

Motoman NX100 Controller

T-Axis Speed Control Function Manual

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Revision: 0

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Chapter 1

Introduction

1.1 About This Document

This manual provides information for the T-Axis Speed Control 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 SPEED CONTROL INSTRUCTIONS

Provides detailed information for the T-Axis Speed Control 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

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





MANDATORY

- **This manual explains the T-axis speed control 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.**



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 button is located on the right of front door of the NX100 and 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 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.**

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

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.

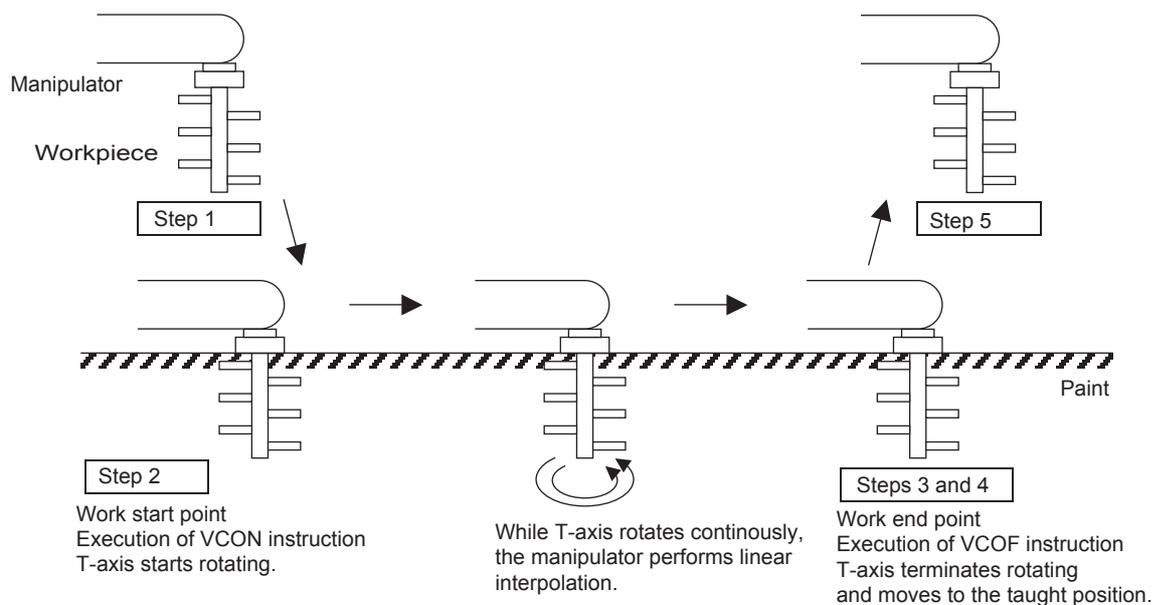
1	Outline	
2	Description of Function	
	2.1	Starting Rotation..... 2-1
	2.2	Terminating Rotation 2-1
	2.3	Suspending or Restarting Rotation..... 2-2
3	Instructions	
	3.1	VCON (Speed Control Start Instruction) 3-1
	3.2	VCOF (Speed Control End Instruction) 3-1
4	Registration of the Instructions	
	4.1	VCON (Speed Control Start Instruction) 4-2
	4.2	VCOF (Speed Control End Instruction) 4-3
5	Display of Rotation Amount	
6	Resetting the Rotation Amount	
7	Restrictions	
	7.1	Rotating Speed..... 7-1
	7.2	Maximum Rotation Amount..... 7-1
	7.3	T-axis Speed Control With Two Manipulators 7-2
	7.4	Specifying NWAIT 7-2
	7.5	After Turning OFF Power Supply during T-axis Speed Control.. 7-2
	7.6	Turning ON the Servo Power Supply..... 7-3
	7.7	Resetting the Rotation Amount 7-3
8	Alarm List	

1 Outline

With the T-axis speed control function, the T-axis, the end tip axis of the manipulator, can be continuously rotated according to the specified rotating speed.

