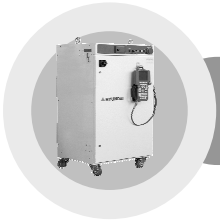
WARNING

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

Hyundai Robot

Hi4aCC071001FMEN3



Hi4a Controller Function Manual

Cooperation Control

HYUNDAI
HEAVY INDUSTRIES CO.,LTD.

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1 Overview

1.1. Introduction of robot cooperation function

Robot cooperation function is the function to execute an operation using several robots to complete an operation that would not be possible with one robot.

This function can be applied to the following cases.

- When handling work object of which the load exceeds the possible handling range
- When handling work object of which the volume exceeds the possible range one robot can handle
- When the master robot is handling the work object and at the same time the slave robot is executing a jigless operation such as arc welding or sealing.

You can synchronize the cooperation work among a maximum of 4 robots.
Each robot can execute an independent operation and a cooperation operation from one program.

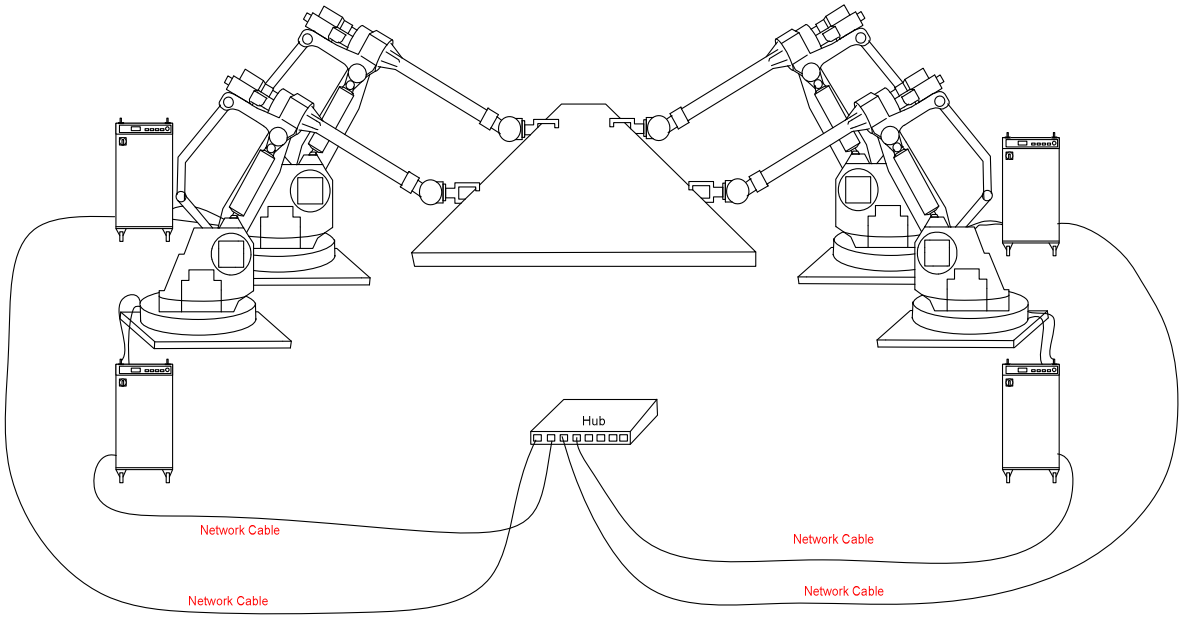


Figure 1.1 Robot cooperation function

1.2. Major function

1.2.1. Major function specification

Table 1-1 Major function specification

Major function specification	Remarks
Number of cooperation robots	Maximum of 4
Communication method	Exclusive for Ethernet (HiNet™)
Communication speed	10/100MBPS
Possible number of master robot	1 robot
Possible number of slave robot	3 controllable slave under 1 master
Main axis	Main axis cooperation is possible
HiNet I/O	32 output point per robot
Jigless cooperation	Optional specification

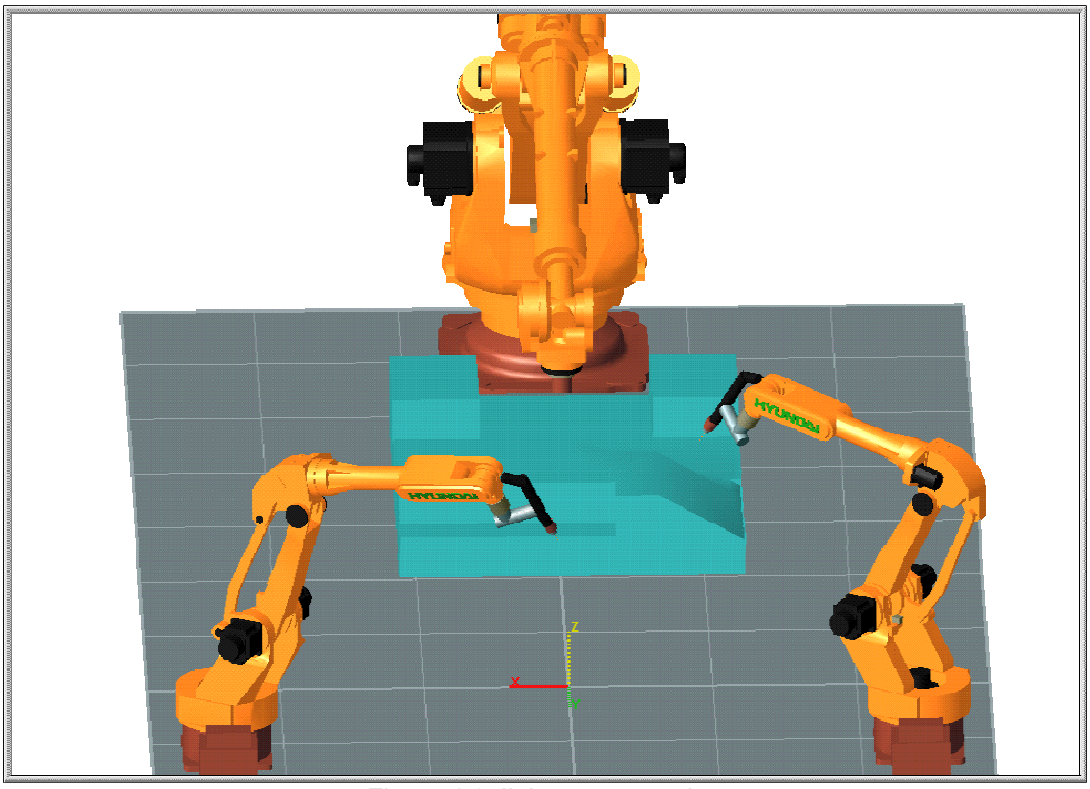


Figure 1.2 Jigless cooperation

1.2.2. Functional characteristics

- Communications
  Cooperation control function can control up to maximum of 4 robots through communication using the HiNet (exclusive for Ethernet).

- Common coordinate setting among cooperation robots
  This is the calibration function to evaluate the relative position of the robot. The common coordinate system among the robots is decided by teaching same 3 points in the work area.

- Manual mode cooperation
  This enables the user to easily prepare the program with the master robot operation in manual mode. The user sets the master and slave role of each robot. For applied handling operations, operate only the master to enable teaching and for jigless cooperation, operate the slave to teach the position on the master work object.

- Positioner master support
  You can enable Cooperation Control by setting the master robot's positioner as the master. In other words, you can enable 4 robots to collaborate on 1 positioner.

- Teaching
  Cooperation robots are independently program to each controller. You can use one program to easily assign independent operation and cooperation operation.

- Playback cooperation
  Cooperation robots wait in the cooperation position for the other robot according to the COWORK command and when all cooperation robots are ready at the cooperation position, the cooperation operation will start.

- HiNet I/O
  This function enables signal input/output through HiNet, Ethernet network exclusively for Cooperation Control without separate robot interlock control panel.

1.3. Operating sequence

This explains the sequence of using the cooperation robot function. Details are as follows.

Robot calibration
Set the axis and tool constants correctly for collaborative control.
- Refer to automatic constants setting function.

Hardware installation
Connect the hardware necessary for controller communications.
- Connect the network card and the communications cable.

Cooperation control parameter setting
Set the whether to apply cooperation control and set each robot number for the robots connected to the network

Cooperation robot coordinate setting
Do the calibration operation that notifies the position of cooperation robots.

Teaching
Allocate the function key for cooperation teaching and designate the robot roles of master and slave. Then teach the master robot.

Check operation
Check the cooperation operation in manual mode.
Operate the cooperation robots to step forward at the same time.

Continuous operation
Switch to auto mode. Set the program to head position and press all the operating switches of the controller designated for cooperation robot.

2 System Setting

2.1. Hardware installation

2.1.1. Emergency stop line connection

When there is an emergency stop during cooperation operation, the corresponding robot is also supposed to stop because it monitors each other through communication. But because the hardware signals have higher priority, the position of the cooperation robots is misaligned. To minimize this misalignment during an emergency stop, make the connections for external emergency stop.

An external emergency stop function for user is prepared in the Hi4a controller. The connection diagram of the external emergency stop is as follows.

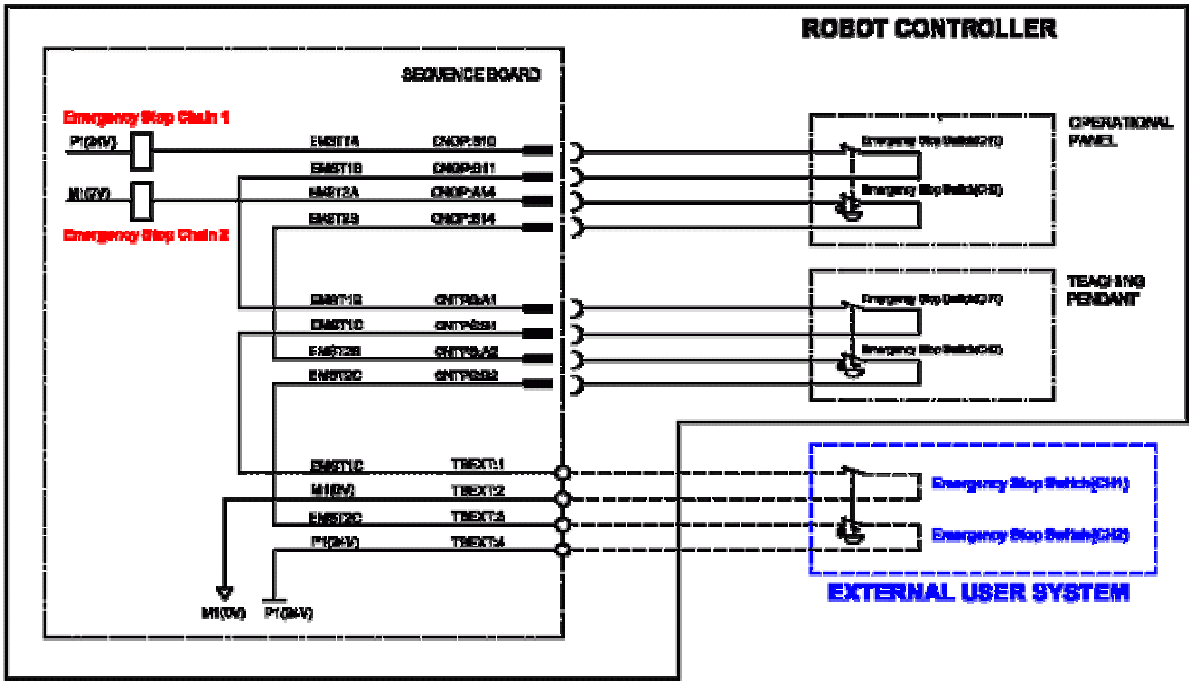


Figure 2.1 User emergency stop connection when using one robot

When using the cooperation robot function, a separate emergency stop switch must be installed for simultaneous emergency stops. Using the external emergency stop connection prepared for the user, integrate to one emergency stop system as shown in Figure 2.2.This will minimize the cooperation position misalignment for the emergency stop.

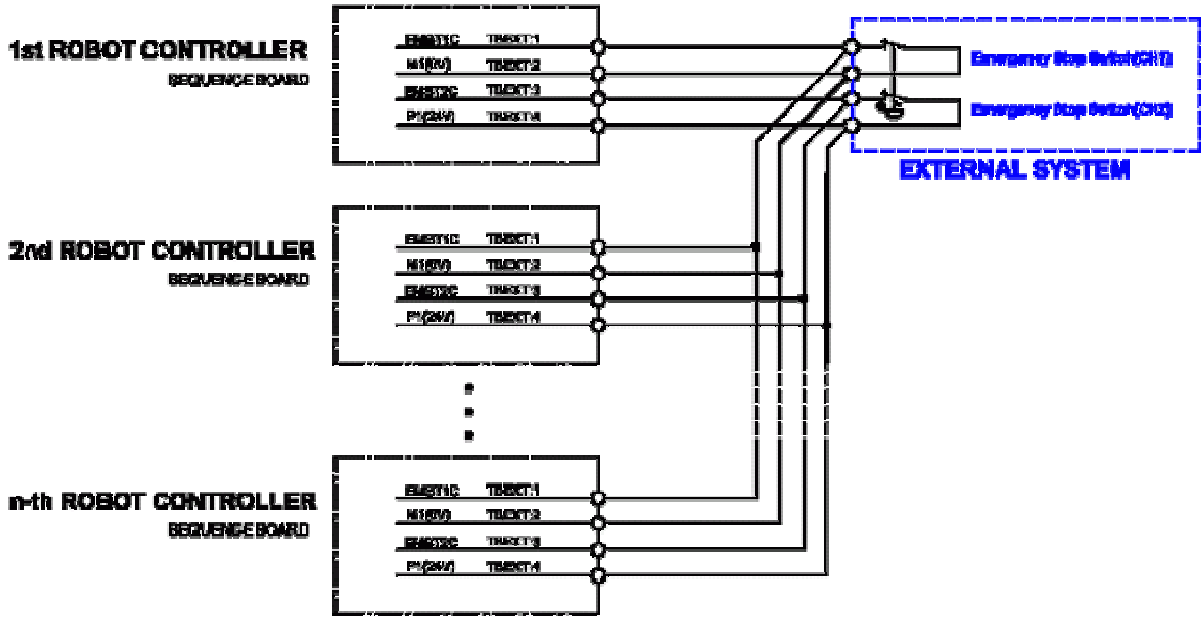


Figure 2.2 Emergency stop connection for cooperation robot

◆ 【Caution】 ◆

- There can be a misalignment of relative cooperation position in case of an emergency stop during cooperation.
- When applying the handling function, you must install the floating equipment to absorb the cooperation misalignment (emergency stop error, synchronization error, calibration error, trace error).
- When applying the handling function and installing the floating equipment, it is recommended to install at least 1 for 2 cooperation robots.

2.1.2. Network composition

(1) Requirements

Components	Specification
BD411 board	BD411 ver 1.0 or above ispLSI BD411V25 or above
PCMCIA LAN card	Specification provided by HHI
UTP cable	-
Network Hub	Specification provided by HHI

(2) Connecting method

- Install the network card to the PCMCIA slot of controller BD411 board.
- Connect the network card and hub using UTP cable.
- Check the network connection

2.1.3. Network connection check

(1) Check for network error in the following cases.

- Initial installation
- When a network error is detected during cooperation control

(2) Check points

- Check if the card is correctly installed in the PCMCIA slot.
- Check the cable.
- Check whether the network card is connected between the controllers.
- Check the network status using the network test function (HiNet diagnosis).

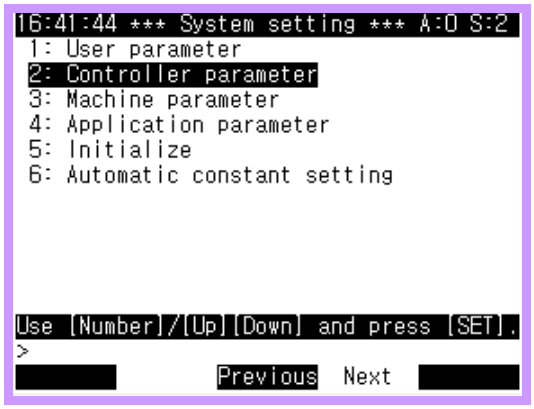
◆【Caution】◆

- HiNet for cooperation control is the network exclusively for Hi4a cooperation control.
- **For normal operation, the cooperation control network must be composed separately from the general network.**

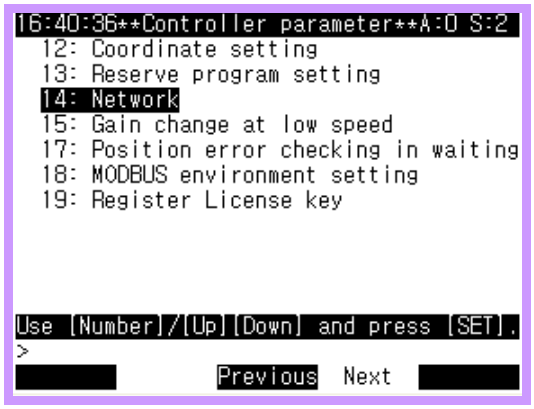
2.2. Controller setting

This sets the communication and robot number etc. for cooperation control of the controller.

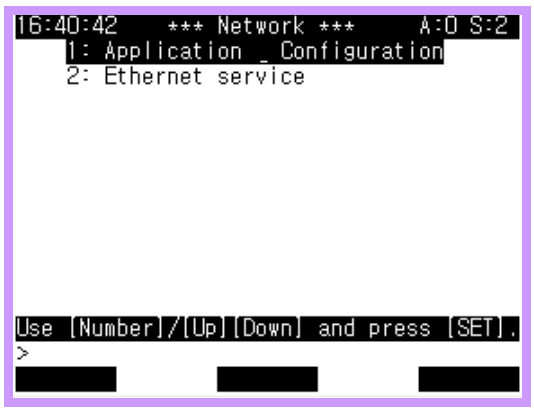
(1) Select 『[PF2]: System』 → 『2: Controller parameter』 in manual mode.

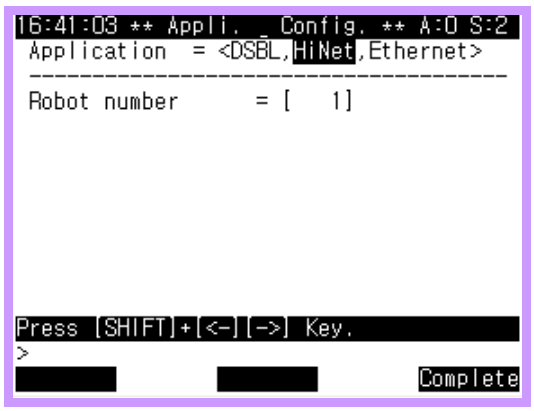


(2) Select 『14: Network』.



(3) Select 『1: Application & Configuration』.





(4) The usage for the above parameter is as follows.

- Usage <DSBL,HiNet,Ethernet>: Select the usage for the network.
  The network usage can be classified into robot cooperation and Ethernet. Select robot cooperation and the Ethernet will be set to HiNet.

- Robot number: Set the robot number. <1~4>
  The robot number is the number to identify the controller within the connected network in cooperation control. You can compose the collaborative network with a maximum of 4 robots for the Hi4a controller. Set the robot numbers so that they are not duplicated.

◆【Caution】◆

- The cooperation control function cannot be applied to special robot and robots with a freedom degree of less than 6. In this cane, the cooperation function cannot be switched to Enable.

- Robot cooperation and Ethernet cannot be used at the same time. When set to robot cooperation, a separate network must be connected within the robots selected for robot cooperation.

2.3. Common coordinate setting among cooperation robots

2.3.1. Introduction to common coordinate setting

For cooperation operation, the installed position among robots must be accurately known. The controller calculates the position of tool end based on its own base coordinate. Calibration process among robots is needed to identify the position of the corresponding robot. The coordinate calibration among robots is done by setting the common coordinate.

Set the common coordinate to mutually identify the position of robot 1 and robot 2. (Figure 2.3) It can be set by teaching 3 same points in the area for each robot.

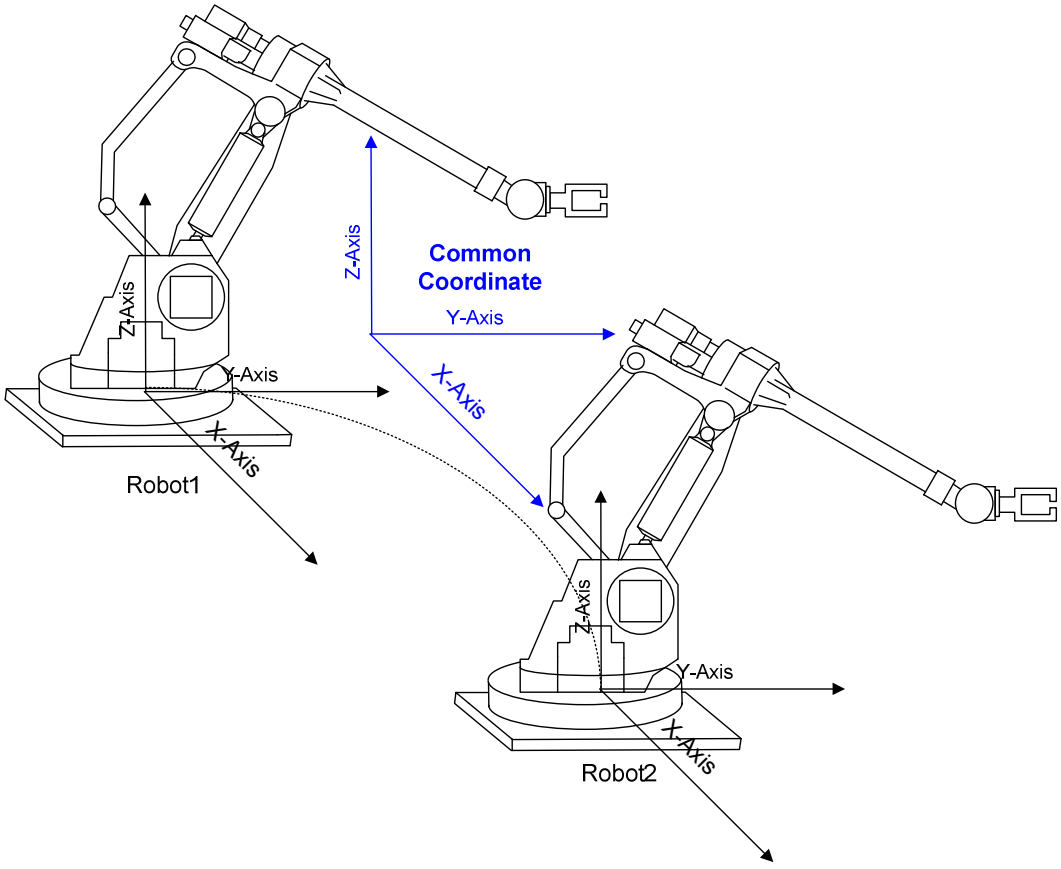


Figure 2.3 Common coordinate setting among cooperation robots

2.3.2. Setting common coordinate for 2 or more robots

The common coordinate for the cooperation robot must be set with same points among the robots. Therefore make sure all the robots are pointing to the same point. Therefore if the robots are far spread out, it is impossible to set a common coordinate. For such cases, you can create a separate tool to teach the same points to the robots.

