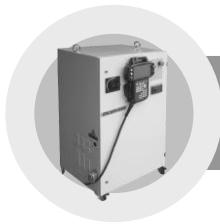# HYUNDAI
HEAVY INDUSTRIES CO.,LTD.

WARNING

THE INSTALLATION SHALL BE MADE BY QUALIFIED INSTALLATION PERSONNEL AND SHOULD CONFORM TO ALL NATIONAL AND LOCAL CODES

Hi5 Controller Function Manual

Positioner synchronization

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Introduction

Positioner synchronization function is the function that enables the robot to trace the operation of jig installed externally or to operate linear or arc form relative to the jig operation. External jig device applied to the positioned synchronization function is called the positioner, which is also called the station.

Challenging task from the limitation of the work area of the robot can be supplemented by using this function. That is, if the workpiece is fixed on the positioner and the positioner moves, the robot is designed to follow the movement of the positioner to execute linear or arc operation on the workpiece.

Specifications of key functions are as follows.

Key functional specification	Characteristic
Positioner group	Support 1~4 groups
Number of positioner axis	Support positioner of 1 axis and 2 axes (Rotating axis)
Interpolation method	Supports linear and arc interpolation
External input independent jog (SELSTN)	Positioner selected from auto mode supports jog operation function irrelevant from the robot
External input independent playback (AXISCTRL)	Positioner selected from auto mode supports independent playback (MOVE) function irrelevant from the robot
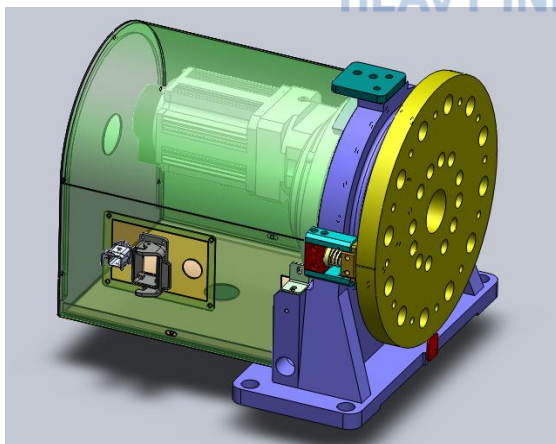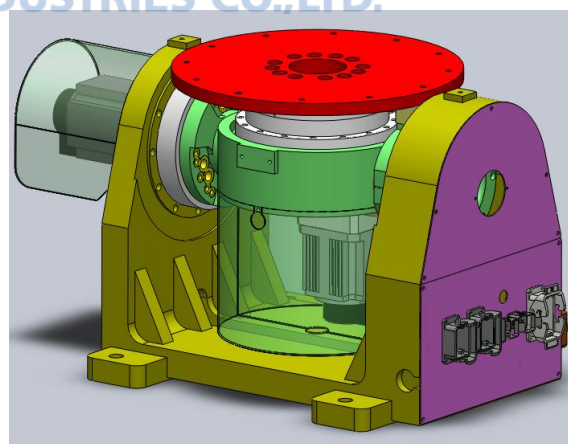
1 axis positioner   2 axes positioner

1.1. Characteristics of function

■ **Multi-group positioner**

The jig axis set as additional axis can be set as positioner group for control. Total of 3 groups of positioners can be registered and each group can set up to 2 axes positioner.

■ **Positioner calibration**

To set the positioner coordinate, 3 points must be taught for the 1 axis positioner and 5 points for 2 axes positioner for calibration.

■ **Positioner independent jog operation function**

Function to operate the axis individually during auto mode playback for the axis registered as position group. By using this function, you can operate the position not working to operate the jog based on external input signal.

■ **Teach**

Teach of positioner independent operation function can be done based on selection of supplementary axis key by switching to robot Cartesian coordinate, position synchronization jog and additional axis operation by design. Therefore it is convenient to teach the positioner synchronized operation command (SMOV).

■ **Playback**

Positioner synchronization function supports both linear and arc interpolation. When a synchronized operation command (SMOV) is executed, the interpolation operation is executed on the position and playback. The position independent job operation function can be one for axis other than the selected (SELSTN S#) positioner.

■ **Additional axis independent MOVE function**

This function enables the user to operate the MOVE command registered separately using the external signal in auto mode. By using this function, the robot operation and independent operation can be realized using the MOVE command. To use this function, unit and mechanism must be set and the command independent execution statement must be registered. This function cannot be used with the positioner independent jog function.

1.2. Operating order

Initialization
Set the applicable additional axis as the positioner in the additional axis constant setting and set the positioner group from mechanism setting.

Robot calibration
Execute tool end fixed motion and if incorrect, use the auto constant setting function to calibrate the robot.

Positioner calibration
When the robot calibration is completed, use the calibrated tool to calibrate the positioner.

Teach
Use the mechanism key to select the group and operate the synchronized jog. If the step is recorded with the position group selected, it will be recorded as positioner synchronized step. (SMOV S#)

Check operation
Check the program with step forward/backward function in manual mode.
Continuous operation

