAP".
5. When overlapping is completed, the manipulator moves to the end point specified by "CUT IN LENGTH" and "CUT IN ANGLE".

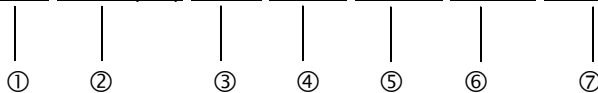
4 Form Cutting Start Motion Instruction

4.1 FORMAPR Instruction (Form Cutting Start Motion Instruction)

The FORMAPR instruction is to move the manipulator to the position where the form cutting motion starts according to the conditions set in the form cut setting file.

The additional items to the FORMAPR instruction are as follows. The additional items can be omitted except for "FORM CUT SETTING".

FORMAPR P000 FCF#(10) R=10 W=50 H=100 V=100 ROT=90



① POSITION VARIABLES IN CENTER OF PATTERN

Set when the center of the form cutting pattern is registered as position variables.

The variable number is omitted when the center of the form cutting pattern is taught to be registered.

② FORM CUT SETTING

The manipulator moves to the starting point of the cutting motion according to the conditions of the file No. specified by the FORMAPR instruction.

③ RADIUS (mm)

Specifies the radius when the radius in the file conditions specified in ② should be changed. The radius specified in ③ has a priority.

④ WIDTH (mm)

Specifies the width when the width in the file conditions specified in ② should be changed. The width specified in ④ has a priority.

⑤ HEIGHT (mm)

Specifies the height when the height in the file conditions specified in ② should be changed. The height specified in ⑤ has a priority.

⑥ APPROACH SPEED (cm/min) (mm/min) (inch/min)

Specifies the approach speed when the approach speed in the file conditions specified in ② should be changed. The approach speed in ⑥ has a priority.

⑦ ROTATION ANGLE (degrees)

Specifies the rotational angle when the rotational angle in the file conditions specified in ② should be changed. The rotational angle in ⑦ has a priority.



Set the same value for both the FORMAPR and FORMCUT instruction tag values (form cut setting file No., etc.) except for "SPEED". If the values are different, the FORMAPR instruction tag value is validated. The speed in the FORMAPR instruction is for the speed when moving to the starting point, and the FORMCUT instruction is for the speed when cutting.

```

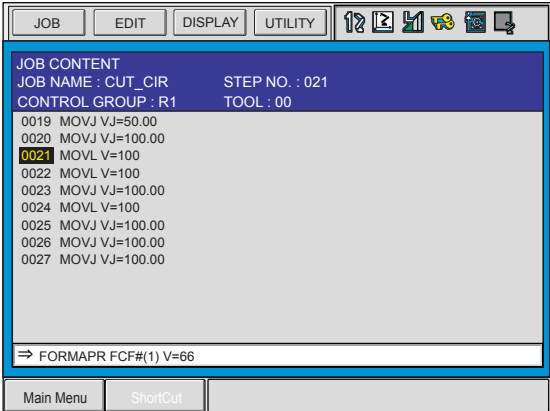
CONTROL GROUP : R1      TOOL : 00
0003 MOVJ VJ=100.00
0004 MOVJ VJ=100.00
0005 MOVJ VJ=100.00
0006 FORMAPR FCF#(1) R=10.000 W=50.000 V=100
0007 FORMCUT FCF#(1) R=10.000 W=50.000 V=50
0008 MOVL V=100
0009 END
    
```

→ Move to the shelter point
 Move to the starting point of the pattern
 Cutting
 Move to the shelter point



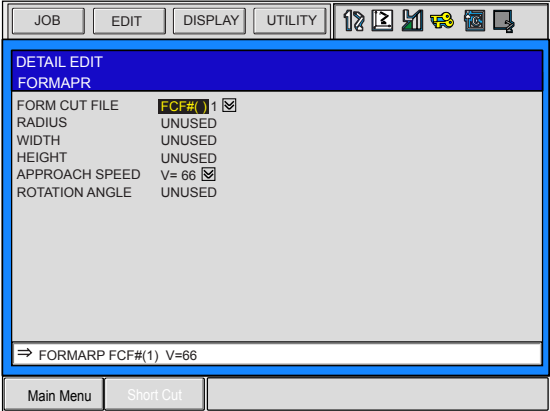
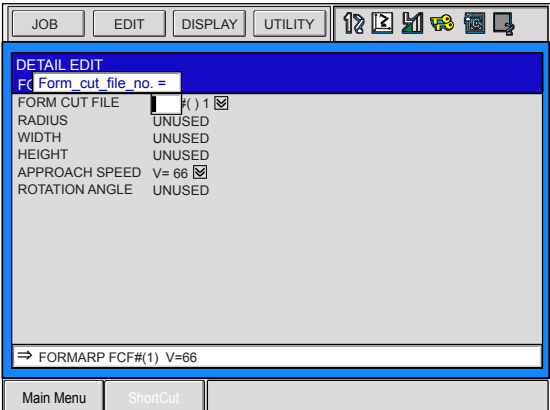
4.2 Registering Instructions

