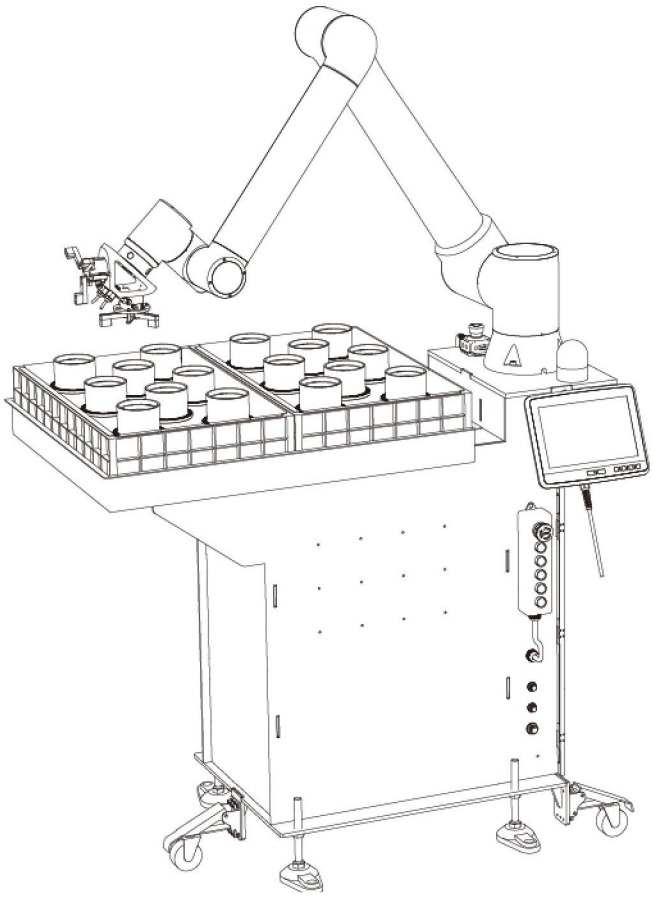
FAIRINO

CNC Loading and Unloading Cap Software User Manual



Fairino (Suzhou) Robot Technology Co.,Ltd

Data Encoding 20200310

Contents

1 Foreword

First of all, thank you very much for choosing our company's FR series collaborative robot products and the CNC loading/unloading Cap software. Our products have undergone multiple rounds of careful design and testing to ensure that they can meet your various needs.

Please carefully read the Collaborative Robot User Manual and the CNC Loading/Unloading Cap Software Manual to ensure that you can use our products correctly and achieve the best possible user experience. If you encounter any issues during use, please refer to the Troubleshooting section in the Collaborative Robot User Manual, or contact our after-sales support staff. We truly appreciate your support and trust, and look forward to providing you with even better service and products in the future.

2 Disclaimer

This statement applies to FAIRINO Robot’s (hereinafter referred to as "we" or "us") CNC Loading and Unloading Cap Software (hereinafter referred to as "the Software") and the equipment systems used in conjunction with it (hereinafter referred to as "the System"). Before using the System, please be sure to read this statement carefully. Use of the System constitutes your full understanding and acceptance of all the contents of this statement.

2.1 Disclaimer regarding external equipment (CNC equipment)

2.1.1 Risk of device incompatibility

This system is capable of communicating and cooperating with third-party CNC devices (including, without limitation, FANUC, SYNTEC, and similar systems). Our warranty is limited solely to the proper operation of data interaction between this software and CNC devices under standard communication protocols. We disclaim all liability for the performance, reliability, security, transmission delays, data correctness, or any damages or losses resulting from defects, faults, or failures of the third-party CNC equipment.

2.1.2 Communication anomalies and data loss

We disclaim all liability for any communication abnormalities, loss of control, data loss, or processing errors resulting from, or caused by, discrepancies in CNC equipment protocol versions, hardware failures, network outages, electromagnetic interference, or any other such factors beyond our reasonable control.

2.1.3 CNC machine operation permissions

Operation, maintenance, parameter adjustments, and safety device settings for CNC equipment must be carried out by duly qualified and authorized personnel. We assume no responsibility or liability for any incidents or accidents resulting from operator error on the CNC equipment side, inappropriate parameter settings, or malfunctioning safety devices.

2.2 Disclaimer regarding operational specifications

2.2.1 Operator qualification requirements

Operators of this system are required to have adequate knowledge of industrial robot and CNC equipment operations and to have completed the official training program offered by our company or its authorized representatives. The user assumes full liability for any and all consequences resulting from operation of this system by individuals who have not received such training or who lack the requisite qualifications.

2.2.2 Risk of improper operations

It is strictly prohibited to run any workflow without first confirming the safety of the working area, setting a safety point (pHome), correctly configuring the tool/workpiece coordinate system, checking the gripper signals, or verifying the machine status. We shall not be held liable for any accident resulting from failure to comply with this software user manual or on-site safety operating procedures, including but not limited to overspeed operation, forcible intervention in a running program, bypassing safety checks, and similar violations.

2. 2. 3 Teaching and Calibration Precision

The following operations — robot point teaching, tool coordinate system calibration, and workpiece coordinate system calibration — all depend on the operator's proficiency and judgment. Any production anomalies, collisions, or equipment damage resulting from inaccurate teaching, calibration errors, or failure to follow standard procedures shall be the responsibility of the user.

2. 2. 4 Workflow Development and Validation

The workflows (including logic such as loops, conditional branches, signal controls, wait conditions, etc.) are written and configured by operators or technicians. We shall not be held liable for any equipment malfunction, damage, or personal injury caused by programming logic errors, improper condition settings, or incorrect variable assignments. It is strongly recommended that, after the initial deployment or any program modification, each step be verified in manual mode before switching to automatic operation.

2. 3 Disclaimer Regarding System Operation Status

2. 3. 1 Abnormal status handling

This software provides system status monitoring (Normal / Warning / Error) and logging functionalities, but does not cover all potential faults. Users should remain vigilant to system alerts at all times and must immediately cease operation upon receiving a warning or error notification to investigate the root cause. We assume no liability for any consequences arising from failure to heed system alarms or delays in addressing anomalies.

2. 3. 2 Emergency handling

In the event of an emergency (such as collision, personnel entering a hazardous area, abnormal sounds, etc.), the operator shall immediately press the emergency stop button, rather than relying on software stop functions. Any losses exacerbated by failure to take prompt physical emergency stopping measures shall be borne solely by the user.

2.4 Disclaimer Regarding Software Updates and Data Backup

We recommend that users regularly back up system data (including recipes, points, workflows, coordinate systems, etc.). We shall not be held liable for any data loss or configuration failure resulting from failure to back up data or from improper operations during software updates or system restoration.

Software version updates may result in changes to functionality or the user interface. Users are advised to thoroughly review the most current user manual. We assume no responsibility for any operational errors arising from failure to familiarize oneself with the updated version.

2.5 Final right of interpretation

We reserve the sole and final right to interpret this disclaimer and reserve the right to amend it without prior notification. The most current version shall be as set forth in the software release or as posted on our official website.

3 Start Quickly

3.1 Access to the CNC loading/unloading Cap software

1) After successful WebApp login, navigate to the "System Settings – Plugin Configuration" interface and select the plugin file named "TendingCap-v1.0.0plugin" for import. Once imported, click the "Enable" button in the "Operations" section of the list below.

2) In the WebApp, click the "Auxiliary Applications" navigation bar to ex pand the submenu; locate the "TendingCap" submenu and click it to ac cess the login interface of the CNC loading/unloading Cap software, or open the Google Chrome browser and visit the target URL: http://192.168.58.2:3000/frcap/e36e0670-6ee9-11f1-8003-efb9f455c642/#/.

3) Users select an operation role based on their position. Roles currently include Operator and Technician. Operators can log in directly without a password, while Technicians must enter a password for authentication; the default password is 1234.

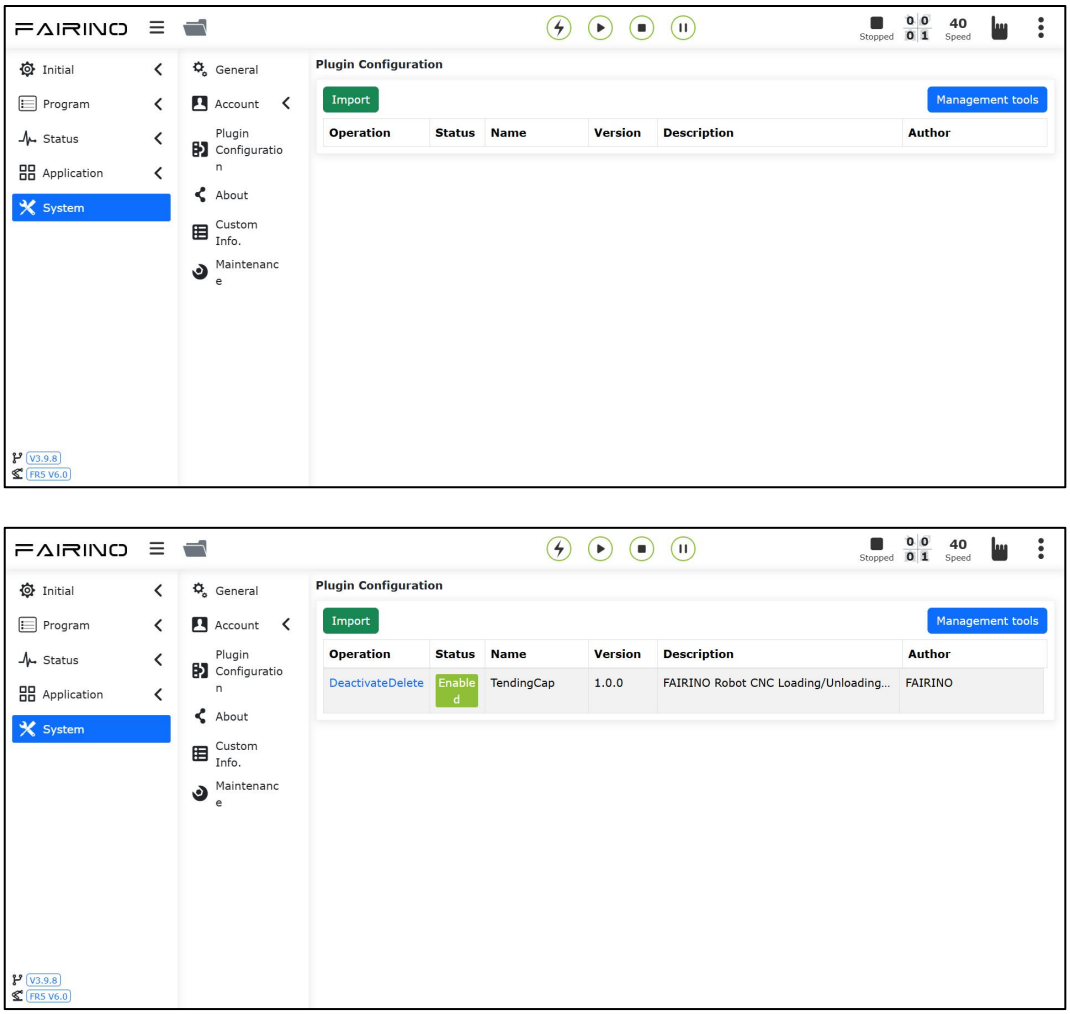


Figure 3-1 WebApp Import of the CNC Material Handling Cap Plugin Package

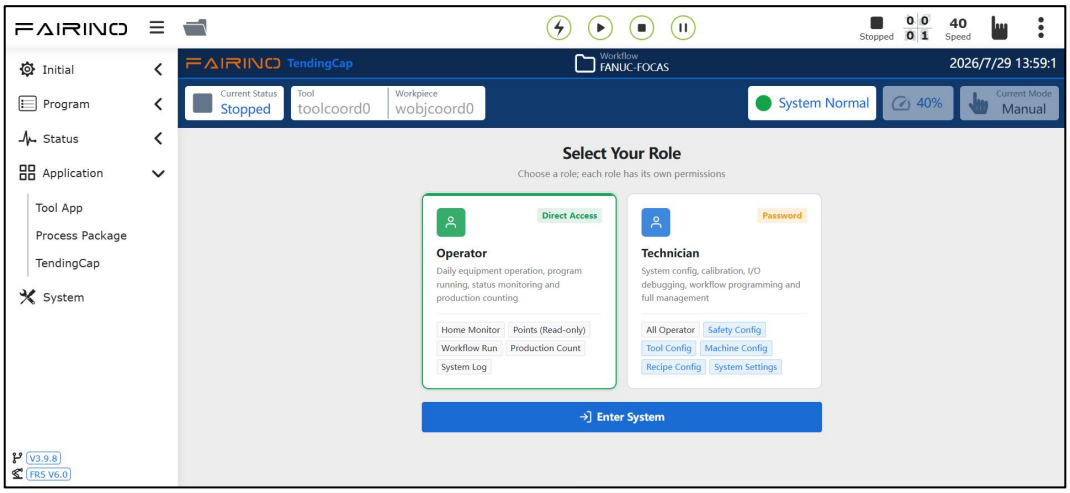


Figure 3-2 In the WebApp, navigate to the login page for the CNC material loading/unloading Cap software.

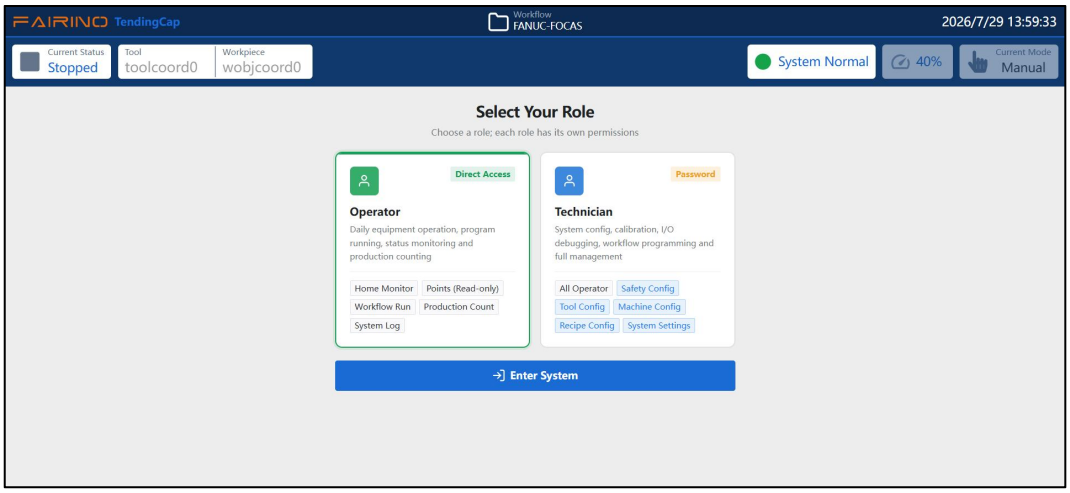


Figure 3-3 Enter the direct access address in your browser to access the CNC material handling Cap software.

3.2 CNC Loading and Unloading Parameter Configuration

Before creating a CNC loading/unloading workflow, configure safety points, tools, machine tools, and function signal parameters. Once these basic settings are configured, select the tool in the loading/unloading method and choose the machine tool and loading/unloading method in the recipe to complete recipe creation. This allows you to directly generate workflow content based on the recipe in subsequent workflows.

3.2.1 Security Point Configuration

Perform the teaching of safety points in "Configuration – Safety"; the name for these points is fixed as "pHome". Click the "Configuration" button to send the current robot pose as safety point data.

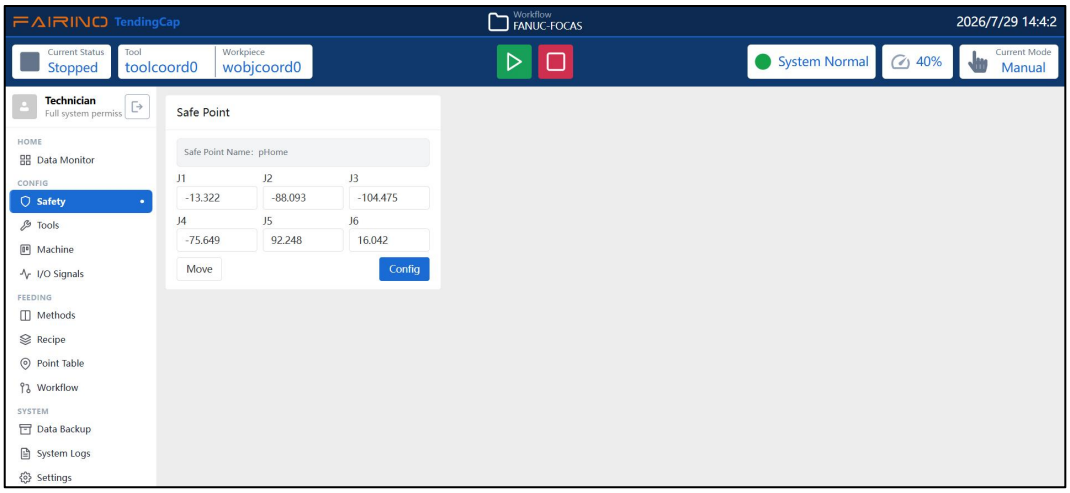


Figure 3.2.1-1 Security Point Configuration

3.2.2 Tool Configuration

To configure the end tool in "Configuration – Tools", follow these configuration steps:

1) Click the Add tab to enter End Effector, enter the tool name (e.g., End Tool) based on functional requirements, add grippers (e.g., loading and unloading grippers), and configure signals for the corresponding grippers.

2) Click the "Next" button to enter the "End Load and Center of Gravity" section; use the tool to select the load and set its weight and center of gravity.

3) Click the "Next" button to access the "Tool Coordinate System" section, where you can configure the tool coordinate systems for each gripper; if you wish to select a non-default tool coordinate system, click the "Calibrate" button to perform a four-point method tool coordinate system calibration.

4) Click the Complete button to add a tool, or click the Edit button in the upper-right corner of the content card to modify it.

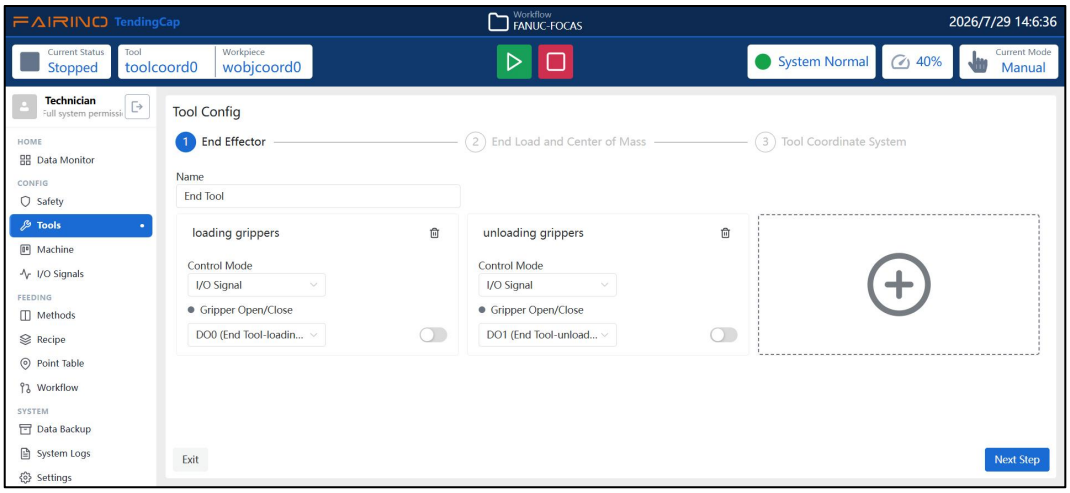


Figure 3.2.2-1 Tool Configuration – End Effector

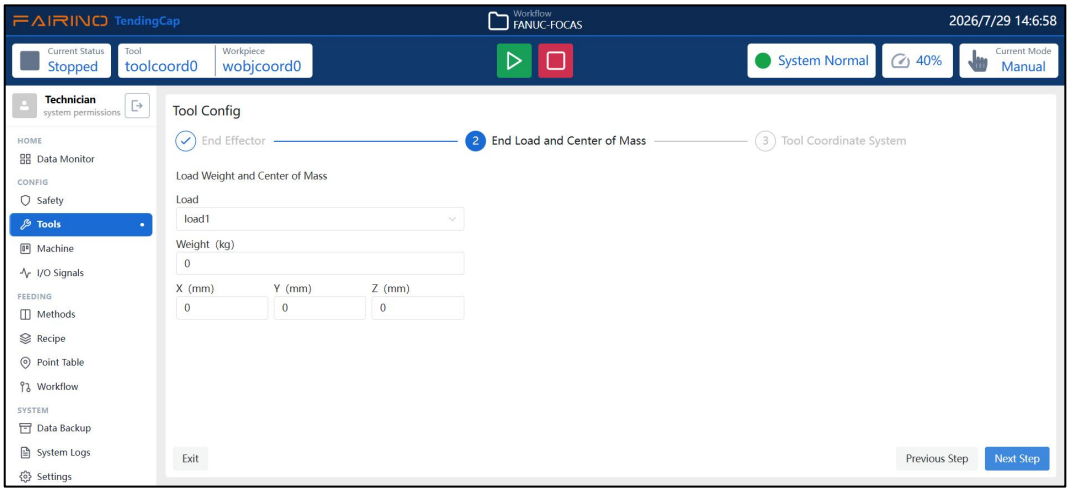


Figure 3.2.2-2 Tool Configuration – End Effector Load and Center of Gravity

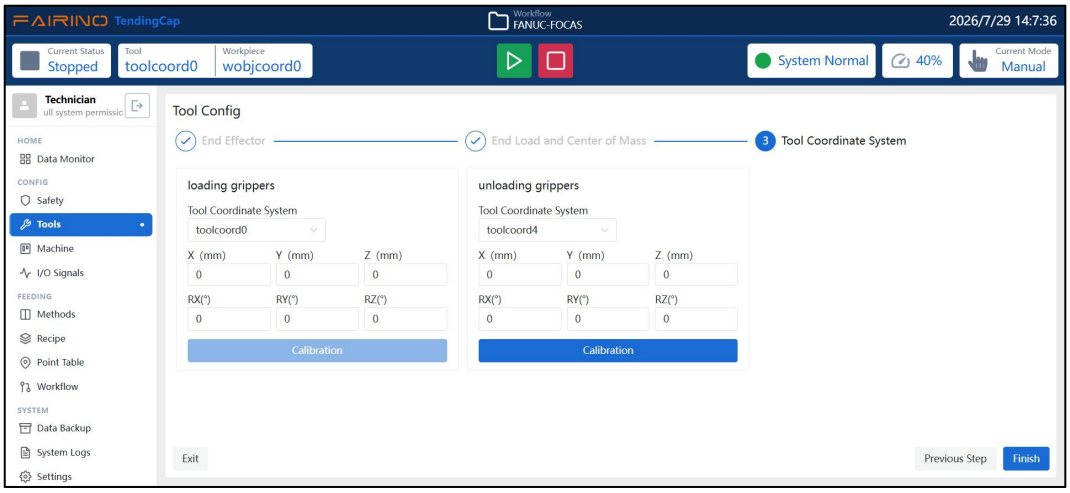


Figure 3.2.2-3 Tool Configuration — Tool Coordinate System

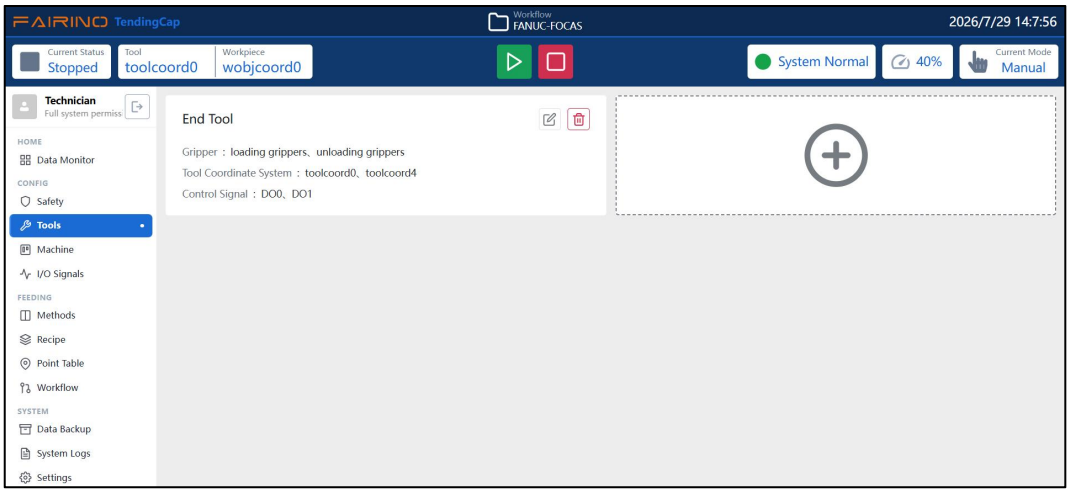


Figure 3.2.2-4 Tool configuration completed

3.2.3 Machine Configuration

To configure the end tool in "Configuration – Machine Tool", follow these steps:

1) Click the "Add" card to access "Machine Tool Parameters"; enter the machine tool's name (e.g., "FANUC") based on your functional requirements, and select the machine tool system (available options: FANUC, Xinda, and Other).

2) Click the "Next" button to enter Communication Configuration, where you select the communication method based on your machine tool system and configure relevant signals. Common signal functions include "Machine Door Opening/Closing", "Chassis Release/Fixing", and "Process Start". If you choose FOCAS or the New Generation protocol, you must upload a pre-written protocol file in Lua format with a name starting with "CtrlDev_CNC".Taking the "FOCAS" communication protocol as an example, in the configuration interface, click the "Edit" button to access the protocol editing page and upload the protocol. After successful upload, select the protocol and click "Configure"; under "Device Connection," you can view the configured protocol files. Click the "Load" icon to initiate communication. Once the connection is established, perform debugging preparations in the "Device Debugging" section on the right side.

3) Click the "Complete" button to add a machine tool; click the "Edit" button in

the upper right corner of the content card to make modifications.

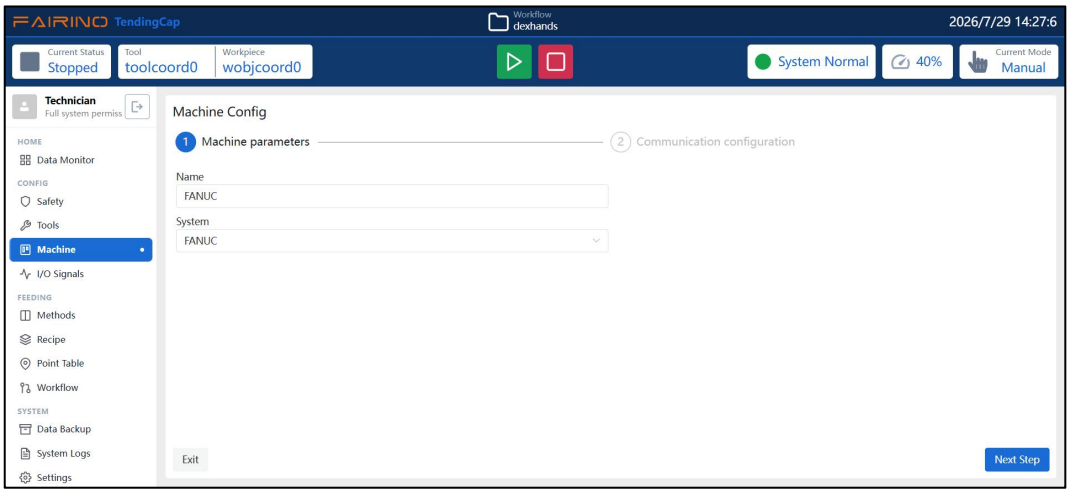
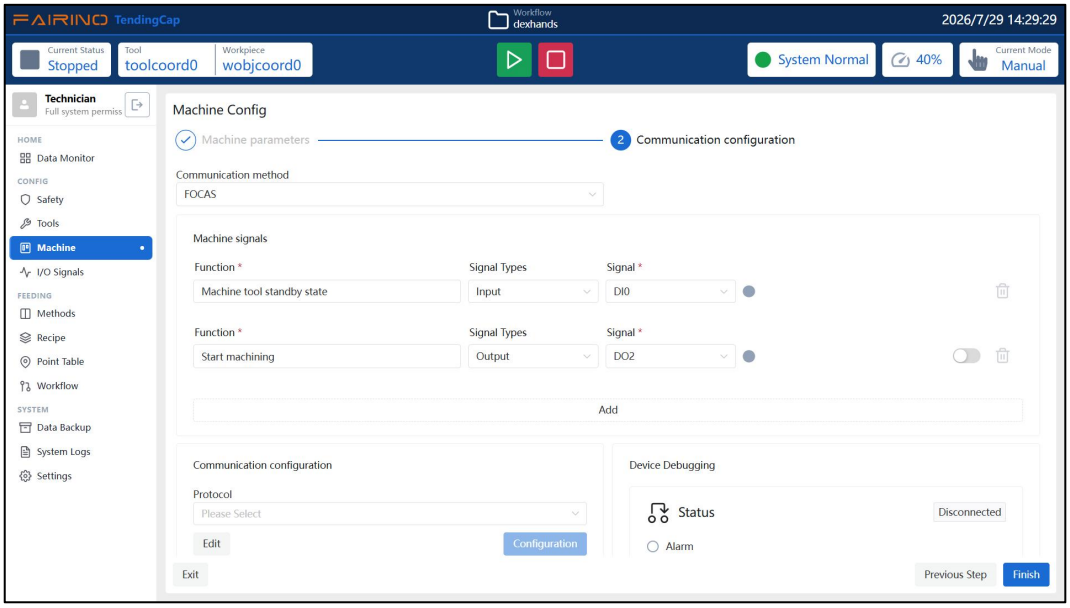


Figure 3.2.3-1 Machine Parameters



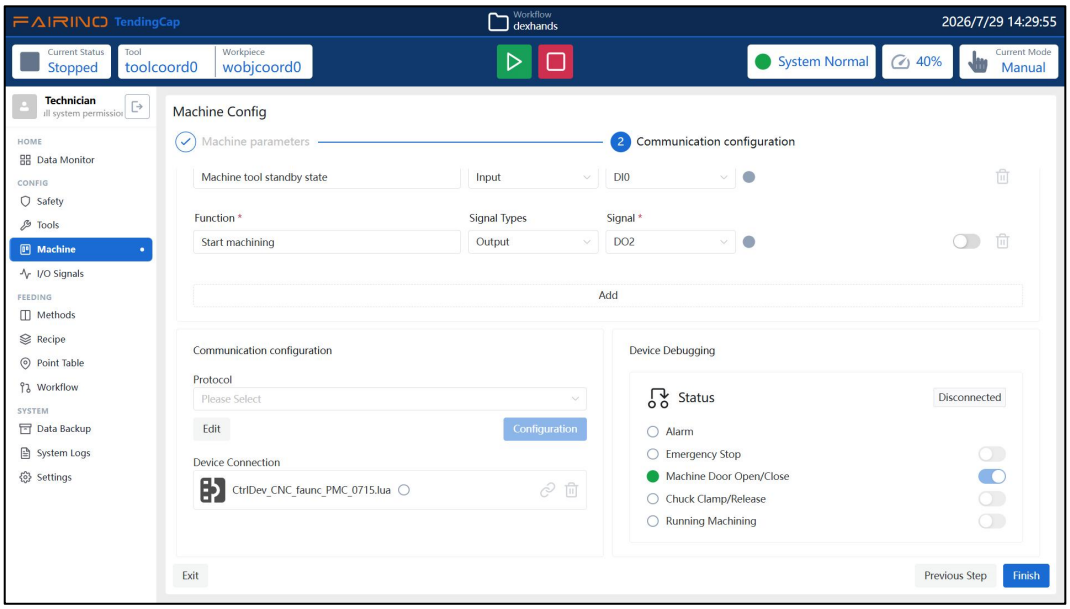


Figure 3.2.3-2 Communication Configuration

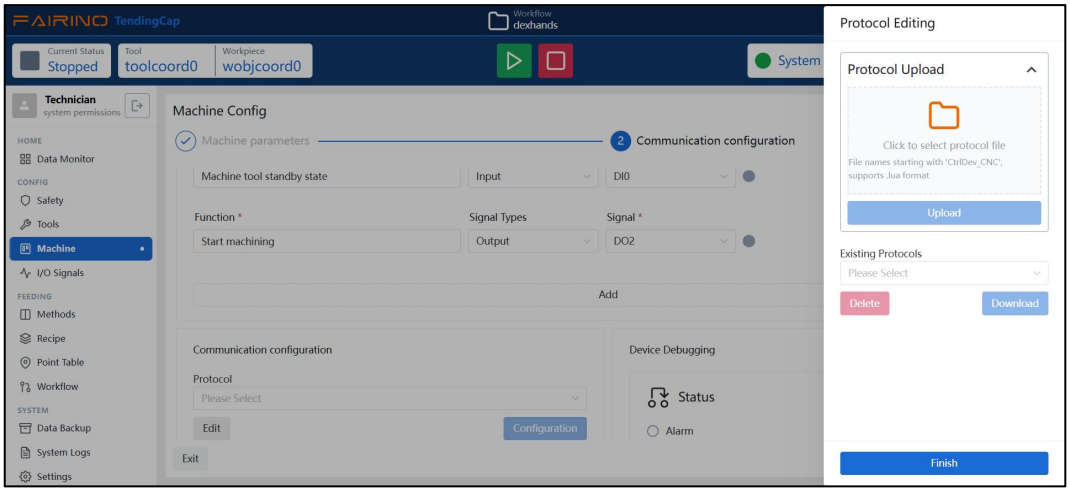


Figure 3.2.3-3 Agreement Editing

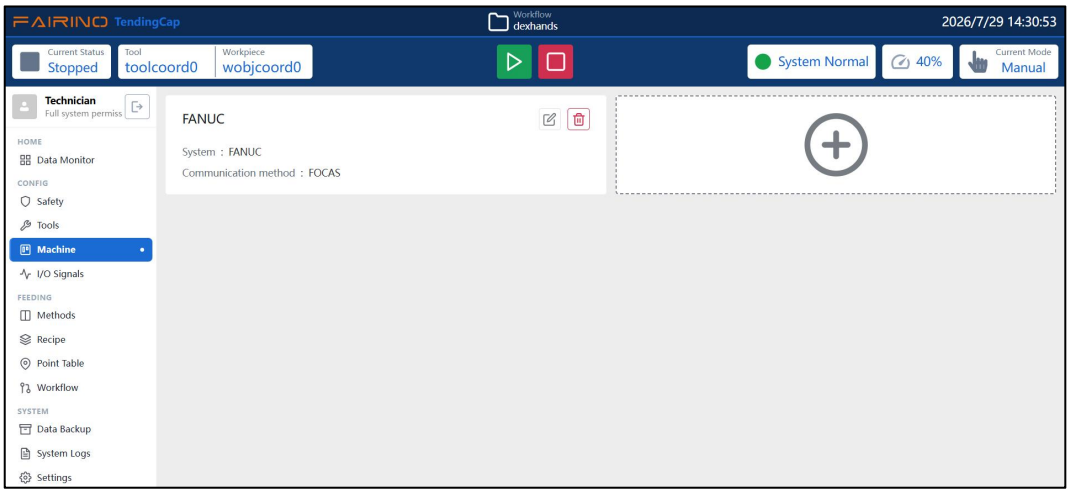


Figure 3.2.3-4 Machine Configuration

3.2.4 Function Signal Configuration

To configure custom functional signals, navigate to "Configuration – Functional Signals," click the "Add Custom Function" button at the bottom, which will open the "Add Custom Function" drawer; enter a name based on your operational scenario, and select the signal type and signal. For example, during the loading and unloading process, an output signal can be used to display red, yellow, and green indicator lights to inform the operator of the machining status, while an input signal can be used to indicate whether the workpiece is in position during the machining process.

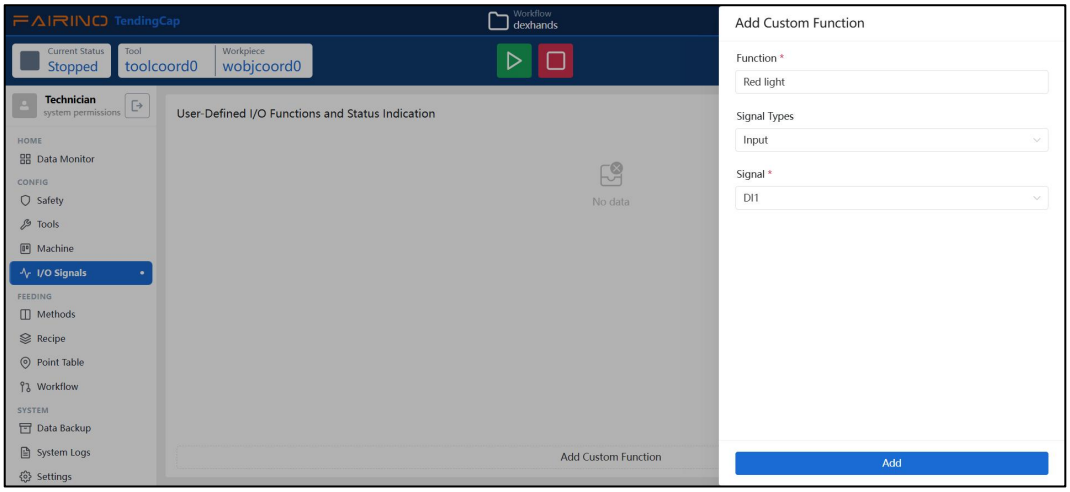


Figure 3.2.4-1 Functional Signal Configuration – Adding Custom Functions

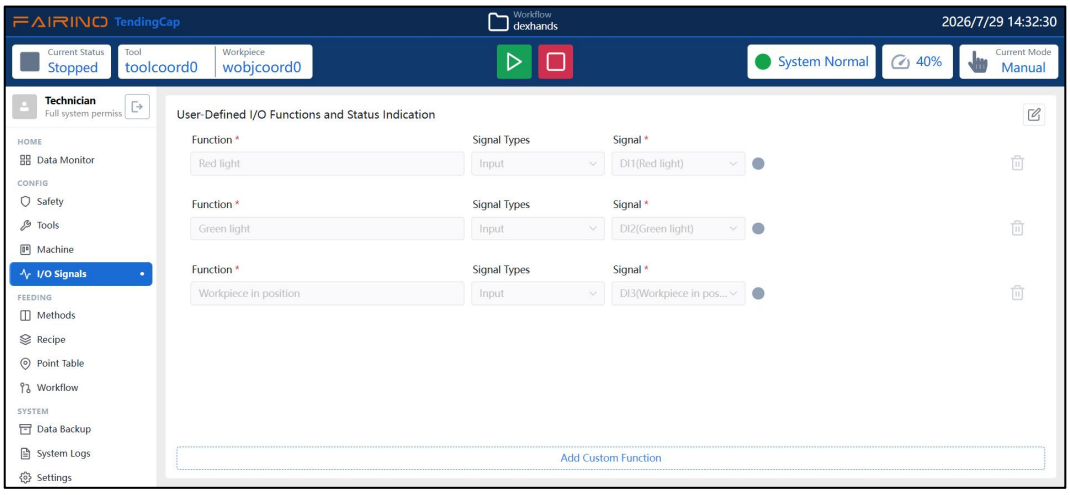


Figure 3.2.4-2 Function Signal Configuration

3.2.5 Loading and Unloading Method Configuration

The "Loading/Unloading – Method" section allows for configuring loading

and unloading processes using two methods: material trays and conveyor belts; these methods can be combined together.

The tray-based method employs a three-point-defined matrix as its primary working configuration, with the steps as follows:

1) Click the Add tab to enter Plate Parameters, enter a name based on functional requirements, select a tool, and choose whether to use an extended axis.

2) Click the Next button to enter the Material Disk Coordinate System section. Select the workpiece coordinate system for the material disk. For non-default systems, click Calibrate to set the workpiece coordinates using either the Origin – X-axis – Z-axis or Origin – X-axis – XY-plane methods.

3) Click the Next button to enter the tray array and configure the matrix tray's number of rows, columns, layers, layer height (unit: mm), transition point offsets (X, Y, Z, unit: mm), motion path, and configuration method—point teaching using the three-point method.

4) Click the Complete button to add a tray. Click the Edit button in the upper-right corner of the content card to modify it.

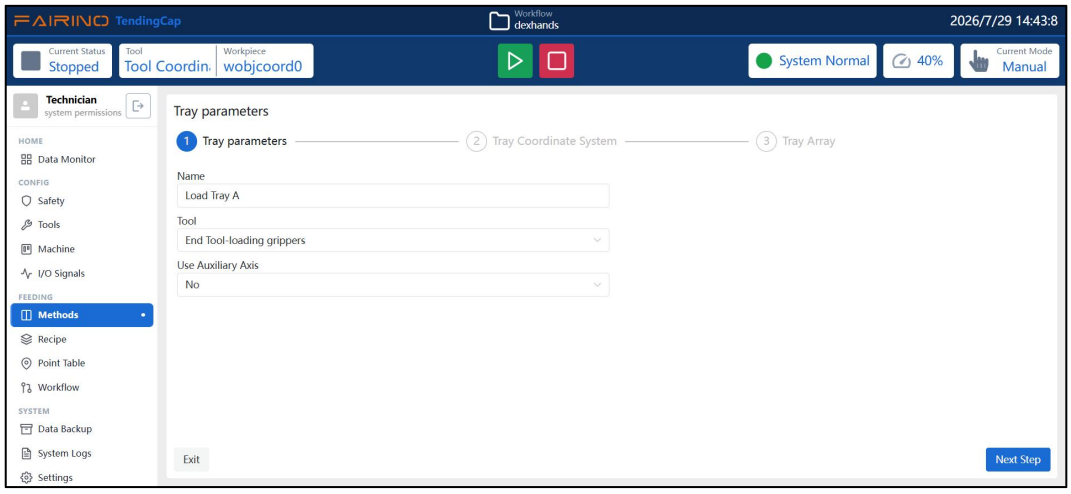


Figure 3.2.5-1 Material Disk Configuration – Material Disk Parameters

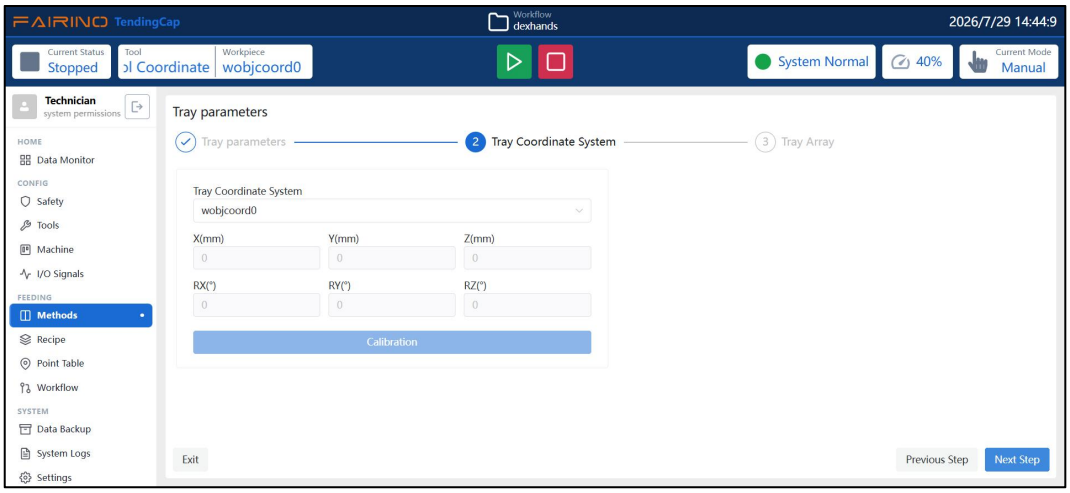


Figure 3.2.5-2 Material palleting method – Material pallet coordinate system

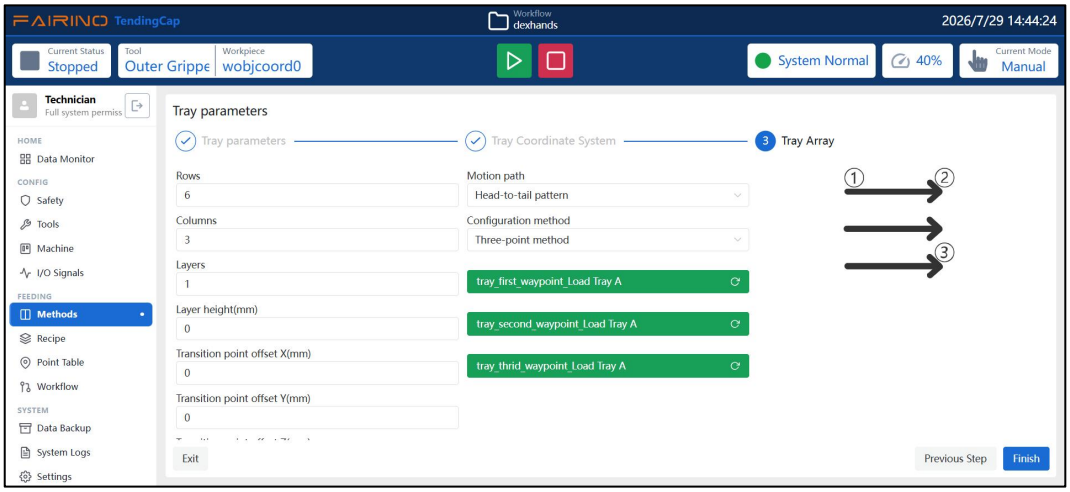


Figure 3.2.5-3 Material Disk Method – Material Disk Array

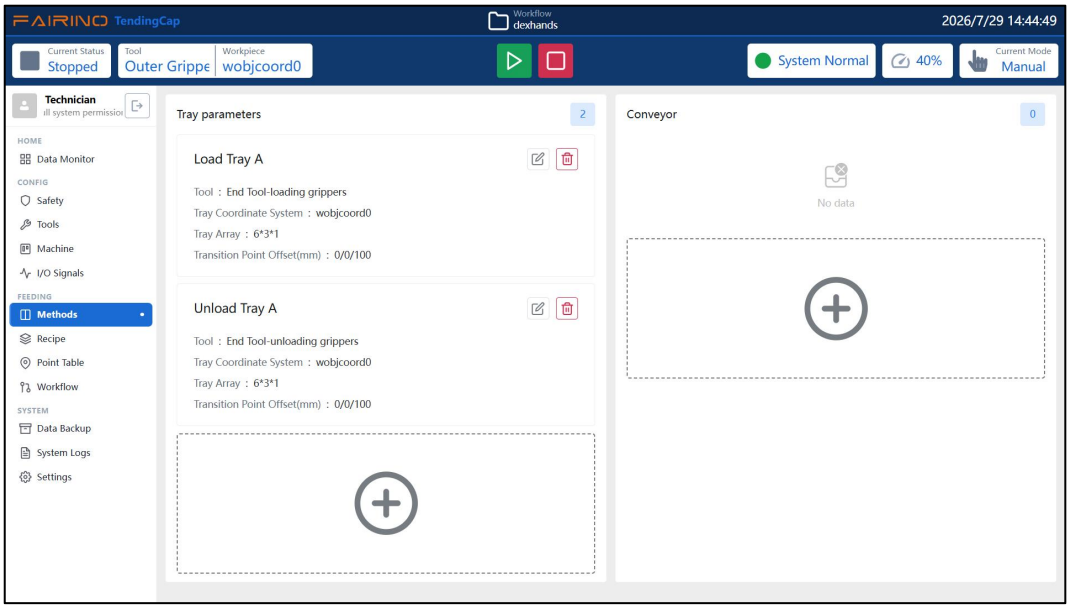


Figure 3.2.5-4 Material tray method

The steps for configuring the conveyor belt setup are as follows:

1) Click the Add tab to enter Belt Parameters, enter a name based on functional requirements, and select a tool.

