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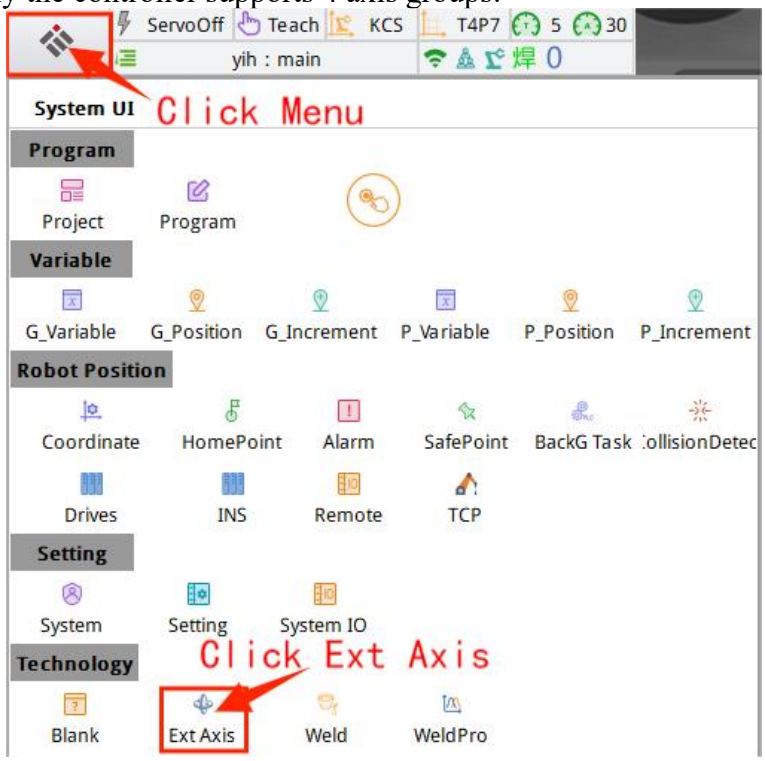
Contents

1. Process Description of the External Axis

The external axis cooperates with the robot, so that the workpiece displacement or displacement can reach the optimal working position of the robot, which can avoid the problems of insufficient arm length and unsatisfactory posture of the robot.

Currently the controller supports 4 axis groups:

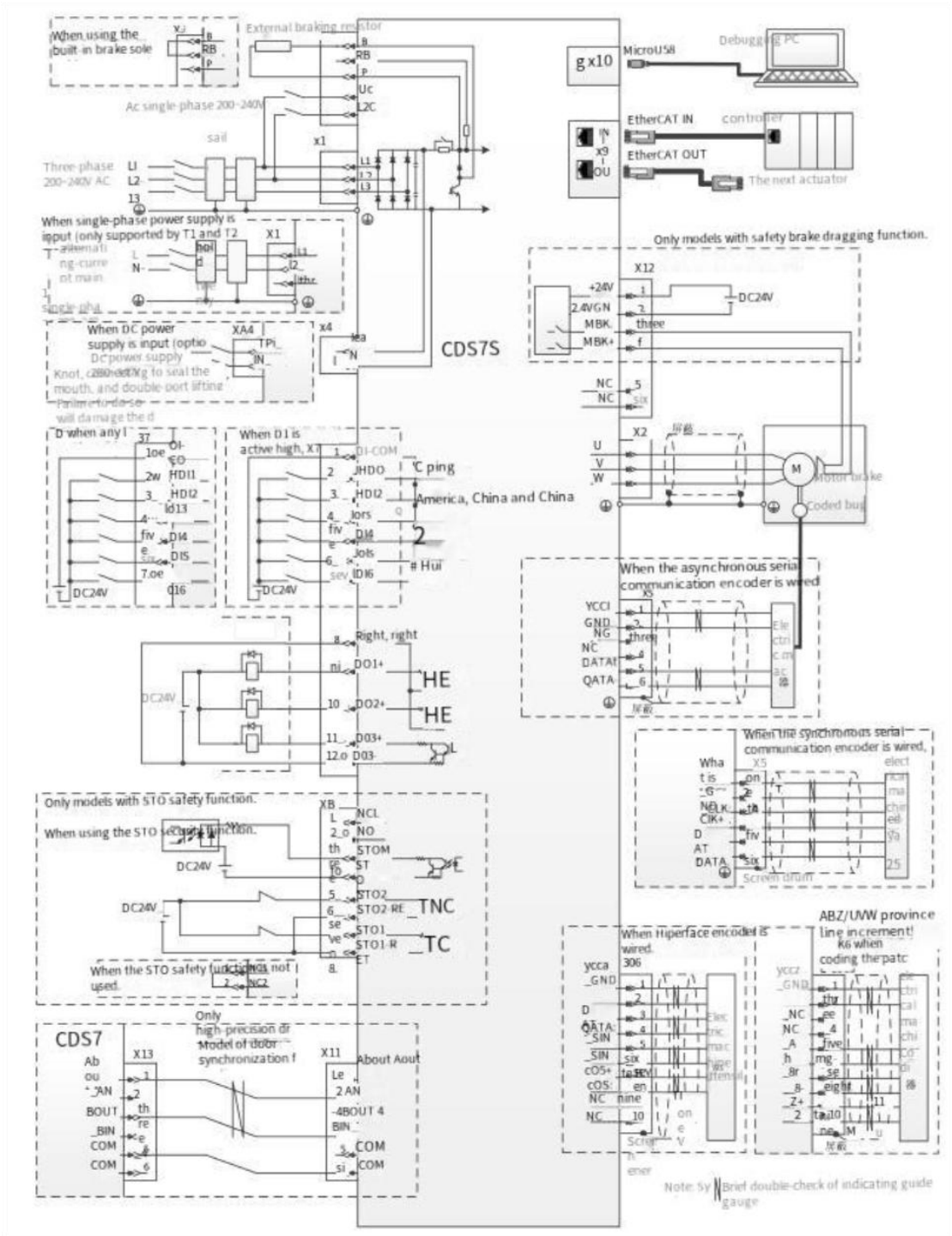


2. Preparation

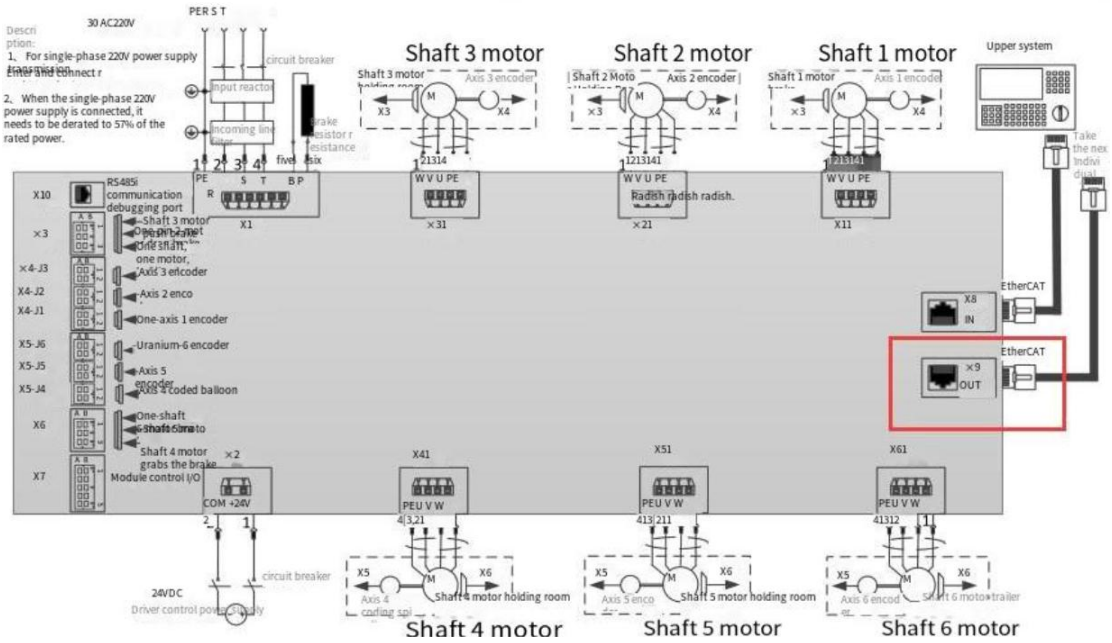
Take ″QingnengDechuang″ RC6+2 S7 standard 6-axis robot + dual-axis positioner as an example. For different drivers, please refer to the corresponding instructions or consult relevant technical support.

