HYUNDAI ROBOTICS

WARNING

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

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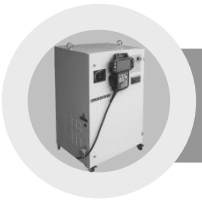

Hi5a Controller Function Manual

Cube interference prevention

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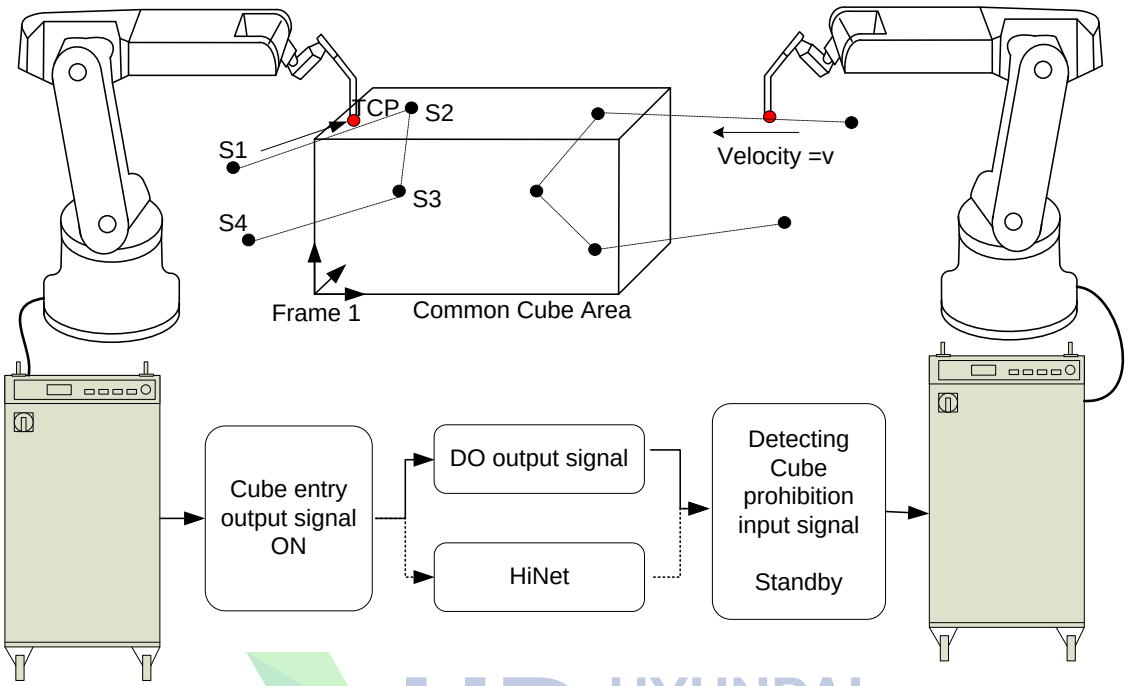
1 Overview

1.1. About the Function of Cube Interference Prevention

1.1.1. Purpose of the Function

- The purpose of the function is to prevent several robots from entering the same cube area d at a time during operation.
- When a robot enters the cube area where the robot's tool center point (TCP) has been set, a signal is output so that the users may use the signal for diverse applications.

1.1.2. Scope of the function



1) When robot programs start up

- If a robot's TCP is inside the set cube area, an assignment signal is output; if the TCP is outside the set cube area, the assignment signal is not output.
- When a robot's TCP has entered the cube area or the step target position enters the cube area while the robot is stepping, it secures the job priority over the area and outputs the Cube entry output signal (in this case, the left robot in the above figure).
- The Cube entry output signal is translated into the input signal of prohibiting other robots' access to the cube (in this case, the right robot in the above figure), and the robot that has received the input signal automatically stops when there is possibility of the cube interference.
- When the job of the robot which has entered the cube area first is completed, the other robot in a standby mode restarts up automatically.

2) When a robot is in the jog mode or stops

- In a manual mode (JOG), a robot plays a role in detecting the TCP position and outputting the Cube entry output signal.
- The robot in the jog mode does not stop automatically even though the input signal of prohibiting access to the cube has been sent; therefore, close attention shall be paid.

3) Other matters

- The function is provided by Hi5 Controller version **MV40.07-00** and over. **(Impossible to mix the current version with a previous version when using HiNet)**
- DIO and HiNet methods may be used for the cube detection signal I/O

1.1.3. Limitations on the Function

This function is designed for robots to automatically stop when they are expected to enter the cube at the same time; when the input signal of prohibiting access to the cube is cleared, they restart up automatically.

However, although the robots reduce their speeds to the maximum extent at a time when they detect the input signal of access prohibition to the cube, in some case, when they enter the cube area at the same time, which is called dead-lock.