This continuous rotating operation starts with execution of the speed control start instruction (VCON) and terminates with execution of the speed control end instruction (VCOF). During the continuous rotation, the rotating speed of T-axis is independently controlled. When operating the manipulator with the T-axis speed control function, the T-axis rotates at the specified speed disregarding teaching while other axes operate as taught.

This function can be used for such applications as the manipulator grasping a workpiece to put into the paint, rotating the workpiece continuously. Because the T-axis working envelope is limited in the normal position-control method, the continuous rotating operation is disabled. Using this function, however, the T-axis can continuously rotate without its working envelope being limited.



Line	Step		
000		NOP	
001	001	MOVJ VJ=12.50	Moves to the waiting point.
002	002	MOVJ VJ=12.50	Moves to the work start point.
003		VCON RV=10	Starts rotation. Speed : 10 [min ¹]
004		TIMER T=0.50	Waits for rotation to start.
005	003	MOVL V=100	Moves to work end point by linear interpolation at 100.0 [mm/s].
006		VCOF	Terminates rotation.
007	004	MOVJ VJ=12.50	Moves T-axis to the taught position.
008	005	MOVJ VJ=12.50	Moves to the waiting point.
009		END	

2 Description of Function

2.1 Starting Rotation

The T-axis starts rotating continuously with execution of the VCON instruction. Although it takes several hundred [ms] to start rotation, the job is continuously executed. Therefore, if the next operation needs to be performed after the T-axis starts rotating, create a job using the TIMER instruction to wait for the T-axis to rotate at a constant speed before the next operation. The T-axis is continuously rotated even if no move instruction is executed (or during execution of TIMER or WAIT instruction). When a move instruction is executed during T-axis rotation, the manipulator moves to the aimed point while the T-axis keeps rotating. The T-axis soft limit check does not function during rotation.

The T-axis position that appears on the position display during rotating differs from its actual position.

2.2 Terminating Rotation

The T-axis terminates rotation with execution of the VCOF instruction. It takes approximately 0.5 seconds to stop rotation, and the execution of the job stops during the time. The position where the T-axis terminates rotation is not fixed but varies each time the job is executed. Register a move instruction to return the T-axis to the taught position after the T-axis terminates the rotation.

When rotation is terminated, the T-axis current value, the position display, and the T-axis home positioning data are updated.

2.3 Suspending or Restarting Rotation

If the job execution is suspended during T-axis rotation by the following operations or in the following cases, the T-axis rotation is also suspended. When the job is restarted, the T-axis rotation also restarts.

- HOLD or external HOLD
- Mode switching operation
- When the operation cycle is changed into STEP

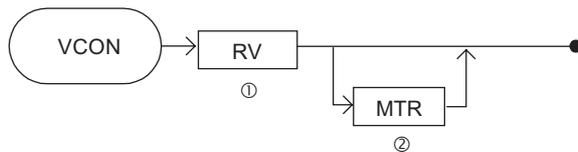
When the job execution is restarted by the following operations or in the following cases, the T-axis moves as it is taught without restarting rotation.

- Emergency stop or external emergency stop
- JOG operation
- Cursor moving operation
- Job selection
- Job editing operation

3 Instructions

3.1 VCON (Speed Control Start Instruction)

The VCON instruction is to start the T-axis speed control.
The additional items to the VCON instruction are as follows.



①RV

Setting range: -32768 to 32767

Unit: min^{-1} (revolutions per minute)

Sets the T-axis rotating speed.

If a positive value is set, the T-axis rotates in the positive direction; if a negative value is set, it rotates in the negative direction.

②MTR

Setting range: 0.1 to 100.0

Sets the T-axis rotating amount.

T-axis rotates for the specified amount.