Operate in auto mode.
At this time, if SELSTN S# is recorded, the applicable positioner will not operate but independent jog is possible by the external signal. Also the additional axis with the AXISCTRL off will not operate.
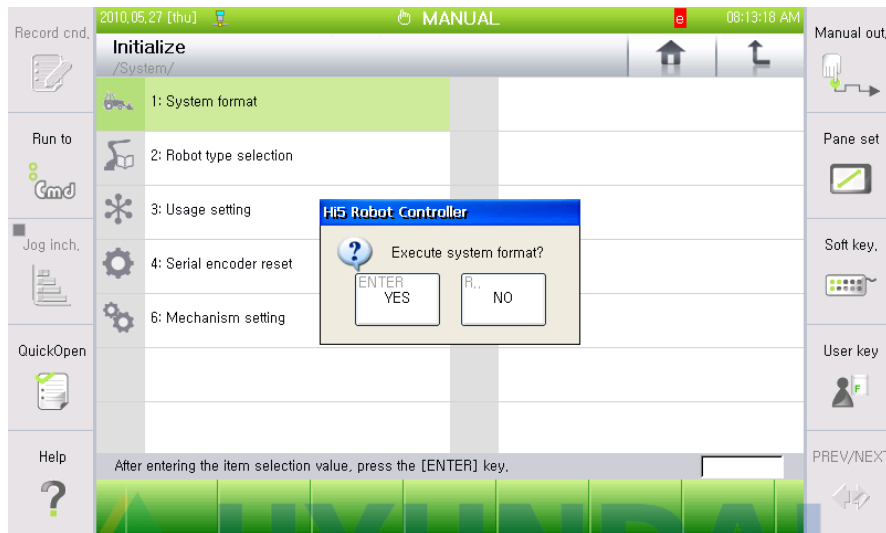
2
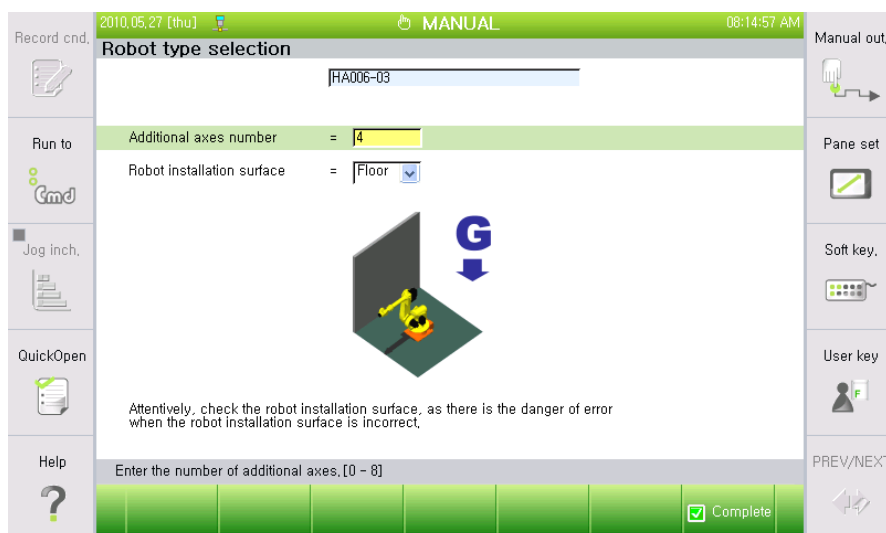# System setting

2.1. System initialization

(1) When setting the controller for the first time, the system must be initialized. The following menu is provided at 『[F2]: System』 → 『5: Initialize』 → 『1: System format』. Select initialize system and then press the "YES" button.

(2) After the system is initialized, select the robot type. When you select the robot type, the following screen will be displayed. At this time, enter the total number of additional axes to use. Also set the installation surface of the robot. When the setting is completed, press the 『[F7]: Complete』 key.

(3) Then when the "Set constant for additional axis?" message, click on Yes. The next screen will be displayed. In this screen the axis specification of the additional axis applicable to the positioner is set as the positioner and the applicable parameter is set. For positioner not provided by HHI, set to 'Any' and set the remaining parameters. Refer to 'User manual of additional axis function' on how to set the additional axis parameter.

(4) When using the positioner provided by HHI, select from the list in the axis structure. In this case, no other parameter setting is required.

(5) The positioner group is set in 『[F2]: System』 → 『5: Initialize』 → 『6: Mechanism setting』 menu. In the following screenshot, T1 and T2 are set to group 1 as 2 axes positioner and T3 axis is set to group 2 as 1 axis positioner and lastly T4 axis is set to group 3 as 1 axis positioner. Generally it is convenient to set the mechanism to the same way as the position group.

(6) When the power is rebooted, the mechanism and positioner group are normally applied.
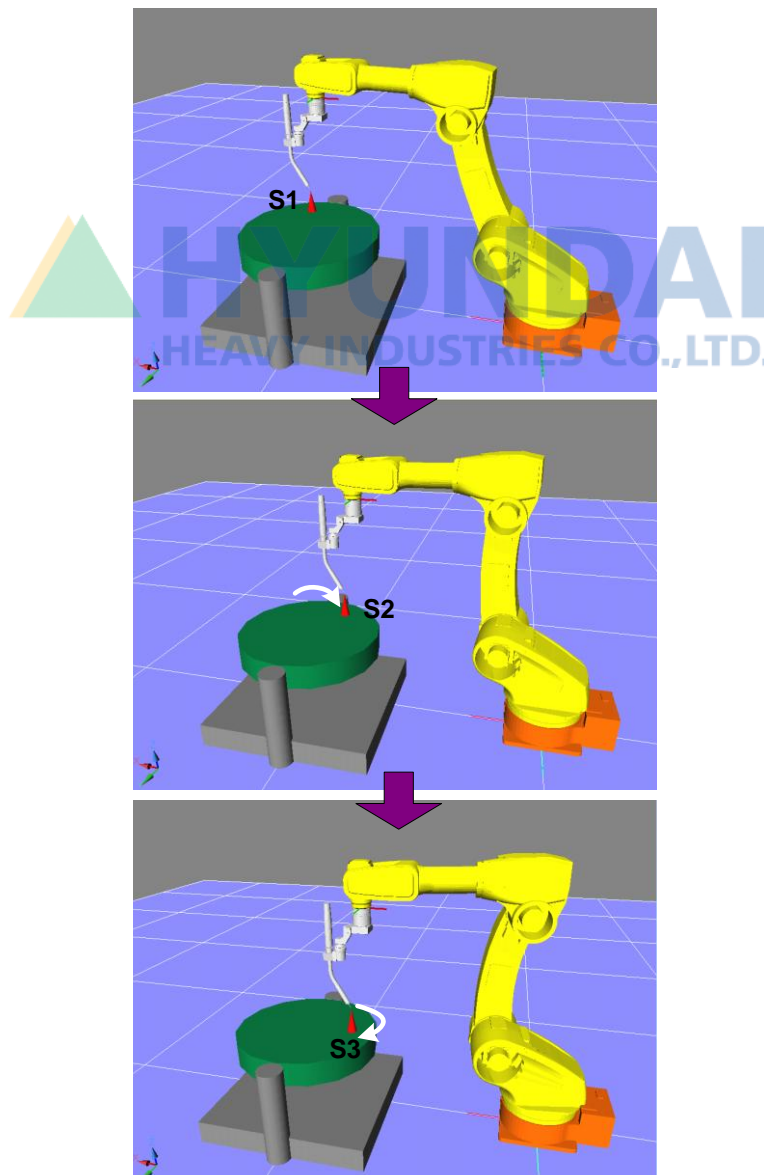
2-5

2.2. Robot calibration

Refer to 『7.6 Auto constant setting』 in Hi5 Operating Manual.

2.3. Positioner calibration

2.3.1. Teach 1 axis positioner calibration program

(1) Select the program to teach.