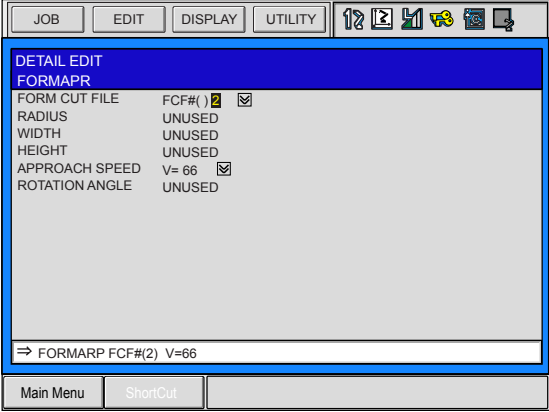
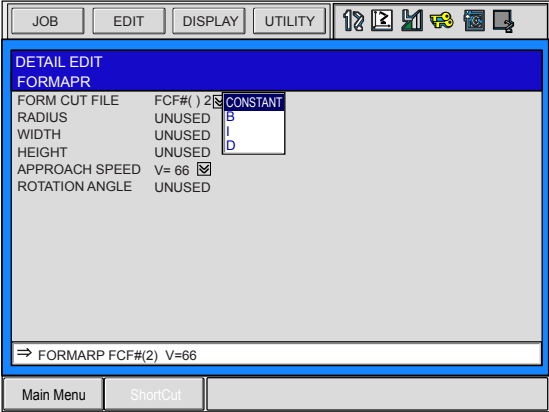
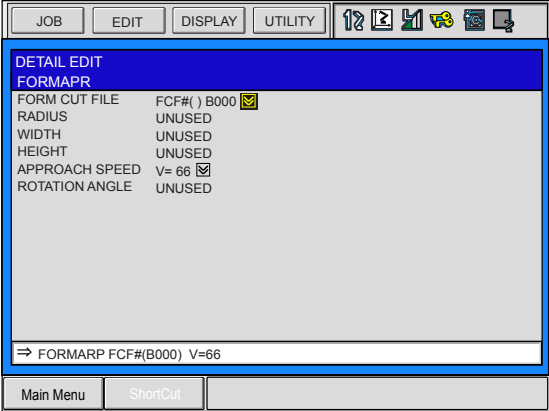
You can register the FORMAPR instruction in two different ways depending on how the position was specified: Registration by teaching the center position and registration by variables.

4.2.1 Registering by Teaching

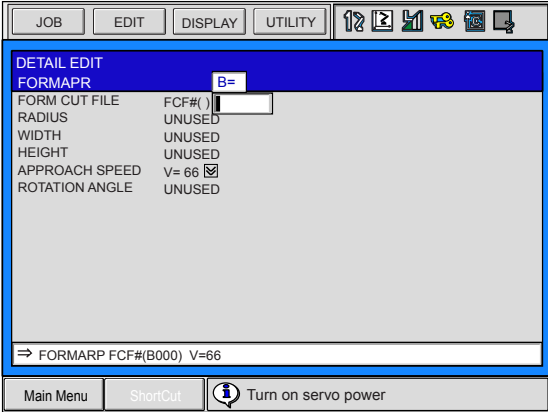
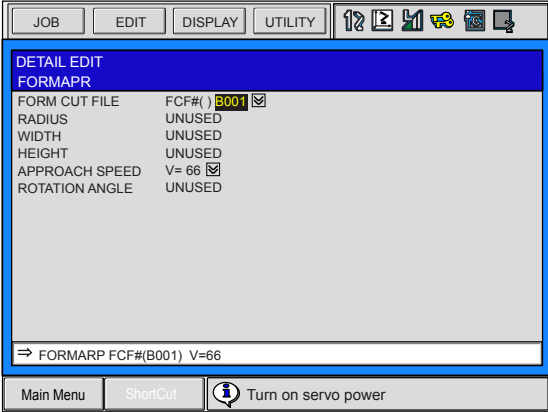
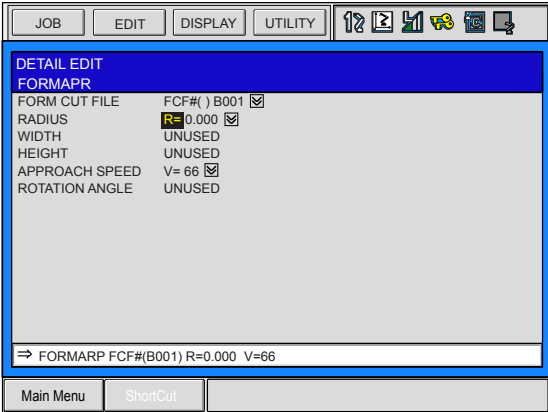
	Operation	Explanation
1	Move the cursor to the previous line where the FORMCUT instruction to be registered.	
2	Press [SHIFT] and [MOTION TYPE].	The FORMAPR instruction is displayed in the input buffer line. 

4.2 Registering Instructions

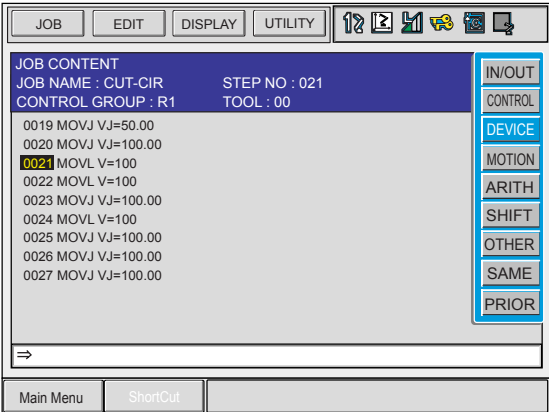
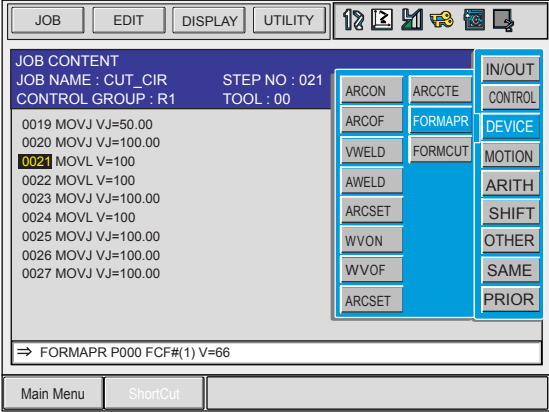

	Operation	Explanation
3	<p>Change the numerical data.</p>	<p><Register without changing> Proceed to the next step to register the instruction in the input buffer line without changing it.</p> <p><Edit additional items> To change the numerical data of the additional items, press [SELECT] and move the cursor to the input buffer line. Then move the cursor to the number to be changed and the number is highlighted. Press [SHIFT] and the cursor keys at the same time to raise or lower the number.</p>  <p>To type the data from the number keys, select where to enter the data, and the input line will be displayed. Type the desired number and press [ENTER] to change the number in the input buffer line.</p>  <p>To add or change any additional items, move the cursor to the instruction in the input buffer line. Then press [SELECT] to call up the detailed editing dialog box.</p>  <p>To change the form cut setting file, select the number of "FORM CUT FILE".</p> 