The dead-lock may happen when there is the wrong connection between the output signal of entry into cube and the input signal of access prohibition to cube over the common cube, or when there is a communication delay between two robots. In this case, errors happen because the two robots may enter the cube area at a time. (E0222 Same cube simultaneous entry detected)

- This function may have the dead-lock phenomenon where two robots enter the common cube area at the same time.
- It does not support the function to return to the starting point, automatically avoiding the dead-lock state, and may not be used in association with the function of detecting the arm interference.

1.1.4. Associated Functions

- Cooperative control function, HiNet
- Function of Arm Interference Prevention

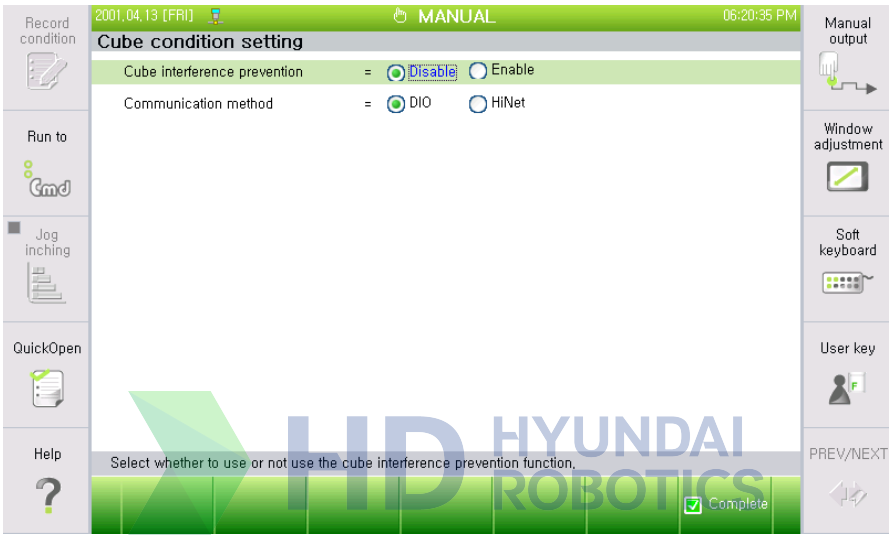
2 Relevant Functions

2.1. Setting Methods

2.1.1. Setting Enable/Disable of the Function and Communication Systems

Determine the Enable/Disable of whether to use the function of preventing the cube interference.

Select the menus as follows: 『**[F2]: System**』 → 『**4: Application Parameter**』 → 『**7: Interference prevention**』 → 『**1: Cube interference prevention**』 → 『**1: Cube condition setting**』, then determine whether to use the function and the communication systems.

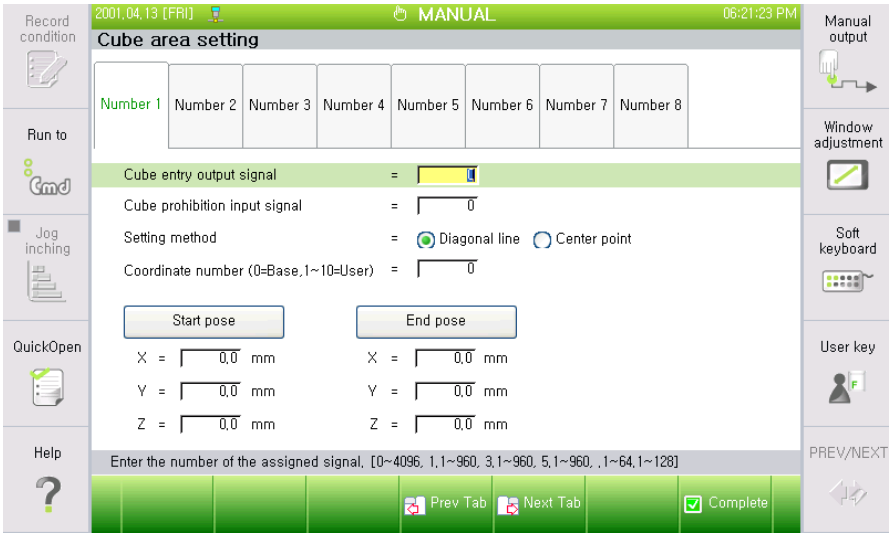


1) **Cube interference prevention <Enable, Disable>**: select whether the function is Enable or Disable.
Set up the cube area and select 'Enable' so as to use the function of preventing cube interference.
When 'Disable' is selected, the interference area may not be set up and the I/O signals are not sent.

2) **Communication method <DIO, HiNet>**: select the communication for I/O signals of cube interference detection.
When DIO is selected, the universal I/O signals shall be chosen; when Hinet is selected, the cooperative control network shall be connected.
When it comes to the cooperation control network, select 『**[F2]: System**』 → 『**2: Control Parameters**』 → 『**9: Network**』→ 『**3: Service**』→ 『**1: Cooperation Control**』 to set the cooperation control as enable as shown below, and then set the group number and the robot number. Take precautions to ensure that there are no overlapping robot numbers within the same group. When it comes to the HiNet network status, select 『**[F1]: Service**』 → 『**1: Monitoring**』 → 『**10: Cooperation Control Data**』→ 『**2: HiNet I/O**』 → 『**[F5]: Overall Configuration**』 to check the status through the HiNet-IO connection status window. In this process, the robots marked in green are the ones participating in the cooperative control network

2.1.2. Cube area setting

Select the menus as follows: 『[F2]: System』 → 『4: Application Parameter』 → 『7: Interference prevention』 → 『1: Cube interference prevention』 → 『2: Cube area setting』.