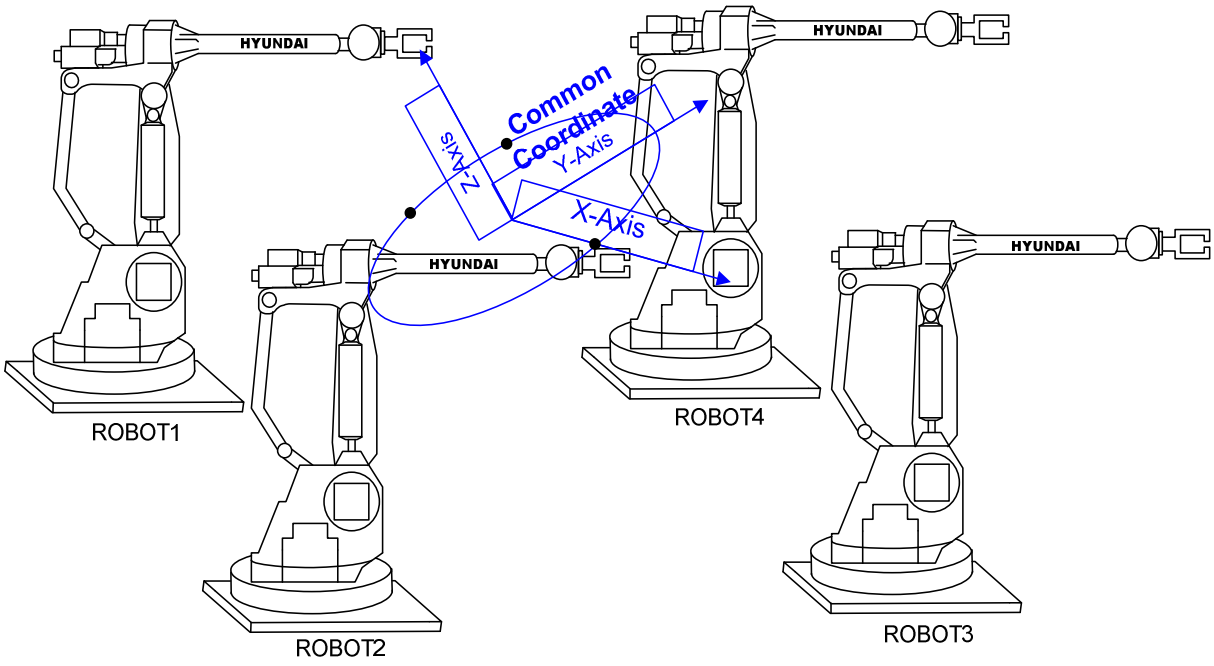


Figure 2.4 Setting common coordinate for 2 or more robots

2.3.3. Traverse axis system

When composing a traverse axis system for cooperation control, the traverse axes with same specification must be installed in parallel as possible.

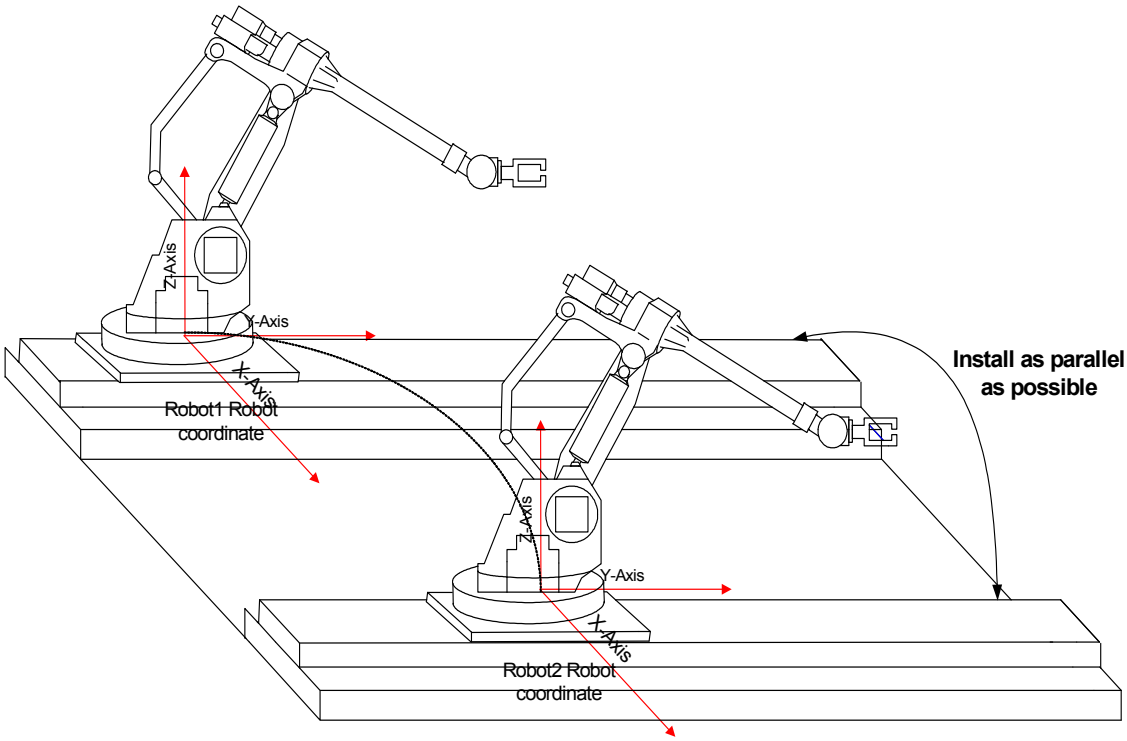


Figure 2.5 Main axis system composition for cooperation control

◆【Caution】◆

- For system with a main axis, set the specification of the traverse axis to ‘arbitrary’ and use it after traverse axis calibration.
- It is recommended that the traverse axes among cooperation robots be installed as parallel as possible.
- If the synchronization error increases as the robot moves along the traverse axis, this can be from inaccurate calibration of traverse axis.
- For details on the traverse axis calibration function, please refer to 『Hi4a Controller operating manual』.
- Traverse axis calibration must be set for both master and slave.

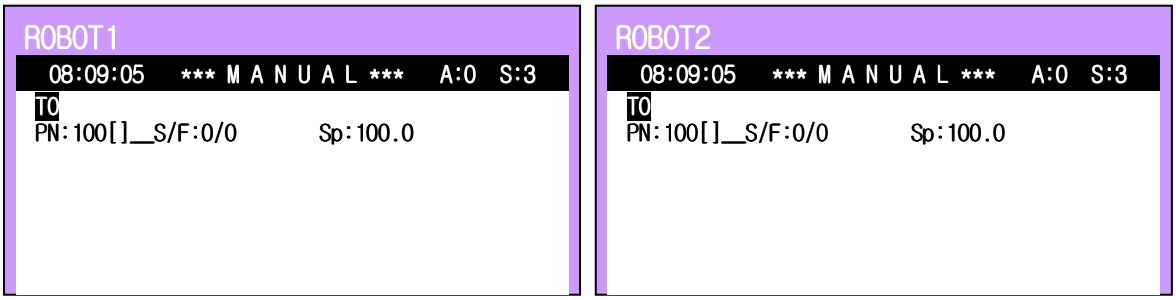
2.3.4. Common coordinate setting

The common coordinate setting is only possible when the accurate position of the cooperation robot tool end is known. At this time, the robot calibration must be done. Hi4a controller provides the axis constant and tool length calibration function (『[PF2]: System) → 『6: Automatic constant setting』 → 『1: Optimizing axis Cnst.& tool length』).
For more details please refer to the 『**Hi4a Controller operation manual**』. **Set the common coordinate after setting the most delicate automatic constant.**

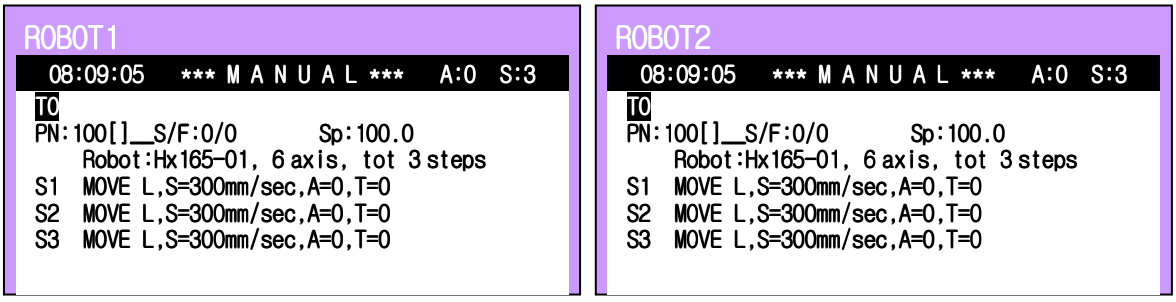
To explain the common coordinate setting, we will use the example of robot 1 and 2, which just finished automatic constant setting.

■ Teaching method

① Select the program to record in the applicable controller for robot 1 and 2.
Ex) When registering the cooperation coordinate system programs of both robots 1 and 2 to 100



② By using each jog of robot 1 and 2, record the 3 points to step 1, 2 and 3 in order to create a triangle, as large as possible.



The recorded position is recorded in the same position in space. Even though the interpolation method and speed are irrelevant, the tool number must be correctly selected.

◆ 【Caution】 ◆

- For the tool data for common coordinate setting, enter the accurate tool specification or calculate the tool data through automatic constant setting.
- It is recommended that the robot position of each point is recorded in the same way.

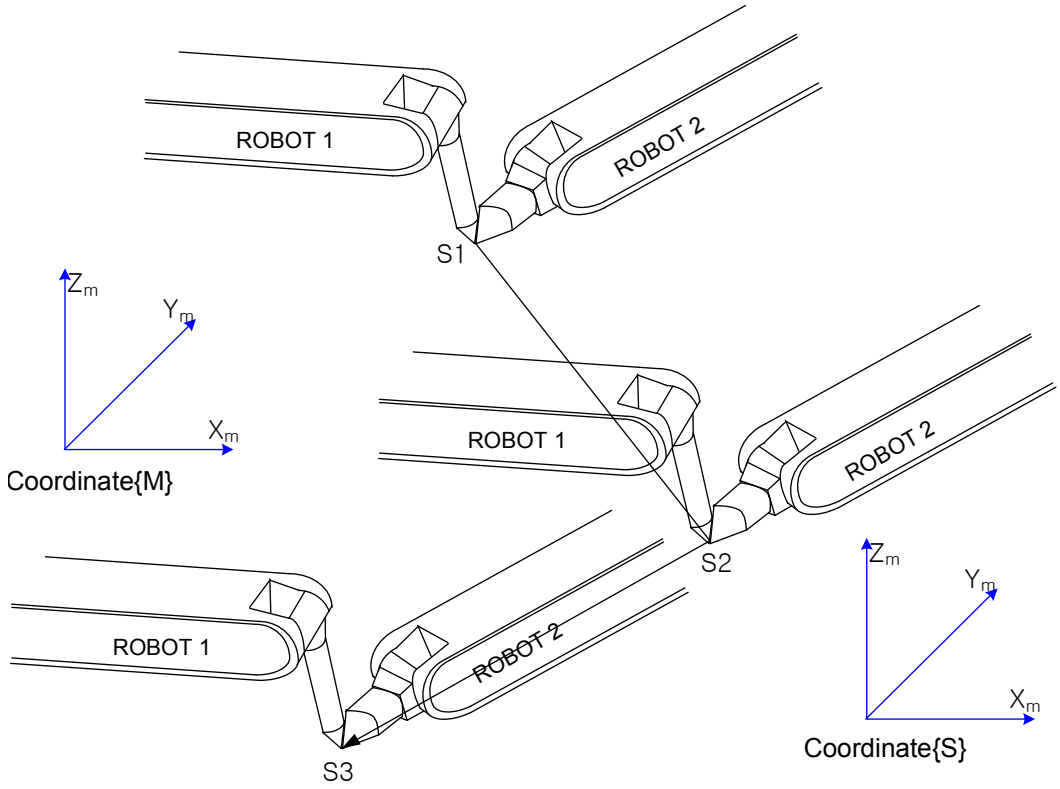
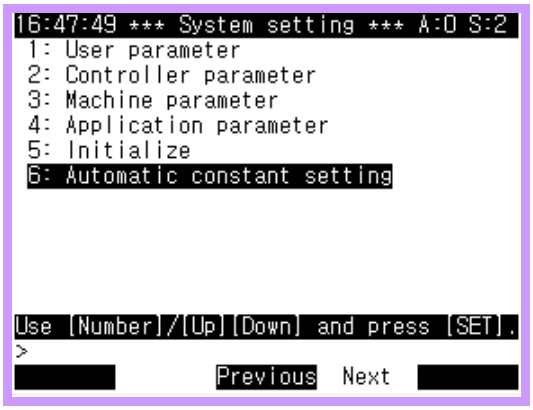
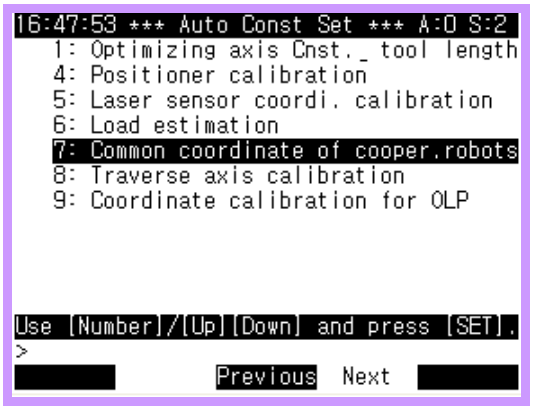


Figure 2.6 Teaching method of common coordinate setting

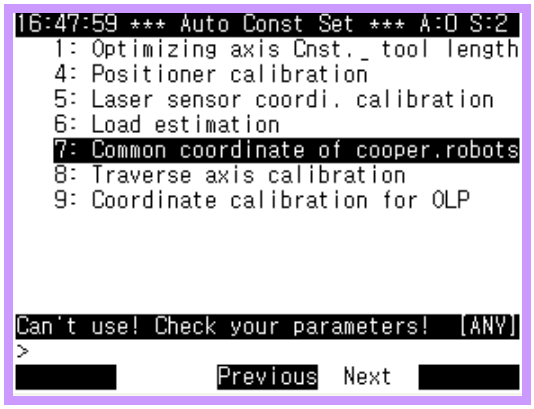
③ Execute the cooperation coordinate setting for each robot (robot 1 and 2).

④ Select 『[PF2]: System』 → 『6: Automatic constant setting』 in manual mode.

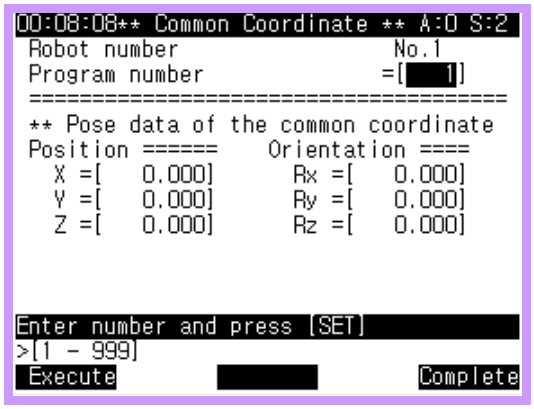




※ If the cooperation control in the cooperation control parameter is set to <DSBL>, the following error message will be displayed.



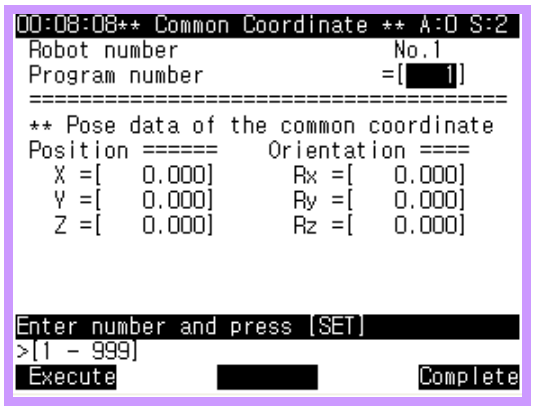
⑤ Select 『7: Common coordinate of cooper.robots』.



※ The meaning of the above parameter is as follows.

- Robot number: The cooperation robot number set in cooperation control parameter.
- Program number: The program number for cooperation robot coordinate registration

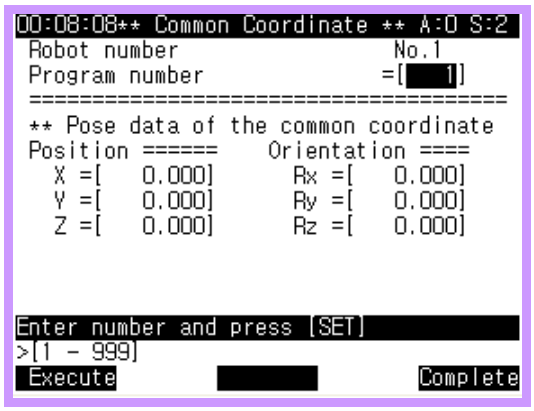
⑥ Press the 『[PF1]: Execute』 key. The results will be displayed in the screen through position and position of the common coordinate from robot base. Relative positions are in X, Y, Z and relative positions are in Rx, Ry, Rz.



⑦ Press the 『[PF5]: Complete』 key to complete the setting.

2.3.5. Common coordinate check

(1) When the common coordinate of the cooperation robot is set, you can always check the setting from the screen of 『Common coordinate of cooperation robot』.



◆【Caution】◆

- The common coordinate can only be registered when the cooperation control is set to <ENBL>.

- The relationship of the position Rx, Ry and Rz of the common coordinate to the robot coordinate is as follows.
  ① Rotate its robot (No. 2) coordinate (ref) to X axis direction by γ angle.
  ② Rotate its robot (No. 2) coordinate (ref) to Y axis direction by β angle.
  ③ Rotate its robot (No. 2) coordinate (ref) to Z axis direction by α angle.

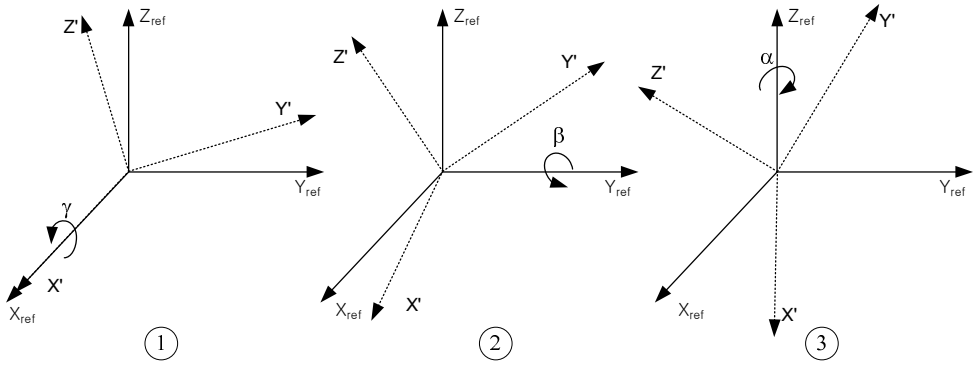


Figure 2.7 Common coordinate position conversion

④ The position in the common coordinate is the position rotated by γ,β and α from the its own robot (No. 2) base coordinate.

- Teach the 3 points by generating a triangle, as large as possible. If the points are too close to one another or if they are on a straight line, it can cause an error.

- If the common coordinate is not set, manual cooperation jog operation or cooperation playback is not possible.
- It is recommended that you check whether the common coordinate in set correctly by actually running the operation without any working object through jog control.

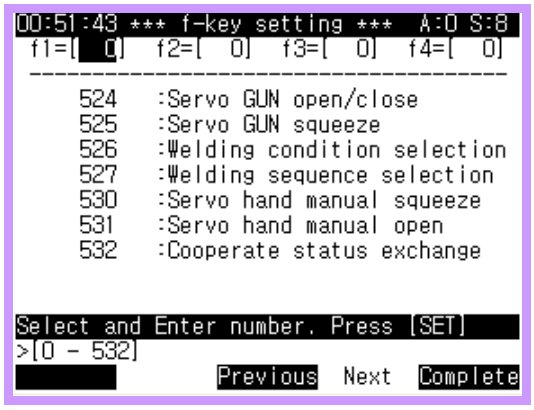
3

Manual Mode Cooperation Operation

3.1. User key (F-Key) registration

This sets the user f key for cooperation control in the manual mode.

(1) Select 『[PF2]: System』 → 『2: Controller parameter』 → 『11: f-key setting』 in manual mode.



(2) Set the item in 『Cooperate status exchange』 to one of the four keys from f1 to f4.

(3) You can switch between manual individual mode and manual cooperation mode by using the allocated f key in manual mode.

3.2. Individual/Cooperation Switch

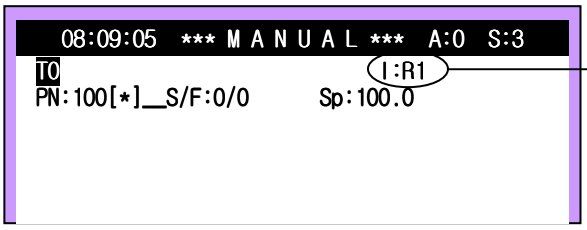
■ Function switch by key operation

There are two ways to switch the cooperation control operation in manual mode; method using the allocated key or method using the R code. Details are shown in the table below.