	Operation	Explanation
3	(cont'd)	<p>Type the file No. in the input buffer line, press [ENTER] and the number changes.</p>  <p>To register the form cut file No. in variables, select <input checked="" type="checkbox"/>.</p>  <p>The dialog box opens. Select the variable.</p> 

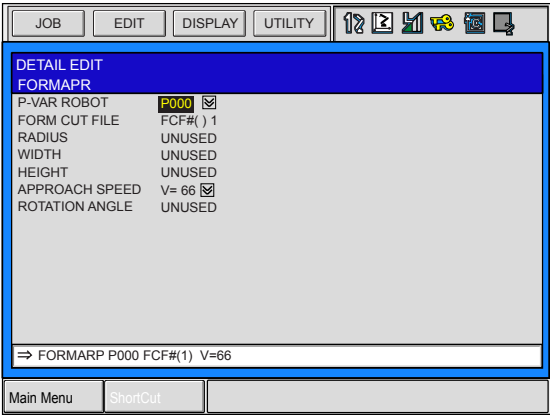
4.2 Registering Instructions

	Operation	Explanation
3	(cont'd)	<p>To change a variable No., select the variable to be changed.</p>  <p>Type the new variable No., press [ENTER], and the number changes.</p>  <p>To add the radius, select {UNUSED} for {RADIUS}. A selection dialog box is displayed. Select {R=}. Add or change any other items in the same manner.</p>  <p>When the additional items are added or changed, press [ENTER]. The detailed editing dialog box closes, and the job text display opens.</p>
4	Press [ADD] and then [ENTER].	

4.2.2 Registering in Variables

	Operation	Explanation
1	Move the cursor to the previous line where the FORMCUT instruction to be registered.	
2	Press [INFORM LIST].	<p>The instruction list dialog box opens.</p> 
3	Select {DEVICE}.	<p>The FORMAPR instruction is displayed.</p> 
4	Select {FORMAPR}.	<p>The {FORMAPR} instruction will be displayed in the input buffer line.</p> 

4.2 Registering Instructions

	Operation	Explanation
5	Change the numerical data.	Refer to Section " 4.2.1 Registering by Teaching " for how to change the numbers. 
6	Press [ADD] and then [ENTER].	The instruction displayed in the input buffer line has been registered.



To register the center of the pattern in position variables, select the FORMAPR instruction from the [INFORM LIST].

5 Form Cutting Instruction

5.1 FORMCUT (Form Cutting Motion Instruction)

The FORMCUT instruction is to execute the form cutting motion according to the conditions set in the form cut setting file.

The additional items to the FORMCUT instruction are as follows. The additional items can be omitted except for "FORM CUT SETTING".

FORMCUT RB1 FCF#(10) R=10 W=50 H=100 V=100 FCR=3 ROT=90

① ② ③ ④ ⑤ ⑥ ⑦ ⑧

① **MANIPULATOR**

Specifies the manipulator.

② **FORM CUT SETTING**

In the form cut setting file, the patterns for the form cutting motion and its dimensions, etc. are to be registered.

The form cutting motion is executed according to the conditions of the file No. specified by the FORMCUT instruction.

③ **RADIUS (mm)**

Specifies the radius when the radius in the file conditions specified in ② should be changed. The radius specified in ③ has a priority.

④ **WIDTH (mm)**

Specifies the width when the width in the file conditions specified in ② should be changed. The width specified in ④ has a priority.

⑤ **HEIGHT (mm)**

Specifies the height when the height in the file conditions specified in ② should be changed. The height specified in ⑤ has a priority.

⑥ **CUTTING SPEED (cm/min) (mm/min) (inch/min)**

Specifies the cutting speed when the cutting speed in the file conditions specified in ② should be changed. The cutting speed specified in ⑥ has a priority.

⑦ **CORNER RADIUS (mm)**

Specifies the corner radius when the corner radius in the file conditions specified in ② should be changed. The corner radius in ⑦ has a priority.

⑧ **ROTATION ANGLE (degrees)**

Specifies the rotational angle when the rotational angle in the file conditions specified in ② should be changed. The rotational angle in ⑧ has a priority.

5.2 Registering Instructions

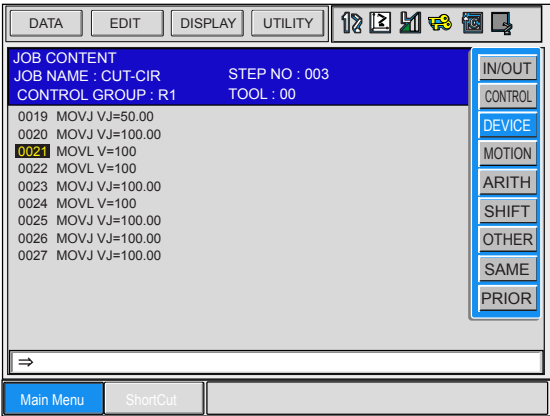


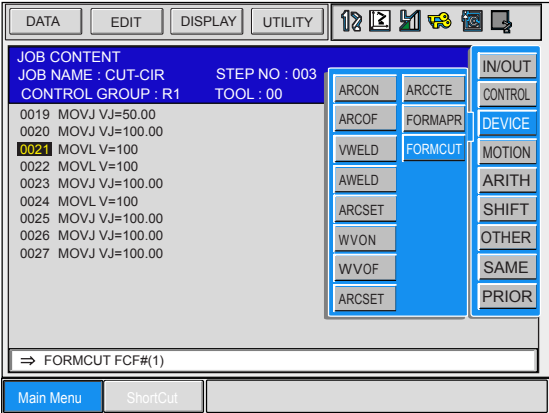



Set the same value for both the FORMAPR and FORMCUT instruction tag values (form cut setting file No., etc.) except for "SPEED". If the values are different, the FORMAPR instruction tag value is validated. The speed in the FORMAPR instruction is for the speed when moving to the starting point, and the FORMCUT instruction is for the speed when cutting.

```
CONTROL GROUP : R1      TOOL : 00
0003 MOVJ VJ=100.00
0004 MOVJ VJ=100.00
0005 MOVJ VJ=100.00
0006 FORMAPR FCF#(1) R=10.000 W=50.000 V=100
0007 FORMAPR FCF#(1) R=10.000 W=50.000 V=50
0008 MOVL V=100
0009 END
```