2) Click the "Next" button to enter "Position and Signal". Set the positioning points for workpiece loading/unloading on the conveyor belt, enter the transition point offsets (X, Y, Z in mm), and add the input signal for the conveyor belt—for example, the signal triggered when workpieces reach the loading/unloading positions.

3) Click the Complete button to add the conveyor belt.

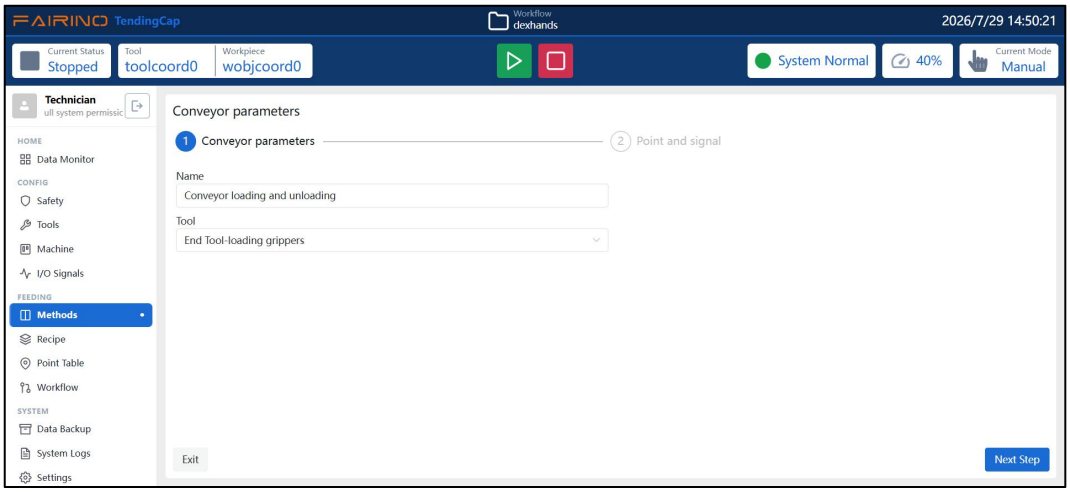


Figure 3.2.5-5 Conveyor Belt Method – Parameters for the Conveyor Belt

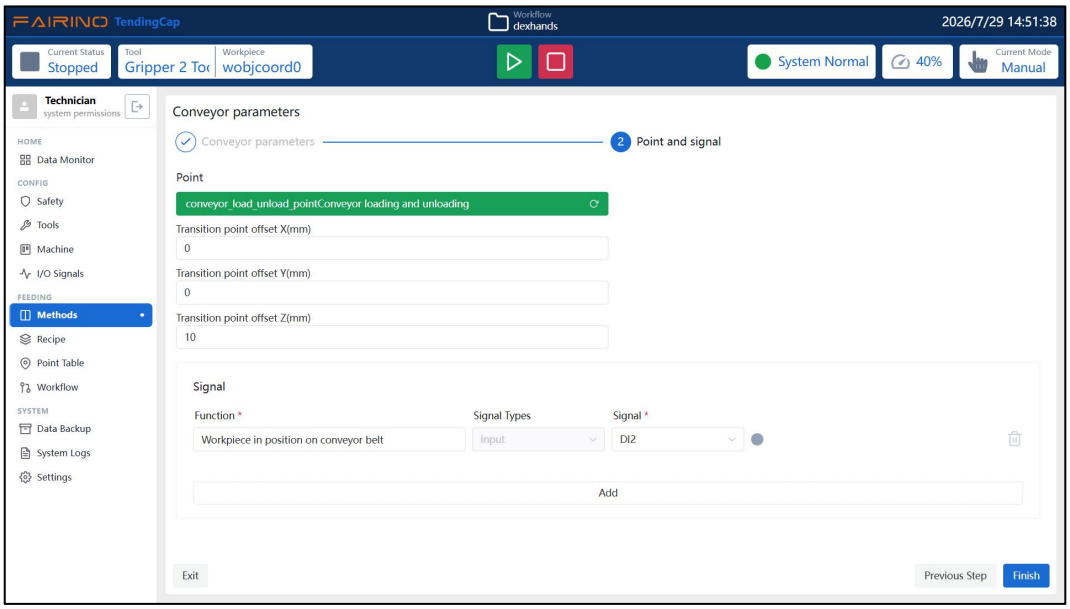


Figure 3.2.5-6 Conveyor belt method – Positioning and signaling

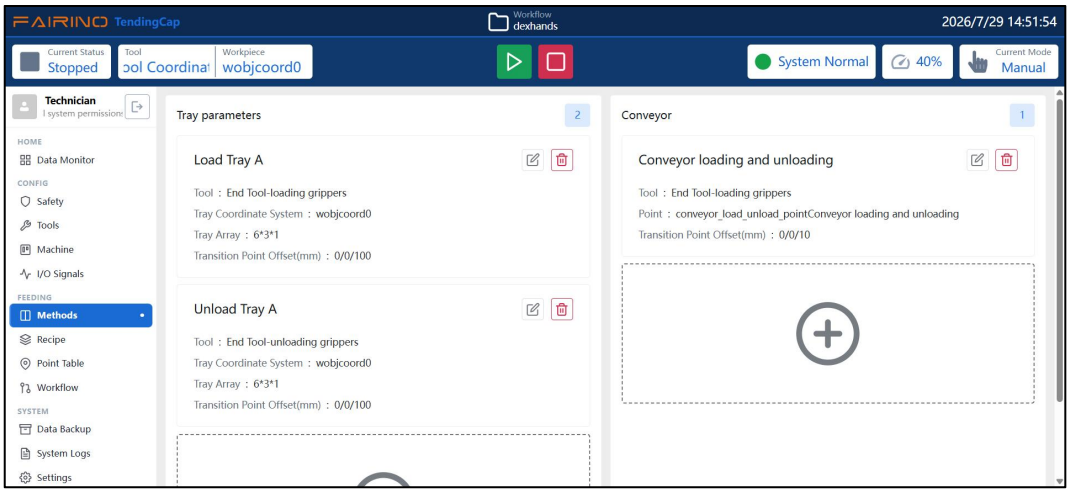


Figure 3.2.5-7 Conveyor Belt Method

3.2.6 Material loading and unloading formula configuration

Configure the recipe in "Material Loading – Recipe" with the following steps:

1) Click the "Add" card to enter the "Recipe Parameters" section; enter a name based on your functional requirements, select the operating mode—material loading/unloading, only loading, or only unloading, and specify whether to use an extended shaft.

2) Click the "Next" button to enter the "Workstation Layout" page, where you can select the machine tool and loading/unloading method (material tray/ conveyor belt).

3) Click Next to enter Material Loading/Unloading Configuration. Click the Add Material Loading/Unloading button at the bottom; data for the selected method will appear on the right side. Check the option and click Add at the bottom to confirm.

4) Click the "Next" button to enter the "Process Flow" section, where you can set the core process steps as: "Material pickup from tray/ conveyor belt – Material feeding to machine – Material ejection from machine – Material release from tray/ conveyor belt". Based on the configuration of the first three steps, clicking "Add Step" will display different content, with the data within this content being automatically populated according to the configuration. By clicking "Insert Step Here", you can add additional process steps such as "Secondary Positioning" and "Custom Process" based on your

specific scenario. Within each step, clicking "Add Sub-step" will take you to the sub-step addition interface, where you can select step types including "Point-to-Point", "Linear Motion", "Control Signal", "Wait Signal", and "Matrix Movement".

5) Click the Complete button to add a recipe, or click the Edit button in the upper-right corner of the content card to modify it.

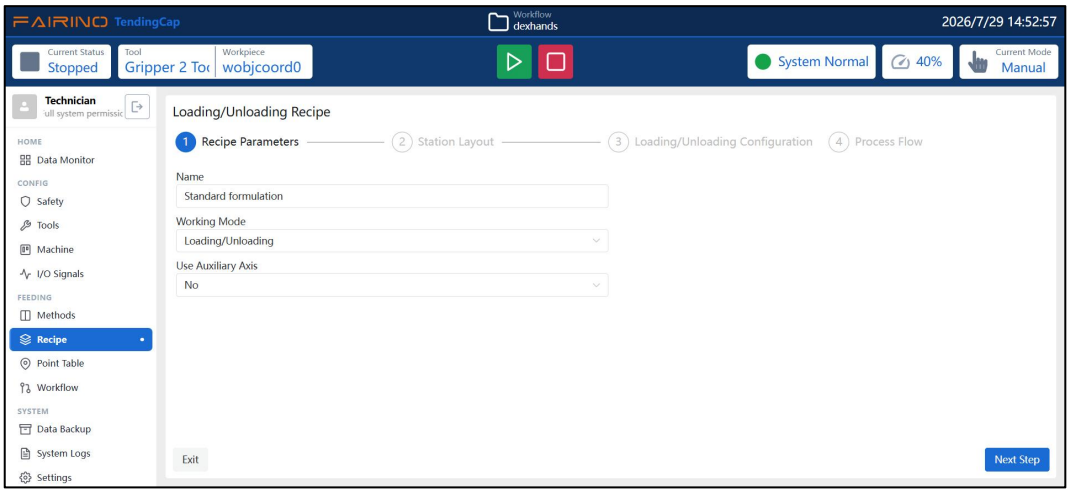


Figure 3.2.6-1 Recipe Parameter

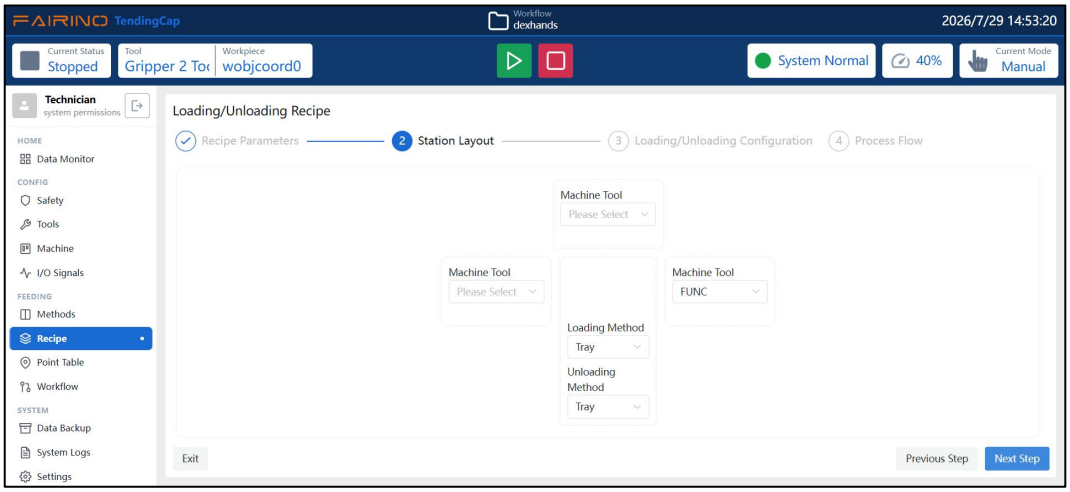


Figure 3.2.6-2 Process Layout for Recipe

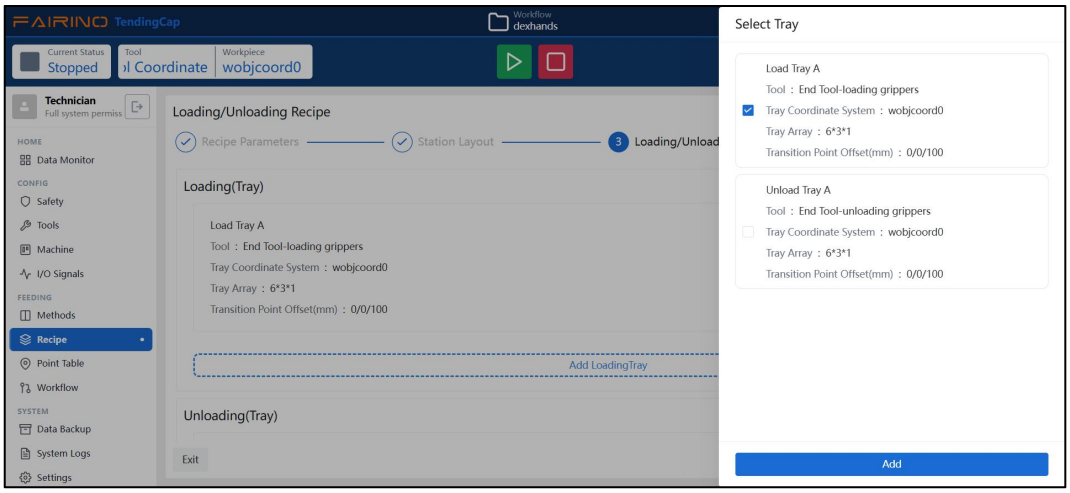


Figure 3.2.6-3 Formula – Material Loading Configuration

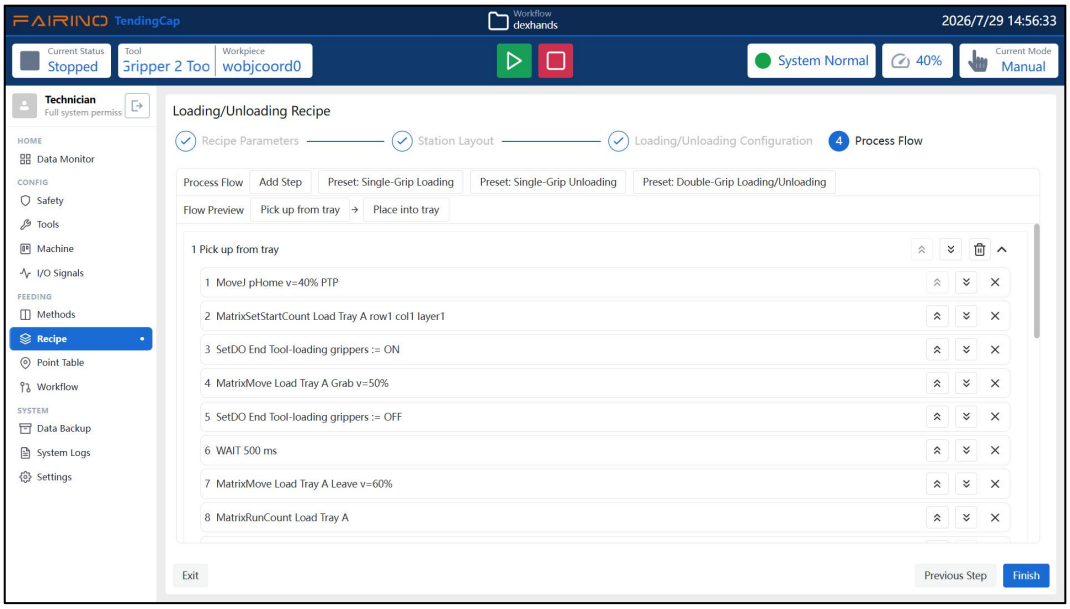


Figure 3.2.6-4 Recipe Process Flow

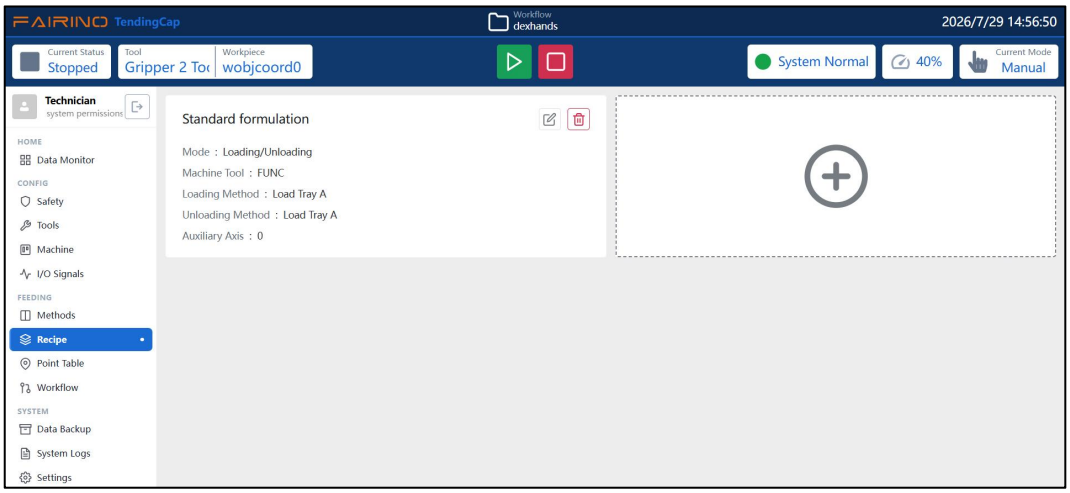


Figure 3.2.6-5 Recipe

3.3 Robot Manual Teaching

3.3.1 Manual demonstration and recording of points

Manual demonstration includes two methods:

1) Press and hold the end drag button or tap the top button to switch to drag mode for teaching.

2) In the "Loading/Unloading – Position Table" interface, under the "Move Card" section on the right side, you can perform movements based on either Cartesian space or joint space.

After the teaching path reaches the target position, you can click the "Record Point" button in the "Loading/Unloading – Point Table" to save the point. When saving the point, the coordinate system for this teaching point will be the coordinate system used by the current robot application.

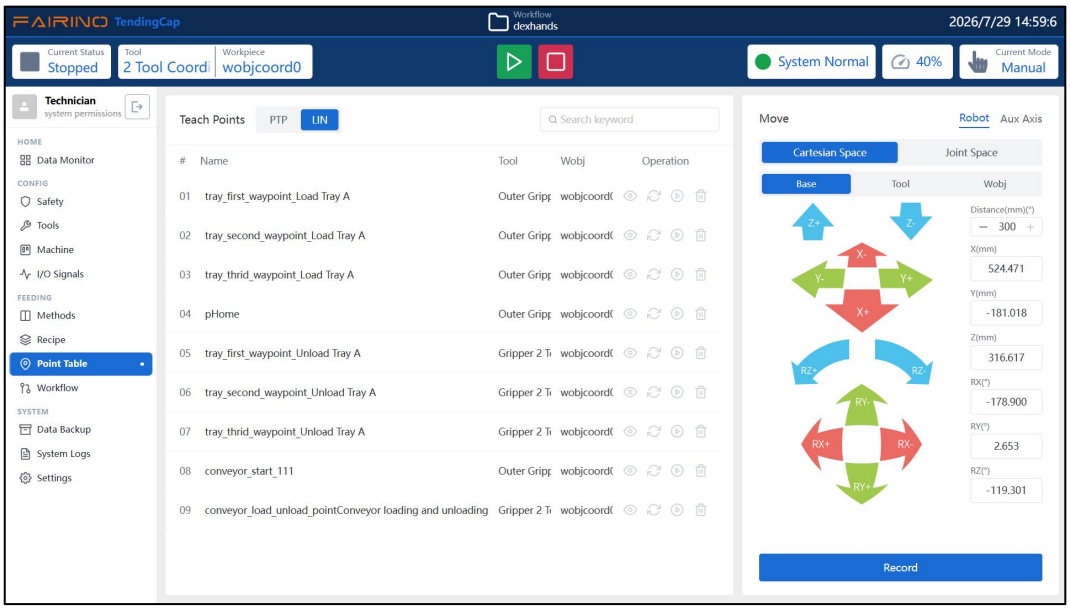


Figure 3.3.1-1 Robot Movement in Cartesian Space

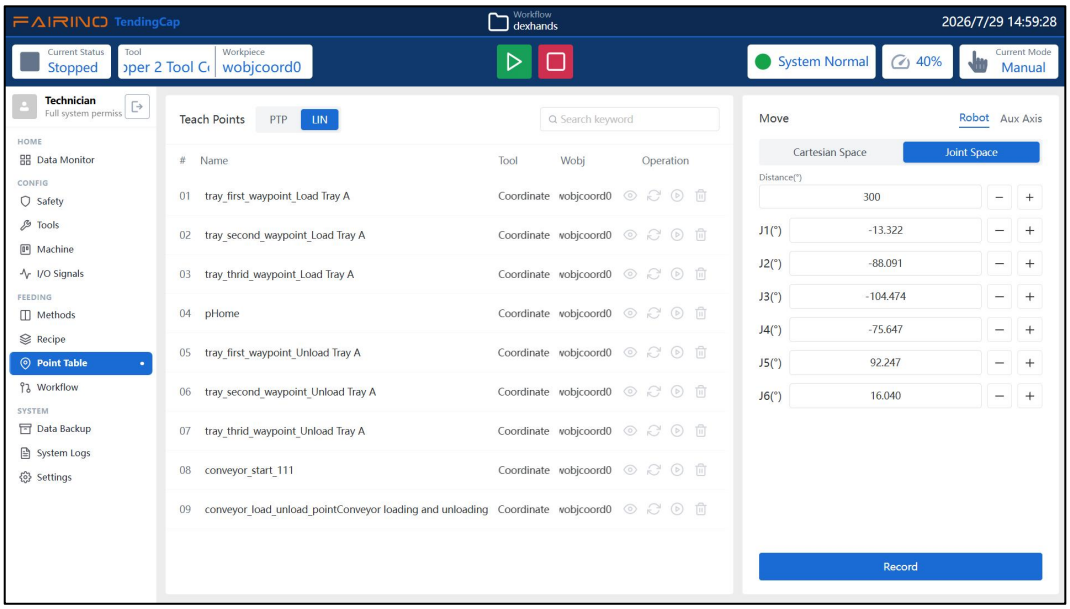


Figure 3.3.1-2 Robot joint-space motion

3.3.2 View points

The "Material Loading/Unloading – Point Table" displays all recorded point data. After entering each data entry, the operation buttons become highlighted in sequence: View, Update, Run Stepwise, and Delete. Clicking a point name opens an input field where you can enter a new name to rename it. In the upper-left corner of the table, select the Run Stepwise mode (PTP – Point-to-Point or LIN – Linear), and enter filtering criteria in the upper-right corner to filter and view points.

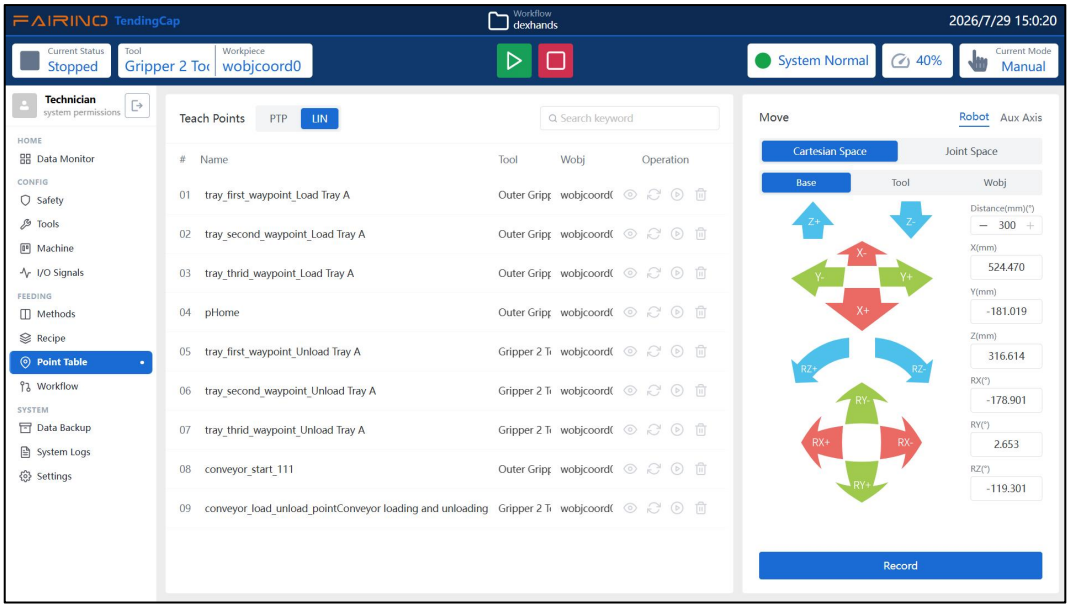


Figure 3.3.2-1 Point Table

3.4 Quick addition of CNC loading and unloading workflows

3.4.1 Introduction to Simple Workflow Instructions

3.4.1.1 MoveJ

Click "MoveJ" to open the "Edit MoveJ" interface on the right. Select the destination point, enable smooth transition, and enter the smooth transition time to ensure a seamless movement from one point to the next.The specific path is the optimal path automatically planned by the motion controller.

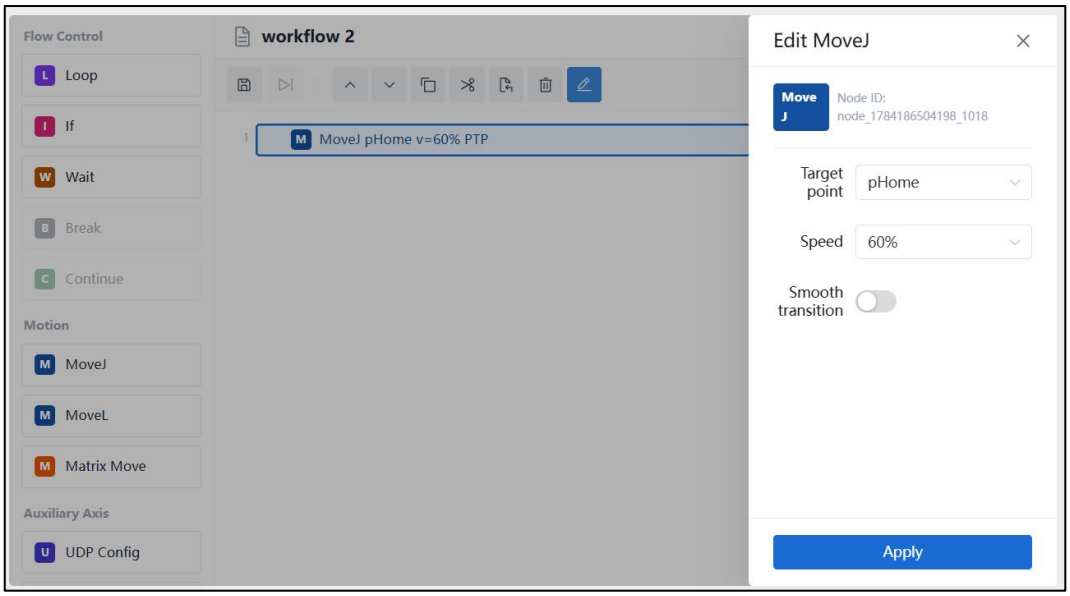


Figure 3.4.1.1-1 MoveJ instruction

3.4.1.2 MoveL

Click "MoveL" to open the "Edit MoveL" interface on the right, select the destination point, enable smooth transition, enter the smooth transition radius, and choose the transition method.The path to the destination is a straight line.

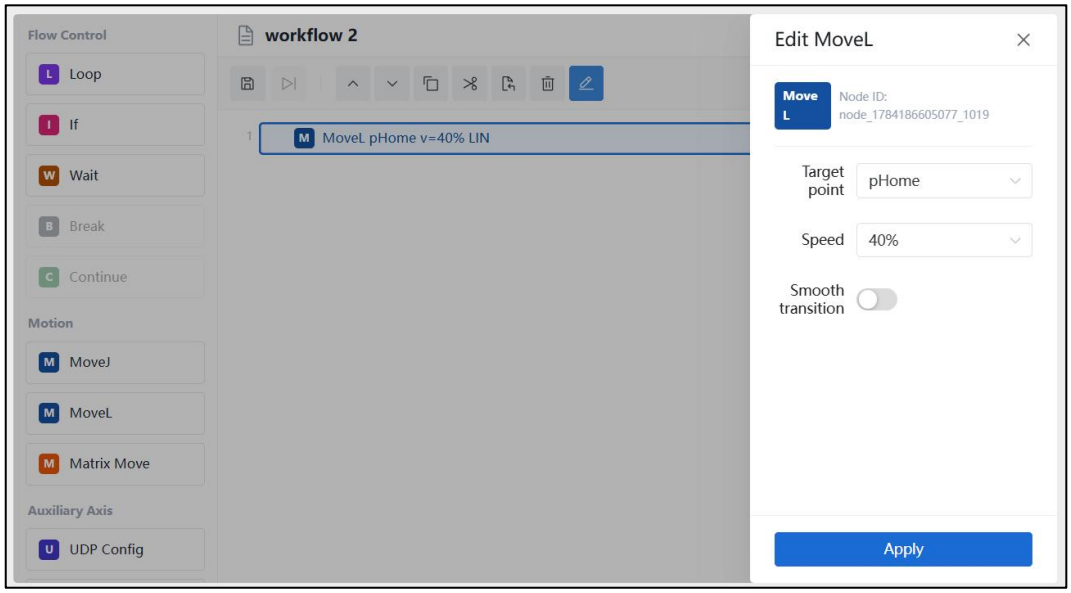


Figure 3.4.1.2-1 MoveL instruction

3.4.1.3 Matrix Move

Click "Matrix Move" to open the "Edit Matrix Move" interface on the right, select the tray and execution action, and the execution action scenario is as follows.

- Matrix Movement: The robot moves to load/unload and grasp/exit.
- Matrix operation count: Counting the row, column, and layer of the robot's loading/unloading operation.
- Set starting count: Define where the robot begins loading/unloading operations (row, column, and layer).
- Get matrix count: Determine the row, column, and layer of the robot's loading/unloading operation.
- Total processing count +1: Increase the total number of robot loading/unloading operations by 1.
- Total cleared processing operations: Total robot loading/unloading operations plus.
- Get total processing count: Get total robot loading/unloading operations.

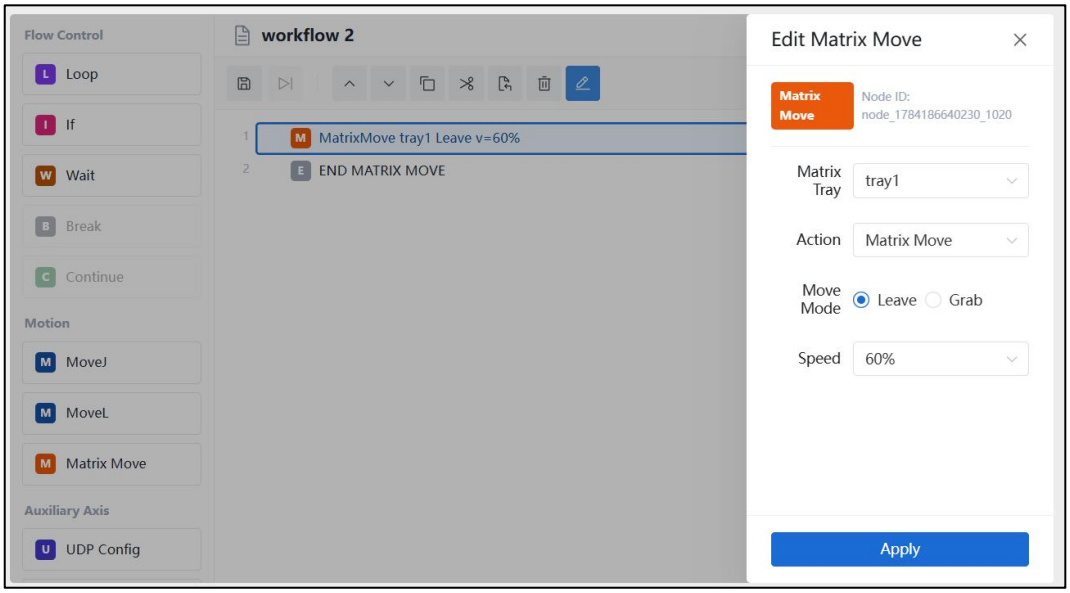


Figure 3.4.1.3-1 Matrix Move

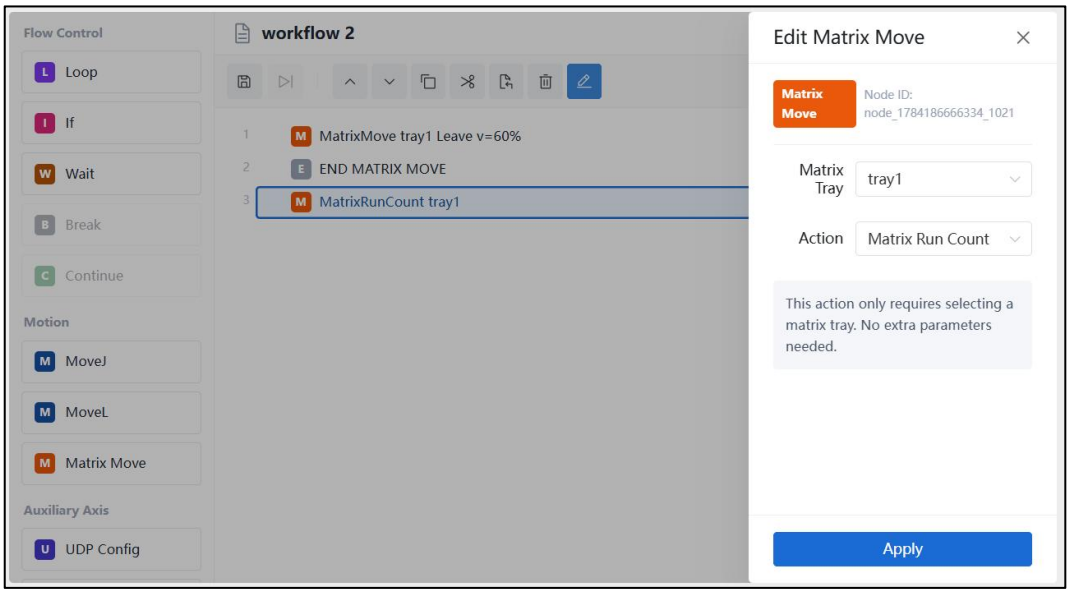


Figure 3.4.1.3-2 Matrix Execution Count

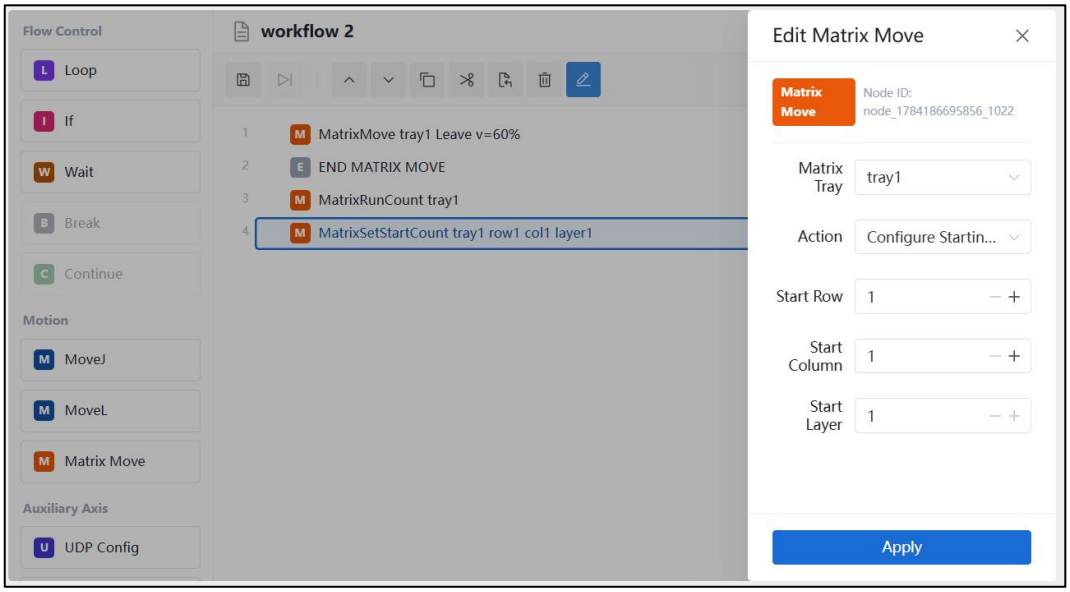


Figure 3.4.1.3-3 Configure starting count

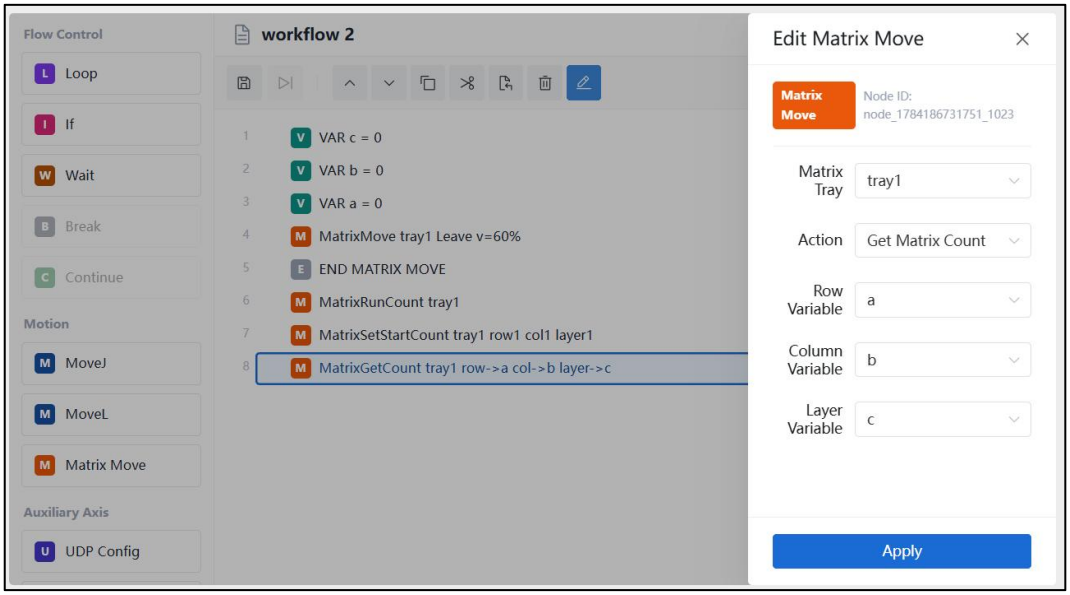


Figure 3.4.1.3-4 Get Matrix Count

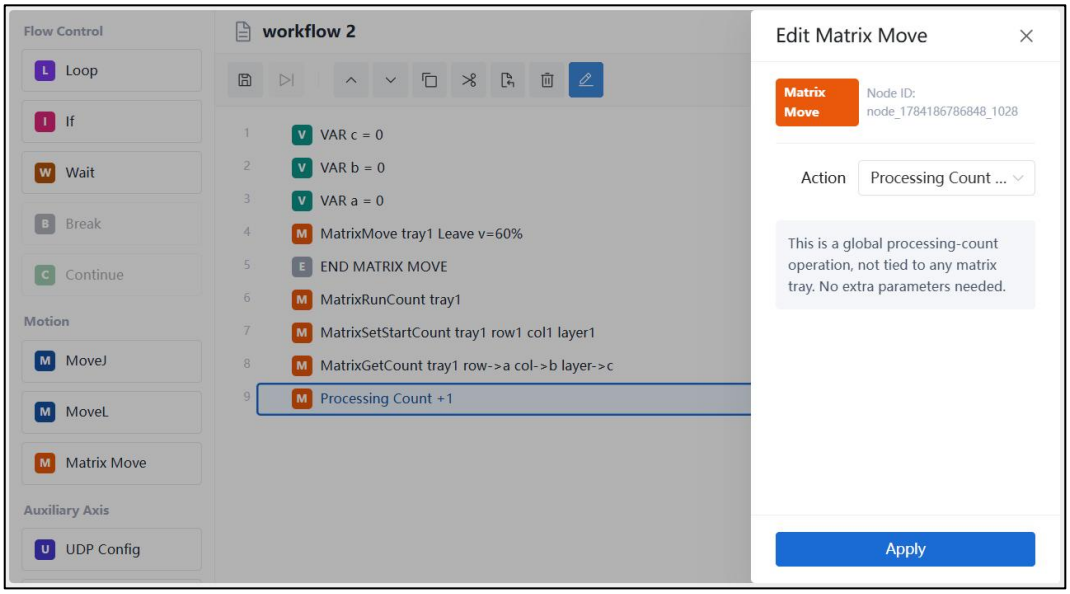


Figure 3.4.1.3-5 Total Processing Count +1

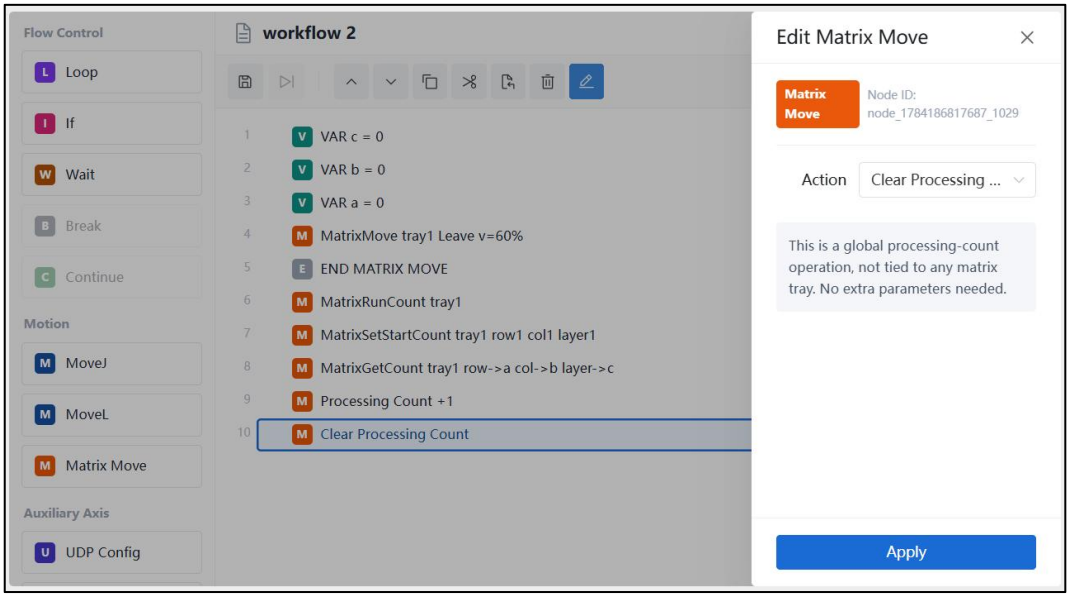


Figure 3.4.1.3-6 Total cleaned processing count

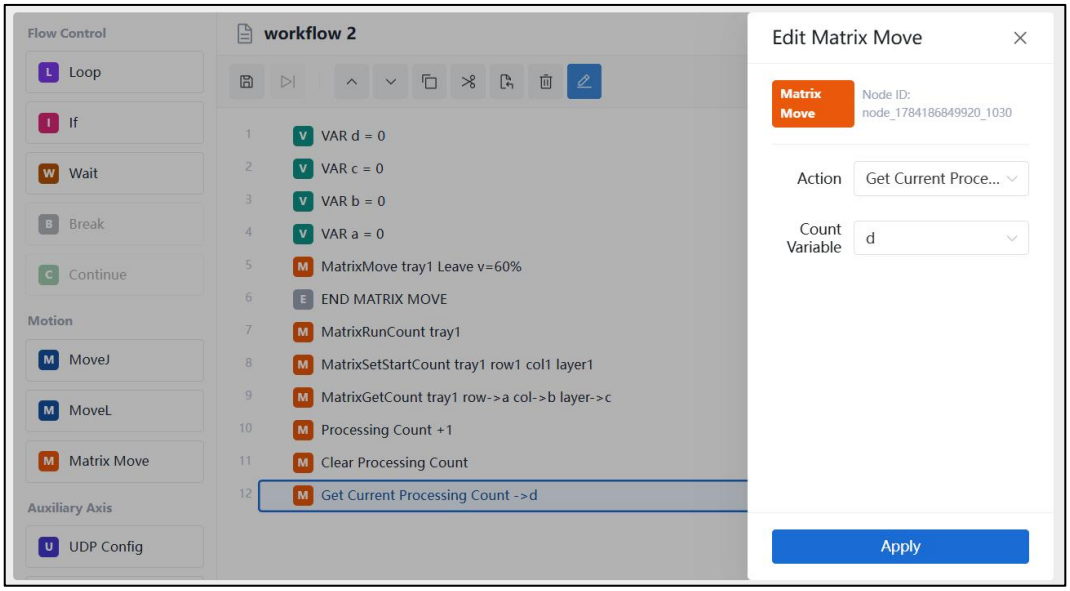


Figure 3.4.1.3-7 Get the total number of current processes

3.4.2 Perform operations on workflows

 Name: Save. Function: Save workflow content.

 Name: Run in One Step. Function: executes the selected workflow instruction in a single step.

 Name: Move Up. Function: Move the selected workflow instruction up；

 Name: Move Down. Function: Move the selected workflow instruction down；

 Name: Copy. Function: Copy selected workflow instructions.

 Name: Cut. Function: Cut the selected workflow instruction.

 Name: Paste. Function: Paste a copied or cut-and-paste workflow instruction.

 Name: Delete. Function: Remove the selected workflow instruction.

 Name: Edit. Function: Edit selected workflow instructions.

3.4.3 Run a Workflow

The left side primarily displays workflow list data; to create a new workflow, click the "Add" icon in the upper-left corner of the list; select the desired items from the list; then click the "Delete" button at the bottom to remove them.

After selecting any workflow, the workflow instructions and operation bar will be displayed. Click on any keyword on the left side to open the detailed interface for adding a workflow instruction; after filling in the detailed information for each instruction, click the "Apply" button at the bottom to save the added workflow instruction to the selected workflow file on the right side. For instructions that do not require parameters, simply click them to add them to the workflow content area.

Click the Start button to run the workflow; click the Stop button to stop the workflow; click the Pause/Restore button to pause or resume the workflow; during program execution, a running icon will appear immediately before the currently executing workflow node.

In manual mode, select any node in the workflow; clicking the "Run Step-by-Step" button allows the robot to execute this instruction individually, while clicking the "Edit" button enables you to modify the parameters of the workflow instructions.