Table 3-1 Function switch by key operation

Key operation	Function switch
F key (Cooperation condition change key)	Manual individual mode (Indiv) ↔ Manual cooperation mode (MASTER/SLAVE)
SHIFT + f key	MASTER ↔ SLAVE (CMOV record mode)
R351,0	Manual individual mode
R351,1	Manual cooperation mode, designate master
R351,2	Manual cooperation mode, designate slave
R351,3	CMOVE record mode, designate SLAVE jog mode

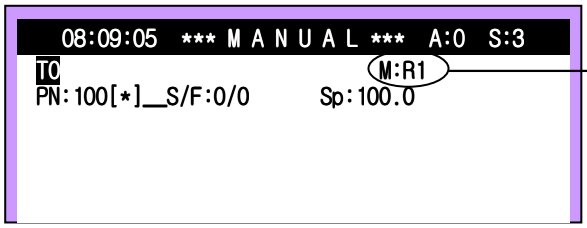
■ Manual mode individual condition



Select as INDIVIDUAL, robot number 1

In this condition, each robot can be individually controlled with jog.

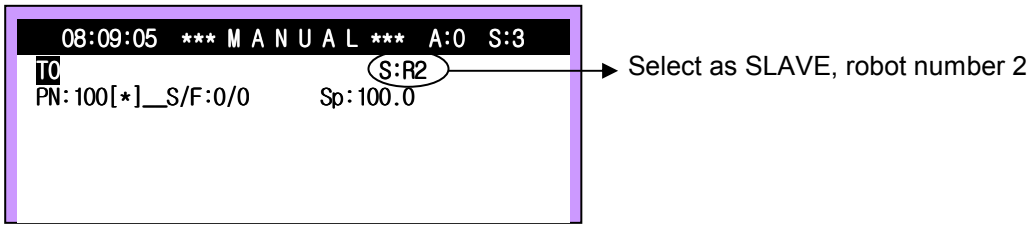
■ Manual mode cooperation condition (master designation)



Select as MASTER, robot number 1

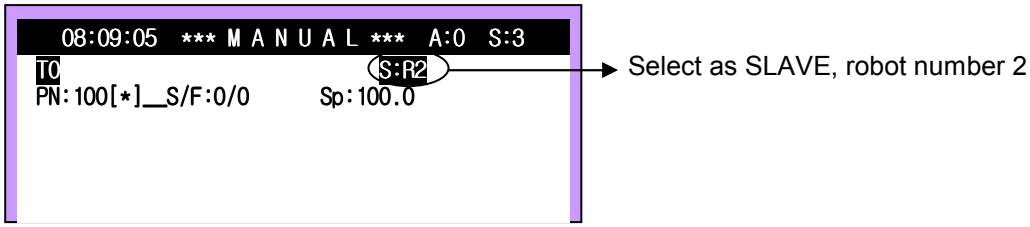
This is the condition for synchronized operation of the slave according to the movement of the master.

■ Manual mode cooperation condition (slave designation)



This is the condition to designate the slave to follow the movement of the master.

■ CMOV record mode, SLAVE jog mode condition (Optional)



This is the condition to record CMOV, check the teaching position by moving the step of CMOV command forward/backward and jog control the slave based on the master robot's end effecter coordinate.

◆ 【Caution】 ◆

- When the common coordinate is not set, it is impossible to switch the cooperation role between master and slave in the individual condition.
- In manual cooperation condition switch through R code, the R351,3'CMOV record condition' can only be done in 'manual cooperation condition (slave designation mode)'(R351,2).
- To change the 'CMOV record condition' using the allocated F key, first change the robot role to slave using the F key and then use the SHIFT+F key to change the condition.

① Individual/Cooperation switch

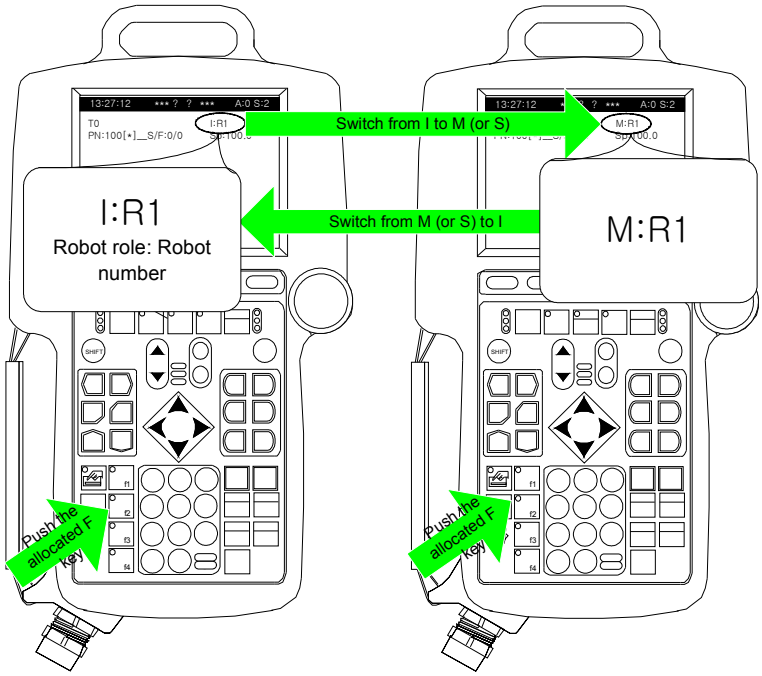


Figure 3.1 Individual/Cooperation switch

② SLAVE/SLAVE switch

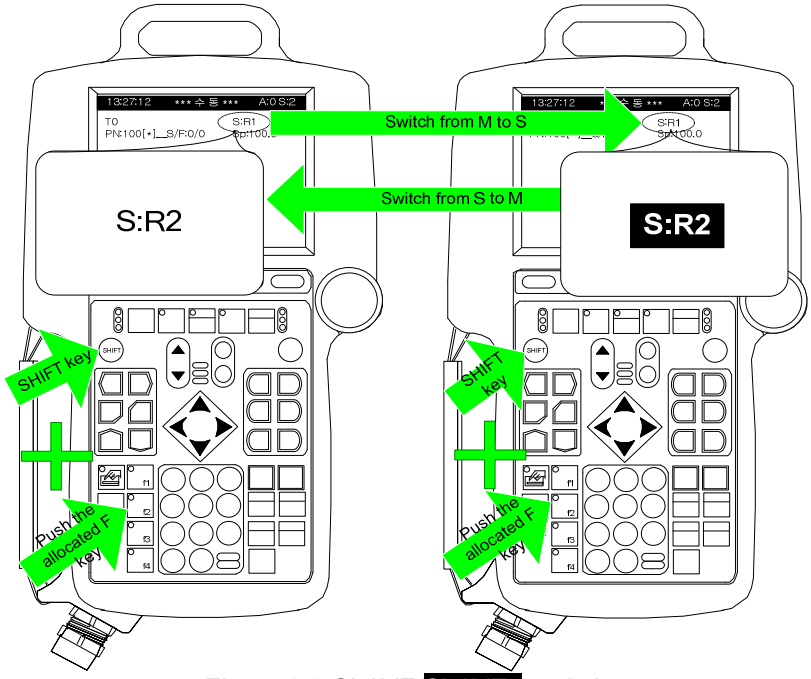


Figure 3.2 SLAVE/SLAVE switch

3.3. Manual mode cooperation operation

■ **Setting master and slave robot**
Set the robot roles of master and slave using the set f key (or R351, R352 code). You can designate the robot role irrelevant of the robot number.

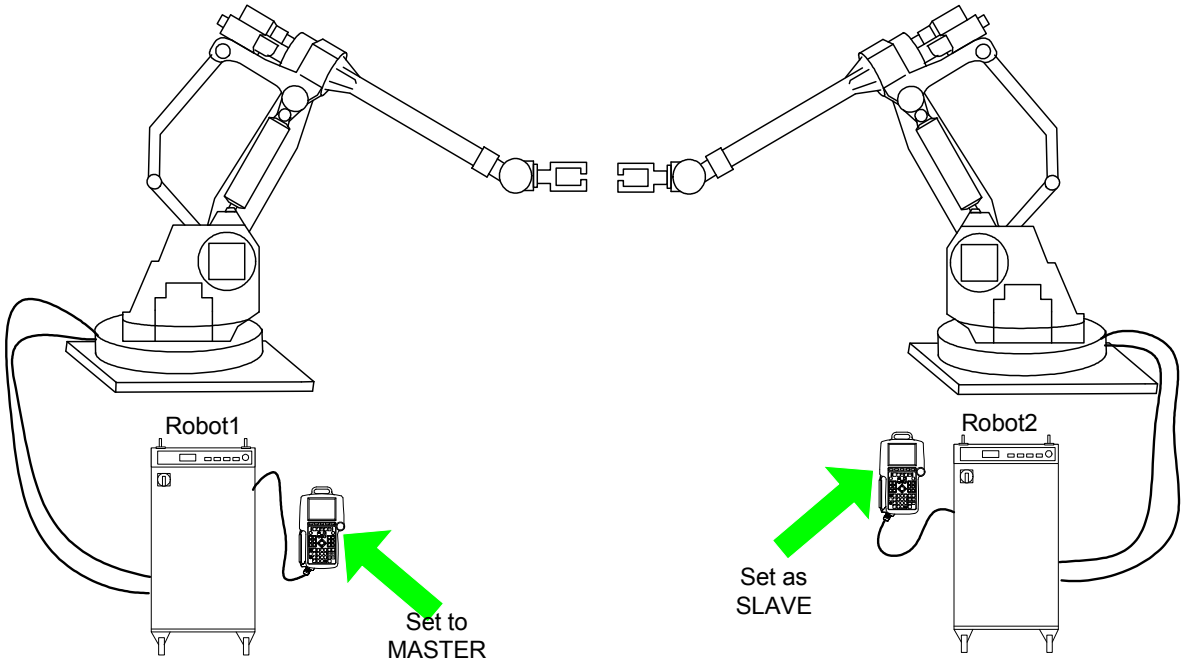


Figure 3.3 Manual mode cooperation operation
(Setting master robot and slave robot)

① Check if both master and slave robot are in 'manual mode'.
② Keep both the master and slave robot in operation ready ON condition.
③ Set the slave robot to JOG OFF condition and set the master robot to JOG ON.
④ Use the Enable switch of the slave robot and maintain it to operation ready ON condition, and also check if the master robot is in operation ready ON condition.
⑤ When you control the master robot, the slave robot will follow in a relative position.

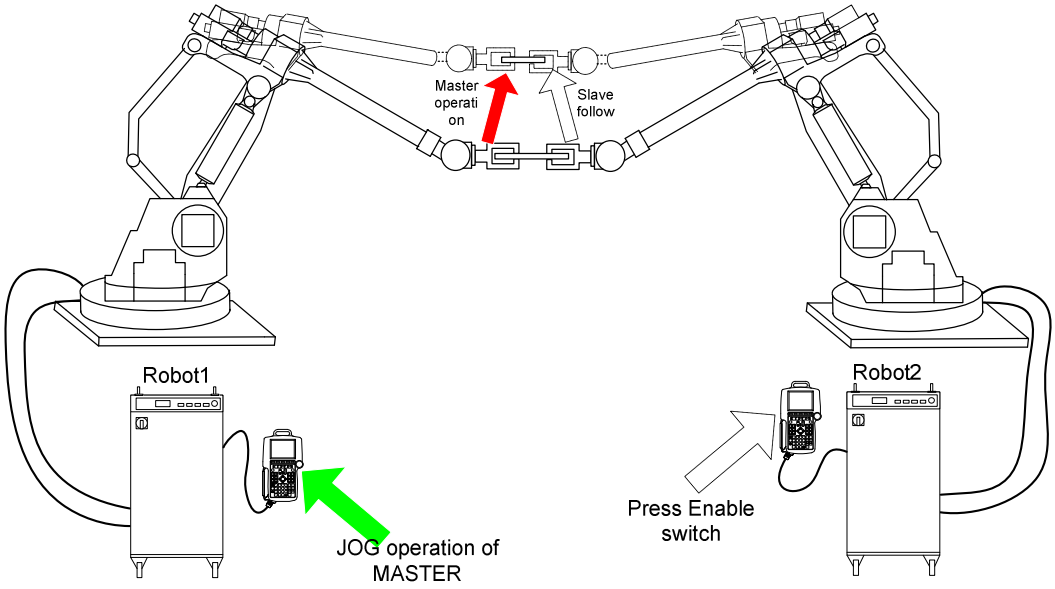


Figure 3.4 Manual mode cooperation operation
(Master robot operation / Slave robot follow)

◆【Caution】◆

- **Manual collaborative job is not possible in the following cases.**
  ① When operating two or more master robots
  ② When operating the slave robot
  ③ When the Enable switch for master or slave robot is not pressed
  ④ When the collaborative coordinate among robots is not set

- Jog operation is not possible for the slave robot during manual mode cooperation function. For jog function of the slave robot, you must change the robot role to individual.

- When the cooperation control is set to <Disable>, I:R#/S:R#/M:R# will not be displayed on the top part of the screen in manual mode and the setting will not be in effect. Therefore, manual cooperation jog is also not possible.

3.4. Cooperation Traverse Axis Jog

Cooperation traverse axis jog is the same operation as the general cooperation jog. If you operate the master robot on the traverse axis in cooperation jog condition, as shown in Figure 3.5, the slave robot will adjust and move to the relative position of the traverse axis.

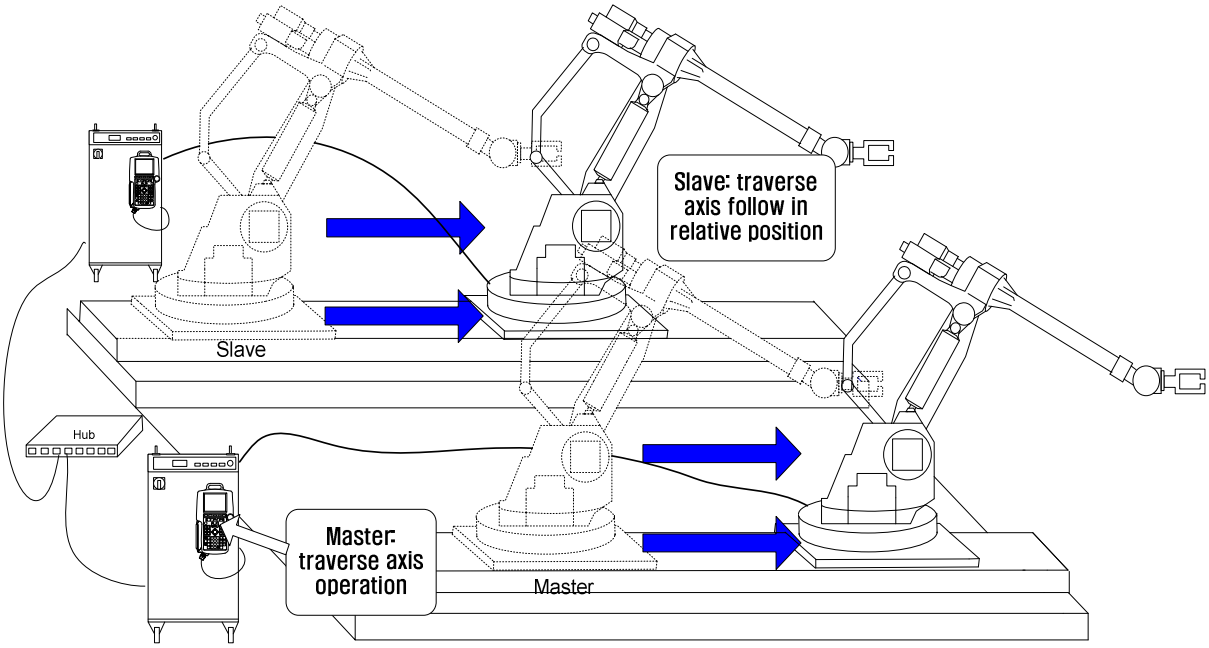


Figure 3.5 Cooperation traverse axis jog

◆【Caution】◆

- The traverse axes of the master and slave robot for cooperation control system must be installed in parallel, as possible.
- Cooperation control traverse axis system only supports one axis.
- For cooperation traverse axis function, the main axis calibration function must be used prior to the operation.

3.5. CMOV record mode jog (SLAVE)

(1) CMOV record mode is the mode to teach the slave position for jigless cooperation operation.

(2) Select the robot role as Slave to set the CMOV record mode.
(After entering the R 351,2 code, allocate the cooperation condition switch F key and use the SHIFT+F key to change the robot role. S:R2 will be displayed with the robot role and number on the top right side of the screen.)

(3) Set the master robot to manual cooperation condition. (R351,1)

(4) Set the JOG ON LED to ON and operate it in orthogonal coordinate jog condition. You will see the orthogonal coordinate jog based on master tool end effecter coordinate as shown below in the figure.

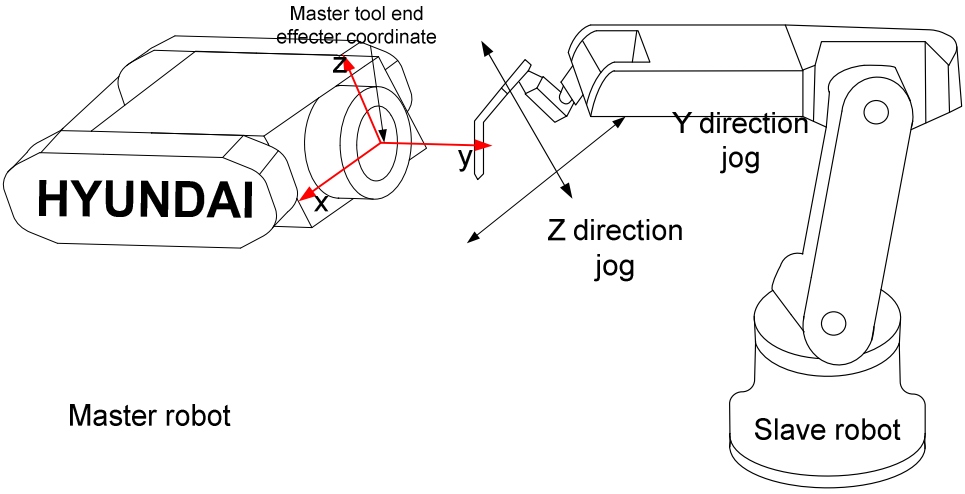


Figure 3.6 CMOV record mode jog

◆ 【Caution】 ◆

- When the slave is in CMOV record mode, jog operation for master robot in manual cooperation condition is not possible.
- This function is an optional specification.

3.6. Arm interference and soft limit detection among cooperation robots

During cooperation operation, the master controls the slave's movement. When the user is controlling the master robot in manual mode and the one of the slave robots generated a soft limit or arm interference angle error, the corresponding robot in cooperation also stops at its current position.

3.6.1. Error detection

When one of the robots stops from an error caused from an arm interference error or soft limit, the robot stops keeping its current position. Even when the error is caused by the slave, the master also stops the operation.

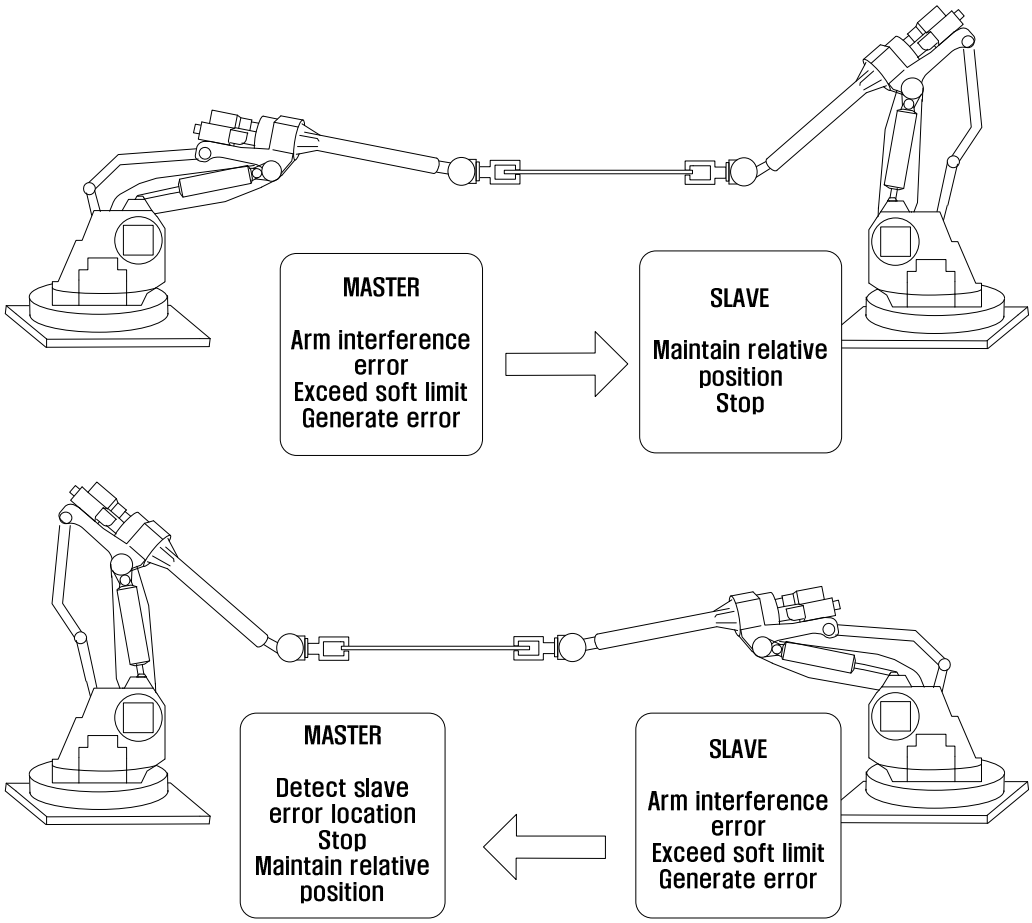


Figure 3.7 Error detection

3.6.2. Error cancel

To cancel the error, you can press the operating key of the master robot to the direction where it does not generate an error. And when you press the operating key to the direction where it does not generate an error one more time, you can proceed the operation.