(2) For 1 axis positioner, fixate the sharp teaching point on the positioner. At this time, the teaching point must be installed far from the rotating center as much as possible for the calibration to be accurate.

(3) Rotate the positioner by 30° in one direction to accurately teach 3 points and record the program. The following picture shows the teaching method.

(4) Keep the position of the robot same while teaching.

2.3.2. Teach 2 axes positioner calibration program

(1) Select the program to teach.

(2) Keep the sharp teaching point far from the rotating center as much as possible.

(3) For 2 axes positioner, move only the 2nd axis just as the 1 axis positioner to teach 3 points first. And then from the 3rd teach point (S3) move only the first axis to teach the 4th point (S4) and 5th point (S5).

(4) Do not change the position of the robot while teaching for accurate calibration.
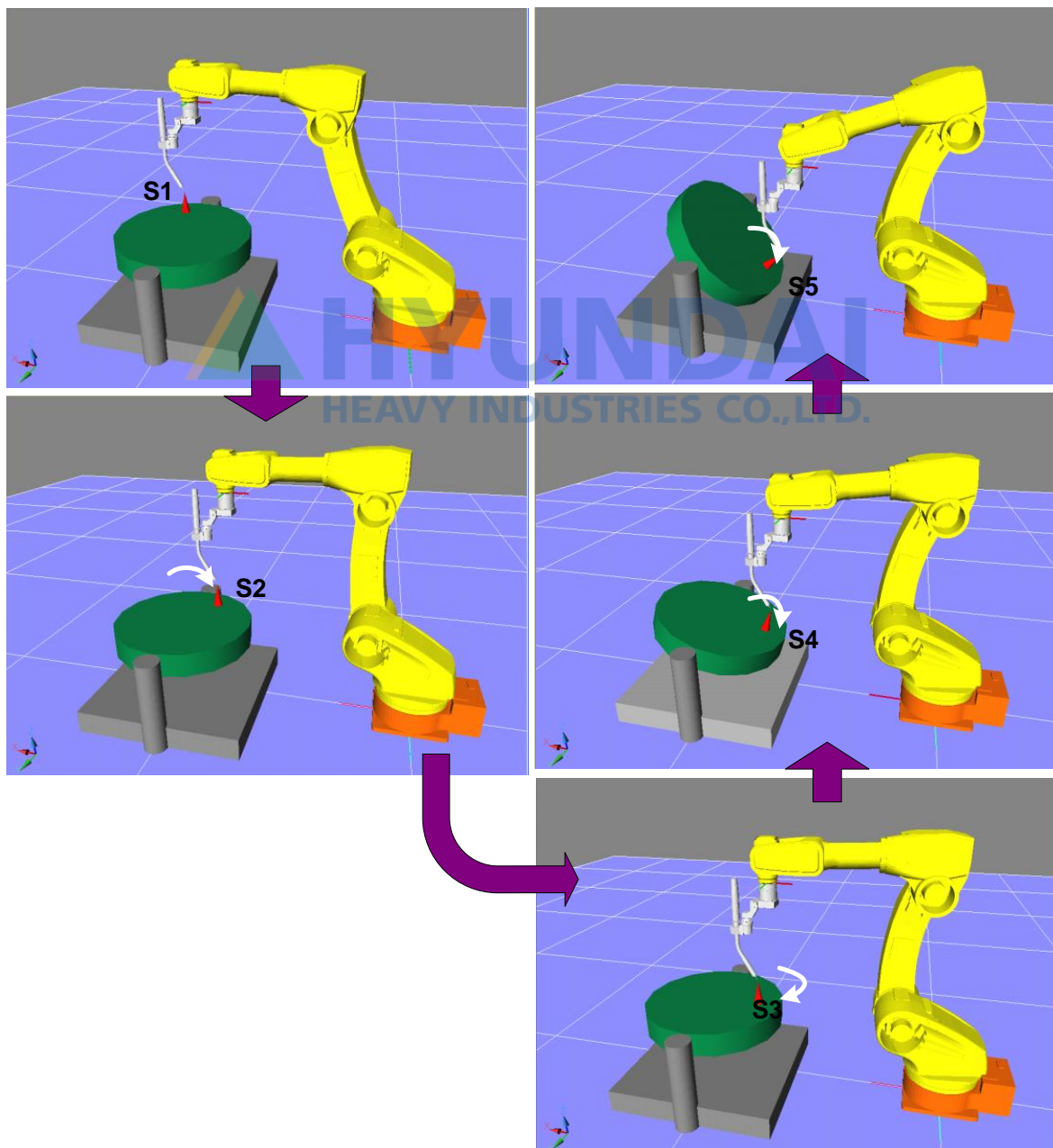
2.3.3. Execute positioner calibration

(1) Select 『[F2]: System』 → 『6: Automatic constant setting』 → 『2: Positioner calibration』 .

(2) Select the positioner group to calibrate and the applicable job program, and then press 『[F1]: Execute』
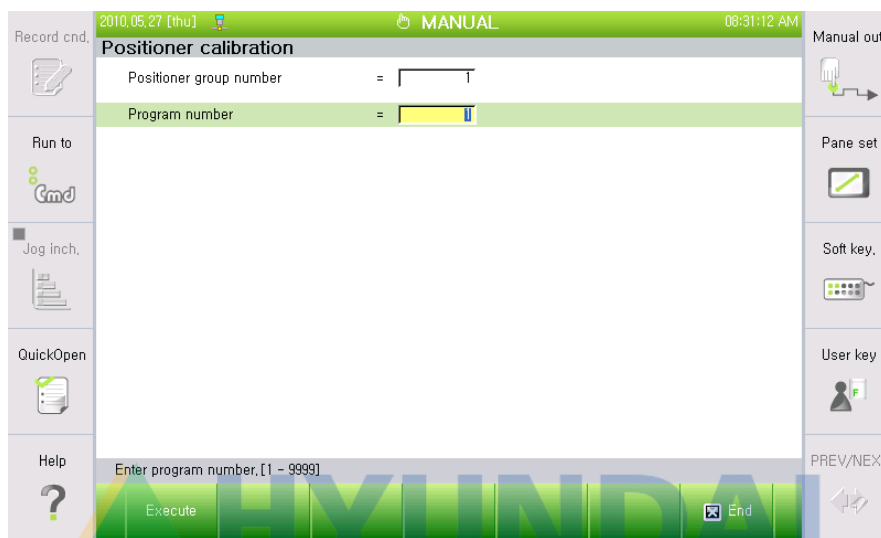
(3) Calibration result will be displayed. When the 『[F7]: End』 key is pressed, the applicable data will be saved to the constant file (ROBOT.MCH) and the setting will be completed.