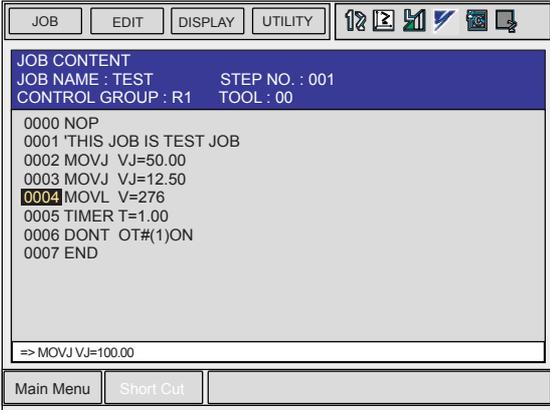
3.2 VCOF (Speed Control End Instruction)

The VCOF instruction is to terminate the T-axis speed control.
The additional items to the VCOF instruction are as follows.

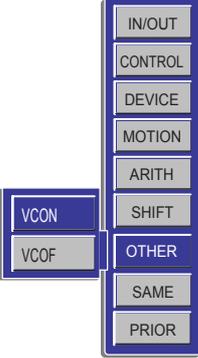
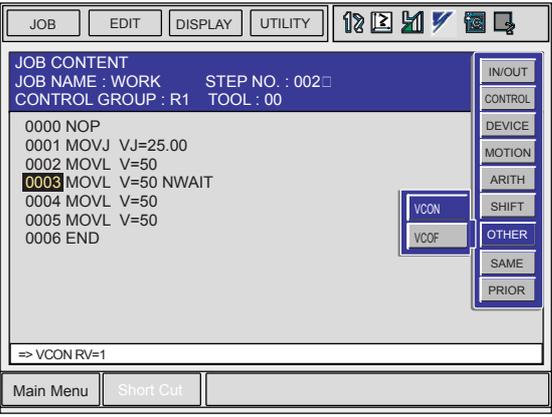
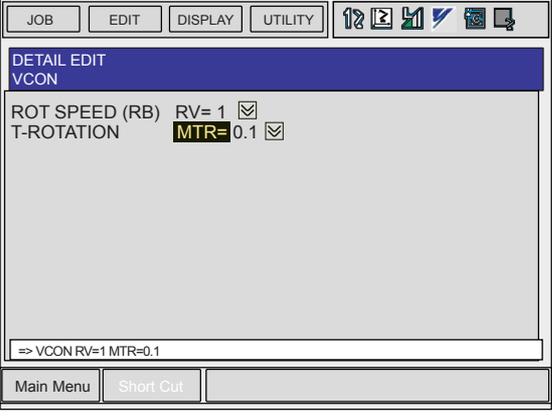


4 Registration of the Instructions

Register an instruction when the cursor is in the address area of the JOB CONTENT display in the teach mode.

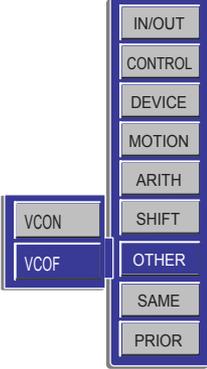
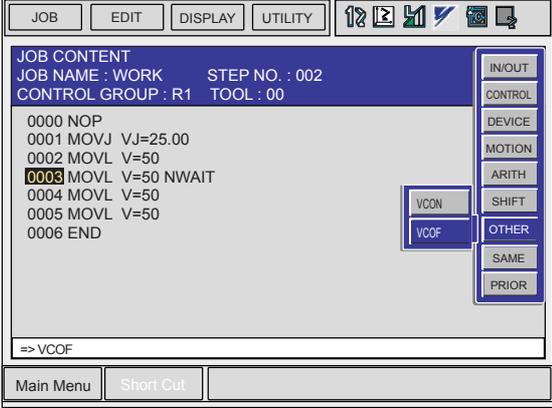
	Operation	Explanation
1	Select {JOB} under the main menu.	
2	Select {JOB CONTENT}.	<p>The JOB CONTENT display appears.</p>  <p>The screenshot shows a software window titled 'JOB CONTENT'. At the top, there are buttons for 'JOB', 'EDIT', 'DISPLAY', and 'UTILITY', along with several icons. Below the buttons, the window displays the following text:</p> <pre> JOB CONTENT JOB NAME : TEST STEP NO. : 001 CONTROL GROUP : R1 TOOL : 00 0000 NOP 0001 'THIS JOB IS TEST JOB 0002 MOVJ VJ=50.00 0003 MOVJ VJ=12.50 0004 MOVL V=276 0005 TIMER T=1.00 0006 DONT OT#(1)ON 0007 END </pre> <p>At the bottom of the window, there is a status bar showing '=> MOVJ VJ=100.00' and two buttons: 'Main Menu' and 'Short Cut'.</p>
3	Move the cursor to the address area.	