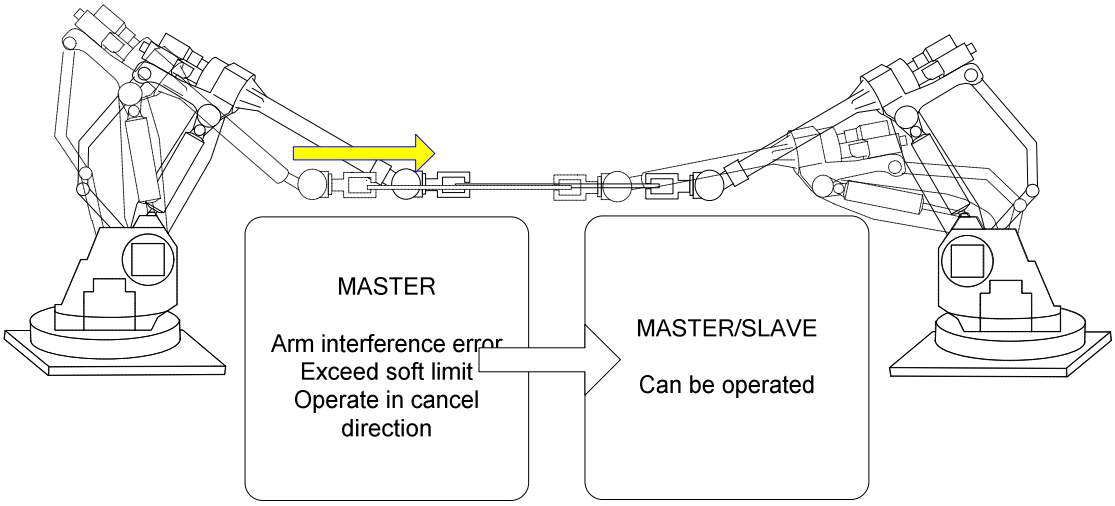


Figure 3.8 Error cancel

4

Cooperation Operation Teaching

4.1. COWORK function

4.1.1. Function parameter

COWORK function is recorded in the program as a function and indicates the start and end of the cooperation control. This function also designates the master and slave of each robot.

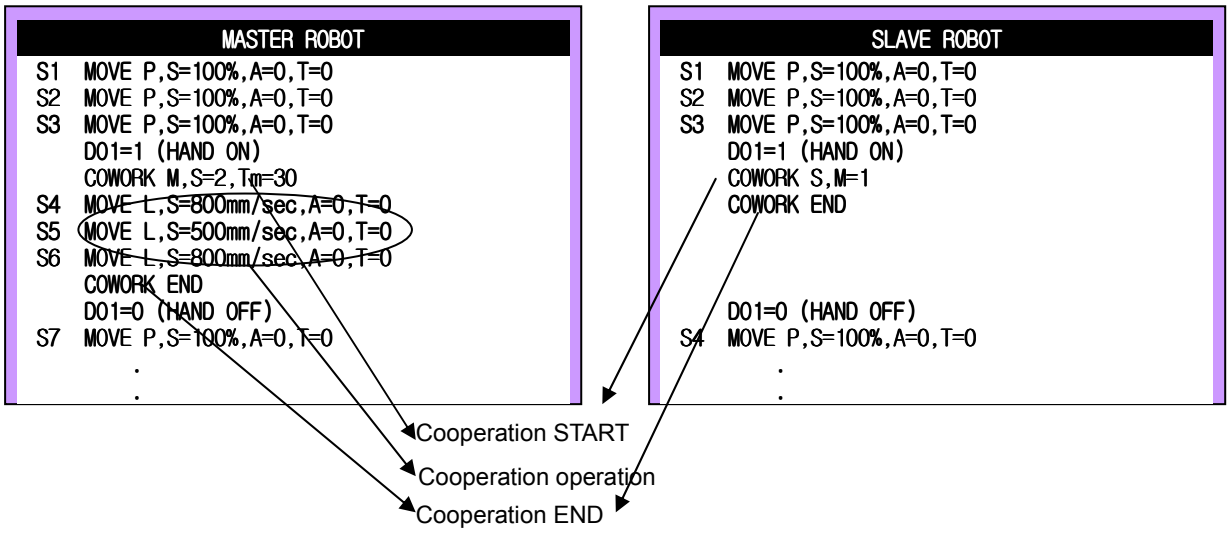
COWORK {parameter1},{parameter2},{parameter3},},{parameter4} **…** **(Cooperation program)** **…** **COWORK END**	**Start cooperation** **End cooperation**
parameter1	□ Designates own robot role (MASTER/SLAVE) □ Designates end of cooperation operation **M**: Designates itself as master **COWORK M,S=…,** **S**: Designates itself as slave **COWORK S,M=…** **END** : End cooperation operation **COWORK END**
parameter2	□Designates other robot number **When designated itself as master : COWORK M,S=2,3,4** Others become the slave and designates the slave robot number (maximum of 3) **When designated itself as slave : COWORK S,M=1** Other robot becomes the master and designates the master robot number
parameter3 (Optional)	□ **Manipulator ID number designated as master from the master robot controller** **When designated itself as slave : COWORK S,M=1,ID=0** ID = 0 is robot manipulator ID = 1 is positioner group 1 registered as additional axis (When the positioner group is set as additional axis to master axis)
parameter4	□ Collaborative corresponding robot standby time (Sec) < 0 ~ 120 > When not designated, it is infinite standby **When designated itself as master : COWORK M,S=2,T=30** Standby time until slave returns to collaborative reference position **When designated itself as slave : COWORK S,M=1,T=30** Standby time until master returns to collaborative reference position

4.1.2. Method of using COWORK function

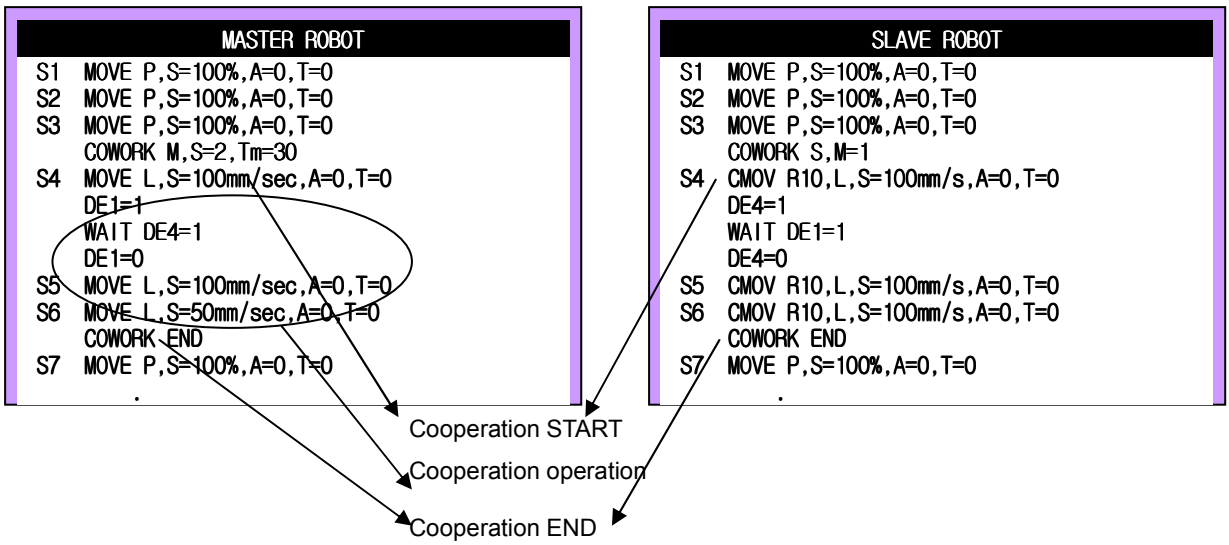
(1) For the master robot, the operating command in the zone between COWORK and COWORK END becomes the collaborative zone command. The slave cannot insert an operating command.

(2) The slave cannot use the general move command and must use the CMOV command which is the COWORK MOVE command.

(3) For handling operation, which is for the slave to follow the master robot, the slave moves with the master while keeping a relative position even though the CMOV command is not inserted, as shown in the below example.



(4) You can insert a CMOV command to the slave based on the master end effecter coordinate, and the recording position of CMOV is based on the master tool end effecter coordinate. If taught as shown in the below example, the cooperation operation is done in the COWORK~COWORK END zone. In this operation, the slave follows the master robot on the CMOV trace recorded in the master end effecter coordinate. (**Jigless cooperation control is an option**.)



◆【Caution】◆

- At the end position of the cooperation operation, a COWORK END command must be inserted.
- For the slave robot, the MOVE command cannot be inserted within the cooperation zone. For the master robot, the CMOV command cannot be inserted.

4.2. Program Teaching and Preparation for Cooperation Handling

(1) You need the same number of operators as the number of cooperation control units. Therefore you need as many operators as the robots.

(2) Check whether the common coordinate of the cooperation robot is set. Allocate the f key necessary for cooperation control.

(3) Move the master and slave robot to the starting position of the cooperation operation and record the starting position based on the reference position.

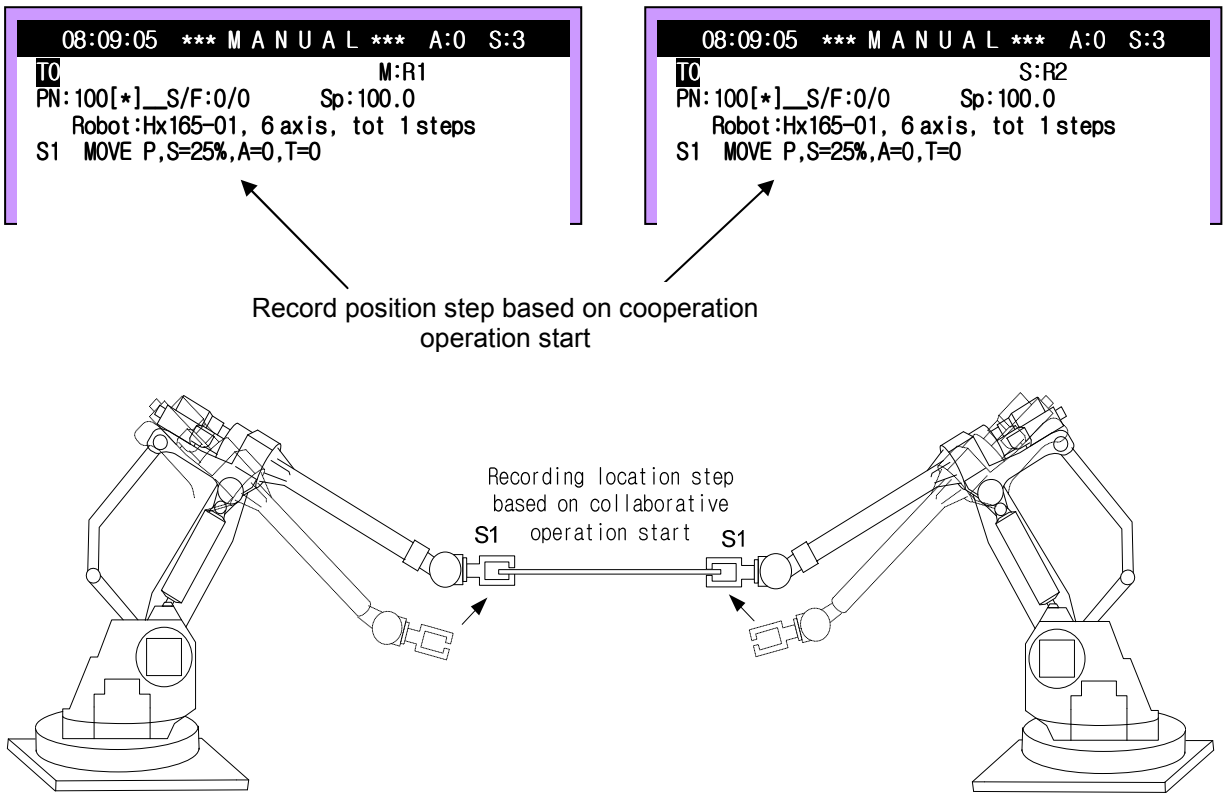
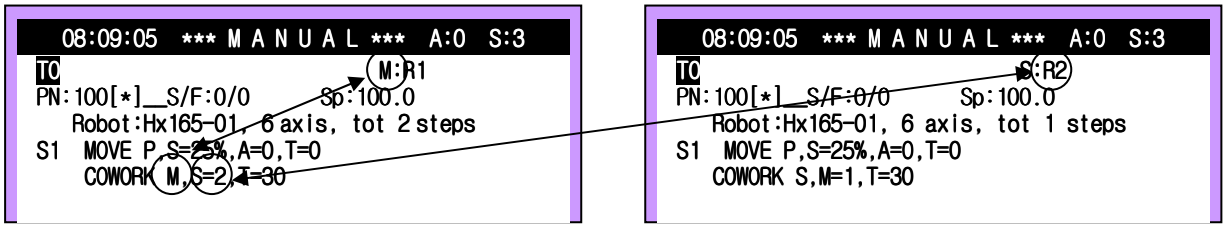


Figure 4.1 Recording position step based on cooperation operation start

(4) Set the master and slave robot to cooperative status using the f key. The robot roles can be set by entering the R351 code.

(5) Check if the master robot is set to master and slave robot to slave and also check whether the operation ready is ON. Set it to jog on for master and jog off for slave.

(6) Register the COWORK M/S command and record the step. COWORK command designates the master/slave recognition and designates the slave/master number.



(7) Control the master robot with jog. At this time the slave follow the master robot's movement in relative position at the tools end position. At this time, the Enable switch must be pressed for the slave. The step is recorded only to the master from record position. It is not recorded in the slave robot controller.

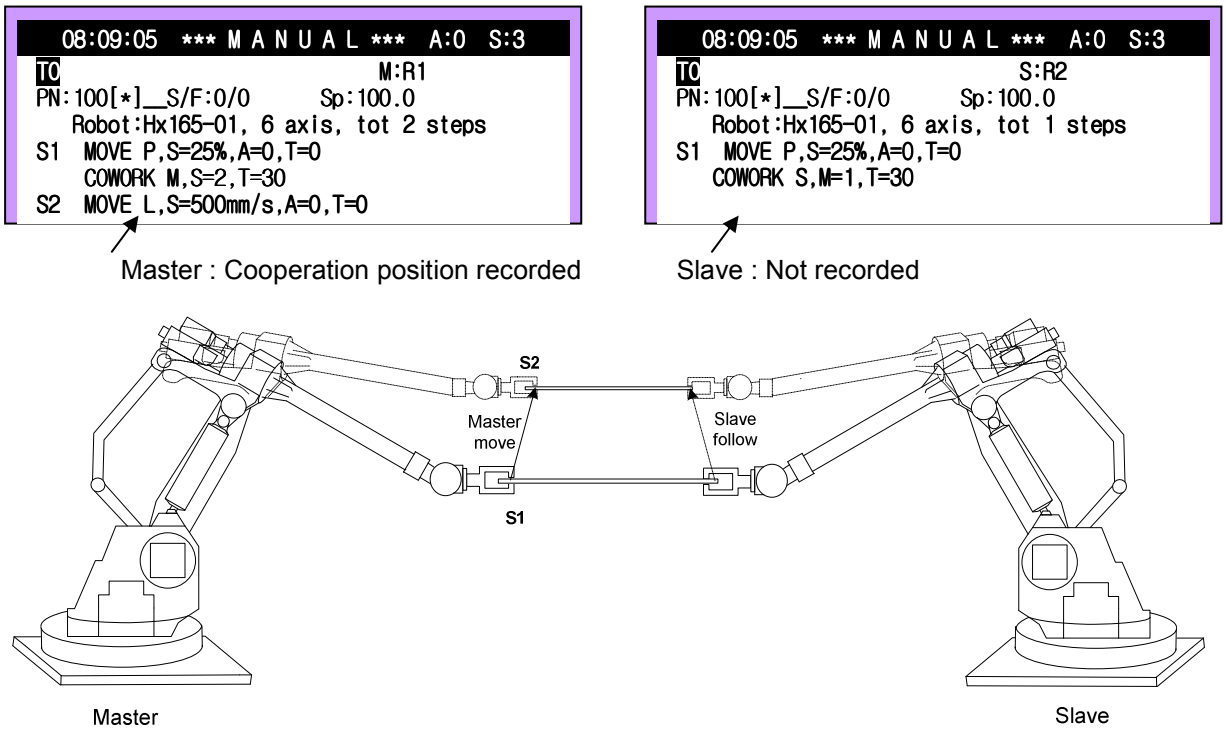
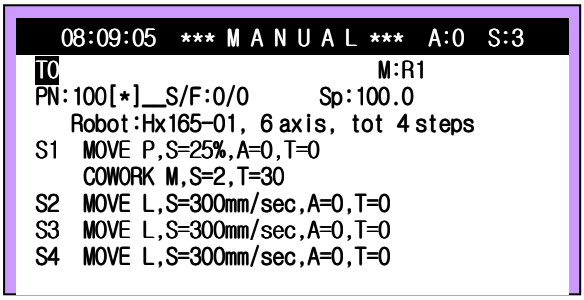
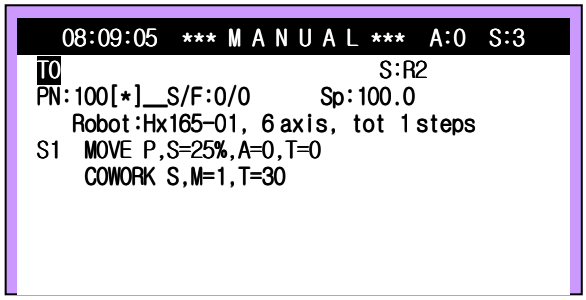


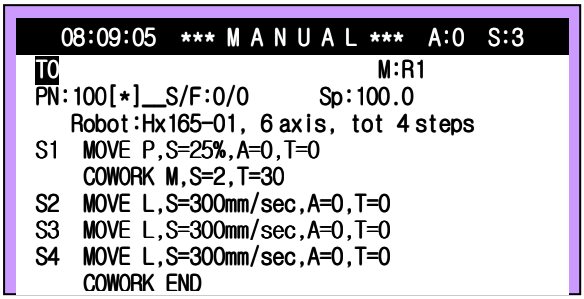
Figure 4.2 Master robot operation

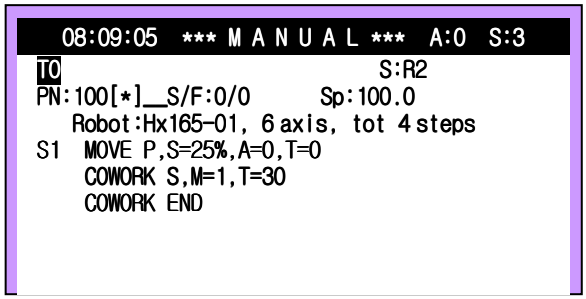
(8) Cooperation operation step is recorded to the master. Set the interpolation type and speed of the master. Use the general move command within the cooperation operation function. (SMOV cannot be used.)





(9) When the cooperation operation is done, the COWORK END command is inserted to the master and slave.





◆ 【Caution】 ◆

- Manual cooperation robot role and COWORK robot role must be the same. For example, if the manual cooperation condition is set to set to slave, COWORK M cannot be executed.

- Do not set to Enable switch of the slave to OFF during manual cooperation operation. Because the hardware signal is processed prior to the communication speed, a misalignment between the robots can occur. In this case, it can damage the work object or robot hand in severe cases.

4.3. CMOV command

CMOV {parameter1},{parameter2},{parameter3},{parameter4},{parameter5}	
parameter1	□ Manipulator identifier of master system R(#1)(#2) #1 : Master robot system number (1 ~ 4) #2 : Master manipulator identifier of robot system (0: Robot, 1: Positioner Group 1)
parameter2	□ Interpolation Designs the slave robot's interpolation method. Only applies to straight line or arc. (L: Linear, C: Circular)
parameter3	□ Interpolation speed Designates the relative speed compared to work object
parameter4	□Accuracy (0~3)
parameter5	□Tool number (0~7)

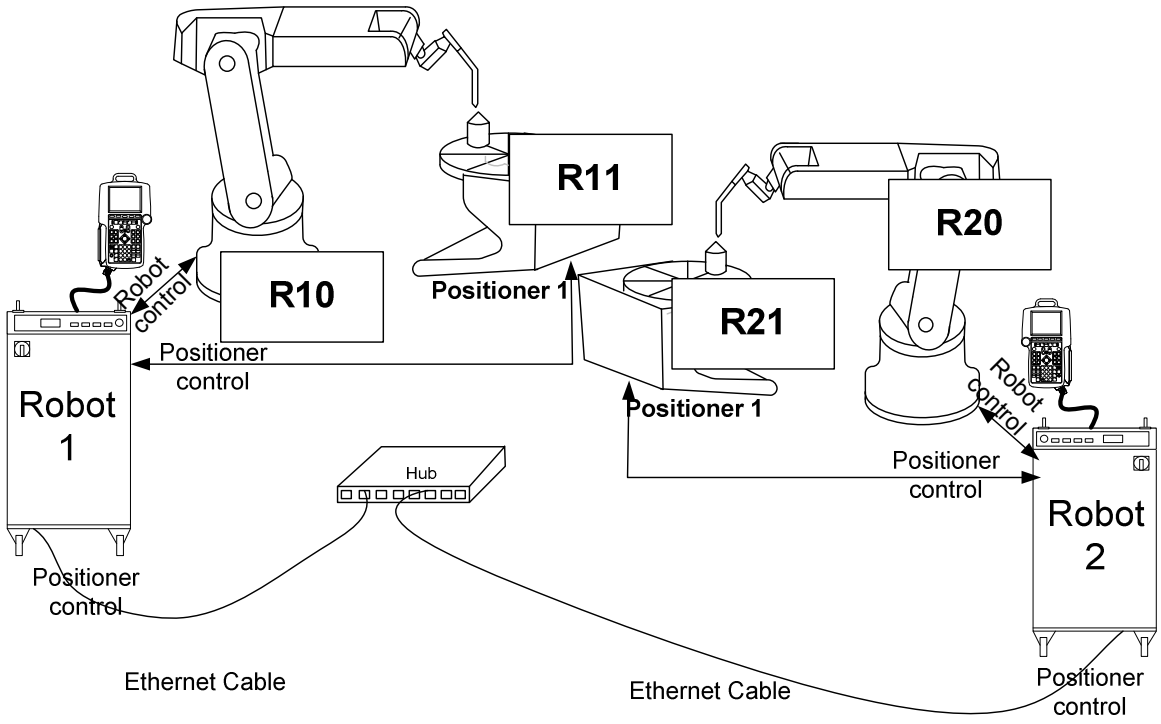
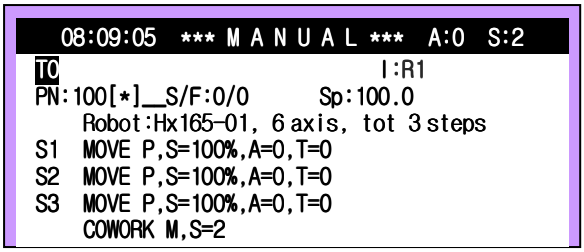


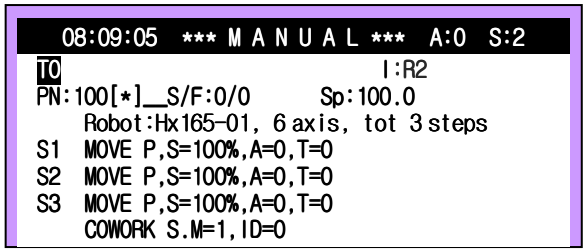
Figure 4.3 Method of distinguishing ID identifier

※ CMOV command is an operational command for jigless cooperation control.