(4) If the user accurately knows the location of the positioner based on CAD data, set the location and DH parameter of the positioner manually and press the 『[F7]: End』 key to reflect to the constant file.

3
Manual operation

3.1. Positioner independent jog mode

There are two ways to jog the positioner. One is the 'Independent jog method' that only jogs the positioner and the other is the 'Synchronized jog method' that enables the robot to follow in synchronization when the positioner is jogged. First for the independent job method, press the 'Mechanism' key on the teach pendant and the applicable mechanism can be selected by toggling. In the following condition, the positioner can be jogged independently.

3.2. Positioner synchronization jog mode

When the 'Crd' key on the teach pendant is pressed in positioner independent jog condition, 'Sync S1' will be displayed as shown below if the positioner has been calibrated. When the positioner is moved in this condition, the robot will jog following the movement of the positioner.
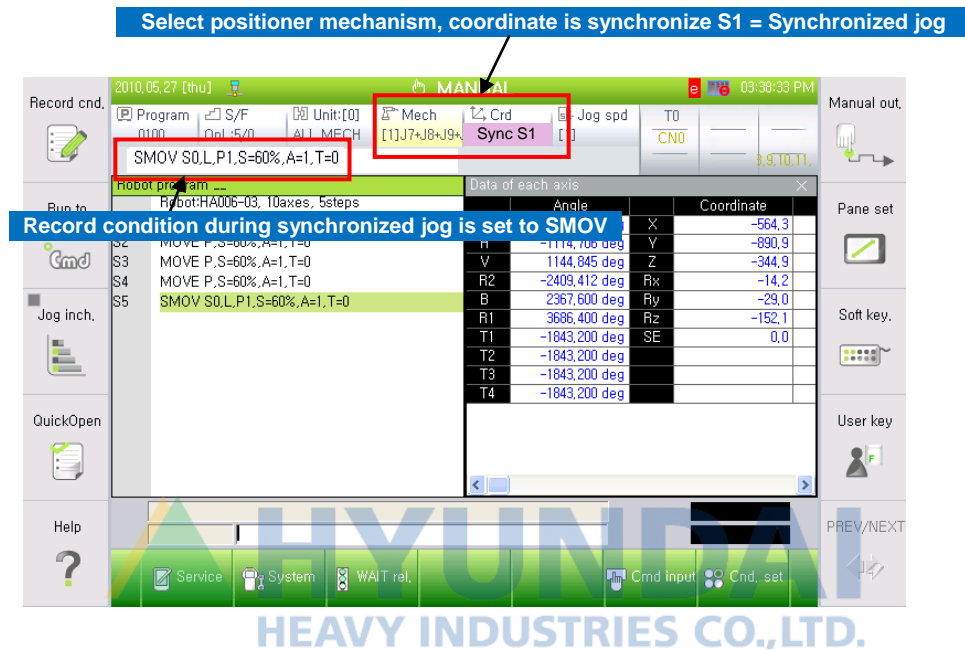
Select positioner mechanism, coordinate is synchronize S1 = Synchronized jog

Record condition during synchronized jog is set to SMOV

4

Create program

4.1. Record step

In positioner independent jog operation, the program record condition is set to MOVE command and in positioner synchronized job operation, it is set to SMOV command to support positioner synchronized command.

4.2. SMOV

SMOV {Station number}, {Interpolation method }, {Speed}, {Accuracy}, {Tool number}

①   Station number: This means the positioner group number. (S1~S4)
②   Interpolation method: Linear (L) or arc (C) interpolation is possible on the workpiece.
③   Speed: Set the speed the TCP of robot moves on the workpiece.
④   Accuracy: Set the accuracy of the linear or arc interpolation on the workpiece.
⑤   Tool number: Set the robot tool number to execute the task.

Setting of SMOV command is decided on the position coordinate. For example, when moving the two points to a line while moving the positioner, the TCP moving speed on top of the positioner is set.

4.3. Example of linear interpolation on positioner

(1) Decide the start and target point on the workpiece.
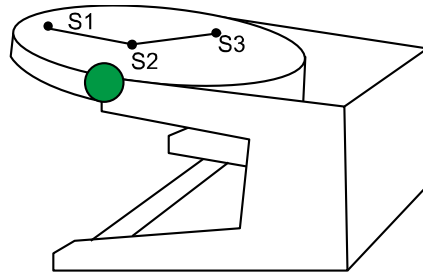
(2) Use the mechanism key and coordinate to select and move the positioner. Use the mechanism key again to select the robot and align the starting point to the starting point of the robot tool end. In this condition, press the record key to record the 'MOVE' command. (Record with SMOV if necessary.)

(3) Use the mechanism key and coordinate key to set the positioner synchronized jog mode. If the current positioner is group 1, select the coordinate 'Synchronized S1'.
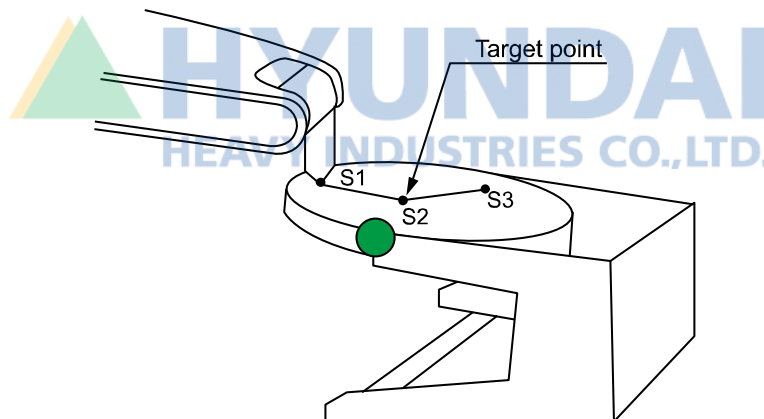
(4) With the master selected, move the position to the location desired and the robot will maintain the position and location according to the task starting point on the positioner.

Reference)
In the above condition, the error between one point of the positioner and the tool end is the error from the calibration of the robot and positioner, and this error does not show up in trace error during playback. That is, if the robot moves to the target location again and record with "SMOV" even with some level of error, the trace error of the step during playback will not cause any error.