2.1 Driver Wiring Debugging

2.2 Driver Wiring

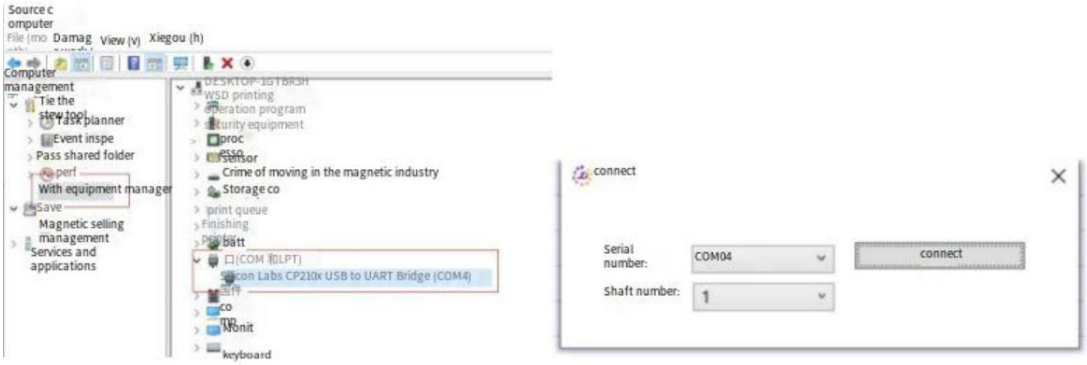


Connect the power wire, power wire, encoder wire and brake wire of S7 driver according to the wiring diagram. The EthercAT network cable comes out from the X9 port [0UT] of RC6 and connects to the next slave station in sequence (S7).

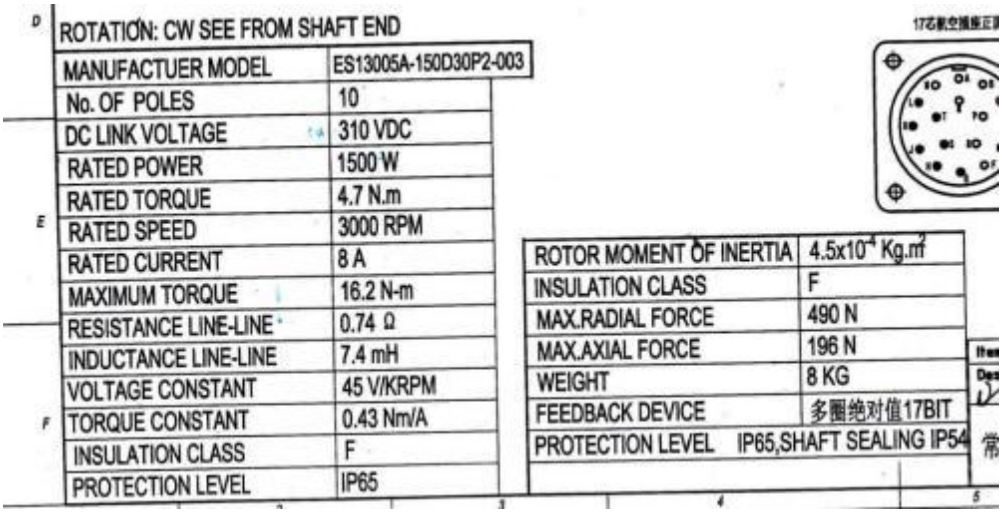


2.2.1 Driver Debugging

1. Use Qingneng Dechuang driver debugging software to connect the driver



2. Motor parameter setting



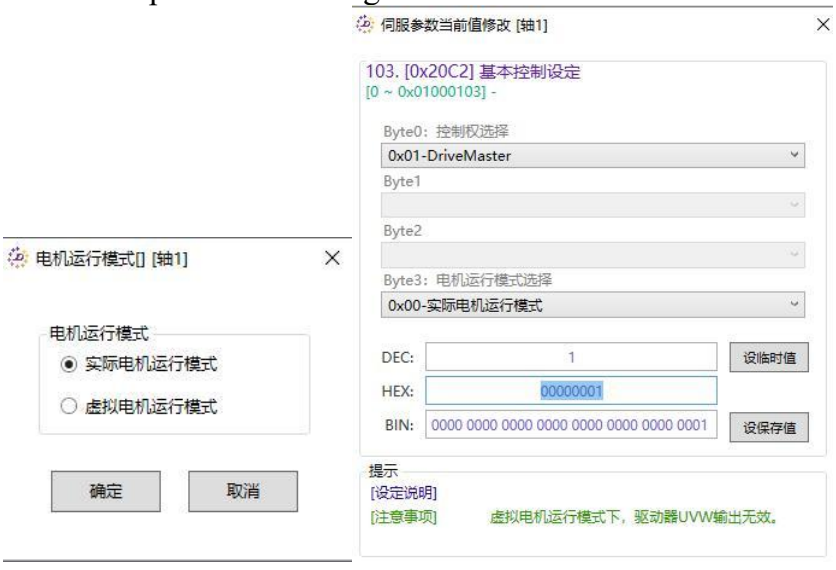
ROTATION: CW SEE FROM SHAFT END	
MANUFACTUER MODEL	ES13005A-150D30P2-003
No. OF POLES	10
DC LINK VOLTAGE	310 VDC
RATED POWER	1500 W
RATED TORQUE	4.7 N.m
RATED SPEED	3000 RPM
RATED CURRENT	8 A
MAXIMUM TORQUE	16.2 N-m
RESISTANCE LINE-LINE	0.74 Ω
INDUCTANCE LINE-LINE	7.4 mH
VOLTAGE CONSTANT	45 V/KRPM
TORQUE CONSTANT	0.43 Nm/A
INSULATION CLASS	F
PROTECTION LEVEL	IP65

ROTOR MOMENT OF INERTIA	$4.5x10^{-4}$ Kg.m^2
INSULATION CLASS	F
MAX.RADIAL FORCE	490 N
MAX.AXIAL FORCE	196 N
WEIGHT	8 KG
FEEDBACK DEVICE	多圈绝对值17BIT
PROTECTION LEVEL	IP65,SHAFT SEALING IP54

Change the parameters according to the motor manual, where the maximum torque: the maximum torque divided by the rated torque, multiplied by 1000 (the set value is a multiple of the rated torque); The maximum current of the motor is generally 3 times.