4.1 VCON (Speed Control Start Instruction)

	Operation	Explanation
1	Move the cursor to the address area.	
2	Press the [INFORM LIST].	<p>The instruction list dialog box appears.</p> 
3	Select {OTHER}.	
4	Select {VCON}.	<p>The "VCON" instruction appears in the input buffer line.</p> 
5	Press [SELECT] and set each item in the DETAIL EDIT display.	<p>The DETAIL EDIT display appears. Move the cursor to the item to be set, and press [SELECT]. Use the number keys to input each setting item and press [ENTER].</p> 
6	Press [ENTER].	

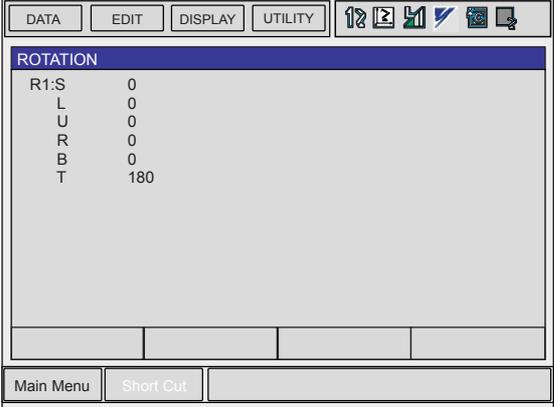
4.2 VCOF (Speed Control End Instruction)

4.2 VCOF (Speed Control End Instruction)

	Operation	Explanation
1	Move the cursor to the address area.	
2	Press the [INFORM LIST].	<p>The instruction list dialog box appears.</p> 
3	Select {OTHER}.	
4	Select {VCOF}.	<p>The "VCOF" instruction appears in the input buffer line.</p> 
5	Press [SELECT].	
6	Press [ENTER].	

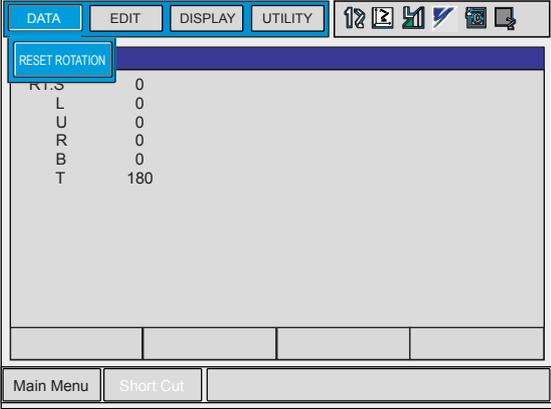
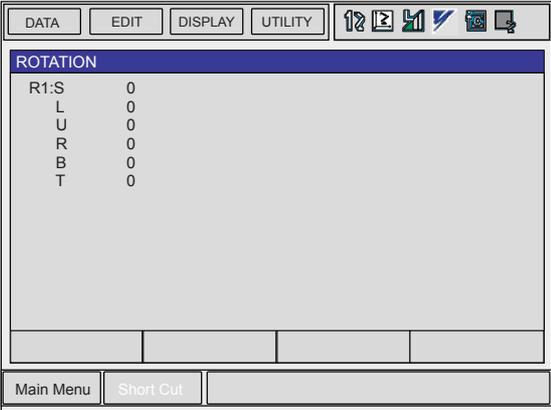
5 Display of Rotation Amount

The T-axis rotation amount can be viewed in the ROTATION display.