(5) After selecting the mechanism back to robot, use the jog key to move and align the robot to 'Target point' (S2).
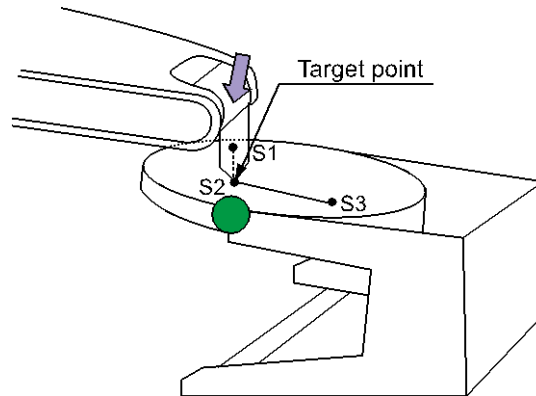
(6) To record the synchronized step (SMOV), it must be reset positioner synchronized jog mode. Select the coordinate to be 'Synchronized S1'and press the [Record] key to record "SMOV" step.

(7) Follow the process of ③→④→⑤ for following steps.
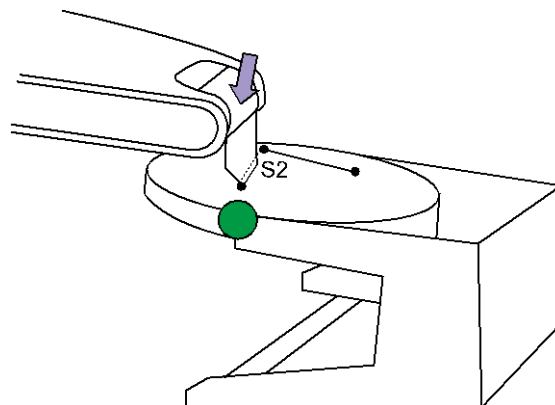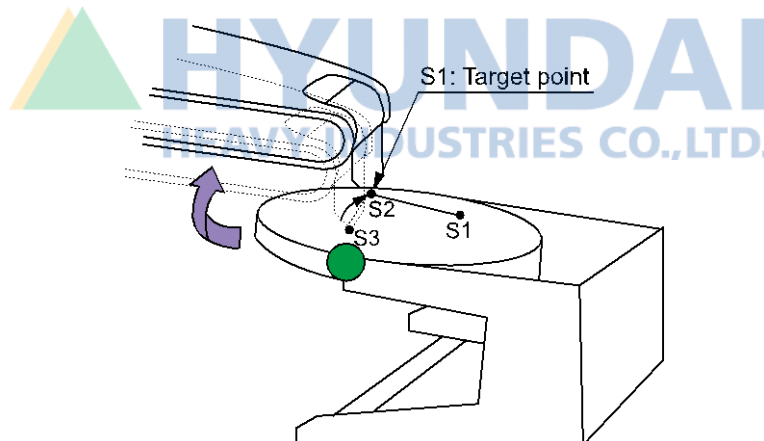
(8) When the recorded program is executed, the positioner will move in linear interpolation for the workpiece on top of the positioner.
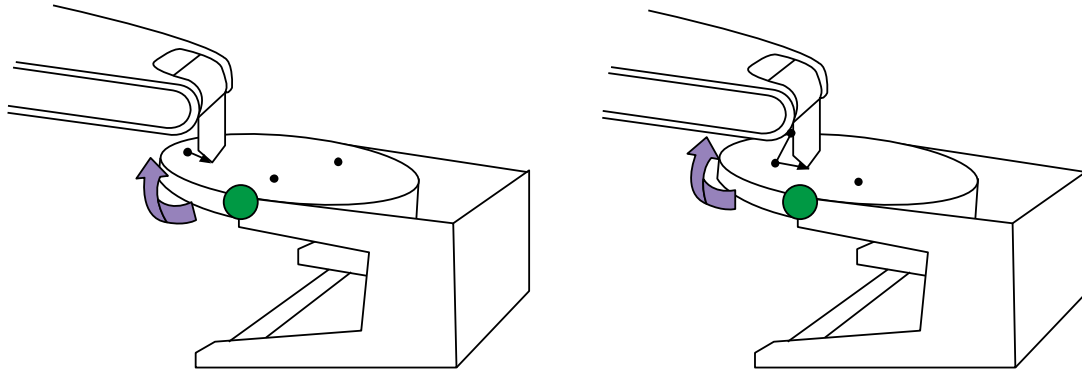
◆ 【**Caution**】 ◆

① Recording the positioner synchronized step (SMOV) does not always have to be done this way. Independently operate the robot and positioner to decide the location and position, and the record as SMOV step. The robot will move by the designated interpolation method on top of the workpiece of the positioner.

② When the interpolation methods of two steps recorded with "L", it will execute a cornering motion as in MOVE.

③ Speed of the step recorded with SMOV is the task speed. Therefore if the task distance between the recorded steps is short, the task speed of the positioner will be nearly ∞ (Infinite), making the positioner move in maximum speed, even when the positioner has moved a lot. In this case to limit the speed of the positioner, the speed unit can be set to "SEC". By setting the unit of the step movement to time rather than speed, the moving time will be designated even when the distance of task on the workpiece is 0.

(Ex) Program example

```
S1    MOVE   L,S=60%,A=1,T=0              → Start location access step
S2    SMOV   S1,L,S=100mm/s,A=1,T=0       → Positioner synchronized linear   interpolation
S3    SMOV   S1,L,S=100mm/s,A=1,T=0
S4    SMOV   S1,L,S=100mm/s,A=1,T=0
S5    MOVE   P,S=10%,A=1,T=0              → Retract step(Not synchronized with
                                             positioner)
S6    MOVE   L,S=200mm/s,A=1,T=0
END
```

5
Positioner independent operation

Positioner independent operation function is the function that can e applied to the system controlling multiple sets of positioners. In a system with multiple positioners, positioner that does not execute a specific task with the robot executes the setting task while the specific positioner executes a task with the robot. Therefore there is a need to manually control the positioner.

Positioner independent operation function uses the robot language command (SELSTN) to select the positioner to operate. This function should be used when the user wants to operate only the specific positioner by playback the program and operate the other unselected positioners based on the external input signal independently.

This function can change the positioner to operate by the program interval to classify and use positioner to operate based on the program playback and by independent operation.

5.1. Positioner independent operation setting

This function uses several positioners to compose the system. This function supports the positioner to execute the jog operation by external input signal while one positioner works with the robot. Therefore, the setting including external input signal number is required.

(1) Select 『[F2]: System』 → 『4: Application parameter』 → 『6: Positioner independent operation』.

(2) This sets each positioner (Station).