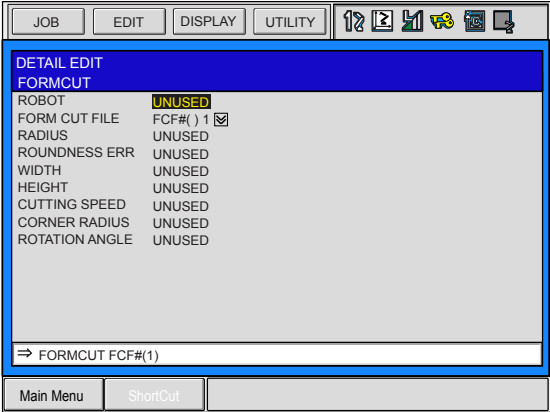
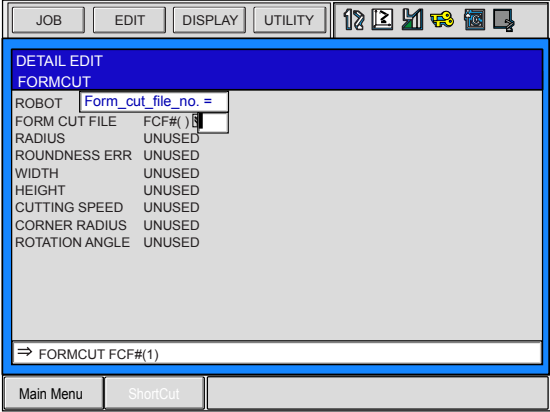
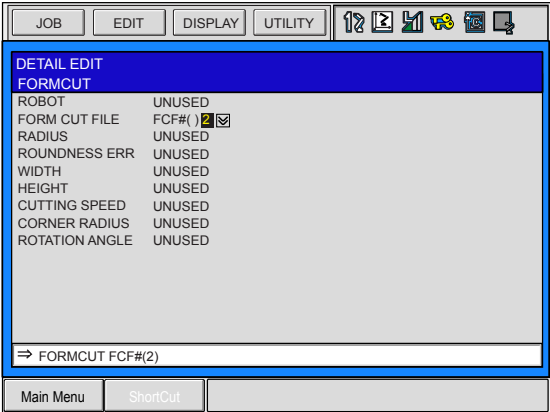
Move to the shelter point
 Move to the starting point of the pattern
 Cutting
 Move to the shelter point

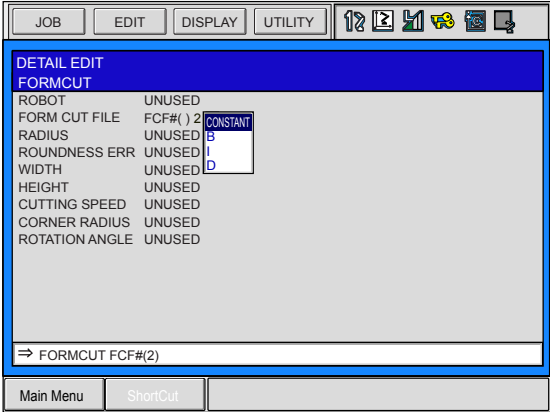
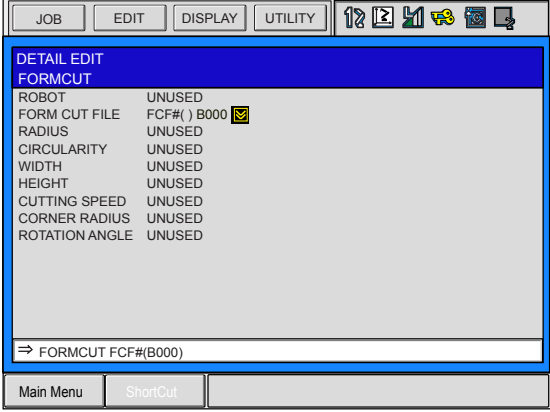
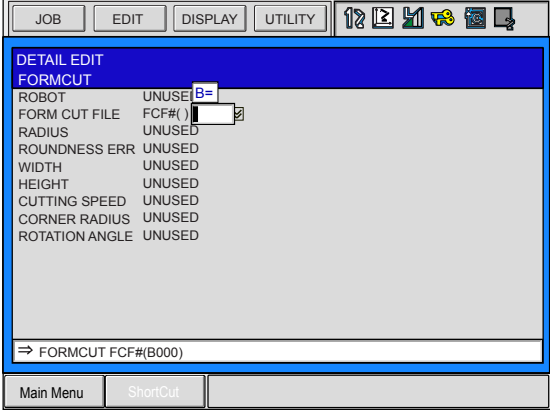
5.2 Registering Instructions

	Operation	Explanation
1	Move the cursor to the previous line of which FORMCUT instruction to be registered.	
2	Press [INFORM LIST].	The instruction list dialog box opens. 

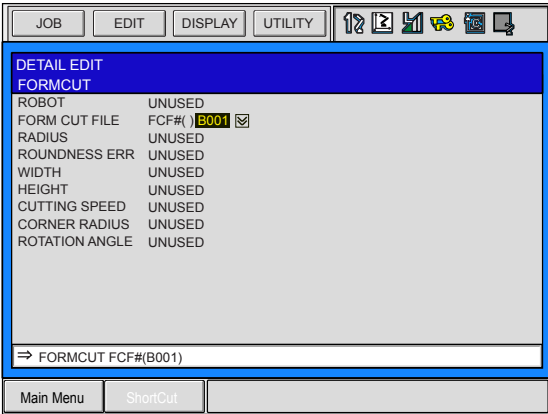
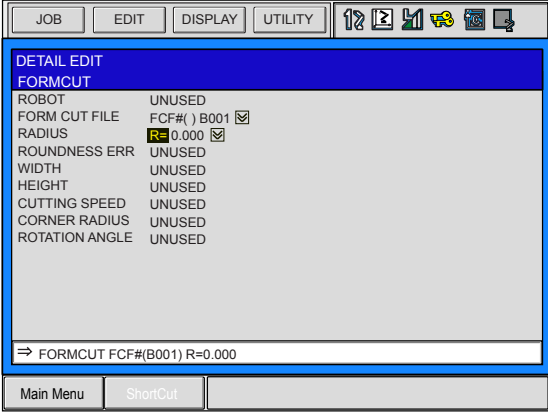
	Operation	Explanation
3	Select {DEVICE}.	<p>The FORMCUT instruction is displayed.</p> 
4	Select {FORMCUT}.	<p>The {FORMCUT} instruction will be displayed in the input buffer line.</p> 
5	Change numerical the data.	<p><Register without changing> Proceed to the next step to register the instruction in the input buffer line without changing it. <Edit additional items> To change the numerical data of the additional items, move the cursor to the number to be changed and the number is highlighted. Press [SHIFT] and the cursor keys at the same time to raise or lower the number.</p>  <p>To type the data from the number keys, select where to enter the data, and the input line will be displayed. Type the desired number and press [ENTER] to change the number in the input buffer line.</p> 