4.4. Teaching for Arc Welding and Sealing (Jigless Cooperation Control:Option)

(1) After setting the manual cooperation robot role of master and slave to 'individual', teach the COWORK start step for the individual step and insert the COWORK command.





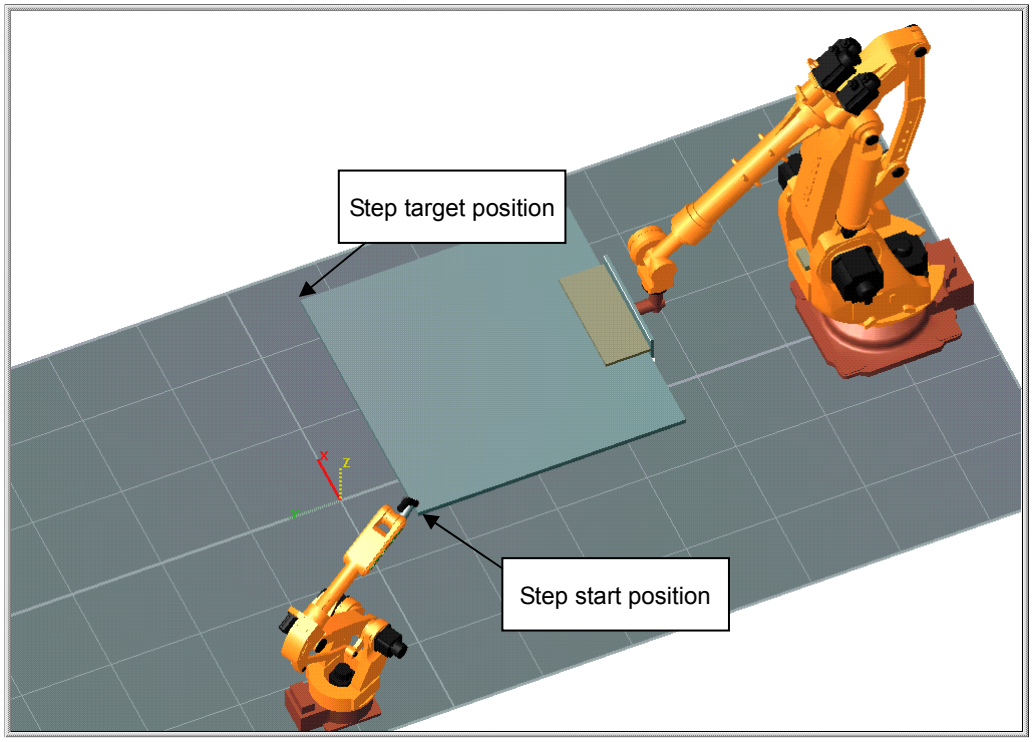
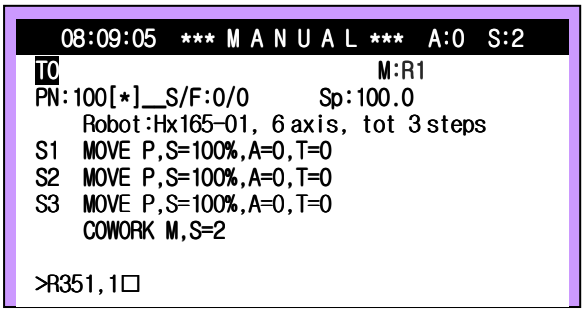
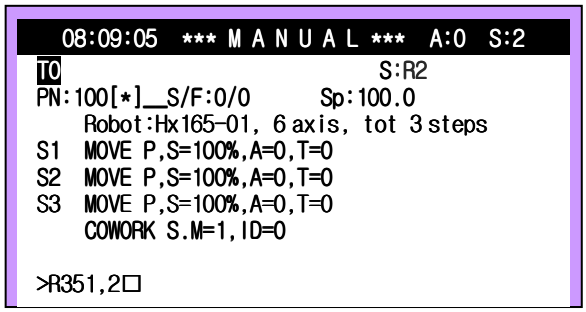


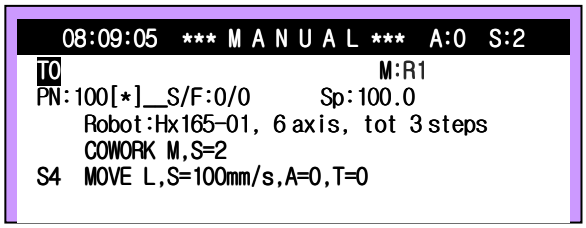
Figure 4.4 Step start and target position

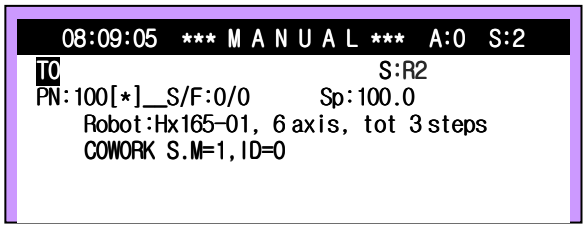
(2) Change the role of master and slave to its role in manual cooperation condition.



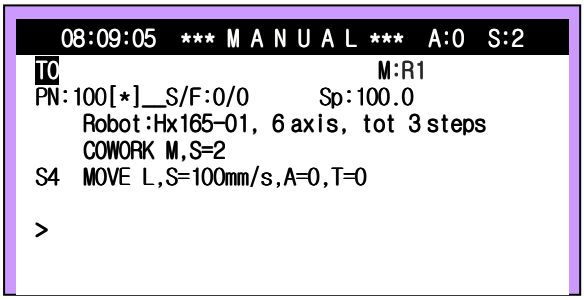


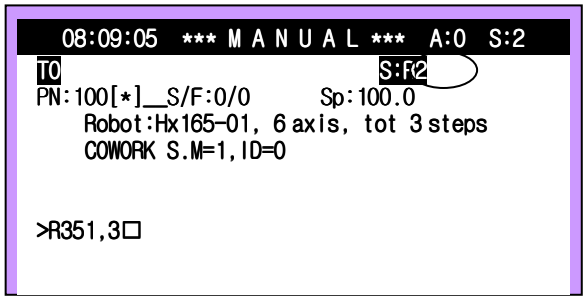
(3) Operate the master with jog operation and the slave will follow. Record the master step in the desired recording position.





(4) Change the slave to CMOV record condition using SHIFT+F key or R351,3 command. The robot role is highlighted and displayed on the top right part of the screen.





(5) Jog operate the slave robot to the target position and press the ‘REC’ key.

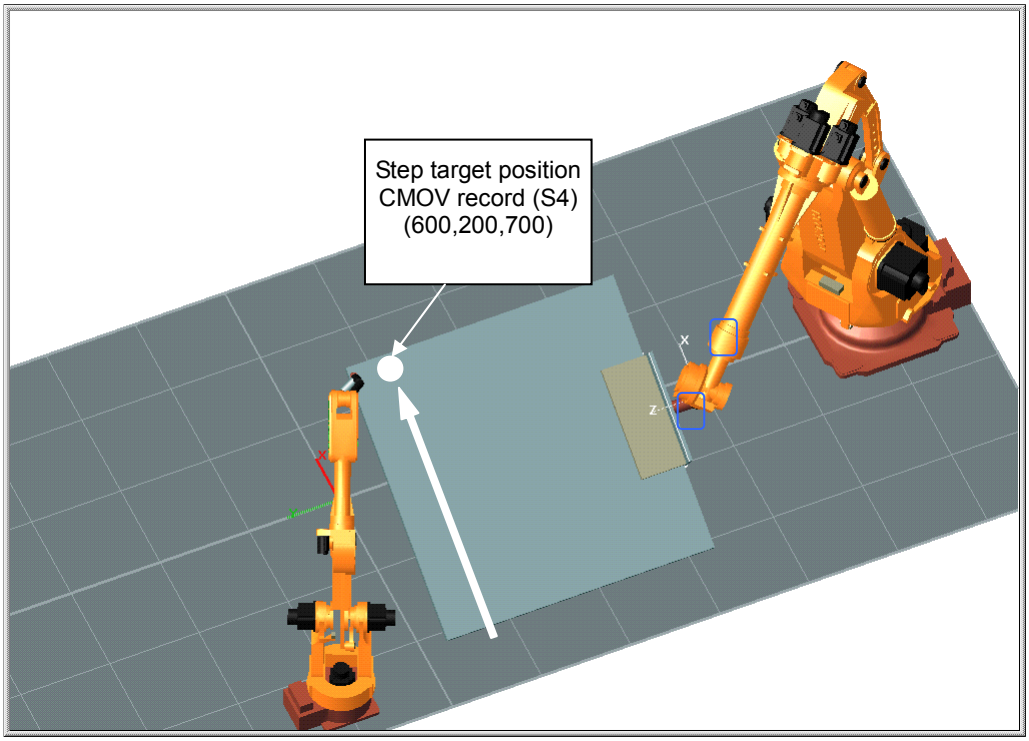
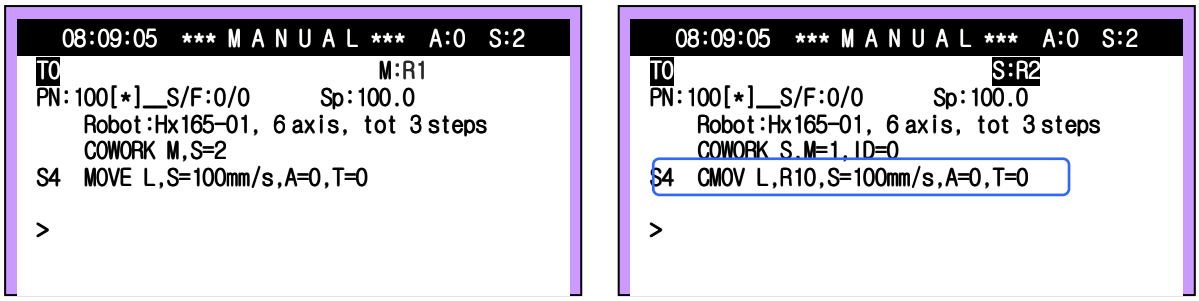
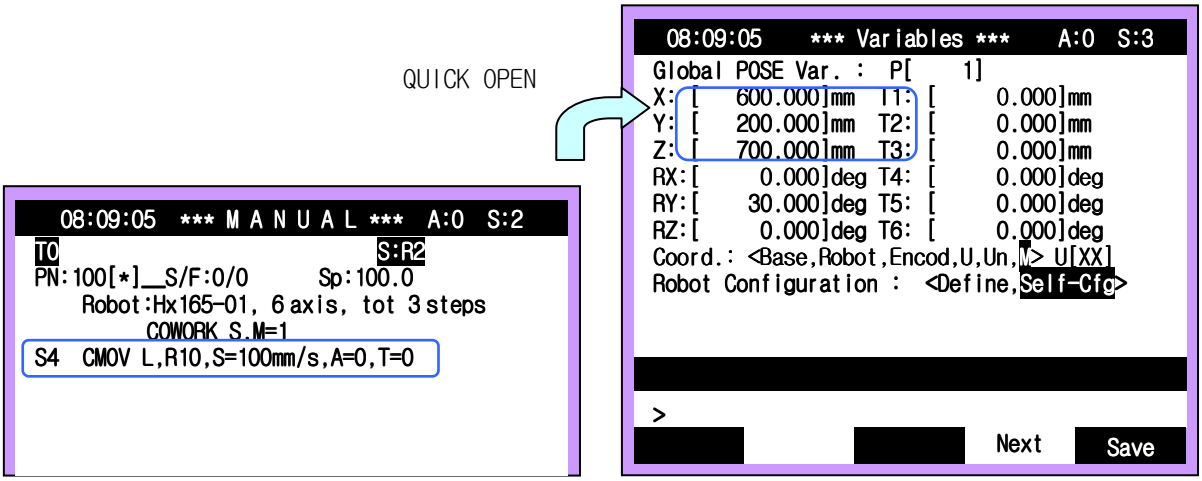


Figure 4.5 Step target position CMOV record

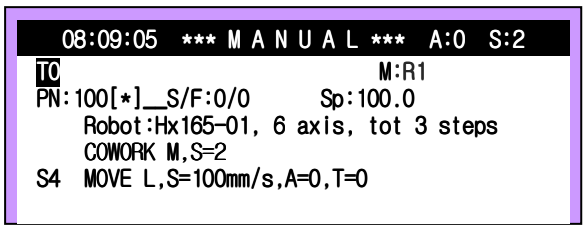


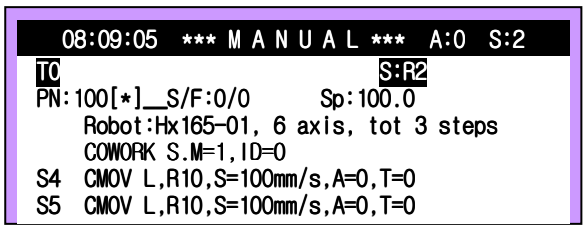
CMOV is recorded to the slave. The recording position of CMOV is based on the master tool end effecter coordinate. Press the QUICK OPEN to check and edit the recorded coordinate position.



At this time, the recorded coordinate is displayed in master end effecter coordinate <M>.

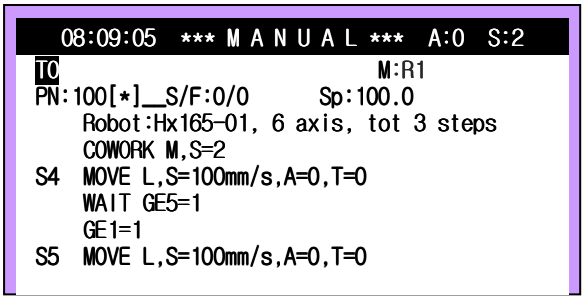
(6) If you move the slave in the same way, CMOV step will be recorded.

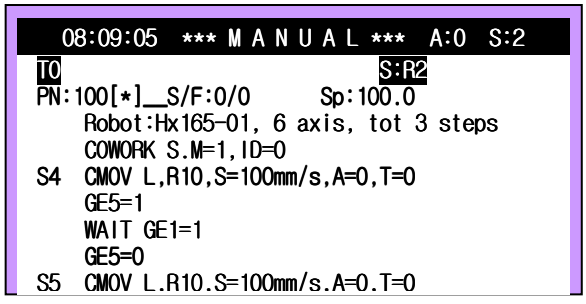




(7) But because the moving plan for recording step is executed individually between the master and slave, the time reaching the target position is different. Therefore, in order to align the timing of master MOVE position and slave CMOV start position in the collaborative zone, mutual interlock method is used with HiNet I/O.

(8) For example, to synchronize the starting point of step 5 (S5) of master and slave, method of checking whether they arrived with GE or DE parameter is used.





※ If the above method is used, the master and slave robot checks each other whether they have arrived at step 4 (S4) and moves to step 5 (S5).

(9) When the cooperation operation is completed, the COWORK END command is inserted to both master and slave to complete the cooperation control teaching.

```
08:09:05  *** M A N U A L ***  A:0  S:2
TO                                M:R1
PN:100[*]__S/F:0/0       Sp:100.0
     Robot:Hx165-01, 6 axis, tot 3 steps
     COWORK M,S=2
S4   MOVE L,S=100mm/s,A=0,T=0
     WAIT GE5=1
     GE1=1
S5   MOVE L,S=100mm/s,A=0,T=0
     WAIT GE5=0
S6   MOVE L,S=100mm/sec,A=0,T=0
     COWORK END
     GE1=0
```

```
08:09:05  *** M A N U A L ***  A:0  S:2
TO                                S:R2
PN:100[*]__S/F:0/0       Sp:100.0
     Robot:Hx165-01, 6 axis, tot 3 steps
     COWORK S.M=1,ID=0
S4   CMOV L,R10,S=100mm/s,A=0,T=0
     GE5=1
     WAIT GE1=1
     ARCON
S5   CMOV R10,L,S=50mm/sec,A=0,T=0
S6   CMOV R10,L,S=50mm/sec,A=0,T=0
     ARCOF
     GE5=0
     COWORK END
```

The whole program explained above can control the timing such as ⓐ, ⓑ and ⓒ to control the timing of cooperation control, as shown below.

```
MASTER ROBOT1
S1   MOVE P,S=100%,A=0,T=0
S2   MOVE P,S=100%,A=0,T=0
S3   MOVE P,S=100%,A=0,T=0
     DO1=1
     COWORK M,S=2,T=30 (Cooperation START)
S4   MOVE L,S=100mm/s,A=0,T=0

     WAIT GE5=1 (wait slave)
     GE1=1
S5   MOVE L,S=100mm/sec,A=0,T=0



     WAIT GE5=0 (wait ARCOF of slave)
S6   MOVE L,S=100mm/sec,A=0,T=0
     COWORK END (Cooeration END)
     GE1=0
S7   MOVE P,S=100%,A=0,T=0
          .
          .
          .
```

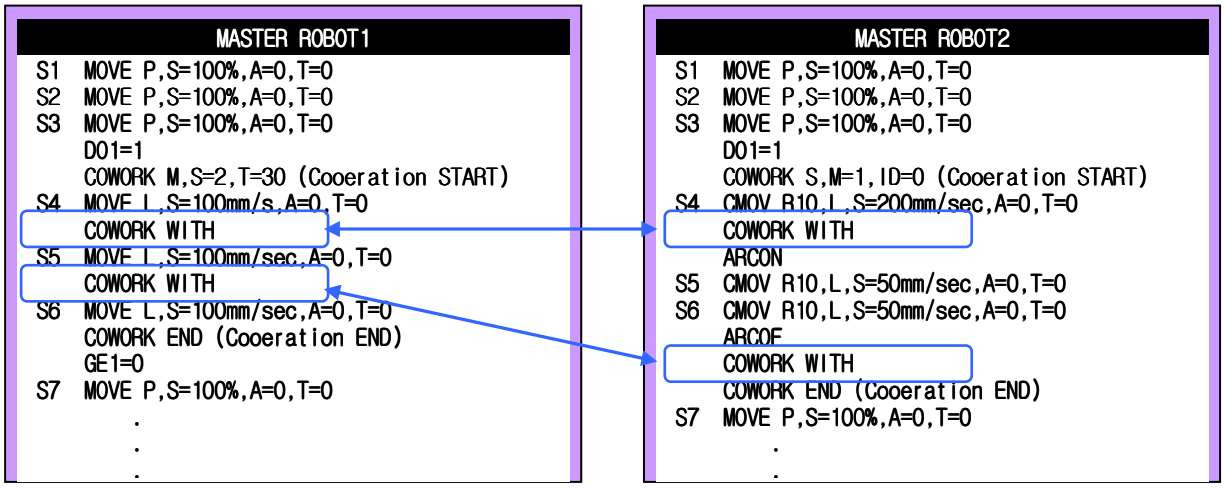
```
MASTER ROBOT2
S1   MOVE P,S=100%,A=0,T=0
S2   MOVE P,S=100%,A=0,T=0
S3   MOVE P,S=100%,A=0,T=0
     DO1=1
     COWORK S,M=1,ID=0 (Cooeration START)
S4   CMOV R10,L,S=200mm/sec,A=0,T=0
     GE5=1



     WAIT GE1=1 (wait master)
     ARCON
S5   CMOV R10,L,S=50mm/sec,A=0,T=0
S6   CMOV R10,L,S=50mm/sec,A=0,T=0
     ARCOF
     GE5=0
     COWORK END (Cooeration END)
S7   MOVE P,S=100%,A=0,T=0
          .
          .
          .
```

ⓐ ⓑ ⓒ

※ Programming method using COWORK WITH command

COWORK WITH command is the command used to synchronize the master and slave robot during cooperation control (between COWORK and COWORK END).

When the robot reaches a COWORK WITH command during cooperation control, it waits until other robots reach COWORK WITH function. When all cooperation robots reach the COWORK WITH command, the program proceeds. Therefore the above program can also be changed as follows.



You can easily synchronize the starting position of cooperation between master and slave by using the COWORK WITH command as shown above.

※ Reference

- Mutual interlock in cooperation control using HiNet can be composed in different ways from the above method.
- You can check the CMOV record position of slave according to the master position by using the step forward/backward function.
- For the contents on HiNet I/O, please refer to chapter 6.

◆【Caution】◆

- To use the weaving operation of CMOV, reference PREF setting must be recorded within cooperation control zone (COWORK~COWORK END).
- CMOV trace seam-tracking function using the laser vision sensor is not supported.
- COWORK WITH command must be used for same number for both master and slave in the cooperation control zone (COWORK~COWORK END).

4.5. CMOV Step Shift (Jigless Cooperation Control: Option)

4.5.1. Parameter Shift

The pose parameter reading the current position in COWORK S (Slave) ~ COWORK END, is recorded in master end effecter coordinate.

```
08:09:05  *** M A N U A L ***  A:0  S:2
TO                                S:R2
PN:100[*]__S/F:0/0       Sp:100.0
     Robot:Hx165-01, 6 axis, tot 4 steps
     COWORK S.M=1,ID=0
     P1=P*          ·····①
     R1.X=50        ·····②
     P2=P1+R1       ·····③
S4   CMOV R10,L,P2,S=100mm/s,A=0,T=0 ④
     COWORK END
```

In the above program for ①, if you enter the current position (P*) to P1 between COWORK S and COWORK END, P1 is recorded in master end effecter coordinate designated in COWORK S. For example, if the COWORK S,M=1, ID=0 as shown in above, it is recorded in end effecter coordinate of master robot 1. If the COWORK S,M=1, ID=1, it is recorded in the end effecter coordinate of master robot 1.