(3) Meaning of signal setting is as shown in the following table

I/O signal	Content	Remarks
Permit independent operation	Prohibit (0) / Permit (1) independent operation	Independent operation possible after permitted pressure
Select high speed	Select speed level (0=Low 1=High)	Select speed at level at by operating speed Select operating speed: Set at % of maximum speed
1st axis forward rotation	Forward direction (+) rotation of 1st axis of positioner	Both axis 1 and 2 can be operated simultaneously
1st axis reverse rotation	Reverse direction (-) rotation of 1st axis of positioner	Both axis 1 and 2 can be operated simultaneously
2nd forward rotation	Forward direction (+) rotation of 2nd axis of positioner	Both axis 1 and 2 can be operated simultaneously
2nd reverse rotation	Reverse direction (-) rotation of 2nd axis of positioner	Both axis 1 and 2 can be operated simultaneously
Setting location movement	Move the setting location to target point	Move full target point of 1st and 2nd axes, but they cannot be used as the axis operation signal
Aligned output signal	When both 1st and 2nd axes within the setting location range are reached, output confirmation signal	Allocated signal output [DO# signal]

◆ 【Caution】 ◆

① Signal allocated to the I/O signal cannot be duplicated for allocation.

② The positioner group must be set first for position independent operation function.

③ When using both the additional axis MOVE independent execution function (AXISCTRL) and positioner independent operation function (SELSTN) simultaneously, it can generate an abnormal error. Therefore never mix the two

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5.2. SELSTN command

This is the command to set the take with the specific positioner in the positioner synchronization function. When this command is set, axis other than the selected positioner cannot be operated by the JOB program.

SELSTN, station number, independent operation completion standby time, retract location			
Station number	ALL	Select all positioners All positioners cannot be operated independently	Cancel SELSTN S# All positioners are playback
Station number	S0	Independently operate all positioners	
Station number	S1 ~ S3	Select number of position for playback	Only selected positioners are playback
Standby time	0~60	Standby time until the independent operation of selected station is completed	0 = Infinite standby
Retract location	Division location	If the independent operation is not completed within the standby time, designate the retract step	STEP, LABEL, row number

◆ 【Caution】 ◆
   Positioner independent operation function is only effective in auto mode.

5.3. Program teaching method using SELSTN command

(1) Designate the positioner group number to synchronize with SELSTN S# command. Selected station will operate based on recording on job program and other stations will be set to be independently operated by the external signal.(SELSTN S1)

(2) After the SELSTN command, record the synchronized reference step on the reference location to start the positioner.(S1)

(3) Record the step by operating the selected positioner. (S2, S3, S4, S5) At this time, do not operate the unselected positioner if possible (Positioner group 2 and 3).

(4) Program example
```
SELSTN S1
S1   MOVE L,S=300mm/s,A=0,T=0
S2   SMOV S1,L,S=100mm/s,A=0,T=0
S3   SMOV S1,L,S=100mm/s,A=0,T=0
S4   MOVE L,S=300mm/s,A=0,T=0
S5   SMOV S1,L,S=100mm/s,A=0,T=0
```

◆ 【Caution】 ◆

① IF the station number set by SMOV and number set by SELSTN are different, an error (E0219) will be generated.

② When set to SELSTN S0, all stations set will not be operated by the program playback (S1~S3). At this time, all stations can be operated independently.

(5) If the positioner group number to operate during playback has changed, the station number must be designated newly. (SELSTN S2)

(6) Record the reference step to start the synchronized operation of the position with the robot with the MOVE command. (S6)

(7) Operate the selected positioner and record the step. (S7, S8, S9) At this time, do not operate the remaining positioner (Station 1 and Station 3) and record the details.

(8) Program example
```
SELSTN S1
S1   MOVE L,S=300mm/s,A=0,T=0
S2   SMOV S1,L,S=100mm/s,A=0,T=0
S3   SMOV S1,L,S=100mm/s,A=0,T=0
S4   MOVE L,S=300mm/s,A=0,T=0
S5   SMOV S1,L,S=100mm/s,A=0,T=0
SELSTN S2                    → Change station, positioner group 2 playback from step 6
S6   MOVE L,S=300mm/s,A=0,T=0
S7   SMOV S2,L,S=100mm/s,A=0,T=0
S8   MOVE L,S=300mm/s,A=0,T=0
S9   SMOV S2,L,S=100mm/s,A=0,T=0
```

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◆ 【Caution】 ◆

If the station number has changed (S1~S3) from SELSTN command, the selected position groups will be canceled to switch to independent operation function condition.

(9) Independent operation of the positioner canceled from group selection is prohibited and if all axes of jig axis want to be at the recorded location on step, cancel the station selection with the SELSTN ALL command. (SELSTN ALL)

(10) After SELSTN ALL command, all positioners will operate to the step location based on the playback command and even when the independent operation input signal is received, the positioner cannot be operate independently. (S10, S11, S12)

(11) Program example
SELSTN S1
S1   MOVE L,S=300mm/s,A=0,T=0
S2   SMOV S1,L,S=100mm/s,A=0,T=0
S3   SMOV S1,L,S=100mm/s,A=0,T=0
S4   MOVE L,S=300mm/s,A=0,T=0
S5   SMOV S1,L,S=100mm/s,A=0,T=0
      SELSTN S2
S6   MOVE L,S=300mm/s,A=0,T=0
S7   SMOV S2,L,S=100mm/s,A=0,T=0
S8   MOVE L,S=300mm/s,A=0,T=0
S9   SMOV S2,L,S=100mm/s,A=0,T=0
      SELSTN ALL   → Cancel station selection
S10 MOVE P,S=100%,A=0,T=0
S11 MOVE L,S=1200mm/s,A=0,T=0
S12 MOVE L,S=200mm/s,A=0,T=0

◆ 【Caution】 ◆
When there is an entry in operation including change in step, change in program and external reset, the station selection will automatically be canceled and the positioner in independent operation will stop.

5.4. Playback positioner independent operation

When independent operations are in progress as shown in the following picture, the applicable axis cannot be selected using SELSTN and operated by JOB program when independent operation of the positioner is already in progress.

When in playback, the independent operation of the positioner must be completed to proceed to the next step to change the station by SELSTN S# and SELSTN ALL command. Refer to the following program example.