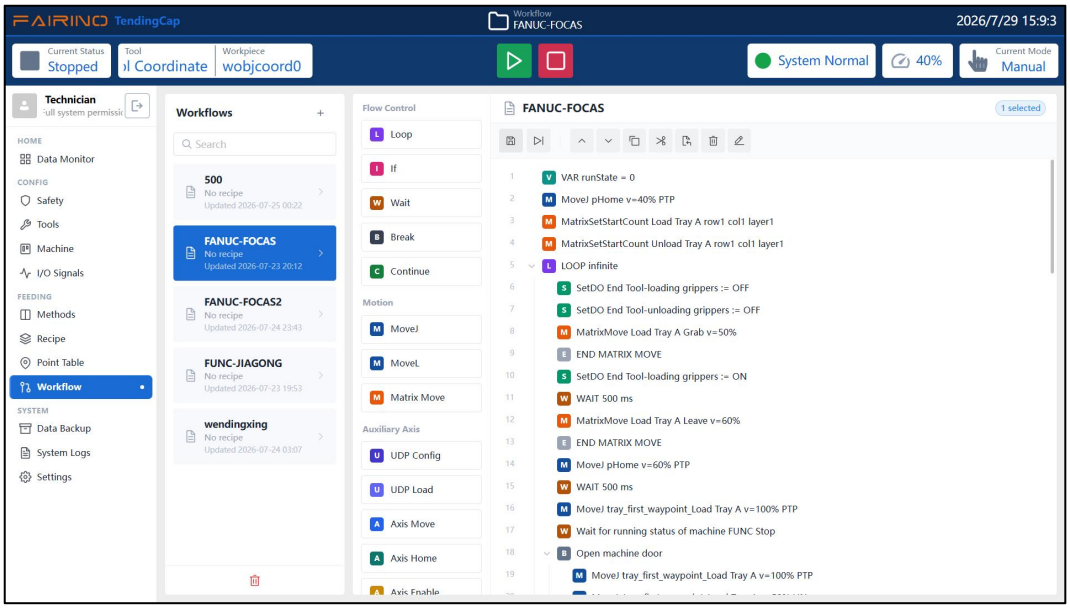


Figure 3.4.3-1 Workflow

4 Role Entry and Permissions

Upon initial launch of the CNC loading/unloading Cap software, users choose their operating role according to their job function. Each role is granted specific permissions, and there is no need for account registration or login. The current roles are Operator and Technician, with the following permissions:

- Operator: Responsible for daily equipment operation, program execution, status monitoring, and production count management. No password verification is required; direct system access is granted.

- Technician: All operator permissions, plus system configuration, coordinate calibration, I/O debugging, workflow programming, and all management functions. Password verification is required for access; the initial password is 1234.

Role entry and permissions are as shown in the figure below:

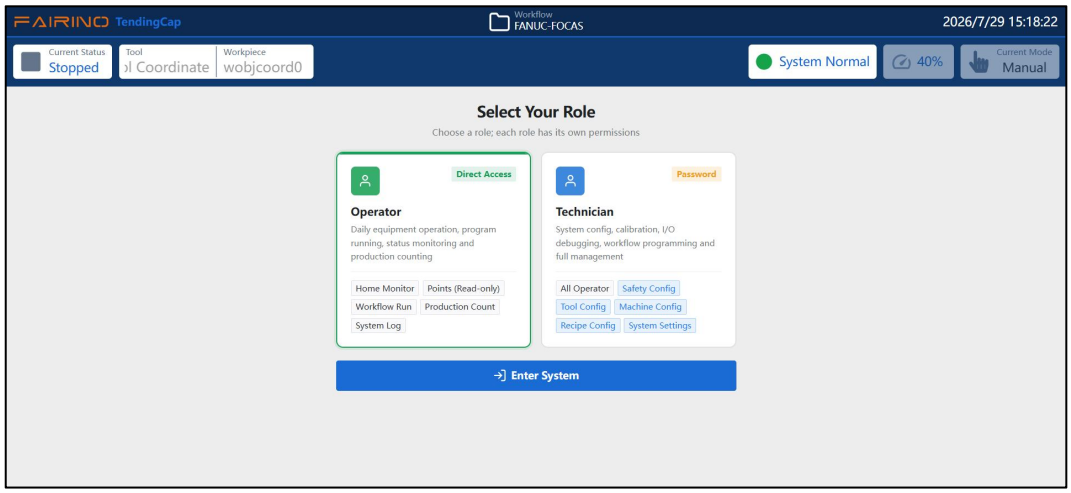
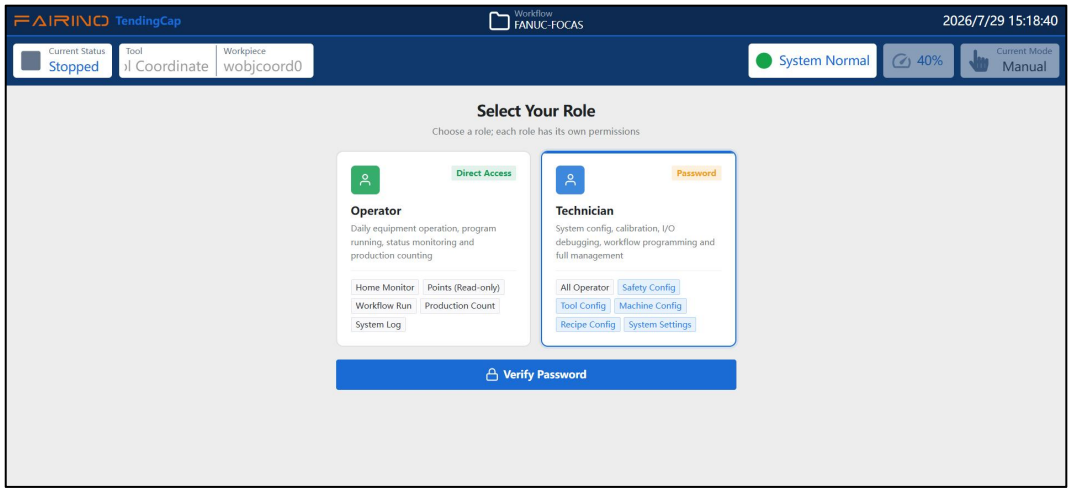


Figure 4-1 Operator role permissions



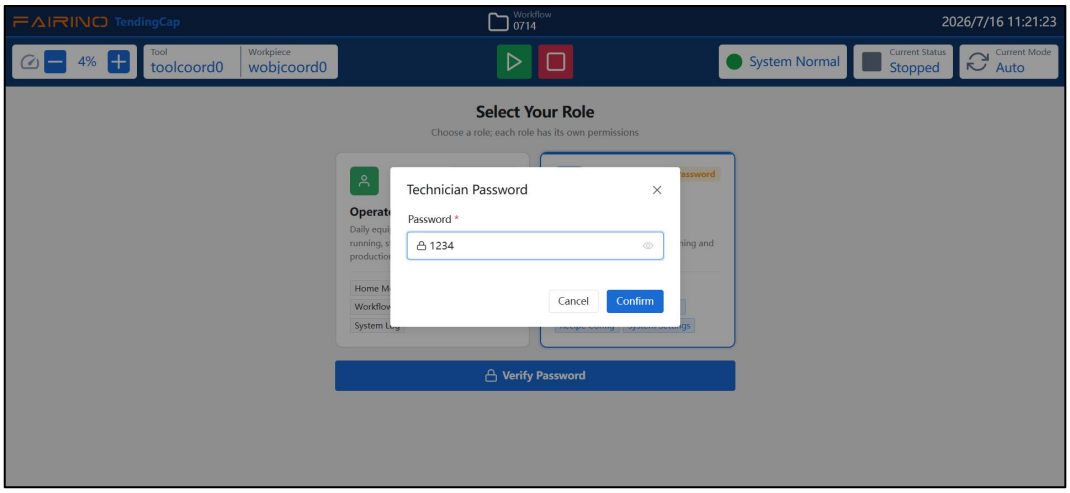


Figure 4-2 Technician role login password verification and permissions

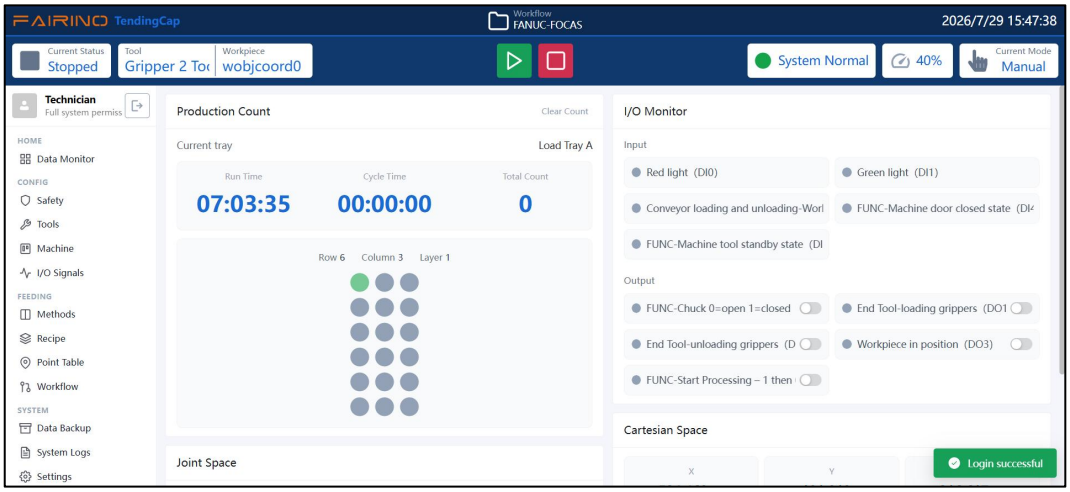


Figure 4-3 Technician role login successful

5 System initial interface

After successful login, enter the "Initial Interface" of the CNC loading/unloading Cap software, which mainly includes:

- Top first layer (from left to right): FAO logo, current running workflow name, current system time.
- Top second layer: robot running status, current tool/workpiece coordinate system, robot control area (start, stop, pause, resume), system status (normal, error, and warning), robot global speed, robot manual/automatic mode.
- Above the menu bar is the currently logged-in role. Click the exit icon on the far right to log out.

- Menu bar and corresponding menu interfaces

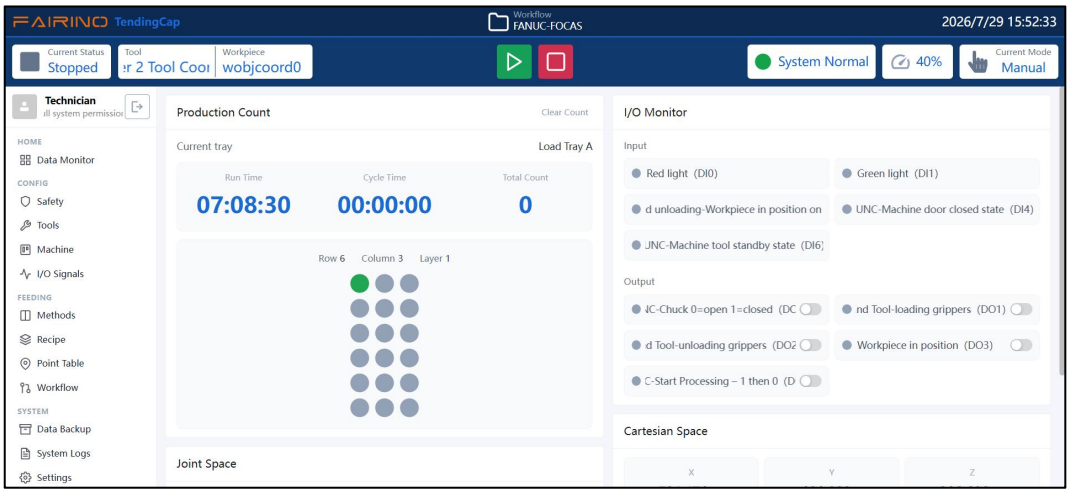


Figure 5-1 The initial interface of the CNC loading/unloading Cap software

5.1 Current Workflow Name

When the user opens a workflow, record the workflow name. When the user closes the interface and re-enters, display the current workflow name.


Name: Current Workflow Name. Function: Click to navigate to the Workflow interface in Loading/Unloading and open the content corresponding to the current workflow name.

5.2 Robot operating status


Name: Running. Function: Displays the operational status of the robot.


Name: Pause. Function: Displays the paused status of the robot.


Name: Stop. Function: Displays the stopped state of the robot.

5.3 Current tool coordinate system

Display the current application's tool coordinate system. Click the dropdown to show all tool coordinate systems, and click on any of them to apply.

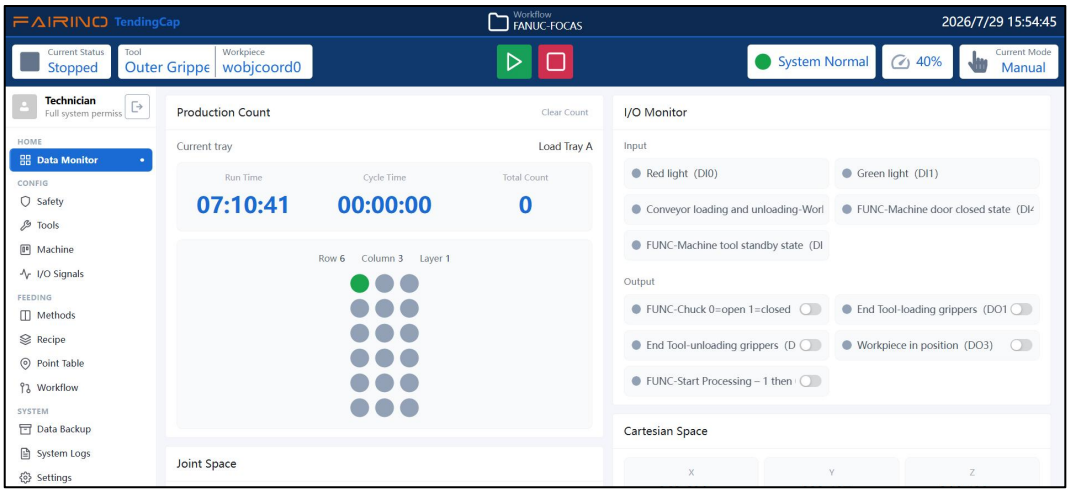


Figure 5.3-1 Current tool coordinate system

5.4 Current workpiece coordinate system

Display the current application's workpiece coordinate system. Click the dropdown to show all workpiece coordinate systems, and click any of them to apply it.

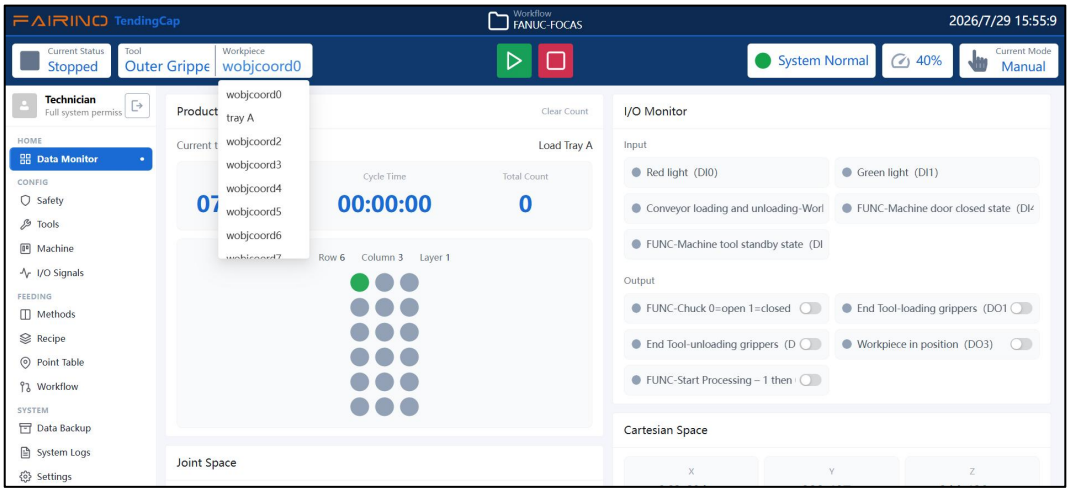


Figure 5.4-1 Current workpiece coordinate system

5.5 Robot Control Area


Name: Start. Function: Upload and start running the workflow.


Name: Stop. Function: Stops the current workflow run.


Name: Pause. Description: Pause the current workflow execution.

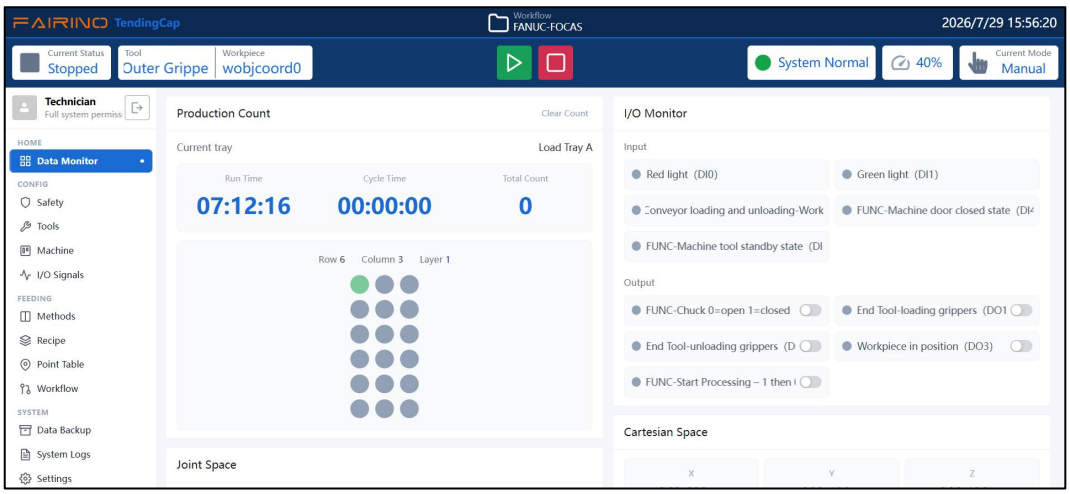

Name: Resume. Function: Resume the current workflow execution.

5.6 System Status

Display the current system status: Running Normally, Has Errors, or Has Warnings. When errors or warnings are present, hovering over the status area will display the detailed error and warning messages. Click the Clear button at the bottom to clear some of the errors.


Name: Normal system state. Function: The system is currently normal.


Name: Error/Warning Status. Function: Displays when warnings or errors are present; hides when there are no errors or warnings.



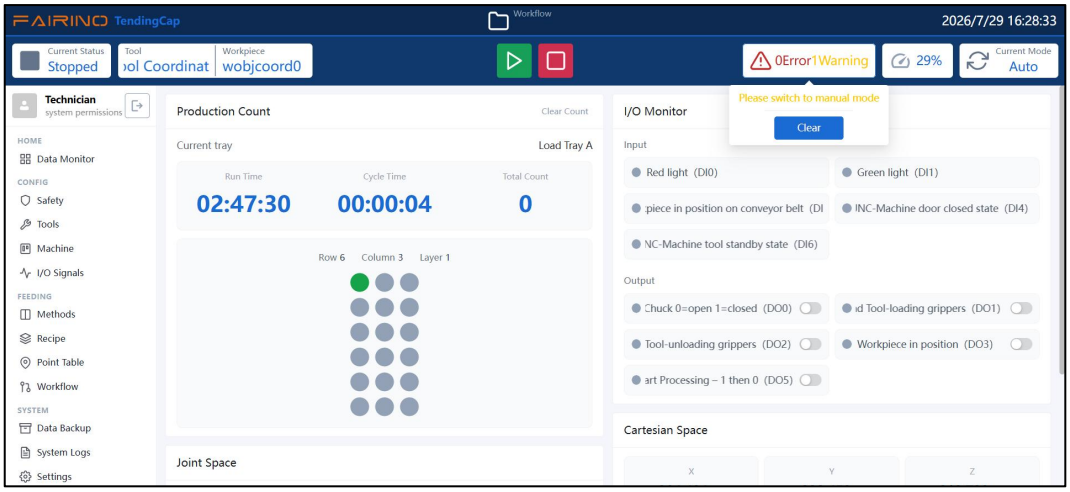


Figure 5.6-1 System Status

5.7 Robot global velocity

After moving to the robot's global speed, display the slider for the robot's global speed, which can be adjusted by sliding, and can also be modified by entering values in the input box.

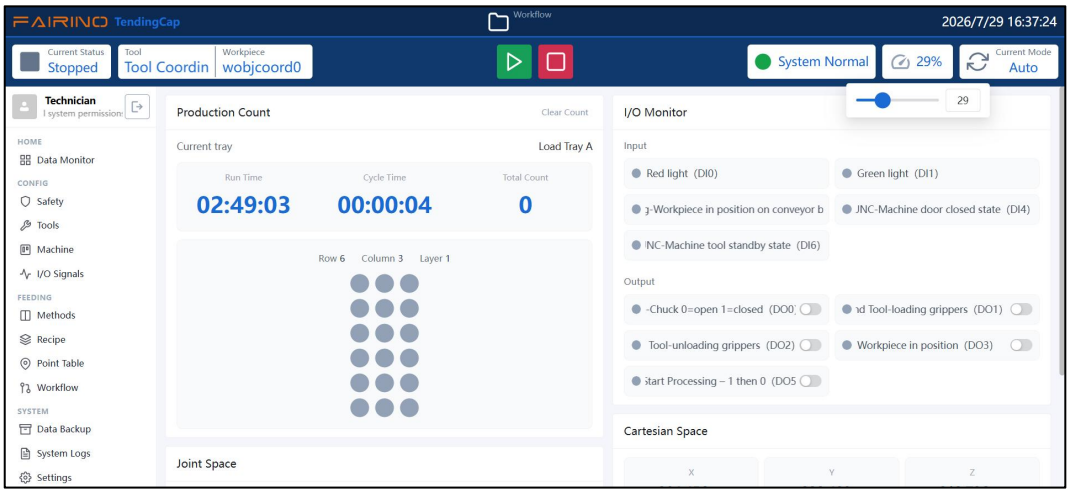


Figure 5.7-1 Robot global velocity

5.8 Robot Current Mode

 Name: Automatic Mode. Function: Robot automatic operation mode.

 Name: Manual Mode. Function: Robot manual mode for teaching/teach pendant operations.

 Name: Drag Mode. Function: The robot's drag mode for performing dragging operations. It cannot be switched to Drag Mode in Automatic Mode; only switchable from Manual Mode. Once the robot enters Drag Mode, it cannot revert to Automatic Mode—switching to Manual Mode will exit Drag Mode.

5.9 Current logged-in role

After the role successfully logs in, it is displayed on the menu bar. Click the rightmost icon to pop up a 'Confirm Logout' prompt.

 Name: Logout. Function: Display a logout prompt for secondary

confirmation by the user.

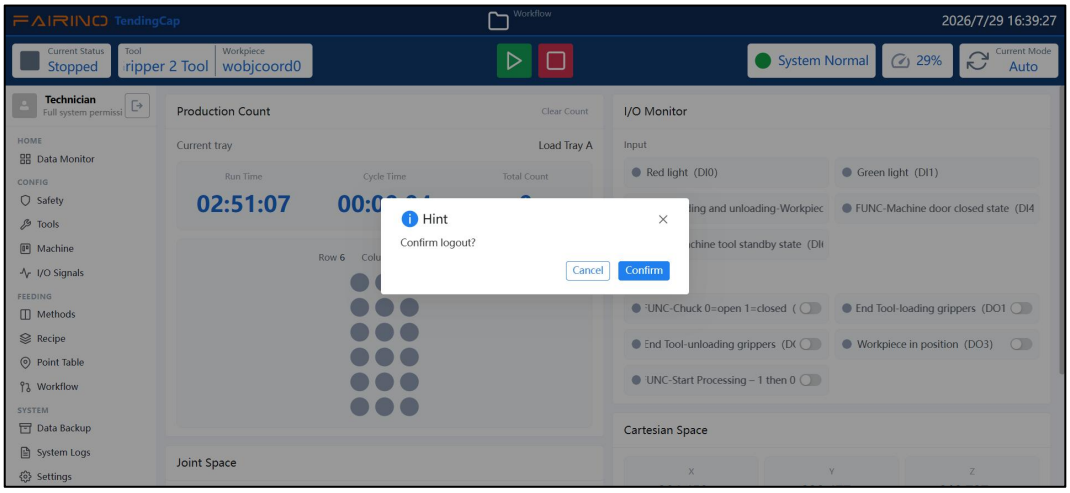


Figure 5.9-1 Confirm exit prompt

5.10 Menu bar

Table 5.10-1 Menu bar table

Menu Type	Menu Bar Name
Home	Data Monitor
Config	Safety
	Tools
	Machine
	I/O Signals
Feeding	Methods
	Recipe
	Point Table
	Workflow
System	Data Backup
	System Logs
	Settings

6 Home

6.1 Data Monitor

View real-time status data for loading/unloading production counts, signal monitoring, and joint space and Cartesian space states in Home > Data Monitor. The modules are described as follows:

- Production count: Current loading/unloading formula, running time and cycle duration of the current formula, current row, column, and layer number, indicated by a flashing green light.

- Signal Monitoring: Real-Time Status Display of I/O Corresponding to Each Function During Loading and Unloading Processes.

- Joint space: current data of robot joints J1 to J6.

- Cartesian space: current robot Cartesian pose data X, Y, Z, RX, RY, and RZ.

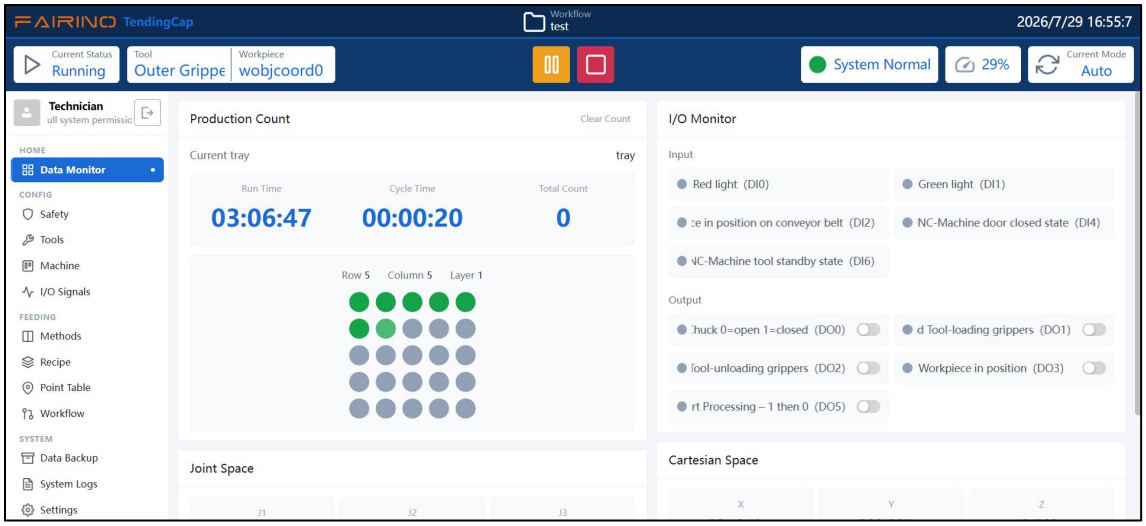


Figure 6.1-1 Data Monitor

7 Config

7.1 Safety

In "Config—Safety", teach the safety point with the fixed name "pHome". If the safety point does not exist, prompt "No pHome point data found". Click the "Configure" button to send the current robot pose as the safety point data. After the safety point is successfully configured, click the "Move" button to move to the safety point position for verification.

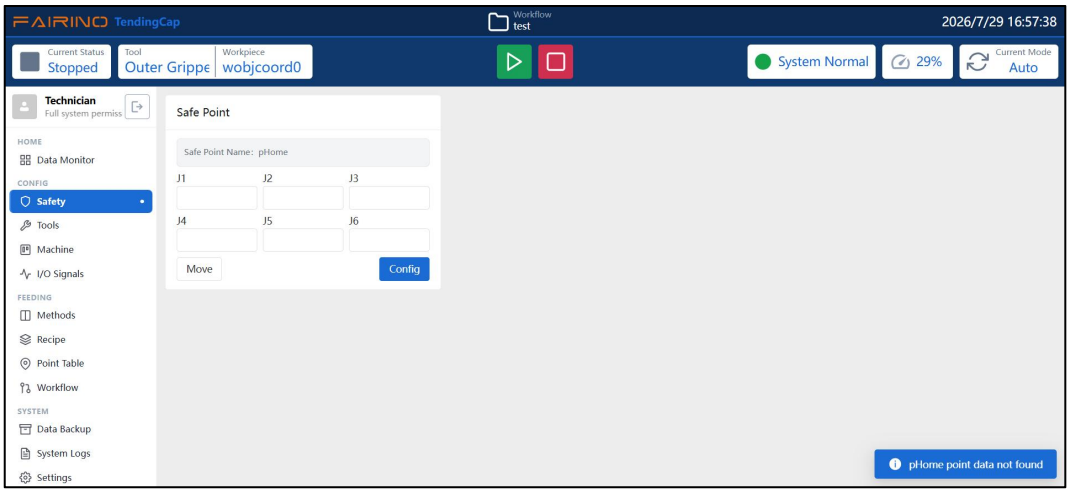


Figure 7.1-1 pHome point data not found

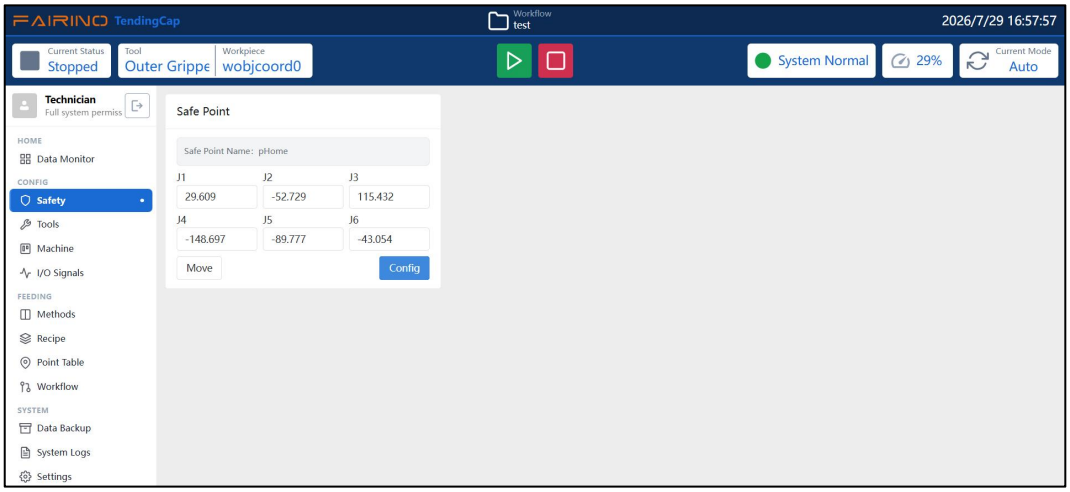


Figure 7.1-2 Safety point configured successfully.

7.2 Tools

Configure the end effector in "Config—Tools". Upon entering the page, retrieve the tool list data. When no data exists, display 'No data available.

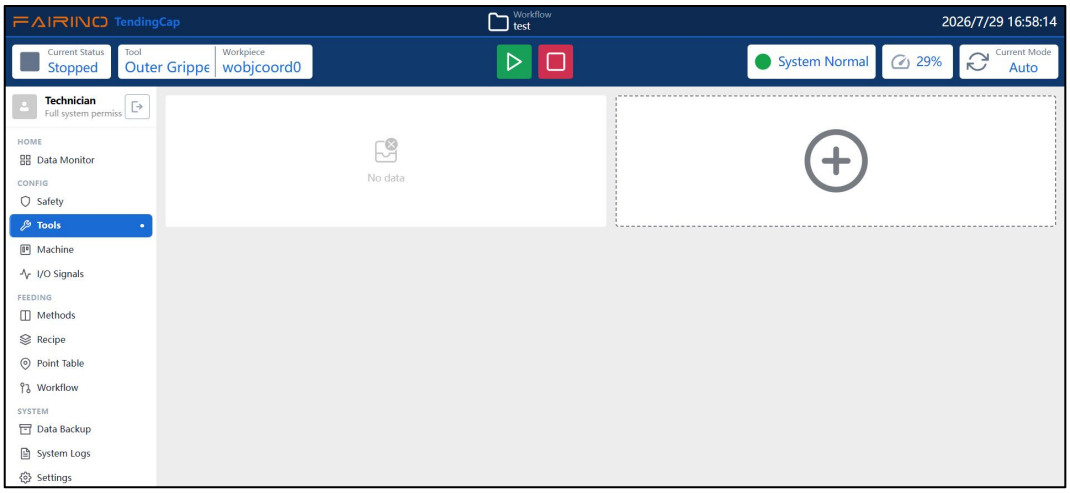


Figure 7.2-1 The tool currently has no data.

Click the 'Add' card to add a new tool in three steps, as described below.

- End Effector: Enter the end effector name based on functional requirements. If the name field is left empty, clicking the 'Next' button will prompt the message 'Name cannot be empty.' Add gripper quantities (removable) and configure the corresponding I/O signals and testing for each gripper.

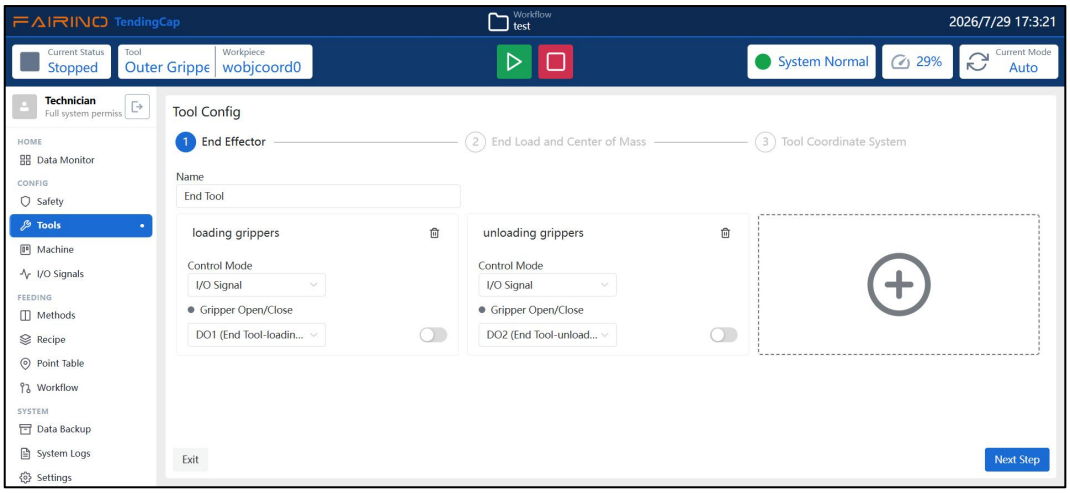


Figure 7.2-2 End effector

- End load and center of mass: Select the load number, enter the weight (unit: kg) and the center of mass coordinates X, Y, Z (unit: mm). The load data will be applied after switching the load number.

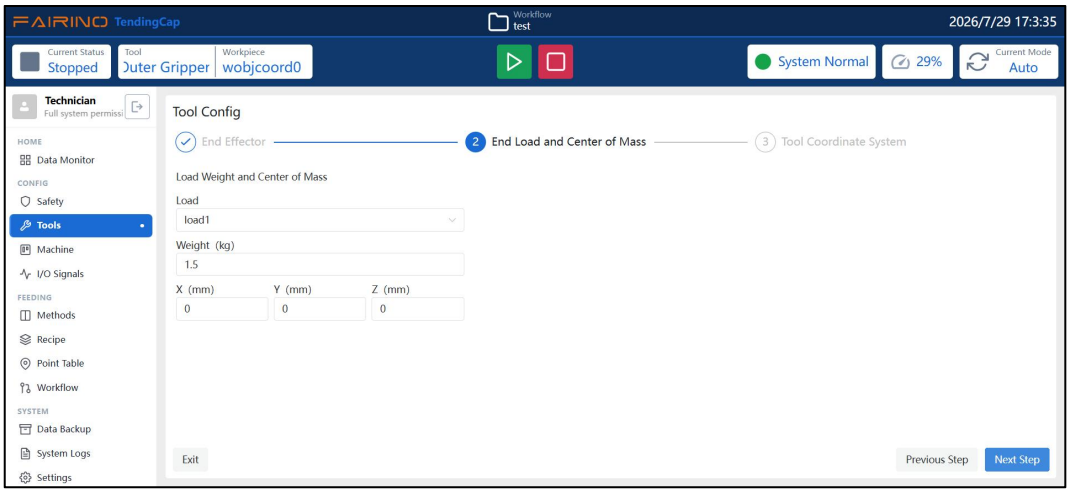


Figure 7.2-3 End load and centroid

- Tool coordinate system: Configure the tool coordinate system corresponding to the gripper, then click the Done button to complete adding the new tool. To switch to a non- default tool coordinate system, tap the “Calibrate” button at the bottom to bring up the calibration interface for the corresponding gripper tool coordinate system. The default calibration method is the “4- point method”; on this interface, you can also rename the tool coordinate system.

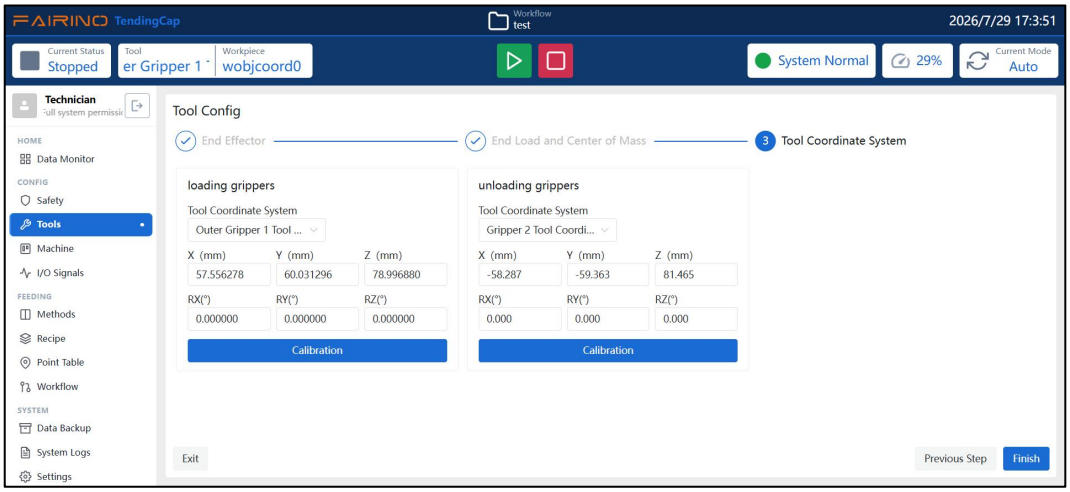


Figure 7.2-4 Tool coordinate system

After clicking the Complete button and successfully adding new data, you will return to the tool homepage, where the data list will be reloaded. Click the Edit button to view or modify the tool's data. Click the Delete button, and a secondary confirmation dialog with the title "Delete End Effector" will appear; click the Confirm button to complete the deletion.

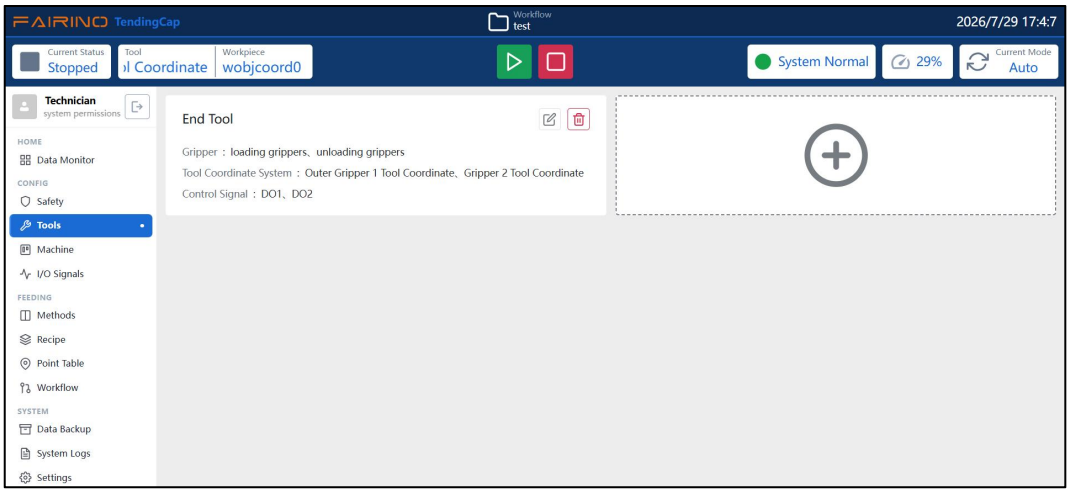


Figure 7.2-5 Tool List

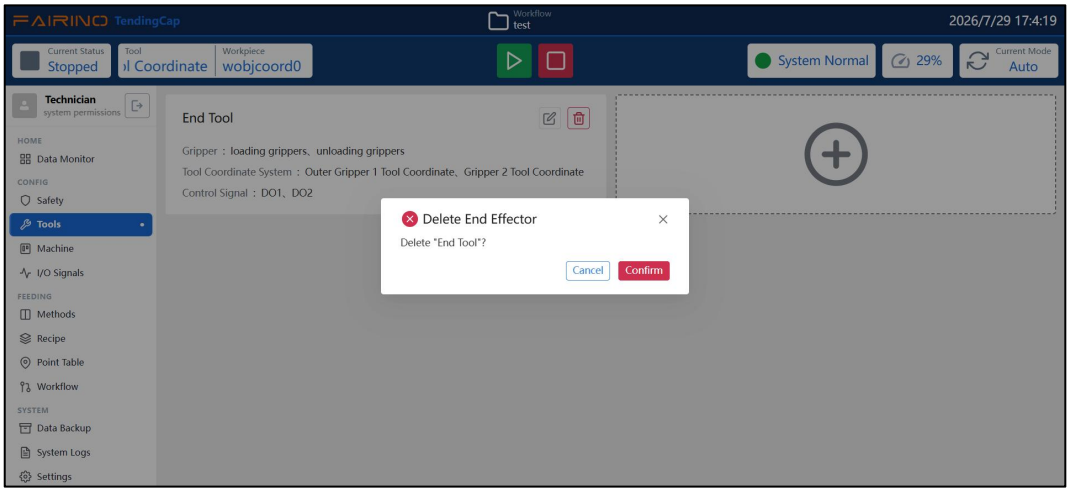


Figure 7.2-6 Confirm before deleting tool

7.2.1 Tool Coordinate System Calibration

The four-point method only calibrates the tool TCP, i.e., the position of the tool center point, and its orientation is by default consistent with that of the end effector. Select a fixed point in the robot workspace, move the tool to the fixed point in three different orientations, and teach Points 1, 2, and 3 in sequence. Then move the tool vertically to the fixed point and teach Point 4. After teaching is complete, click the Calculate button to view the calibration results. Click the Apply button to apply the calculated results to the tool coordinate system.

Important：

- The default tool coordinate system cannot be calibrated. When a non-default tool coordinate system is selected, clicking the calibration button will automatically

apply the default tool coordinate system.