P1 pose parameter

```
08:09:05    *** Variables ***    A:0  S:3
Global POSE Var. :          P[    1]
X: [   600.000]mm  T1: [     0.000]mm
Y: [   200.000]mm  T2: [     0.000]mm
Z: [   700.000]mm  T3: [     0.000]mm
RX:[     0.000]deg T4: [     0.000]deg
RY:[    30.000]deg T5: [     0.000]deg
RZ:[     0.000]deg T6: [     0.000]deg
Coord.: <Base,Robot,Encod,U,Un,M> U[X]
Robot Configuration: <Define,Self-Cfg>

>
                          Nex    Save
```

R1 shift parameter

```
08:09:05    *** Variables ***    A:0  S:3
 Global SHIFT Variable
Var.  : R [    1]
Coord.: <Base,Robot,Tool,U,Un,M> U[X]
X: [     0.000]mm
Y: [     0.000]mm
Z: [     0.000]mm
RX:[     0.000]deg
RY:[     0.000]deg
RZ:[     0.000]deg

>
          Var Type          Save
```

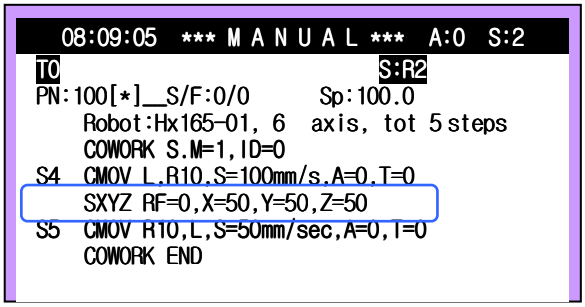
For ②, the shift coordinate must be set to master end effecter coordinate if the shift parameter is to be used for ③. The master end effecter coordinate can only be shifted with the master end effecter coordinate shift parameter and in this case, P1 is the master end effecter coordinate.

For ③, when both P1 and R1 are set to master end effecter coordinate, it will not generate an error. But if either one of P1 and R1 is set to the master end effecter coordinate and the other is not, an error is generating saying ‘Coordinate not supporting E1347 shift calculation’.

For ④, CMOV step can also be designated as the general pose parameter.

4.5.2. XYZ Shift (SXYZ)

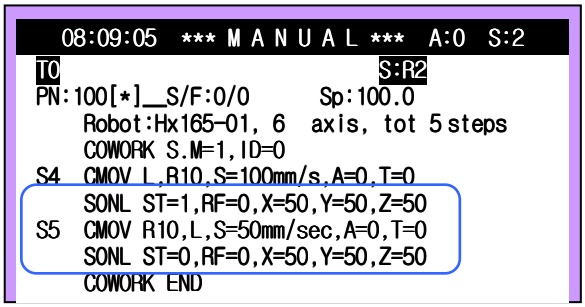
When you are trying to shift the CMOV step based on <Master end effecter coordinate;M> using the XYZ shift function, set the shift coordinate to <Robot> and execute (RF=0). Any coordinate besides <Robot> will generate an error.



If SXYZ RF=0, X=50, Y=50 and Z=50, and CMOV step position of S5 is X=100, Y=100 and Z=100, as shown above, the shift is done to X=150, Y=150 and Z=150. But this is based on master end effecter coordinate.

4.5.3. Online Shift (SONL)

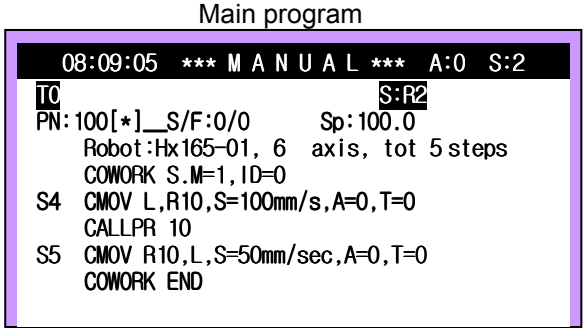
When you are trying to shift the CMOV step based on <Master end effecter coordinate;M> using the online shift function, set the shift coordinate to <Robot> and execute (RF=0). Any coordinate besides <Robot> will generate an error.



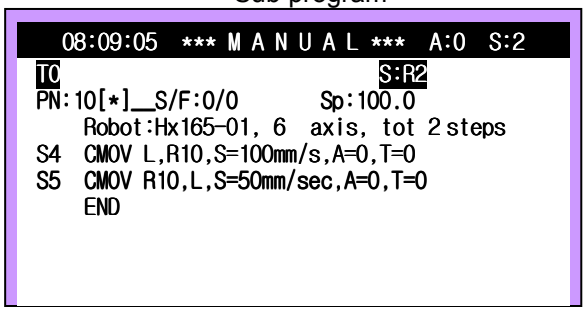
4.5.4. Program Call (CALLPR)

When using the program call function (CALLPR) in COWORK S ~ COWORK END zone, it moves to the relative position using the relationship between CMOV step of called program and current position in master end effecter coordinate. Therefore you can program the CMOV step recorded based on master end effecter coordinate to be the sub program.

Main program



Sub program



4.6. CMOV record position check

CMOV step is a useful function to check the teaching position during CMOV record mode using the step forward/backward function. Because CMOV step records position and position of master tool end effecter coordinate, the tool position of the master must be checked before executing.

(1) Set the master robot (COWORK M) to the master condition for manual cooperation. (R351,1)

(2) Set the slave robot (COWORK S) to CMOV record condition. (R351,3)

(3) Move and stop the master robot to the step position for cooperation.

(4) Select the CMOV step to move and press the step forward key to move the slave to the recording position on master end effecter. For example, if the CMOV recording position is at the zero point of master end effecter coordinate (0,0,0), the master CMOV step position will move the zero point of master end effecter coordinate irrelevant of whether the master robot is in the solid line or dotted line.

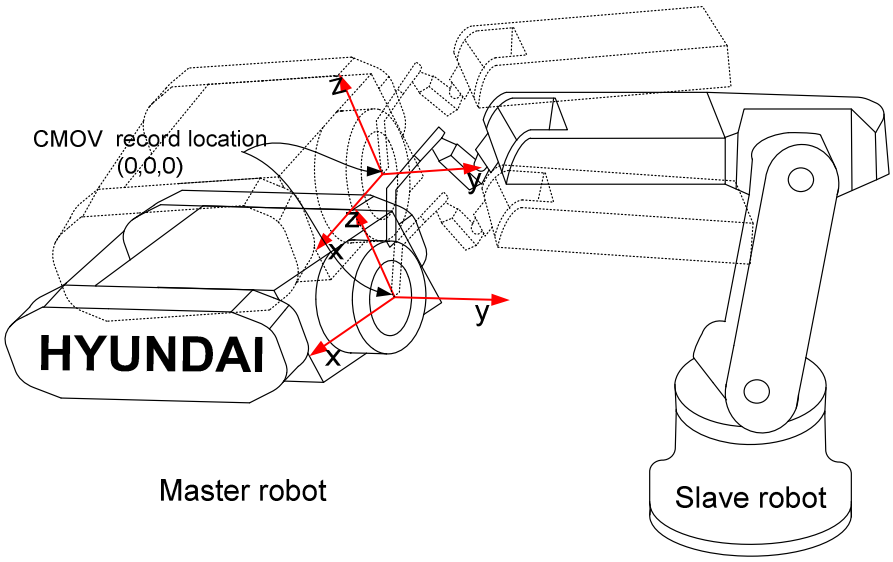


Figure 4.6 CMOV record position check

◆【Caution】◆

- In CMOV record condition (R351,3 condition), it moves to the applicable step position irrelevant of whether the COWORK command is executed or not.
- Master jog cannot be used in CMOV record condition.
- Because real time cooperation operation does not work in CMOV record condition, keep the master stopped and not operate it step forward/backward.
- After changing the master position of the CMOV record, stop the robot. If you move the CMOV step forward it will move the renewed position.

4.7. Positioner master system

This function allocates the collaborative master to the positioner so that the slave robot can collaborate with the master positioner. But this specification is only supported in positioner group 1.
※ This function is optional.

4.7.1. Positioner master jog

(1) This executes the positioner group setting and positioner calibration for positioner synchronization.

(2) Set the robot to set for the positioner to master using the R351, 1 or F key, to manual collaborative master.

(3) Press the additional axis key and set the LED to on and off.

(4) Set the slave robot to the slave role by using R351,2.

(5) If you execute the positioner synchronized jog operation, the robot 1 and 2 will be synchronized to the positioner.

4.7.2. Positioner master teaching and playback

(1) You can teach the master and slave using the COWORK command. Set the ID=1 for the slave to select the master positioner to master.

(2) When the positioner is set to master (condition when additional axis LED of the master robot goes on and off), record the slave position. At this time, this position is recorded based on positioner end effecter coordinate.

Master robot

```
08:09:05    *** M A N U A L ***    A:0  S:2
TO                                 M:R1
PN:100[*]__S/F:0/0       Sp:100.0
    Robot:Hx165-01, 8  axis, tot 0 steps
    COWORK M.S=2
```

Slave robot

```
08:09:05    *** M A N U A L ***    A:0  S:2
TO                                 S:R2
PN:100[*]__S/F:0/0       Sp:100.0
    Robot:Hx165-01, 6  axis, tot 0  steps
    COWORK S.M=1,ID=1
```

(3) For the master side to collaborate with the positioner, teach SMOV step in the same way as the existing positioner. If the step is recorded for the slave when the master positioner is set to master (condition when the additional axis LED of the master robot goes on and off), the robot number reflecting the master ID is recorded.

Master robot

```
08:09:05    *** M A N U A L ***    A:0  S:2
TO                                 M:R1
PN:100[*]__S/F:0/0       Sp:100.0
    Robot:Hx165-01, 8 axis, tot 0 steps
    COWORK M.S=2
S1  SMOV S1,L,S=100mm/s,A=0,T=0
```

Slave robot

```
08:09:05    *** M A N U A L ***    A:0  S:2
TO                                 S:R2
PN:100[*]__S/F:0/0       Sp:100.0
    Robot:Hx165-01, 6 axis, tot 0 steps
    COWORK S.M=1,ID=1
S1  CMOV R11,L,S=100mm/s,A=0,T=0
```

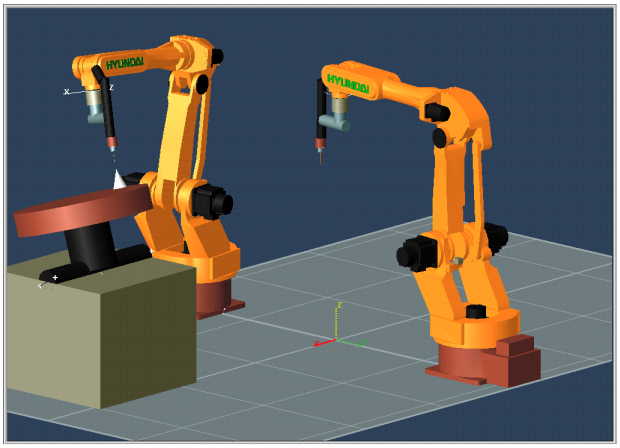
The master is the same as the positioner synchronization function. The slave is recorded in R11.

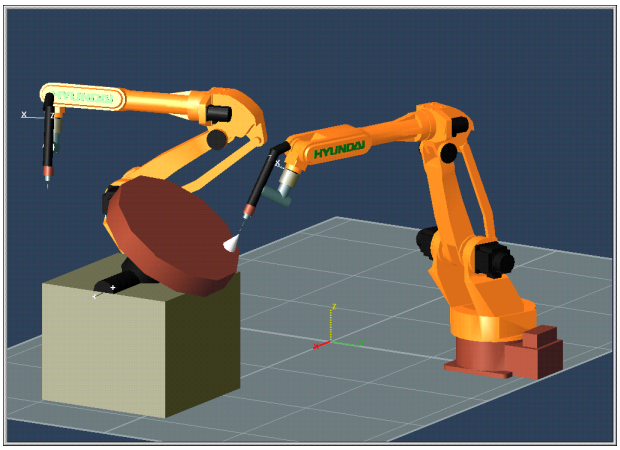
(4) Teach the master and slave in the above method in (3) and finalize with COWORK END.

```
08:09:05  *** M A N U A L ***  A:0  S:2
TO                                 M:R1
PN:100[*]__S/F:0/0       Sp:100.0
    Robot:Hx165-01, 8 axis, tot 0 steps
    COWORK M.S=2
S1  SMOV S1,L,S=100mm/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  SMOV S1,L,S=100mm/s,A=0,T=0
    COWORK END
    END
```

```
08:09:05  *** M A N U A L ***  A:0  S:2
TO                                 S:R2
PN:100[*]__S/F:0/0       Sp:100.0
    Robot:Hx165-01, 6 axis, tot 0 steps
    COWORK S.M=1,ID=1
S1  CMOV R11,L,S=100mm/s,A=0,T=0
S2  CMOV R11,L,S=100mm/s,A=0,T=0
S3  CMOV R11,L,S=100mm/s,A=0,T=0
S4  CMOV R11,L,S=100mm/s,A=0,T=0
    COWORK END
    END
```

(5) Check the operation in manual mode and operate in auto mode.





◆【Caution】◆

- Only 1 positioner group is supported in jigless cooperation control. You must select positioner group number 1 for positioner jog and CMOV.
- If the value set in COWORK S,M=#1, ID=#2 for slave is different from the CMOV R#1#2 value, an error is generated saying『E1365 CMOV master No. ID is inappropriate.』.

5

Cooperation Operation Playback

5.1. Introduction of Cooperation Playback

Cooperation program can be divided into individual operation and cooperation operation part.

Individual operation is the general control method as same as the individual operation method, and the cooperation operation is the COWORK ~ COWORK END part in which the program position of the master decides the slave operation.

(1) Cooperation operation part is the COWORK ~ COWORK END part and the when the COWORK command starts all collaborating robots standby until COWORK is executed.

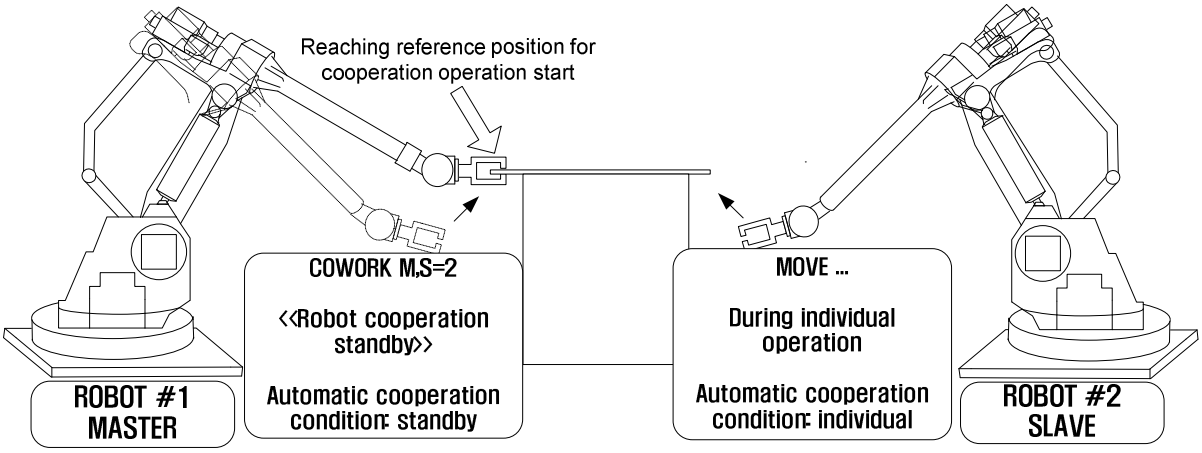


Figure 5.1 Cooperation playback 1

(2) When the collaborating robots are all in COWORK position, the cooperation operation starts.

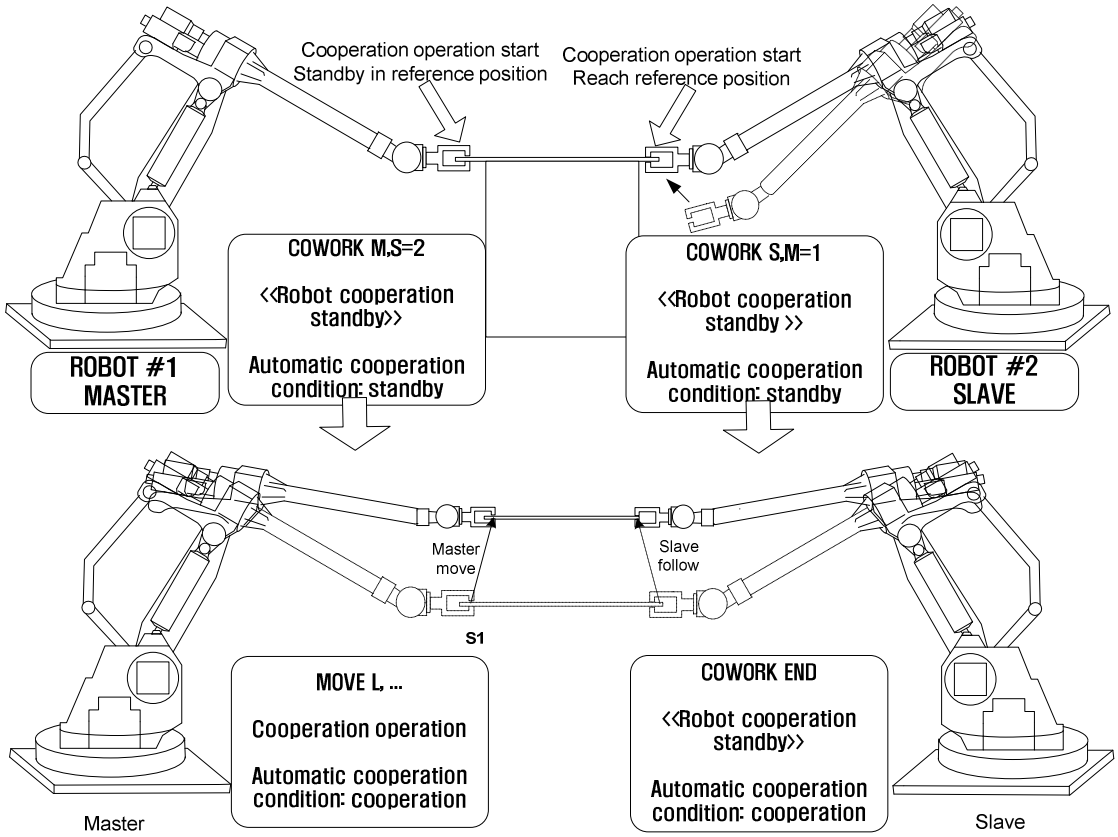


Figure 5.2 Cooperation playback 2

(3) If the collaborative zone operation is completed, master reaches the COWORK END command to end the cooperation condition.

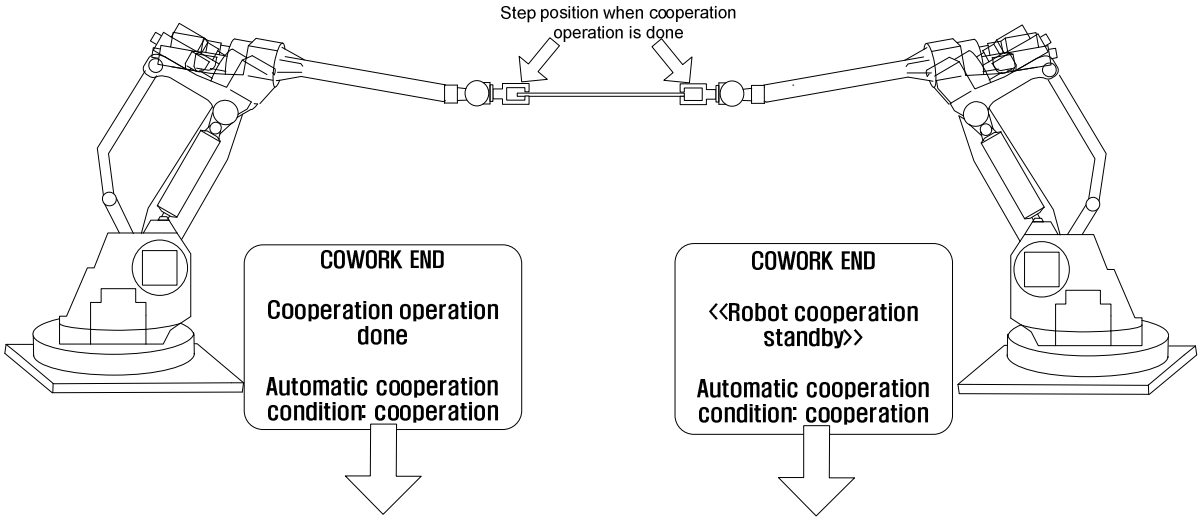


Figure 5.3 Cooperation playback3

(4) When the cooperation operation is completed, each individual operation is resumed.

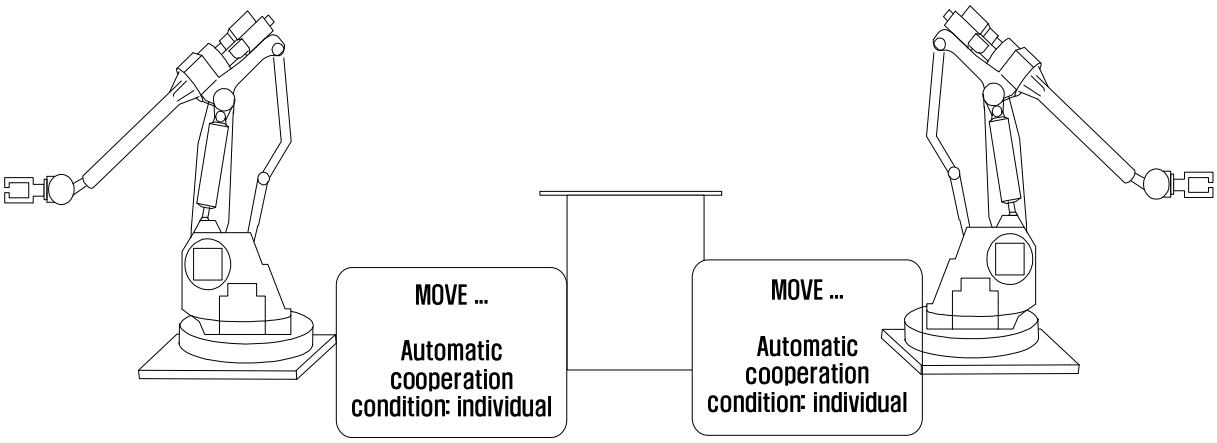


Figure 5.4 Cooperation playback 4

5.2. Program check in manual mode

(1) In manual mode, the role of the master robot sets the manual cooperation condition to I (Individual) or M (Master). The manual cooperation condition of the slave robot can be set to I (Individual) or S (Slave).

(2) Set the operation ready condition to On, set all the jogs on for both sides and press the 'Step forward' key to begin operation.

(3) To check the synchronized operation of the master and slave, press the step forward key of the slave until the cooperation operation is completed.