	Operation	Explanation														
1	Select {ROBOT} under the main menu.															
2	Select {ROTATION}.	<p>The ROTATION display appears.</p>  <p>The screenshot shows a software interface with a menu bar at the top containing 'DATA', 'EDIT', 'DISPLAY', and 'UTILITY'. Below the menu bar is a toolbar with several icons. The main display area is titled 'ROTATION' and shows the following data:</p> <table border="1"><thead><tr><th>Axis</th><th>Rotation Amount</th></tr></thead><tbody><tr><td>R1:S</td><td>0</td></tr><tr><td>L</td><td>0</td></tr><tr><td>U</td><td>0</td></tr><tr><td>R</td><td>0</td></tr><tr><td>B</td><td>0</td></tr><tr><td>T</td><td>180</td></tr></tbody></table> <p>At the bottom of the interface, there are buttons for 'Main Menu' and 'Short Cut'.</p>	Axis	Rotation Amount	R1:S	0	L	0	U	0	R	0	B	0	T	180
Axis	Rotation Amount															
R1:S	0															
L	0															
U	0															
R	0															
B	0															
T	180															

6 Resetting the Rotation Amount

The T-axis rotation amount can be reset in the ROTATION display.

	Operation	Explanation
1	Select {ROBOT} under the main menu.	
2	Select {ROATAION}.	
3	Select {DATA} of the menu.	<p>The pull-down menu appears.</p> 
4	Select {RESET ROTATION}.	<p>The displayed T-axis rotation amount is changed into "0."</p> 

7 Restrictions

The following describes the restrictions of the T-axis speed control function.

7.1 Rotating Speed

The rotating speed varies in the following cases.

- When either the B-axis or R-axis operates
- Limited to the maximum rotating speed when the setting of the rotating speed exceeds the motor's maximum rotating speed.

7.2 Maximum Rotation Amount

The maximum rotation amount is calculated as follows. The result differs depending on the manipulator models.

$$\text{Maximum rotation amount} = \pm 536870912 \text{ [pulses]} / \text{resolutions [pulse/min}^{-1}\text{]}$$

Do not set the rotation amount in one speed control section greater than the maximum rotation amount.

7.3 T-axis Speed Control With Two Manipulators

Speed control start instruction (VCON) and end instruction (VCOF) cannot be set in a job of the multi-axis control group. Therefore, in a system using two manipulators, perform the speed control from each manipulator by creating the following job to call each job from the job whole control group is R1 + R2 and independently start and end the speed control.

- Example where R1 job is called

JOB: Work

Control group: R1+R2

Line	Step	
000		NOP
001	001	MOVJ +MOVJ
002	002	MOVJ +MOVJ
003		CALL JOB:VCON-R1
004		TIMER T=0.50
005	003	MOVL +MOVL
006		CALL JOB:VCOF-R1
007	004	MOVJ +MOVJ

JOB: VCON-R1

Control group: R1

Line	Step	
000		NOP
002		VCON
003		END

JOB: VCOF-R1

Control group: R1

Line	Step	
000		NOP
002		VCOF
003		END

7.4 Specifying NWAIT

When a move instruction added with NWAIT is executed, the instructions that have been registered before the next move instruction are executed in order. However, only the VCOF instruction is not executed at this time, but executed after completion of the move instruction.

7.5 After Turning OFF Power Supply during T-axis Speed Control

When the control power supply is turned OFF and then ON during T-axis speed control, be sure to reset the rotation amount in the ROTATION display.

7.6 Turning ON the Servo Power Supply

In a system where the T-axis speed control is available, it takes longer to turn ON the servo power supply than ordinary operations. Keep pressing the servo ON button until you confirm that the servo power supply is turned ON.

7.7 Resetting the Rotation Amount

The rotation amount is automatically reset when the servo power supply is turned ON. When restarting after an emergency stop, the operation starts with the rotation amount reset.

8 Alarm List

Alarm Number	Message	Cause	Remedy
4353	DEFECTIVE TAUGHT POINT (ENDLESS)	Feedback pulses for speed-controlled axis exceeds ± 536870912 pulses.	Reset the rotation amount. (Refer to "6 Resetting the Rotation Amount.") Recheck the setting so as not to exceed the maximum number of pulses in one speed control section.

NX100 OPTIONS INSTRUCTIONS

FOR T-AXIS SPEED CONTROL FUNCTION

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