

Motoman NX100 Controller

External Reference Point Control Function Manual

Part Number: 149648-5CD
Revision: 1

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Chapter 1

Introduction

This manual provides system information for the External Reference Point Control Function 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 - EXTERNAL REFERENCE POINT CONTROL INSTRUCTIONS

Provides detailed information about the External Reference Point Control Function.

1.1 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

1.2 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 (EA1400, HP20, etc.)
- 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)

NOTES

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

FOR EXTERNAL REFERENCE POINT CONTROL 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 functions of the NX100 external reference point control. 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.

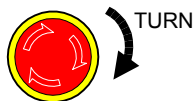
Emergency Stop Button



- **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, on the floor, or near fixtures.

- **Read and understand the Explanation of Warning Labels in the NX100 Instructions 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 keys, 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 Numeric Keys	“Axis Keys” and “Numeric 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.

1 External Reference Point

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2 Teaching and Modification

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1 External Reference Point

The external reference point function makes it possible to use a point in space as a control point of the manipulator for teaching and playback. This point in space is called the external reference point.

During sealing or spot-welding where the workpiece is held by the manipulator, by defining the tip of a nozzle or the gun as a reference point, the orientation of the workpiece, etc. can be changed.

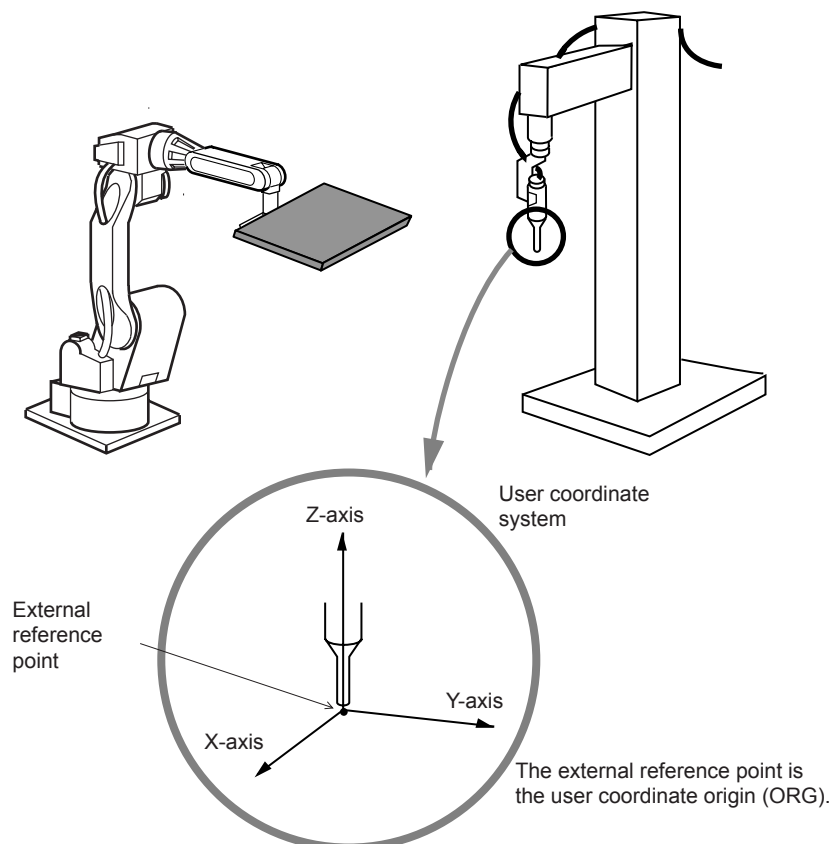
For interpolation during playback, the speed of an external reference point is controlled in relation to the speed of the workpiece.


The external reference point function saves teaching time and makes it easier to control relative speeds of the nozzle and the workpiece.

An external reference point is defined to the user coordinate origin (ORG). Therefore, external reference point control is possible only when user coordinates are registered.

Since up to 24 user coordinates can be stored in memory, up to 24 external reference points can be set up.

An example of sealing by a workpiece-holding manipulator is shown in the following figure.





 For the user coordinate system, refer to “2.7 User Coordinates” in the NX100 operator’s manual.


NOTE The external reference point control is not available with the coordinated job.