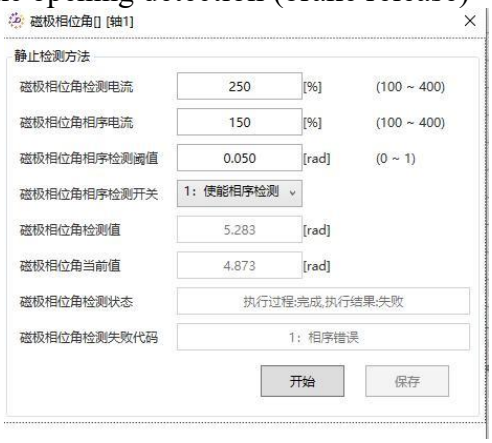
3. Encoder parameter settings

4. Basic control parameter settings



5. Magnetic pole phase angle

Static detection, the brake must be closed detection (the brake is closed). Dynamic detection, brake opening detection (brake release)



Select phase sequence detection to report an error, then switch UVW, the detection is successful, save the data and restart.

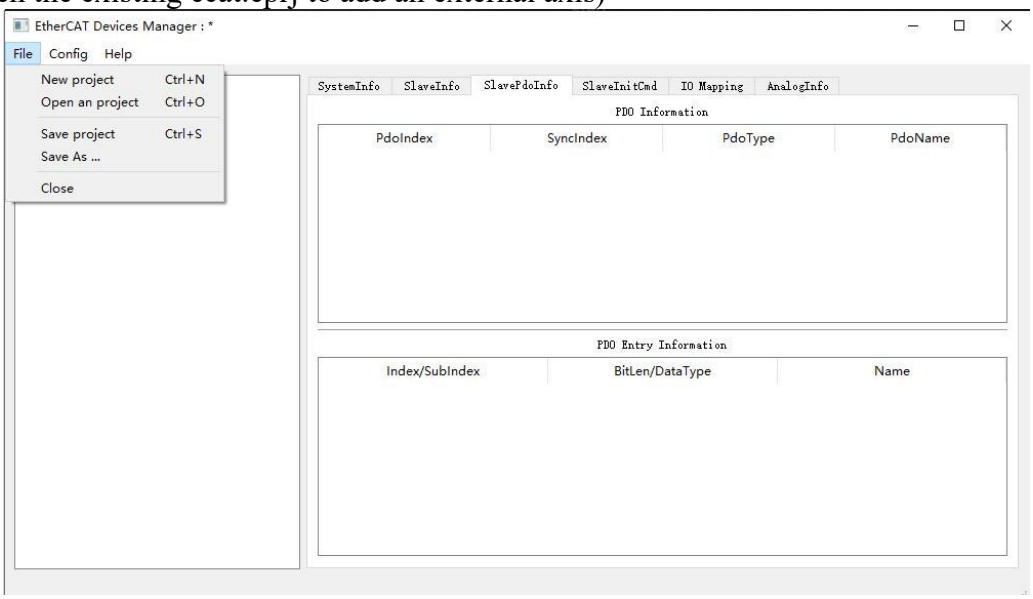
6. Trial running

Speed loop: enabled after writing, can be reversed forward

Position loop: According to reduction ratio 133.5854 * encoder resolution 8388608 (23 bits) = 1,120,595,555.

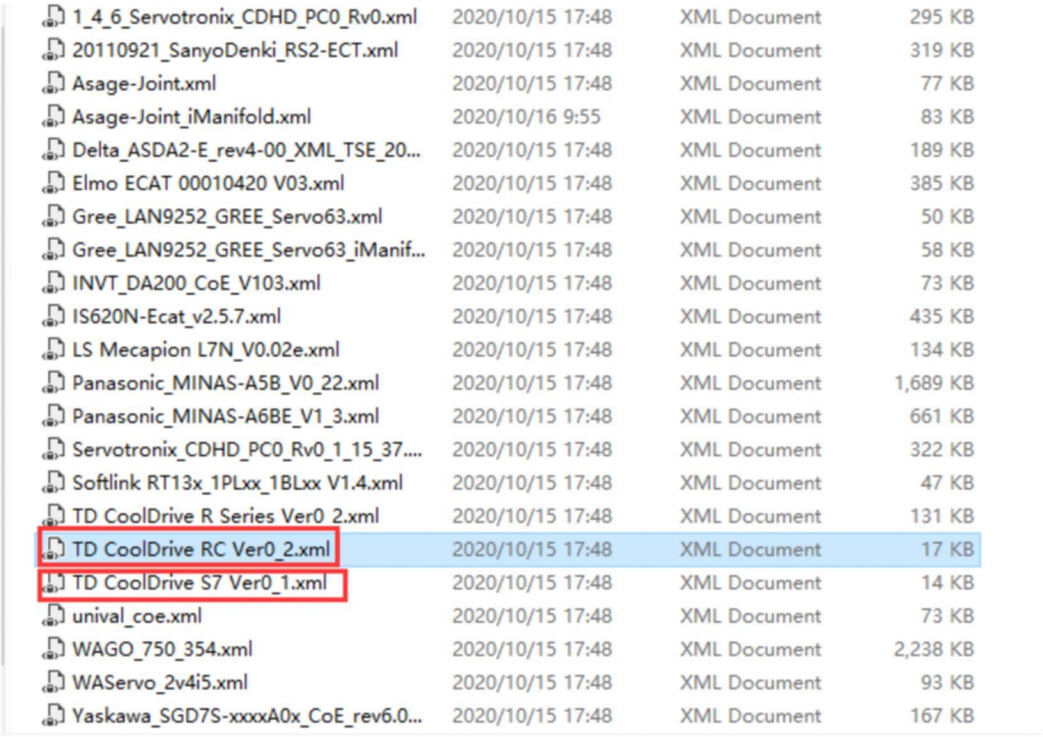
2.3 Modify the Controller Ethercat Configuration File

Open the software EtherCAT Devices Manager and create a new project (or open the existing ecat.eprj to add an external axis)

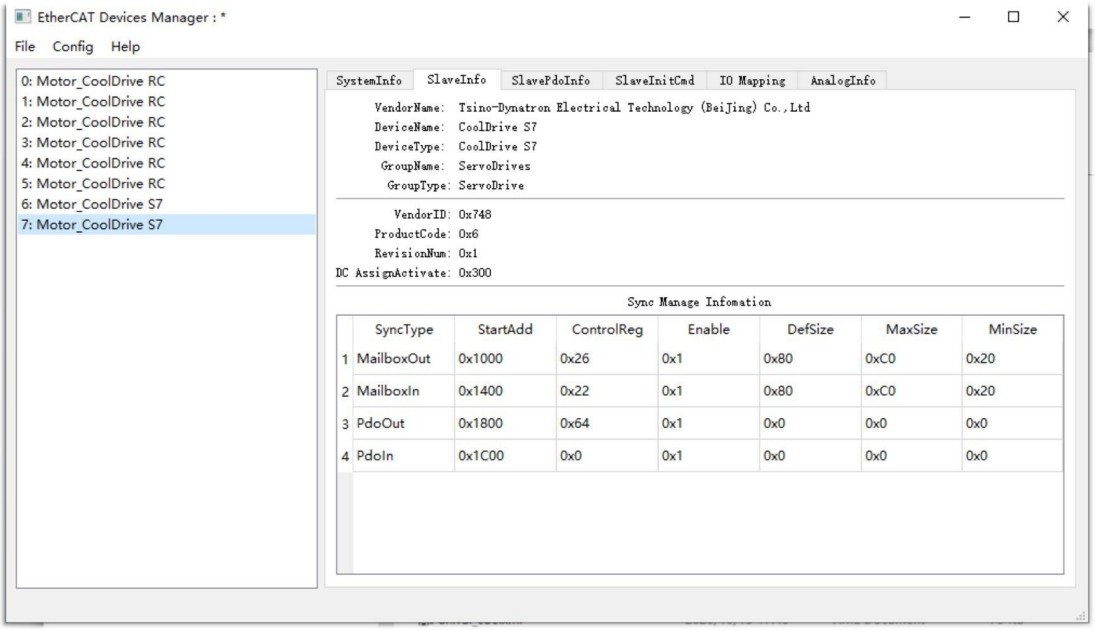


Right-click in the blank space to add

Select the corresponding device description file (xmI) and add it sequentially.