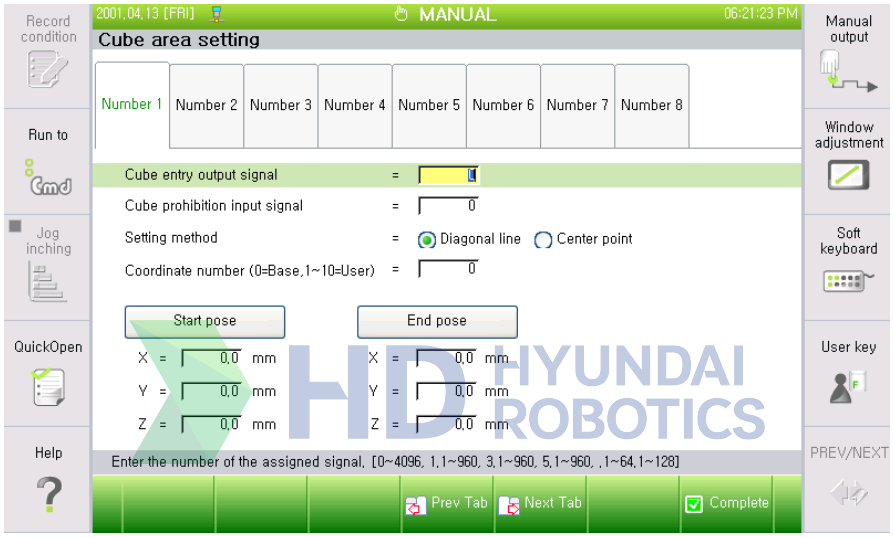
2.1.2.1. Methods of Setting a Cube

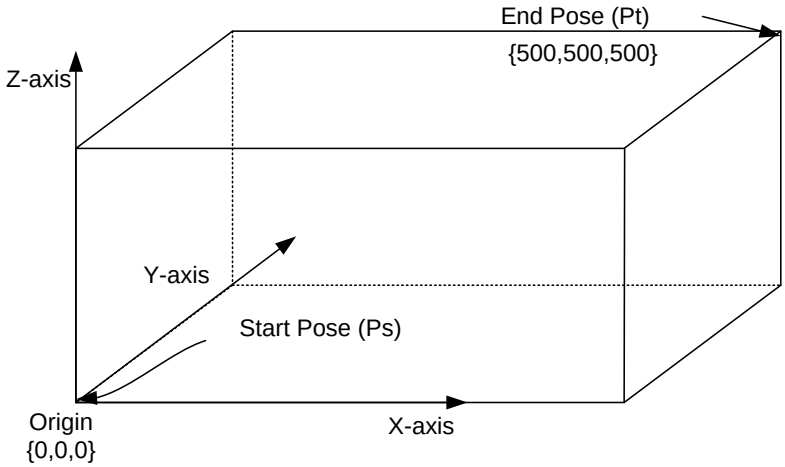
Two methods of setting a cube are provided

1) Diagonal Method

- Set up hexahedron's two points, located diagonally as diagonal points. Manually input the diagonal starting and terminal positions as seen in the following figure.
- If recording the current robot's position as a TCP, put a cursor on the <Start Pose> or <End Pose> button, and press the 'ENTER' key.

Example)