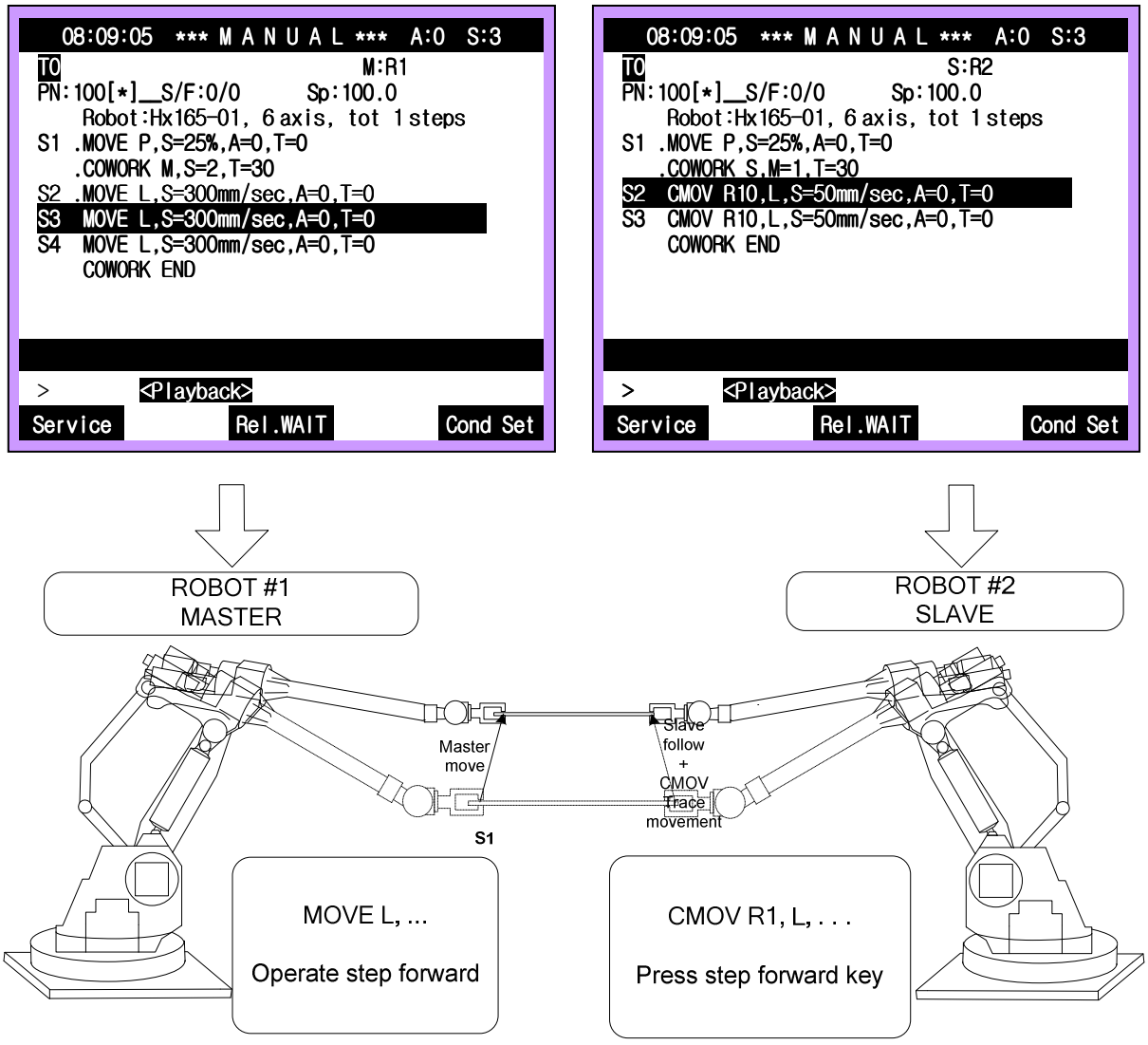


Figure 5.5 Program check in manual mode

◆【Caution】◆

- If you set the slave to CMOV record mode (R351,3), cooperation operation in manual mode with the master will not work. Always set to I (Indiv., R351,0) or S (Slave, R351, 2).
- If you release the 『Step forward』 key during cooperation operation, the robot will stop and 『Stop input from partner robot』 message will be displayed. To restart at this time, move forward the slave side first then the master side.
- If you do not set the master and slave to 'manual', an error saying "Cooperation operation start error" will be generated and the playback will not start.
- When executing step forward/backward, the condition must be set to『Function in step GO/BACK = On』.
- The master and slave robot check the execution position only when executing the COWORK command, and step position synchronization of master and slave is not done in other work zones. Therefore, the relative position checked with step forward/backward function can change during auto mode playback.

5.3. Playback in auto mode

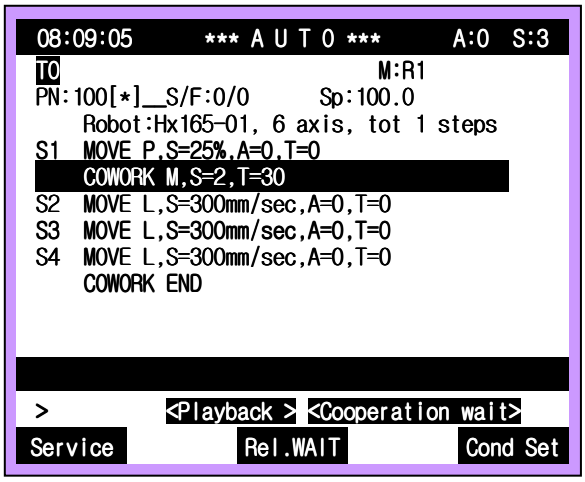
(1) Switch all collaborating robots to auto mode.
(2) Check if the operation ready condition is ON for all the collaborating robots.
(3) Start the program from the beginning.
(4) Operate all the collaborating robots.
(The operating sequence of master and slave can be either way.)

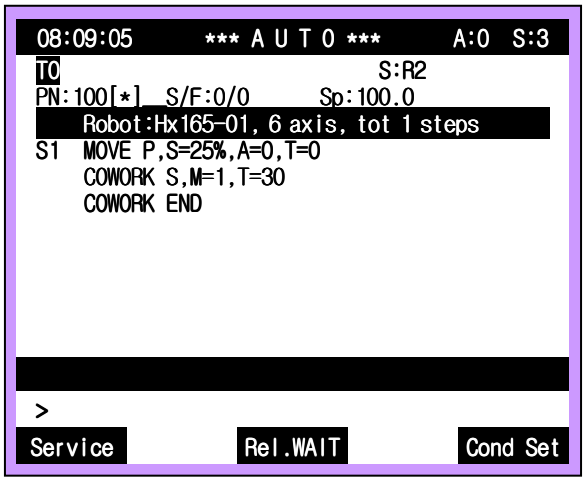
◆ 【Caution】 ◆

- Do not execute the COWORK M (or COWORK S) in any arbitrary position that is not the reference position for cooperation playback. You must calculate the relative position of master and slave in COWORK M (COWORK S) position and always operate it in the collaborative reference position.

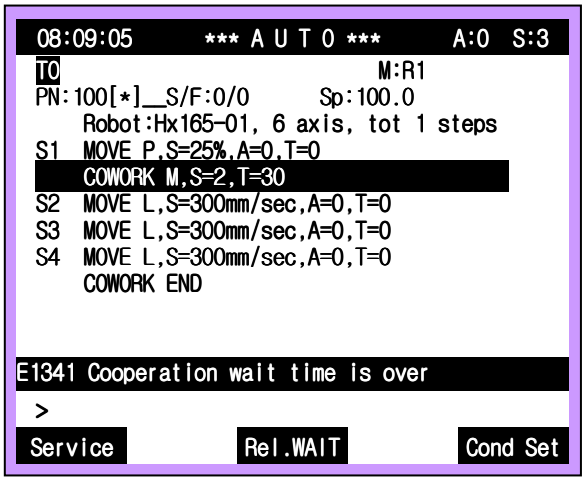
- Set the collaborative standby time appropriately. An error will be generated if one of the master or slave arrives to the collaborative reference position and the other does not within the 'collaborative standby time'. Set the collaborative standby time to 0 to make it standby infinitely.

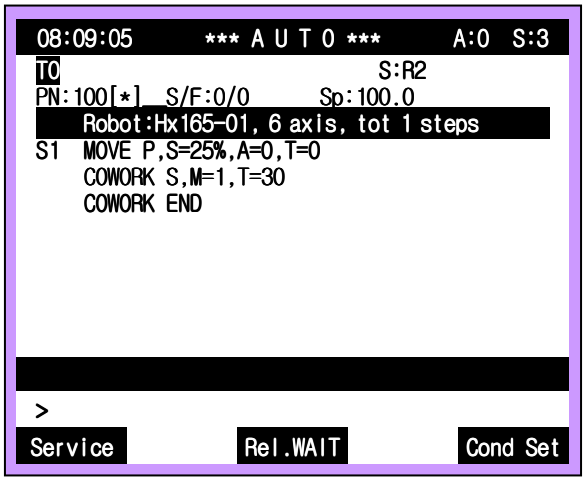
  Ex) When operating the master side and the slave side not working





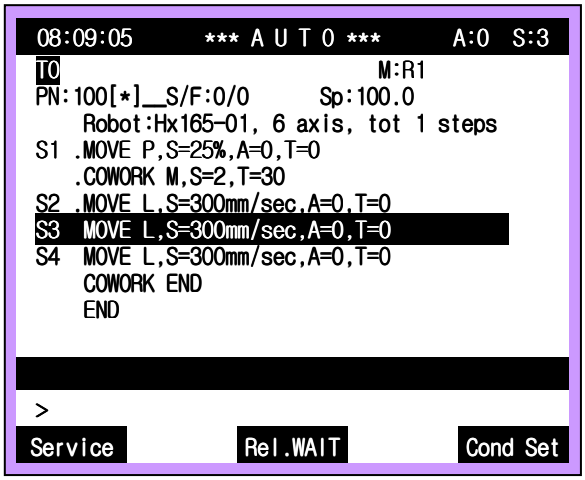
An error is generated after waiting for the collaborative standby time to expire and the slave is still not in step 1.

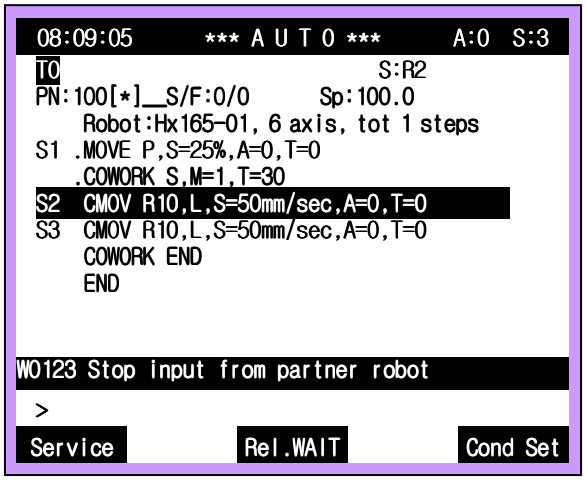




5.4. Cooperation Playback Stop/Restart

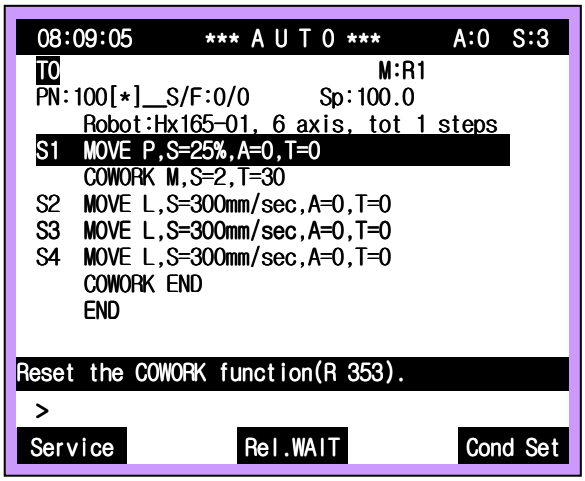
(1) If the user enters the stop command (external stop, internal stop) during cooperation operation, all the robots in cooperation stop.





(2) To restart after stopping, start the slave robots and then the master robot. An error will be generated is the slave robot is not in collaborative standby condition.

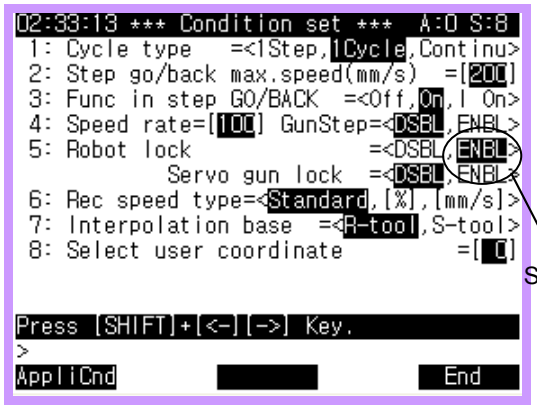
(3) After stopping during cooperation operation, changing the step number and restarting the robot is only possible if the cooperation playback condition is disabled. In this case, the system requires the user to enter the R353 code as a warning.



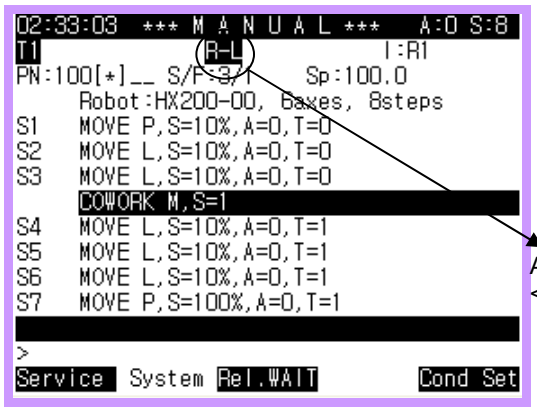
(4) When you enter the reset command (R353) for cooperation control condition, the operation resumes with the cooperation condition canceled. To operate with the cooperation condition maintained, designate the stop step number and execute the operation.

5.5. Robot Lock Function

(1) Set the 『[PF5]: Cond Set』 → 『5: Robot Lock』 to <Enable>.



(2) If you select the robot lock playback, you will see the R-L sign on the top part of the screen.



(3) If you set the robot lock playback to <Enable> for the master robot and execute playback, the slave will execute cooperation operation and the master robot will not operate. The axis data monitoring changes.

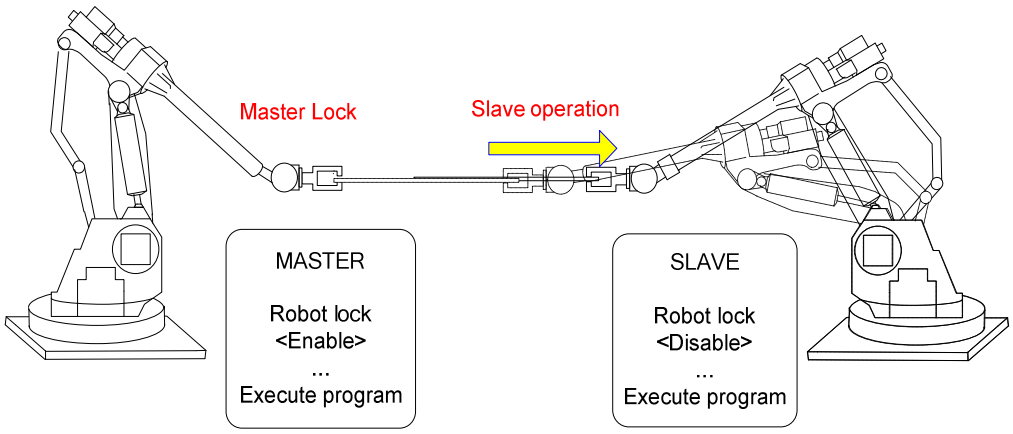


Figure 5.6 Robot lock function (Master Lock)

(4) If you set the robot lock playback to <Enable> for the slave robot and <Disable> for the master robot, the master robot will operate normally and the slave robot will stay stopped with only monitoring data moving.

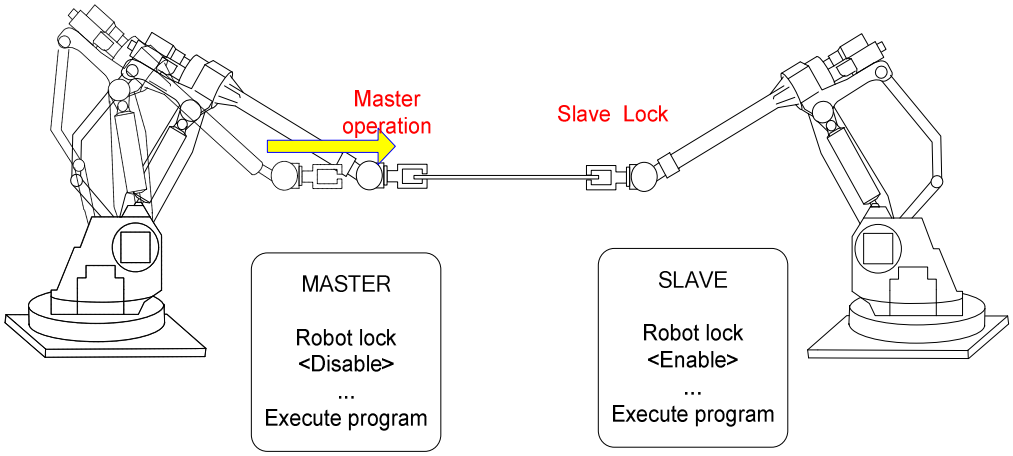


Figure 5.7 Robot lock function (Slave Lock)

(5) If you set the robot lock playback to <Enable> for both master and slave, both will execute the program while stopped.

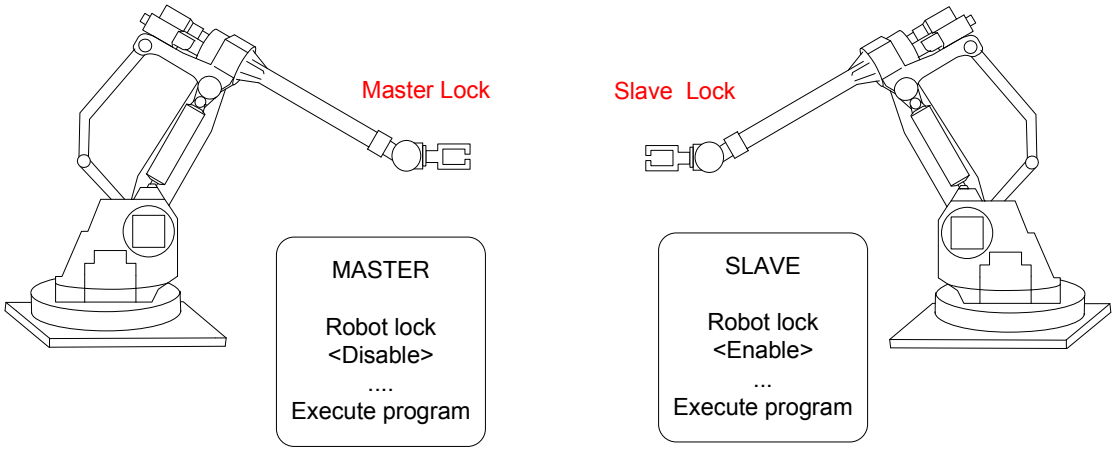


Figure 5.8 Robot lock function (Master, Slave Lock)

◆【Caution】◆

- Because the robot that has been set to <Enable> with robot lock playback function does not move, move the robot to a position where it will not interfere with other robot and then execute the program.
- If you change the robot lock playback back to <Disable>, the position of the robot and the position of the step will not correspond. Therefore you must execute the program from the start.

6 Hinet I/O Function

This function shares the I/O through the HiNet connected to the collaborative network. Each controller monitors the signal between cooperation robots and allocates the shared signals to I/O so that they can be freely flow. The output size each controller can use is 4 bytes.

Because this function can not only be used to detect the I/O signal by using the robot language (HR-BASIC) but also be used as a parameter, there are various applied methods to meet the various needs of the user.

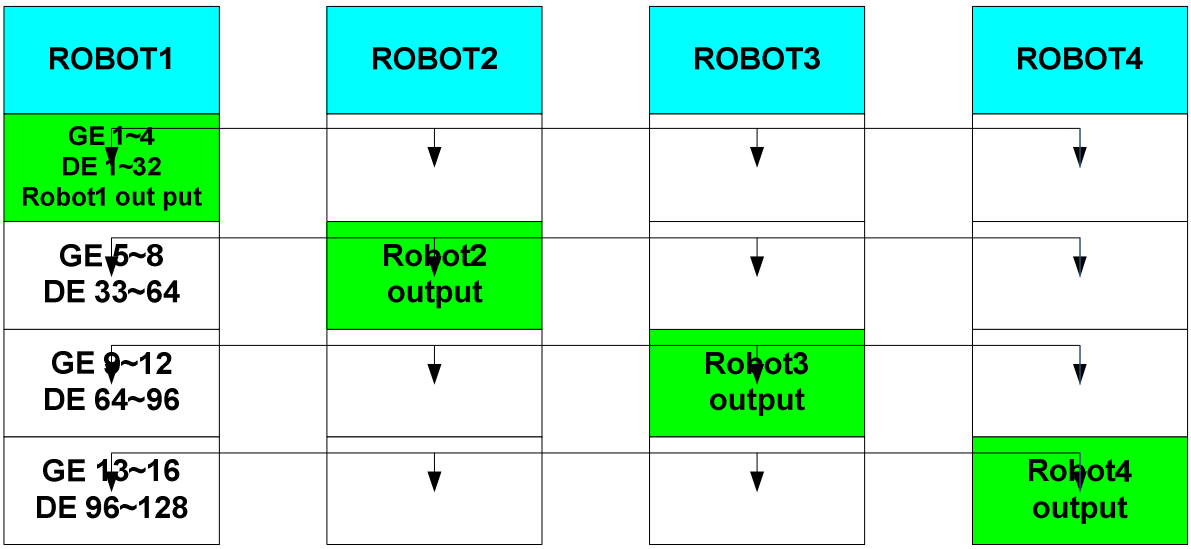


Figure 6.1 HiNet I/O

Table 6-1 I/O Zone by robot number

Robot no.	GE (OUT)	GE (IN)	DE (OUT)	DE (IN)
	Output allocated zone	Input allocated zone	Output allocated zone	Input allocated zone
Robot 1	1~4	5~16	1~32	33~128
Robot 2	5~8	1~4, 9~16	33~64	1~32, 65~128
Robot 3	9~12	1~9, 13~16	65~96	1~64, 97~128
Robot 4	13~16	1~12	97~128	1~96

6.1. DE command

DE command inputs and outputs the self area in 1 bit unit to the HiNet I/O function.