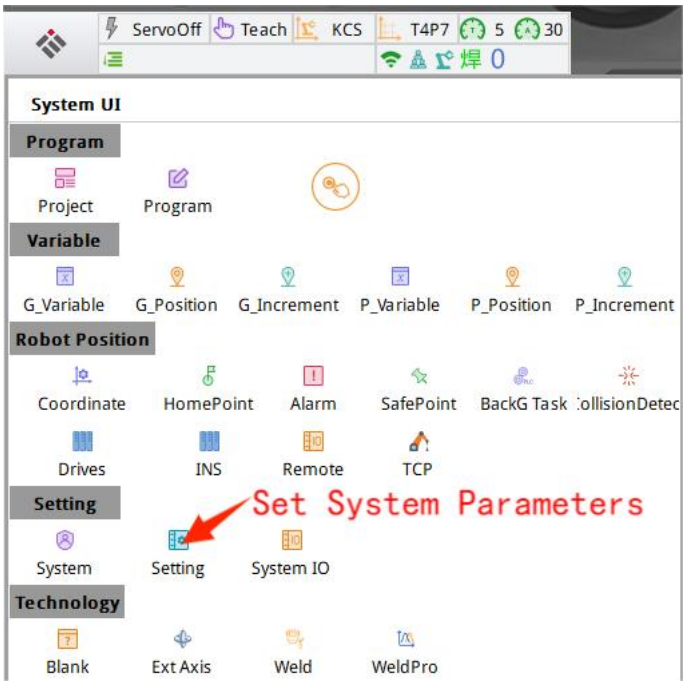


1_4_6_Servotronix_CDHD_PC0_Rv0.xml	2020/10/15 17:48	XML Document	295 KB
20110921_SanyoDenki_RS2-ECT.xml	2020/10/15 17:48	XML Document	319 KB
Asage-Joint.xml	2020/10/15 17:48	XML Document	77 KB
Asage-Joint_iManifold.xml	2020/10/16 9:55	XML Document	83 KB
Delta_ASDA2-E_rev4-00_XML_TSE_20...	2020/10/15 17:48	XML Document	189 KB
Elmo ECAT 00010420 V03.xml	2020/10/15 17:48	XML Document	385 KB
Gree_LAN9252_GREE_Servo63.xml	2020/10/15 17:48	XML Document	50 KB
Gree_LAN9252_GREE_Servo63_iManif...	2020/10/15 17:48	XML Document	58 KB
INVT_DA200_CoE_V103.xml	2020/10/15 17:48	XML Document	73 KB
IS620N-Ecat_v2.5.7.xml	2020/10/15 17:48	XML Document	435 KB
LS Mecapion L7N_V0.02e.xml	2020/10/15 17:48	XML Document	134 KB
Panasonic_MINAS-A5B_V0_22.xml	2020/10/15 17:48	XML Document	1,689 KB
Panasonic_MINAS-A6BE_V1_3.xml	2020/10/15 17:48	XML Document	661 KB
Servotronix_CDHD_PC0_Rv0_1_15_37....	2020/10/15 17:48	XML Document	322 KB
Softlink RT13x_1PLxx_1BLxx V1.4.xml	2020/10/15 17:48	XML Document	47 KB
TD CoolDrive R Series Ver0 2.xml	2020/10/15 17:48	XML Document	131 KB
TD CoolDrive RC Ver0_2.xml	2020/10/15 17:48	XML Document	17 KB
TD CoolDrive S7 Ver0_1.xml	2020/10/15 17:48	XML Document	14 KB
unival_coe.xml	2020/10/15 17:48	XML Document	73 KB
WAGO_750_354.xml	2020/10/15 17:48	XML Document	2,238 KB
WAServo_2v4i5.xml	2020/10/15 17:48	XML Document	93 KB
Yaskawa_SGD7S-xxxxA0x_CoE_rev6.0...	2020/10/15 17:48	XML Document	167 KB

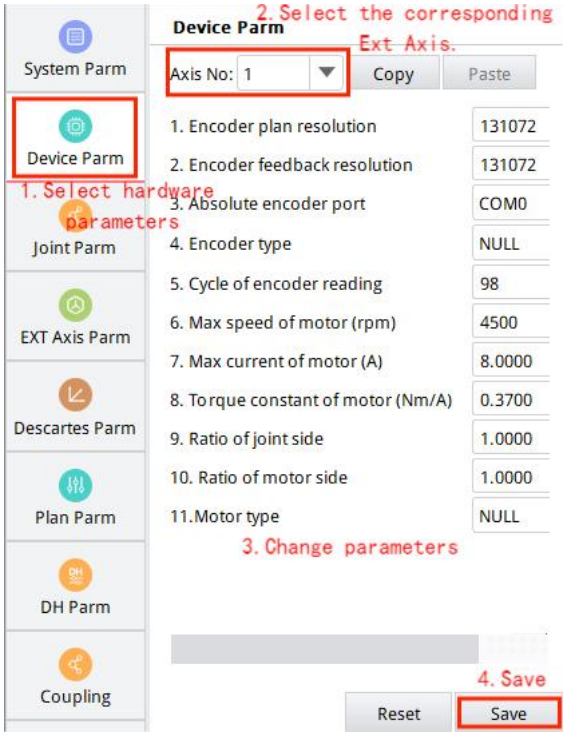


Save it as ecat.eprj and put it in the controller system/etc directory

2.4 Set System Parameters



2.4.1 Device Parameters



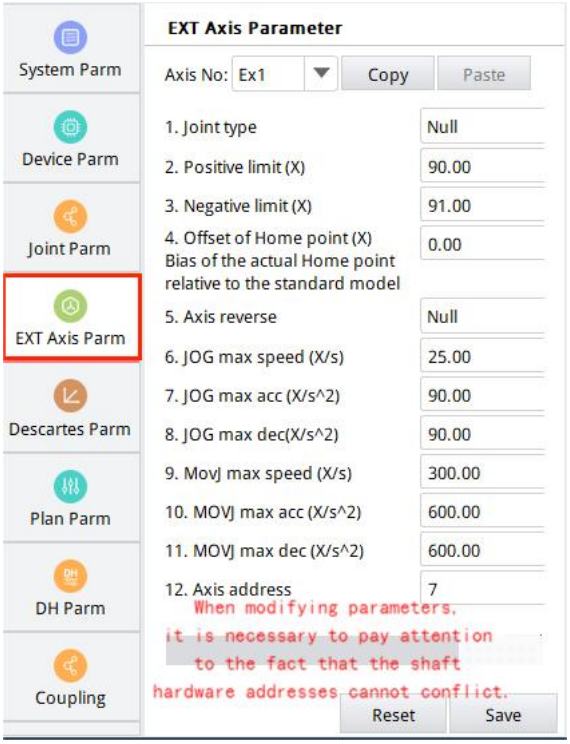
List of parameters:

No.	Parameter Name	Parameter description
1	Encoder planning resolution	Examples of encoder lines: the resolution of the 17-bit encoder is 131072; The 23-bit encoder has a resolution of 8388608
2	Encoder feedback resolution	
3	Read the absolute encoder port	Reserved parameters, not effective
4	Encoder type	Reserved parameters, not effective
5	Periodic read absolute encoders	Reserved parameters, not effective
6	Maximum motor speed (rpm)	The maximum speed of the motor is not allowed to exceed this speed during actual operation.
7	Maximum current of motor (A)	Reserved parameters, not effective
8	Motor Torque Constant(Nm/A)	Reserved parameters, not effective
9	Reduction ratio at the joint end	The ratio of the rotation angle of the motor end to the rotation angle of the actuator end (the allowable value is positive or negative to change the direction of joint movement)
10	Reduction ratio motor end	

Translation joint (mm) reduction ratio calculation method:

$$\frac{\text{Articular end}}{\text{Motor end}} = \frac{\text{Number of teeth} * \text{spacing between teeth}}{360 * \text{reduction ratio}}$$

2.4.2 EXT Axis Parm



List of parameters:

No.	Parameter Name	Parameter description
1	Type of joint	Not used; A rotating joint (deg); E.g. a positioner translation joint (mm); Such as guide rails
2	Positive joint limit	Maximum joint range of motion (soft limit)
3	Joint negative limit	Minimum joint range of motion (soft limit)
4	Joint zero offset	User defines the deviation value of the joint zero from the robot model zero within the system (the auxiliary axis defaults to.)
5	Joint reverse	User defines whether the rotation direction of the joint is opposite to the robot model in the system (the auxiliary axis is invalid by default)
6	Joint JOG Maximum Speed	Maximum movement speed of jog axis operation key in joint coordinate system
7	Joint JOG Maximum Acceleration	Maximum value of motion acceleration of jog axis operation key in joint coordinate system
8	Joint JOG maximum deceleration	Maximum motion deceleration of jog axis operation key in joint coordinate system
9	Maximum speed of joint movement	MOVJ command joint motion speed maximum
10	Maximum acceleration of joint motion	MOVJ command joint acceleration maximum
11	Maximum deceleration of joint motion	MVJ command joint motion deceleration maximum
12	Axis hardware address	The station number used for bus communication must match the settings of the host computer (one servo drive

		with multiple motors needs to be changed when it is out of sequence)

Supplementary Instructions for Parameter Setting:

1. Formula for calculating the maximum speed of joint movement:

The maximum speed of joint movement = the maximum speed of the motor 6 / reduction ratio.

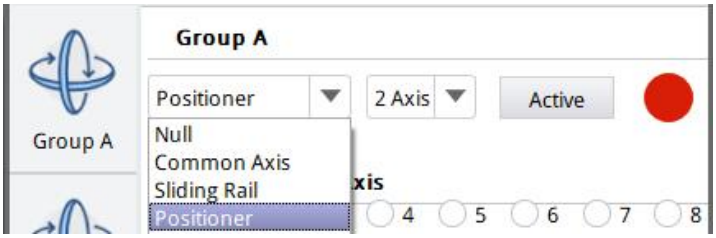
2. The maximum acceleration / deceleration is generally set to 5 times the maximum speed, if the acceleration / deceleration is too large, there is jitter, it will be reduced, and if the speed does not go up, it will be increased. The adjustment range is 310 times the maximum speed, which is adjusted according to the actual movement effect.

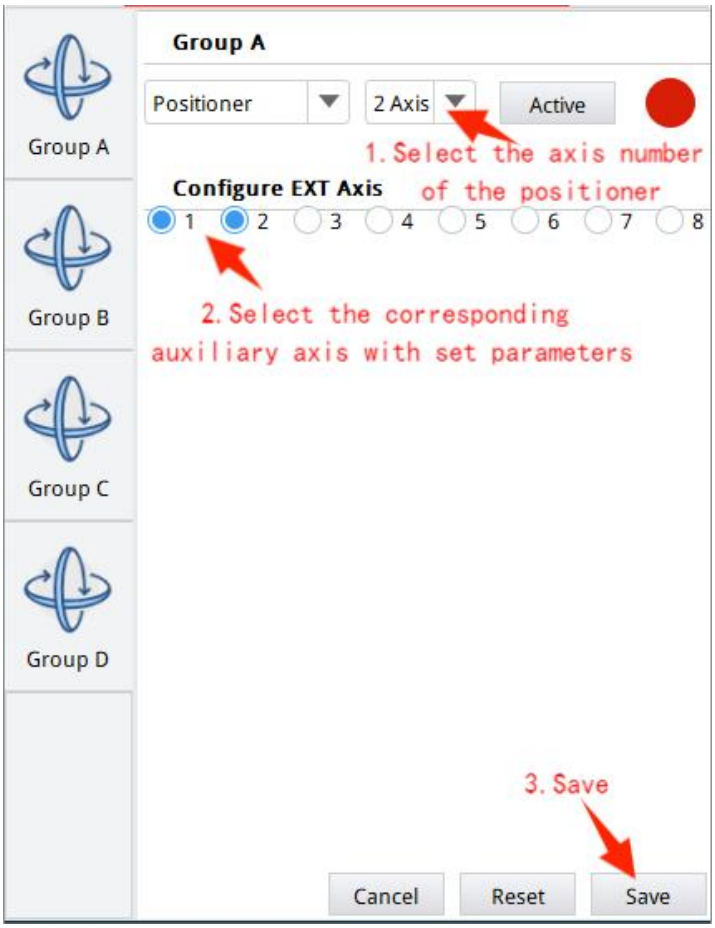
3. JOG speed is set to a small value (about one-tenth of the maximum speed of joint movement) for manual speed setting, and then adjusted according to the actual movement effect.

3. Positioner Usage Process

3.1 Set the Axis Group

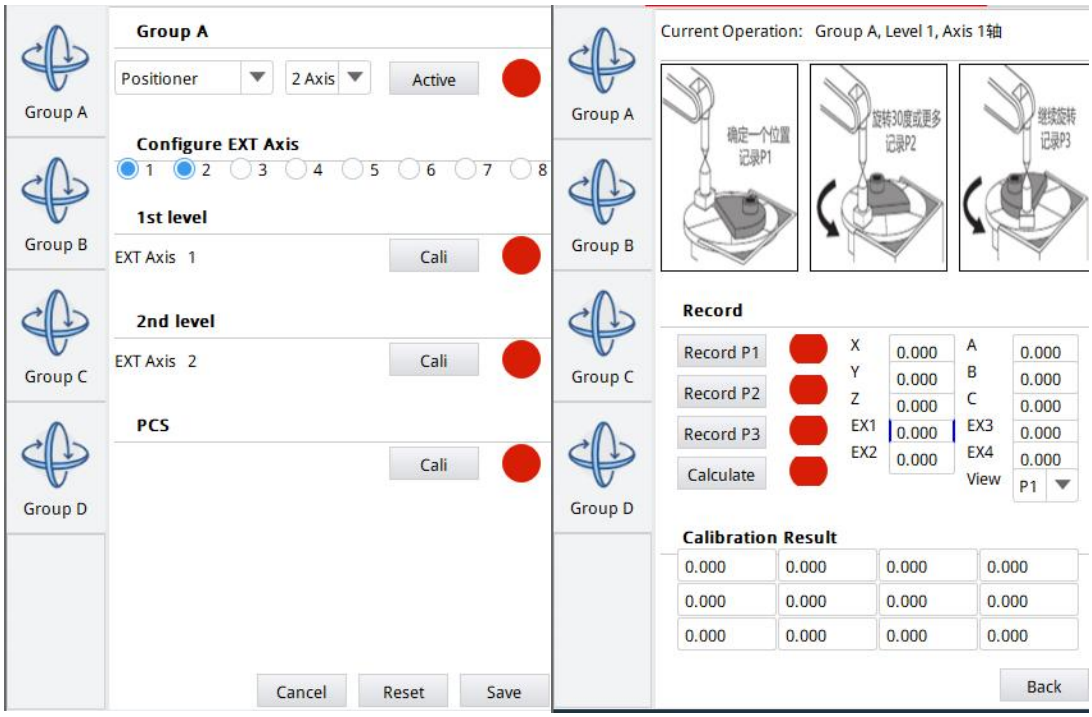
3.1.1 Select Axis Group and Axis Number





3.1.2 Calibration Auxiliary Axis

The configured auxiliary axis number should correspond to the axis number in (System Parameters).