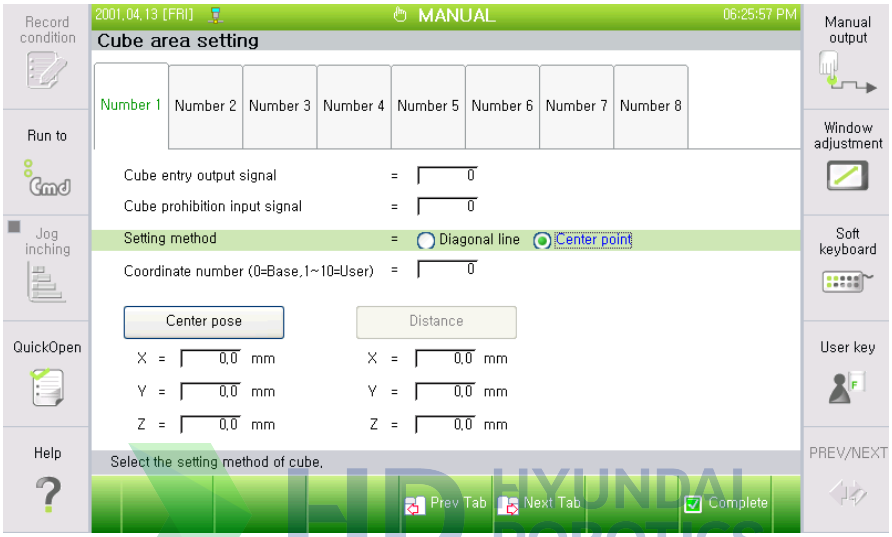


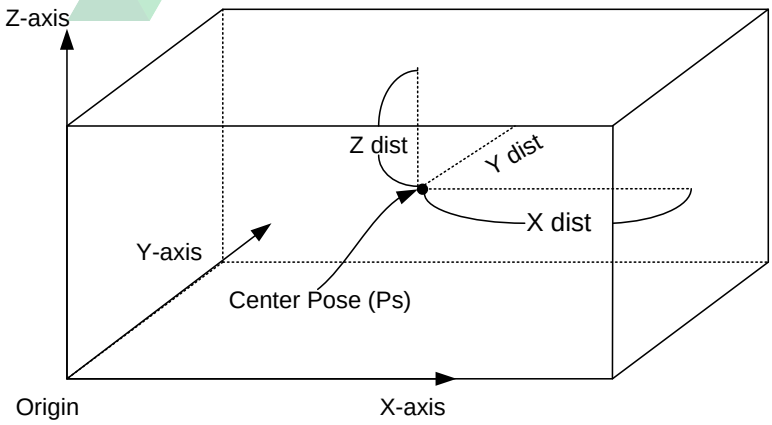


2) Method of Setting a Center Point

- The method of setting a Center Point is to establish the cube's Center Point and each distance in the X, Y, and Z directions, respectively.
- If recording the current robot's position as a Center Point, put a cursor on the <Central Position> button and press the 'ENTER' key.

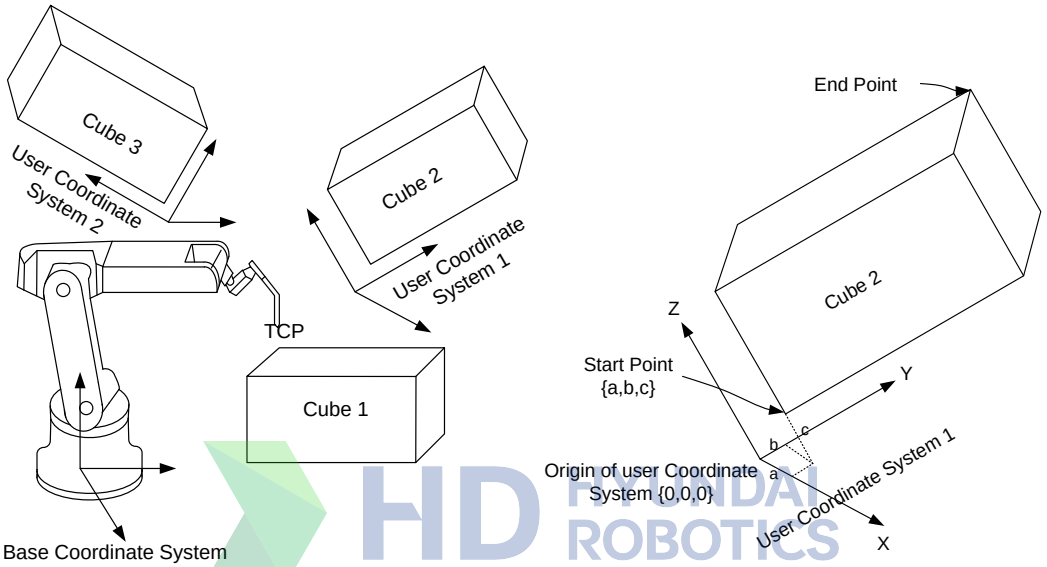
Example)





3) Setting a Cube in the User Coordinate System

- The cube area is created in the shape of a rectangular parallelepiped. So, if the user coordinate system is used in setting the cube, cube areas with various positions in space may be created.
- As seen in the following figures, several cubes may be established: cube 1 is set in the base coordinate system; cube 2, the user coordinate system; and cube 3, the user coordinate system 2.