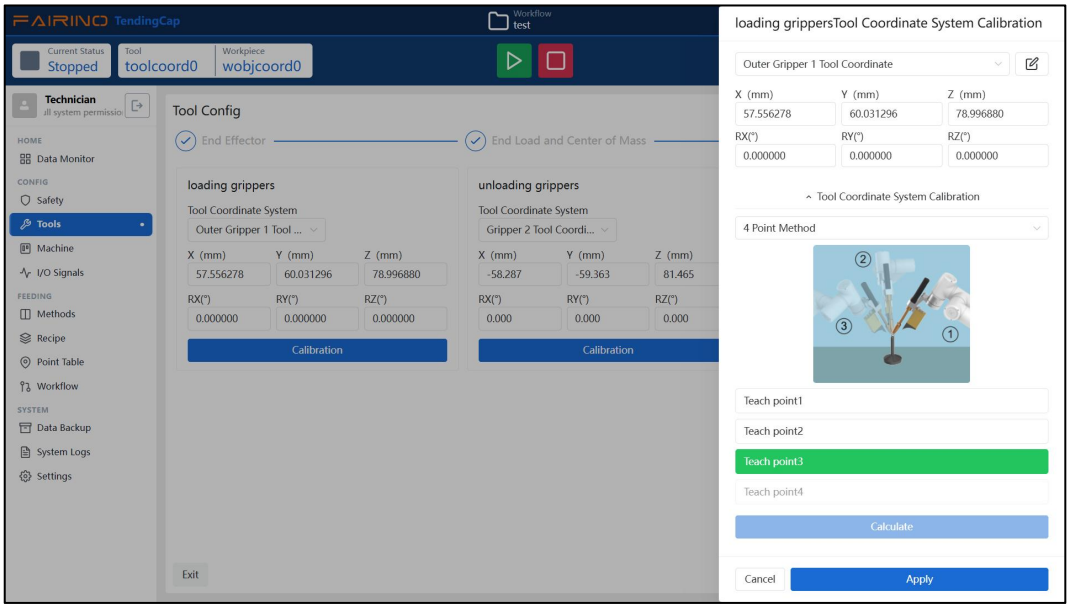


Figure 7.2-7 Tool Coordinate System Four-Point Calibration Points 1, 2, and 3

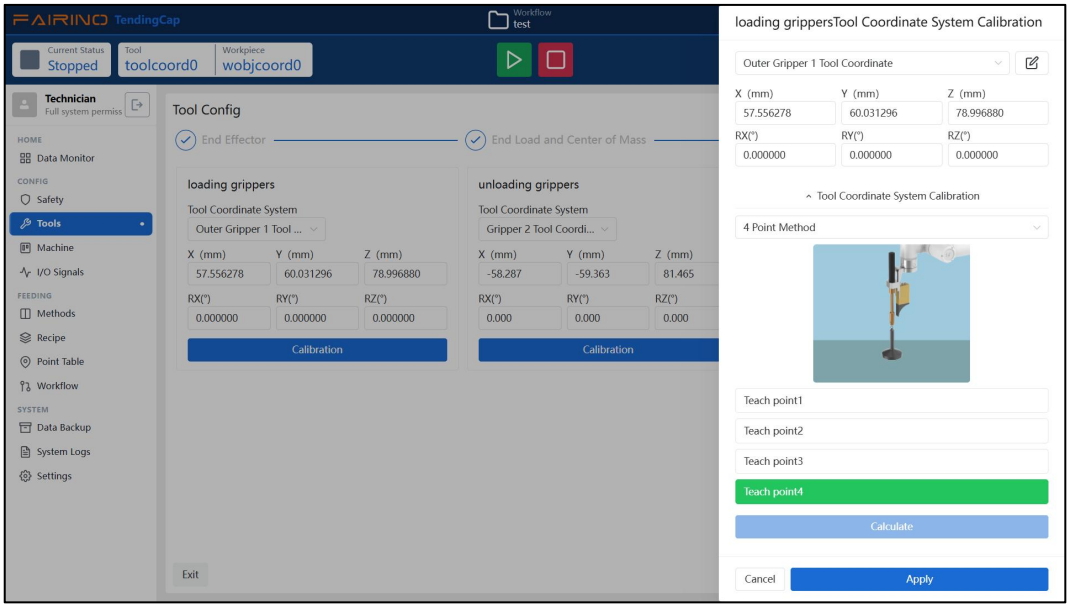


Figure 7.2-8 Tool coordinate system calibration using the 4-point method

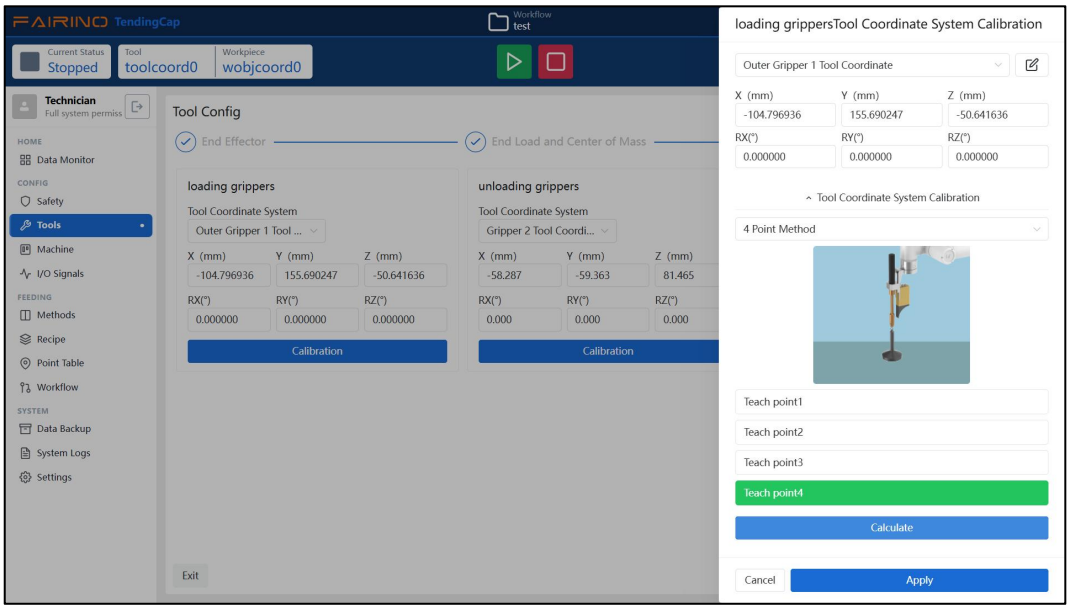


Figure 7.2-9 Tool coordinate system four-point method calibration calculation results

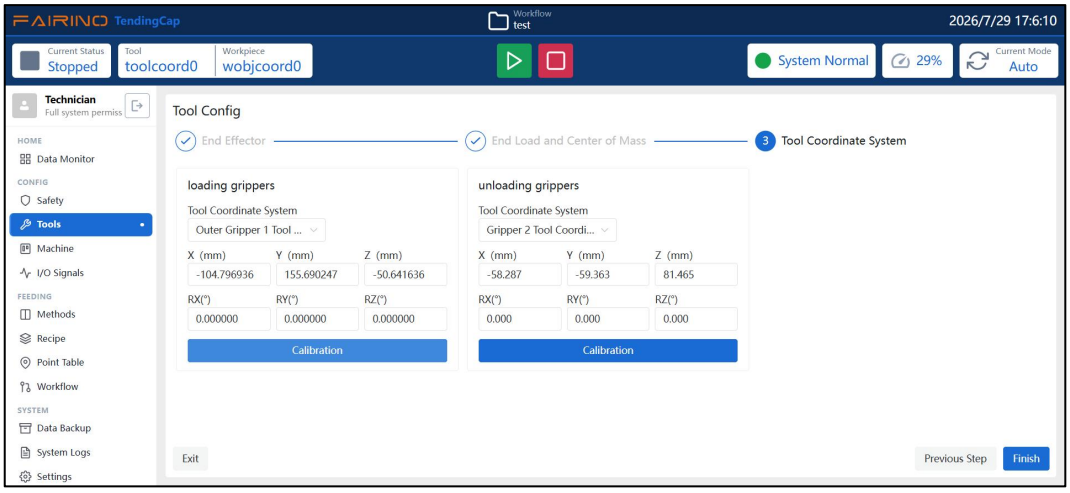


Figure 7.2-10 Application of the Four-Point Method Calibration Results for the Tool Coordinate System

7.3 Machine

In "Configuration – Machine Tool", configure the machine tool. After entering the page, retrieve the machine tool list data. When no data exists, display "No data available".

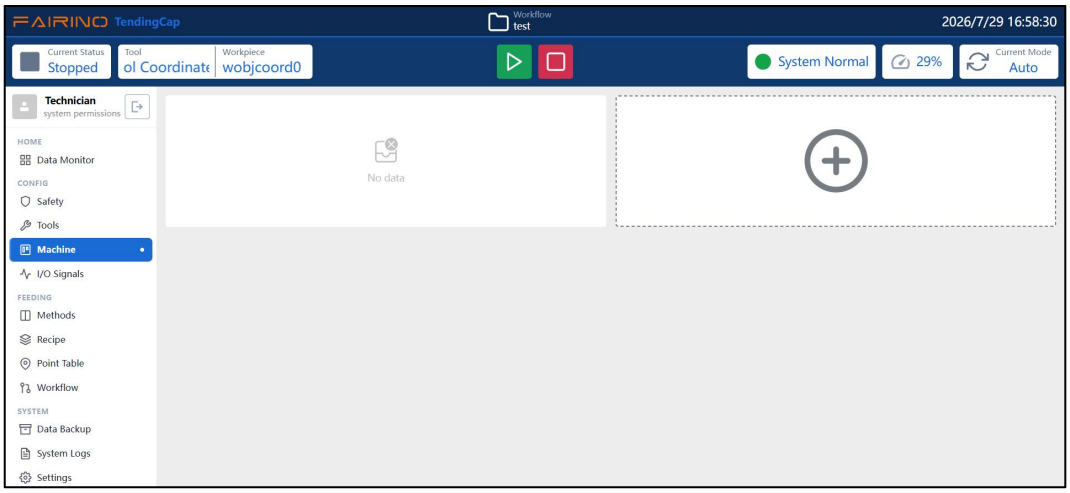


Figure 7.3-1 No machine tool data found.

Click the 'Add' card to create a new machine tool entry, in two steps, as described below:

- Machine tool parameters: The user inputs a name based on functional requirements. If the name is left blank and the "Next" button is clicked, a prompt "Name cannot be empty" will appear. Currently, the machine tool supports the following control systems: "FANUC", "SYNTEC", and "Others".

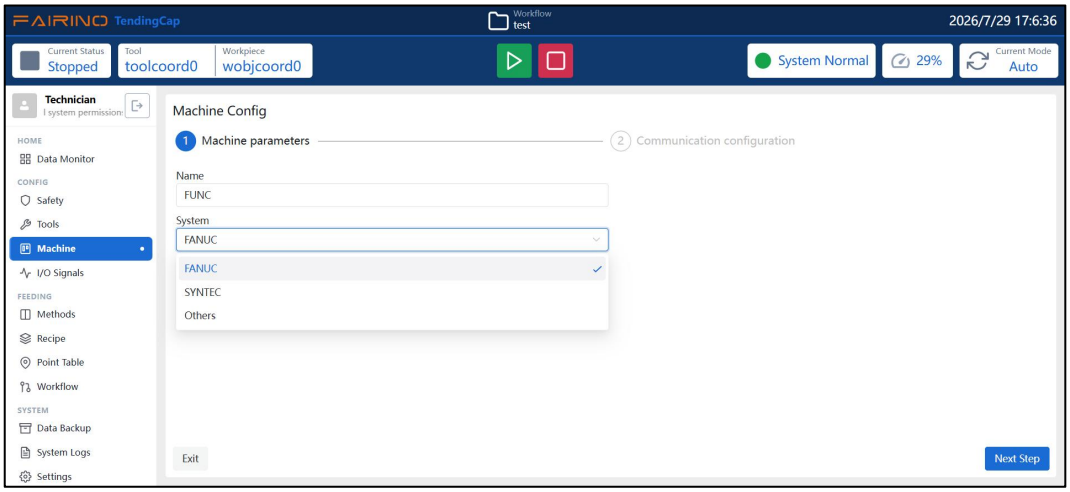


Figure 7.3-2 Machine parameters

- Communication Configuration: Depending on the selected system, the communication modes supported by the FANUC system are "I/O" and "FOCAS" (available only on Linux systems); the SYNTEC systems support "I/O" and the "SYNTEC Protocol"; other systems only support "I/O".

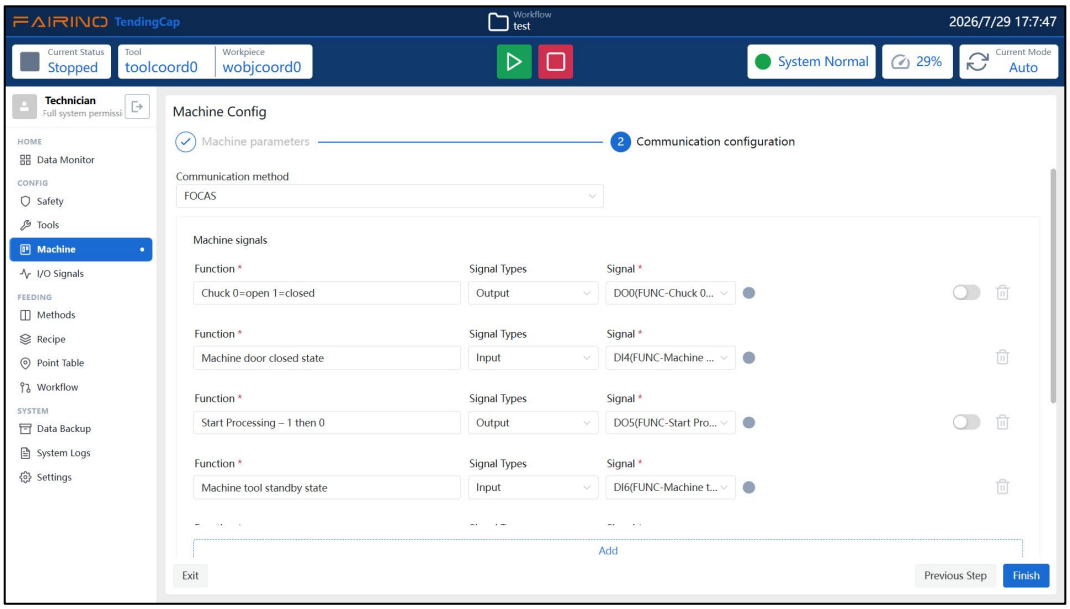


Figure 7.3-3 Communication Configuration – Machine Tool Signals

After successful addition, the homepage displays configured machine tools. Click the "Edit" button in the upper-right corner of each tool configuration card to view or modify details. Click the "Delete" button in the upper-right corner to confirm deletion; click OK to remove the tool.

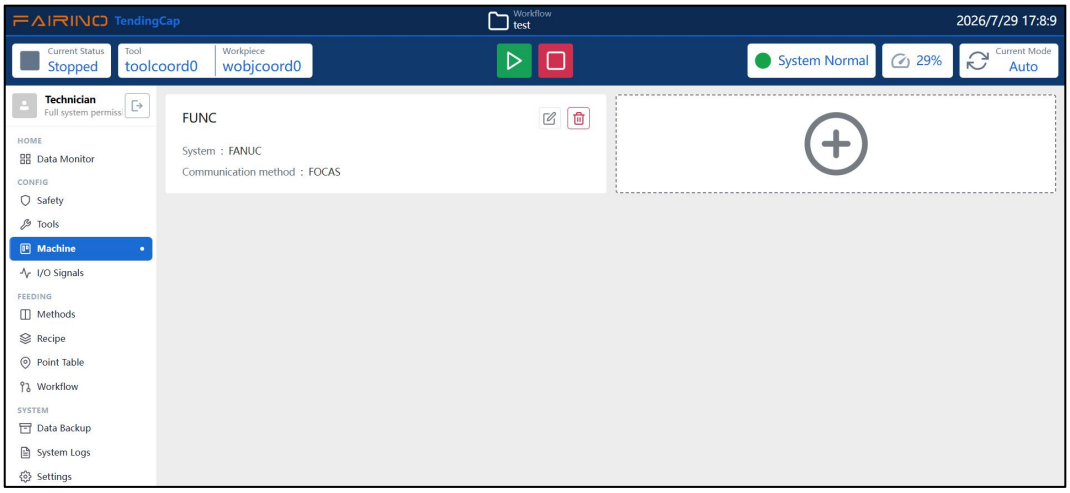


Figure 7.3-4 Machine Tool List

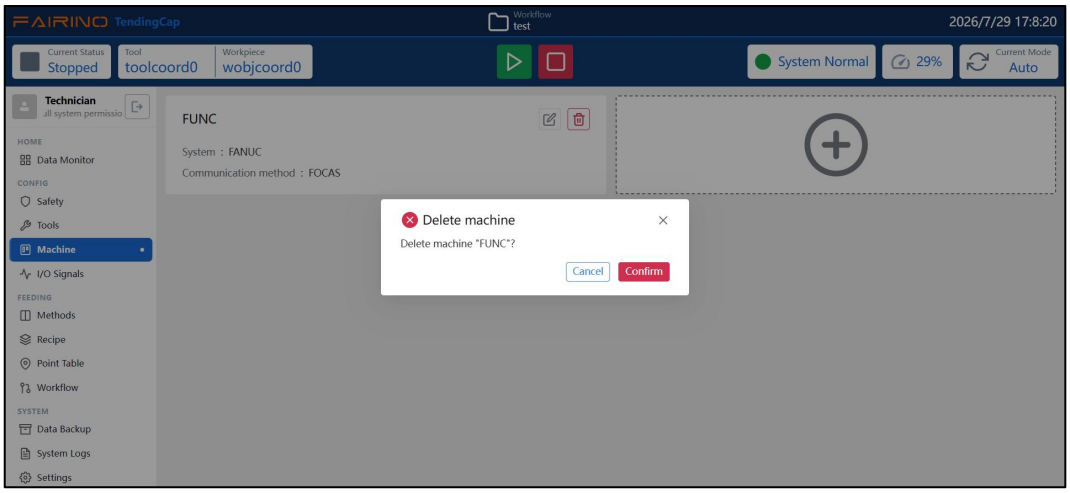


Figure 7.3-5 Machine Tool Deletion Second Confirmation

7.3.1 Communication method

7.3.1.1 I/O

Display only the machine tool signal details. Click the "Add" button at the bottom of each signal to add it, enter the function name, and select the signal type and identifier. For DO signals, use the slider for manual testing and status display; click the "Delete" icon on the right side to remove them. Machine tool signals must not be empty. After successful communication configuration, click the "Complete" button to finalize addition.

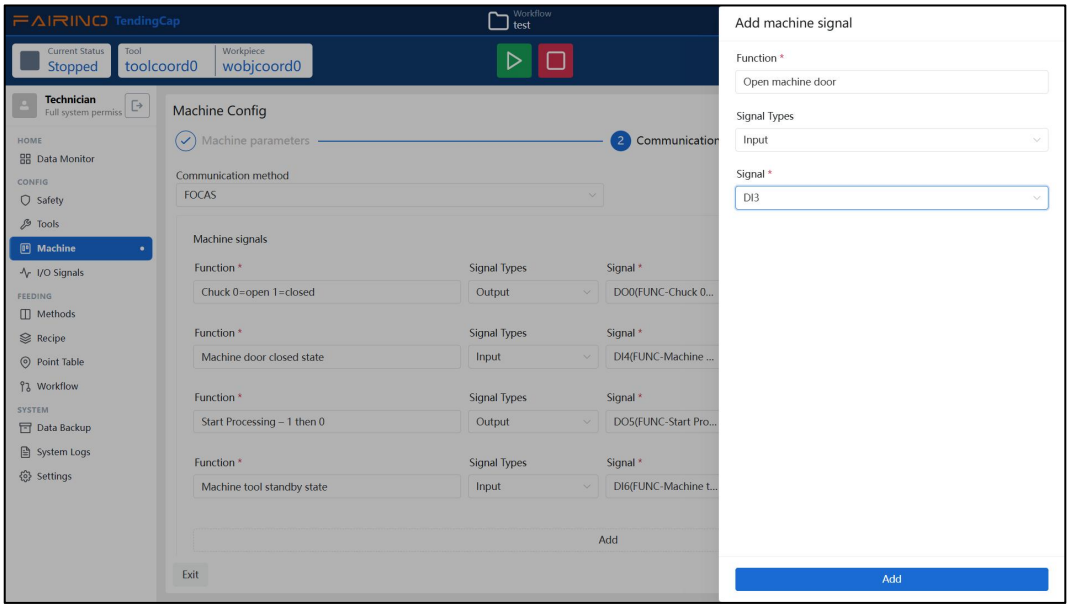


Figure 7.3-6 Communication method – Add Machine Tool Signals

7.3.1.2 FOCAS

Show the machine tool signals, communication configuration for the FOCAS protocol, and procedures for machine tool debugging.

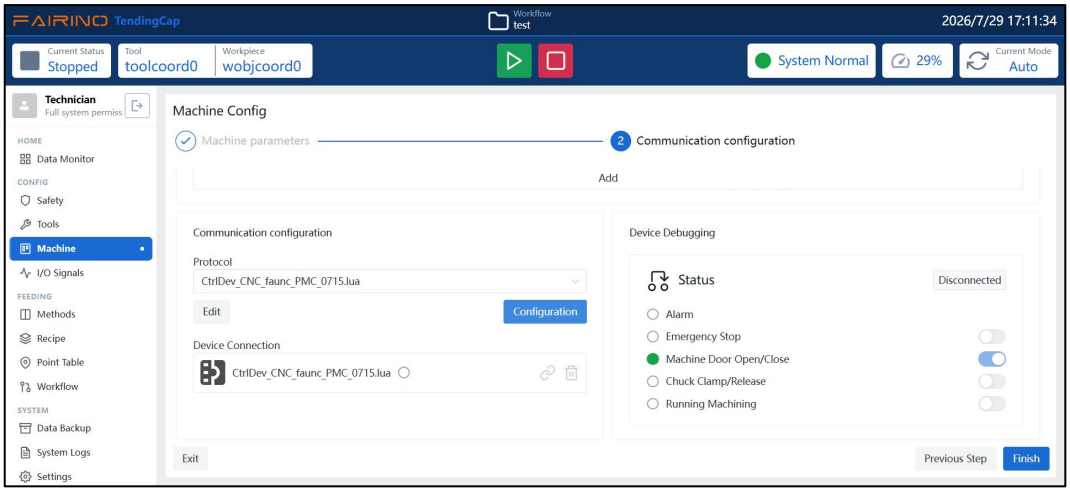


Figure 7.3-7 Communication method – FOCAS

In Communication Configuration, configure protocols, connect devices, and make edits. Details are as follows：

- Protocol Configuration: Click the "Configure" button to use the selected protocol file as the open protocol for establishing FOCAS communication with the machine tool.

- Device Connection: Displays configured protocol files. The green light indicates the name of the protocol currently connected. Click the "Load/Unload" icon on the far right to connect or disconnect a protocol. Click the "Delete" icon to remove the protocol configuration from display.

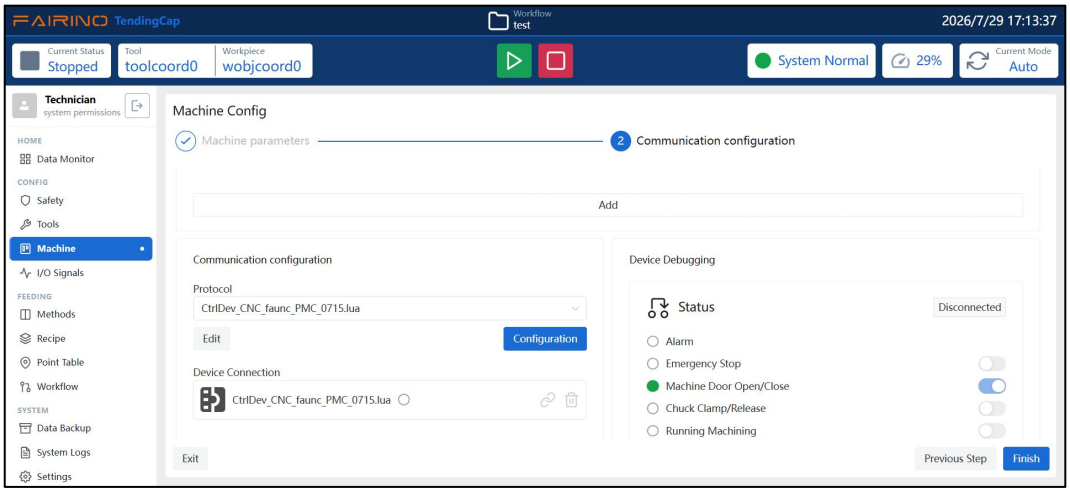


Figure 7.3-8 Communication method – FOCAS Protocol and Device Connection

- Protocol Editing: Click the "Edit" button to enter the Protocol Editing interface for uploading, deleting, or downloading protocols. The file name for uploading a protocol must start with "CtrlDev_CNC" and have the ".lua" extension. Upon successful upload, the existing protocol list will update; select the desired protocol from the list to delete or download it.

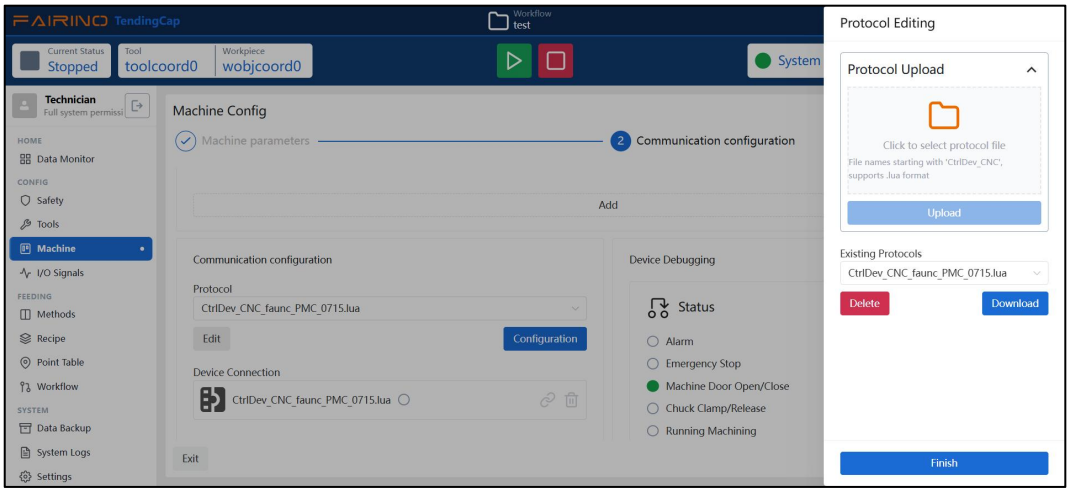


Figure 7.3-9 Communication method – FOCAS Protocol Editing

During equipment debugging, perform machine tool calibration operations and display real-time status feedback.

- Alarm: Gray circles indicate no alarm; green lights indicate an alarm.

- Emergency Stop: The gray circle indicates exiting emergency stop; the green light indicates entering emergency stop. Click the slider to adjust emergency stop settings.

- Machine tool opening/closing: A gray circle indicates the machine is closed, while a green light indicates it is open. Click the slider to adjust the machine's opening/closing settings.

- Chuck engagement/unengagement: The gray circle indicates the chuck is released, while the green light indicates it is engaged. Click the slider to adjust chuck engagement/unengagement.

- Processing Status: Gray circles indicate the machine tool has stopped processing; green lights indicate it is in operation. Click the slider to adjust the machine tool's processing settings.

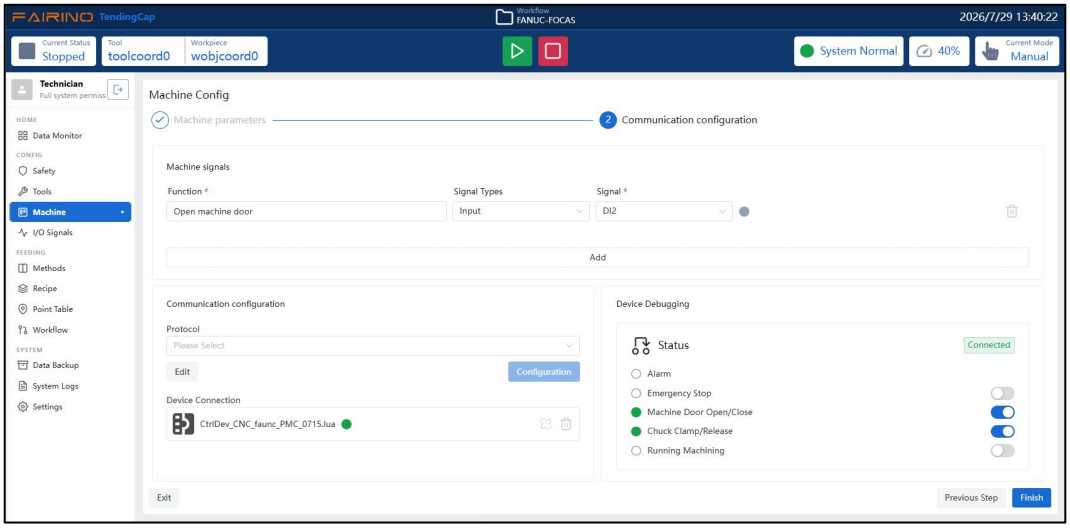


Figure 7.3-10 Communication method – FOCAS Protocol Device Debugging

7.3.1.3 SYNTEC Protocol

Displays the machine tool signals, communication configuration details for the new-generation protocol, and equipment debugging procedures. The communication configuration and debugging content are identical to those of FOCAS.

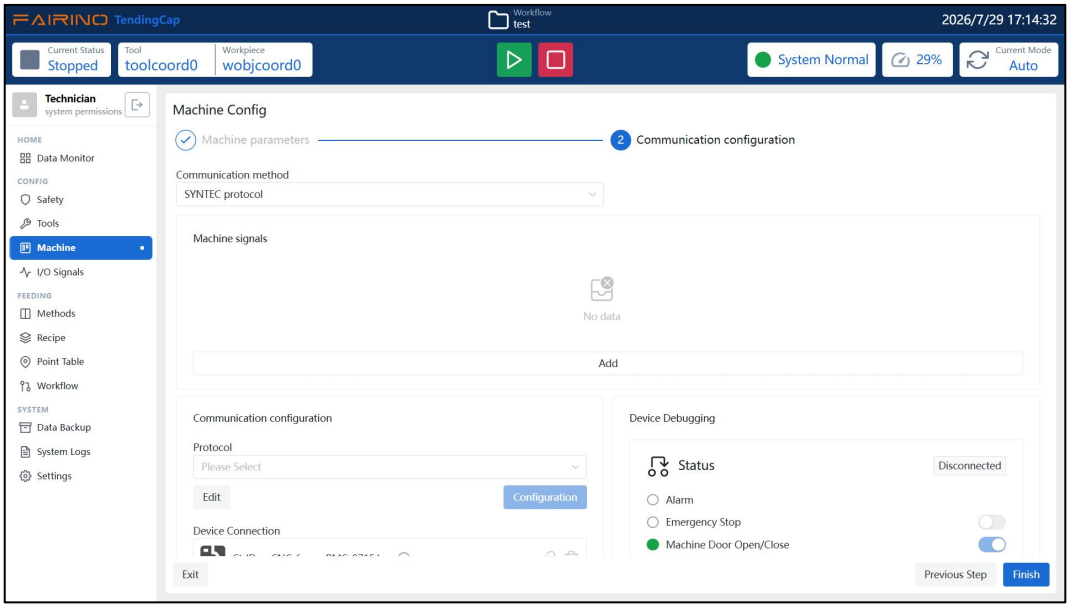


Figure 7.3-11 Communication method – SYNTEC Protocol

- Example Protocol：

```
1  -- CtrlDev_test_syntecCNC_0708.lua
2  -- SYNTEC system Modbus TCP communication control (based on the fairino Interaction
   Description.xls file, sequential addresses)
3  -- IP: 192.168.58.100    Port: 502 From Station Number: 100
4  --
5  -- Address Conversion: R Register → Modbus Holding Register
```

```
--    The 16-bit high value of RN = N*2; the 16-bit low value of RN = N*2+1
--    The signal value is written with the lower 16 bits and the upper 16 bits set to 0.

local id = 1
ModbusTCPMasterClose(id)
rtn = ModbusTCPMasterCreate('192.168.58.100', 502, 100, id)
CNCComSet(2, rtn, '192.168.58.100', 502)  -- Parameter 1: Machine Tool Manufacturer – 1. FANUC, 2. SYNTEC Parameter 2: Communication Status
SetCNCConfig(0,1,0,0) -- Open Protocol Options Have Taken Effect

-- Output array: 11 R values from R1100 to R1110 = 22 U16 values
local ctrlValues = {0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0}

-- Pulse Timer:  1. Clamp  2. Release  3. Position 1  4. Position 2  5. Feed completion  6. Reset  7. Stop  8. Start
local pulse_timers = {0, 0, 0, 0, 0, 0, 0, 0}
local PULSE_TICKS = 10  -- Number of pulse holding periods (10 × 100 ms = 1 second)

-- The last original signal value used for rising edge detection
local prev_run, prev_emerg, prev_chuck, prev_reset, prev_feed_pos, prev_feed_done = 0, 0, 0, 0, 0, 0

while(1) do

    ------------------------------------------------------------
    -- 1. Obtain the robot control signals (9 in total)  --  GetCNCCtrlState Return: Run, Emergency Stop, Door, Chopper, Reset, Feed Positioning
    --                                The spindle moves to enter the machine tool; feeding is complete.
    ------------------------------------------------------------
    local run, emerg, door, chuck, reset, feed_pos, spindle_jog, robot_enter, feed_done = GetCNCCtrlState(2)

    ------------------------------------------------------------
    -- 2. Pulse signal: Triggered by rising edge → Set to 1 and held → Automatically returns to 0
    --    Level Signal: Direct Transmission
    ------------------------------------------------------------

    -- R1100 Chuck engagement (Pulse: chuck 0→1 triggered)
    if chuck == 1 and prev_chuck == 0 then
        pulse_timers[1] = PULSE_TICKS
```

```
41      end
42      local clamp_close = (pulse_timers[1] > 0) and 1 or 0
43
44      -- R1101 Chuck released (Pulse: Chuck 1 → 0 triggered)
45      if chuck == 0 and prev_chuck == 1 then
46          pulse_timers[2] = PULSE_TICKS
47      end
48      local clamp_open = (pulse_timers[2] > 0) and 1 or 0
49
50      -- R1102 Feed Position 1 (Pulse: feed_pos → 1 triggered)
51      if feed_pos == 1 and prev_feed_pos ~= 1 then
52          pulse_timers[3] = PULSE_TICKS
53      end
54      local feed_pos1 = (pulse_timers[3] > 0) and 1 or 0
55
56      -- R1103 Feed Position 2 (Pulse: feed_pos → 2 triggered)
57      if feed_pos == 2 and prev_feed_pos ~= 2 then
58          pulse_timers[4] = PULSE_TICKS
59      end
60      local feed_pos2 = (pulse_timers[4] > 0) and 1 or 0
61
62      -- R1104 Feed completed (Pulse: feed.done 0→1 triggered)
63      if feed_done == 1 and prev_feed_done == 0 then
64          pulse_timers[5] = PULSE_TICKS
65      end
66      local feed_done_set = (pulse_timers[5] > 0) and 1 or 0
67
68      -- R1107 Machine Tool Reset (Pulse: Reset from 0 to 1 triggered)
69      if reset == 1 and prev_reset == 0 then
70          pulse_timers[6] = PULSE_TICKS
71      end
72      local cnc_reset = (pulse_timers[6] > 0) and 1 or 0
73
74      -- R1109 Process Stop (Pulse: triggered by run 1→0)
75      if run == 0 and prev_run == 1 then
76          pulse_timers[7] = PULSE_TICKS
77      end
78      local stop_proc = (pulse_timers[7] > 0) and 1 or 0
79
80      -- R1110 Processing initiation (Pulse: triggered by run 0→1)
81      if run == 1 and prev_run == 0 then
82          pulse_timers[8] = PULSE_TICKS
```

```
83      end
84      local start_proc = (pulse_timers[8] > 0) and 1 or 0
85
86      -- Level signal (direct transmission)
87      -- R1105: Main spindle movement; R1106: Entry into the machine tool; R1108:
    Emergency stop of the machine tool.
88
89      ----------------------------------------------------------------
90      -- 3. Write to Modbus TCP (Function Code 0x10, Base Address 2200,22 U16 bits)
91      --      R1100~R1110 = Modbus addresses 2200~2221
92      --      When an exception occurs, Modbus TCP Master Set Hold Registers returns the
    error string.
93      ----------------------------------------------------------------
94      ctrlValues[1]  = 0;  ctrlValues[2]  = clamp_close     -- R1100
95      ctrlValues[3]  = 0;  ctrlValues[4]  = clamp_open      -- R1101
96      ctrlValues[5]  = 0;  ctrlValues[6]  = feed_pos1       -- R1102
97      ctrlValues[7]  = 0;  ctrlValues[8]  = feed_pos2       -- R1103
98      ctrlValues[9]  = 0;  ctrlValues[10] = feed_done_set -- R1104
99      ctrlValues[11] = 0;  ctrlValues[12] = spindle_jog     -- R1105 electrical level
100ctrlValues[13] = 0;  ctrlValues[14] = robot_enter     -- R1106 electrical level
101ctrlValues[15] = 0;  ctrlValues[16] = cnc_reset       -- R1107
102ctrlValues[17] = 0;  ctrlValues[18] = (emerg == 1) and 0 or 1   -- R1108 Emergency stop
    (anti-logic: No emergency stop → 0; Emergency stop → 1)
103ctrlValues[19] = 0;  ctrlValues[20] = stop_proc       -- R1109
104ctrlValues[21] = 0;  ctrlValues[22] = start_proc      -- R1110
105
106local wret = ModbusTCPMasterSetHoldRegs(id, 2200, 22, ctrlValues, "U16")
107local comm_err = 0
108     if type(wret) == "string" then
109          comm_err = 1
110     end
111
112     ----------------------------------------------------------------
113     -- 4. Read the machine tool status (CNC → Robot)
114     --      Base address 6220,18 U16 fields (each R value occupies 2 bytes: high byte + low
    byte)
115     --      The signal value is at the low bit (odd address).
116     --      The first return value in an exception is the error string.
117     --
118     --    Modbus Address with Subscript R Register Signal
119     --    6220 High/6221 Low      v1/v2      R3110      Clamping Feedback
120     --    6222 High/6223 Low      v3/v4      R3111      Clamp release feedback
```

```
-- 6224 High/6225 Low v5/v6 R3112 Main spindle positioning completed
-- 6226 High/6227 Low v7/v8 R3113 Main spindle positioning completed
-- 6228 High/6229 Low v9/v10 R3114 Request Shipping Feedback (1 = Allow Shipping)
-- 6230 High/6231 Low v11/v12 R3115 Machine Tool Alarm Feedback
-- 6232 High/6233 Low v13/v14 R3116 Safety Screen Feedback
-- 6234 High/6235 Low v15/v16 R3117 Door opening completion feedback
-- 6236 High/6237 Low v17/v18 R3118 Operation Status: 1 = Running; 2/0 =Stopped; 3 = Emergency Stop
----------------------------------------------------------------------
local v1,  v2,  v3,  v4,  v5,  v6,  v7,  v8,
      v9,  v10, v11, v12, v13, v14, v15, v16,
      v17, v18 = ModbusTCPMasterGetHoldRegs(id, 6220, 18, "U16")

if type(v1) == "string" then
    -- Communication error: all statuses set to 0
    v1,  v2,  v3,  v4,  v5,  v6,  v7,  v8,
    v9,  v10, v11, v12, v13, v14, v15, v16,
    v17, v18 = 0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
    comm_err = 1
end

local clamp_fb_close = v2    -- R3110 Low: Card clamping feedback
local clamp_fb_open  = v4    -- R3111 Low: Card release feedback
local spindle_pos1   = v6    -- R3112 Low: Spindle positioning 1 completed
local spindle_pos2   = v8    -- R3113 Low: Spindle positioning 2 completed
local feed_request   = v10   -- R3114 Low: Request shipping feedback (1 = Allow shipping)
local cnc_alarm      = v12   -- R3115 Low: Machine tool alarm feedback
local safety_curtain = v14   -- R3116 Low: Safety Light Screen Feedback
local door_open_fb   = v16   -- R3117 Low: Door opening feedback
local run_state      = v18   -- R3118 Low: Operation Status  1 = Running  2/0 =Stopped  3 = Emergency Stop

-- Spindle Angle Status: Bit 0 = Positioning 1 completed; Bit 1 = Positioning 2 completed
local spindle_angle = spindle_pos1 + spindle_pos2 * 2

```

```
154     -- Clamping status: 1 = Clamped, 0 = Released (A clamp feedback value of 1 indicates the clamp is engaged)
155     local chuck_state = clamp_fb_close
156
157     ----------------------------------------------------------------
158     -- 5. Report to Robot
159     --      SetCNCStatus(Communication status, Operating status, Door status, Chucks status, --Spindle angle status, Machine tool alarm, Safety light screen, --Feed allowed, Reserve 1, Reserve 2, Reserve 3, Reserve 4)
160     ----------------------------------------------------------------
161     SetCNCStatus(comm_err,          -- 0 = Normal communication; 1 = Fault
162                  run_state,         -- 1 = Run 2 = Stop 3 = Emergency Stop
163                  door_open_fb,      -- The door is open properly.
164                  chuck_state,       -- 1 = Clamped | 0 = Released
165                  spindle_angle,     -- bit0 = Position 1    bit1 = Position 2
166                  cnc_alarm,         -- Machine Tool Alarm
167                  safety_curtain,    -- Safety Screen
168                  feed_request,      -- Allow shipping
169                  0,                 -- obligate 1
170                  0,                 -- obligate 2
171                  0,                 -- obligate 3
172                  0)                 -- obligate 4
173
174     ----------------------------------------------------------------
175     -- 6. The pulse timer decrements and saves the previous signal value (for rising edge detection in the next cycle).
176     ----------------------------------------------------------------
177     for i = 1, 8 do
178         if pulse_timers[i] > 0 then
179             pulse_timers[i] = pulse_timers[i] - 1
180         end
181     end
182
183     prev_run      = run
184     prev_emerg    = emerg
185     prev_chuck    = chuck
186     prev_reset    = reset
187     prev_feed_pos = feed_pos
188     prev_feed_done = feed_done
189
190     ----------------------------------------------------------------
191     -- 7. Connect Check and Exit
```

```
192     ----------------------------------------------------------------
193     CNCCheckDisConnect()
194     local stopFlag = GetOpenLUAStopFlag(id)
195     if(stopFlag ~= 0) then
196         ModbusTCPMasterClose(id)
197             SetCNCStatus(0,           -- 0 = Normal communication; 1 = Fault
198                 0,          -- 1 = Run 2 = Stop 3 = Emergency Stop
199                 0,      -- The door is open properly.
200                 0,       -- 1 = Clamped | 0 = Released
201                 0,    -- bit0 = Position 1     bit1 = Position 2
202                 0,          -- Machine Tool Alarm
203                 0,   -- Safety Screen
204                 0,     -- Allow shipping
205                 0,                  -- obligate 1
206                 0,                  -- obligate 2
207                 0,                  -- obligate 3
208                 0)                  -- obligate 4
209
210         break
211     end
212
213     sleep_ms(100)
214end
```

- Analysis of the new generation of CNC open protocols:

The new-generation CNC Open Protocol primarily consists of three components.

① **Establish a communication connection.** Specify the protocol ID (the number set when loading an open protocol must match that in the protocol file), CNC IP address, port number, and other parameters, then use the "Modbus TCP Master Create()" command to establish a Modbus TCP connection between the robot and the new-generation CNC system.

②**Write control data to the CNC in a cyclic manner.** When executing the CNC Open Protocol, the system first reads the current CNC control data from the robot controller's internal memory, then packages and writes this data to command the CNC-controlled machine tool. The return value of the GetCNCCtrlState() instruction for reading CNC control data is defined in Table 4.3.1-1; control data can be parsed based on CNC register specifications, and subsequently written in batches to registers R1100 – R1110 via Modbus TCP.

Table 7.3.1-1 GetCNCCtrlState () returned value

Order	Type	Name	Description
1	uint16_t	run	Operation control: 0 – Stop processing; 1 – Start processing (pulse signal, maintained for 1 second)
2	uint16_t	emerg	Emergency stop control: 1 – No emergency stop (safe); 0 – Trigger emergency stop
3	uint16_t	door	Door control: 0 – Close door; 1 – Open door
4	uint16_t	chuck	Chuck control: 1 – Clamping (triggers R1100 pulse); 0 – Releasing (triggers R1101 pulse)
5	uint16_t	reset	Machine tool reset: 0 – No reset; 1 – Reset (pulse signal, maintained for 1 second)
6	uint16_t	feed_pos	Transportation location selection: 1 – Location 1 (pulse R1102); 2 – Location 2 (pulse R1103)
7	uint16_t	spindle_jog	Main axis incremental movement: 0 – Stop; 1 – Incremental rotation (level signal)
8	uint16_t	robot_enter	Enter the machine tool: 0 – Not entered; 1 – Robot has entered the machine tool (level signal)
9	uint16_t	feed_done	Delivery completed; 0 – Not completed; 1 – Delivery completed (pulse signal, maintained for 1 second)

③**Read status data from the CNC in a loop.** The CNC Open Protocol first reads real-time status data (R3110 – R3118) from the CNC via Modbus TCP, then writes the relevant data to the robot controller, enabling the robot to monitor the

CNC's real-time status. The protocol defines the CNC status interface parameter SetCNCStatus() as shown in the table below.

Table 7.3.1-2 SetCNCStatus () Detailed Parameters

Order	Type	Name	Description
1	uint16_t	comm_err	Communication status: 0 – Normal communication; 1 – Communication failure
2	uint16_t	run_state	Operation status: 1 – Running; 2/0 – Stopped; 3 – Emergency stop
3	uint16_t	door_open_fb	Door opening status feedback: 1-Door fully open; 0-Door not fully open
4	uint16_t	chuck_state	Chuck status: 1-Clamped; 0-Released
5	uint16_t	spindle_angle	Spindle angle status (reserved): bit0 – Position 1 completed; bit1 – Position 2 completed
6	uint16_t	cnc_alarm	Machine tool alarm; 1 – Machine tool fault; 0 – No fault
7	uint16_t	safety_curtain	Safety light curtain (reserved); 1 – Light curtain activated; 0 – Light curtain normal
8	uint16_t	feed_request	Allow shipping: 1-Allow; 0-Do not allow
9	uint16_t	reserved1	obligate 1
10	uint16_t	reserved2	obligate 2
11	uint16_t	reserved3	obligate 3
12	uint16_t	reserved4	obligate 4

7.4 I/O Signals

Configure user-defined I/O functions and status indicators in Configuration> Functional Signals. Upon entering the page, retrieve the list of functional signals. If no data is available, display "No Data".

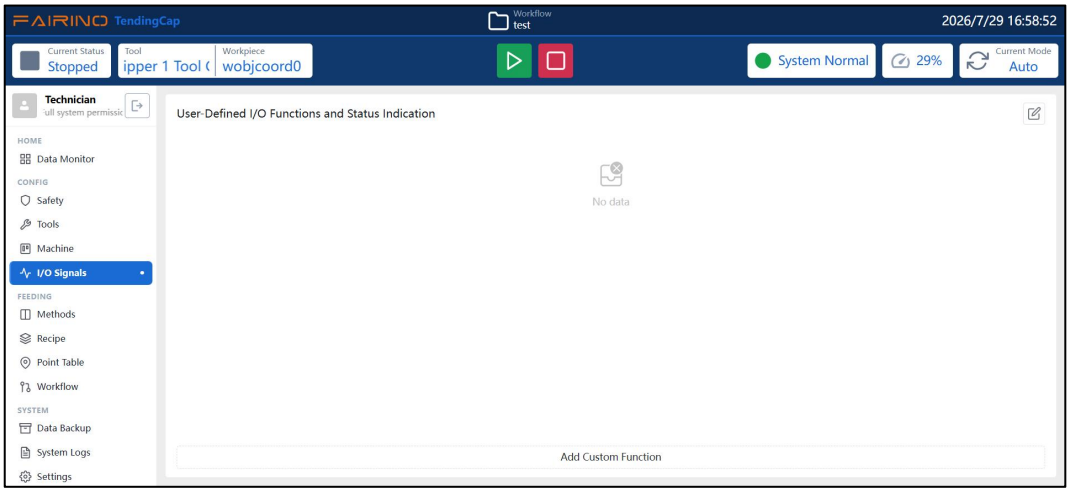


Figure 7.4-1 No data available for function signals

Click the Add Custom Function button at the bottom. A drawer will appear on the right. Enter a name, select the signal type and signal, then click Add at the bottom to complete configuration. Name and signal are required; otherwise, an error message will appear. Once added, the data in the list cannot be modified by default.

