Motoman NX100 Controller

T-Axis Endless
Function Manual

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Chapter 1

Introduction

1.1 About This Document

This manual provides information for the T-Axis Endless function and contains the following sections:

CHAPTER 1 - INTRODUCTION
Provides general information about the structure of this manual, a list of reference documents, and customer service information.

CHAPTER 2 - SAFETY
This section provides information regarding the safe use and operation of Motoman products.

CHAPTER 3 - T-AXIS ENDLESS INSTRUCTIONS
Provides detailed information for the T-Axis Endless function.

1.2 Reference to Other Documentation

For additional information refer to the following:

- NXC100 Controller Manual (P/N 150975-1)

- 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 (HP3JC, EA1400N, HP20, etc.)

- Application Type (welding, handling, etc.)

- Robot Serial Number (located on back side of robot arm)

- Robot Sales Order Number (located on back of controller)

Notes

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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.

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- 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

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NX100 OPTIONS
INSTRUCTIONS

FOR T-AXIS ENDLESS 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 manual above corresponds to specific usage.
Be sure to use the appropriate manual.

YASKAWA

MANUAL NO.
HW0480494

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ⓘ MANDATORY

- **This manual explains the T-axis endless function of the NX100 system and general operations. 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.**

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⚠ 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.**

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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.

> **NOTE** To ensure safe and efficient operation at all times, be sure to follow all instructions, even if not designated as "CAUTION" and "WARNING".

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⚠ 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.

  TURN
  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 button is located on the right of front door of the NX100 and programming pendant.

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<table>
<tr><td colspan="2" align="center">⚠️ CAUTION</td></tr>
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• **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 manipulator's work area, on the floor, or near fixtures.

• **Read and understand the Explanation of Warning Labels in the NX100 instructions before operating the manipulator.**

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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.

The MOTOMAN manipulator is the YASKAWA industrial robot product.

In this manual, the equipment is designated as follows.

Equipment	Manual Designation
NX100 Controller	NX100
NX100 Programming Pendant	Programming Pendant

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Descriptions of the programming pendant and playback panel 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 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}
Playback Panel	Buttons	Playback panel buttons are enclosed in brackets. ex. [TEACH] on the playback panel

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   T-axis Endless Function

2   Specifying T-axis Continuous Rotation

3   Registering MRESET Instruction

4   Display of T-axis Rotating Amount

5   Resetting the Axis Rotating Amount

6   Job Example

7   Restrictions

8   Alarm Message List

1 T-axis Endless Function

This function is used for endless rotation of the T-axis. Since interpolation is not possible if the T-axis rotates more than one time for the endless rotation, a function to reset the endless rotation position to a position within one revolution is also available.

The following outlines the functions.

1.1 Endless Rotation

By specifying " How many times the T-axis is to be rotated" for a move instruction (MOVJ), the T-axis rotates for "the specified rotating amount + the taught position pulse" during moving to the target position. "How many times the T-axis is to be rotated" is specified with "MT" tag.

For the rotating amount, up to ±100 revolutions can be specified for one move instruction. To rotate the axis more than 100 times continuously, register consecutively multiple number of move instructions for which the tag "MT" is registered.

<Format>
MOVJ VJ=Speed, MT=T-axis rotating amount

1.2 Resetting the Rotating Amount

To perform an interpolation after completion of endless rotation, re-create the T-axis current value pulse and the motor feedback pulse at a position within one revolution in one of the following operations.

- Execution of MRESET instruction
- Operation from the programming pendant

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2 Specifying T-axis Continuous Rotation

The T-axis continuous rotation is specified by setting a T-axis rotating amount tag "MT" to a move instruction (MOVJ) for joint motion.