The robot system needs to be calibrated to obtain the spatial pose of the auxiliary axis in the basic coordinate system of the robot. We choose a tip fixed on the external axis to represent the position point P1. This point has the following characteristics: this point changes its spatial position with the rotation of the auxiliary axis, and the rotation of other auxiliary axes will also change the position of this point in space. Therefore, during the calibration process of this step, only the position of the auxiliary axis that needs to be calibrated can be changed when recording P1, P2 and P3, and other axes cannot be changed.

1. Move the TCP point teaching at the end of the robot tool to point P1, and press and click the "Record P1" button while keeping the servo enabled until the status indicator next to it turns green to complete the recording of point P1;

2. Remove the robot TCP point, then rotate the auxiliary axis by a certain angle (the rotation is greater than 30° or the moving distance exceeds 100mm), so that the p1 position point rotates to the P2 position point, and move the TCP point at the end of the robot tool to the P2 point. In the servo enabled state, press and click for a long time the "Record P2" button to complete the recording of point P2;

3. Remove the robot TCP point, then rotate the auxiliary axis by a certain angle (the rotation is greater than 30° or the moving distance exceeds 100mm), so that the p1 position point rotates to the P3 position point, and move the TCP point at the end of the robot tool to the P3 point. In the servo enabled state, press and hold the "Record P3" button to complete the recording of the P3 point.

After recording the three position points, click Calculate to obtain the position and direction information of the current axis in the robot coordinate system. After calculating the current axis, use the same steps to calculate the position and direction information of the second axis.

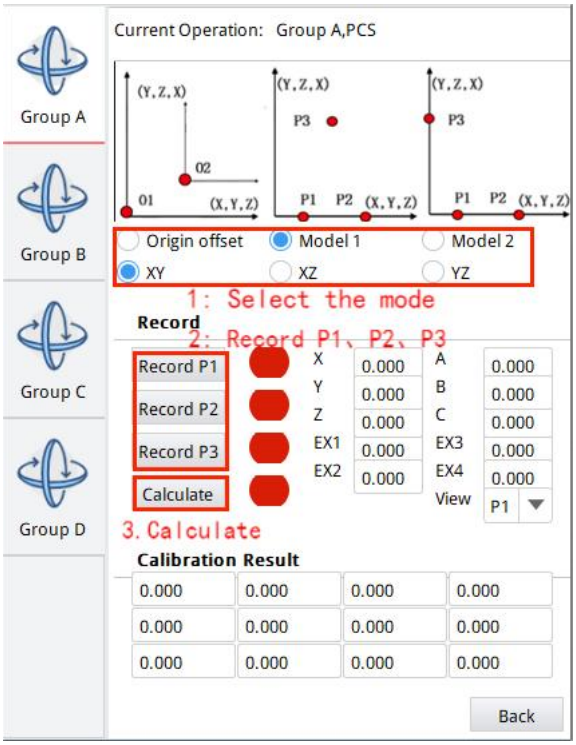
Special attention should be paid to:

1. In order to make the calibration of the auxiliary axis as accurate as possible, the three points P1, P2, and P3 should be separated as much as possible: the rotation is greater than 30° or the movement distance exceeds 100mm.

2. You can only change the rotation angle of the axis that needs to be calibrated, and cannot move other axes.

3. If it is interrupted during the calibration process, the calculation needs to be started from the first auxiliary axis. For example, when two auxiliary axes are calibrated, after the first auxiliary axis is calibrated (calculation is completed), the system restarts and continues to calibrate. The first-level auxiliary axis should be calculated first, and the second-level auxiliary axis can only be calculated after the calculation is completed, otherwise the calculation will Report an error.

3.1.3 Calibrate User Coordinates (Workpiece)

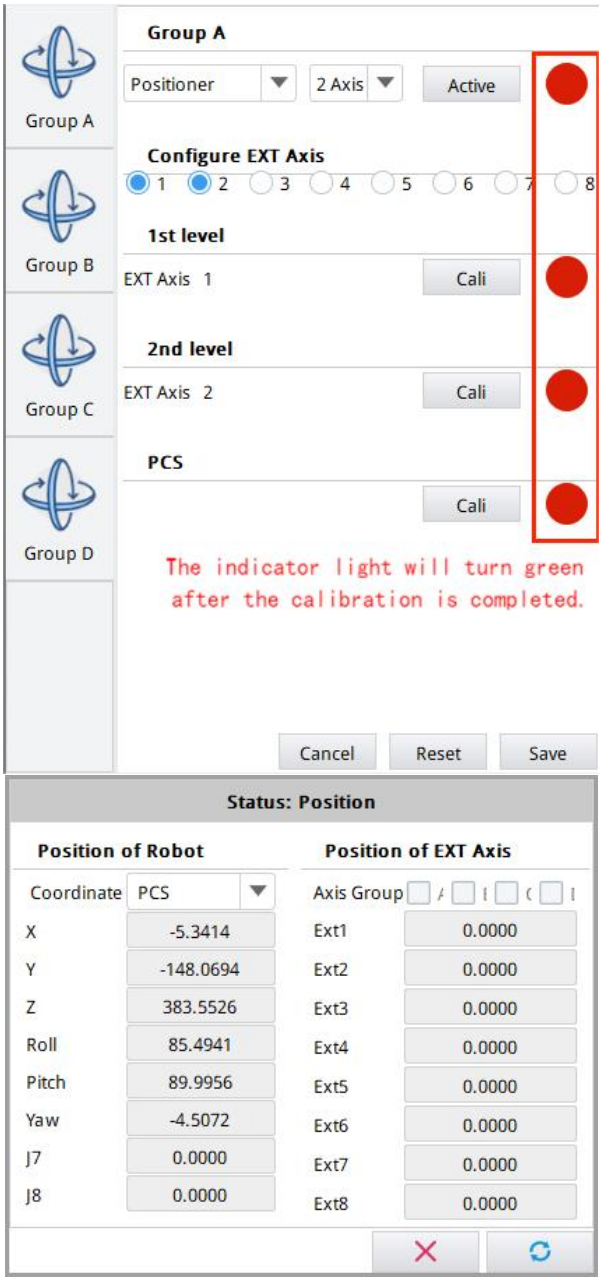


Once all the external axis position orientation information has been calculated, a user workpiece coordinate system needs to be established at the end of the positioner. The calibration user coordinates are the same as the coordinate system of the calibration robot workpiece, if you have any questions, please refer to the *Intelligent Manifold Control System User Manual*. Note: During this step of calibration, P1, P2 and P3 cannot move any auxiliary axes when recording.

3.2 Activation Verification

When all auxiliary axes and workpiece coordinate systems have been calibrated, return to the axis group interface, click [Activate] to show that the light turns green, and the user can start using the displacement system normally. If the robot wants to execute an accurate trajectory on the positioner system, it needs to record the taught position points in the user coordinate system. If the trajectory executed by the robot has nothing to do with the positioner system, that is, the positioner system and the robot system are independent of each other. For movement, the taught position points can be recorded in other coordinate systems at this time.