1.1 Operation at Teaching

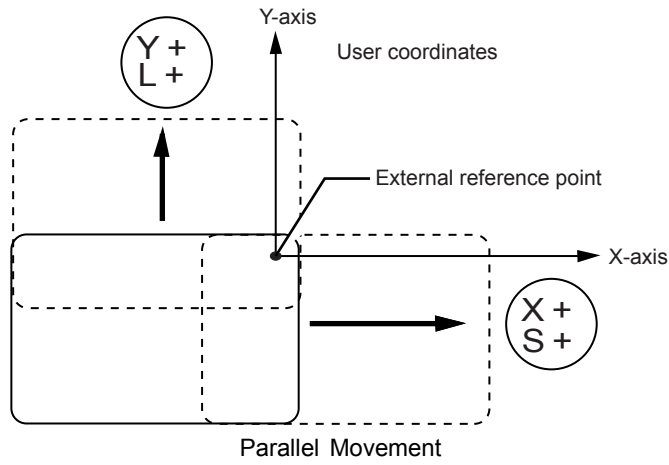
Teaching must be performed in the user coordinate system. For operations to change to the user coordinate system, refer to “2.1 Teaching.”

The “Axis Key” operations are the same as that in a user coordinate system, as explained in the following table.

Axis	Axis Keys	Motion
Major Axes		Moves parallel to the X-, Y-, and/or Z-axis of the selected user coordinate.
Wrist Axes		Executes the motion about TCP. (The external reference point is set as the TCP.)

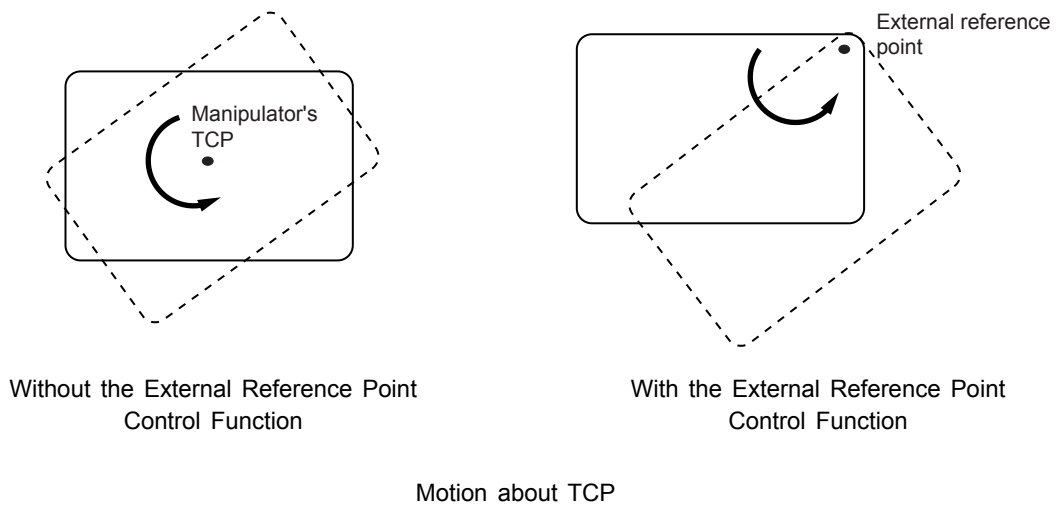
 For details, refer to “2.7 User Coordinates” and “2.8 Tool Tip Operations” in the NX100 operator’s manual.