5.2 Registering Instructions

	Operation	Explanation
5	(cont'd)	<p>To add or change any additional items, move the cursor to the instruction in the input buffer line. Then press [SELECT] to call up the detailed editing dialog box.</p>  <p>To change the form cut setting file, select the number of "FORM CUT FILE".</p>  <p>Type the file No. in the input buffer line, press [ENTER] and the number changes.</p> 

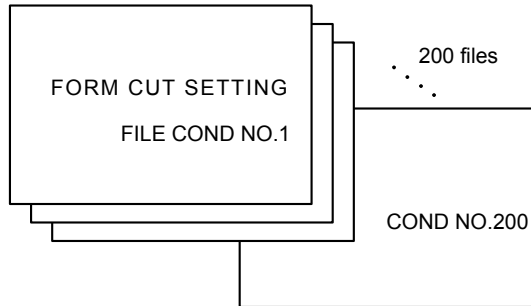
	Operation	Explanation
5	(cont'd)	<p>To register the form cut file No. in variables, select <input checked="" type="checkbox"/>.</p>  <p>The dialog box opens. Select the variable.</p>  <p>To change a variable No., select the variable to be changed.</p> 

5.2 Registering Instructions

	Operation	Explanation
5	(cont'd)	<p>Type the new variable No., press [ENTER], and the number changes.</p>  <p>To add the radius, select {UNUSED} for {RADIUS}. A selection dialog box is displayed. Select {R=}. Add or change any other items in the same manner.</p>  <p>When the additional items are added or changed, press [ENTER]. The detailed editing dialog box is closed, and the job text display opens.</p>
6	Press [ADD] and then [ENTER].	The instruction displayed in the input buffer line has been registered.

6 Form Cut Setting File

The form cut setting file is to set the conditions for a form cutting motion and used in the FORMAPR and FORMCUT instructions. Up to 200 files can be registered.



Form Cut Setting Files

Set the desired form cut setting file condition No. in the FORMAPR and FORMCUT instructions.

6.1 Settings

The details of the settings in the form cut setting file are:

FORMAPR FCF#(1) V=66

Form cut setting file No. 1

FORMCUT FCF#(1)

Form cut setting file No. 1

6.1 Settings

Setting	Value
FIGURE	CIRCLE
CUTTING SPEED	10.0 mm/sec
RADIUS	150.000 mm
ROUNDNESS ERR	0.250 mm
WIDTH	0.000 mm
HEIGHT	0.000 mm
CORNER RADIUS	0.000 mm
START POINT	CENTER
END POINT	PATH
CUT IN LENGTH	5.0 mm
CUT IN ANGLE	45.0 deg.
AMOUNT OF OVERLAP	10.000 mm
FIRST STOP TIME	0.50 sec
SECOND STOP TIME	0.00 sec
ROTATION DIRECTION	W
ROTATION ANGLE	0.0 deg.

① **COND NO. (1 to 200)**

Form cut setting file condition No.

② **FIGURE**

Select the desired pattern.

A circle, rectangle, ellipse, pentagon, or hexagon can be selected.

③ **CUTTING SPEED**

Set the cutting speed.

④ **Dimensions**

Set the dimensions of the pattern.

The items to be set are marked with "■" while the items not to be set are marked with "□".

Set a numerical value in the items marked with "■".

⑤ **START POINT**

Select the starting point.

The "CENTER", "PLACEMENT" or "AUTO" are choices for selecting a starting point.

When "CENTER" is selected, the cutting motion starts from the center of the cutting pattern.

When "PLACEMENT" is selected, the cutting motion starts from a point near the cutting pattern that is defined by "CUT IN LENGTH" and "CUT IN ANGLE".

When "AUTO" is selected, the cutting motion starts from either the point used for "CENTER" or the point used for "PLACEMENT", depending on the dimensions of the pattern.

When the "FIGURE" is a circle, an ellipse, a pentagon or a hexagon:

The starting point is the CENTER where $(\text{Radius} \times 2) \leq S1C \square G66 \times 10^{-3}$.

The starting point is the PLACEMENT where $(\text{Radius} \times 2) > S1C \square G66 \times 10^{-3}$.

When the "FIGURE" is a rectangle:

The starting point is the CENTER where $\text{height} \leq S1C \square G66 \times 10^{-3}$.

The starting point is the PLACEMENT where $\text{height} > S1C \square G66 \times 10^{-3}$.

⑥ END POINT

Select the end point.

"PATH" or the "PLACEMENT" can be selected.

When "PATH" is selected, a point on the cutting pattern becomes the end point.

When the "PLACEMENT" is selected, a point near the cutting pattern that is defined by "CUT IN LENGTH" and "CUT IN ANGLE" becomes the end point.

⑦ CUT IN LENGTH

Set the cut in length for the cutting motion.

Valid only when "START POINT" or "END POINT" is the PLACEMENT.

⑧ CUT IN ANGLE

Set the cut in angle for the cutting motion.

Valid only when "START POINT" or "END POINT" is the PLACEMENT.

⑨ AMOUNT OF OVERLAP

Set the length to be overlapped.

⑩ FIRST STOP TIME (sec)

Using a timer, the manipulator can be stopped at the position to start cutting. The first stop timer can be set for all the pattern (circle, rectangle, ellipse, pentagon, or hexagon).