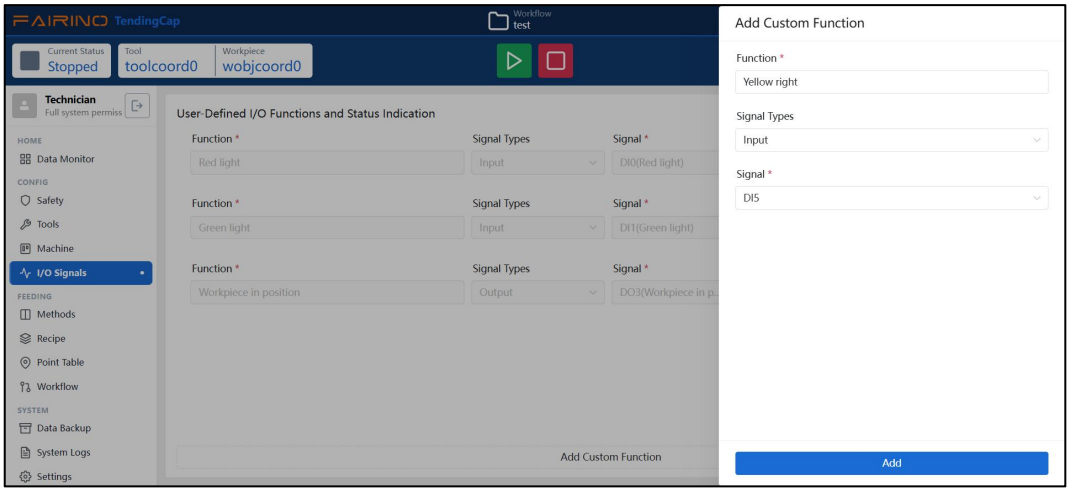


Figure 7.4-2 Add Function Signal

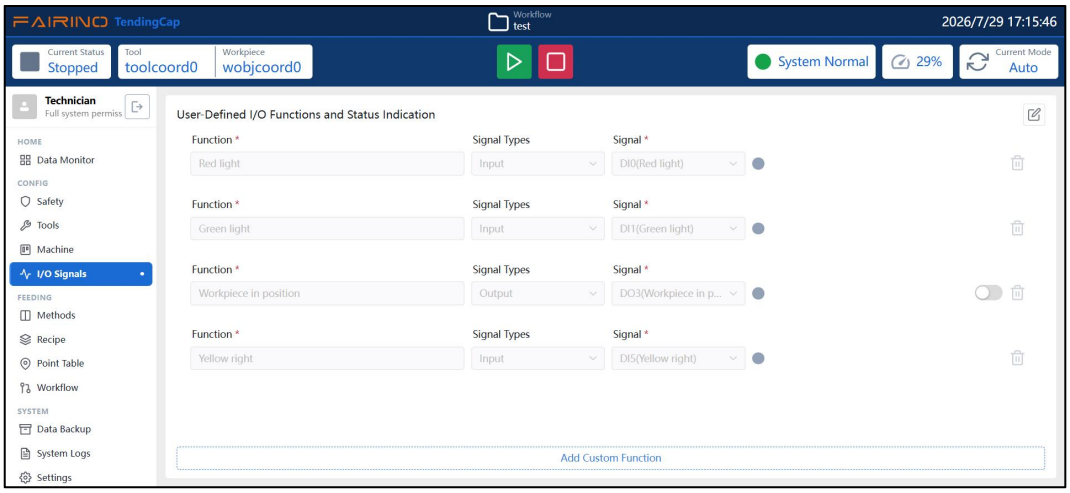


Figure 7.4-3 Function Signal List

Click the "Edit" icon in the upper-right corner to enter editing mode, where you can modify functional signal data. You may also use the slider to test signal reception on the interface; when connected and activated, a green light will illuminate after configuration. At the end of each data entry, click the "Delete" button to display a secondary confirmation prompt for "Delete Functional Signal"; confirm to delete.

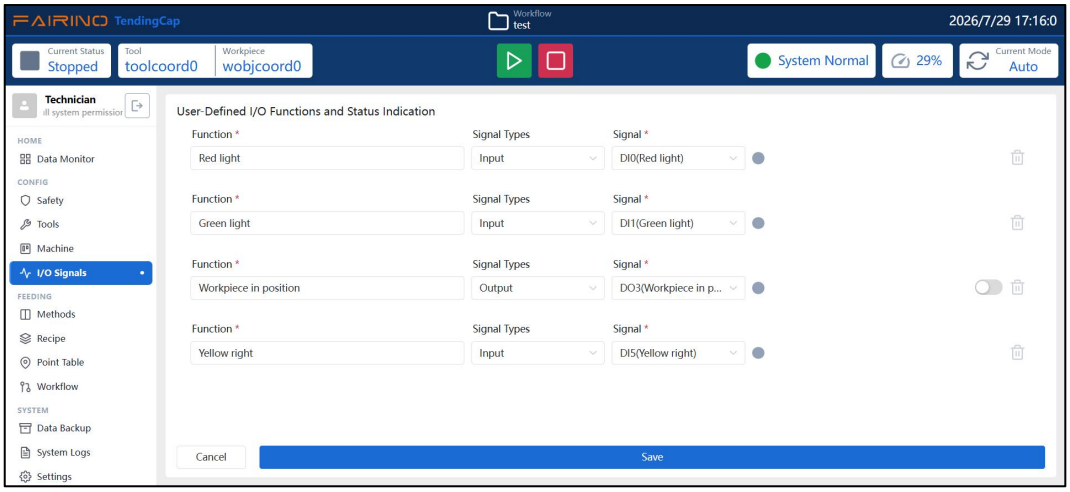


Figure 7.4-4 Function Signature List Editing Status

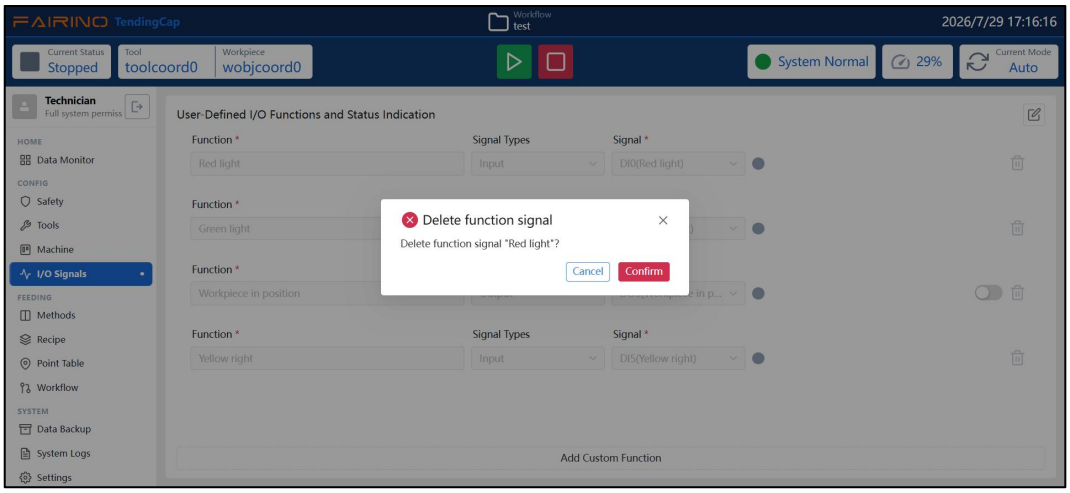


Figure 7.4-5 Delete functional signal data

8 Feeding

8.1 Methods

There are two material loading methods: tray and conveyor belt. After entering the interface, retrieve data for both methods; if no data is available, display "No parameters". Click the add cards at the bottom of each method to enter data.

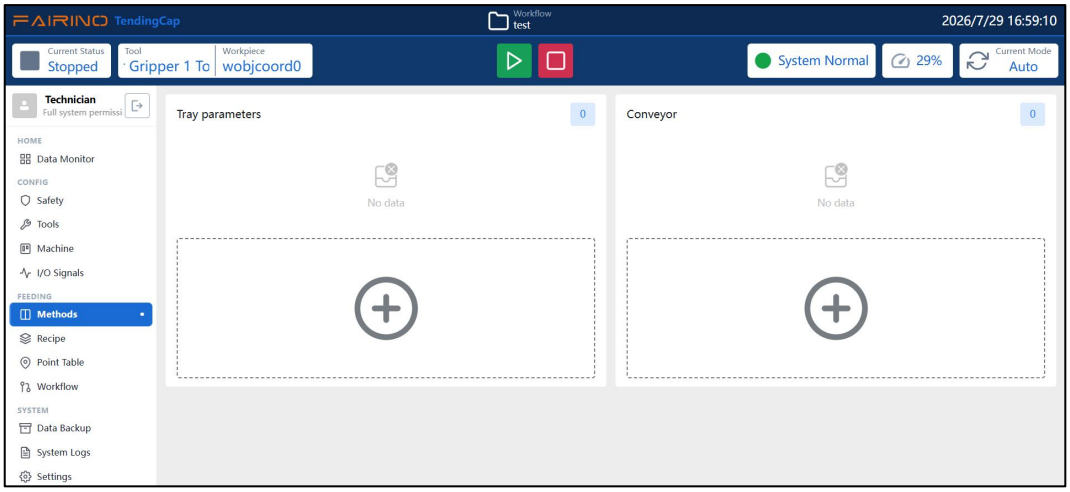


Figure 8.1-1 No data available for this method

8.1.1 Tray

The material tray configuration consists of three steps, as described below.

- Material tray parameters: Enter a name based on functional requirements; if

the name field is empty, clicking "Next" will display the message "Name cannot be empty." Select a tool, and clicking "Next" will apply the corresponding tool coordinate system, ensuring that teaching points align with the current tool coordinate system when setting tray positions. Choose whether to use extended axes; configuration for extended axis functionality requires setup and connection in the Web App. If extended axes are selected, their connection status, IP address, and port number will be displayed.

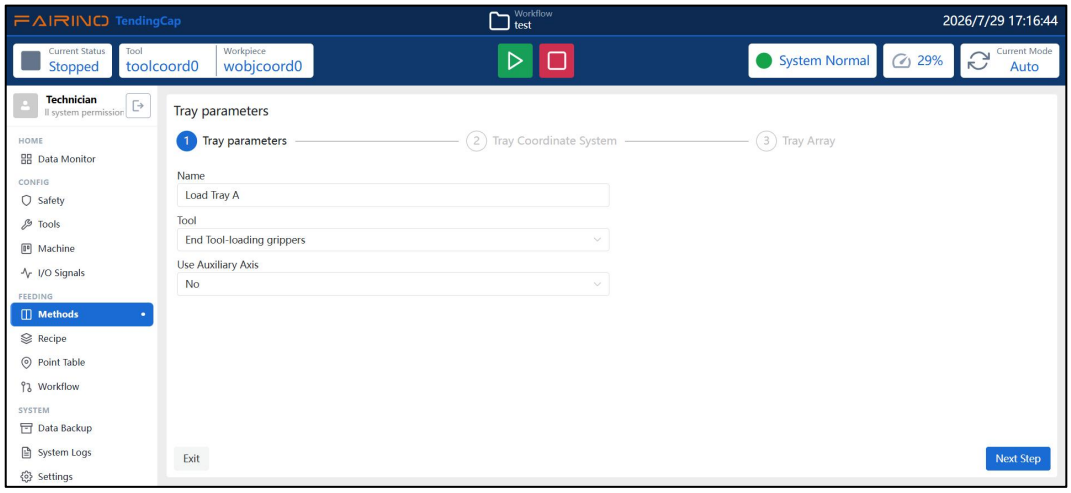


Figure 8.1-2 Material Plate Parameters

- Workpiece coordinate system: Select the workpiece coordinate system and rename or automatically calibrate it.

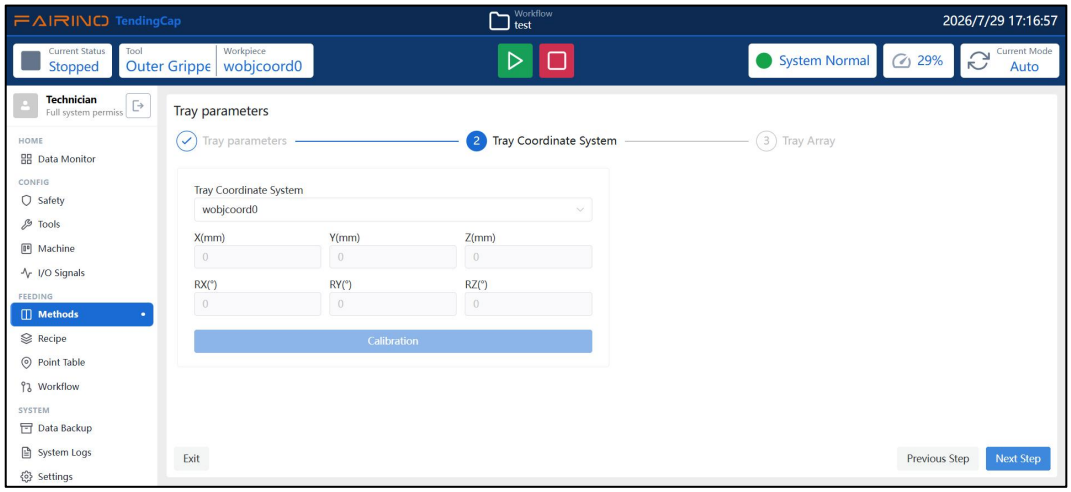


Figure 8.1-3 Material Plate Coordinate System

- Material Disk Array: Configure the number of rows, columns, layers, layer height (unit: mm), transition point offsets (X, Y, Z), and motion path settings — including point teaching using the three-point method. Click the "Complete" button to

finish adding the array.

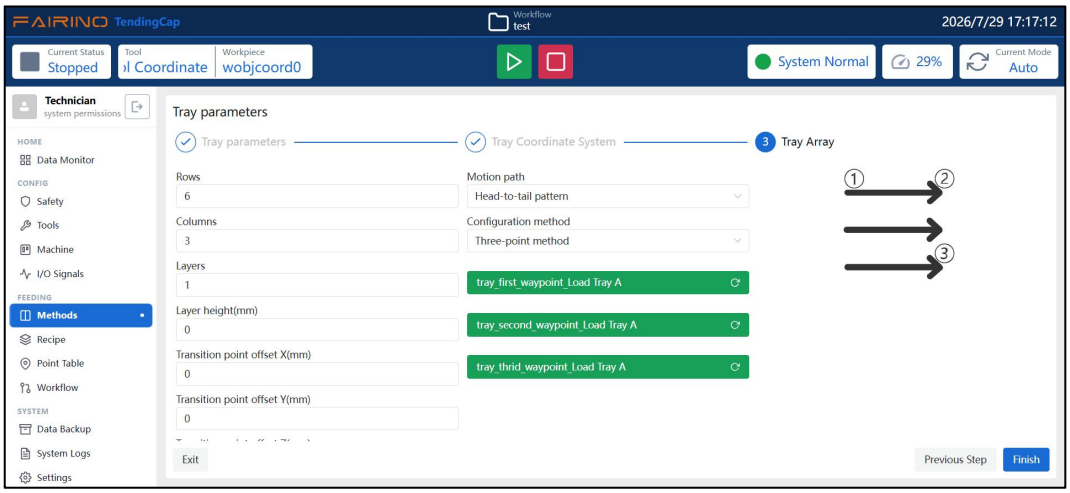


Figure 8.1-4 Material Disk Array

The movement paths are categorized into the head-to-tail walking method and the bow-shaped walking method, as detailed below.

Step-by-step progression: From left to right, complete the first row and return to the left starting point; then repeat for the second row; continue this pattern for the third row, until full coverage is achieved.

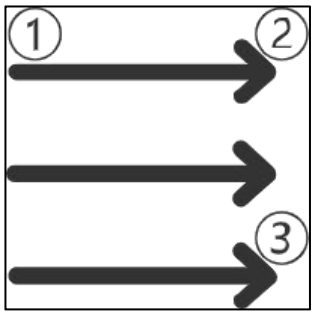


Figure 8.1-5 From start to finish, the walking pattern remains consistent.

Bow-shaped progression: Complete the first row from left to right, then move vertically downward. Next, complete the second row from right to left. Then move vertically downward again, and complete the third row from left to right until the area is fully covered.

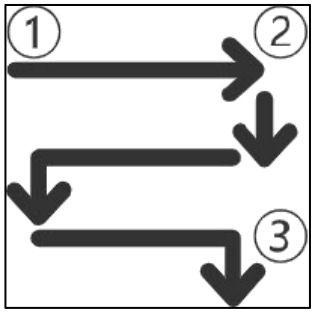


Figure 8.1-6 Arch-shaped movement pattern

After successful addition, the homepage displays configured material trays. Click the "Edit" button in the upper-right corner of each tray configuration card to view or modify details. Click the "Delete" button in the upper-right corner to confirm deletion; click OK to remove the tray.

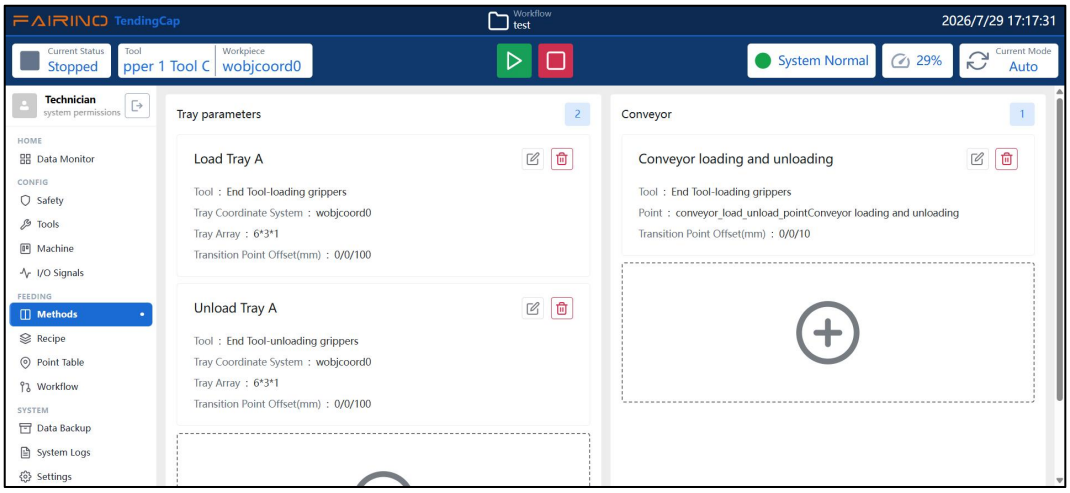


Figure 8.1-7 Tray List

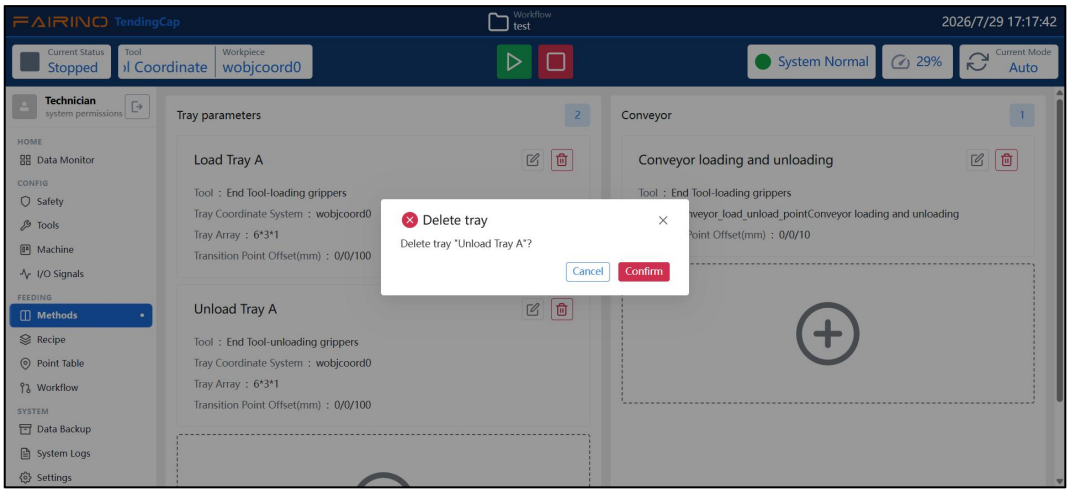


Figure 8.1-8 Secondary confirmation required to delete the material list

After modifying tools and workpieces in the editing interface, you must re-teach

the matrix material inventory positions; otherwise, the changes cannot be completed. When clicking the Complete button, the system will verify whether the tool and workpiece coordinate systems match the matrix points. If they do not match, a prompt will appear: "The parameter point coordinate system has changed. Confirm consistency before completing configuration."

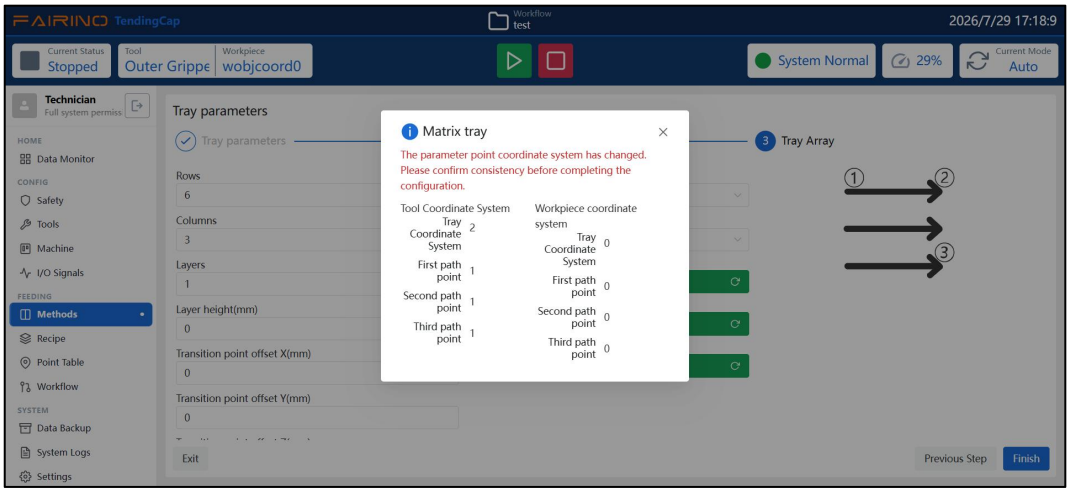


Figure 8.1-9 Warning: The coordinate system for the inventory location has changed

8.1.1.1 Workpiece Coordinate System Calibration

Select a non-default workpiece coordinate system, fix the workpiece position, and choose either the calibration method "Origin-X-Axis-Z-Axis" or "Origin-X-Axis-XY+Plane". The first two points are identical for both methods; only the third point differs: the first method calibrates the Z-axis of the workpiece coordinate system, while the second method calibrates a point on the XY+ plane. Perform calibration as shown in the diagram. After completing the point teaching, click the Calculate button to compute the workpiece pose; upon obtaining the result, click Apply to finalize the calibration.

Important:

- The workpiece coordinate system is calibrated based on the tool coordinate system and must be established upon the existing tool coordinate system.
- The default workpiece coordinate system cannot be calibrated. When selecting a non-default workpiece coordinate system, click the Calibrate button to automatically apply the default system.

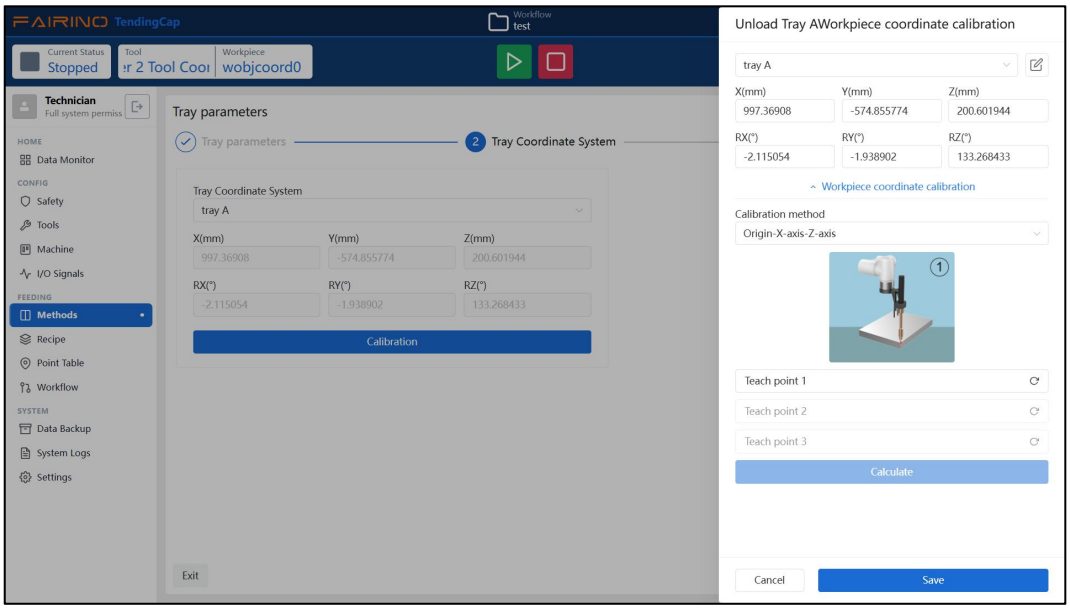


Figure 8.1-10 Material tray coordinate system reference point 1

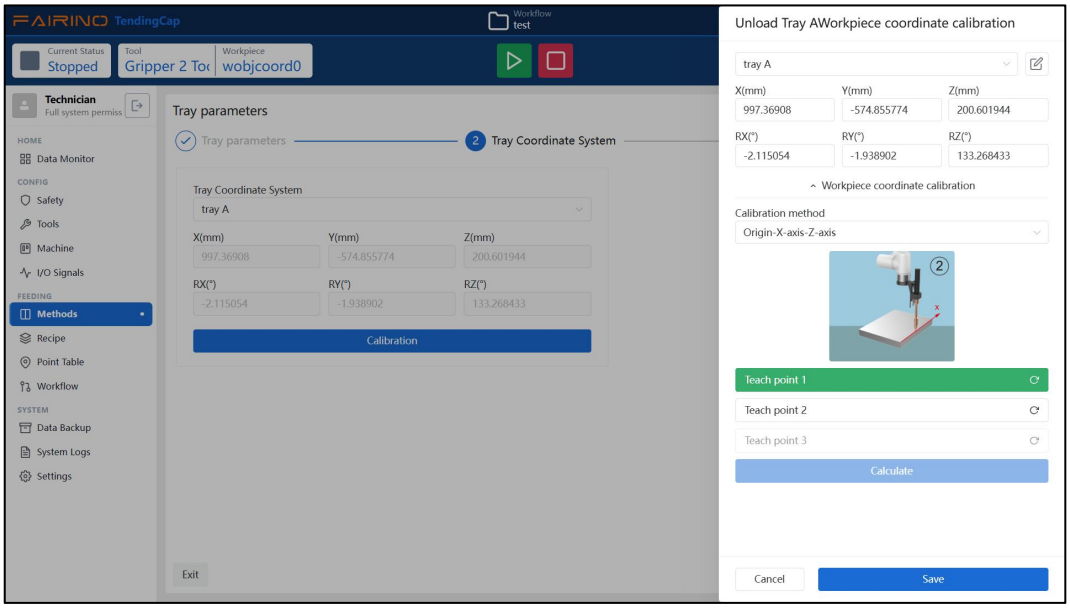


Figure 8.1-11 Material Plate Coordinate System Reference Point 2

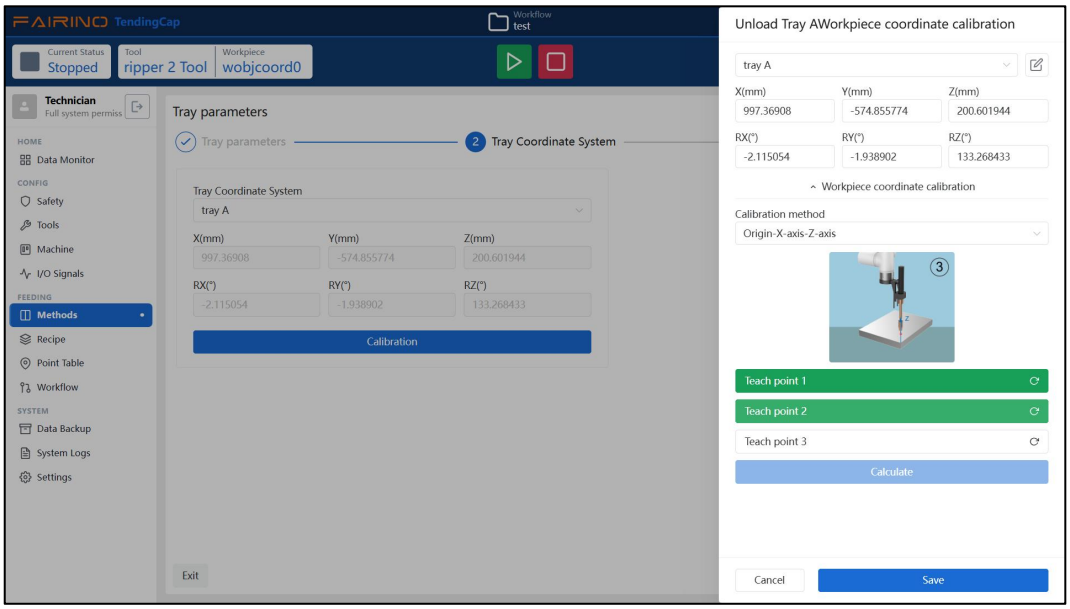


Figure 8.1-12 Material tray coordinate system calibration: Origin – X-axis – Z-axis point 3

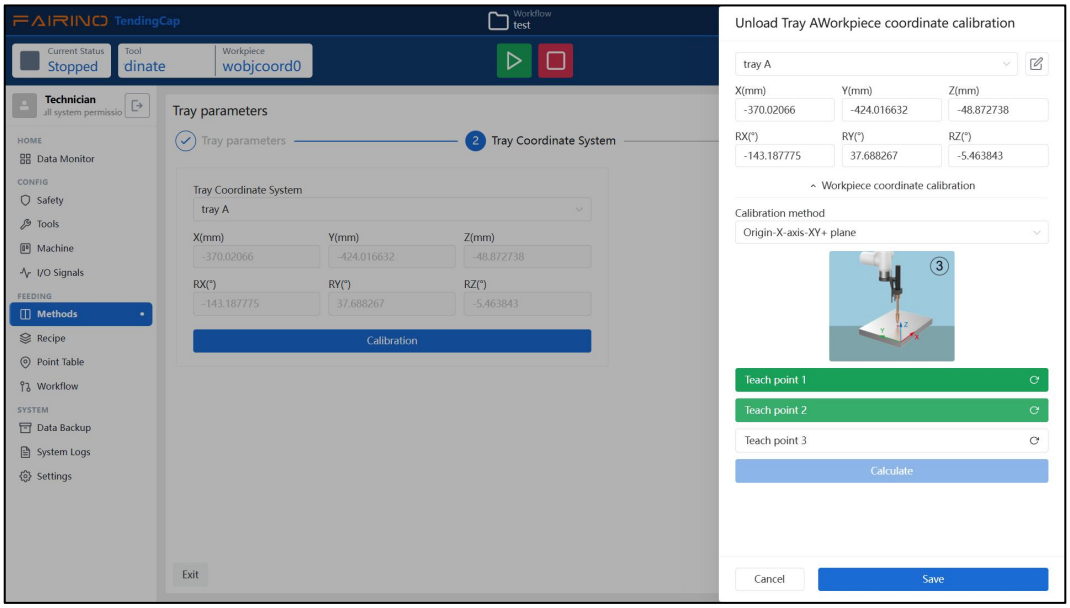


Figure 8.1-13 Material tray coordinate system calibration: Origin – X-axis – XY+ plane point 3

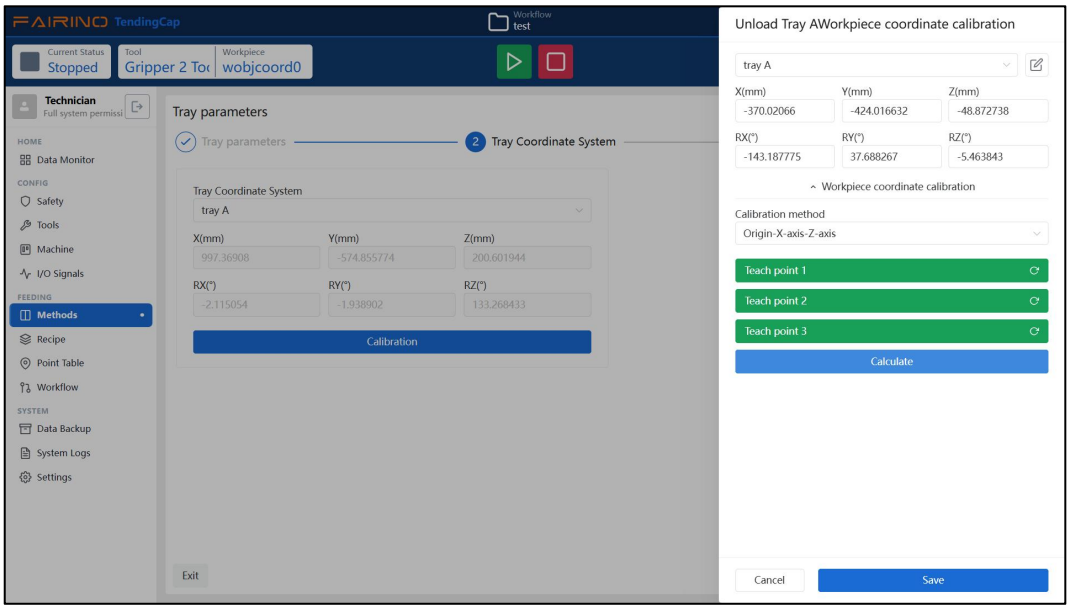


Figure 8.1-14 Results of the material tray coordinate system calibration

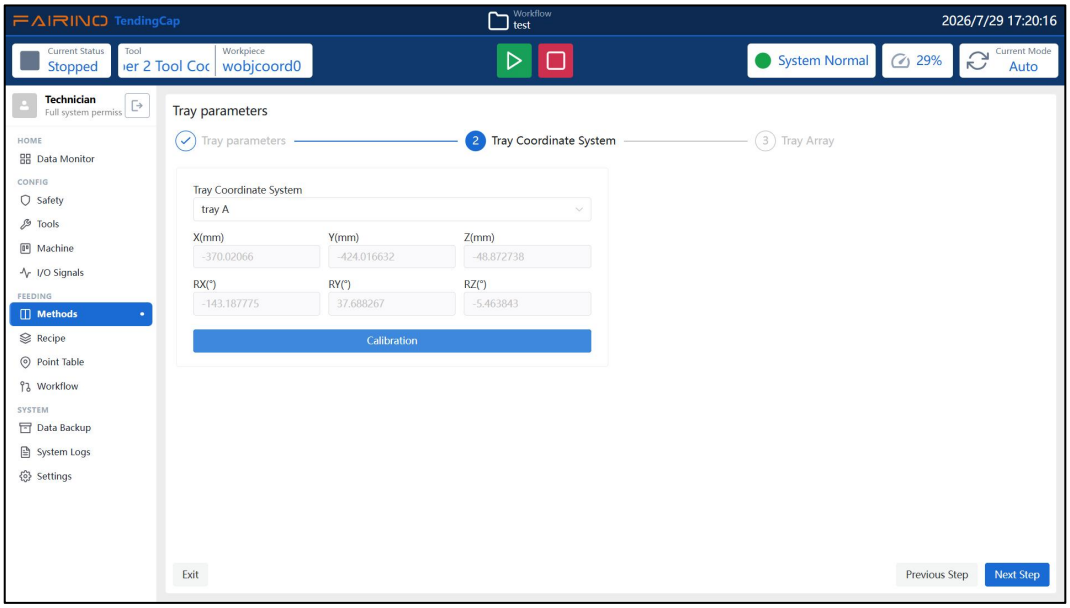


Figure 8.1-15 Material tray coordinate system calibration results saved

8.1.2 Conveyor

The conveyor belt configuration consists of two steps, as described below.

- Conveyor belt parameters: Enter a name based on functional requirements. If the name field is empty, click Next to see the prompt "Name cannot be empty." Select a tool; clicking Next will apply the corresponding tool coordinate system. This ensures that when setting loading/unloading points for the conveyor belt, the teaching points align with the current tool coordinate system.

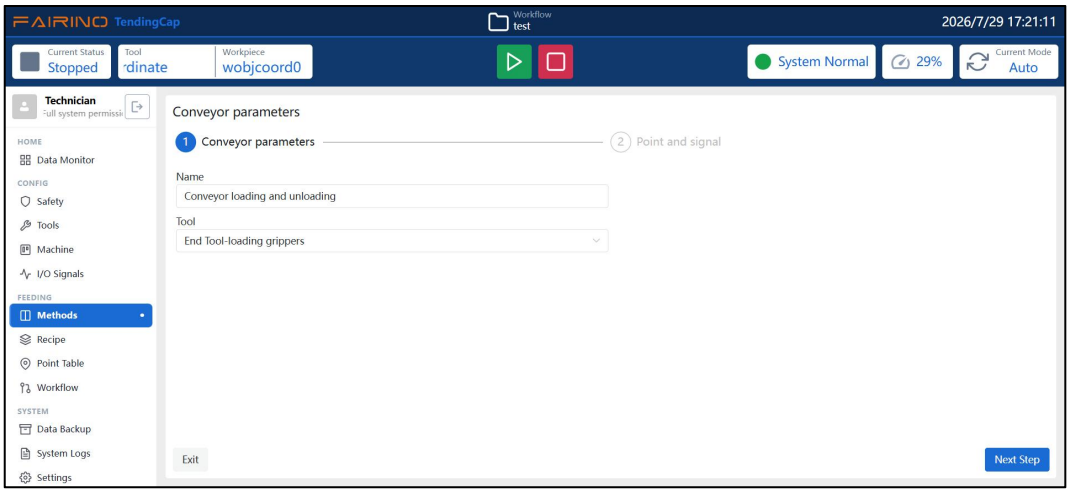


Figure 8.1-16 Conveyor Belt Parameters

- Position and Signals: Click the "Set Loading/Unloading Positions" button to teach the current robot pose as the conveyor belt loading/unloading position data, then enter the transition point offsets (X, Y, and Z). Signals may not need to be configured; if you wish to add one, click the "Add Conveyor Belt Signal" drawer on the right. By default, only input signal types are available. After entering the function and signal details, click Add to complete the addition. Finally, click Add to finalize the new conveyor belt configuration.

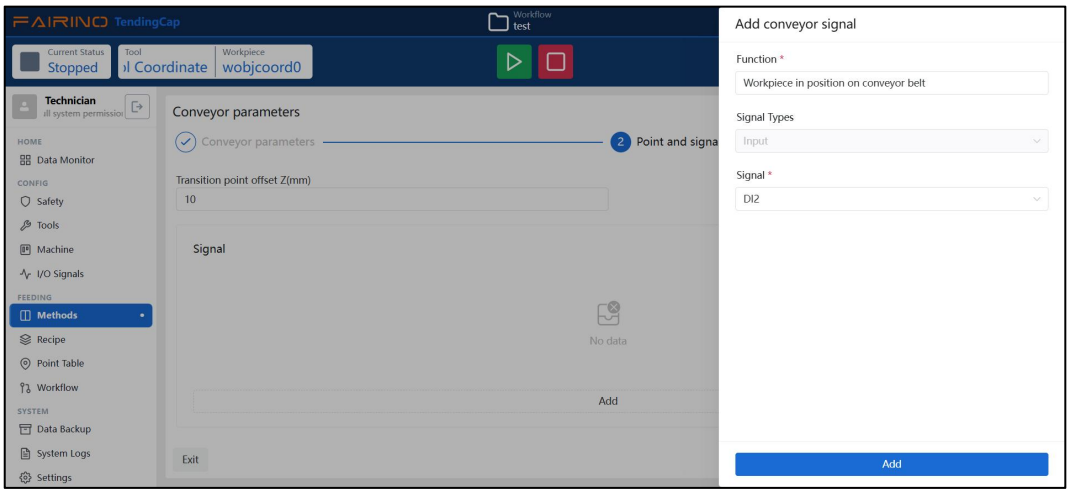


Figure 8.1-17 Signal Addition

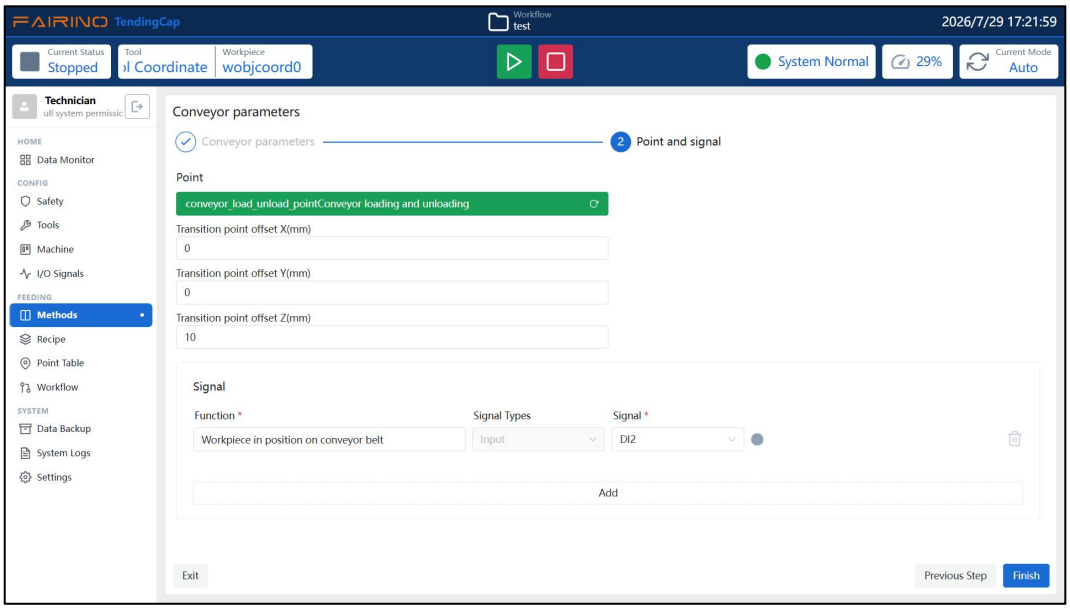


Figure 8.1-18 Point Location and Signal

After successful addition, the homepage displays configured conveyor belts. Click the "Edit" button in the upper-right corner of the conveyor belt configuration card to view or modify details. Click the "Delete" button in the upper-right corner to display a secondary confirmation for "Delete Conveyor Belt"; click confirm to delete.

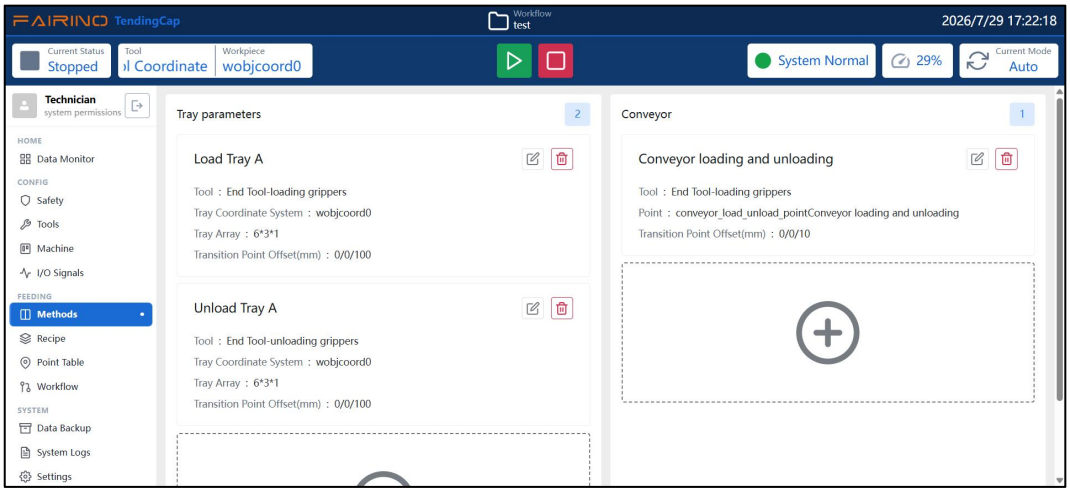


Figure 8.1-19 Conveyor Belt List

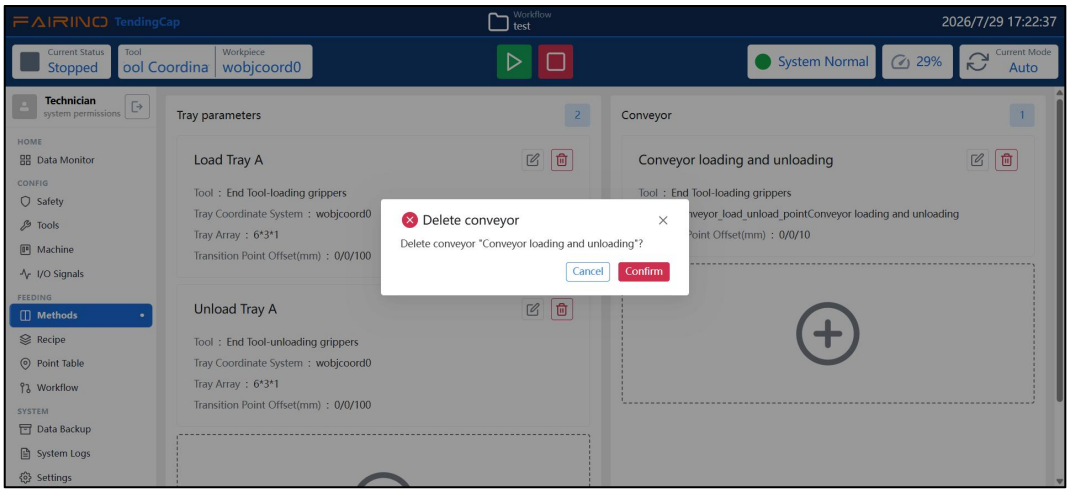


Figure 8.1-20 Delete secondary confirmation for the conveyor belt

After entering the editing interface to modify the tool, you must re-configure the conveyor belt loading/unloading points; otherwise, the modification cannot be completed. When clicking the Complete button, the system will verify whether the tool matches the conveyor belt loading/unloading points. If they do not match, a prompt will appear: "The parameter point coordinate system has changed. Confirm consistency before completing configuration."

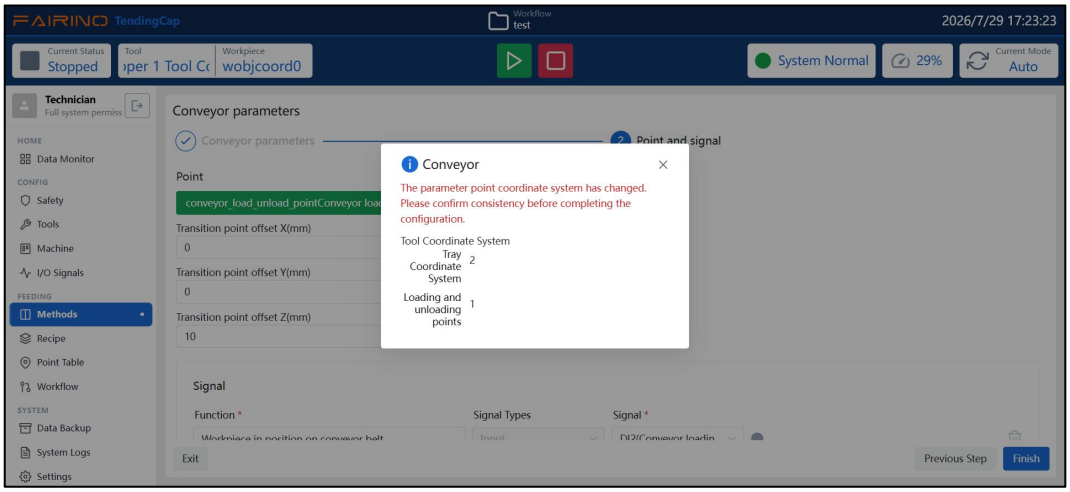


Figure 8.1-21 Warning: The coordinate system for the conveyor belt location has changed

8.2 Recipe

Configure the recipe in the "Material Loading – Recipe" section. Upon entering the page, retrieve recipe list data. If no data is available, display "No Data".