	Operation	Explanation
1	Move the cursor to the instruction area.	
2	Move the cursor to the move instruction for which a T-axis rotating amount is to be set.	
3	Press [SELECT] two times.	Press [SELECT] once to display the contents registered in the job in the input buffer line. Press [SELECT] once more to call the detail edit display of the move instruction.
4	Select "T-ROTATION."	
5	Select "MT=."	The contents are displayed in the input buffer line.
6	Press [ENTER] two times.	The set contents are registered.
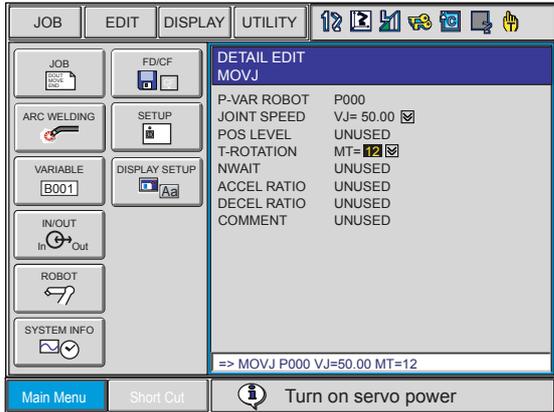
2-1

3 Registering MRESET Instruction

Register a MRESET instruction to reset the rotating amount in the following manner.

	Operation	Explanation
1	Move the cursor to the address area.	
2	Move the cursor to the line where a MRESET instruction is to be registered.	
3	Press [INFORM LIST].	The instruction list dialog appears. Move the cursor to the instruction list dialog. The cursor in the address area changes to an under-bar.
4	Select "OTHER."	
5	Select "MRESET."	The selected instruction is displayed in the input buffer line.
6	Press [ENTER].	The set contents are registered in the job.
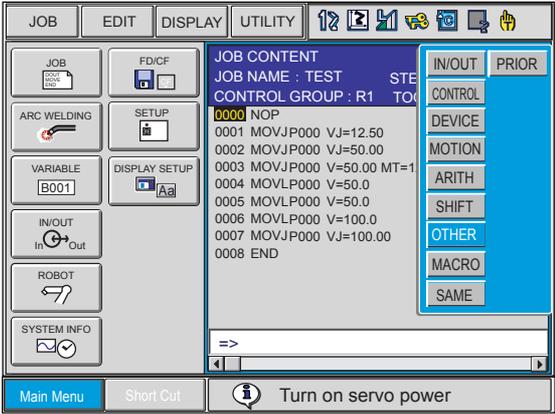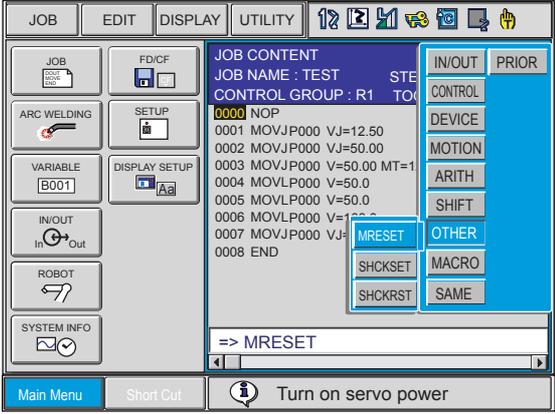
3-1

4 Display of T-axis Rotating Amount

The T-axis rotating amount can be displayed in the rotation display.

	Operation	Explanation
1	Select {ROBOT} under the main menu.	
2	Select {ROTATION}.	The rotation display appears.

5 Resetting the Axis Rotating Amount

The rotating amount can be reset to "0" on the rotation display.

	Operation	Explanation
1	Select {ROBOT} under the main menu.	
2	Select {ROTATION}.	
3	Select {DATA} of the menu.	The pull-down menu appears.
4	Select [RESET ROTA-TION}.	The T-axis rotating amount (T) is reset to "0".
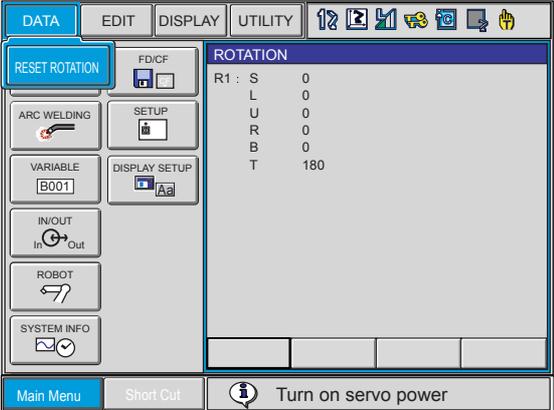
5-1

6 Job Example

An example of job preparation using the T-axis endless function is shown below.