⑪ SECOND STOP TIME (sec)

When the pattern "RECTANGLE" is selected without specification of the "CORNER RADIUS", or when the pattern "PENTAGON" or "HEXAGON" is selected, the manipulator can be stopped at each corner.

This timer is not available for cutting other patterns.

⑫ ROTATION DIRECTION

Select the rotational direction.

CW or CCW can be selected.

The "ROTATION DIRECTION" defines if the rotation is clockwise or counterclockwise for the Z-axis of the tool coordinate in the positive direction when the center point of the cutting pattern is registered.

⑬ ROTATION ANGLE

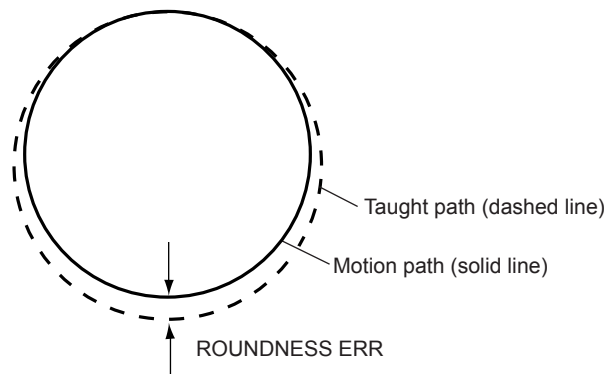
Set the rotational angle.

The "ROTATION ANGLE" uses the center point of the cutting pattern as the center of rotation. The forward direction is clockwise for the Z-axis of the tool coordinate in the positive direction when the center point of the cutting pattern is registered.

6.2 Details of File Settings

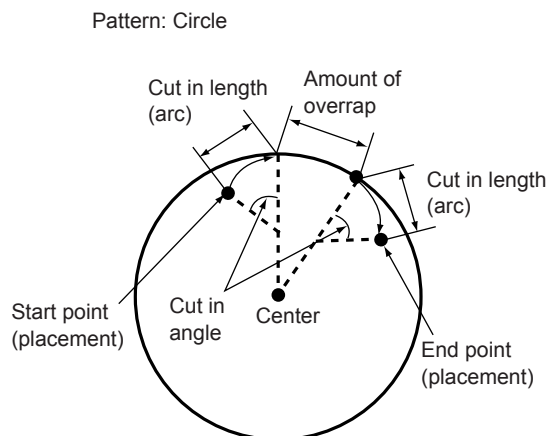
6.2.1 Specifying the ROUNDNESS ERR

The manipulator operates within the set value of "ROUNDNESS ERR" and completes a cutting motion inward from the taught path as shown by the dashed line circle in the figure below. Because the cutting speed is automatically adjusted according to the value of "ROUNDNESS ERR", users do not need to adjust the taught speed confirming the path. To this extent, the teaching operations can be reduced.



6.2.2 Specifying the CUT IN LENGTH and the CUT IN ANGLE

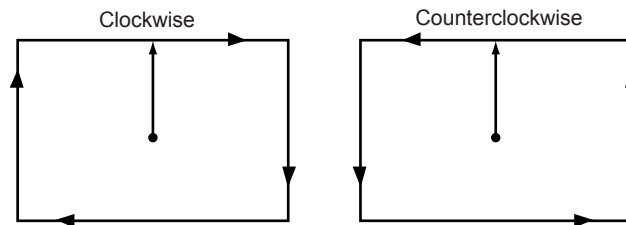
When the "START POINT" or the "END POINT" of the form cut setting file is PLACEMENT, the starting point or end point of the form cutting motion is a point near the pattern. This point is defined by the "CUT IN LENGTH" and the "CUT IN ANGLE" of the form cut setting file.



6.2.3 Specifying the ROTATION DIRECTION

Specify the rotational direction (cutting direction) for a form cutting motion.
Specify the direction in "ROTATION DIRECTION".

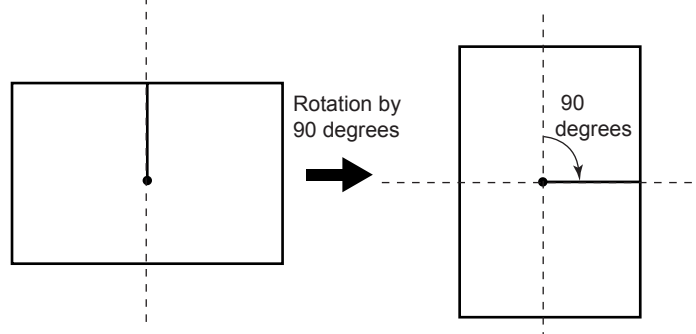
Pattern: Rectangle



6.2.4 Specifying the ROTATION ANGLE

Specify the rotational angle for the center of the cutting pattern.
Specify the angle in "ROTATION ANGLE".

Figure: Rectangle
Rotation angle: 90 degrees

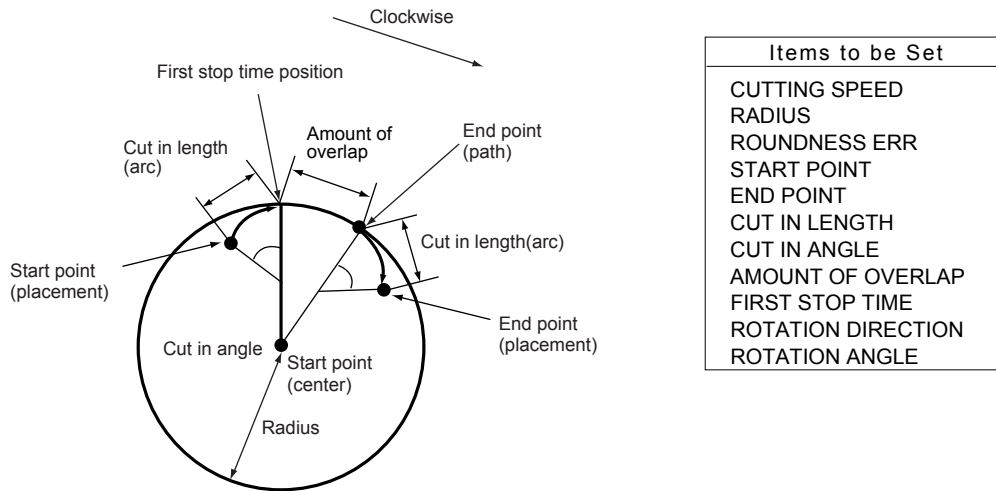


6.3 Examples of File Setting for Each Pattern

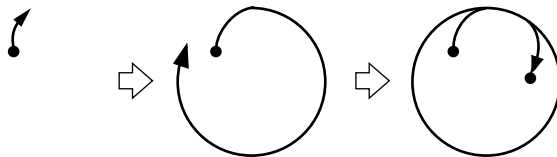
6.3 Examples of File Setting for Each Pattern

The examples of file setting for each pattern are shown.