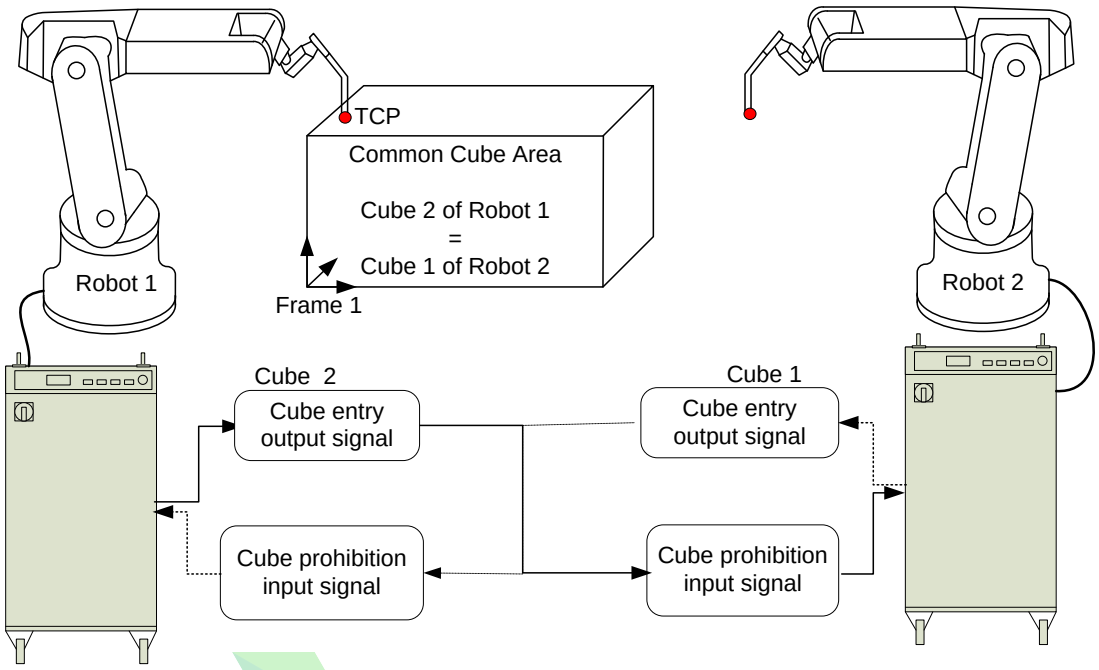
- When the user coordinate system is used in setting the cube, the diagonal and central positions shall be created in the user coordinate system.

2.1.2.2. Setting Cube I/O Signals

- Cube entry output signal:
  It functions for outputting a signal by detecting whether the robot has entered the cube area. Set up the signal number in the Output Signal of Entry into Cube.
- Cube prohibition input signal:
  Set up the signal number for other robots to receive the signal when they have entered the involved cube area.

The above two robots' common cube area is the cube 2 of robot 1 and the cube 1 of robot 2. In these cases, connect the 'Cube entry output signal' of the cube 2 of robot 1 to the 'Cube prohibition input signal' of the cube 1 of robot 2, and vice versa.

2.1.3. Setting Cube I/O Signals for the Common Cube area



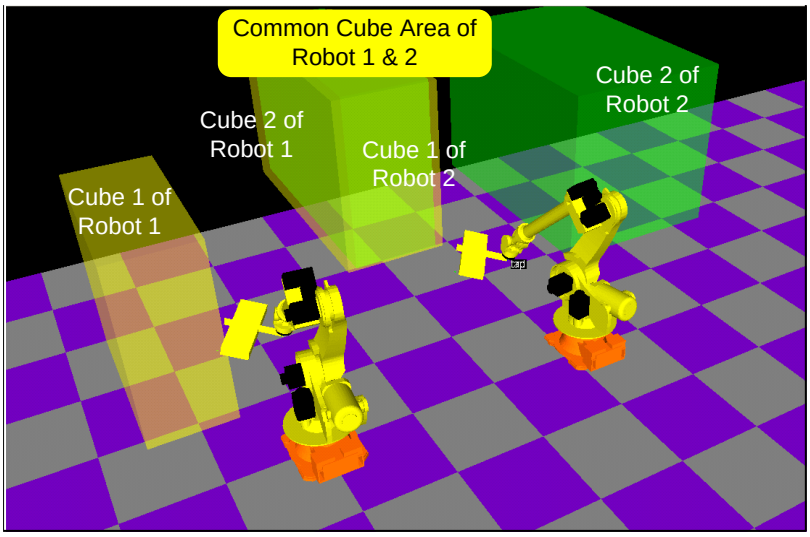
The common cube area shall be set up in the same area of each robot's space. In order to create the common area by means of the same area, first, the two robots' TCPs shall be set up precisely, then the TCPs are moved to the same position in space so as to set the cube's position (refer to the methods of setting diagonal and Center Points) and the cube's size shall be also determined in the same way.

Function of automatic mutual Interlock for the common cube area

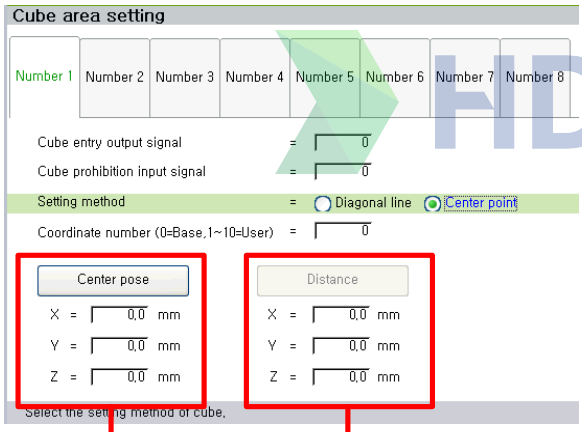
As seen in the above figure, when the output signal of entry into cube of robot 1 is connected to the input signal of prohibiting access to cube of robot 2, and if the robot 1 is equipped with the conditions to enter the common cube prior to the robot 2, the robot 2 stops and is in a standby mode.