DE[{Script}]={parameter}	
Script	□I/O output signal designation (1~128) 0 : Select all I/O bit 1~128 : Select applicable I/O bit
parameter	□On/Off setting 1 : On 0 : Off

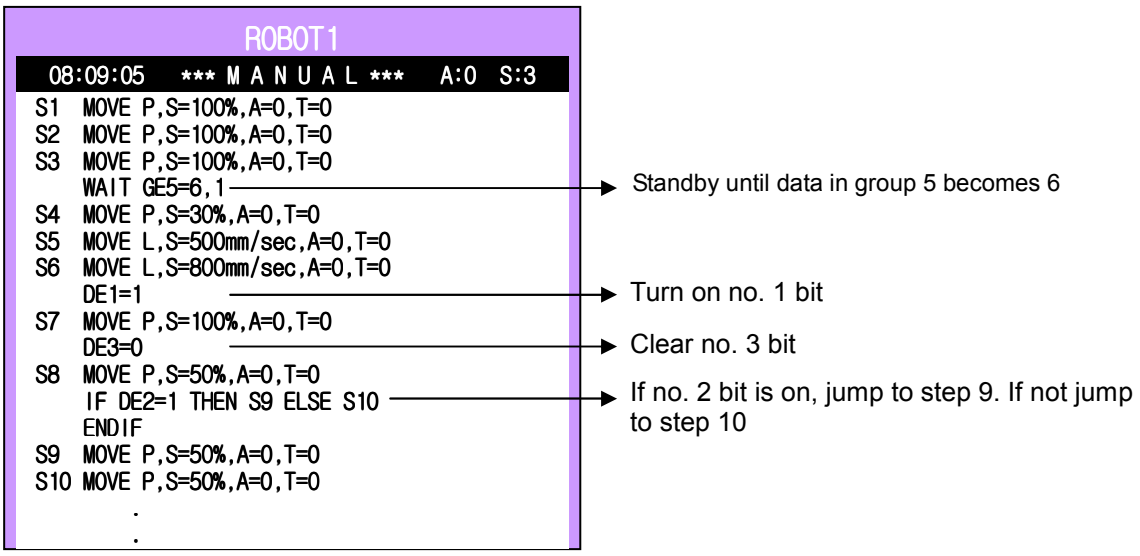
6.2. GE command

GE command inputs and outputs the self area in 1 byte unit to the HiNet I/O function. 128 bit is allocated for HiNet shared I/O area and it is possible to output self area in 32 bit units.

GE[{Script}]={parameter}	
Script	□I/O signal group designation (1~32) 0 : Select all I/O group 1~32 : Select applicable I/O group
parameter	□It designates 1byte of I/O signal.(0~255)

6.3. Application example

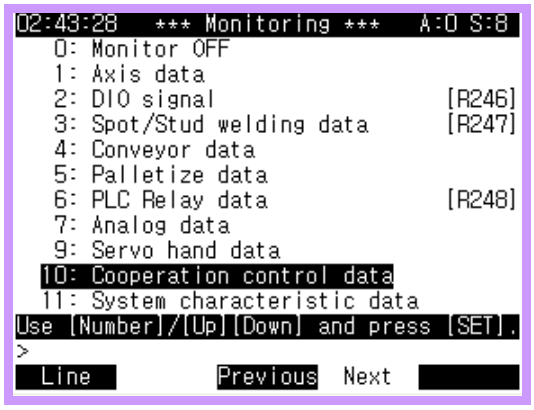
The following is a simple applied example to help you better understand the application of robot language. Because DE and GE can also be used as a parameter, it has an advantage in terms of flexibility of application.

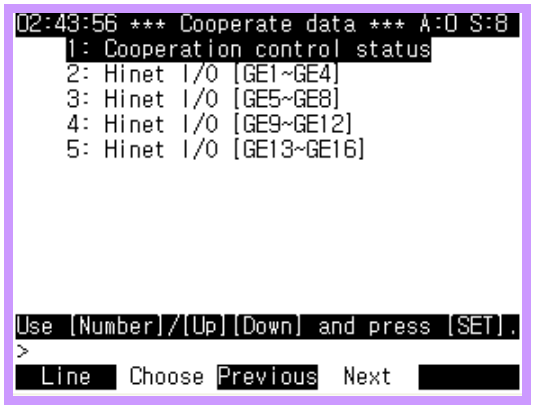


7 Service Function

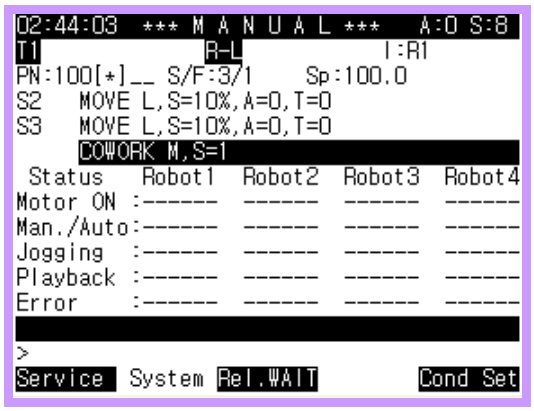
7.1. Cooperation control condition monitor

(1) Select 『[PF1]: Service』 → 『1: Monitoring』 → 『10: Cooperation control data』.





(2) Cooperation control condition will be displayed as follows.

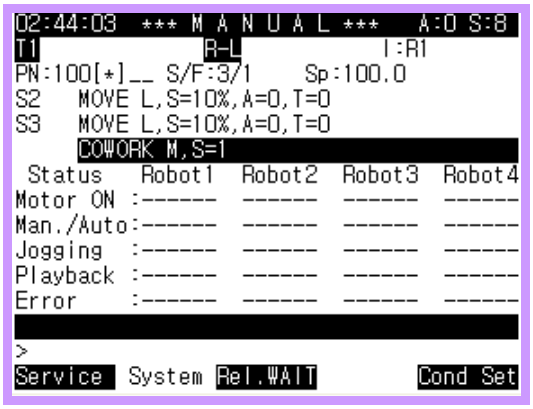


(3) Each condition of monitoring function has different meanings as follows.

.

- Motor ON : This shows whether each robot is ready for operation. (ON/OFF)
- Man./Auto : This shows whether each robot is set to manual or auto mode.(Manual/Auto)
- Jogging :
  This shows the cooperation condition of each robot in manual mode.
  Indiv. : Individual jog condition
  Master : Cooperation jog condition, designated as master
  Slave : Cooperation jog condition, designated as slave
- Playback: This shows the cooperation condition during robot playback.
  Stop: Robot is not in operation
  Indiv.: Individual robot playback
  Wait: Standby for collaborating robots to be in position for COWORK command
  Cowork: Playback during cooperation
- Error: This shows the recent error condition of each robot and it is cleared when operation starts.

◆ 【Caution】 ◆



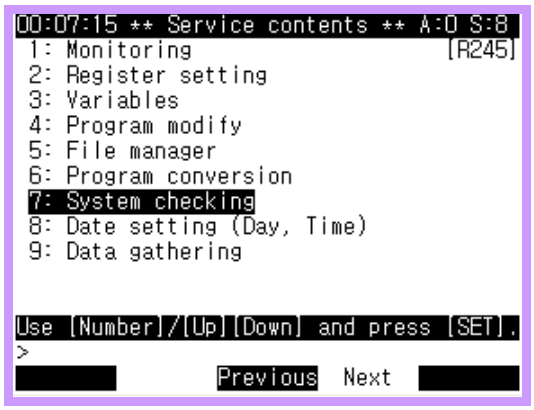
- If the cooperation control is set to <Disable> in cooperation control, the monitoring information will not be displayed.

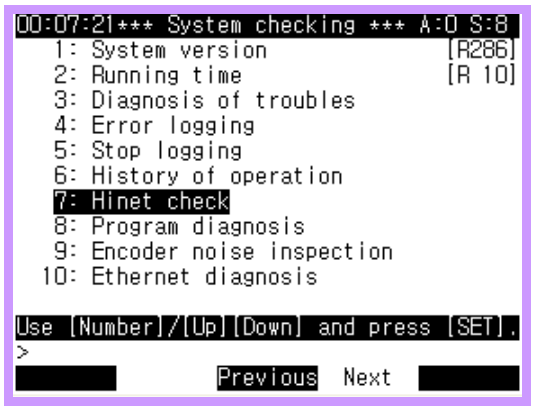
7.2. Communication Diagnosis Function

7.2.1. General Diagnosis

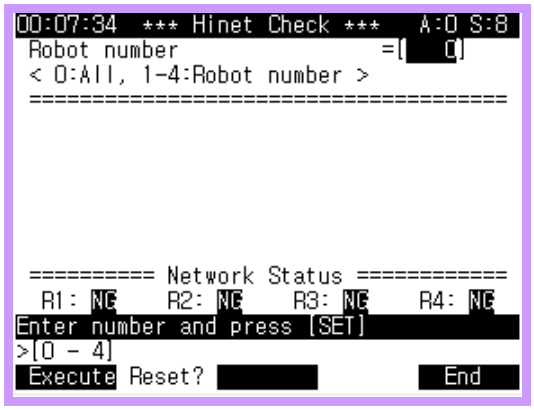
General diagnosis function detects whether there is an error in the communication between the robots during normal setting and execution of cooperation control. This is applied when the cooperation control is set to <Enable> and it detects where the issue is.

(1) Select 『[PF1]: Service』 → 『7: System checking』 → 『7: Hinet check』.

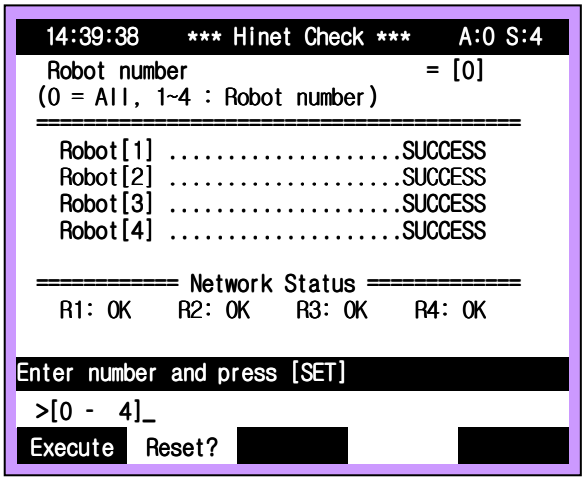




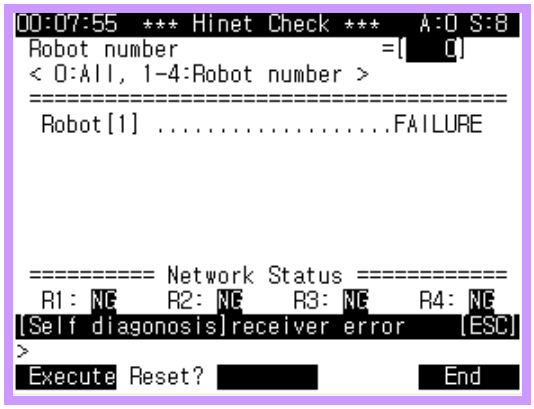
(2) If you see the following screen, select the robot number to diagnose the communication of. Current network condition is displayed at the bottom.



(3) Press the 『[PF1]: Execute』 key to diagnose the communication condition as shown in the following screen. If not normal, the system will display a FAILURE sign with the cause.

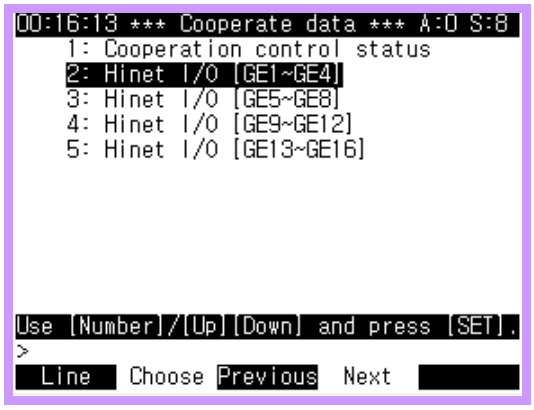


(4) When the collaborating robot has a communication issue.

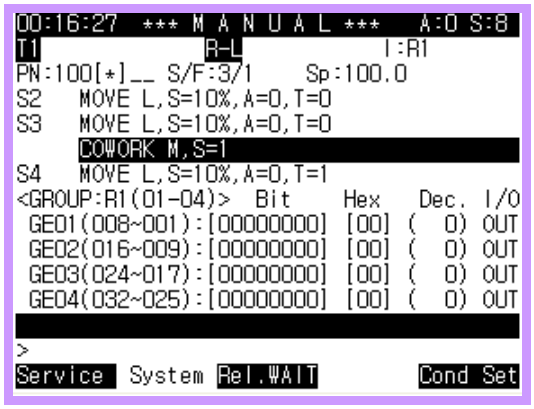


7.3. HiNet I/O monitor

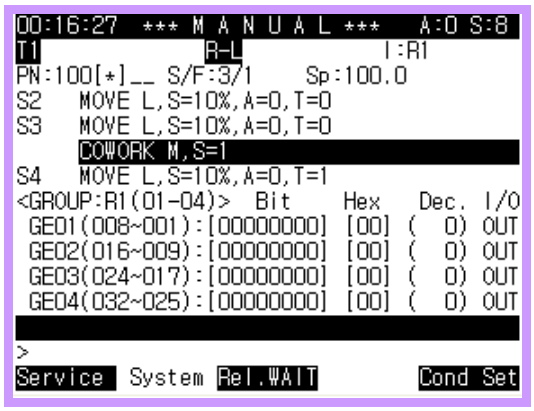
(1) Select 『[PF1]: Service』 → 『10: Cooperation control data 』.



(2) Select the area to monitor. The monitor screen shows area of 4 bytes. For example, select 1 and select GE1~GE4, and you will see the following screen.



(3) When each signal is set to ON, all are displayed in binary, hexadecimal or decimal numbers.



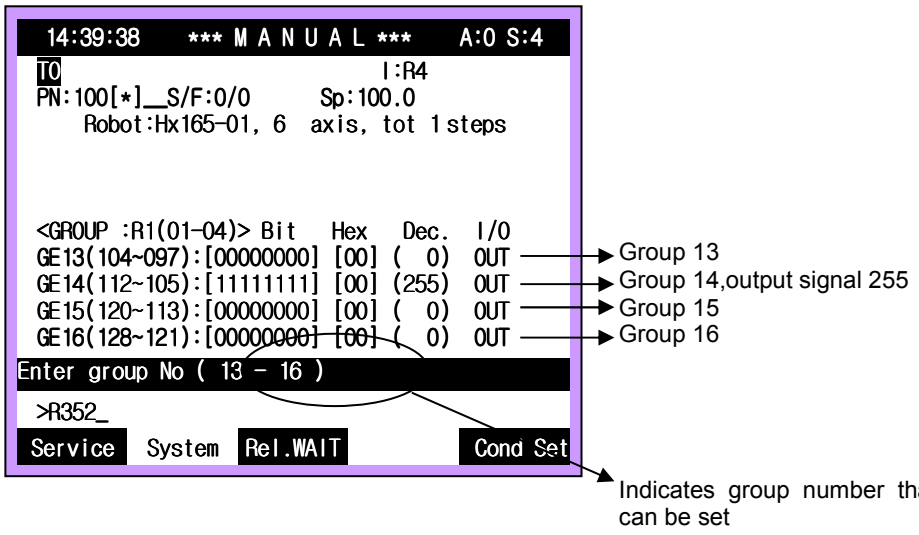
7.4. Manual output function (R352)

You can manually send out the HiNet I/O signal for cooperation control.

Operation	Output signal
R352, group no. (1~32), output signal (1~128)	Output signal corresponding to group no. Ex) R352,14,255

Ex) R352,14,255

First its own robot number has to be able to output GE14. From GE13 to GE16 is the output alposition area for robot 4. You cannot enter in other areas besides these.



7.5. R code

This is the R code used in cooperation control.

Table 7-1 R code used in cooperation control

Operation	#1	#2	Content
R351,#1	Robot role		Robot role 0 = Indiv
			1 = Master
			2 = Slave
R352,#1,#2	Group no.	Output value	Manual output of group no.
R353			Cooperation playback condition clear

8
Error Code

8.1. Warning

Code	W0016 Improper use of GE or DE signal No
Cause	The specified values for GE or DE variable are incorrect. The values are out of range.
Action	- It is different from coworking robot number. - GE: Min.=(robot #-1)*4+1, Max.=(robot #-1)*4+4 - DE: Min.=(robot #-1)*32+1, Max.=(robot #-1)*32+32

Code	W0123 Stop input from partner robot
Cause	Stop instruction is received from the partner robot during cowork control operation. In this case, the above message is output, and the robot stops.
Action	Start running a master to resume a program after starting the robot on the part of slave.

Code	W0124 Slave is Impossible to jog
Cause	It is set as salve in the condition of manual cowork control. The robot set as slave is impossible to operate separately.
Action	To operate each robot individually in a manual mode, change the condition of manual cowork. To change the condition of manual cowork, users need to use F key or R351 code.

Code	W0131 Jog Prohibited - Master overlaped
Cause	Among robots connected to HiNet are more than two robots set as Master in their manual cowork.
Action	Only one Master for manual cowork is possible to set. Change the setting.

Code	W0132 Jog Prohibited - No slave selected
Cause	Jog operation is attempted for Master robot without setting the Slave robot to be available to cowork.
Action	Check if Slave robot is selected, and get it ready to be available to cowork before operating(Jog Off/Enabling Switch On).

Code	W0133 Slave jog status are changed-Stop
Cause	A robot chaged its manual cowork is detected among the coworking Slave robots Master during cowork jog operation with robot.
Action	Doublecheck the cowork condition of Slave before operating.

Code	W0134 Master Tool Coord. isn't selected
Cause	It occurs when attempting to operate jog for Slave robot in a CMOV recording mode(R351,3). Master robot is not specified. Or it may occur when using forwarding function of CMOV step. The currently set number of Master is different from the recorded Master number in CMOV.
Action	Set a correct master robot for manual cowork Master.

8.2. System Error

Code	E0200 (axis 0) Speed over while cooperating
Cause	An instruction in excesse of robot maximum speed is input during cowork operation.
Action	Change the robot posture, cowork record position, or lower the record speed in a standard position of Slave which has the cowork operation.

Code	E0201 Start time mismatch
Cause	There is an error in receiving/sending signals between cowork robots. It was playedback in different modes.
Action	Check the communication condition. Match the modes between cowork robot before operating.

Code	E0203 Partner robot is Emergency
Cause	Partner robot motor is OFF during cowork operation. It turns motor OFF to stop.
Action	Take necessary actions to the cause of partner robot. Turn motor ON and re-start it.

Code	E0204 Rbt#1 Communication is not working
Cause	Communciation with the corresponding robot is disconnected during cowork, jog, and play.
Action	Check if the connection between communication line and communication card is good. Error can be detected by Hint diagnostic.

Code	E0205 HiNet is not working
Cause	Hinet communication for cowork is not working.
Action	Check if connection between communicatin line and communication card. Error can be detected by Hinet diagnostic.

Code	E0227 Seq. error of Cooperative control
Cause	There is a difference in instruction sequence between master robot and slave robot during cowork control.
Action	Check the connection of network for cowork control. Check if slave is excecuting power saving function. Set the power saving function of slave robot as Disable.

8.3. Operation Error

Code	E1340 Disable condition for co-work run
Cause	Controller is inadequately set to execute COWORK instruction.
Action	Check if communication is normal, if partner's common coordinate system is set, and if the manual coworking is identical with COWORK robot's role.
Code	E1341 Cooperation wait time is over
Cause	All the coworking robots are not ready to cowork for the set standby time after meeting with COWORK instruction.
Action	Set the standby time taking the reaching time for all coworking robot to the position into account. If 0 is set, it would continue to standby until all robot could reach.
Code	E1342 Invailded COWORK or common coordi.
Cause	COWORK instructions cannot be executed because robot coworking is disable or common coordinate system is not set.
Action	Set the common coordinate system after setting <enable> in a system setting/control parameter/cowork control parameter.
Code	E1343 COWORK execution mismatch
Cause	COWORK instructions are executed repeatedly, or program END is executed without COWORK END
Action	Program to make COWORK instruction and COWORK END instruction in pairs. Double execution by step change is prohibited.
Code	E1344 COWORK Para.(M/S,robot No.) error
Cause	Partner robot's number is incorrectly set, indicating my robot's number in COWORK instruction.
Action	Change it because the robot's number corresponding to COWORK M(S),S(M)=robot number cannot be set to my robot.
Code	E1345 The slave already executed COWORK.
Cause	Slave robot's cowork is already working in the position of COWORK END, or it stops.
Action	For normal coworking of Master & Slave, do not change step artificially.
Code	E1347 Coord. system not supporting shift
Cause	Base / Robot / Tool / User coordinate shift is addable to Base / Robot / Encoder / Usercoordinate system pose, and other shift calculation in coordinate system is not allowed.
Action	Check the coordinate system of pose or shift variable/constant, and convert it to the allowable coordinate system. [QuickOpen]

Code	E1355 Partener robot is error stoped
Cause	Partner robot stops during Cowork so that it is impossible to cowork any longer. It stops because cowork is impossible.
Action	Check if the operation mode is identical between robots. Restart Slave first before restarting Master if restarting after stop during cowork.
Code	E1356 Duplicated robot number is set
Cause	Overlapping robot number makes it impossible to control COWORK.
Action	Check the robo number connected to Hinet to change the overlapping robot number, and apply power again.
Code	E1360 ROBOT.C00 file is damaged.
Cause	ROBOT.C00 file structure is damged.
Action	Initialize the memory with a support of our A/S staff. TEL : 052-202-5041 FAX : 052-202-7960 E-Mail : robotas@hhi.co.kr
Code	E1361 ROBOT.C01 file is damaged.
Cause	ROBOT.C01 file structure is damged.
Action	Initialize the memory with a support of our A/S staff. TEL : 052-202-5041 FAX : 052-202-7960 E-Mail : robotas@hhi.co.kr
Code	E1362 ROBOT.C00 file is read only.
Cause	Impossible to record a data in ROBOT.C00 file.
Action	Change the property of ROBOT.C00 file.
Code	E1363 ROBOT.C01 file is read only.
Cause	Impossible to record a data in ROBOT.C01file.
Action	Change the protect of ROBOT.C01 file.

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