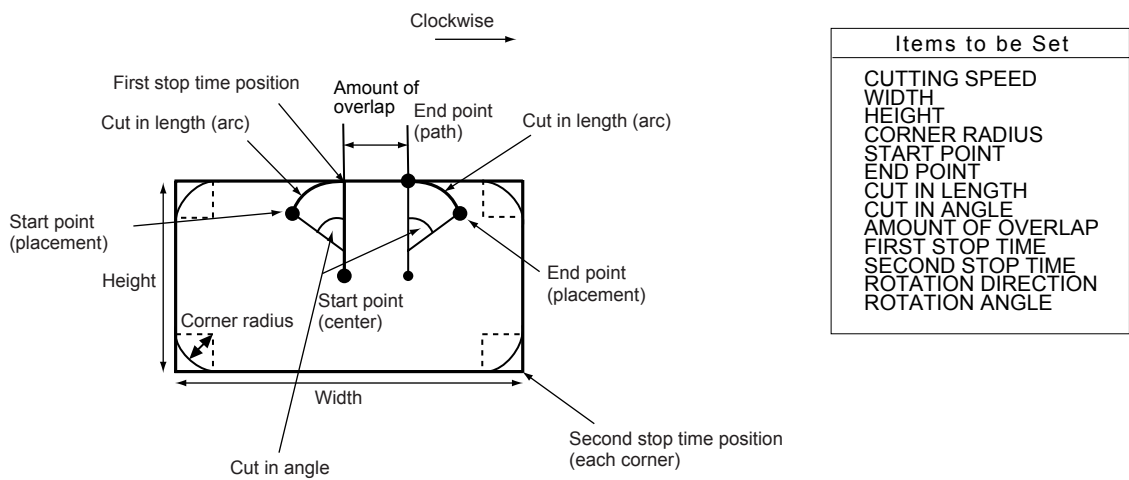
6.3.1 Circle



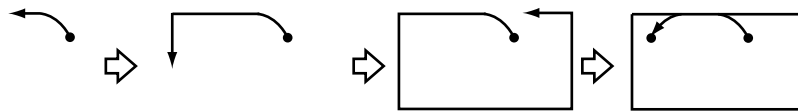
Example of {START POINT}: PLACEMENT, {END POINT}: PLACEMENT, {ROTATION DIRECTION}: CLOCKWISE



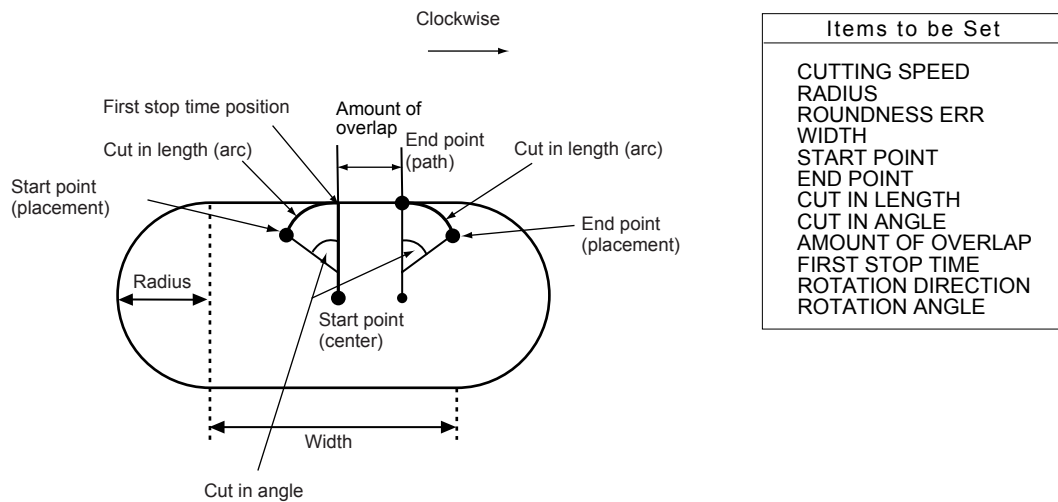
6.3.2 Rectangle Including Squares



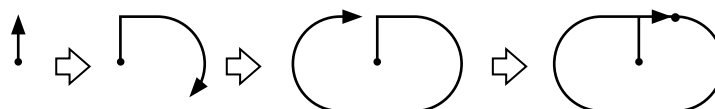
Example of {START POINT}: PLACEMENT, {END POINT}: PLACEMENT, {ROTATION DIRECTION}: COUNTERCLOCKWISE