1.1.1 Major Axes



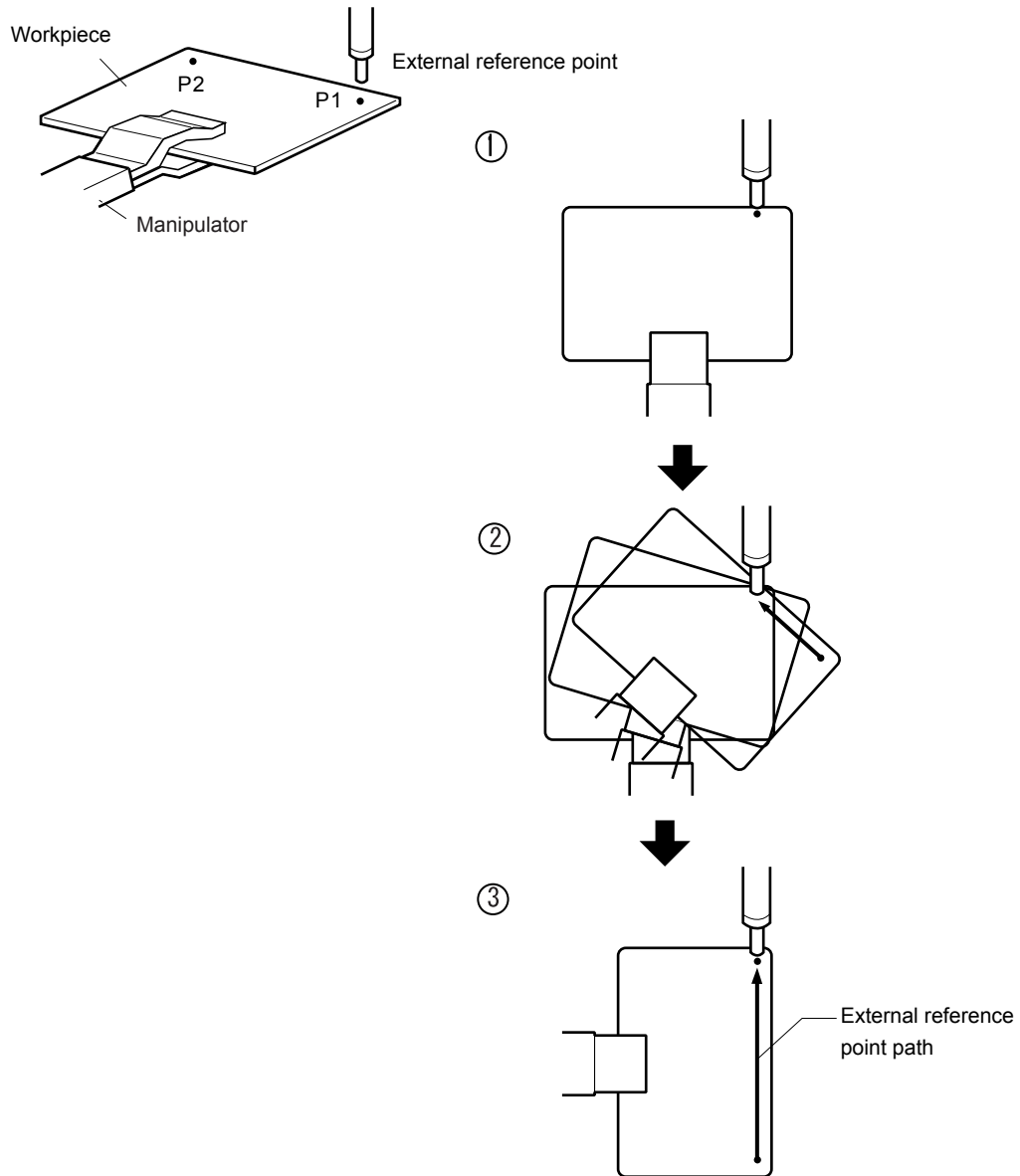
1.1.2 Wrist Axes

With a motion about TCP by the wrist axes, the manipulator's posture can be changed without changing the position of the TCP (the external reference point).



1.2 Operation at Playback

External reference point control with linear interpolation between teaching points P1 and P2 is shown in the following figure.



1.3 Preparations for External Reference Point Control

To perform the external reference point control for teaching, user coordinates must be registered.

1.3.1 Registration of User Coordinates

For registration of user coordinates, refer to “2.7 User Coordinates” in the NX100 operator’s manual.

1.4 Move Instructions

1.4.1 Type

There are two move instructions for external reference point control.

EIMOV L : Used for external linear interpolation.

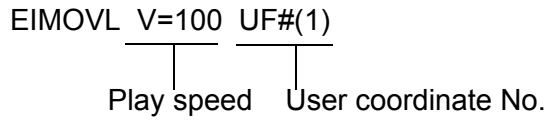
EIMOV C : Used for external circular interpolation.

1.4.2 Play Speed

The setting procedure is the same as that for linear or circular motions.

1.4.3 User Coordinate No.

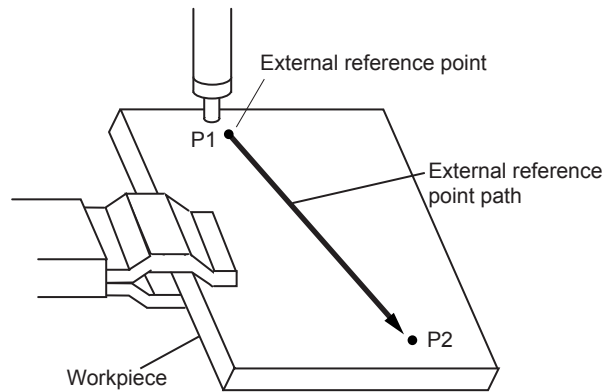
When a move instruction for the external reference point control is registered, the user coordinate number of the external reference point selected at the time is automatically registered.