In the same manner, if the output signal of entry into the cube of the robot 2 is connected to the input signal of prohibiting access to cube of the robot 1 and the robot 2 is equipped with the conditions to first enter the common cube area, the robot 1 stops and is in a standby mode.

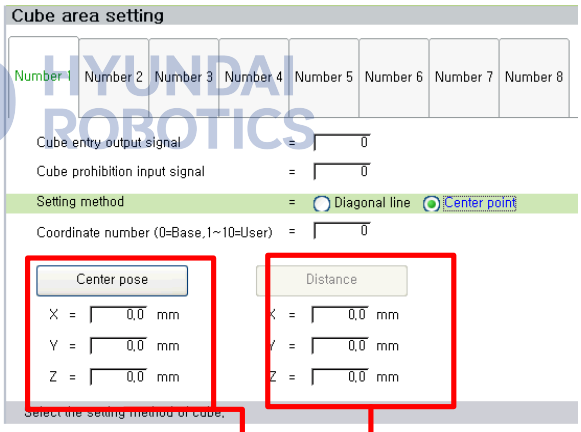
2.1.4. Examples of Preparing for and Running Job Programs



Setting Cube 2 of Robot 1



Setting Cube 1 of Robot 2



Same Size

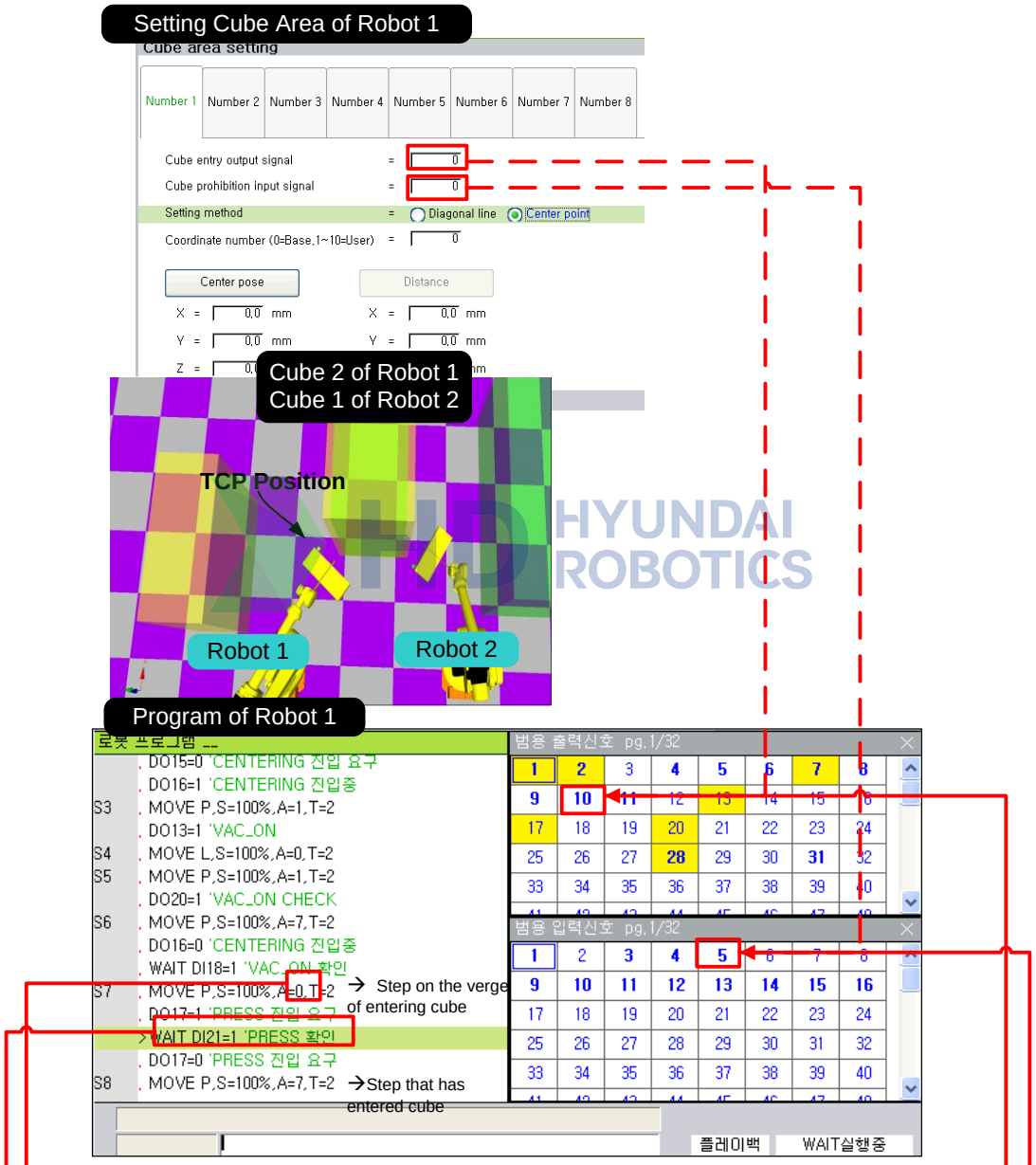
Same Position

The same positions may have different coordinates because each robot has different base coordinate systems, but the same cube shall be set up to have the same position in space.

2.1.4.1. Robot 1

1) The robot 1 is on the verge of entering the common cube area (cube 2).

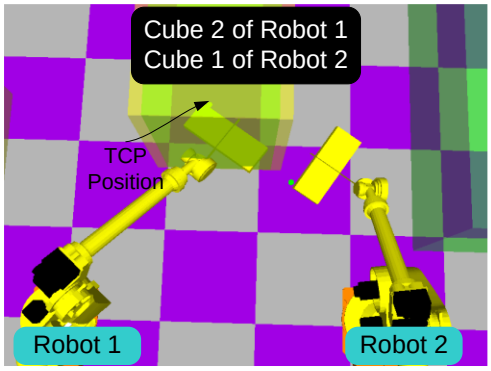
→ The Cube entry output signal of the robot 1 and the Cube prohibition input signal of the counterpart (robot 2) are switched off.



1. The step on the verge of entering the cube shall be set up as a discontinuous step (A=0).
2. If needed, insert the commands of discontinuous motion of the step on the verge of entering the cube (WAIT, DELAY, etc.).
3. Because the robot 1 does not enter the cube yet, the output signal of entry into cube is switched off.