6.3.3 Ellipse

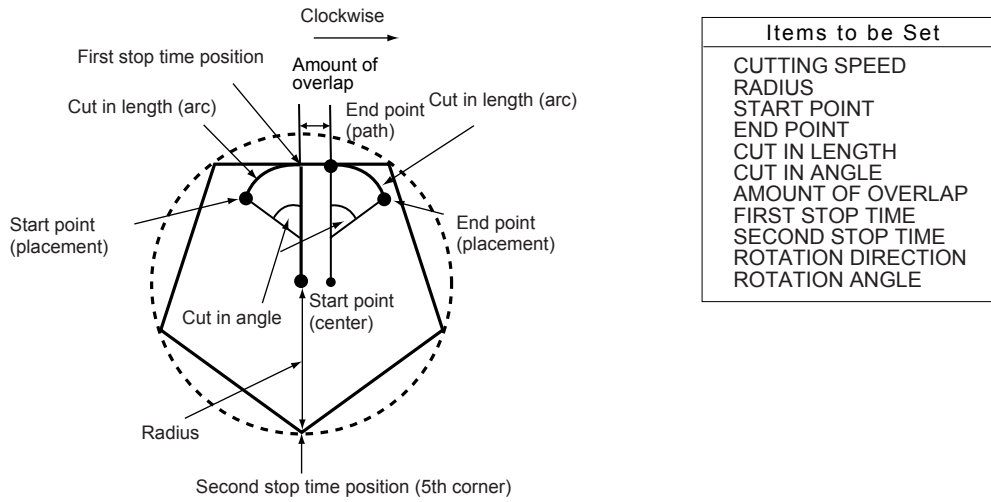


Example of {START POINT}: CENTER, {END POINT}: PATH, {ROTATION DIRECTION}: CLOCKWISE

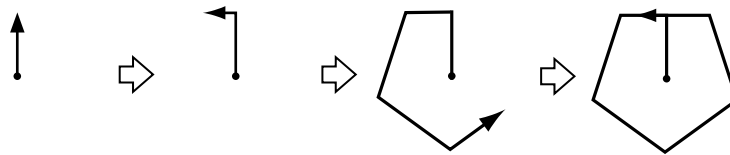


6.3 Examples of File Setting for Each Pattern

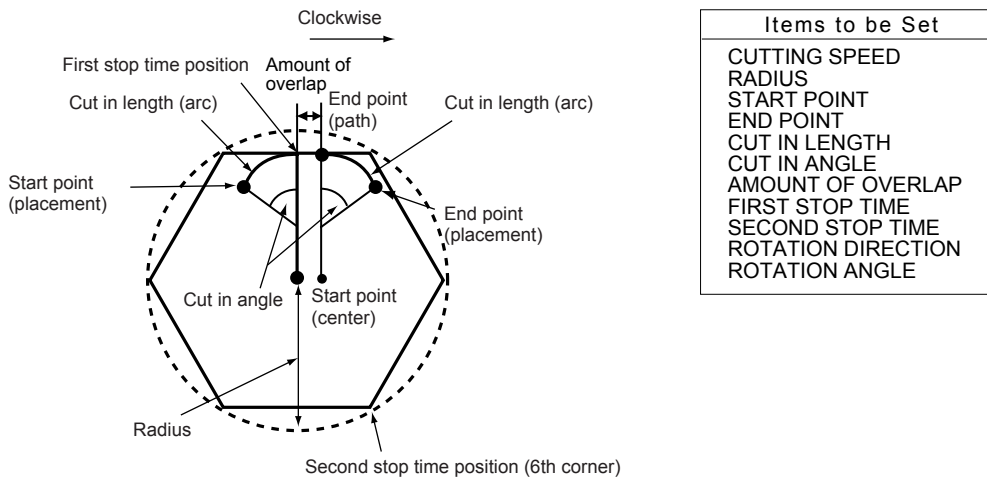
6.3.4 Pentagon



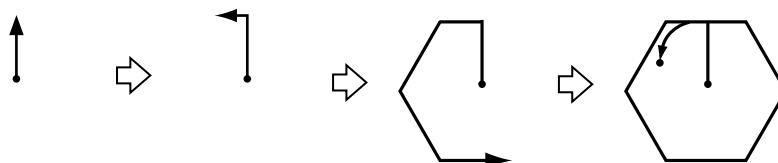
Example of {START POINT}: CENTER, {END POINT}: PATH, {ROTATION DIRECTION}: CLOCKWISE



6.3.5 Hexagon



Example of {START POINT}: CENTER, {END POINT}: PLACEMENT, {ROTATION DIRECTION}: COUNTERCLOCKWISE



6.4 Displaying and Editing File

	Operation	Explanation
1	Select the application menu under the top menu.	The application menu differs depending on the robot application : <ul style="list-style-type: none"> • For arc welding : {ARC WELDING} • For handling : {HANDLING} • For general-purpose : {GENERAL} • For spot welding : {SPOT WELDING}
2	Select {FORM CUT SETTING FILE}.	
3	Display the file of desired condition No.	There are two methods to display the file of desired condition No. <ul style="list-style-type: none"> • Call the file of desired condition No.using [PAGE]. Press [PAGE] to call the next condition No. Press [SHIFT]+[PAGE] to call the previous condition No. • Enter the desired condition No. Move the cursor to the COND NO. and press [SELECT]. Enter the desired condition No. with number keys, then press [ENTER].
4	Select each setting item and set.	

7 Alarm Message List

Alarm Number	Message	Cause	Remedy
4595	CAN'T DO FIXED FORM CUT MOTION	1 : Wrong setting for RADIUS	<ul style="list-style-type: none"> • Check the radius value. • Move the cursor to the instruction (FORMAPR, etc.) which was executed for teaching the center of the pattern, and execute the instruction again.
		2 : Wrong setting for WIDTH	Check the width value.
		3 : Wrong setting for HEIGHT	Check the height value.
		4 : Wrong setting for CORNER RADIUS	Check the corner radius value.
		5 : Wrong setting for AMOUNT OF OVERLAP	Check the amount of overlap.
		6 : Wrong setting for CUTTING SPEED	Check the cutting speed.
		7 : With slave designation for coordinated control	Execute FORMCUT instruction in a single job.
		8 : No setting for pattern cutting motion minimum diameter	Check the set value for minimum diameter.
		9 : No setting for pattern cutting motion maximum diameter	Check the set value for maximum diameter.

Alarm Number	Message	Cause	Remedy
4595	CAN'T DO FIXED FORM CUT MOTION	10: FORMAPR instruction not executed	<ul style="list-style-type: none">• Execute the FORMAPR instruction.• Do not register any move instruction between the FORMAPR and FORMCUT instructions.• To execute the FORMCUT instruction by pressing PLAY-BACK, TEST RUN, or INTER-LOCK and NEXT at the same time after a NEXT or BACK operation, be sure to execute the NEXT or BACK operation several steps before the FORMCUT instruction. All the instructions between the instruction carried out by pressing the NEXT or BACK and the FORMCUT instruction must be executed by pressing PLAY-BACK, TEST RUN, or INTER-LOCK and NEXT at the same time.

NX100 OPTIONS INSTRUCTIONS

FORM CUTTING FUNCTION

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