SELSTN S1,5.0,S12   → Proceed after completing independent operation of station 1
(Standby 5 seconds)
S1   MOVE L,S=300mm/s,A=0,T=0
S2   SMOV S1,L,S=100mm/s,A=0,T=0
S3   SMOV S1,L,S=100mm/s,A=0,T=0
S4   MOVE L,S=300mm/s,A=0,T=0
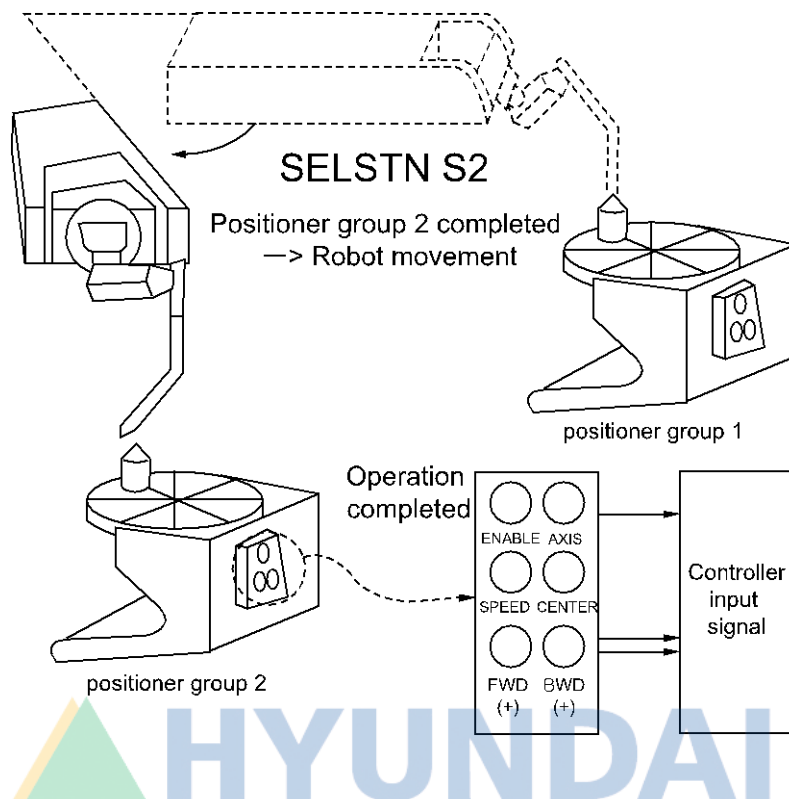S5   SMOV S1,L,S=100mm/s,A=0,T=0

SELSTN S2,10.0,S12   → Proceed after completing independent operation of station 2
S6   MOVE L,S=300mm/s,A=0,T=0
S7   SMOV S1,L,S=100mm/s,A=0,T=0
S8   MOVE L,S=300mm/s,A=0,T=0
S9   SMOV S1,L,S=100mm/s,A=0,T=0

SELSTN ALL   → Proceed after completing independent operation of station 3
S10 MOVE P,S=100%,A=0,T=0
S11 MOVE L,S=1200mm/s,A=0,T=0
S12 MOVE L,S=200mm/s,A=0,T=0
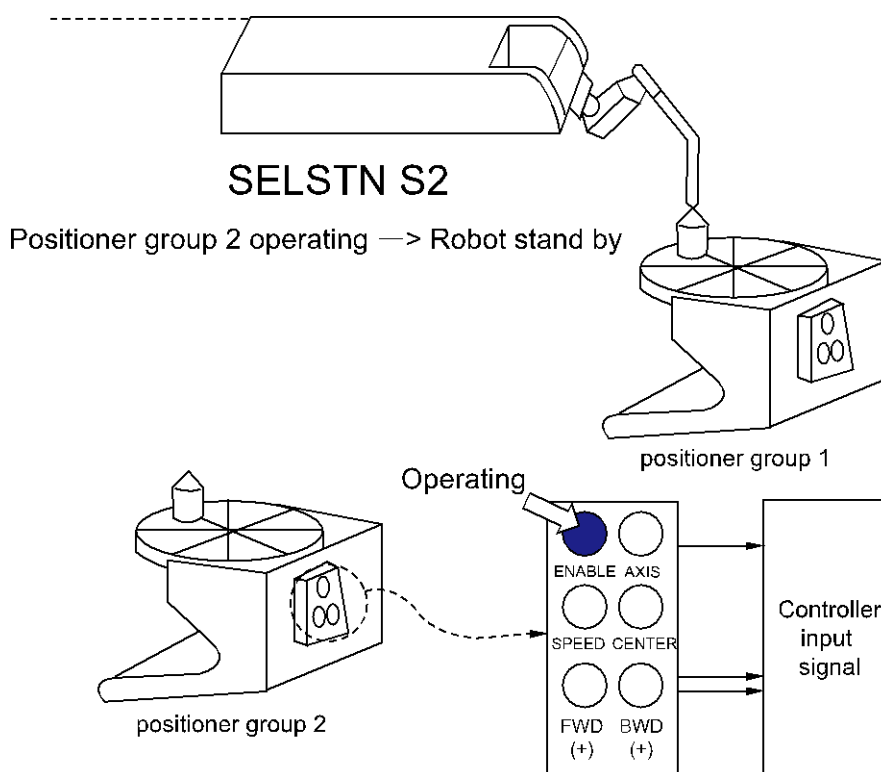
◆【Caution】◆
When the <Permitted> signal of the selected positioner is being entered, the robot will stand by in SELSTN location. When the independent operation of the selected positioner is completed, the robot will then move.

◆【Caution】◆
① When operating the program, the robot waits until the independent operation signal becomes <Prohibited> according to the position group selection condition. This action is for the safety of the user. This considers that when the independent operation signal is at <Permitted> that there is a worker.

② Because the change in step, change in program and external reset cancels the station selection (SELSTN ALL), the robot waits until the independent operation signals of all positioners have switched to <Prohibited> when reset.