4. Because the signal of access prohibition is switched off, it is in the state where the entry through S8 is possible.

2) After the robot 1 has entered the common cube area (Cube 2),

→ The Cube entry output signal of the robot 1 is switched on.



Program of Robot 1

```
로봇 프로그램 __
S4    . MOVE L,S=100%,A=0,T=2
S5    . MOVE P,S=100%,A=1,T=2
      . DO20=1 'VAC_ON CHECK
S6    . MOVE P,S=100%,A=7,T=2
      . DO16=0 'CENTERING 진입중
      . WAIT DI18=1 'VAC_ON 확인
S7    . MOVE P,S=100%,A=0,T=2
      . DO17=1 'PRESS 진입 요구
      . WAIT DI21=1 'PRESS 확인
      . DO17=0 'PRESS 진입 요구 →Step entering
S8    . MOVE P,S=100%,A=7,T=2 cube
      . DO18=1 'PRESS 진입중
S9    >MOVE P,S=100%,A=1,T=2 → Current Step
S10   . MOVE L,S=100%,A=0,T=2
      . DO13=0 'VAC_OFF
```

범용 출력신호 pg.1/32

1	2	3	4	5	6	7	8
9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40

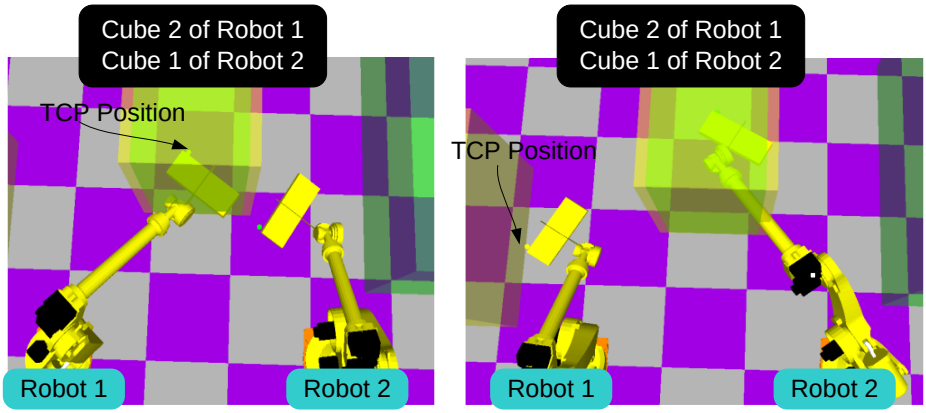
범용 입력신호 pg.1/32

1	2	3	4	5	6	7	8
9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40

1. Because the robot 1 has entered the cube, the ‘Output Signal of Entry Into Cube’ is switched on.
2. The signal of access prohibition to cube is switched off because the robot 2 did not enter the cube.

3) The robot 1 has withdrawn from the common cube area (Cube 2) and the robot 2 enters it.

→ The Cube entry output signal of the robot 1 is switched off.