<Examples of instruction registration and movement>

- An example of instruction registration for EIMOV L

0000	NOP		
0001	MOVJ VJ=50.00	•	Move instruction for manipulator's TCP
0002	EIMOV L UF#(5) V=138	•	P1
0003	EIMOV L UF#(5) V=66	•	P2
0004	MOVJ VJ=50.00		
0005	END		

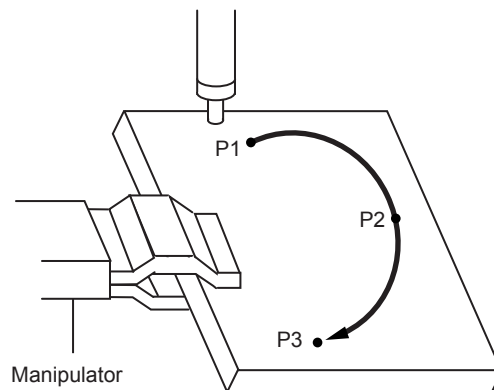


EIMOV L (Linear interpolation)

Fig. A

- An example of instruction registration for EIMOV C

0000	NOP		
0001	MOVJ VJ=50.00		
0002	TIMER T=1.00		
0003	EIMOV C UF#(4) V=138	•	P1
0004	EIMOV C UF#(4) V=66	•	P2
0005	EIMOV C UF#(4) V=66	•	P3
0006	MOVJ VJ=50.00		
0007	END		



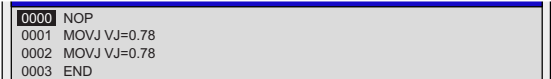
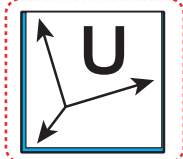

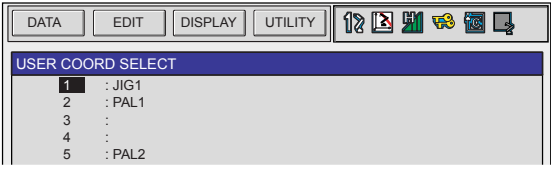
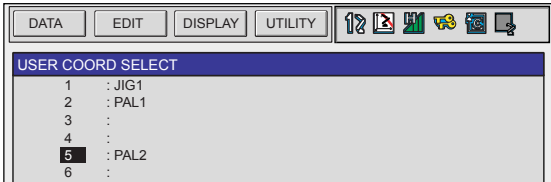
EIMOV C (Circular interpolation)

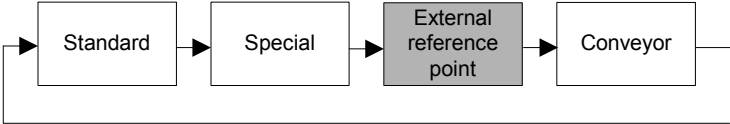
Fig. B

2 Teaching and Modification

After registering user coordinates, move instructions for external reference point control can be taught or modified.

2.1 Teaching

	Operation	Explanation
1	Select {JOB} from {JOB} under the main menu.	The JOB CONTENT window appears. 
2	Move the cursor to the line above where the move instruction is to be inserted.	
3	Press [COORD] to set the external reference points' coordinates.	 
4	When the desired user coordinate file is not shown, press [SHIFT] + [COORD].	The USER COORD SELECT window appears. 
5	Move the cursor to the desired user coordinate file No., and then press [SELECT].	

	Operation	Explanation
6	By pressing the axis key, set the external reference point to the desired position.	
7	Press [SHIFT] + [MOTION TYPE] to select the external reference point interpolation mode.	<p>The interpolation mode is switched in the following order. (When the special interpolation mode and the conveyor interpolation mode are invalid, the mode is switched between the standard interpolation mode and the external reference point interpolation mode.)</p>  <pre> graph LR A[Standard] --> B[Special] B --> C[External reference point] C --> D[Conveyor] D --> A </pre>
8	Press [MOTION TYPE] to select either EIMOV L (external linear interpolation) or EIMOV C (external circular interpolation).	<p style="text-align: center;"> ⇒ EIMOV L UF#(5) V=66 </p>
9	With the cursor on the line No., press [SELECT].	<p style="text-align: center;"> ⇒ EIMOV L UF#(5) V=66 </p>
10	Change the value.	<p>Press the right cursor key to move the cursor on the speed indication “V=**.” Then hold down [SHIFT] and press the top or bottom of the cursor key to change the play speed.</p> <p style="text-align: center;"> ⇒ EIMOV L UF#(5) V=66 </p>
11	Press [ENTER] to register the move instruction.	

2.2 Checking Paths

To check whether the taught step positions are correct, use [FWD] and [BWD] on the programming pendant.

For details, refer to “4.3 Checking Steps” in the NX100 operator’s manual.

2.3 Modifying Paths

If the paths need to be modified, refer to the following sections in the NX100 operator’s manual.

- 4.4.2 Inserting Move Instructions
- 4.4.3 Deleting Move Instructions
- 4.4.4 Modifying Move Instructions

NX100 OPTIONS INSTRUCTIONS

FOR EXTERNAL REFERENCE POINT CONTROL FUNCTION

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