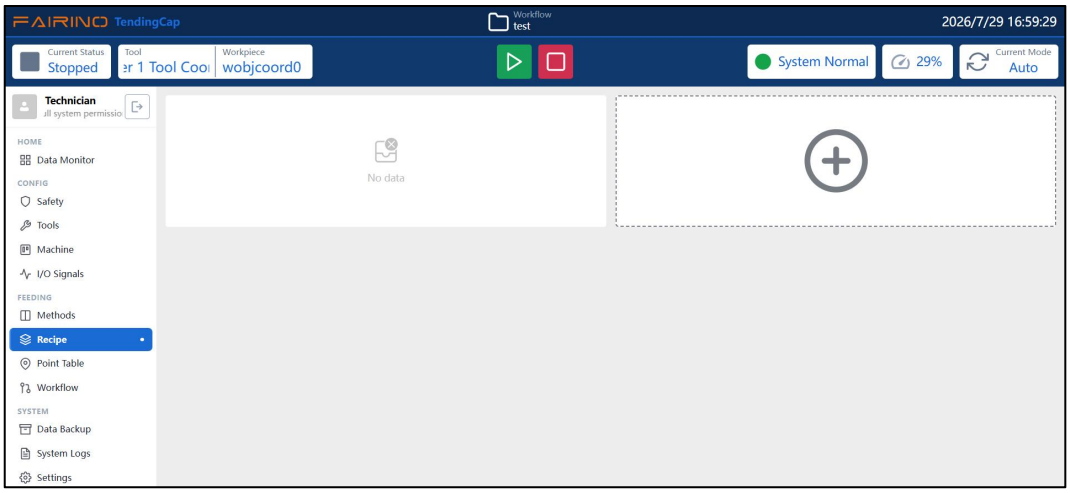


Figure 8.2-1 No formula data available

Click the Add tab to create a recipe in four steps, as follows.

- Formula Parameters: Enter the formula name as required. If the name field is empty, click "Next" to see the prompt "Name cannot be empty." Select the operation mode based on your loading/unloading scenario—loading/unloading, loading only, or unloading only. Choose whether to use an extended axis; configuration for extended axis functionality requires setup and connection in the Web App. After confirming usage, the extended axis's connection status, IP address, and port will be displayed.

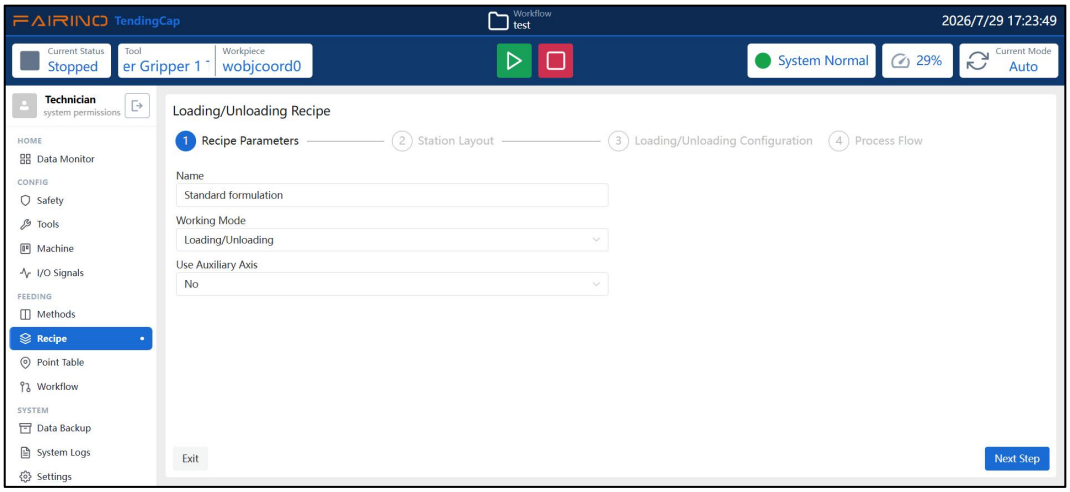


Figure 8.2-2 Formula Parameters

- Process Layout: Select machine and loading/unloading methods ("material trays" and "transfer belts").

Important：

➢ When no machine tool is selected, click the Next button to display the message "Configure at least one machine tool".

➢ When the operation mode in the formula parameters is set to loading/unloading mode, both loading and unloading methods are displayed. If only loading is selected, only the loading method is shown; if only unloading is selected, only the unloading method is displayed.

➢ The selection of loading/unloading method determines the configuration and process steps. Select the appropriate method based on your requirements.

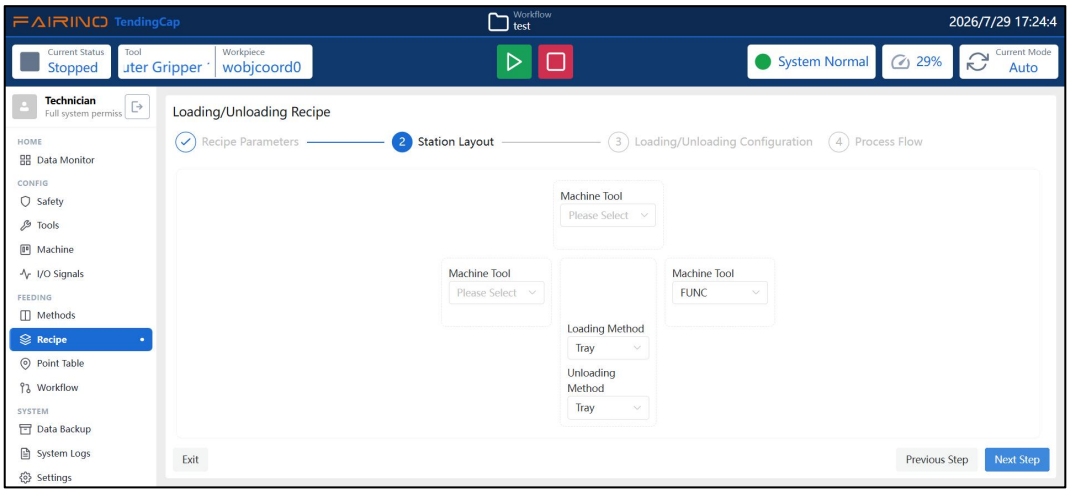


Figure 8.2-3 process layout

● Material loading configuration: Displays the corresponding loading details based on the operational mode of the formula parameters and the material handling method in the process layout. The combination scenarios are as follows:

➢ Working mode: Load/Unload — Loading from tray, Unloading to tray.

➢ Working mode: Load/Unload — Loading from tray, Unloading to conveyor.

➢ Working mode: Load/Unload — Loading from conveyor, Unloading to conveyor.

➢ Working mode: Load/Unload — Loading from conveyor, Unloading to tray.

➢ Working mode: Load only— Loading from tray.

➢ Working mode: Load only— Loading from conveyor.

➢ Working mode: Unload only— Unloading to tray.

➢ Working mode: Unload only— Unloading to conveyor.

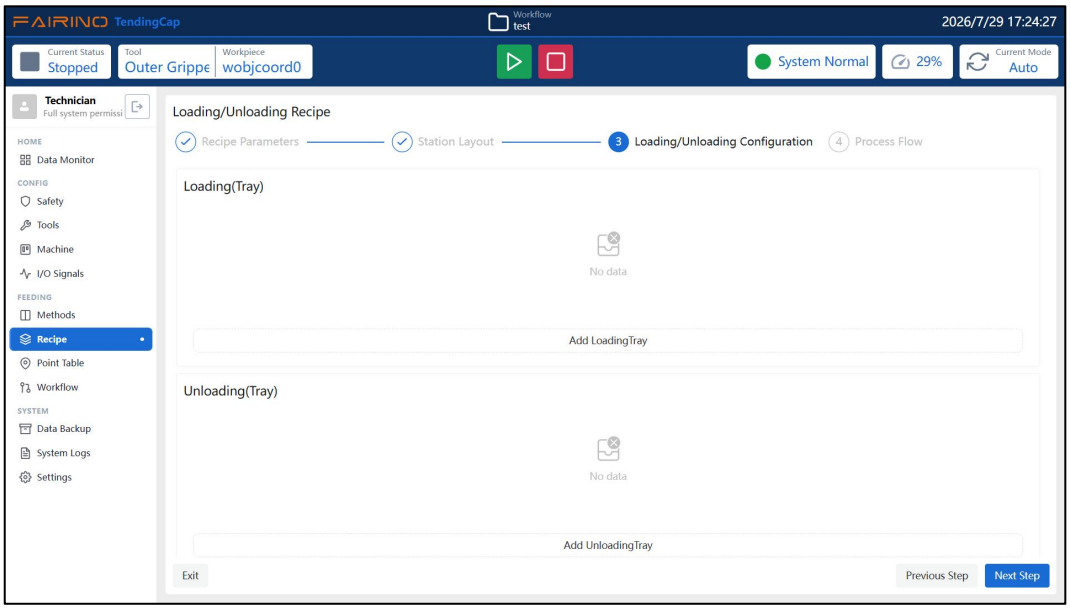


Figure 8.2-4 Work mode — loading and unloading, loading method — tray, unloading method — tray

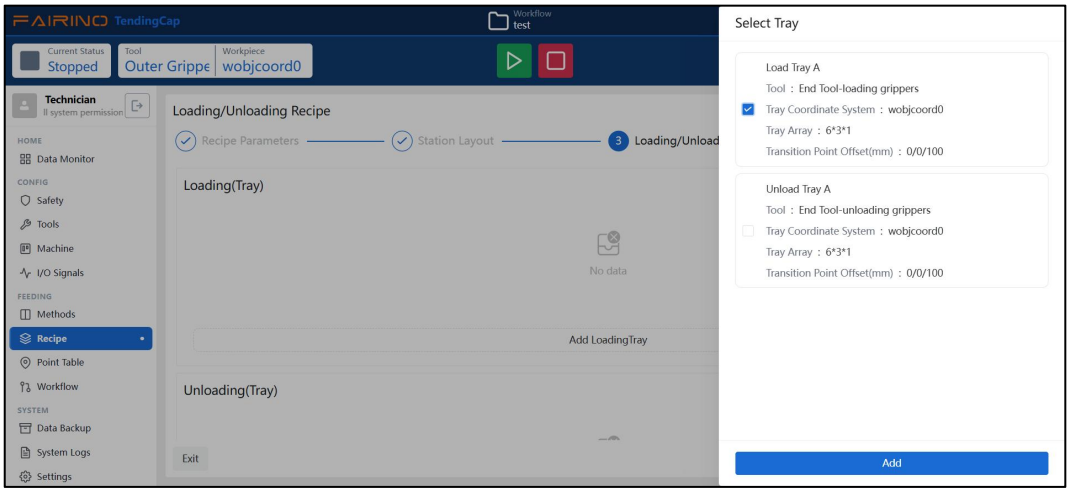


Figure 8.2-5 Add feeding tray

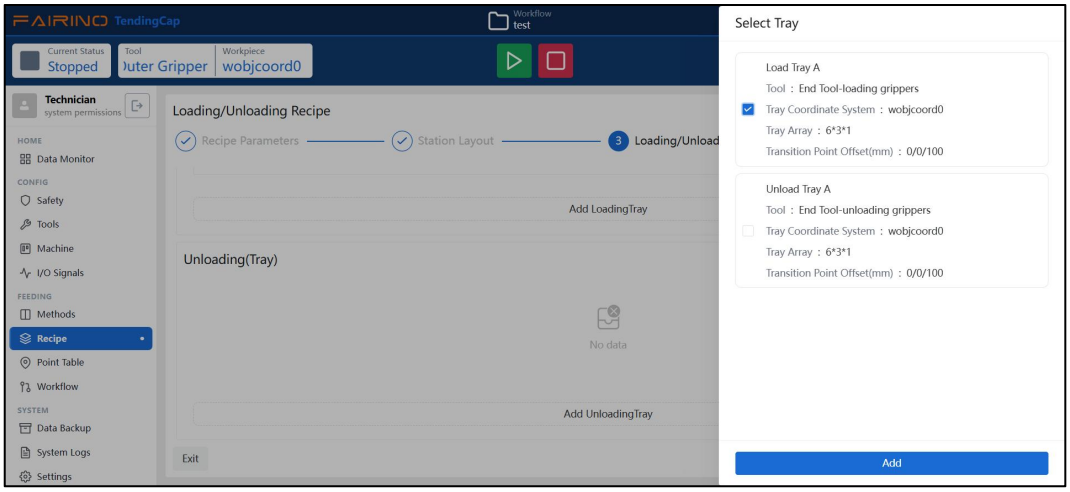


Figure 8.2-6 Add the material feeding conveyor belt

- Process Flow: Set the core steps as "Material pickup from tray/belt – Material feeding to machine tool – Material discharge from machine tool – Material release from tray/belt". After configuring the first three steps, clicking "Add Step" will display corresponding content, with data automatically populated based on configuration settings. Clicking "Insert Step Here" allows you to add core steps or integrate additional process steps such as "Secondary Positioning" and "Custom Process" according to specific requirements. Within each step, click "Add Sub-step" to select from available options including "Point-to-Point", "Linear Motion", "Control Signal", "Wait Signal", or "Matrix Movement". Once the process flow is complete, click the "Complete" button to finalize the addition.

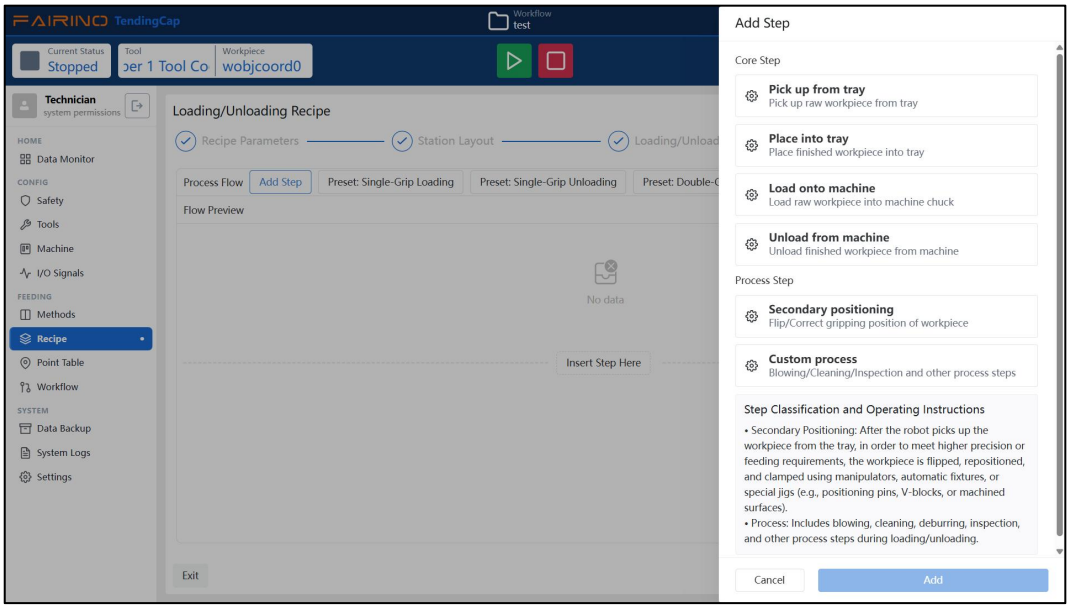


Figure 8.2-7 Add Step / Insert Step Here

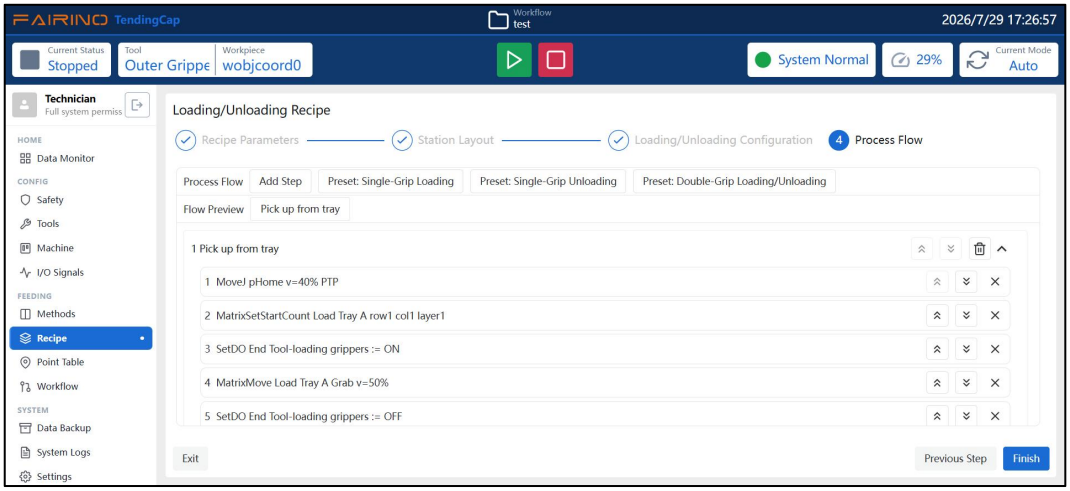


Figure 8.2-8 Add Step / Insert Step Here – Example: Material Disk Extraction

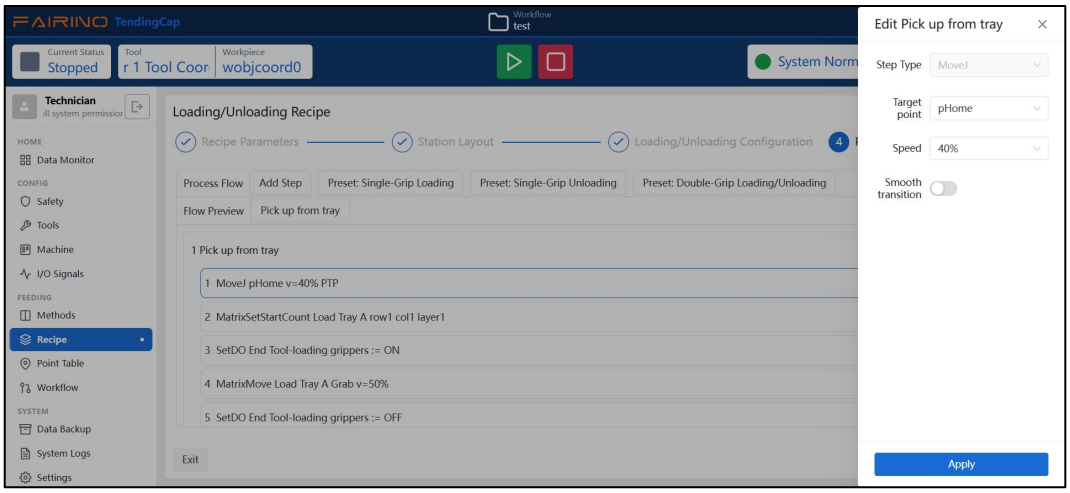


Figure 8.2-9 Add Sub-step

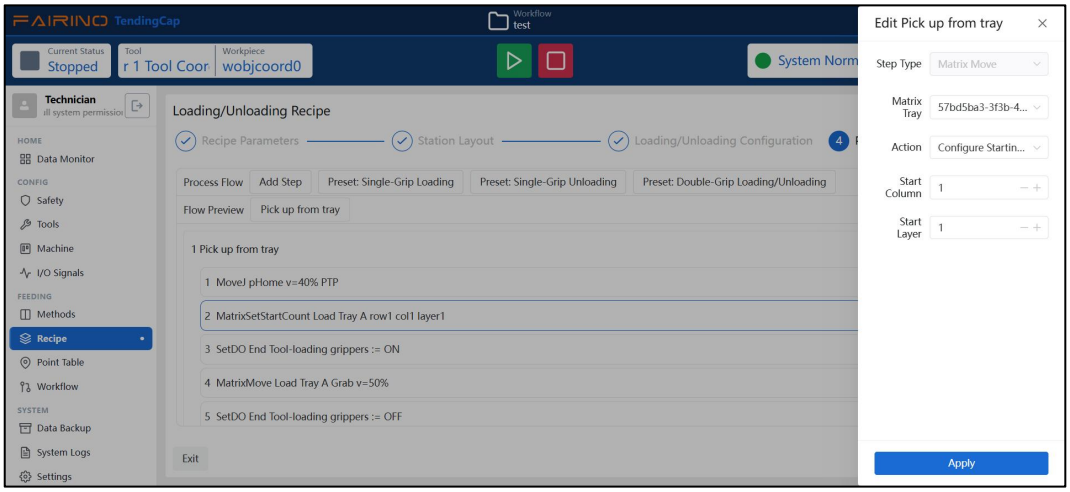


Figure 8.2-10 Select sub-step to edit and modify

After successful addition, the homepage displays configured recipes. Click the Edit button in the upper-right corner of the recipe configuration card to view or modify details. Click the Delete button in the upper-right corner to confirm deletion; click OK to remove the recipe.

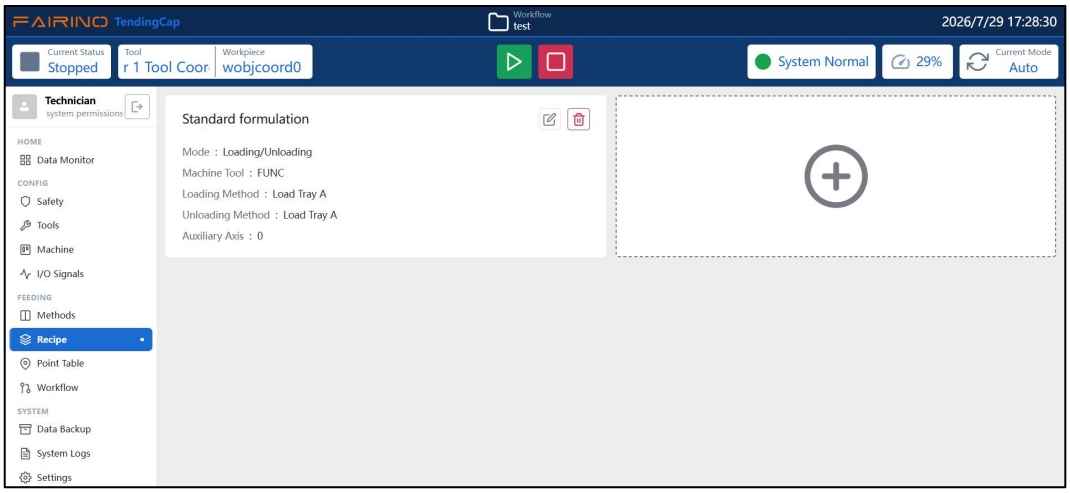


Figure 8.2-11 Formula List

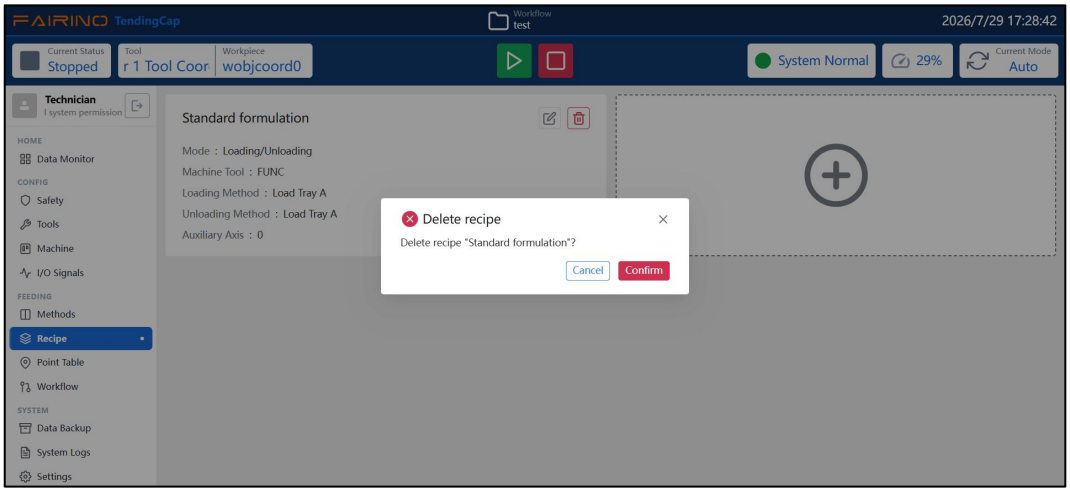


Figure 8.2-12 Formula deletion requires two-factor confirmation

During the workflow process, click the button for each step under "Process Preview" to automatically scroll the corresponding content to the top for easy viewing. Users can move steps up or down, delete them, or fold/unfold them as needed; they can also move sub-steps up or down, delete them, or edit them by selecting the drawer on the right side of the step bar.


Name: Move Up. Function: Move a process or sub-step up.


Name: Move Down. Function: Move a process or sub-step down.


Name: Fold. Function: Fold and hide process content.


Name: Expand. Function: Display process content in detail.

Name: Process deletion. Function: Delete process content.

Name: Sub-step deletion. Function: Delete sub-step content.

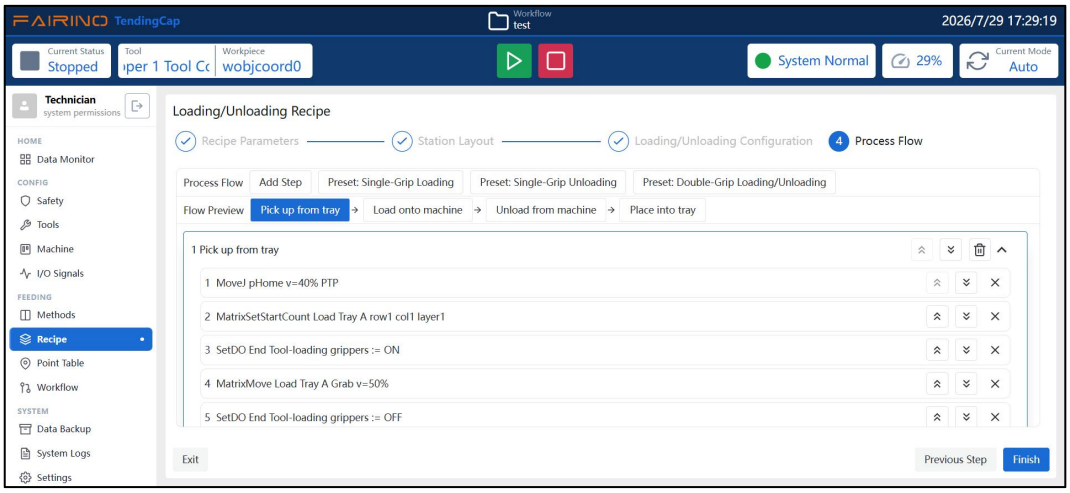


Figure 8.2-13 Material retrieval from the storage tray

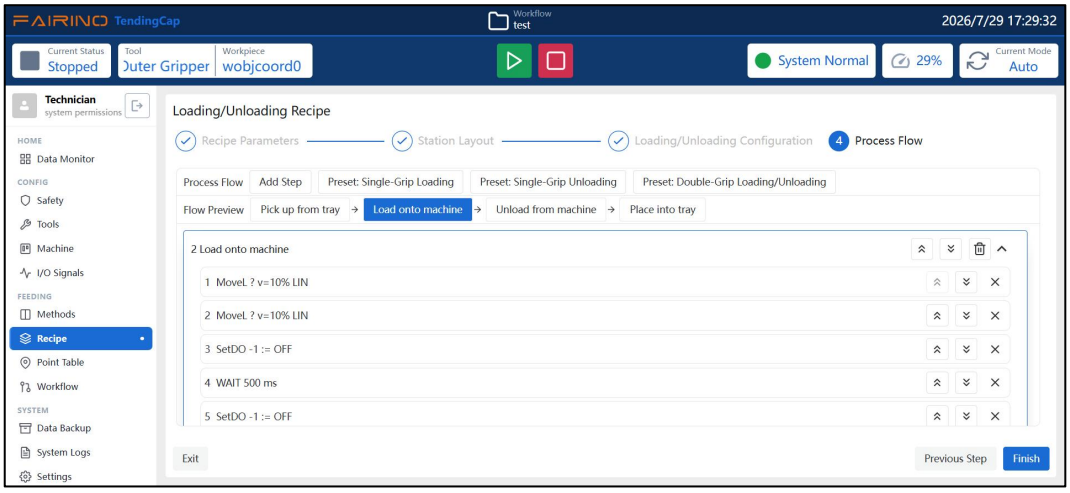


Figure 8.2-14 Material loading on the machine tool

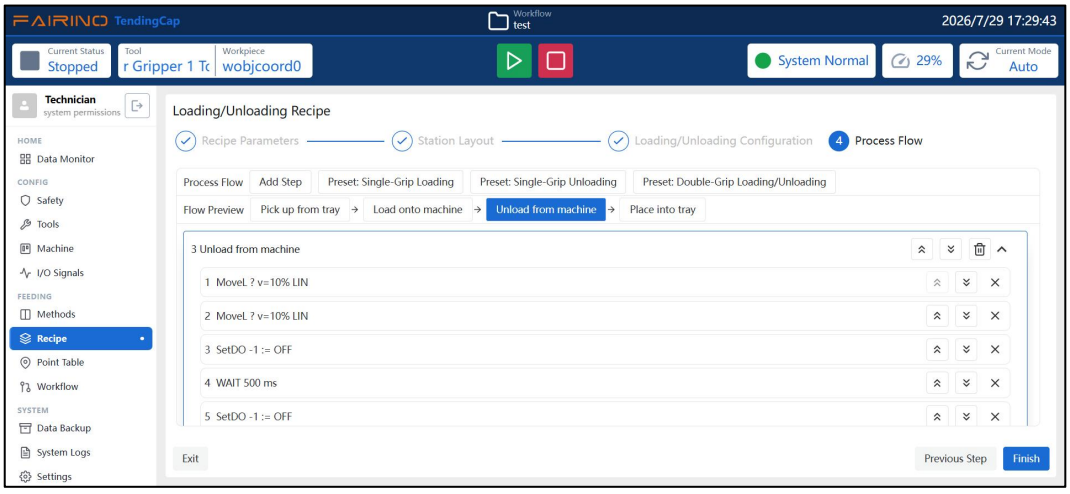


Figure 8.2-15 Material cutting on the machine tool

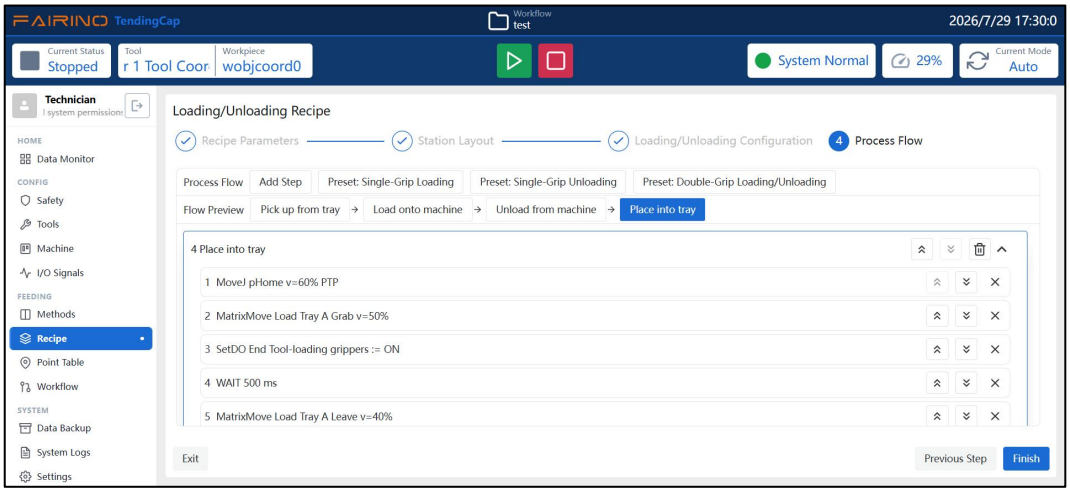


Figure 8.2-16 Conveyor belt discharge

When there is existing content in the workflow, click a preset instruction in "Workflow" and a prompt will appear: "The workflow already has content. Generating again will overwrite existing content. Continue?" Click OK to generate. If no content is selected, the preset workflow content will be displayed directly on the interface.

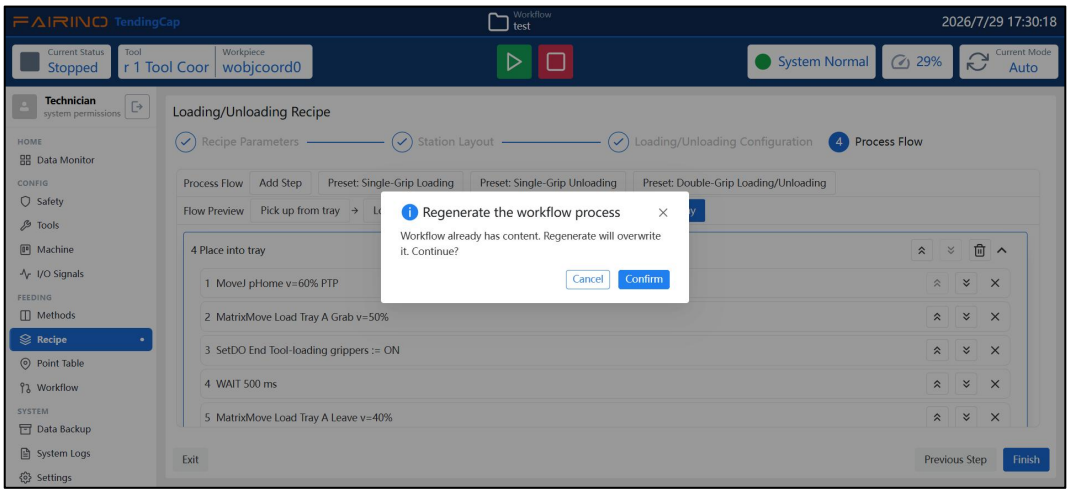


Figure 8.2-17 Regenerate workflow prompt

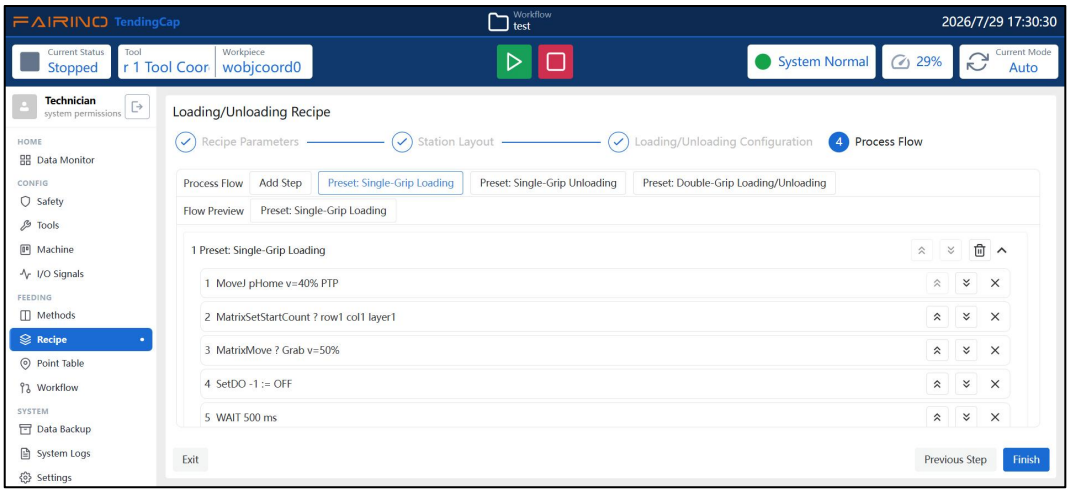


Figure 8.2-18 Confirm and generate the preset workflow

8.3 Point Table

In the "Material Handling – Point Table" section, you can view, update, perform single-point operation tests, delete, and record point data.

- The left "Teaching Point" card displays and views point data. At the top of the card, you can select the "PTP/LIN" mode for single-point operation, filter table data, and perform point recording based on the current robot pose. The point table supports renaming, viewing, updating, testing with single-point operation, and deleting point names.

- On the right, the "Move" tab displays the Cartesian space for robot movement (based on Base/Tool/Wobj). The interface features button groups to switch between corresponding Cartesian pose (X, Y, Z, RX, RY, RZ) and joint (J1 – J6) data. Long-pressing a button controls the robot to move linearly along the X, Y, or Z axes or rotate around RX, RY, or RZ.

- On the right side, the "Move" tab displays the joint space for robot movement (single-axis point motion); operate the left-side increment/decrement buttons to control robot motion. In manual mode and joint coordinate system mode, rotate a specific robot joint. When the robot exceeds its motion range (soft limit) and stops, use single-axis point motion for manual operation to move it out of the restricted position. Single-axis point motion is faster and more convenient than other operation modes for rough positioning or large-scale movements. Set the "Move Distance" parameter (the maximum travel distance when holding the button; input range: 0 –

300). Pressing the increment/decrement buttons controls robot movement; releasing the button immediately stops motion, while holding it continuously causes the robot to move until reaching the set threshold before stopping.

- Right-side "Move" tab – Expansion Axis: After successfully establishing a UDP connection, perform enable/disenable and forward/reverse tests, as well as zero-point calibration.

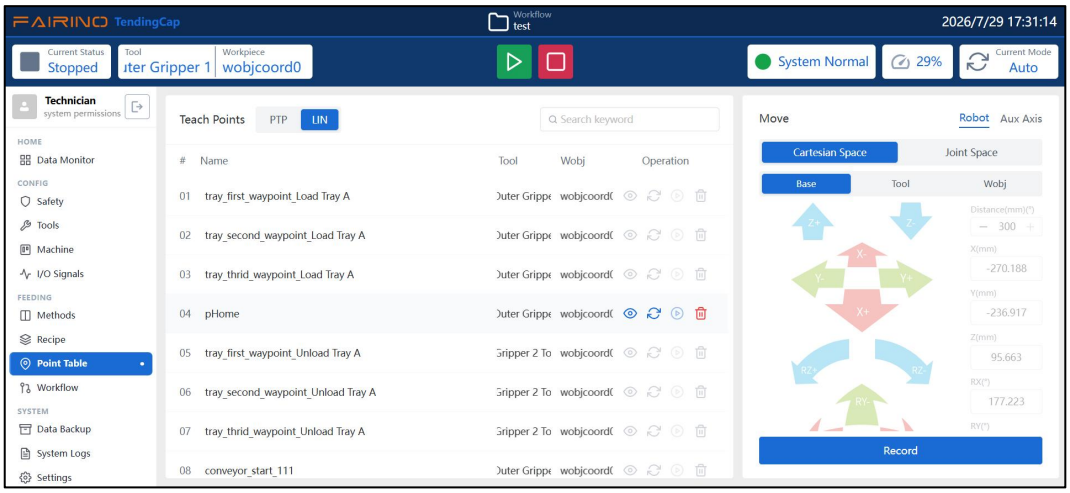


Figure 8.3-1 Point Table

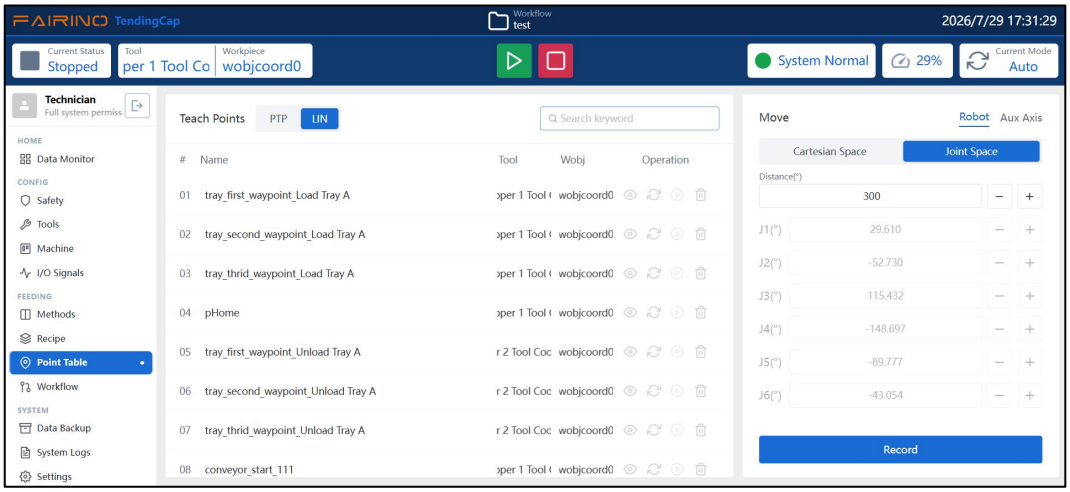


Figure 8.3-2 Joint space

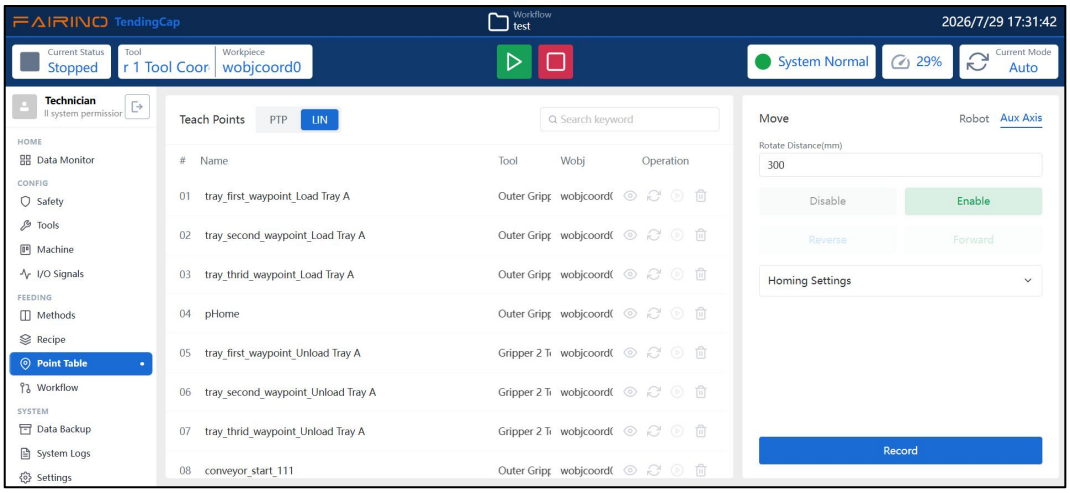


Figure 8.3-3 Extension Axis

8.4 Workflow

Configure the workflow in the "Material Handling – Workflow" section. Upon entering the page, retrieve workflow list data. If no data is available, display "No Workflows".

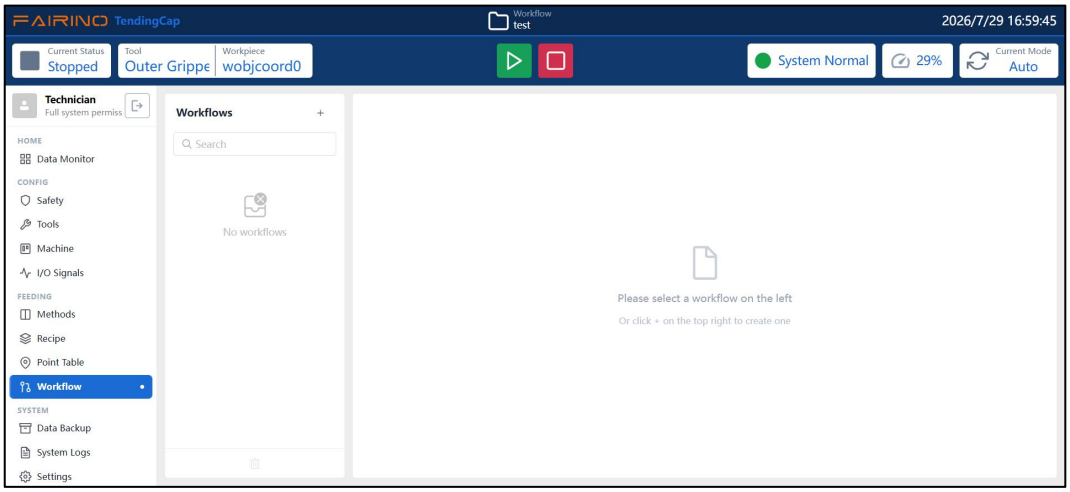


Figure 8.4-1 No workflow data

When adding a workflow, you can create a new one from a blank template or copy an existing one, and link it to an existing recipe. Then click the Create button to complete the workflow design. After successful creation, click the Generate by Recipe button to generate the workflow content based on the recipe's workflow steps. The workflow content is displayed in a tree structure.