Program of Robot 1

1. The robot 1 has withdrawn from the cube, so the 'Output Signal of Entry into Cube' changes from switch-on to switch-off.
2. The signal of access prohibition to cube is switched on because the robot 2 has entered the cube.

2.1.4.2. Robot 2

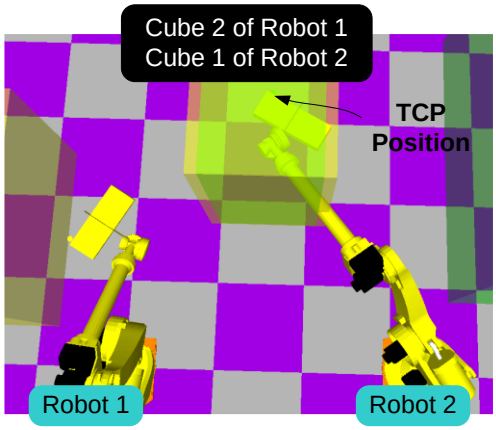
(1) The Robot 2 is fully ready to enter the common cube area (Cube 1)

→ Because the robot 1 has first entered the area and is doing its job, the robot 2 automatically stops and is in a standby mode (“on standby for entry into the cube”)

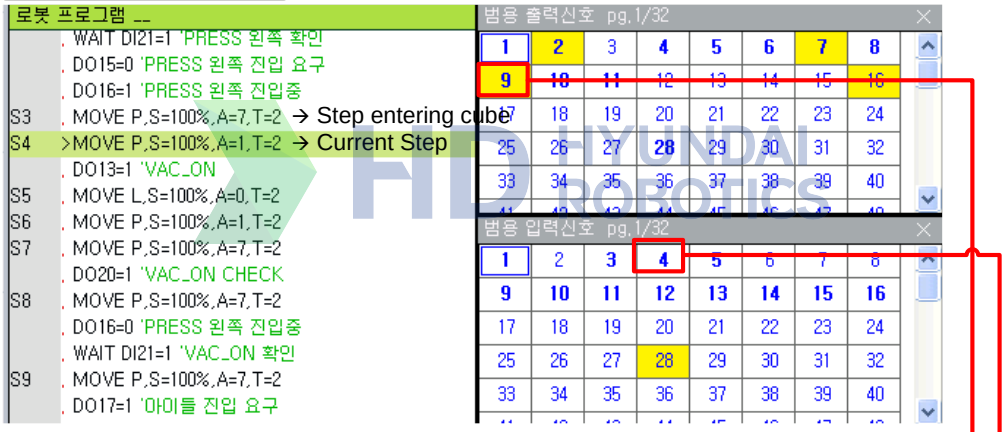
1. The step on the verge of entering the cube shall be set up as a discontinuous step. (A=0).
2. If needed, insert the commands of discontinuous motion of the step on the verge of entering the cube (WAIT, DELAY, etc.).
3. Because the robot 2 does not enter the cube yet, the output signal of entry into cube is switched off.
4. Because the signal of access prohibition to cube is switched on, it is on standby for entry into S3.

(2) After the robot 1 withdrew, the robot 2 has entered the common area (Cube 1)

→ The output signal of entry into cube of robot 2 is switched on.



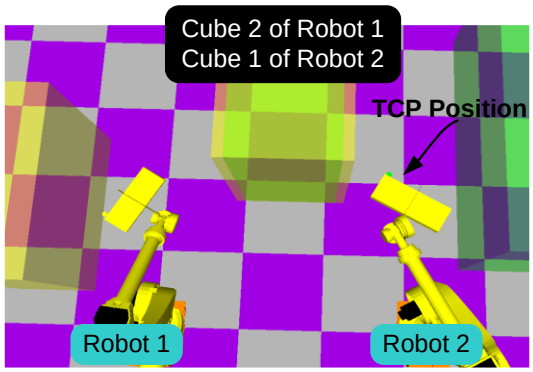
Program of Robot 2



1. Because the robot 2 has entered the cube, the ‘Output Signal of Entry into Cube’ is switched on.
2. The signal of access prohibition to cube has been switched off because the robot 1 withdrew from the cube.

(3) The robot 2 has withdrawn from the job area.

→ The output signal of entry into cube of robot 2 is switched off and cleared.



Program of Robot 2

1. Because it has withdrawn from the cube, the 'Output Signal of Entry into Cube' is switched off.
2. The signal of prohibition access to cube is switched off because the robot 1 did not enter the cube.

2.2. Error Detection

Possible Causes of Errors	The cause is that the signal of access prohibition to the cube is input when a robot has entered the cube.
Error Message	E0222 Same cube simultaneous entry detected
Solutions	1) Move the robot outside the cube area and restart it up. 2) Correct the program so that these errors do not occur. - Designate the step which is on the verge of entering the cube area as a discontinuous step. - Execute an additional Interlock function by using the WAIT command when the robot is on the verge of entering the cube.

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