③ When executing the following function, the positioner independent operation is disabled.
- Auto reset function of endless step, executing endless reset
- During collaborative control
- During gun change

6

Additional axis MOVE independent execution function

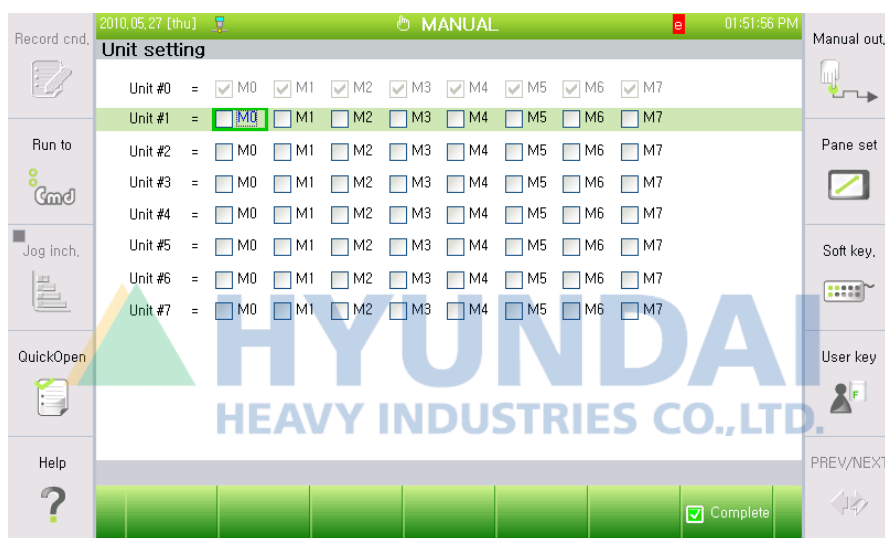Additional axis MOVE independent execution function is similar to the positioner independent operation function. But the independent operation function by positioner external input signal is the jog function where as the additional axis MOVE independent execution function is to execute the MOVE command independently by the external signal. The user should choose between the two functions based on the ease of application and use it.

6.1. System setting

(1) 『[F2]: System』 → 『5: Initialize』 → 『7: Unit setting』 allocate the unit number to the position to set the additional axis MOVE independent function setting. In the following case shows that mechanism 1 is set to unit 1, mechanism 2 is set to unit 2 and mechanism 3 is set to unit 3.

(2) When the unit setting is completed, reboot the power.

(3) Select 『[F2]: System』 → 『4: Application parameter』 → 『10: Command independent execution』 to record the MOVE command to the command.

Input signal:
When the applicable signal is received, execute the command while the input signal is set to ON.
Target location: Not applicable. No setting required
Executing Output signal:
Signal number to output externally when moving by additional axis MOVE independent command
Completed Output signal: Output signal when execution is completed

(4) Select the MOVE command and press the 『Quick Open』 key to edit the location. At this time, select the unit number to operate and record the moving location.

(5) Set the axis to execute the additional axis MOVE independent execution with AXISCTRL OFF command. MOVE independent execution by external input signal is only effective in the range of AXISCTRL OFF~AXISCTRL ON.

(6) Program example

```
AXISCTRL OFF,T7,T8      → Proceed after completing independent operation of station 1
                              (Standby 5 seconds)
S1   MOVE L,S=300mm/s,A=0,T=0
S2   SMOV S1,L,S=100mm/s,A=0,T=0
S3   SMOV S1,L,S=100mm/s,A=0,T=0
S4   MOVE L,S=300mm/s,A=0,T=0
S5   SMOV S1,L,S=100mm/s,A=0,T=0
AXISCTRL ON,T7,T8       → Proceed after completing independent operation of station 2
AXISCTRL OFF,T9
S6   MOVE L,S=300mm/s,A=0,T=0
S7   SMOV S1,L,S=100mm/s,A=0,T=0
S8   MOVE L,S=300mm/s,A=0,T=0
S9   SMOV S1,L,S=100mm/s,A=0,T=0
AXISCTRL ON,T9         → Proceed after completing independent operation of all stations
S10 MOVE P,S=100%,A=0,T=0
S11 MOVE L,S=1200mm/s,A=0,T=0
S12 MOVE L,S=200mm/s,A=0,T=0
```
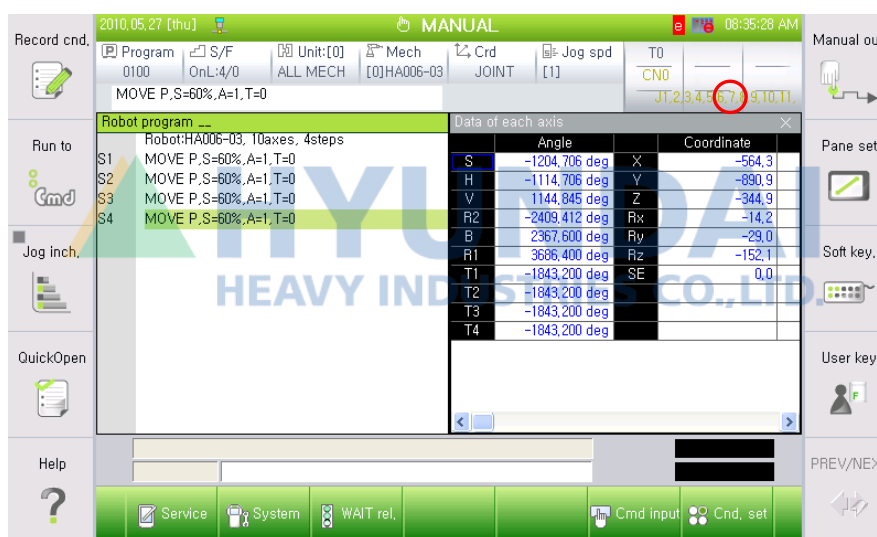
6.2. AXISCTRL

AXISCTRL {OFF/ON}, {T1,T2,T3,T4 }

AXISCTRL command selects whether to control the additional axis by the JOB program. Axis with AXISCTRL OFF during program playback does not move to the location recorded on the JOB program and cannot move independently. Axis with AXISCTRL ON will move to the location recorded on JOB program.

If the control of additional axis is turned OFF using this command and the designated signal from 『[F2]: System』 → 『4: Application parameter』 → 『10: Command independent execution』 is received, the applicable command will be executed. If this command is MOVE command, it will execute the MOVE command irrelevant from the JOB program.
Axis with AXISCTRL OFF is displayed on the top right corner of the screen as J7.

AXISCTRL OFF/ON setting can be done using the R362 code in manual mode.

◆ 【Caution】 ◆

① But, the unit information of the recorded MOVE must be composed only of the axis of AXISCTRL OFF.

② When the independent operation is not completed while executing AXISCTRL ON command, 'E1455 T#) axis independent operation is not completed' message will be generated and the robot axis will stop. At this time, the independent operation axis will move to the applicable location. This error means that the execution time of the JOB program is faster than that of the independent MOVE command. Therefore adjust the program or use the WATT command on top of the AXISCTRL ON command to change to inspect whether the MOVE independent execution completion signal is generated.

③ When the additional axis MOVE independent execution function (AXISCTRL) and positioner independent operation function (SELSTN) function are used simultaneously, the controller can generate an abnormal error. Therefore do not mix them up.

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