Line	Instruction	Contents
0000	NOP	
0001	MOVJ VJ=25.00	Normal move instruction
0002	MOVL V=500.0	Normal move instruction
0003	MOVJ VJ=25.00	Normal move instruction
0004	MOVJ VJ=25.00 MT=100	T-axis rotates 100 times until reaching the step 4.
0005	MOVJ VJ=25.00 MT=100	T-axis rotates 100 times until reaching the step 5.
0006	MRESET	In order to perform an interpolation motion at the next step, a MRESET instruction is executed to reset the T-axis position to a position within one revolution.
0007	MOVL V=500.0	Linear interpolation motion
0008	MOVJ VJ=25.00	Normal move instruction
0009	END	End of the job

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7 Restrictions

The restrictions for the T-axis endless function are as follows.

7.1 FWD and BACK Operations

During FWD and BACK operations, the T-axis does not perform a continuous rotation motion.

Also when a playback is executed after having executed the FWD operation until 1 to 3 steps before the step where an endless operation is specified, the T-axis does not perform a continuous rotation motion. This is because the status of FWD operation and BACK operation remains. In this case, after having executed the FWD and BACK operation, move the cursor and start the job in play mode. Thus, the T-axis performs a continuous rotation motion.

Normally, when the manipulator current value coincides with the reference position value after having reached the target step by FWD or BACK operation, the cursor stops blinking. In FWD or BACK operation after the T-axis continuous rotation by using playback operation, the T-axis does not have the manipulator current position coincident with the reference position even after having reached the target position. Therefore, the cursor does not stop blinking. In this case, execute a MRESET instruction before FWD or BACK operation so that the cursor stops blinking when the manipulator reaches the target position.

7.2 When NWAIT is Specified

Normally, when a move instruction where a NWAIT is added is executed, the instructions that are registered before the next move instruction, are executed sequentially. For the MRESET instruction, NWAIT specification is not applied and the MRESET instruction will be executed after the completion of the move instruction.

7.3 Maximum Endless Rotating Amount

The maximum endless rotating amount can be obtained by the following equation. The amount differs depending on the type of manipulator.

Maximum endless rotating amount = ± 536870912 (pulse) / Resolution (pulse/revolution)

7.4 Execution of MRESET Instruction

Since the execution of MRESET instruction is processed for the manipulator feedback pulse, it is executed in the status that the manipulator is completely stopped. Accordingly, it takes a several seconds to execute the MRESET instruction. In the meantime, the manipulator does not stop and the start lamp is not unlit even by hold or changing mode operation.

7.5 T-axis Position at Teaching

In a position where the T-axis has rotated more than one time, the teaching is disabled. If teaching is executed in this state, the following error occurs.

Error 2110 ; Over softlimit

When the above error occurs, reset the axis rotating amount manually.

7.6 Display of Rotating Amount

When the sign of the taught position of the MOVJ instruction where a rotating amount is specified and the sign of the rotating amount specification are different, the display value of rotating amount may be one revolution less than the specified rotating amount. For example, when the taught position is at -1000 pulses and the rotating amount is specified to be 100 revolutions, the displayed value of rotating amount is 99 revolutions.

8   Alarm Message List

Alarm No.	Message	Cause	Corrective Action
4490	DEFECTIVE TAUGHT POINT (ENDLESS)[1]	Linear interpolation disabled. During playback operation or operation from the programming pendant, a linear interpolation has been attempted without execution of MRESET instruction after completion of continuous rotation.	When this alarm occurs at operation from the programming pendant, reset the alarm and reset the axis rotating amount. When this alarm occurs during playback operation, set a MRESET instruction before execution of MOVL or MOVC instruction.
	DEFECTIVE TAUGHT POINT (ENDLESS)[4]	The reference position of the step where the cursor is, exceeds 536870911 pulses.	Reconsider the teaching positions.

NX100 OPTIONS
INSTRUCTIONS

FOR T-AXIS ENDLESS FUNCTION

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