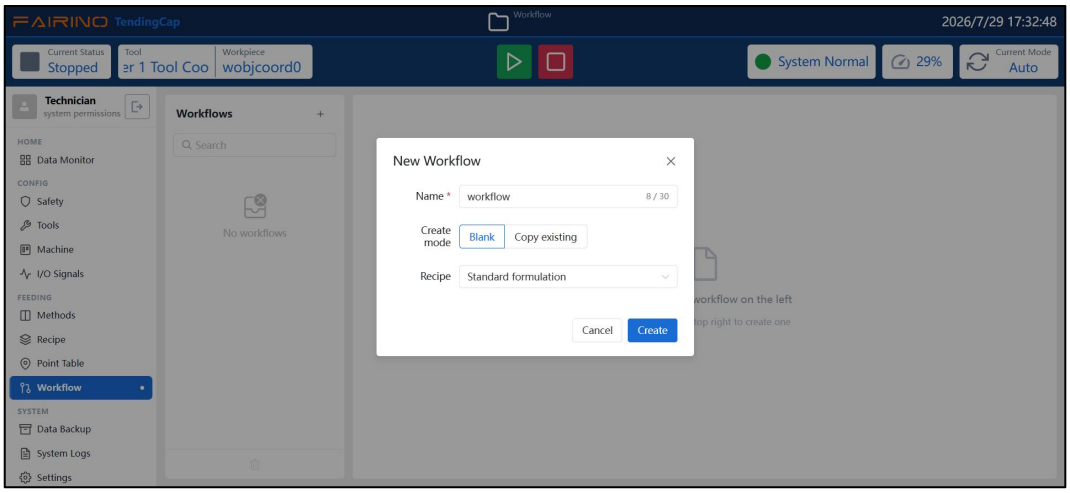


Figure 8.4-2 Create New Workflow Blank

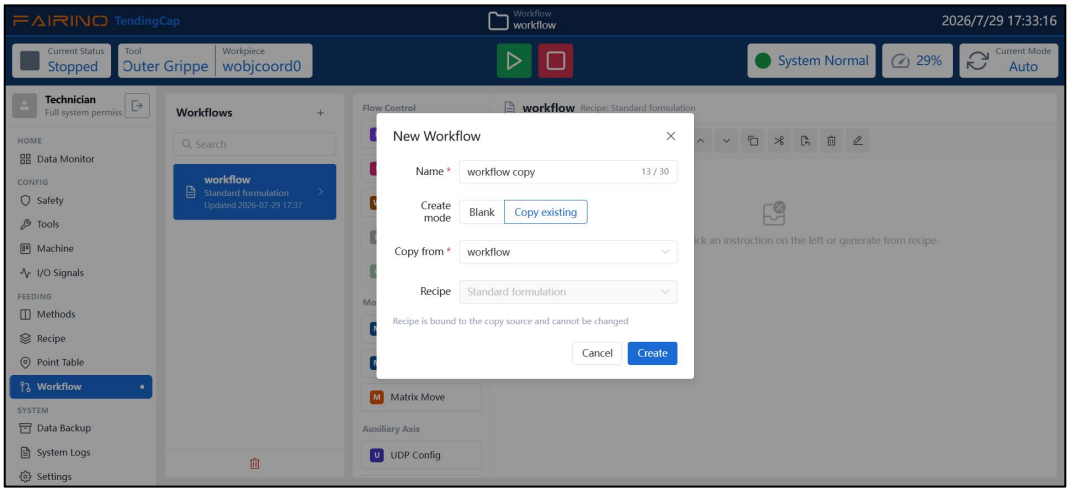


Figure 8.4-3 Workflow copies existing items and creates new ones

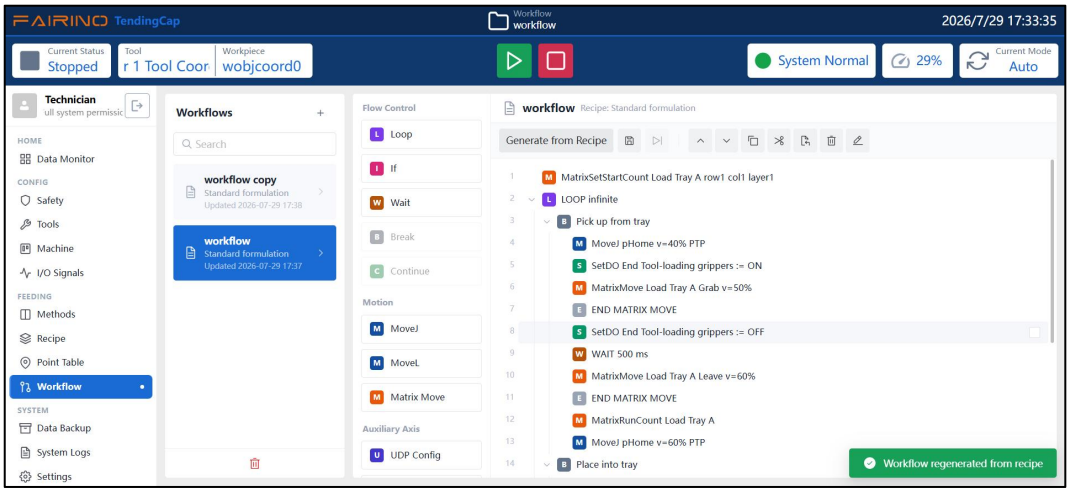


Figure 8.4-4 Workflow generated based on the recipe

8.4.1 Toolbar

 Name: Save. Function: Save workflow content.

 Name: Run in One Step. Function: executes the selected workflow instruction in a single step.

 Name: Move Up. Function: Move the selected workflow instruction up；

 Name: Move Down. Function: Move the selected workflow instruction down；

 Name: Copy. Function: Copy selected workflow instructions.

 Name: Cut. Function: Cut the selected workflow instruction.

 Name: Paste. Function: Paste a copied or cut-and-paste workflow instruction.

 Name: Delete. Function: Remove the selected workflow instruction.

 Name: Edit. Function: Edit selected workflow instructions.

8.4.2 Flow control

8.4.2.1 Loop

Click "Loop" to open the "Edit Loop" interface on the right. The loop scenario is as follows：

- infinite loop
- Limited iterations: Number of iterations to input
- Condition-based loop: Select the signal state or variable comparison type based on requirements, and add conditions

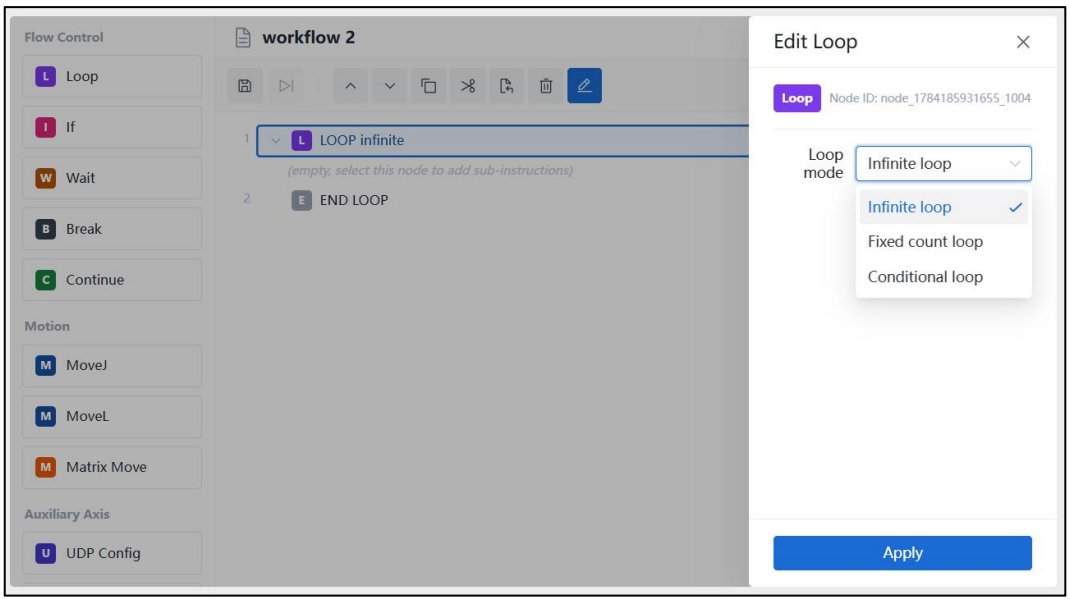


Figure 8.4.2.1-1 Loop instruction

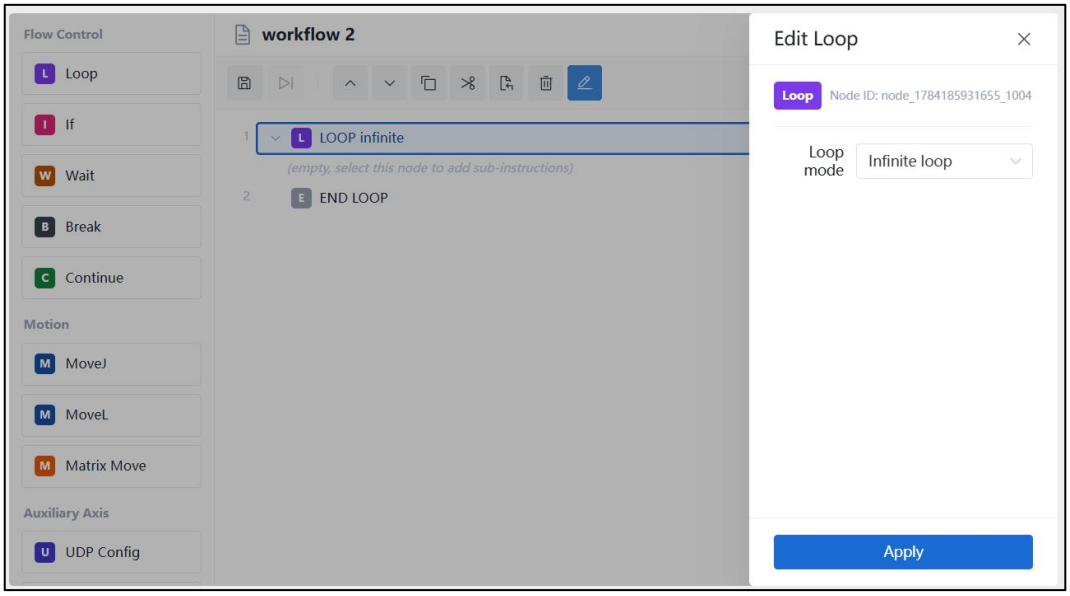


Figure 8.4.2.1-2 Loop Instruction – Infinite Loop

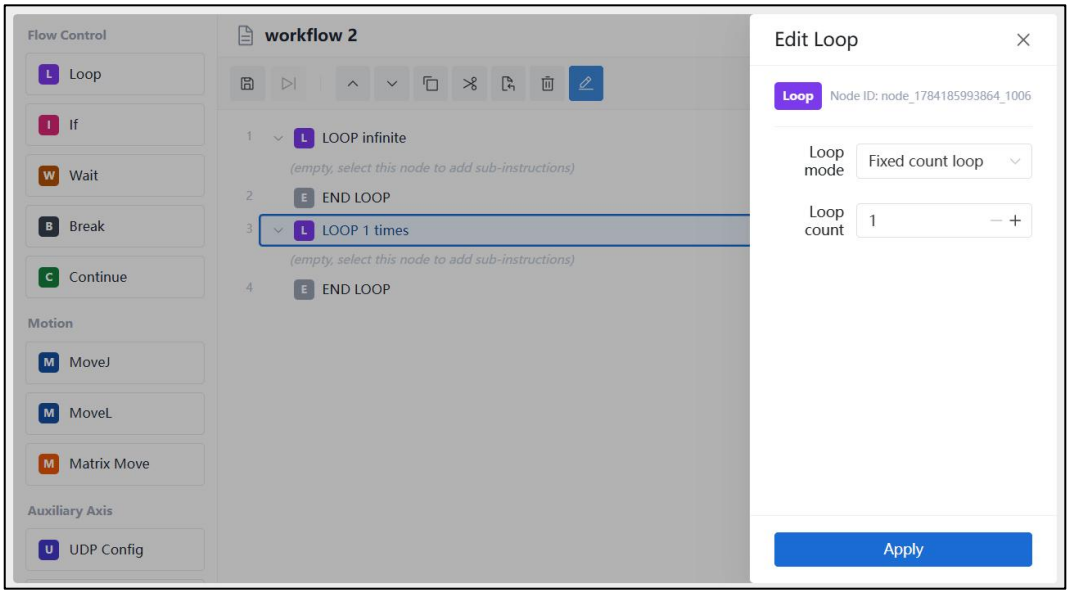


Figure 8.4.2.1-3 Loop Instruction – Limited Number of Loops

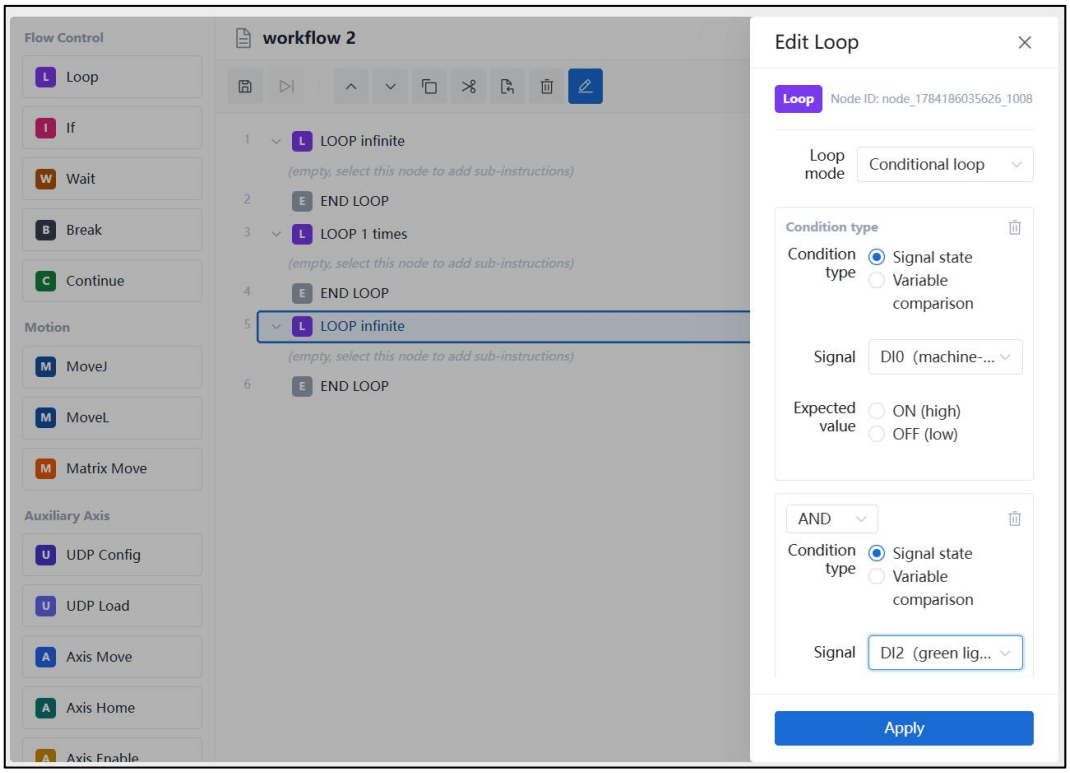


Figure 8.4.2.1-4 Loop Instruction – Loop if the condition is met

8.4.2.2 If

Click "If" to open the "Edit If" interface on the right. The scene is as follows：

- Add Condition: Add a judgment condition
- Add Otherwise Clause: Add additional logic for judgment
- Add Otherwise: No configuration required; executed when none of the other

branches meet the conditions.

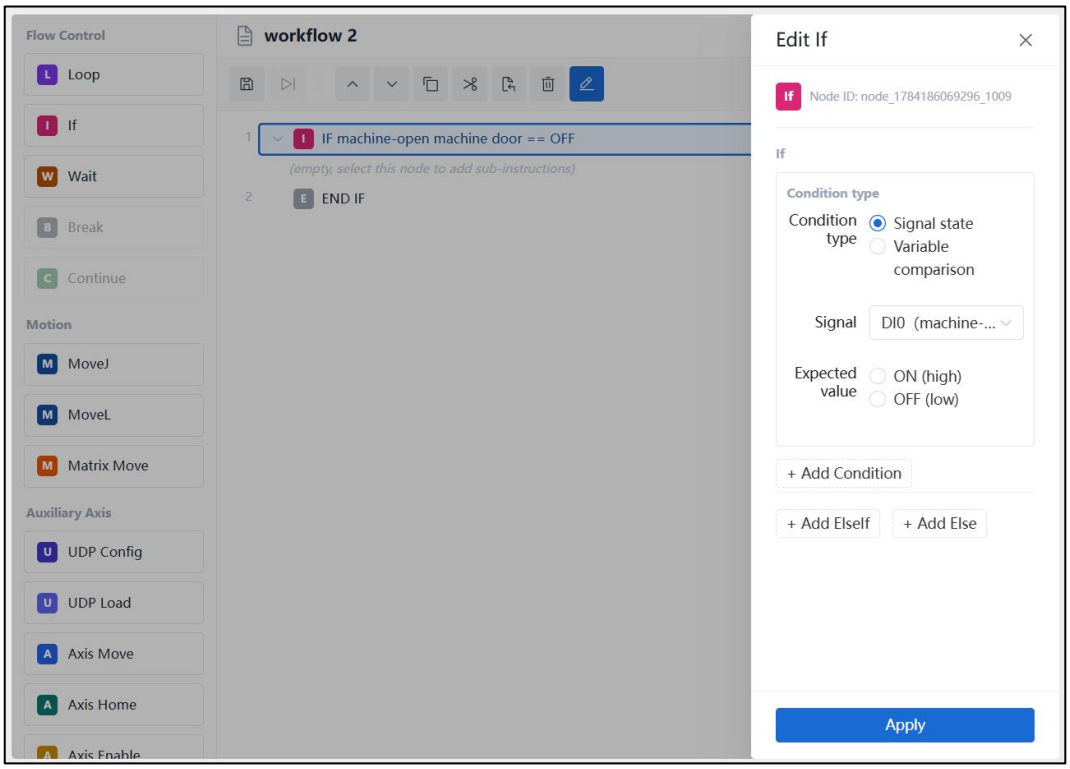


Figure 8.4.2.2-1 if instruction

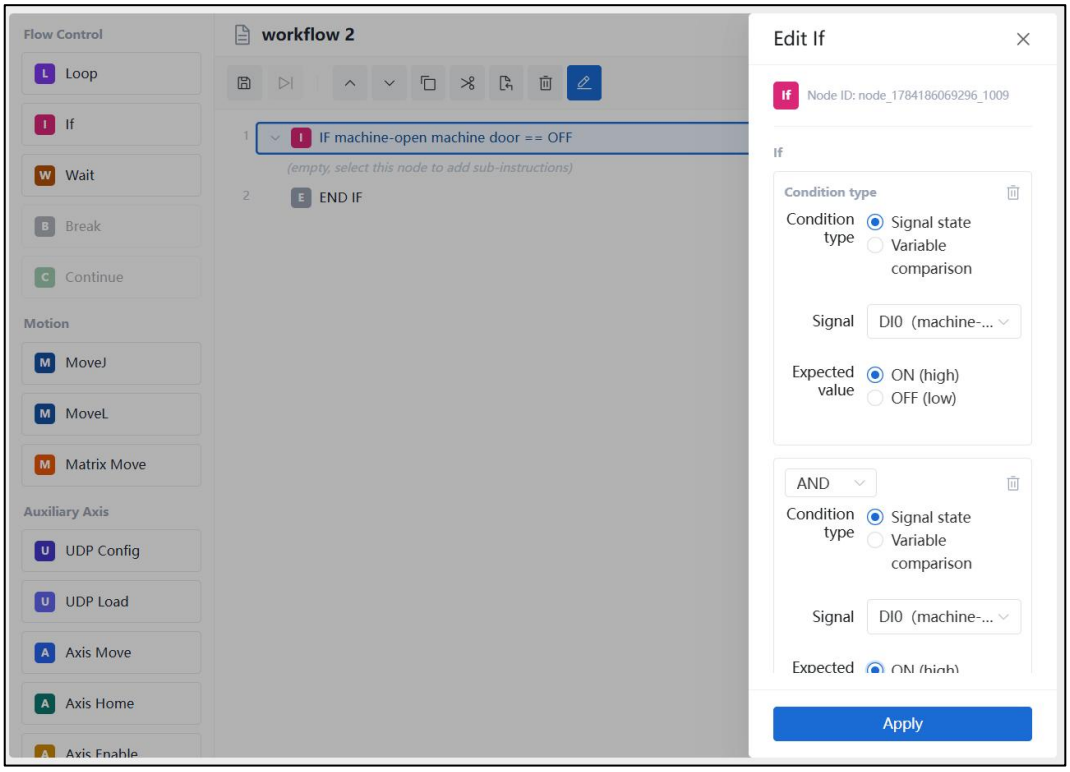


Figure 8.4.2.2-2 If Instruction – Add Condition

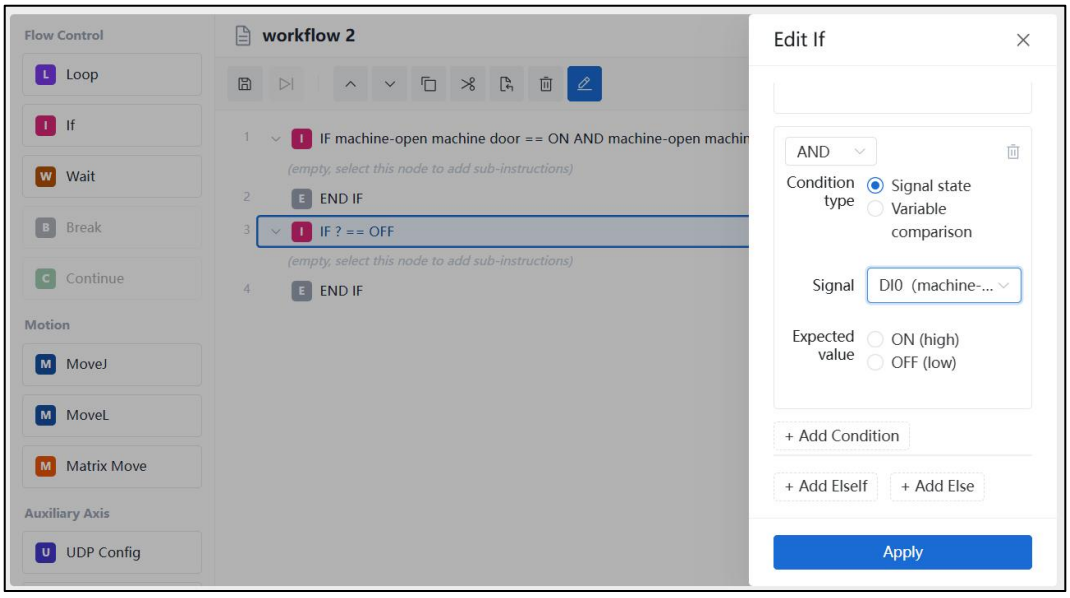


Figure 8.4.2.2-3 If Instruction – Add Otherwise Judgment

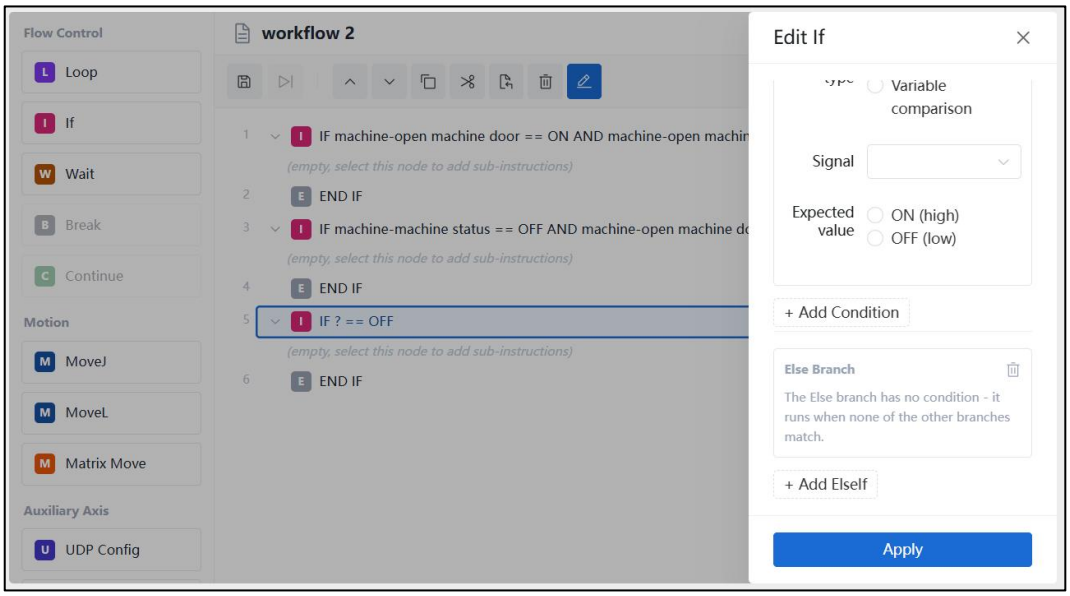


Figure 8.4.2.2-4 If Instruction – Add Otherwise

This instruction requires basic programming knowledge. For assistance, please contact us.

8.4.2.3 Wait

Click "Wait" to open the "Edit Wait" interface on the right, and enter the delay duration in milliseconds

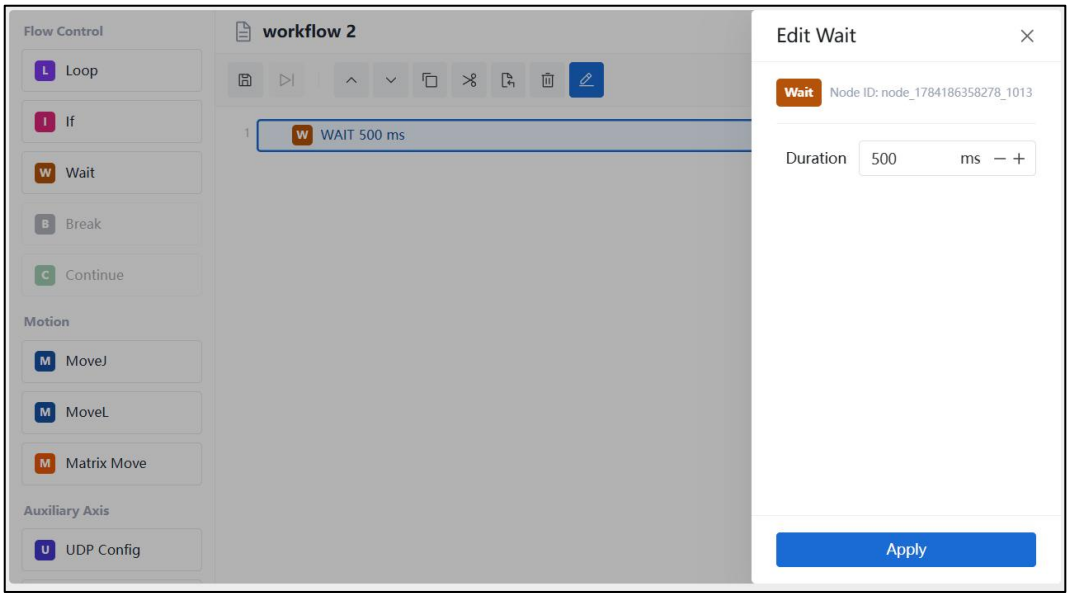


Figure 8.4.2.3-1 Wait Instruction

8.4.2.4 Break

Click "Break" to open the "Edit Break" interface on the right and use it with loop instructions.

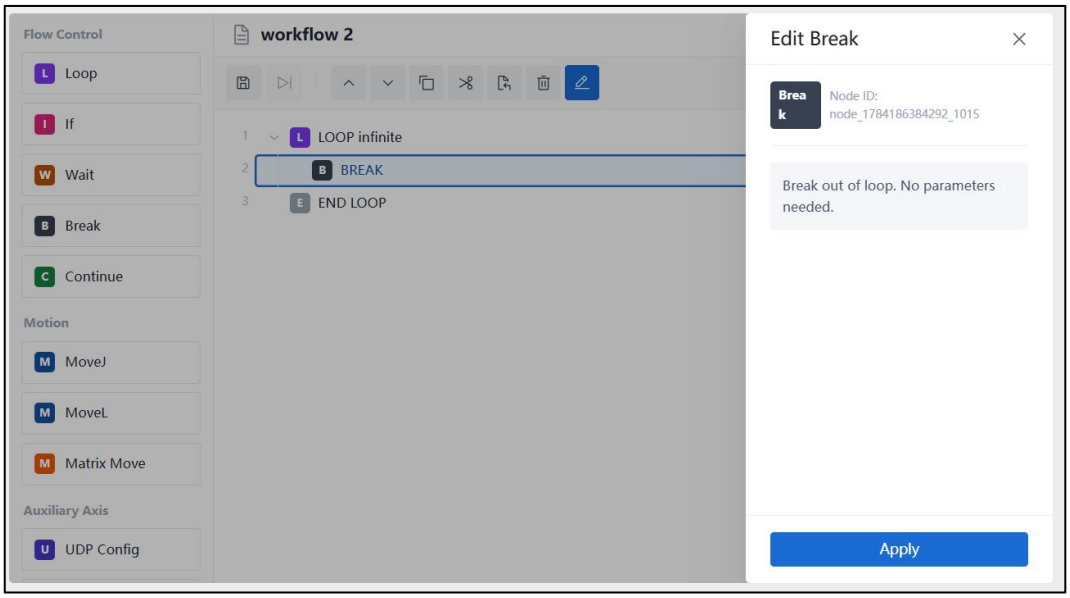


Figure 8.4.2.3-1 Breakinstruction

8.4.2.5 Continue

Click "Continue" to open the "Edit Continue" interface on the right and use it with the loop instruction。

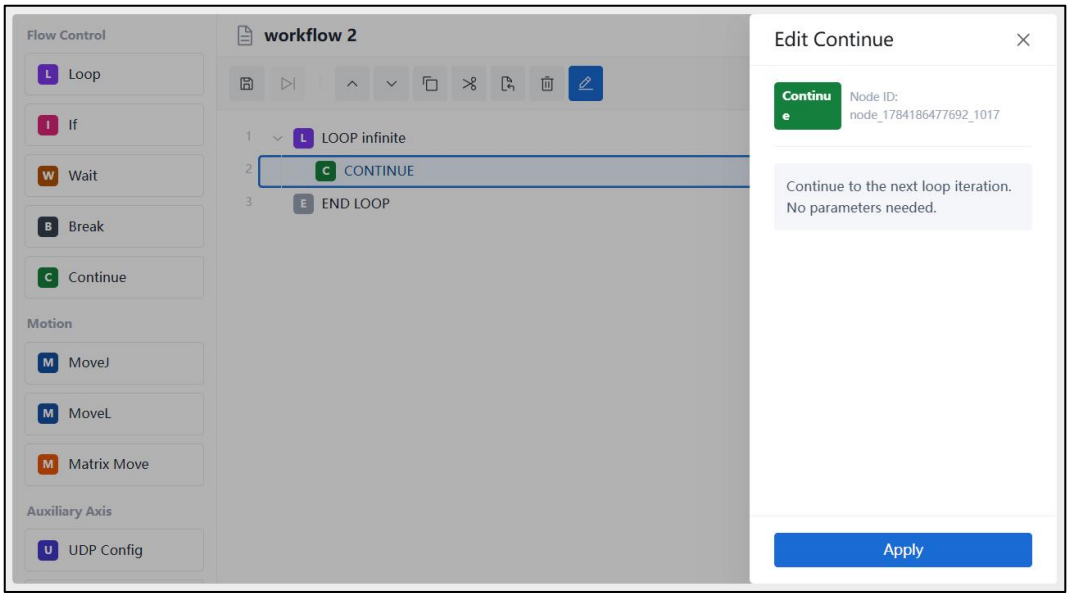


Figure 8.4.2.5-1 Continue Instruction

8.4.3 Movement Instruction

8.4.3.1 MoveJ

Click "MoveJ" to open the "Edit MoveJ" interface on the right. Select the destination point, enable smooth transition, and enter the smooth transition time to ensure a seamless movement from one point to the next.The specific path is the optimal path automatically planned by the motion controller.

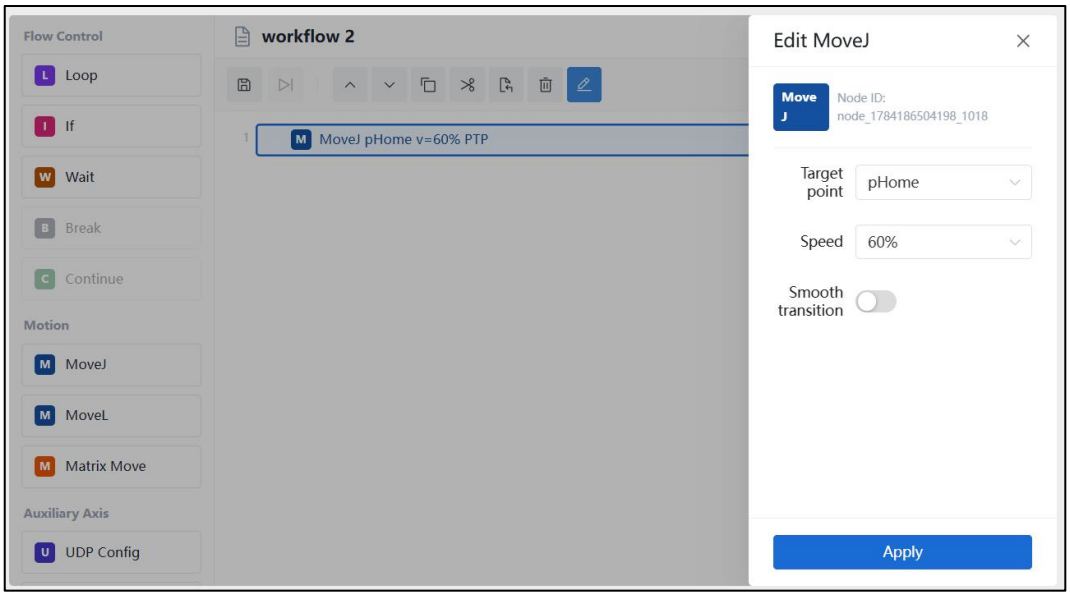


Figure 8.4.3.1-1 MoveJ instruction

8.4.3.2 MoveL

Click "MoveL" to open the "Edit MoveL" interface on the right, select the destination point, enable smooth transition, enter the smooth transition radius, and choose the transition method.The path to the destination is a straight line.

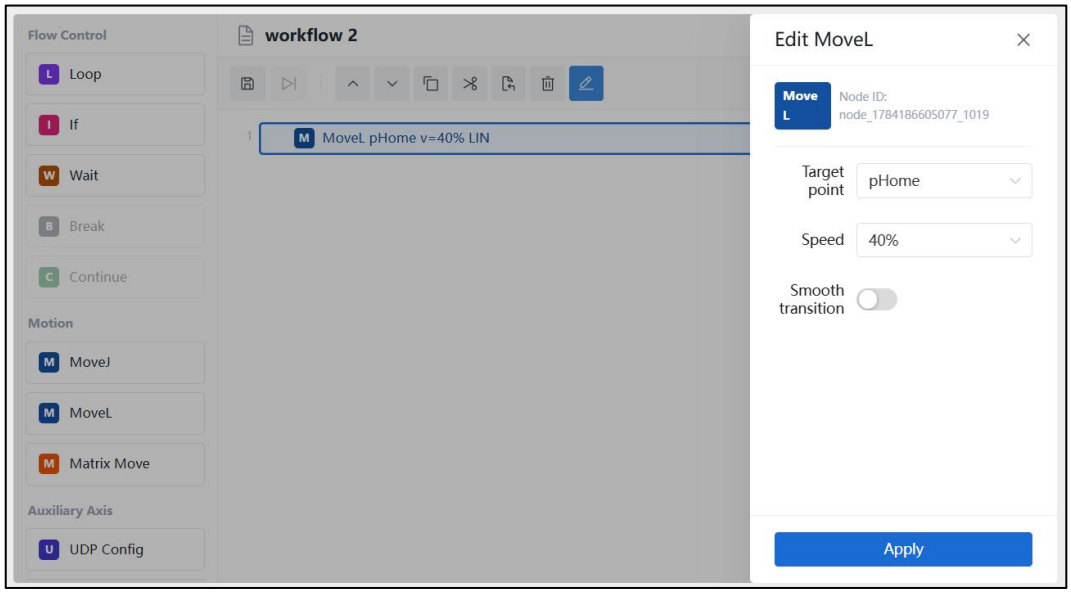


Figure 8.4.3.2-1 MoveL instruction

8.4.3.3 Matrix Move

Click "Matrix Move" to open the "Edit Matrix Move" interface on the right, select the tray and execution action, and the execution action scenario is as follows.

- Matrix Movement: The robot moves to load/unload and grasp/exit.
- Matrix operation count: Counting the row, column, and layer of the robot's loading/unloading operation.
- Set starting count: Define where the robot begins loading/unloading operations (row, column, and layer).
- Get matrix count: Determine the row, column, and layer of the robot's loading/unloading operation.
- Total processing count +1: Increase the total number of robot loading/unloading operations by 1.
- Total cleared processing operations: Total robot loading/unloading operations plus.

- Get total processing count: Get total robot loading/unloading operations.

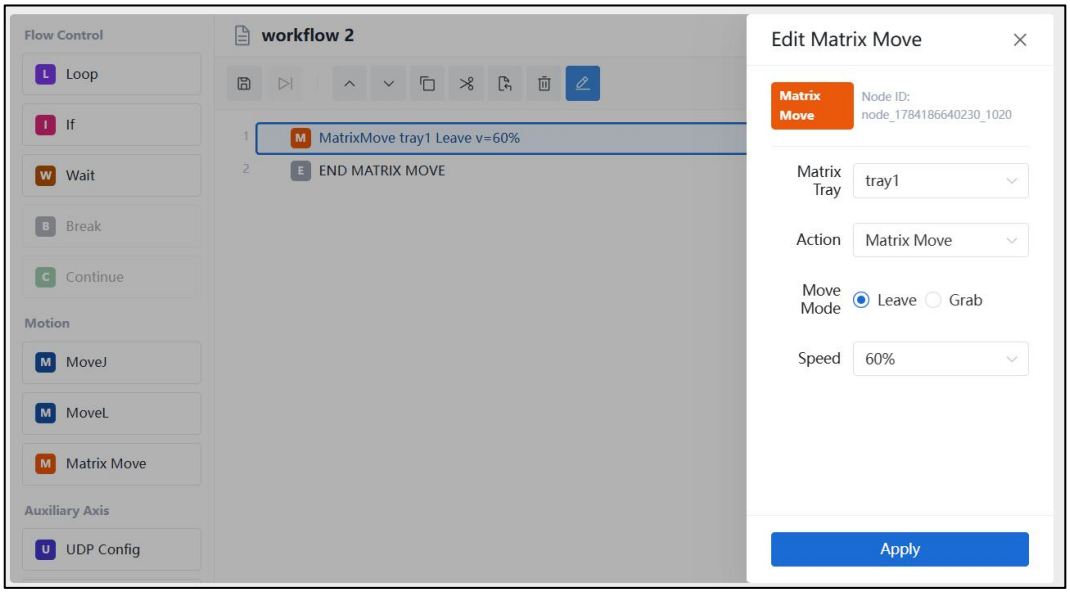


Figure 8.4.3.3-1 Matrix Move

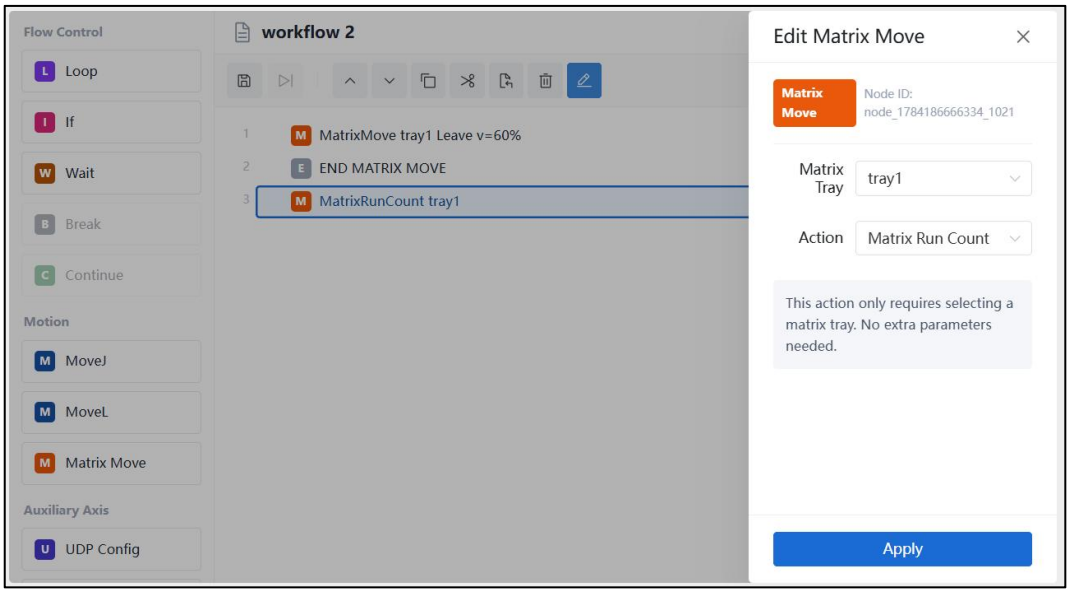


Figure 8.4.3.3-2 Matrix Execution Count

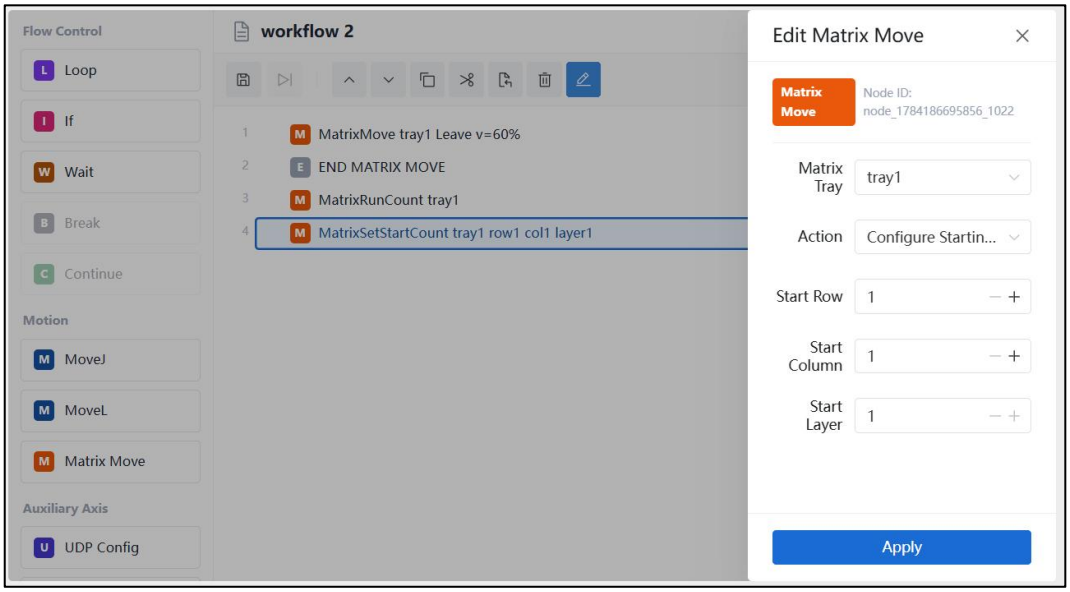


Figure 8.4.3.3-3 Configure starting count

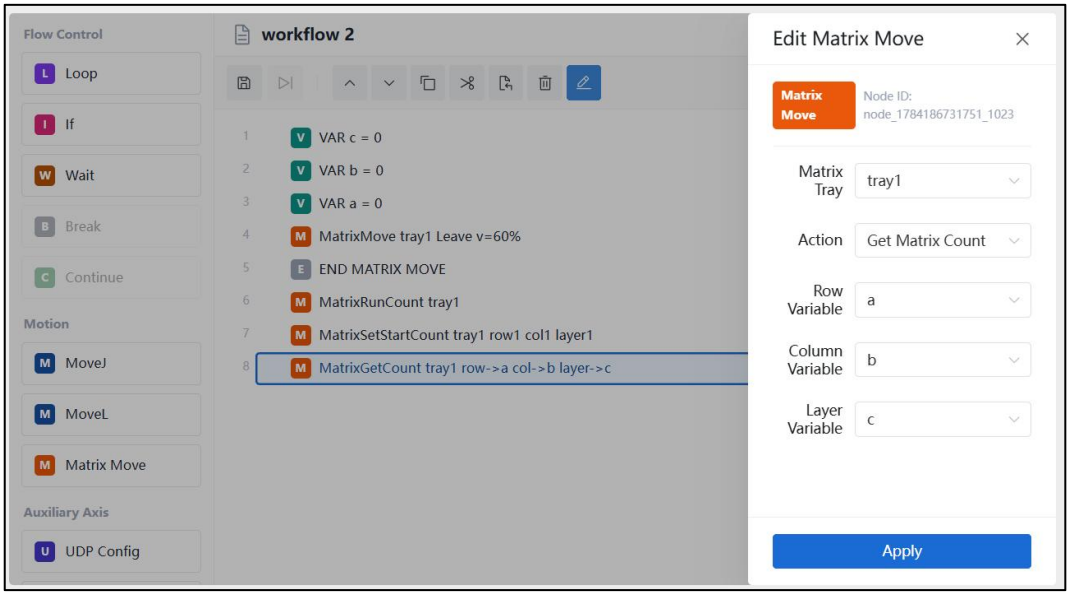


Figure 8.4.3.3-4 Get Matrix Count

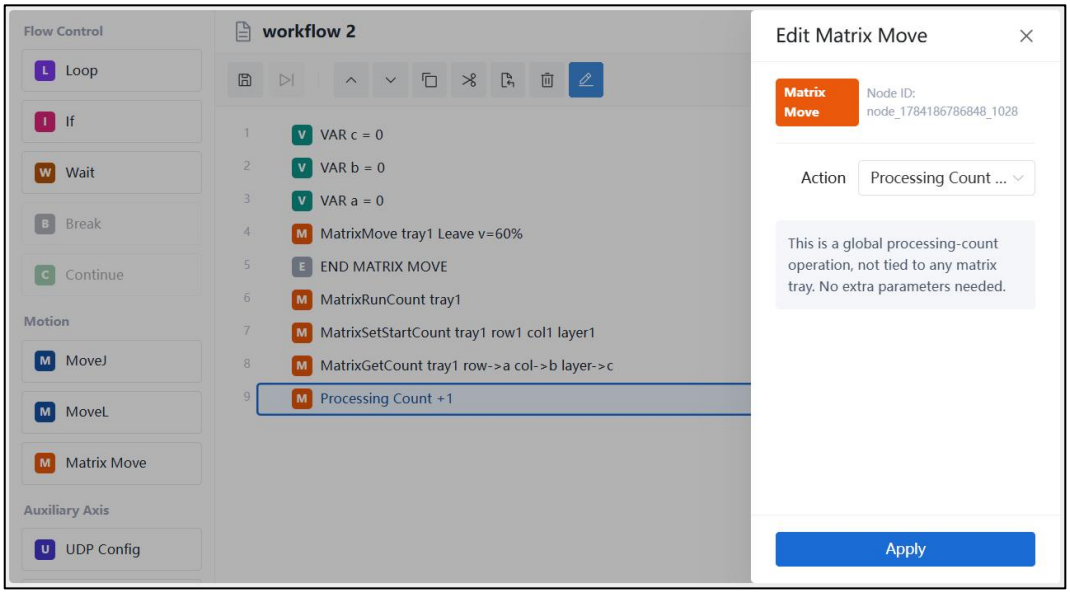


Figure 8.4.3.3-5 Total Processing Count +1

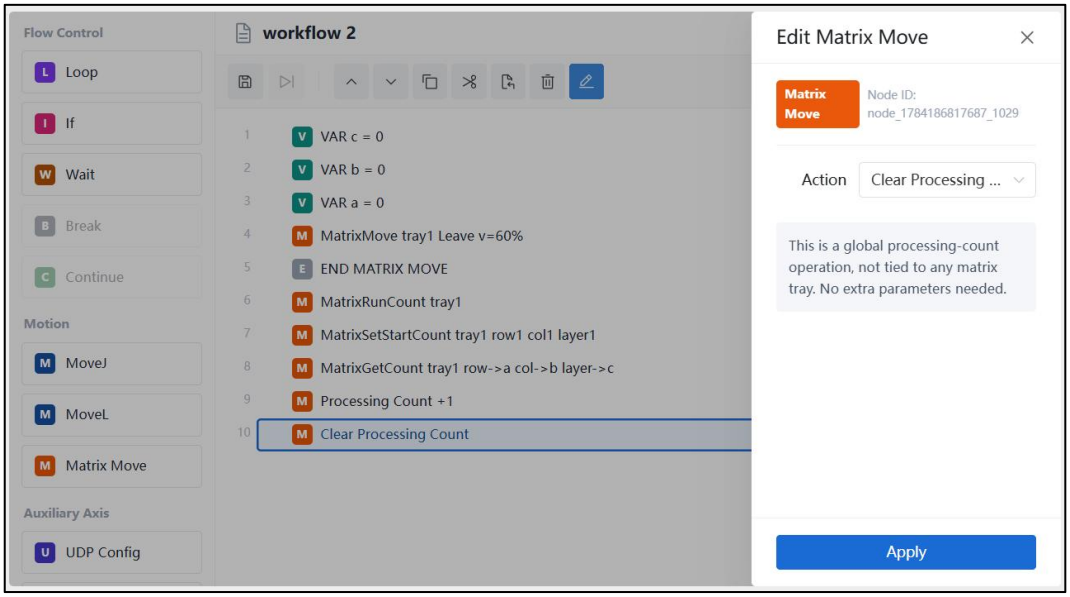


Figure 8.4.3.3-6 Total cleaned processing count

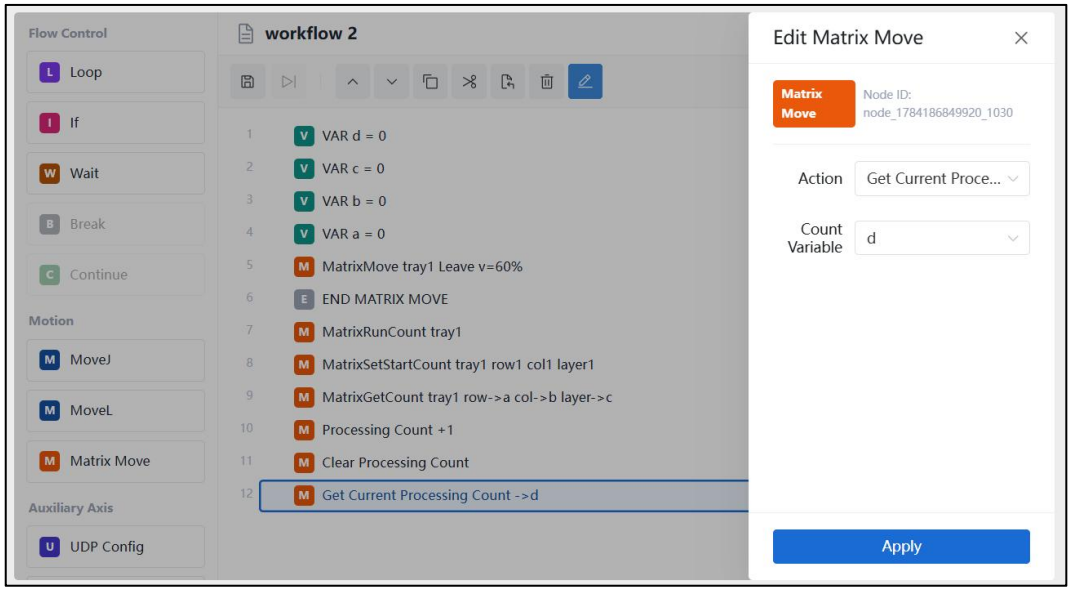


Figure 8.4.3.3-7 Get the total number of current processes

8.4.4 Auxiliary Axis

For scenarios using extended shafts, the combination mode consists of a controller and PLC (UDP).