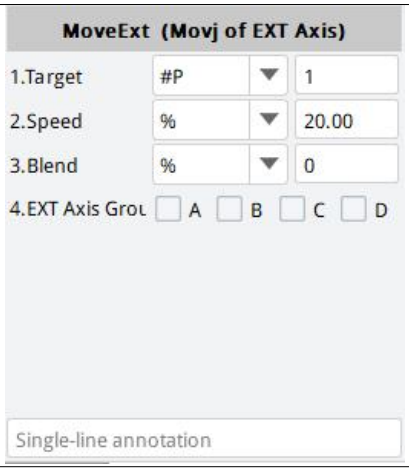
The changing PCS coordinate system represented by the four axis groups of ABCD corresponds to the coordinate system No.29-32 of the workpiece coordinate system of the system respectively. For example, the A-axis group is activated, and the workpiece coordinate system 29 is activated as the current workpiece coordinate system by default.



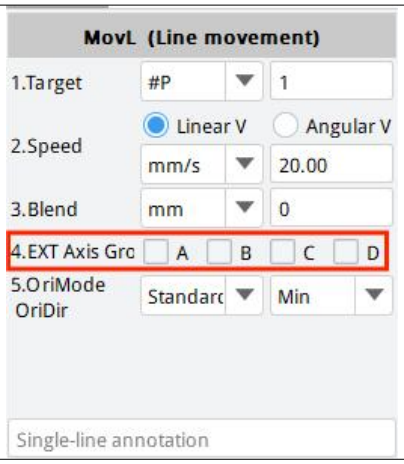
After activating the axis group of the positioner, the movement of the positioner is controlled, and the robot can follow up with the positioner in a stationary state. In this way, whether the data of the calibration coordinate system is correct can be verified.

4. External axis Command

4.1 MoveExt External axis Joint Motion

Instruction format	MoveExt P = pointV = speed% [BI = Blend%] [Ext = [A-0]	
Settings interface		
Example	MoveExtP = # p1V = 20% Ext = A	
Parameter description	Target point	Point: Target Point, using only the part related to the external axis.
	Velocity	speed: percentage of synthesized speed at the end of the joint space, speed =% * maximum synthesized speed at the end of the joint space.
	Transition section	Blended: percentage of joint space transition radius, transition radius =% * total length of joint space trajectory.
	Axis set	Ext: The number of the external axis group that needs to be moved, the values are A, B, C, D. Whether the robot moves synchronously depends on whether the starting position points PCS are the same (synchronization is only effective for the PCS position points).

4.2 MovL Linear Motion

<table>
<tr><td>Instruction format</td><td colspan="2">Movl P = point V = speed% [BI = Blend%] [Ext = [A-0]</td></tr>
<tr><td>Settings interface</td><td colspan="2"> 
</td></tr>
<tr><td>Example</td><td colspan="2">MoveExt P = # P1 V = = 20% Ext = A</td></tr>
<tr><td rowspan="4">Parameter description</td><td>Target point</td><td>Point: Target Point, using only the part related to the external axis.</td></tr>
<tr><td>Velocity</td><td>speed: The synthesis speed at the end of the joint space, speed =% * the maximum synthesis speed at the end of the joint space. Values are from 1 to 100, and the default value is 20.</td></tr>
<tr><td>Transition section</td><td>Blended: joint space transition radius, transition radius =% * total length of joint space trajectory.</td></tr>
<tr><td>Axis set</td><td>The number of the external axis group that needs to move synchronously, the values are A, B, C, and D. Supports multi-axis group linkage (synchronization only takes effect on PCS position points. When multi-axis group independent positioners are linked, the linkage axis group needs to record the points in the corresponding PCS coordinate system), and axis groups A-D correspond to fixed PCS29-32.</td></tr>
</table>

4.3 MovJ Linear Motion

<table>
<tr><td>Instruction format</td><td colspan="2">Movj P = point V = speed% [BI = Blend%] [Ext = [A-0]]</td></tr>
<tr><td>Settings interface</td><td colspan="2"> 
</td></tr>
<tr><td>Example</td><td colspan="2">MoveExt P = # P1. V = 20% Ext = A</td></tr>
<tr><td rowspan="4">Parameter description</td><td>Target point</td><td>Point: Can be joint space or Cartesian space Point</td></tr>
<tr><td>Velocity</td><td>speed: The synthesis speed at the end of the joint space, speed =% * the maximum synthesis speed at the end of the joint space. Values are from 1 to 100, and the default value is 20.</td></tr>
<tr><td>Transition section</td><td>Blended: joint space transition radius, transition radius =% * total length of joint space trajectory.</td></tr>
<tr><td>Axis set</td><td>Ext requires the external axis group number of synchronous motion, and the values are A, B, C, and D. For Movj, there is only the synchronous motion planning of the robot and the external axis, but there is no strict position following planning. The speed of the external axis is the smaller value of the robot movement speed and the maximum allowable speed of the external axis, and there is no need to set the speed of the external axis separately.</td></tr>
</table>

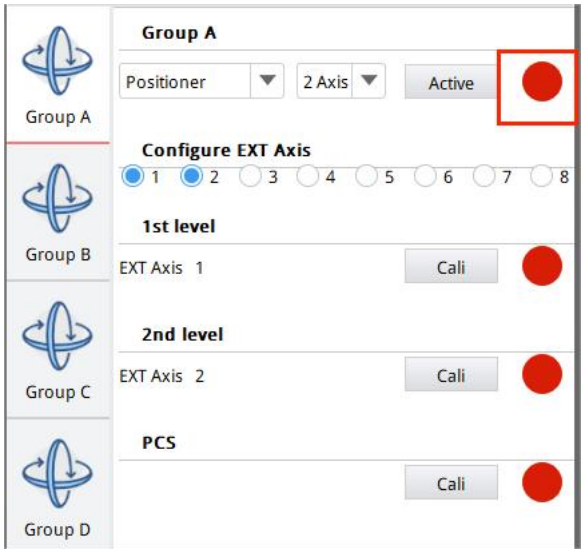
5. Instructions for Use of External Axis

1.For external axis versions above 1.11.1, click the floating button [Ext] to select the external axis group, and the inserted motion command will automatically check the external axis. It is now possible to switch in the enabled state.

2.View the currently selected external axis 

3.Engineering position points will be forcibly recorded in the workpiece coordinate system corresponding to the current axis group. Axis group A corresponds to workpiece coordinate system No. 29, B corresponds to workpiece coordinate system No. 30, C corresponds to workpiece coordinate system No. 31 and D corresponds to workpiece coordinate system No. 32. If 0 is selected, the point is recorded in the currently selected coordinate system  .

4. The external axis linkage can now only be activated in the external axis process.



5. Two ways to move the external axis in the teaching mode

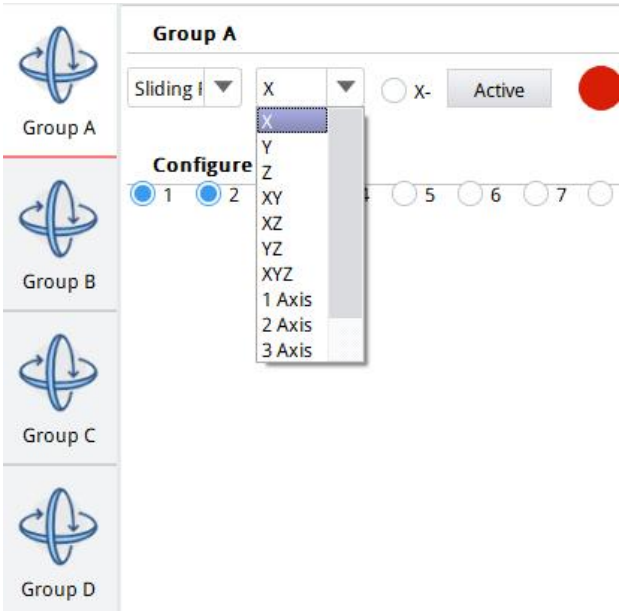
5.1 The floating menu is switched to the auxiliary axis by handheld operation of the [fn2] key on the teaching pendant (at this time handheld [J1]-[J8] represent the external auxiliary axis). 