8.4.4.1 UDP Config

Click "UDP Communication Configuration" to open the "Edit UDP Communication Configuration" interface on the right.

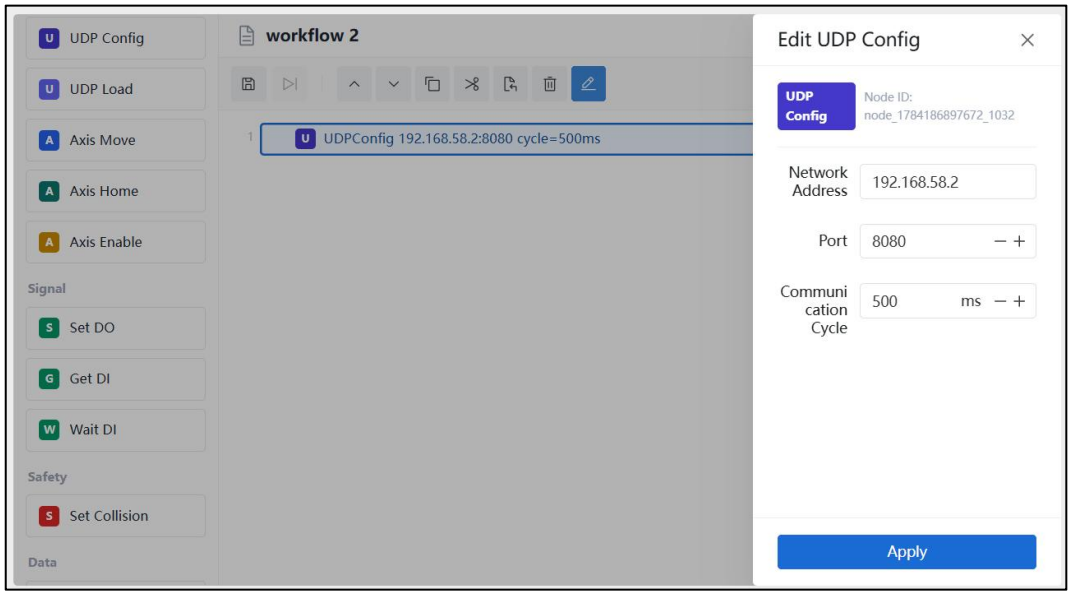


Figure 8.4.4.1-1 UDP Communication Configuration Command

8.4.4.2 UDP Load

Click "UDP Communication Load" to open the "Edit UDP Communication Load" interface on the right.

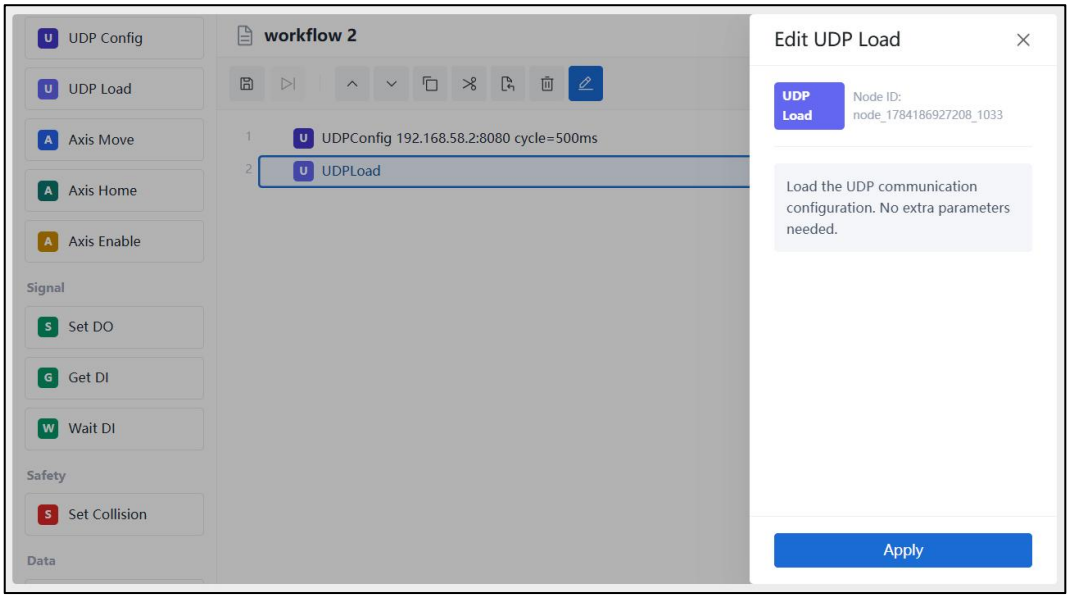


Figure 8.4.4.2-1UDP Communication Loading Instruction

8.4.4.3 Axis Move

Click "Extend Axis Movement" to open the "Edit Extend Axis Movement" interface on the right.

When used with a point-to-point command, it breaks down spatial movement along the X-axis into movements along external axes. Select "Synchronous" as the motion mode and choose the destination point.

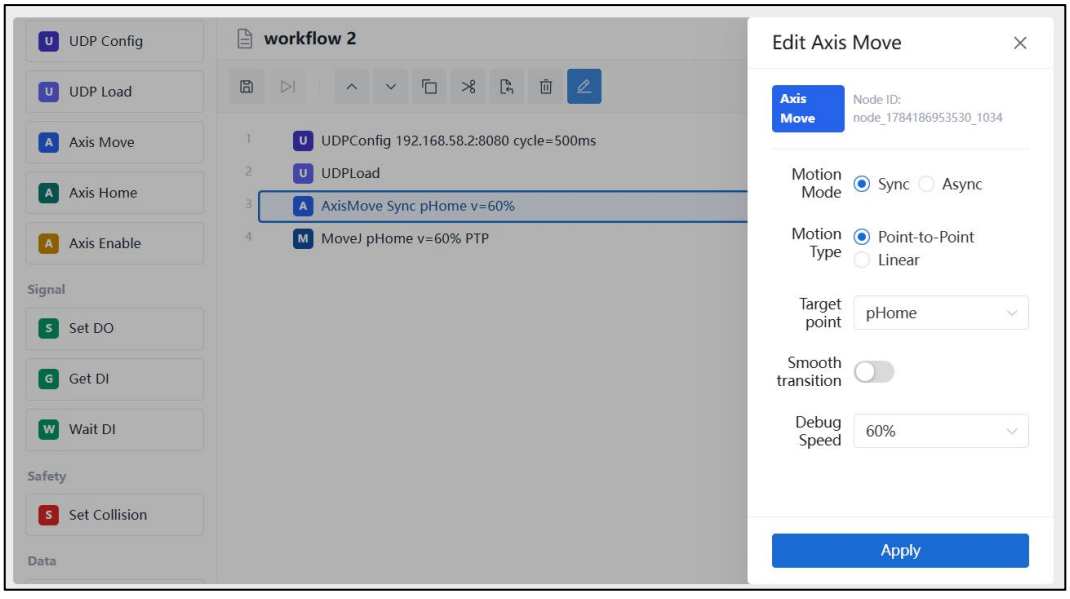


Figure 8.4.4.3-1 Extension Axis Movement Command

8.4.4.4 Axis Home

Click "Set Axis Zero" to open the Edit Axis Zero interface on the right.

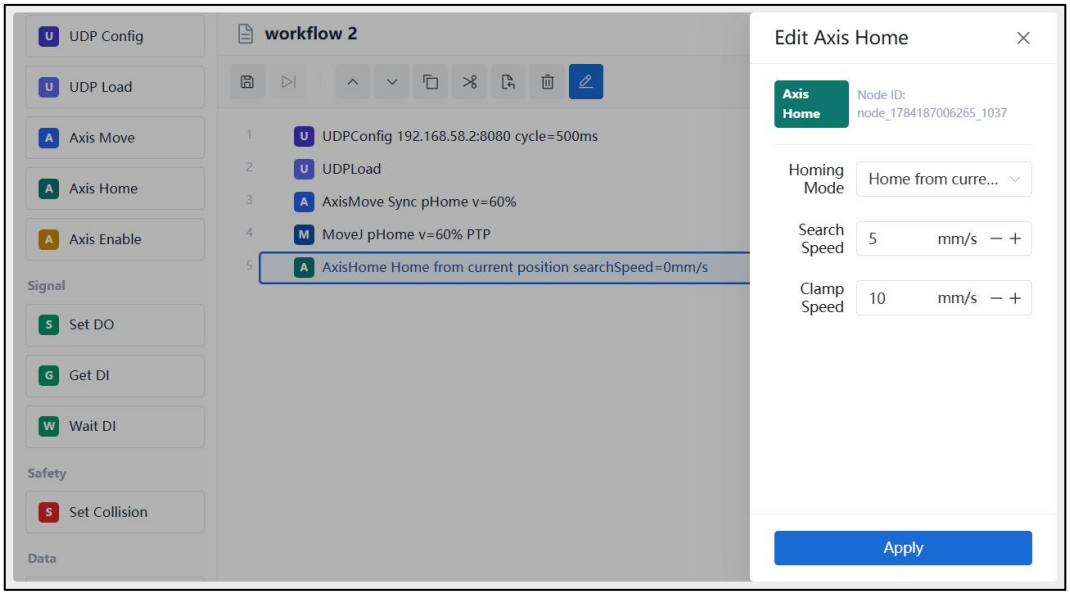


Figure 8.4.4.4-1 Extension Axis Zero Command

8.4.4.5 Axis Enable

Click "Enable Expansion Axis" to open the "Edit Enable Expansion Axis" interface on the right.

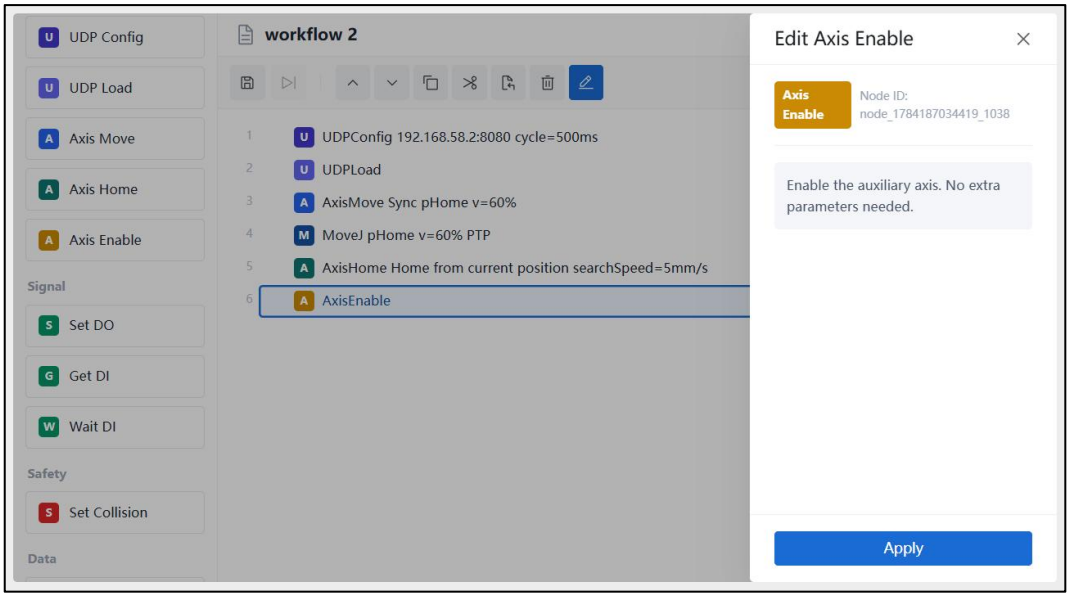


Figure 8.4.4.5-1 Extension Axis Enable Command

8.4.5 Signal

8.4.5.1 Set DO

Click the Control Signal Switch to open the Edit Control Signal Switch interface on the right. Select the signal port and signal value to turn it on/off.

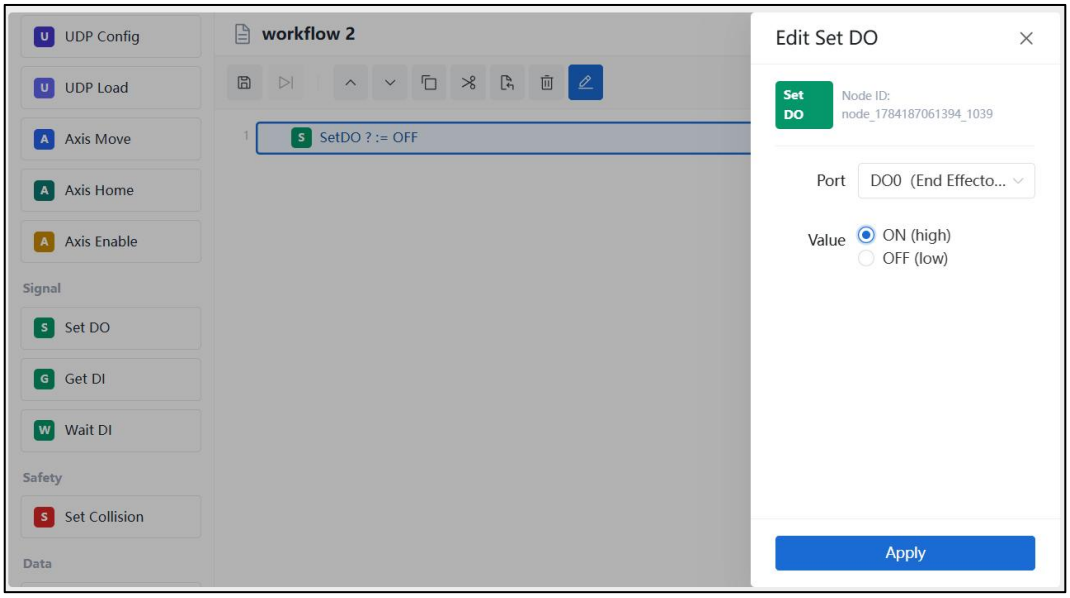


Figure 8.4.5.1-1 Control Signal Switching Instruction

8.4.5.2 Get DI

Click "Get Signal Switch" to open the "Edit Get Signal Switch" interface on the right. Select the signal port and input variable value.

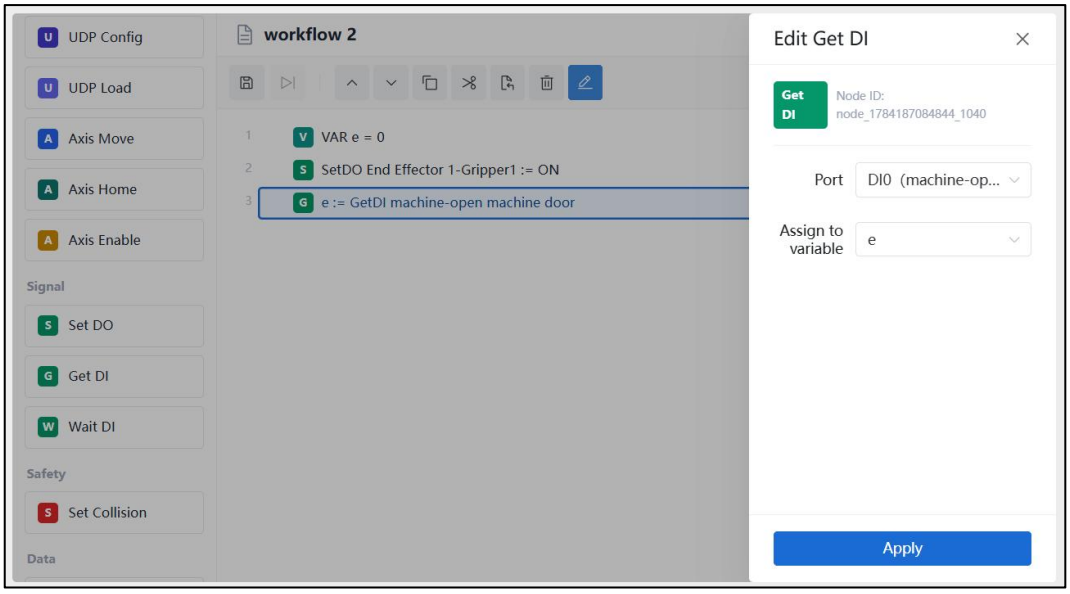


Figure 8.4.5.2-1 Obtain the signal switching instruction

8.4.5.3 Wait DI

Click "Wait Signal" to open the Edit Wait Signal interface on the right. Select a signal port, choose whether to enable or disable the target value, and select the timeout handling option (stop error reporting, wait for execution, or continue waiting). For stop error reporting and wait for execution, enter a timeout duration.

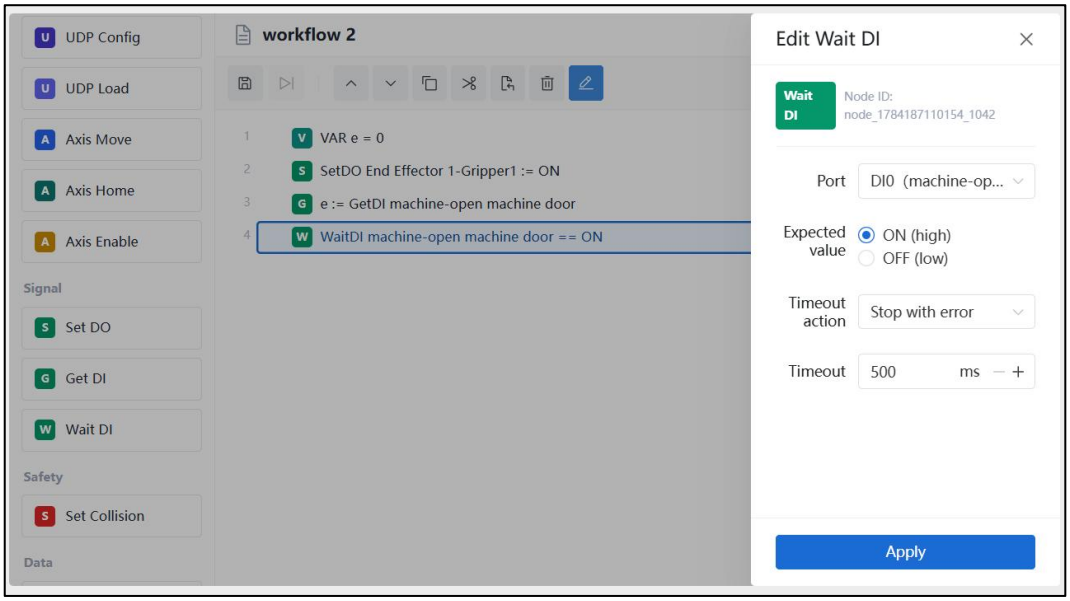


Figure 8.4.5.3-1 Waiting for the signal instruction

8.4.6 Safety

8.4.6.1 Set Collision

Click "Set Collision Level" to open the "Set Collision Level" interface on the right. This command allows you to adjust collision levels for each axis in real time during program execution, providing more flexible deployment options.

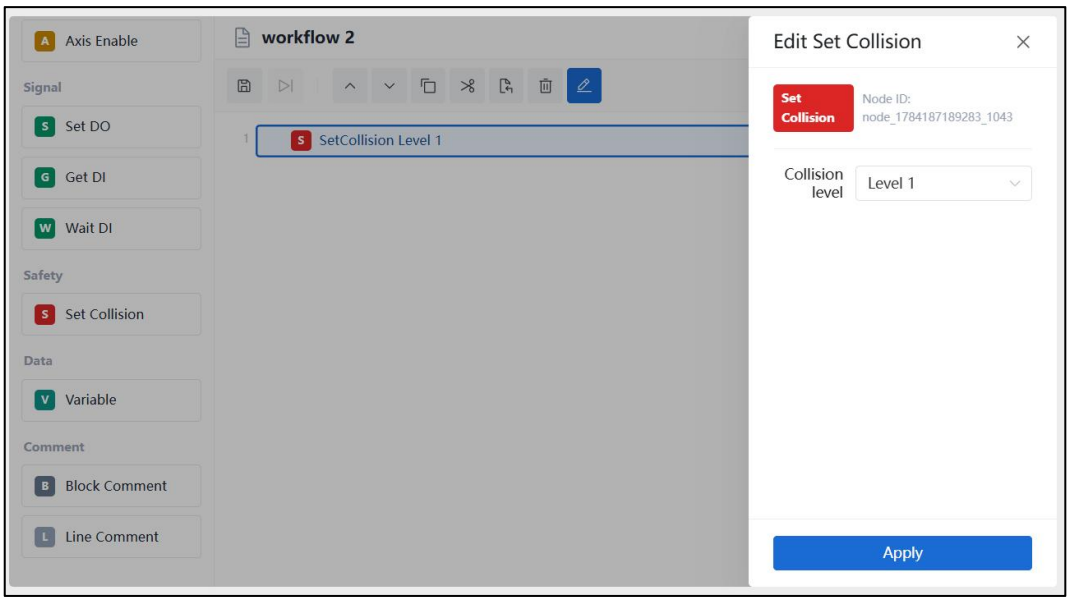


Figure 8.4.6.1-1 Set Collision Level Directive

8.4.7 Machine

8.4.7.1 Control Machine

Click "Control Machine Tool" to open the "Edit Control Machine Tool" interface on the right. Different execution action options will automatically match based on the selected machine tool communication method. The available actions are as follows:

- Processing Operation (Hide when the machine system is of the SYNTEC)
- Stop processing (Hide when the machine system is of the SYNTEC)
- Open the Door
- Close the door
- Clamp chuck tightened
- Release the chuck
- Emergency stop effective
- Stop and Exit
- Robot entry (Display when the machine system is of the SYNTEC)
- Shipment completed (Display when the machine system is of the SYNTEC)

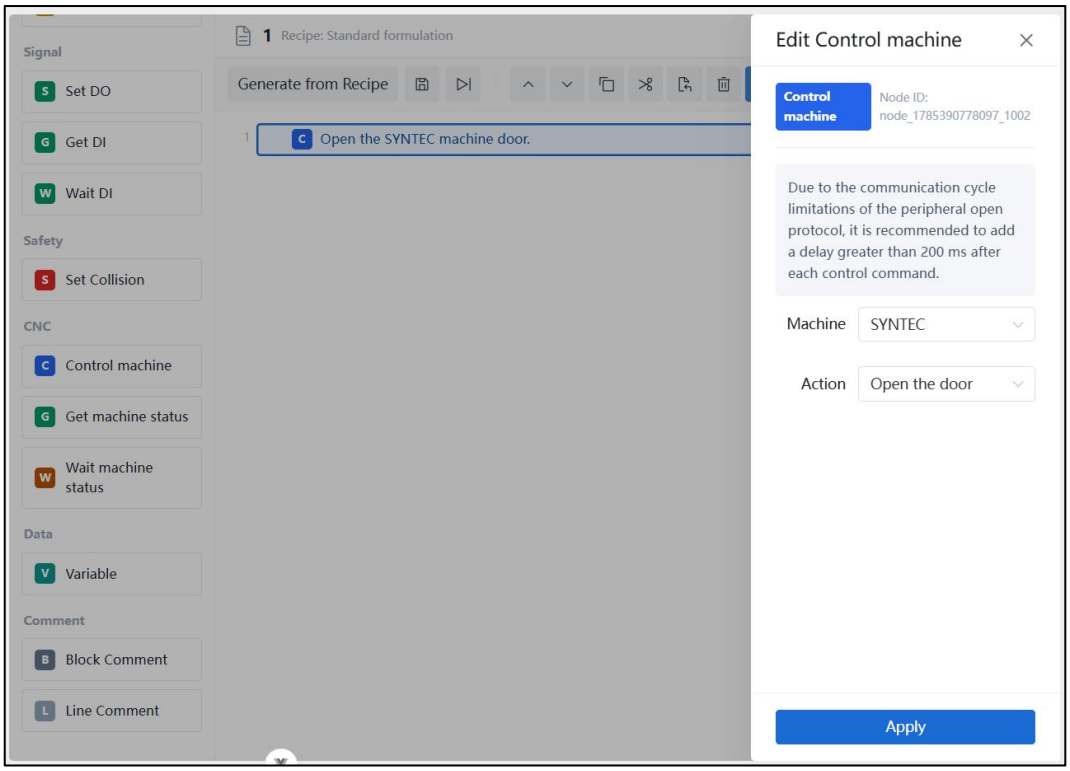


Figure 8.4.7.1-1 Machine – Controlling Machine Instructions

8.4.7.2 Get Machine Tool Status

Click "Get Machine Tool Status" to open the "Edit Get Machine Tool Status" interface on the right. Different action options will automatically appear based on your selected machine tool communication method. Enter the name of the variable to assign the retrieved machine tool status. The actions are as follows:

- Get the current status of the machine tool
- Get Operation Status
- Get Access Status
- Get Disk Status
- Get emergency stop status
- Get Alarm Status
- Get the delivery request status (displayed when the machine tool system is of the SYNTEC and uses a SYNTEC protocol)
- Get the material delivery positioning status (displayed when the machine tool system is of the SYNTEC and uses a SYNTEC protocol)

- Get the security screen status (displayed when the machine tool system is of the Get the security screen status (displayed when the machine tool system is of the SYNTEC and uses a SYNTEC protocol)

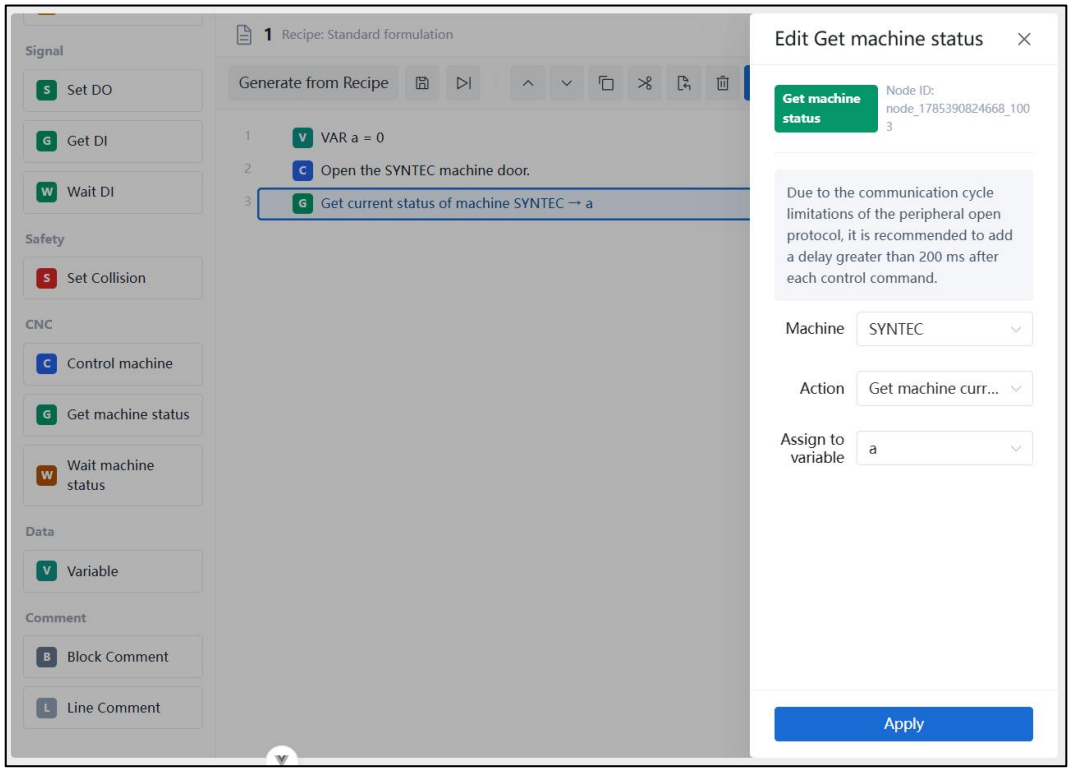


Figure 8.4.7.2-1 Machine – Obtain Machine Status Instructions

8.4.7.3 Waiting for machine status

Click "Wait for Machine Tool Status" to open the "Edit Wait for Machine Tool Status" interface on the right. Different execution action options will automatically appear based on the selected machine tool communication method. Select the target status for each execution action. For timeout scenarios, choose either "Wait Forever" or "Timeout Time"; selecting "Timeout Time" will display an input field. Timeout strategies include "Stop with Error" or "Continue Operation". The available execution actions are as follows:

- Machine operation status: Select stop/machining status.
- Machine tool chuck status: Select loose/tightened state.
- Wait for feeding request status (displayed when the machine tool system is of the SYNTEC and uses a SYNTEC protocol): Select failure/success status of the feeding request.

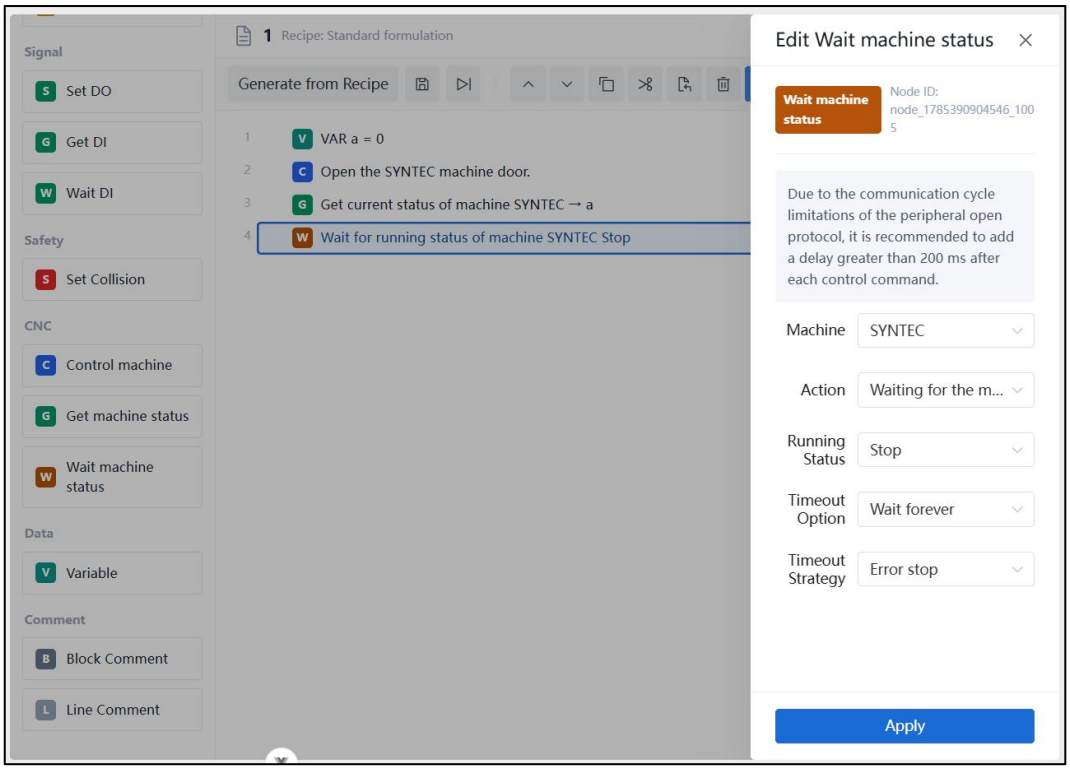


Figure 8.4.7.3-1 Machine – Waiting for a machine status command

8.4.8 Data

8.4.8.1 Variable

Click Variable to open the Edit Variable interface on the right.

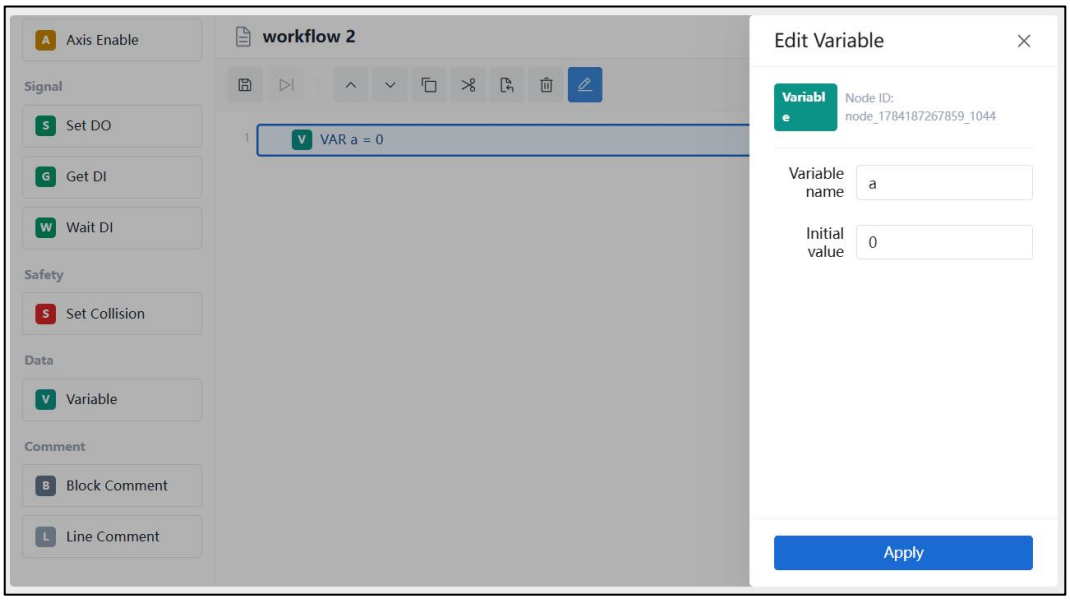


Figure 8.4.8.1-1 Variable Instruction

8.4.9 Comment

8.4.9.1 Block Comment

Click "Block Comment" to open the "Edit Block Comment" interface on the right. After entering the annotation content, add instructions below it to facilitate understanding of the workflow content later.

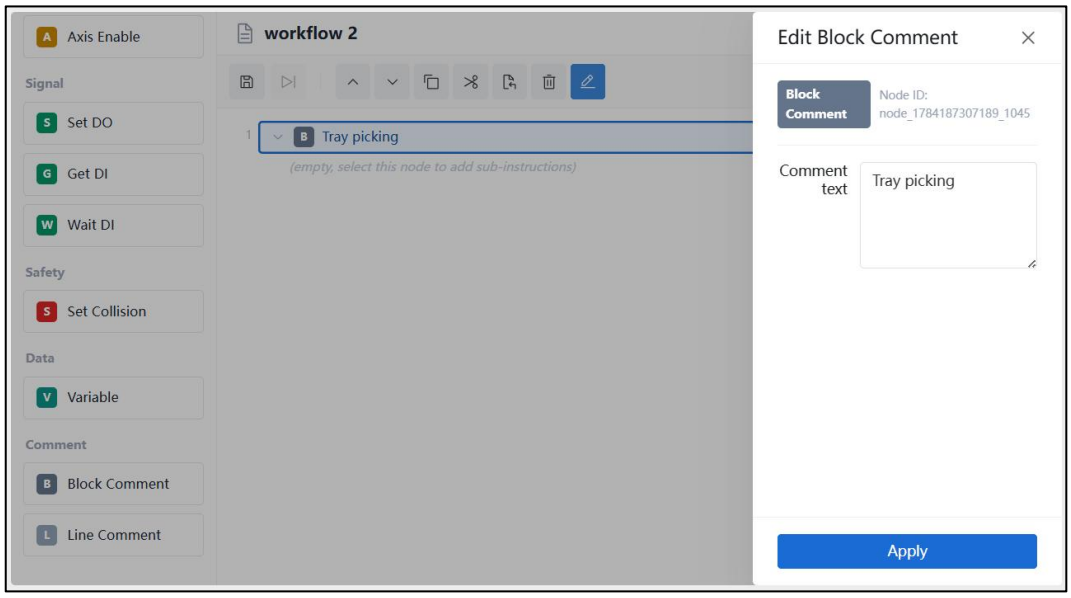


Figure 8.4.9.1-1 Block Comment

8.4.9.2 Line Comment

Click "Line Comment" to open the "Edit Line Comment" interface on the right. After entering the commentary content, add instructions after this row commentary to facilitate understanding of the workflow content later.

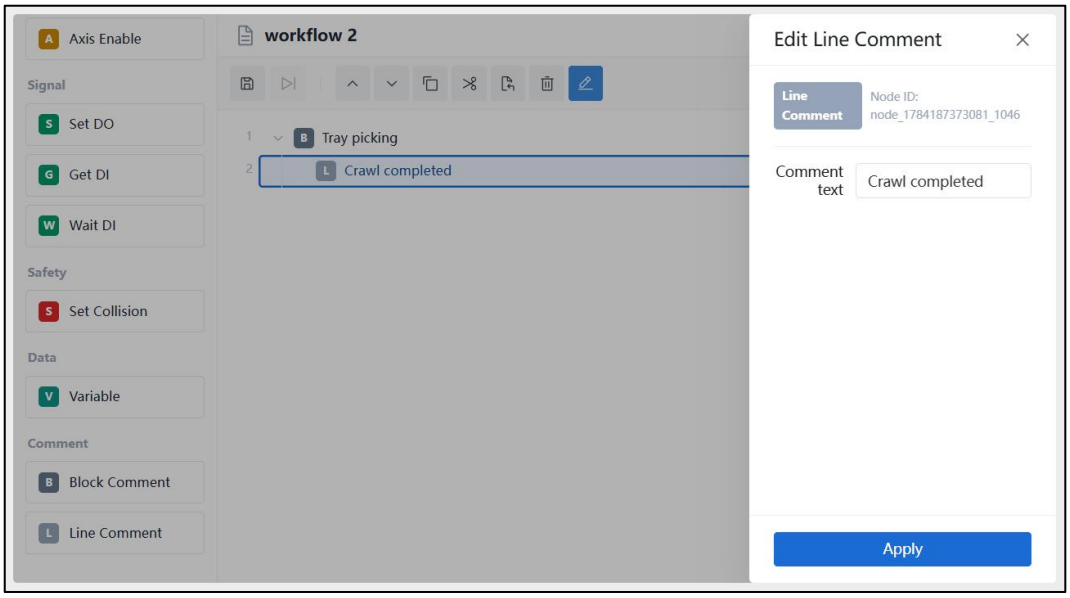


Figure 8.4.8.2-1 Line Comment

9 System

9.1 Data backup

Import and export backup packages containing loading/unloading formulas, points, workflows, and coordinate systems in System – Data Backup. Export is defaulted to.tcbk format, and imports only support this format.

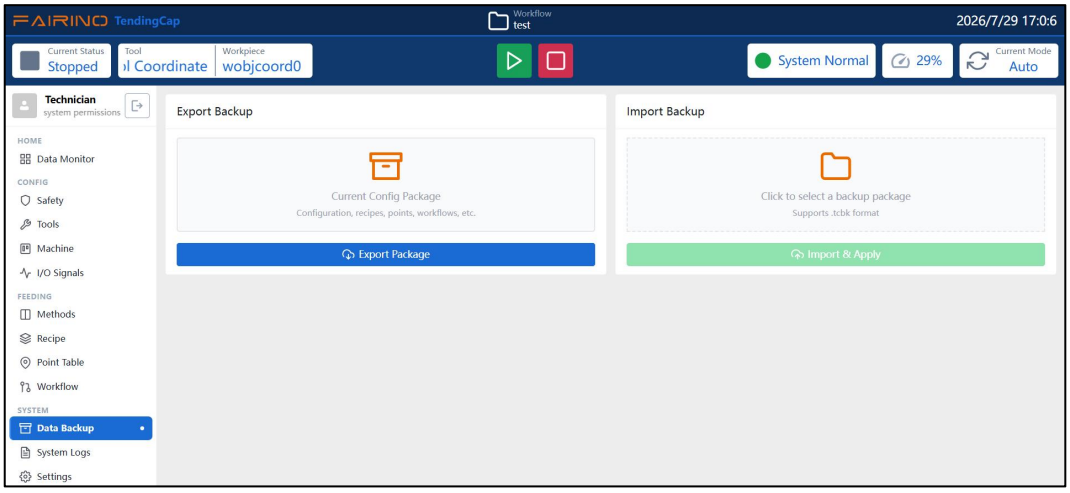


Figure 9.1-1 Data backup

9.2 System log

In "System – System Logs", view logs based on the returned date list; by

default, all types are displayed. Current types include: Operations, Warnings, and Errors. Enter keywords in the search box on the right to filter results.

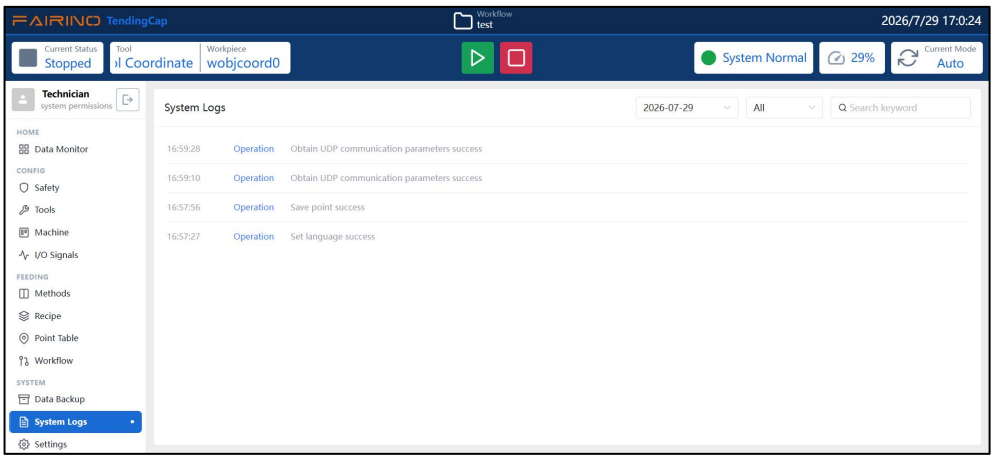


Figure 9.2-1 System log

9.3 System Settings

In "System – System Settings," you can find language switching (Chinese/English), access permission control, and one-click update of teaching points.

- Language Switch: Currently supports Simplified Chinese and English.
- Access control: Use the slider button to display and configure whether password protection is enabled for technicians accessing the page. When enabled, technicians can change their passwords and require two-factor authentication.
- One-click update of demonstration points: Update location data based on Joint/TCF.

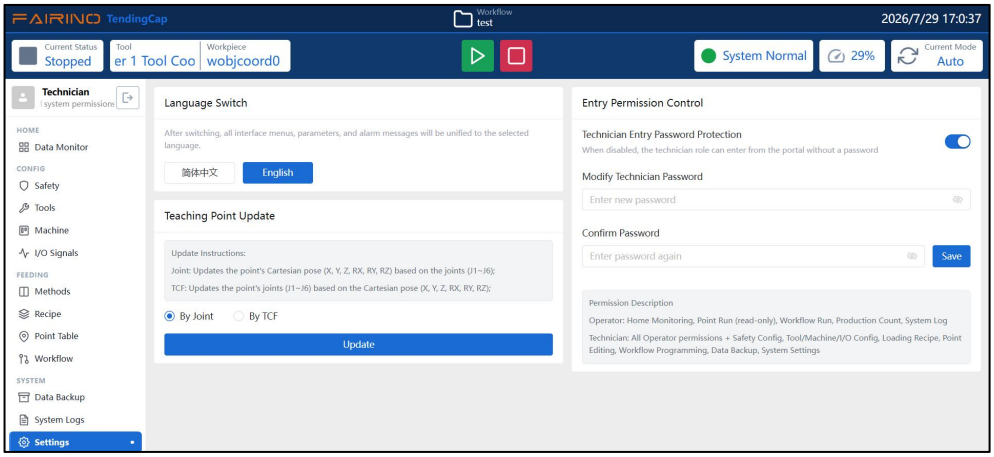


Figure 9.3-1 System Settings