5.2 Press and hold [Up] + [J1]-[J8] to move the external axis

6. Guide Rail

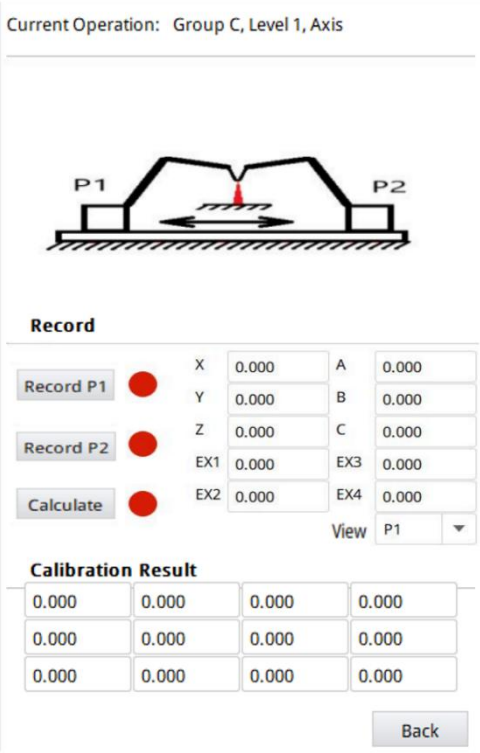
The usage process is the same as that of the positioner, and there is more direction choice when selecting the number of axes.

If the installation direction of the guide rail is the same as the direction of the robot coordinate system KCS, select the corresponding direction (XYZ as shown in the figure below) and the auxiliary axis, and then click (Save) at the bottom right.



If the direction of the guide rail is inconsistent with the KCS, calibration is required.

Move the guide rail, align the tip with the tip of the robotic tool at both sides of the tip and record the position.



7. Ordinary Axis

The axes that do not require robot cooperation can be set as ordinary axis groups and used by instructing MoveExt.

8. Teaching cases

The positioning machine and the guide rail are linked with the robot respectively

Configure axis group A (guide rail) and axis group B (positioner). All teaching points should be stored in a fixed coordinate system. It is recommended to use the workpiece coordinate system PCS calibrated during calibration. Check it when recording points (binding the current coordinate system during recording is convenient for operation.

PROGRAM set speed vel = 2% Mov l P = p1 V = 5mm/s Ext = A set speed vel = 60%; Movl P = p1 V = 100 mm/s Ext = B; Movl P = p2 V = 100 mm/s Ext = B; Movl P = p3 V = 100 mm/s Ext = B; Movl P = p4 V = 100 mm/s Ext = B; Movl P = p5 V = 100 mm/s Ext = B; Movl P = p2 V = 100 mm/s Ext = B; MOVC P = p4 M id = p5 V = 100 mm/s Ext = B; MOVC P = p2 M id = p3 V = 100 mm/s Ext = B; Movl P = p1 V = 100 mm/s Ext = B; set speed vel = 2% Movl P = # p6 V = 5 mm/s Ext = A; set speed vel = 60%; Movl P = p1 V = 100 mm/s Ext = B; Movl P = p2 V = 100 mm/s Ext = B; Movl P = p3 V = 100 mm/s Ext = B; Movl P = p4 V = 100 mm/s Ext = B; Movl P = p5 V = 100 mm/s Ext = B; Movl P = p2 V = 100 mm/s Ext = B; MOVC P = p4 M id = p5 V = 100 mm/s Ext = B; MOVC P = p2 M id = p3 V = 100 mm/s Ext = B; Movl P = p6 V = 100 mm/s Ext = B; set speed vel = 2% Movl P = p1 V = 5 mm/s Ext = A; Movl P = p6 V = 5 mm/s Ext = A set speed vel = 40%; Movl P = p7 V = 100 mm/s Ext = A; MOVC P = p9 M id = p8 V = 100 mm/s Ext = A; MOVC P = p2 M id = p10 V = 100 mm/s Ext = A; Movl P = p1 V = 100 mm/s Ext = A; END PROGRAM	The end position of the robot remains unchanged, and the moving speed of the guide rail should be set lower to avoid overspeeding. P1 is the transition point. At the guide rail A, the robot is linked with the positioner to make linear motion and arc motion Return to the transition point The robot moves to guide rail B, and the end remains stationary Linkage with positioner to do linear motion and circular arc motion Linkage with the guide rail to make circular arc motion

9. Error Alarm

Error Code	Error messages	Error analysis	Solution
Ox80050001	ex it axis database open failed	External axis database opening failed	
ox80050002	ext axis config file open failed, id =% 1	Failed to open external axis interface configuration file, file number =% 1	
ox80050003	ext axis config files version d is match, id =% 1	External axis interface profile version mismatch, file number =% 1	
ox80050004	Ext axis cal i cube file open failed, id =% 1	External axis calibration file failed to open, file number =% 1	
ox80050005	ext axis calicube files version d is match, i d =% 1	External axis calibration file version mismatch, file number =% 1	
ox80050006	Read ext _ axis mod bus error	Failed to read external axis process modbus	
ox80050007	Write ext _ axis mod bus error	Failed to write external axis process modbus	
ox80050008	Write error ext _ axis ca l i cube result	Failed to write external axis calibration result to database	
ox80050009	Reset error ext _ axis ca l i cube result	Failed to reset database external axis calibration results	
OX8005000A	calicube process others ext axis changed	The position of other external axes change during calibration of this external axis	
ox8005000B	calicube points	Position distance between calibration points 1 and 2	
	1 and 2 d i stance too near	Being too close	
ox8005000c	calicube points coord are not WCS	The calibration point coordinate system is not WCS	
ox8005000D	calicube points 2 and 3 d distance too near	Calibration points 2 and 3 are too close together	
OX8005000E	calicube points 1 near and 3 distance too	Calibration points 1 and 3 are too close together	
ox8005000F	Calicube error: norm of vector is zero	Calculation failed: modulo of vector is zero, unitization failed	
ox80050010	calicube error: 3 point in line	Calculation failed: three points collinear, calculation failed to cross multiply	
Ox80050011	calicube error	Calculation failed	
ox80050012	Coord sys calculate error, divide by ZERO	The calculation failed, the divisor is.	
ox80050013	this mode not support	This mode is not yet	

		supported	
ox80050014	user coord Error	The user chose not to use the external axis user coordinate system, but the default value is wrong	
ox80050015	user coord not ca l i ed	User selected to use external axis user coordinate system, but not calibrated	
ox80050016	read system mod bus fa i led	Failed to read system modbus status	
ox80050017	cannot active ext ax is i n servo status	The enabled state cannot activate the external axis group	
ox80050018	cannot disactive ext axis in servo status	The enabled state cannot deactivate the external axis group	
ox80050019	active ext ax i s failed	Axis group activation failed	
ox8005001A	disactive ext ax is fa i led	Axis group deactivation failed	
OX8005001B	ext axis param is not set	Axis group parameter not set	